Running head: RELAXATION RESPONSE IN ADULT ADHD

Effects of the Relaxation Response (RR) on Adults with Attention-deficit/Hyperactivity Disorder (ADHD)

Roberta Tsukahara
Beth Israel Deaconness Medical Center

Theresa Lavoie
New England Medical Center

Abstract

This pilot study assessed the effects of a 15-min relaxation response (RR) training on right-handed adult males (M age = 35.0 years) with (n = 30) and without (n = 30) attention-deficit/hyperactivity disorder (ADHD). All were free of psychiatric/neurological comorbidity and psychoactive medication during testing. Half were assigned to an experimental group where they were individually administered attentional tasks examining ADHD symptoms before and after the RR. Half were assigned to a control group, where they completed the tasks twice but did not receive the RR. Analyses revealed: (a) overall differences in attentional functioning between those with and without ADHD; and (b) some trends toward differential changes in attentional functioning after the RR for those with ADHD.

Effects of the Relaxation Response (RR) on Adults with Attention-deficit/Hyperactivity Disorder (ADHD)

The *relaxation response* (RR) is a term coined by Benson (1974) to describe the physiological changes (e.g., decreases in stress hormones and heart rate) that occur during states of relaxation. A plethora of studies have suggested that the RR may be a promising therapeutic intervention for different clinical groups (e.g. Benson & Wallace 1972; French & Tupin, 1974; Otis, 1974; Shapiro & Giber, 1978). For example, Benson and his colleagues (e.g., Benson & Wallace, 1972; Benson, Rosner, & Marzetta, 1974; Patel, 1973) have found considerable evidence that the RR is effective in reducing symptoms of hypertension, anxiety, depression, insomnia, AIDS, infertility, and cancer (Roush, 1997). Margolis (1990) has also found relaxation training to demonstrate promising results in lessening the anxiety, impulsivity, hyperactivity, distractibility, and emotional lability of exceptional learners, while positively influencing their self-concept, academic achievement, and classroom behavior.

A natural extension of the RR research is to apply it, specifically, to individuals with ADHD. Thus, on the most general level, this pilot study attempted to gather empirical data on the effects of the RR on sustained attention, impulsivity, and resistance to distraction in adults with ADHD. To date, these specific areas of attention and the effects of the RR in this clinical group have not been investigated empirically. Prior to presenting our formal hypotheses, three areas of literature are briefly reviewed. The first discusses the concept of ADHD (with respect to both the nature of diagnosis particularly in adulthood and of neuroanatomical and neuropsychological findings relevant to attentional processes); the second discusses the RR and provides a definition of the larger context of meditation also with respect to attentional processes; and the third reports relevant findings from work on the effects of the RR on the cognitive functioning of individuals with ADHD and related symptoms.

Attention-deficit/Hyperactivity Disorder (ADHD)

Diagnostic considerations. ADHD is one of the most commonly diagnosed psychiatric conditions (Baird, Stevenson, & Williams, 2000). Symptoms of ADHD--which include inattention and hyperactivity/impulsivity--usually appear in early childhood and are relatively chronic in nature. Co-morbid conditions have been reported to include: conduct disorder; mood disorders; anxiety disorders; and learning disorders (e.g., Biederman, Newcorn, & Sprich, 1991). Current estimates of the rate of ADHD in the general population have ranged from 1.7 percent to 17.8 percent (Elia, Ambrosini, & Rapoport, 1999). The large variation has been related to differences in informants (parent vs. teacher), culture (with European and Asian countries reporting lower rates of ADHD than the United

States), and the degree of impairment needed for diagnosis. Among children, the boy to girl ratios have ranged from 3:1 to 9:1.

