I. OVERVIEW

If the language of the brain lies in its neuronal coding, then the expression of the brain lies in its rhythmicity and timing. The rhythmicity is due to the selective synchronization and desynchronization of the encoding within billions of pools of neurons which provide the sensory activity of everything that is sensed, thought, or done. Berger (1929) observed all four main rhythms—the alpha, beta, theta, and delta—in his very first EEG recording. It should come as no surprise, therefore, that since the earliest EEG studies, interest has turned toward rhythmic sensory stimulation, and its possible effects on brain function.

Auditory or visual stimulation (AVS) can take a wide variety of forms, generating different subjective and clinical effects. The simplest form of stimulation is to present a series of arbitrary light flashes or sound clicks to a subject, and investigate the resulting subjective or EEG effects, whereas audio-visual entrainment (AVE) would involve stimulation at a particular frequency. This "open loop" stimulation is not contingent on the EEG brainwave in any way. From this basic form, changes can be made in the type of stimulation, without dependence on the EEG waves.

Clinical reports of flicker stimulation appear as far back as the dawn of modern medicine. It was at the turn of the twentieth century when Pierre Janet, at the Salpêtrière Hospital in France, reported that by having his patients gaze into the flickering light produced from a spinning, spiked wheel in front of a kerosene lantern, there was a reduction in their depression, tension and hysteria (Pieron, 1982). With the development of the EEG, Adrian and Matthews published their results showing that the alpha rhythm could be “driven” above and below the natural frequency with photic stimulation (Adrian and Matthews, 1934). This discovery prompted several small physiological outcome studies on the “flicker following
response,” the brain’s electrical response to stimulation (Bartley, 1934, 1937; Durup and Fessard, 1935; Jasper, 1936; Goldman et al., 1938; Jung, 1939; Toman, 1941).

In 1956, W. Gray Walter published the first results on thousands of test subjects comparing flicker stimulation with the subjective emotional feelings it produced (Walter, 1956). Test subjects reported all types of visual illusions and in particular the “whirling spiral,” which was significant with alpha production. Finally, in the late 1950s, as a result of Kroger’s observations as to why US military radar operators often drifted into trance, Kroger teamed up with Sidney Schneider of the Schneider Instrument Company, and produced the world’s first electronic clinical photic stimulator—the “Brainwave Synchronizer.” It had powerful hypnotic qualities, and soon after studies on hypnotic induction began to be published (Kroger and Schneider, 1959; Lewerenz, 1963; Sadove, 1963; Margolis, 1966).

In the “open-loop” system of visual stimulation, flickering or flashing light can be replaced with sine wave and other types of modulated light. Generally, the more elaborate the photic stimulation, the greater the potential for the brain to interpret and respond. For example, sine-wave modulated light has a significantly greater effect on endogenous rhythms than a simple flickering light. In the case of auditory stimulation, simple clicks can be replaced with modulated or “warbling” sounds, or with binaurally presented “beats.” In the case of binaural beats, two different signals are presented to each ear, and the reconstruction of the frequency difference or “beat” is performed within the brain itself.

It is also possible to introduce dependence of the stimulation on the EEG wave, so that it becomes EEG-driven, or “closed-loop,” or “contingent.” Contingent stimulation is produced when the parameters of the feedback are determined by the properties of the EEG. There is a variety of ways to achieve closed-loop control of feedback. These include both direct (phase-sensitive) and indirect (frequency or amplitude-sensitive) methods. Contingent stimulation greatly increases the possibility for learning to occur, and learning may even occur without conscious effort (“volition”). When the brain is presented with information (including stimulation that reflects EEG information), the possibilities for classical conditioning, operant conditioning, concurrent learning, and self-efficacy arise.

There is a variety of ways to make the stimulation contingent on the EEG, and these include approaches described by Carter (1999), Davis (2005) and Collura (2005). These methods can be broken into two types: phase-sensitive and frequency-sensitive. In phase-sensitive feedback, the photic stimulation is determined by the exact details of the EEG wave, including the timing of peaks and valleys (Davis, 2005). The original Roshi I and Roshi II devices employed a proprietary algorithm that converted the complex EEG waveform into a pattern of flashes. The resulting stimulation was EEG-dependent, and reflected the details of the time behavior of the signal.

With frequency-sensitive methods, some EEG frequency parameter is first determined, such as peak or dominant frequency, and then the stimulation rate is set based upon this information (Russell, 1996; Ochs, 1994; Carter and Russell,
1993). It is further possible to control the onset and end of stimulation using EEG parameters. For an overview and bibliography of the technical and physiological issues see Collura (2002).

As EEG equipment improved, so did a renewed interest in the brain’s evoked electrical response to photic and auditory entrainment, and soon a flurry of studies was completed (Barlow, 1960; Van der Tweel and Lunel, 1965; Kinney, 1973; Townsend, 1973; Donker, 1978; Frederick et al., 1999; Chatrain et al., 1959).

II. EVIDENCE OF SENSORY EFFECTS OF AVE

Published work in AVE tends to fall into one of three categories: 1) Subjective experiential effects of AVE, 2) EEG changes associated with AVE with possible diagnostic value, and 3) clinical applications of AVE. The first type of work has been reported by Huxley (1954), Budzynski & Tang (1998), and others. These have shown that rhythmic information can produce unique sensory experiences, associated with the properties of the stimulation. These can include sensations such as activation, relaxation, or discomfort, visual experiences, and “twilight” states.

