FEATURE

The Application of Audio-Visual Entrainment for the Treatment of Seniors' Issues: Part I

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Keywords: seniors, cognitive decline, depression, audio-visual entrainment

As the majority of the North American population continues to age, cognitive decline in older adults becomes an ever-growing concern. With the increase in age comes a decrease in cerebral blood flow, slowing of the brain's alpha rhythm, and increased theta activity. These changes correlate with an increase in cognitive deficits, including memory impairments, loss in problem-solving ability, difficulty with language and speech, and impaired locomotion. Chronic stress impairs hippocampal function, leading to a host of disorders including Alzheimer's disease. The left hemisphere of the brain has a tendency to lose functionality before the right side, which may enhance spatial creativity, and when coupled with fears and feelings of helplessness, may also bring forth depression.

Introduction

Cognitive decline and dementia in aging adults is an ever-growing problem, not only because the number of older adults is expanding, but because longer lifespan increases the likelihood of loss of memory and decline in cognitive performance (dementia). The Diagnostic and Statistical Manual of Mental Disorders (DSM IV) describes dementia as the development of multiple cognitive deficits that include memory impairment and one or more of the following cognitive disturbances: aphasia (impaired ability to use and comprehend words); apraxia (difficulty moving parts of the mouth, tongue, or lips with resultant impaired speech); agnosia (difficulty recognizing shapes or copying drawings); or a disturbance in executive functioning (logical thinking). The cognitive deficits must be severe enough to cause impairment in occupational or social functioning and must represent a decline from a previously higher level of functioning (American Psychiatric Association, 1994, p. 134).

Dementia including both the more common ischemic vascular dementia (IVD) and dementia of the Alzheimer type (DAT) increases linearly with aging (Mohs, Breitner, Silverman, & Davis, 1987; Rocca et al., 1991) to the point where these dementias have become epidemic within our aging population (Fratiglioni et al., 1991; Bachman et al., 1992). Mortel et al. (1994) state that, "The pathogenesis of DAT appears to be largely determined and characterized by beta amyloid deposits, neurofibrillary tangles, and neuritic plaques that impair cortical and subcortical synaptic function" (p. 172). Their study also found that in the IVD population, hypertension and smoking are roughly 1.5 times that of normal, heart disease is double, and diabetes is triple that of normal. In the DAT population, hypertension is roughly two thirds that of normal, and heart disease is one half that of normal. DAT has been characterized as a "hippocampal dementia." Rae-Grant et al. (1987) reported that a number of individuals with excessive theta brain wave activity were found on autopsy to have neuronal loss in the hippocampi.

Here Cometh the Rain Man

Some individuals with autism have brilliant skills known as savant abilities. The skills they possess are the aftermath of various kinds of left-hemispheric brain damage, and are therefore typically confined to right brain functioning, which includes music, math, art, and other spatial abilities. Some can play complete concertos after hearing them only once. Others have memorized every name in the phone book or every highway in the United States or draw pictures of amazing detail after just a brief exposure to a scene. Some have brilliant knowledge of sports trivia or license plate numbers. Although these skills are intrinsically tied to a remarkable, specific memory, those with savant abilities lack an understanding of any meaning or reasoning as to what they are doing.

There may be a little "Rain Man" in all of us, because—like savant persons with autism—as some seniors develop certain types of dementia, they become brilliant with artistic and musical abilities (Treffert &

Wallace, 2002; Miller et al., 1998). Neurons in the left temporal and frontal lobes (frontotemporal dementia) appear to be more delicate that those in the right and often take the "hit" sooner in life, allowing the right hemisphere to take control, and like autistic savant persons, leave the inflicted with a loss of reasoning ability but heightened artistic and musical ability (Treffert & Wallace, 2002). These seniors paint magnificent drawings or play concertos although they have never had these abilities before. Unfortunately, as dementia spreads into the right brain, these skills eventually disappear, leaving the person in a withered condition.

Haunted by the Past

The American Psychiatric Association defines psychological trauma as a threat to one's own life or that of someone close accompanied by intense fear, horror, or helplessness. Psychological trauma affects about half of all Americans sometime in their lives. Every year in the United States, more than 1 million children are confirmed to be victims of child abuse (Teicher, 2002). It is estimated that there is 10 times as much trauma and posttraumatic stress disorder (PTSD) in civilians than there is combat trauma in military personnel. A full 8% of Americans have a history of PTSD related to a wide variety of incidents including child abuse, assault, rape, car accidents, and natural disasters (Kessler, Sonnega, Bromet, Hughes, & Nelson, 1995). Approximately 50 million American adults were abused in childhood, not to mention adult traumas. About 30 million Americans have PTSD, making it one of the most common illnesses in the United States (Bremner, 2002).