The diagnosis and assessment of ADHD have changed considerably over the years. Since its inception, ADHD has had numerous labels, including hyperactive child syndrome, hyperkinetic reaction of childhood, minimal brain dysfunction, and attention deficit disorder with or without hyperactivity (Barkley & Murphy, 1998). According to Schaughency and Hynd (1989), the changing diagnostic nomenclature and criteria used to describe this syndrome may be contributory to recent controversy surrounding the disorder. For example, the Diagnostic and Statistical Manual of Mental Disorders-III-R, DSM-III-R (American Psychiatric Association, APA, 1980) has conceptualized the diagnosis of ADHD as comprised of two categories: attention-deficit hyperactivity disorder and undifferentiated attention-deficit disorder (without hyperactivity). Subsequent literature reviews and data re-analyses (see Barkley, 1998) have suggested that it may be best to think of two separate disorders (ADHD vs. ADD); however, most of the theory and research have not made this distinction.

Hence, in the most current Diagnostic and Statistical Manual of Mental Disorders- IV-TR, DSM-IV-TR (APA, 2000), the essential feature of ADHD is a persistent pattern of inattention and/or hyperactivity-impulsivity that is more frequent and severe than is typically observed in individuals at comparable levels of development (Criterion A). Additionally, some symptoms of hyperactivity-impulsivity or inattention that cause impairment must have been present before the age of 7 years, although many individuals are diagnosed after the symptoms have been present for a number of years (Criterion B). Further, it is necessary for some impairment from the symptoms to be present in at least two settings, for example, at home and at school or work (Criterion C). Criterion D requires clear evidence of interference with developmentally-appropriate social, academic, or occupational functioning. Other models have proposed additional facets of attentional difficulties including over-focusing, dysphoria, anxiety, and aggressiveness (e.g., Wishart, Keyes, Flashman, Riordan, Macallister, Sparling, Huey, & Saykin, 2000).

Despite advances in our understanding of the neurobiology and neuropsychology of ADHD (below), an adult diagnosis is still made clinically by establishing a retrospective childhood diagnosis, evaluating the current symptom profile, and excluding alternative medical and psychiatric causes of symptoms (Troller, 1999). Specifically, the symptoms of ADHD predominately hyperactive-impulsive type appear to arise, on the average, between 3 and 6 years of age for most people; others develop their symptoms later in childhood, but the vast majority of people have had some symptoms by the age of 13 years (Barkley & Murphy, 1998). Barkley (1991) has

argued that the diagnostic criteria should be adjusted for age since some older individuals previously diagnosed with ADHD may have outgrown the criteria rather than the disorder. Barkley's (1991) recommendations for assessment of ADHD in both children and adults have included the use of standardized behavioral rating scales, laboratory measures of ADHD where available, and behavioral observations in relevant contexts (e.g., classroom, clinic).

More specifically, the Wender Utah Rating Scale (WURS) has been devised as a diagnostic aid to discriminate the presence and severity of childhood symptoms of ADHD in adult patients (Ward, Wender, & Reimherr, 1993). The WURS is a 25-item self-report measure on which individuals rate their behaviors related to possible ADHD symptoms during childhood. Spencer, Wilens, Biederman, Faraone, Ablon, and Lapey (1995) have addressed the WURS criteria for diagnosing ADHD and its additional indicators of affective lability, hot or explosive temper, and stress intolerance. Because mood and anxiety symptoms often coexist with ADHD, the symptoms that the WURS addresses may not be exclusively those of ADHD. It is, therefore, relevant to address specific items of the WURS and to determine if, for example, there is a correlation with items endorsed on a depression inventory.

According to Leuzzi and Spandorfer (2000), up to two-thirds of childhood ADHD patients continue to have symptoms into adulthood. Cantwell (1985) has also suggested that hyperactivity is not a symptom that disappears over time. Specifically, upon review of retrospective adult studies, he has reported that the majority of hyperactive children continue to have symptoms of hyperactivity or antisocial behavior in adulthood. In a related vein, Hart, Lahey, Loeber, Applegate, and Frick (1995) have found that, although hyperactivity-impulsivity symptoms decline, inattention remains stable, with age. Further, the DSM-IV-TR (APA, 2000) has included revised wording applicable to adults as well as children, although the diagnosis still requires a childhood onset of symptoms. Unfortunately, most patients being evaluated for adult ADHD have not been professionally evaluated as children. Thus, to surmount the problem of retrospectively establishing the childhood diagnosis of ADHD, the WURS is crucial to establishing the presence of ADHD in adulthood.