Aldous Huxley (1954) was among the first to articulate the subjective correlates of what he described as the “stroboscopic lamp.” In his view, “we descend from chemistry to the still more elementary realm of physics. Its rhythmically flashing light seems to act directly, through the optic nerves, on the electrical manifestations of the brain’s activity.” He described subjective experiences of incessantly changing patterns, whose color was a function of the rate of flashing. Between 10 and 15 flashes per second, he reported orange and red; above 15, green and blue; above 18, white and gray. He also described enriched and intensified experiences when subjects were under the effects of mescaline or lysergic acid.

In his view, the rhythms of the lamp interacted with the rhythms of the brain’s electrical activity to produce a complex interference pattern which is translated by the brain’s apparatus into a conscious pattern of color and movement. He remained mystified, however, by one subject who reported seeing an abstract geometry described as a “Japanese landscape” of surpassing beauty, charged with preternatural light and color. Clearly, this simple procedure elicited brain responses far more complex than a simple interference pattern involving basic rhythmic interactions. It comprises the first report of the subjective responses to a simple, non-contingent stimulation.

The second type of work is reported by Walter (1949), Regan (1989), Collura (2001), Silberstein, (1995), and Frederick et al. (2004). These studies have shown that stimulation can produce both transient and lasting changes in the EEG. Collura (1978) articulated the relationship between the low-frequency and high-frequency components of the steady-state visual evoked potential as reflecting anatomically and physiologically distinct response mechanisms, and also demonstrated that the short-term waxing and waning in the steady-state visual evoked response reflects short-term changes in attention. It has been found that contingent
Auditory–visual entrainment in relation to mental health and EEG

stimulation has significantly greater effect in producing lasting changes, when compared to non-contingent stimulation.

The third type of work has been reported by Evans (1972), Hammond (2000), Carter and Russell (1993), Ochs (2006) and (Siever, 2007). This approach emphasizes clinical changes and applies the various forms of AVE, in an effort to delineate the visible effects which can be used therapeutically. When an empirical approach is used, benefits may be observed that would not be expected, based upon first principles. Clinical benefits have included improvements in attention and concentration, and reduction of depression.

Evans (1972) was particularly interested in the potential for simultaneous visual, auditory and tactile stimulation to assist with severely retarded children, and reported promising results. Davis (1999) developed a different type of EEG-controlled nonvolitional method that used parameters of the EEG signal to control light flashes. This approach incorporates particular aspects of the EEG signal in real-time. Hammond’s (2000) report employs this system in a single case study that demonstrated efficacy in the case of depression. More recently, Davis has developed an open-loop method (“pRoshi”) that provides similar stimulation dynamics, but does not utilize EEG control (Davis, 2005). Carter et al. (1999) described a method that extracts a determination of the dominant frequency in the EEG and uses this information to determine the frequency of stimulation. Both stimulation and entrainment are then non-contingent, consisting of a brief presentation of open-loop stimulation. They have reported clinical benefits, particularly in relation to learning and attention.

Additional clinical studies explored the use of photic entrainment to induce hypnotic trance (Kroger and Schneider, 1959; Lewerenz, 1963), to augment anesthesia during surgery (Sadove, 1963) and to reduce pain, control gagging and accelerate healing in dentistry (Margolis, 1966). More recently, the induction of dissociation was explored (Leonard et al., 1999; Leonard, et al., 2000), which aided the understanding of dissociative pathology and development of better techniques for relaxing people suffering from trauma and post-traumatic stress disorder (Siever, 2006).

III. PHYSIOLOGICAL EFFECTS OF AVE SYSTEMS

Srinivarsan (1988) described a method to make the intensity of photic stimulation directly related to the instantaneous amplitude of the subject’s EEG alpha wave. The stimulation was thus both phase-locked to, and proportional to, the size of the alpha signal. He reported enhanced alpha amplitude when subjects attended to the stimulator, with concomitant subjective reports consistent with enhanced alpha activity. Systems such as these do not appeal to any need for operant conditioning, or for instructions to the test subject. These methods are thus deemed “nonvolitional” in that they do not depend on the volition (intent) of the subject.
Collura (2005) has further described a nonvolitional method that employs selective photic entrainment at a predetermined flicker frequency, but which is presented contingent on the EEG meeting certain criteria. This approach can be used to inhibit particular EEG rhythms, and is also a nonvolitional method.

The following single-session example demonstrates the capability of EEG-controlled photic entrainment, when applied in an extinction learning model, to reduce excess theta activity. The trainee complained of not being able to control the level of their theta, and that it was known to be in excess in previous EEG analyses. The sensor was placed at Oz, and a single channel of EEG was used. The method was based on Collura (2005), as a means of reducing the theta activity by nonvolitional EEG-controlled training. The following results were obtained, using a 5-minute photic training period beginning at minute 30, with no additional instructions given to the trainee (see Fig. 8.1).

The chart shows theta (4.0–7.0 Hz) amplitude as a function of time, during a test session. Minutes 1–30: conventional neurofeedback. Minute 30: Contingent photic stimulation (14 Hz peripheral white LEDs flashed when theta > threshold) begins. Minute 35: Contingent photic stimulation is withdrawn. The continued effect of the learned extinction is evident. Minute 47: Trainee is talking, motion artifact is present.

The initial 30 minutes of monitoring showed the expected high levels of theta, averaging above 20 microvolts peak-to-peak. During this time, conventional feedback was presented in the form of bar graphs and sounds indicating when theta was below a threshold. At minute 31, photic stimulation was introduced, so that flashes at 14 per second were delivered, whenever the momentary theta value exceeded a second threshold value. For the next 5 minutes, the trainee experienced the intermittent

![FIGURE 8.1 Effect of contingent photic stimulation on excess theta.](image-url)
14Hz photic stimulation in both eyes, using peripheral LED glasses, so that they could continue to watch the EEG biofeedback display. At minute 35, the stimulation was discontinued, and the trainee continued to watch the neurofeedback display, as before.