Although acute (mild) stress seems to enhance mental function, chronic (severe) stress impairs hippocampal function, which in turn can lead to multiple sclerosis, anxiety, depression, posttraumatic stress disorder, schizophrenia, and Alzheimer's disease (Esch, Stefano, Fricchione, & Benson, 2002). Both Vietnam war veterans and women with abuse-related PTSD have reduced blood flow in the hippocampus and medial prefrontal cortex (Bremner et al., 1999). People with PTSD who do not have normal activation of the prefrontal medial cortex are not able to extinguish their own fear responses while watching a movie involving violence (Bremner et al., 1997), whereas people without PTSD are able to rationalize that they are only watching a movie and do not show a trauma response to the movie. What this means is that those with PTSD live in an irrational and constant state of fear.

Fear also inflicts continued damage to the frontal and temporal regions, known as frontotemporal dementia (Bremner, 2002). Frontotemporal damage impairs the ability to control fear and the ability to reason and understand the significance of events in a person's life (Bremner, 2002), leaving those inflicted in a generalized state of anxiety, fear, and confusion. Anxiety and fear increase cortisol in the brain. Cortisol counteracts a brain-nourishing hormone called brain-derived neurotrophic factor (BDNF; Bremner, 2002). Loss of BDNF leads to neuronal cell death within the hippocampus, which impairs memory. As mentioned above, hippocampal loss plays a major role in the development of DAT, in which the ability to form new memories is impaired. In fact, those inflicted with PTSD often cannot remember what they had for breakfast a few hours before and have extreme difficulty learning new things. Unfortunately, PTSD-inflicted dementia can affect persons as young as teenagers (Bremner, 2002). Seniors who live in fear suffer early-onset dementia.

In relation to fear, a Levy (1996) study revealed that when seniors were given subconscious cues that activated positive stereotypes of aging, their memory and self-reliance in remembering improved, and when they were given negative subconscious cues, their memory and self-reliance in remembering worsened. What most influenced their response, however, was the degree of importance that stereotyping held for their self-image. For those whose self-image was easily affected, a negative stereotype activated fears and impaired memory and self-reliance in remembering. Those who were not concerned about self-image did not respond either way.

I'm Falling for You (or Anything Near the Floor), Baby

Falls involving both seniors and children account for approximately 24% of the 147 million emergency room visits logged every year (Burt & Fingerhut, 1998). Seven million falls each year involve seniors over the age of 65 years (Jacobson, 2001; Zaida & Alexander, 2001), and the costs of these falls is as high as $12.4 billion annually within the United States (National Safety Council, 1996).

Compared with children, however, seniors are 10 times more likely to be hospitalized and eight times more likely to die as a direct result of their fall (Runge, 1993). Falls are the leading cause of injuries and injury-related deaths among persons aged 65 and older (Fife & Barancik, 1985; Hoyert, Kochanek, & Murphy, 1999).

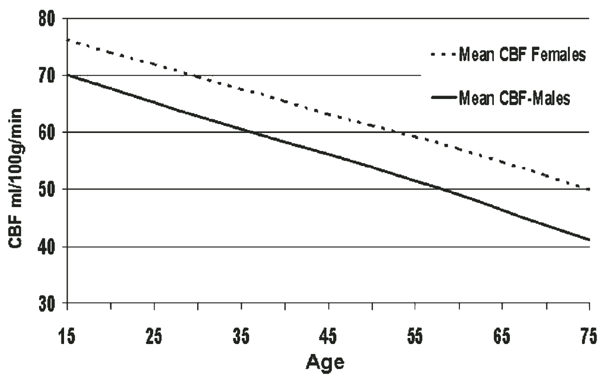

Figure 1. Cerebral blood flow (CBF) declining with age.

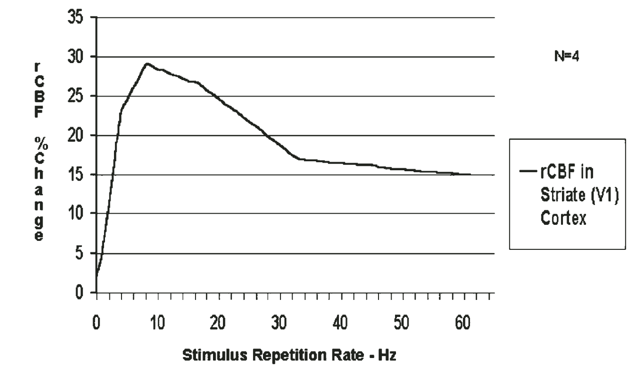

Figure 2. Impact of visual entrainment on cerebral blood flow (CBF).