Spencer and his colleagues (1994, 1995) have questioned if ADHD in adults is a valid disorder. Based on a review of the literature, they have confirmed that the diagnosis of ADHD in adults meets acceptable standards for diagnostic validity. They have further asserted that the diagnosis has considerable power to forecast complications and treatment responses. Specifically, from a review of over 1,700 individuals with a history of ADHD, these researchers have made several additional points regarding adults with persistent ADHD: that is, these individuals

have higher rates of psychosocial dysfunction (e.g., lower socioeconomic status, shorter job tenure) and these differences exist regardless of participants' levels of intelligence and education.

Neuroanatomical/neuropsychological findings. The exact underpinnings of ADHD are unknown related to the extraordinary complexity of the attentional system. Researchers do know that there is not a single lesion in the brain, a single neurotransmitter system, or a single gene that triggers ADHD. It seems likely that people with ADHD have a biological predisposition that probably resulted from pregnancy or birth complications, acquired brain damage, toxins, infections, and/or genetic factors.

From a summary of ADHD neuroanatomical studies, Zametkin and Liotta (1998) have concluded that, although none of the findings present an integrated picture of the disorder's pathophysiology, many have highlighted central nervous system (CNS) abnormalities within the developing brain. For example, researchers have addressed the hypothesis of dopamine under-activity in individuals with ADHD. Dopamine forms a pathway between the motor center and the frontal regions of the brain and from the limbic center to the frontal regions of the brain. Dopamine neurons pass through the central frontal lobe to reach the prefrontal cortex. This implies that dopamine plays a role in connecting motor activity, emotion, attention, and impulse control. Specifically, Levy (1991) has examined the noradrenergic and dopamine hypothesis of ADHD. Integrating literature reviews and data from clinical and animal studies on dopamine systems with theories of neuronal control, the effect of a placebo and D- and L-amphetamine were compared in hyperactive children. He found that D-amphetamine showed an immediate reduction in ADHD symptoms, while L-amphetamine took 3 wks to show a reduction in symptoms. Subsequent research has reported that D-amphetamine was more effective than L-amphetamine in calming hyperactivity, while L-amphetamine reduced aggression only.

Most relevant to the current research is the speculation that exists that relaxation may be affecting the frontal lobes as well. The effects of relaxation on dopamine neurons in the prefrontal cortex is unknown at this time. It is clear, however, that dopamine plays a role in motor activity, emotion, attention, and impulse control. One may speculate that if relaxation is limiting symptoms of ADHD, it is perhaps also influencing dopamine neurons.

Seidman (1999) has employed the use of magnetic resonance imaging (MRI) techniques to explore other neuroanatomical structures implicated in ADHD. Here, they have found abnormalities in adult brains with ADHD, which have included volume reductions in right frontal, striatal, and corpus callosum regions. These areas have previously been hypothesized to be involved in the core impairments of ADHD. Other MRI studies have indicated

that there are subtle anomalies in caudate (e.g., Castellanos, Giedd, Marsh, Hamburger, Vaituzis, & Dickson, 1996; Seidman, Faraone, Biederman, & Waber, 1997) and corpus callosum size and shape (Giedd et al., 1994, in Seidman et al., 1997) and possible reductions in the right frontal area (Hynd, 1990, in Seidman et al., 1997).