Figure 8.1 shows that the theta amplitude changed abruptly, from its standing level of over 20 microvolts to a level below 10 microvolts, within the 5-minute learning period. Moreover, the theta amplitude remains at the new level well after the removal of the stimulation, and does not show any tendency to recover or “creep up” for the remainder of the session. The “blip” at minute 47 occurs when the trainee is talking, basically remarking that “my theta level is staying down.”

It appears from these results that the effect of the 5-minute learning interval was to produce a sustained change in theta activity that persisted well after the stimulation was withdrawn. Therefore, in contrast to “open-loop” stimulation, this method produces a robust and clear learning effect that is lasting. Furthermore, this learning did not depend on intention, as the trainee was given no instructions. Rather, the training was nonvolitional. The learning process was thus a result of intrinsic brain processes mediating the change directly, as a result of the effect of the stimulation on theta production.

Physiological effects of AVE systems
A variety of modifications of audio-visual entrainment have been tested, with promising results. Rozelle and Budzynski (1995) used a prototype “EEG-Driven AVS” device developed by Ochs to augment neurofeedback in the successful treatment of a stroke client. This device sampled the client’s EEG then automatically adjusted the AVE frequency to either lead or lag the dominant EEG frequency. Davis (1999) has developed a different type of EEG-controlled nonvolitional method that uses parameters of the EEG signal to control light flashes. This approach incorporates particular aspects of the EEG signal in real-time. Hammond (2000) describes the application of this system in a single case study that demonstrated efficacy in a case of depression.

More recently, Davis has developed an open-loop method that provides similar stimulation dynamics, but does not utilize EEG control (Davis 2005). Finally, a model of photic entrainment using EEG and cerebral blood flow feedback is eminent, which extracts a determination of the dominant frequency in the EEG, and uses this information to establish the frequency of stimulation. Entrainment is then non-contingent, consisting of a brief presentation of open-loop stimulation. Carter et al. (2000) reported clinical benefits, particularly in relation to learning and attention.

IV. HARMONICS AS A FUNCTION OF ENTRAINMENT
Although photic entrainment can be shown to produce subjective and physiological effects as a result of cortical stimulation, it is another issue entirely to conclude that it interacts with or produces endogenous rhythms. If, for example, a light flashing at 10 flashes per second produces EEG responses at 10 cycles per second, this does not
imply that the flashing is producing an \textit{“alpha”} rhythm. Endogenous rhythms are associated with particular thalamocortical and corticocortical mechanisms, and are self-sustaining (Sterman, 1996). Responses to flickering light, on the other hand, are produced by the same mechanisms that produce simple evoked potentials, and thus involve sensory and perceptual mechanisms that are different from the innate cortical rhythmic generators. This is confirmed by the fact that photic \textit{“entrainment”} effects in the EEG are invariably seen to vanish when the stimulation is withdrawn. In other words, the EEG is not \textit{“entrained”} in the sense of \textit{“driving”} an alpha rhythm. Rather, a repetitive evoked potential is produced, whose frequency content is simply related to the stimulating flashes, and the presence of these frequencies reflects an entirely different mechanism and functional anatomical basis when compared with endogenous rhythms.

Harmonics are also commonly seen in the EEG responses to photic stimulation. Again, these do not need to be interpreted as \textit{“beta”} or \textit{“gamma”} rhythms produced by the stimulation. Rather, the presence of higher harmonics is understood as a simple product of the complex waveform that is elicited. True beta, gamma, and similar high-frequency EEG rhythms are produced by particular cortico-cortical mechanisms, and are modulated as a function of cortical excitability. When a visual evoked response is produced, it has its own low-frequency and high-frequency components, regardless of the frequency of stimulation. The high-frequency components are the primary cortical responses, and low-frequency components reflect secondary cortical mechanisms. It so happens that when the stimulation occurs at certain rates, the overlapping of the separate evoked potential components reinforces a particular component, due to the linear superposition of the waveforms. Thus, the frequencies elicited by repetitive stimulation reflect different neuronal mechanisms than those producing endogenous rhythms.

As a result, the benefits of AVE are not simple or \textit{“automatic.”} That is, by stimulating at or near the alpha frequency, for example, we should not expect to elicit the same effects as the brain producing its endogenous alpha rhythm. There may be subjective correlates to the stimulation that resemble an alpha state, but this is not an intrinsic alpha state. In furthering the field, both the short-term and long-term EEG and clinical effects of the stimulation must be studied, in order to produce solid scientific and clinical rationale.

V. EFFECTS OF AUDIO-VISUAL ENTRAINMENT

AVE is believed to achieve its effects through several mechanisms simultaneously. These include:

1. Altered EEG activity
2. Dissociation/hypnotic induction
3. Limbic stabilization
4. Improved neurotransmitter production
5. Altered cerebral blood flow.

It is important to delineate the difference between audio-visual stimulation (AVS) and audio-visual entrainment (AVE). Watching TV, a car drive by, or being at a noisy mall or theme park all constitute AVS, where there is a great deal of stimulation; all of it, however, is quite random and unorganized. This type of stimulation doesn’t necessarily leave a significant imprint on one’s psyche, cerebral blood flow or brain wave activity.