Falls are the cause of 95% of hip fractures in senior women (Stevens & Olson, 1999). Hip fractures in turn are associated with decreased mobility; onset of depression (Scaf-Klomp, Sanderman, Ormel, & Kempen, 2003); diminished quality of life; and premature death (Zuckerman, 1996). Older age, depression, and gait or balance impairments are primary factors for inability to get up after a fall (Colon-Emeric, 2002). In summary, falls involving seniors come at great health, emotional, and financial cost in those communities where an abundance of seniors reside.

Brain Waves and Dementia

The brain generates four basic brain waves: delta, theta, alpha, and beta. With respect to this article, only beta, theta, and delta brain wave activity will be considered. Beta brain waves are in the frequency range of 13–35 Hz. For the purpose of this article we will consider beta activity in the range of roughly 13–20 Hz. This beta activity is associated with a focused, analytic, thinking state (Demos, 2005). Beta activity is more prevalent in the frontal regions where higher levels of cognitive thought and reasoning take place.

Theta brain waves are in the frequency range of 4–7 Hz. Theta activity is associated with creativity and daydreaming, but also with distractibility, inattention, and emotional disorders (Demos, 2005). Theta is the primary abnormal brain wave form in children with attention deficit/hyperactivity disorder (ADHD). Normal theta/beta ratios for children are around 2.5:1, and roughly 2:1 in adults. Heightened theta/beta ratios are coincident with slow brain wave disorders and are associated with foggy thinking, slow reaction times, difficulty with calculations, poor judgment, and impulse control (Demos, 2005).

Delta brain waves are primarily related to sleep and therefore make up 40% of all brain wave activity in babies and only 5% of activity in adults. High amplitude and rhythmic delta activity are associated with traumatic brain injury (Demos, 2005).

Many brain wave studies have confirmed a slowing of natural alpha activity with age, which is also inversely related to longevity (Nakano, Miyasaka, Ohtaka, & Ohmori, 1992). 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).

The Geriatric Deterioration Scale (GDS) is a seven-stage subjective assessment of DAT. Stage 1 represents the best cognitive function, whereas higher stages represent increases in dementia up to Stage 7, which reflects severe DAT. Prichep et al. (1994) found a direct and linear correlation between progressive increases in theta and increases in severity of cognitive decline as measured on the GDS from Stages 2 through 5. The most severe stages of cognitive decline (Stages 6 and 7) correlated highly with additional increases in delta, the slowest brain wave rhythm (normally associated with sleep or severe brain damage). The regions in the brain with the highest increases in theta carved a temporoparietal arc across the head.

Cerebral Blood Flow

Cerebral blood flow (CBF) has been shown to decline fairly linearly with age (Hagstadius & Risberg, 1989), with men having less CBF than women (Gur, Gur, Obrist, Skolnick, & Reivich, 1987) as shown in Figure 1. Both IVD and DAT groups have roughly 4% less cerebral blood flow than controls: 62 ml/100 g of brain weight/minute vs. 67 ml/100 g of brain weight/minute (Mortel et al., 1994). Hirsch et al. (1997) in a study of 45 seniors with DAT found that the majority of blood flow deficits were in the left and right temporoparietal regions. When the left side was affected, language impairments developed, and when the right side was affected, there were impairments in praxis (the ability to be proficient in doing normal, habitual activities).

Entrainment and Dementia

Visual entrainment (VE)—the use of flashing lights to drive brain activity to specific frequencies—is affected by dementia. Visual entrainment has its greatest impact at one's natural alpha frequency, which is typically at about 10 Hz (Siever, 2003). Dementia causes a downward skew in the peak frequency response to VE (Politoff, et al., 1992). However, despite this downward shift, VE none-the-less affects a wide range of brain wave activity (Politoff et al., 1992), making it a viable method for reducing aberrant dementia-related brain wave activity.

VE also produces an increase in cerebral blood flow, which would seem to be beneficial since dementia involves a reduction in cerebral blood flow. Figure 2 shows the impact of VE on cerebral blood flow in response to various frequencies (Fox & Raichle, 1985).

Conclusion

Dementia is rampant among our senior population, and this in turn is adding a heavy financial toll to taxpayers. Presently there is no available pharmaceutical approach to improve mental function. The development of a low-cost means for preventing or reducing cognitive decline and depression in seniors is of paramount importance. The second article in this series will overview the use of audio-visual entrainment for cognitive decline and depression in the aging population.

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