Further, Zametkin, Nordahi, Gross, King, Semple, Rumsey, Hamburger, and Cohen (1990) have studied the influences of glucose on ADHD symptomology. They have specifically assessed how the brain uses glucose, its energy source, during tests designed to measure attention and vigilance to stimuli. Using PET scans, they have reported the findings of a depressed global cerebral glucose metabolism and possible frontal hypermetabolism in the brains of adults with ADHD. Specifically, the ADHD group metabolized glucose at a rate of 8% slower than the control group. This decrease in metabolic activity was the largest in the prefrontal and premotor regions of the brain. The frontal region of the brain is the major regulator of behavior. It allows for planning, anticipating, impulse control, and is where behavior is initiated. It receives input from the lower brain, which regulates arousal, screens out irrelevant stimuli, and makes decisions about fight-or-flight reactions. It is worth noting that there was not a consistent finding implicating a specific neurotransmitter, modulator, or neuroanatomical substrate.

Mattes and Gualtiri (1980) have also speculated that frontal lobes are involved in ADHD because of the similarity between the symptoms of ADHD and frontal lobe syndromes that result from injuries or lesions to the frontal area. This speculation has led Chelune, Ferguson, Koon, and Dickey (1986) to postulate the frontal lobe hypothesis of ADHD. Specifically, they have posited that both hyperactivity and impulsivity are forms of disinhibition and that the symptoms of ADHD arise because the brain loses its ability to block inappropriate responses and send out appropriate inhibitory messages related to disturbed inhibition in the cortex. These researchers have contended that, in ADHD, inhibition breaks down and that, at the same time, impulsivity and hyperactivity rise.

Further, Giedd, Castellanos, and Casey (1994) have, through the use of MRIs, examined the mid-sagittal cross-section of the corpus callosum in samples of boys with and without ADHD. They have found that, relative to normals, boys with ADHD had two significantly smaller anterior regions. Additionally, Lou, Henriksen, Bruhn, Borner, and Nielson (1989) have found decreased blood flow to the frontal regions of the brain and a deficit in blood flow in the right hemisphere of the brain in individuals with ADHD. The right hemisphere controls our decision-making capacities, visual spatial abilities, and the ability to process many sources of stimuli at once. Further,

additional imaging data have indicated abnormalities in the frontal networks of those with ADHD, specifically, fronto-striatal networks that control attention and motor intentional behavior (Voeller, 1990).

Related to this, the neuropsychological profile of individuals with ADHD has been ambiguous. “Because neuropsychological tests are only indirect measures of brain function, inferences about the nature of associated brain impairment must be made cautiously” (Seidman, Faraone, Biederman, & Waber, 1997, p. 157). Specifically, Lezak (1995) has investigated the neuropsychological profile of individuals with ADHD and posited that, although attention, concentration, and tracking can be differentiated theoretically, they are, in practice, difficult to separate. For example, purely attentional defects appear as distractibility or impaired ability for focused behavior. At the same time, intact attention is a necessary precondition for both concentration and mental tracking activities. Concentration problems may be related to simple attentional disturbances or to an inability to maintain purposeful attentional focus. To complicate the profile even further, conceptual tracking can be prevented or interrupted by attention or concentration problems and also diminished by a person’s ability to maintain focused attention on one’s mental contents while solving problems following a sequence of ideas.

Seidman and his colleagues (1997) have attempted to define a neuropsychology of ADHD in children and adolescents. Their sample has consisted of 822 males between the ages of 9-22 years. Younger and older probands with ADHD were significantly impaired on neuropsychological tests such as the Wisconsin Card Sorting Test (Heaton, Chelune, Talley, Kay, & Curtiss, 1993), the Stroop Color-word Test (Golden, 1978), and the Rey-Osterrieth Complex Figure (Rey, 1941), regardless of psychiatric co-morbidities. Findings have also suggested that children with ADHD have more school failure, learning disability, intellectual impairment, and neuropsychological dysfunction than their non-ADHD counterparts.