AVE is a subset of AVS where constant, repetitive stimuli of the proper frequency and sufficient strength to “excite” the thalamus, and neo-cortex, must be present. These stimuli do not transfer energy directly into the cortex as TV and radio waves do into a tuned circuit, nor in the same manner as placing a tuning fork near another tuning fork that is vibrating at the same frequency thus making the silent fork “hum” as well. The direct transmission of energy from AVE only goes so far as to excite retinal cells in the eyes, and pressure-sensitive cilia within the cochlea of the ears. The nerve pathways from the eyes and ears carry the elicited electrical potentials into the thalamus. From there, the entrained electrical activity within the thalamus is “amplified” and distributed throughout other limbic areas and the cerebral cortices via the cortical thalamic loop. In essence, AVE involves the continuous electrical response of the brain in relation to the stimulus frequency, plus the mathematical representation (harmonics) of the stimulus wave shape. Figure 8.2 shows the visual pathways for visual entrainment. Figure 8.3 shows an occipital record of square wave visual entrainment at 2, 4, 8, 12 and 20Hz (Kinney et al., 1973).
A. Altered EEG Activity

AVE effects on the EEG are primarily found frontally, over the sensory-motor strip, and in parietal (somato-sensory) regions, and slightly less within the prefrontal cortex. It is within these areas where executive function, motor activation and somato-sensory (body) awareness are primarily mediated. It is believed this is why AVE lends itself well for the treatment of such a wide variety of disorders including PTSD, panic, anxiety, depression, cognitive decline, and attentional disorders. Eyes-closed AVE at 18.5 Hz has been shown to increase EEG brain wave activity by 49% at the vertex (CZ) (the only site examined in this study). Auditory entrainment (AE) is the same concept as visual entrainment with the exception that auditory signals are passed into the thalamus via the medial geniculate, whereas visual entrainment passes into the thalamus via the lateral geniculate (McClintic, 1978). At the vertex (with the eyes-closed) AE produced an increase in EEG brain wave activity by 21% (Frederick et al., 1999). Successful entrainment leads to a meditative kind of dissociation, where the user experiences a loss of somatic and cognitive awareness.

Only a sine wave produces a single harmonic. Complex waves are made up of a multitude of harmonics, so it’s therefore to consider that a non-sine wave stimulus could generate harmonics in the brain. Figure 8.4 shows a combination sine-square stimulus with a second harmonic that shows up in the EEG record of this subject.

B. Dissociation

Dissociation occurs in varying degrees when we meditate, exercise, enter a hypnotic trance, read a good book, become involved in a movie or enjoy a sporting event.

![Figure 8.3](image-url) Visual entrainment effects on the occiput.
We get drawn into the present moment and let go of thoughts relating to our daily hassles, hectic schedules, paying rent, urban noise, worries, threats or anxieties and the resultant, often unhealthy, mental chatter. Dissociation involves a “disconnection” of self from thoughts and somatic awareness, as is experienced during deep meditation. As dissociation begins (after approximately 4–8 minutes) from properly applied AVE, a restabilization effect occurs where muscles relax, electrodermal activity decreases, peripheral blood flow stabilizes (hand temperature normalizes to 32–33°C), breathing becomes diaphragmatic and slow, and heart rate becomes uniform and smooth. Visual entrainment alone, in the lower alpha frequency range (7–10 Hz), has been shown to easily induce hypnosis (Lewerenz, 1963); and it has been shown that nearly 80% of subjects entered into a either a light or deep hypnotic trance within 6 minutes during alpha AVE (Kroger and Schneider, 1959), as shown in Fig. 8.5. Additional studies have shown that AVE provides an excellent medium for achieving an altered state of consciousness (Glickson, 1987).

C. Autonomic Calming

The amygdala is activated by fear, anxiety and stress (the fight-or-flight response), and the hypothalamus controls all autonomic functioning including muscle tension, electrodermal response, heart rate, arterial tone, body temperature, eating and satiety. Because AVE can be used to produce hand-temperature normalization, muscle relaxation, reduced electro-dermal activity, reduced heart rate and reduced hypertension, it is speculated that AVE may produce a calming effect on these

![Brain map in 1 Hz bins during 8 Hz AVE (“SKIL” analysis—eyes-closed).](image-url)
limbic structures. AVE therefore lends itself very well to stabilizing panic and anxiety. When using white light as the stimulus, measures of finger temperature, electromyograph (EMG), electro-dermal response (EDR), and heart-rate variability (HRV) have been dramatically improved within 10 minutes.

Figure 8.6 shows increasing (normalizing) finger temperature in one subject. Figure 8.7 shows decreased electrodermal response using white-light AVE (DAVID system) at alpha frequencies. Notice that the normalization effect begins following roughly 6 minutes of AVE.
D. **Neurotransmitter Changes**

People under the influence of long-term anxiety eventually develop *adrenal fatigue* (hypo-adrenalis), characterized by exhaustion and fatigue (Wilson, 2001). And as both serotonin and norepinephrine production shuts down in the brain, depression sets in (Sapolsky, 2003). In one study of AVE, blood serum levels of serotonin, endorphine, and melatonin all increased considerably following 10Hz, white-light photic stimulation (Shealy *et al.*, 1989). Several clinical studies showed declines in depression, anxiety and/or suicide ideation following a treatment program using AVE, e.g., Gagnon and Boersma, (1992); Berg and Siever, (2004).