Other neuropsychological research (e.g., Lovejoy, Ball, Keats, Stutts, Spain, Janda, & Janusz, 1999) has examined the performance of adults with ADHD in attempts to determine potential diagnostic classification estimates for measures of frontal lobe/executive functioning. Such research has found that neuropsychological tests can differentiate adults with ADHD from adults without ADHD as well as depict mild neurological dysfunction associated with the frontal lobes. Specifically, dependent measures have included the Stroop Color-word Test, the Trail Making Test (A and B), the Controlled Oral Word Association (COWA), the California Verbal Learning Test (CVLT), and the freedom from distractibility score from the Weschler Adult Intelligence Scale--Revised (WAIS-R). Relative to adults without ADHD, those with ADHD performed significantly poorer on the COWA, Trails A and B,

and the freedom from distractibility measure. Other researchers (e.g., Trennery, Crosson, DeBoes, & Leber, 1988, in Lovejoy et al., 1999) have found the Stroop Color-word Test to be sensitive to inhibition and impulsivity.

Additional neuropsychological research (e.g., Grodzinsky & Diamond, 1992) has assessed frontal lobe functioning in boys with ADHD and confirmed that, relative to normals, those with ADHD perform more poorly on tasks involving the frontal lobes, particularly on a vigilance task and the Stroop. According to these researchers, previous attempts to connect ADHD with the frontal lobes have provided mixed results. The Stroop interference task is assumed to be sensitive to the failure to inhibit habitual responses and to maintain task focus. This study included 130 participants, 66 of whom were diagnosed with ADHD, and rigorous criteria were used to exclude children with language-based learning disabilities. On the task of vigilance, boys with ADHD generated more errors of omission and commission than controls. As predicted, boys with ADHD were inferior to controls on both tasks considered sensitive to inhibition/impulsivity and on three additional tasks requiring planning and organization of output. Improvement with age was seen on almost all tasks and was consistent with a hypothesis of maturation of the frontal regions during the years between 6-11. These age effects were existent both for boys with and without ADHD.

Although the neuropsychology of ADHD has not been perfectly clear (e.g., some investigators have implicated the frontal cortical regions of the brain as well as the interconnected subcortical structures such as the substantia nigra, striatum, and reticular activating system), researchers have recently agreed that core ADHD deficiencies include impairment in self-regulation, poor sustained attention, and poor impulse control. Further, other neuropsychological data have implicated the right hemisphere in ADHD deficits.

Summary and integration. Initially, the etiology of ADHD was thought to be the result of poor volitional inhibition and defective moral regulation of behavior (Still, 1902, in Barkley, 1997). However, the most current and theoretically robust explanation for ADHD at present has been that of Barkley (1997). Specifically, he has built on the work of predecessors, all of whom have argued that there are underlying deficits in the behavioral inhibition system (e.g., see: Baird, Stevenson, & Williams, 2000; Douglas 1972, 1983; Pennington, Grossier, & Welsh, 1993; Quay, 1988,1997). Barkley's seminal article on a unifying theory of ADHD has primarily focused on behavioral inhibition, sustained attention, and executive functions. He has posited that ADHD comprises a deficit in behavioral inhibition and that this impairment leads secondarily to impairment in four neuropsychological functions, viz., working memory, self-regulation of affect-motivation-arousal, internalization of speech, and reconstitution (behavioral analysis and synthesis).

Barkley's model has provided a more comprehensive account of research findings on the cognitive deficits associated with ADHD than the current clinical view of ADHD. For example, he has postulated that individuals with ADHD have difficulty self-regulating to response stimuli. As a consequence, their behavior is controlled more by the immediate situation and its consequences than is the behavior of others. In contrast, the behavior of individuals without ADHD is controlled by internally represented information (e.g., hindsight, forethought, time, plans, rules, self-motivating stimuli) that ultimately provides for more successful personal and professional outcomes. This unified approach was based on Bronowski's (1967) theory that the individual's unique ability to delay response to a stimulus may be understood along four axes: separation of affect, prolongation, internalization, and reconstruction. Zametkin and Liotta (1998) have contended that these four axes allow the individual to utilize better the complexity of his or her brain and to respond to each stimulus in the most effective fashion rather than by automatic, instinctual habit. In addition, Barkley has argued that the most salient disability in ADHD is the individual's reduced ability to inhibit responses. This disinhibition interferes with several areas of functioning including working memory, planning, and reflection and is demonstrated in a slower acquisition of internal speech (both developmentally as well as in the current moment) resulting in the individual's thoughts and emotions becoming overtly expressed.

Related to this, Newcorn, Halperin, Healey, O'Brian, Pascualvaca, Wolf, Morganstein, Sharma, and Young (1987) have questioned the differences between the DSM-III (APA, 1980) criteria for attention deficit disorder with hyperactivity and the DSM-III-R (APA, 1987) criteria for attention-deficit/hyperactivity disorder. They have contended that inherent in the diagnostic change is the notion that it is not always possible reliably to distinguish inattention, impulsivity, and hyperactivity as independent symptom dimensions. Thus, the present pilot work attempts to differentiate these symptoms as much as possible, examining the effects of the RR in adults with ADHD on the related attentional symptoms of selective attention, sustained attention, complex attention/executive functioning, and cognitive disembedding ability.

Meditation and the RR

Meditation can be defined as the intentional self-regulation of attention from moment to moment (Kabat-Zinn, 1982). This general definition can be applied to all forms of meditation (e.g., Kutz, Borysenko, & Benson, 1985). According to Goleman (1977), meditation may also be considered a systematic narrowing of attention that slows the metabolism and helps produce feelings of relaxation. There are two major divisions of meditation practice: concentration meditation and mindfulness meditation. Concentration methods involve the restriction of attention to a

single point or object (usually a mantra), followed by the experience of breathing and holding it in the mind for extended periods of time. Transcendental meditation (TM) and Benson's relaxation response (RR) are examples of the concentration method of meditation. TM is a form of meditation in which the individual sits upright with eyes closed in a comfortable position and silently repeats a mantra for 20 min twice daily. The meditation is not required to focus attention specifically on the mantra. The individual's attention may wander during TM (Harmon & Myers, 1999). This procedure is similar to the RR with the exception of the individual's mind wandering. In the RR, which is used in this research, the individual attempts to focus his or her attention without the mind wandering. In contrast, mindfulness meditation emphasizes detached observation of a constantly changing field of objects from one moment to the next.

For decades, many forms of meditation have provided positive results. For example, Maharishi Mahesh Yogi (1969) first introduced TM to the United States and proposed that "those who practice TM have more physical energy, are more mentally alert, are less tense and are better able to cope with stress" (p. 289). TM was initially introduced as a technique for expanding consciousness. Recently, TM's emphasis has been on reducing stress and achieving such special effects as lowering blood pressure, alleviating addictions, and increasing energy and powers of concentration.

Benson (1974) has demonstrated that the RR produces similar effects to TM. Specifically, the RR produces the same reductions in oxygen consumption and respiration rate produced during TM without the expense and complex rituals of meditation training. The RR requires a quiet environment and an object upon which to dwell such as a mantra, a sound repetition, or a symbol. The goal is to clear the mind. Specifically, when one is distracted by his or her thoughts, refocusing on the repetition of the object will help eliminate the distraction. Benson and others (e.g., Benson, Rosner, & Marzetta, 1974; Benson & Wallace, 1972; Domar, Seibel, & Benson, 1990; Irvin, Domar, Clark, Zuttermeister, & Friedman, 1996; Patel, 1973; Puskarich, Whitman, Dell, Hughes, Rosen, & Herman, 1992) have found considerable evidence that the RR is effective in reducing symptoms of hypertension, pain, anxiety, depression, and/or seizures in a variety of medical conditions including cardiac disease, infertility, menopause, and epilepsy.