E. **Changes in cerebral blood flow and metabolism**


AVE has been shown to increase brain glucose metabolism overall by 5%, and to increase CBF in the striate cortex, peaking at a 28% increase at 7.8Hz (Fox and Raichle, 1985). This, coincidentally, is the *Schumann Resonance*, the frequency that electro-magnetic radiation propagates around the earth (Schumann, 1952; Bliokh *et al.*, 1980; Sentam, 1987). In addition, AVE has been shown to increase CBF throughout various other brain regions including frontal areas (Mentis *et al.*, 1997; Sappey-Marinier *et al.*, 1992).
VI. CLINICAL PROTOCOLS WITH FREE-RUNNING AUDIO-VISUAL ENTRAINMENT

Hundreds to thousands have successfully used audio-visual entrainment (AVE) to reduce or manage the symptoms of their disorders, syndromes, and ailments. To date, a number of AVE-related studies with clinical outcomes have been completed, and more are in progress. A number of the studies with clinical implications are listed below:

- Attention deficit disorder 4 (n = 359, school children)
- Academic performance in college students 2 (n = 22, college students)
- Improved cognitive performance in seniors 4 (n = 86)
- Reduced falling in seniors 1 (n = 80, seniors)
- Dental—during dental procedures 2 (n = 36)
- Temporo-mandibular joint dysfunction 2 (n = 43, middle-aged)
- Seasonal affective disorder 1 (n = 74, middle-aged)
- Pain and fibromyalgia 3 (n = 66, middle-aged)
- Insomnia 1 (n = 10, middle-aged)
- PTSD 600 cases (public, police and military)
- Migraine headache 1 (n = 7)
- Hypertension 1 (n = 28)
- Stroke 1 (n = 1)

A. How AVE Protocols (Sessions) are Designed

Since the inception of the original DAVID1 in 1984, designing sessions has been a multifaceted approach, and a lengthy process. Session designs are drawn from personal experience, results from clients and from practicing health professionals. The DAVID Session Editor (Fig. 8.8) is a valuable tool for allowing clinicians free reign over their customized session design. The Editor allows independent left and right frequency control from 0–25.5 Hz, including a steady-on state on either side. Intensity of light, type of auditory tone and heart beat pacer, plus its pitch and volume are also adjustable. Various waveforms (sine wave, triangle wave, sine-square combination, and square waves) of the light stimulation are also pre-settable.

Stimulation in the left visual field of both eyes and left ear evokes activity in the right hemisphere of the brain whereas stimulation in the right visual fields of both eyes and right ear evokes activity in the left hemisphere of the brain. Therefore, when this guide refers to left or right brain it is referring to the activity or side of the brain that is being activated. For example, “Left Brain Beta/Right Brain SMR” means that a beta frequency of auditory and visual stimulation is being presented to the right visual fields and right ear to produce a response in the left side of the brain, and SMR stimulation would come from the left side to produce a response in the right side of the brain.
B. Components of a Session

As shown in Fig. 8.9, sessions generally comprise three sections: an initial induction process, body, and ending. With eyes-closed AVE, the induction process is
crucial in dissociating the user so that: a) the cortical-thalamic entrainable rhythm can maximize, and b) there can be calming of the autonomic nervous system as seen in Figs. 8.7 and 8.8 above. With most sessions in DAVID systems, the left and right stimuli begin with a 0.5 Hz difference between them. This sets up a slow beat frequency, which is quite dissociating. A unique randomization process, which follows the frequency offset, also begins following the first minute of AVE. In the case of simple alpha, theta and delta sessions, this randomization continues until the target frequency is reached. Complex sessions do not generally require randomization as the complexity of the session provides its own dissociative induction. All DAVID sessions end with a “soft-off” process, where the session fades out gently, so as not to startle the user (Siever, 2000).

C. “Rules of Thumb”

As with any intervention, there are guidelines as to when to receive treatment, and what the treatment should look like. In order to achieve the best results from AVE, we recommend the following as guidelines or “rules of thumb.”

1. Drink a glass of water before every AVE session. Do this for at least the first six sessions and particularly with depression, ADD/ADHD, and cognitive decline in seniors where a condition of hypoperfusion of cerebral blood flow exists.

2. Close your eyes during the session for best effects, although keeping your eyes open is not harmful.

3. Use beta sessions in the morning, not at night.

4. Use the SMR session in the morning or early afternoon, and the longer “Dissociative SMR” at night for the anxious-mind/quiet-body type of insomnia.

5. Use 10 Hz alpha and theta sessions in the afternoon.

6. Use slower alpha sessions in the afternoon, evening or at bedtime, but not in the morning.

7. Use delta sessions at night only.

D. Session Frequency Ranges and Types

By and large, the AVE frequency chosen is the same as is typically chosen for neuro-feedback. About a dozen key session types can be identified. These include a frequency, the time needed to induce a dissociative/meditative state of mind (the first crucial step toward deep induction), and a fading at the end. AVE sessions can span the entire brain wave range from sub-delta up to 25 Hz, and independently for each hemisphere. Beyond 25 Hz the effects of AVE diminish, and anxiety can be elicited. Marvin Sams (2007, personal communication) has also found that AVE up around gamma (40 Hz) can produce severe negative side effects. However, there are unique AVE sessions which are over and above traditional, straight-on entrainment. These are listed below.
1. **Beta 18–22 Hz**

Beta stimulation in the 18–22 Hz range has been shown to be the most effective for improving cognition (mental performance) and attention, and, to a lesser degree, for reducing depression. Beta has been proven useful for clearing mental “fog” in people with fibromyalgia (Berg et al., 1999). AVE above 20 Hz may produce anxiety. Beta sessions increase arousal in non-ADHD users, whereas those with ADD-ADHD often fall asleep. A study treating seasonal affective disorder (SAD) using 20 Hz AVE showed large reductions in anxiety, depression, and carbohydrate cravings, while eliciting weight loss (Berg and Siever, 2004). Beta sessions are best used after waking, usually while the user is in bed, and run for 20 minutes.

Figures 8.10, 8.11 and 8.12 show results of the SAD study in 2004. Figure 8.10 shows reductions in depression (BDI or Beck Depression Inventory) while...
Fig. 8.11 shows improvement in mood and sociality. Figure 8.12 shows increased energy and reduced carbohydrate cravings. During the 2-week pre-test condition, the participants had an average weight loss of 3 pounds (1.36 Kg). They had further weight reductions of 6.5 pounds (4.3 Kg) during the two-week treatment condition.