An interesting approach to conceptualizing the RR is to consider it in terms of its antithesis, the stress response. For example, Cannon (1914) has referred to the stress response as a fight or flight response that liberates the hormones epinephrine (adrenaline) and norepinephrine (noradrenaline) into the bloodstream. This response to

stress leads to increases in heart rate, blood pressure, breathing rate, and blood flow into the muscles. In evolutionary terms, this response has been critical to our survival. Unfortunately, we continue to encounter fight or flight responses in our daily lives, resulting in psychological and physiological changes (e.g., high blood pressure, cardiac irregularities, lower pain thresholds). Additionally, slower brain waves (alpha) occur in the RR. It is not entirely clear how slower brain waves affect the brain, but higher frequency beta rhythms dominate the brain during the majority of our wakeful hours when we are engaged in everyday thinking and under stressful situations.

Benson (1974) has studied the changes opposite to those of the fight or flight response, that is, the meditative process, and has found that two basic actions are necessary to produce this response. First is the repetition of a sound, a word, a phrase, or a prayer (generally silent); this may even take the form of the awareness of one's own breathing. Second is the passive setting aside of other thoughts when they come to mind and returning to the repetition. After studying secular and religious literatures, Benson has found that these two actions were present in practices in a multitude of Eastern religions and ways of life, including Zen and Yoga with their many variants (Benson, Beary, & Carol, 1974). Further, a passive attitude is necessary to achieve the RR. According to Benson (1974), a passive attitude appears to be most essential in eliciting the RR. It is important that one not concentrate on distractions but allow them to pass. At the same time, the individual should not judge how he or she is doing but simply experience in the moment. The individual is also asked to remain still for approximately 20 min without being uncomfortable. The individual should not lie down since he or she may fall asleep.

In the RR, Benson (1974) has acknowledged the many forms of relaxation and meditation. For example, he has highlighted the physiological similarities among the many different techniques. "This observation led him to propose an integrated central nervous system reaction, the RR, a common final state brought about by a variety of relaxation methods" (Borgeat, Stravynski, & Chaloult, 1983, p. 41). Benson (1974) has also concluded that there are many Eastern religions, including Zen and Yoga, which can elicit the RR. "They employ mental and physical methods including the repetition of a word or sounds, the exclusion of meaningful thoughts, a quiet environment, and a comfortable position, and they stress the importance of a trained teacher" (Benson, Beary, & Carol, 1974, p. 40).

In summary, the RR results in physiological changes such as decreases in stress hormones and heart rate. Since the RR has been effective in lessening anxiety, impulsivity, hyperactivity, distractibility, and emotional

lability in a variety of conditions, a natural progression in research is to assess the effects of RR on individuals with ADHD.

Effects of Relaxation on Cognitive Functioning

Studies on the effects of the RR on cognitive functioning have predominantly employed children and college students. For example, Kratter (1983) has studied children with ADHD and examined the effects of meditation and relaxation training on their symptoms. Treatment included twice-weekly, brief meditation or relaxation sessions. Measures included: a matching task to measure reflection-impulsivity; a selective attention task; the Connors Teacher Rating Scale; and the Connors Abbreviated Parent Teacher Questionnaire. He has found that both TM and RR training groups led to significant decreases in impulsivity in the children with ADHD and to no changes in the control group. Additionally, the meditation group was the only group to improve significantly on selective attention and freedom from distractibility. Parent rating scales reflected a significant improvement in children's behavior in both the meditation and relaxation training groups, but not the control group. The Teacher Rating Scale and the Locus of Control Scale failed to show significant changes for any of the groups.