2. **Low Beta/Sensorimotor Rhythm**

The SMR (sensorimotor rhythm) is the idling rhythm for the motor strip—the long thin area located on top of the head between the ears (McClintic, 1978). As SMR increases, a person’s body becomes more relaxed. Hyperactive (ADHD) children have very little SMR activity. In cortical regions outside of the motor strip, 12–15 Hz is considered to be low beta. Low beta relates to relaxed attention such as reading or engaging in a relaxing hobby such as knitting. SMR has also been used successfully with View-hole “Tru-Vu Omniscreen™” eyesets to improve reading speed and comprehension. The use of 14 Hz was used by Budzynski and Tang (1999) to increase peak alpha frequency and A3/A1 ratios (11–13 Hz/7–9 Hz), which in turn enhanced mental clarity.

Use SMR for:

- Relaxed attention.
- Quieting the body down.
- Reading with the View-hole Omniscreen eyesets.
- Insomnia—“chattery” mind but relaxed body.

There are two variations of SMR. One variation is in keeping with Hauri’s (1982) neurofeedback studies in which he found that uptraining in the 12–15 Hz frequency band helped reduce insomnia in people suffering from insomnia of the
"racy-head," relaxed-body type. The AVE session is typically 40 minutes with a long dissociated, randomized front end to help with sleep onset. The second variation involves ADD/ADHD children with whom this session is used with eyesteds containing view-holes for reading. The session is then played while the person reads. No dissociation is added. Both left and right stimulation are locked in phase. Self-reports from these users indicate that visual tracking, attention, comprehension, and retention are improved.

3. Alpha Sessions

The alpha AVE sessions in the range of 7–10 Hz are the most commonly used. They are used for meditating, going to sleep, calming anxiety and reducing post-traumatic stress syndrome (PTSD) symptoms. Clients have come into our office immediately following a panic attack, and they have been tense, pale and exhausted. Following a Schumann session these same clients have left feeling relaxed, calm, grounded, and stable for up to 2 days. Nothing settles down an irritated amygdala and hypothalamus as alpha AVE does. Most of the time people fall asleep during a slow alpha (7–9 Hz) session.

However, like meditation, deep relaxation and temperature biofeedback, alpha sessions can, in some cases, make the user unsettled and anxious if repressed memories begin to surface, although this is rare. People who are “controller” types and “guarded” don’t generally like alpha sessions (or AVE sessions at all) because they feel like they are losing their control. People who have experienced trauma also often resist “giving in” to the session, not realizing that AVE may be the best thing for them.

Sometimes, continued daytime use of slowed alpha sessions can make a person feel sluggish, moody, and “foggy-headed.” Brain maps we have done show that slowed alpha sessions often dramatically reduce depression but may increase depression as well. Presently, we don’t know how to predict which way a person will go, so make mental body/mind checks when using these sessions during the daytime. Night-time use is okay, because our brainwaves slide through slow alpha and theta on the way to sleep. Afternoon use is also generally okay if the user falls asleep during the session.

All sessions have a natural element of dissociation just by the very nature of AVE. However, extra “chatter” reducing dissociation is achieved by using two slightly different frequencies, and randomization during the first portion of the session (see section on Dissociation above).

Jaw tension and degradation of the joint and its cartilage, more formally known as temporomandibular dysfunction (TMD), is often a direct physiological outcome in response to stress (Yemm, 1969). Auditory entrainment at 10 Hz, plus EMG biofeedback has been shown to directly reduce the symptoms of TMD (Manns et al., 1981). A study by Thomas and Siever, (1989) showed that many people with chronic TMD show dysponesis or bracing (tensing up) when asked to relax. AVE
at 10 Hz produced deep masseter muscle relaxation and finger warming within 6 minutes. Cagnon and Boersma (1992) found that alpha AVE was effective in reducing chronic pain from back injury. Anderson (1989) found that alpha AVE effectively reduced migraine, and Siever (2003) found that alpha AVE normalized breathing and heart rhythms in minutes.

Alpha AVE at 10 Hz has also been shown to reduce jaw tension (Siever, 2003) during wide mouth opening. AVE has been used to reduce jaw pain, patient anxiety and heart rate during dental procedures (Morse and Chow, 1993). During this study, it was found that the most stressful part of a root canal procedure was during the injection (needle). With alpha AVE alone, heart rate was reduced significantly. With increased dissociation by listening to a relaxation tape, heart rate was further reduced.

A study by Williams, et al. (2006) found that as seniors approached 80 years of age, their ability to correctly identify real-language trigrams (three-letter words) versus fake words became impaired. They also found that seniors over 80 had difficulty remembering words they had heard previously in a test where they were required to identify random word-pairs. Based on the premise that healthy alpha near 10 Hz is associated with peak mental performance, a row of light-emitting diodes (LEDs) along the top of the computer testing monitor was flash for just one second at a variety of frequencies (9 Hz, 9.5 Hz, 10 Hz, 10.2 Hz, 10.5 Hz, 11 Hz, 11.5 Hz, and 500 Hz, as a control) just before the task occurred. As expected, the seniors’ performance was best following 10.2 Hz, in accordance with maximal healthy alpha production, as shown in Fig. 8.13.

![Figure 8.13](image-url)  
**FIGURE 8.13**  Results of declarative memory trials vs. photic stimulation frequency (Williams et al., 2006) n = 30.
4. **Alpha/Theta and Theta**

Alpha/theta is a “twilight” state between awareness and sleep. It is associated with deep relaxation and creative insights (Budzynski, 1976). The alpha/theta range spans roughly from 7 to 8.5 Hz. The Schumann session (7.8 Hz) is likely the most popular of all AVE sessions (Fig. 8.14). Alpha/theta training is popular among neurofeedback practitioners for reducing the impact of stress. As has been shown in PET studies, a strong association exists between the perfusion of cerebral flow and slow wave EEG activity (Leuchter et al., 1999). However, a study by Fox and Raichle (1985), found that visual entrainment at 7.8 Hz brought about the large increases in cerebral blood flow of all frequencies spanning from 1 to 60 Hz. Therefore, the metabolism effect of AVE will typically normalize aberrant slowed-alpha activity, even with AVE stimulation at the same aberrant frequency as seen in this 22-year-old lady with ADD and fibromyalgia. Figure 8.15 shows the pre- AVE aberrant EEG activity. The post 7.8 Hz AVE results (Fig. 8.16) were taken 20 minutes following the cessation of the Schumann session.

Alpha/theta AVE is an ideal time to practice heart rate training since autonomic activity is very low, thus an excellent breathing pattern may be easily achieved. A heartbeat pacer is added to sessions in the DAVID devices for these reasons. With the assistance of AVE, the user releases restricted and “chesty” breathing patterns, and begins diaphragmatic breathing quite effortlessly.

5. **Delta**

Sleep studies conducted within our office have shown that delta stimulation does not generally help with anxiety-based insomnia. Delta AVE does however reduce
FIGURE 8.15  QEEG results on Skil Database—pre-AVE.

FIGURE 8.16  QEEG results on Skil Database—post 7.8 Hz AVE.
Auditory-visual entrainment in relation to mental health and EEG

insomnia in those with fibromyalgia (Berg et al., 1999). This coincides with Hauri’s neurofeedback study with insomniacs.

6. Sub-Delta

We believe that sub-delta (1–1.5 Hz) impacts the hypothalamus because of the way it has normalized both pain and hypertension in non-anxious, non-depressed clients. It also has been useful in re-establishing sleep in those with mid-night awakenings.

7. ADD/ADHD Sessions

AVE sessions for treating ADD and ADHD generally comprise complex frequency stimulation. For instance, Carter and Russell (1993) developed a session to treat ADD/ADHD in school children. It provided entrainment at 10 Hz for 2 minutes, 18 Hz for another 2 minutes followed by one minute of silence, and repeated this pattern three times. They also noted that a second group using AVE and auditory entrainment with cassette tapes had greater improvement than those with AVE alone. A study by Budzynski et al. (1999) used an AVE device called Biolight for college students struggling with academic problems. Volunteers, at least one quarter of whom were at the university, were randomly divided into a treatment (AVE) group and a waiting list control group. The Biolight produced one minute alternations of 14 and 22 Hz for 20 minutes. Following 30 sessions, mean alpha frequency and high/low alpha increased during memory tasks. Both groups’ grade point average differences between the fall and spring quarters (they were trained during the winter quarter) showed that the AVE group had improved significantly over the controls.

A study of 99 children showed that treatment with AVE was more effective for inattentiveness than using medications such as Ritalin and Adderall (Micheletti, 1998). Another study (n = 30) provided group treatment for 10 schoolchildren at a time who had attention deficits (Joyce and Siever, 2000). The session presented beta stimulation (19–21 Hz) to the left hemisphere and SMR (12–15 Hz) to the right hemisphere with a minute of alpha stimulation. Michael Joyce later conducted a follow-up ADD study involving 204 children from seven schools in Minnesota. Following 30 AVE sessions, there were reductions in anxiety, depression, inattention, and hyperactivity. On average, children from grades 1 to 11 showed average improvements in oral reading proficiency on the Slosson–R assessment of about one year (Joyce, 2001; Siever, 2003).

E. Special Sessions for Older Adults

Cognitive decline in older adults is an ever-growing problem, not only because the numbers of older adults are increasing, but longer life increases the likelihood
of loss of memory and decline in cognitive performance. Cerebral blood flow has been shown to drop with age (Hagstadius and Risberg, 1989; Gur, et al., 1987). It has also been shown that an increase in overall theta activity is the best and earliest indicator of cognitive decline (Prichep et al., 1994).

Tom Budzynski developed the first “Brain Brightening” AVE session for seniors (Budzynski et al., 2007). Participants were from two seniors’ homes in Seattle. Ten seniors were simultaneously treated from a multiple DAVID system. Budzynski’s session presented randomized light intensity, pulse-tone volume, and frequency from 9–22 Hz. The idea was to frequently initiate the orienting response while entraining with faster frequencies. Both of these effects helped to inhibit slow-wave alpha, and therefore improve cognition. Roughly 65–75% of the participants showed improvements for the measures of the Microcog computerized continuous performance test (CPT), shown in Fig. 8.17.

### F. Depression Session

Depression is the most common psychiatric disorder by far. About 14% of the population will experience clinical depression in their lifetime. Of these, an alarming 15% will unfortunately commit suicide (Rosenfeld, 1997). While acute (mild) stress seems to enhance mental function, chronic (severe) stress impairs hippocampal function which, in turn, may lead to multiple sclerosis, anxiety, depression, post-traumatic stress disorder, cognitive decline, and Alzheimer’s disease (Esch et al., 2002). As shown in Fig. 8.18, the Depression AVE session utilizes right-sided AVE at 19–20 Hz (left brain stimulation), and left-sided AVE at 10 Hz (right brain...
stimulation). This approach normalizes the asymmetry in brain “alpha” activity that is typical of depression (Rosenfeld, 1997). Results have been seen 20 minutes later in QEEG records. Subjective case reports suggesting the effects may last up to 3 or 4 days.

Falls are the leading cause of injuries and injury-related deaths among persons aged 65 and older (Fife and Barancik, 1985; Hoyert, et al., 1999). They are the cause of 95% of hip fractures in senior women (Stevens and Olsen, 1999). Hip fractures in turn are associated with decreased mobility, onset of depression (Scaf-Klomp et al., 2003), diminished quality of life, and premature death (Zuckerman, 1996). A study by Berg and Siever (2004) showed that by treating with the depression AVE session, depression as recorded on the geriatric depression scale (GDS) was reduced significantly (Fig. 8.19), while balance and gait as measured with the Tinetti assessment tool (Tinetti, 1986) were improved (Fig. 8.20). As depression lifted, balance and gait improved.

VII. APPLYING AVE WITH NEUROFEEDBACK

Neurofeedback (NF) and AVE complement each other. Many practitioners use photic entraining eye sets with view-holes during NF sessions. By manually adjusting the AVE frequency to be the same as the NF frequency, or by doubling the inhibition frequency, a patient can get a sense of what it “feels” like to make or inhibit that particular frequency. This speeds up the NF process considerably. In addition, an AVE machine can be taken home to augment the session. Regardless of the approach, clinicians who combine the AVE with NF report that the typical 40-session NF process may often be reduced to 10 NF sessions. The use of AVE in the first couple of weeks of training can sharply decrease the patient’s tension,
and reduce the frustration that many patients experience during the early sessions of NF.

VIII. CONCLUSION

A large and growing body of research and clinical experience demonstrates that AVE quickly and effectively modifies conditions of high autonomic (sympathetic and parasympathetic) activation and over- and under-aroused states of

---

FIGURE 8.19  Reduction in geriatric depression (Berg and Siever, 2004) n = 80.

FIGURE 8.20  Improvement in balance mean scores (Berg and Siever, 2004) n = 80.
Auditory-visual entrainment in relation to mental health and EEG

mind, bringing about a return to homeostasis. AVE exerts a powerful influence on brain/mind stabilization and normalization by means of increased cerebral flow, increased levels of certain neurotransmitters, and by normalizing EEG activity. AVE is proving to be a safe and cost-effective treatment, especially for the large numbers of disorders associated with dysfunctions of the central and autonomic nervous system.

REFERENCES


Collura T. F. (1978). Synchronous Brain Evoked Potential Correlates of Directed Attention, Ph.D. Dissertation, Department of Biomedical Engineering, Case Western Reserve University.


Auditory–visual entrainment in relation to mental health and EEG


Author Queries

{AUQ1}  AU: Is 'auditory' alright? Looking at the refs at end of chapter most of them say 'Audio-visual'.
{AUQ2}  AU: Should this be 'auditory' as in chapter title?
{AUQ3}  AU: If 'Gray' is part of his surname (hence spelt out here, not 'G.') then spell it out in refs at end of chapter and move to the Gs. And add 'Gray' in front of 'Walter' in the text citation I've added in line below.
{AUQ4}  AU: Not in ref list; pls. supply
{AUQ5}  AU: Should this be 'parameters are'?
{AUQ6}  AU: OK as edited?
{AUQ7}  AU: OK as edited?
{AUQ8}  AU: Not in ref list; pls. supply
{AUQ9}  AU: Not in ref list; pls. supply
{AUQ10} AU: Not in ref list; pls. supply
{AUQ11} AU: Not in ref list; pls. supply
{AUQ12} AU: Not in ref list; pls. supply
{AUQ13} AU: Not in ref list; pls. supply
{AUQ14} AU: OK as edited?
{AUQ15} AU: Not in ref list; pls. supply
{AUQ16} AU: OK? Graph in Fig. 8.1 shows more than 5 minutes?
{AUQ17} AU: OK? (Does Fig. 8.1 show this?)
{AUQ18} AU: This is exactly the same as the heading on p. 6. Delete it or reword it?
{AUQ19} AU: OK, or 'auditory'?
{AUQ20} AU: Not in ref list; pls. supply
{AUQ21} AU: OK? Or 'Auditory-visual' as per chapter title?
{AUQ22} AU: OK? Or 'Auditory-visual' as per chapter title? AND OK THROUGHOUT CHAPTER?
{AUQ23} AU: Word missing?
{AUQ24} AU: This doesn't match no. 3 in the numbered list a few pages earlier? (which says 'limbic stablization')
{AUQ25} AU: Doesn't match no. 4 in previous numbered list exactly, but presume ok?
{AUQ26} AU: Doesn't match no. 5 in previous numbered list exactly, but presume ok?
{AUQ27} AU: Not in ref list; pls. supply
{AUQ28} AU: Not in ref list; pls. supply
{AUQ29} AU: Not in ref list; pls. supply
{AUQ30} AU: Should this be 'of'?
{AUQ31} AU: OK?
{AUQ32} AU: Are these correct cross.refs now that figs have been renumbered?
{AUQ33} AU: Not in ref list; pls. supply (or should this be 'Budzynski et al., 1999' which is listed in the ref?)
{AUQ34} AU: Not in ref list; pls. supply
{AUQ35} AU: OK as edited?
{AUQ36} ED: Is the right bit in italic here?
{AUQ37} AU: Not in ref list; pls. supply
{AUQ38} AU: Not in ref list; pls. supply
{AUQ39} AU: Not in ref list; pls. supply
{AUQ40} AU: OK as edited?
{AUQ41} AU: Pls. supply place of publication
{AUQ42} AU: OK as edited?
{AUQ43} AU: Pls. supply page range
{AUQ44} AU: OK as edited?
{AUQ45} AU: Shouldn't this year match the year at the start of the reference, i.e. 2007?
{AUQ46} AU: OK as edited?
{AUQ47} AU: If this is the equivalent of a journal title, it should be in italic.
{AUQ48} AU: Ref not cited in text, OK to delete?