In a related vein, relaxation training, more generally, has also shown promise as a non-chemical means of reducing disruptive behaviors and increasing adaptive behavior in hyperactive children (e.g., Donney & Poppen, 1989). For example, Blanton (1990) has studied biofeedback and induced relaxation with children and concluded that children with ADHD can be taught to relax through a variety of methods. Porter and Omizo (1984) have found that, relative to controls, hyperactive boys who were provided with group relaxation training attended to task significantly better, became significantly less impulsive, and displayed increased locus of control following training. In line with this, Oldfield and Petrosa (1998, in Margolis, 1990) have concluded that "the acquisition of relaxation skills positively influences the ability of children to be attentive to instructional events in a school setting" (p. 221). Specifically, Margolis (1990) has contended that relaxation training can be both effective and efficient in helping children overcome cognitive (e.g., enhanced reading ability, reduced impulsivity), behavioral (e.g., greater attention-to-task, lowered hyperactivity), and affective (e.g., improved self-concepts, lowered anxiety) challenges.

In a second body of work, Hall (1999) has assessed the effects of meditation on the academic performance of African-American college students and found improvement in students' semester and cumulative GPAs when they meditated. Thus, he has proposed that the mental state (e.g., relaxed or anxious) of the learner may significantly influence the learning capabilities of that person. Further, Lev (1994) has found that both meditation and relaxation

were effective in reducing cognitive intrusions in college students. Here, meditation was conceptualized as a method of focused, non-analytic attention deployment coupled with a passive, receptive attitude toward all incoming stimuli. Further, Lindsay and Morrison (1996) has found behavioral relaxation training to be beneficial on performance on tests of short-term memory and incidental learning, but not of long-term memory. They have also found that relaxation treatments were successful with moderately and severely handicapped individuals suffering from poor concentration, short attention span, vocal outbursts, odd mannerisms, and other manifestations of anxiety and agitation. Specifically, there was a clear relationship between relaxation training and improvements in concentration and attention. The only negative finding in this area has been reported by Glanz (1992), who measured adults' ability to disembed figures on the Embedded Figures Test before and after meditation. Here, he found no support for the hypothesis that meditators would out-perform non-meditators.

Hypotheses

The main purpose of this pilot study was to gather preliminary empirical data on the effects of a short RR training on the attentional symptoms of selective attention, sustained attention, complex attention/ executive functioning, and cognitive disembedding ability. These specific areas of attention and the effects of the RR have not been investigated empirically. Based on the previous literature review, two specific hypotheses are presented: first, that there will be overall differences between adults with and without ADHD on aspects of attentional functioning and second, that, relative to other groups, individuals with ADHD who participate in the RR will exhibit fewer ADHD symptoms after the RR intervention. These and other relationships were assessed in the following pilot study.

Method

Participants

To avoid the potentially confounding effects of handedness and gender, only right-handed males were employed. Sixty volunteers between the ages of 21 and 53 years (M age = 35.0 years) were recruited from psychotherapy practices, hospitals, and businesses within the greater Boston area. Half of the participants were rated as having ADHD on the Wender Utah Rating Scale (WURS) and the other half were not. Individuals were excluded if they exhibited any co-morbid medical condition. Specifically, potential participants were excluded if they had any of the following based on a history questionnaire and interview: a primary psychiatric diagnosis; current alcohol or substance abuse; any relevant medical disorder (e.g., epilepsy/seizures, autism, cerebral palsy, stroke, cancer,

dementia, Parkinson's disease, meningitis, encephalitis, HIV infection, Tic disorder, sleep apnea, closed head injury, or history of skull fracture); significant symptoms of depression or anxiety (determined by the Beck Depression Inventory-II and/or the Beck Anxiety Inventory); and current use of antidepressant medication.

The two groups (those with vs. those without ADHD) did not differ on any demographic variables except for the following. That is, those with ADHD (M = 37.5 years) were significantly older than those without ADHD (M =32.0 years), $F(1, 56) = 6.89$, $p < .05$. Thus, age was used as a covariate in all subsequent analyses. Second, those with ADHD (M = 4.3) reported significantly more anxiety on the Beck Anxiety Inventory than those without ADHD (M = 2.1), $F(1, 56) = 6.04$, $p < .05$. However, since no participant scored within the clinical range of anxiety, all were included in the analyses. Although the groups did not differ significantly with respect to education, the mean level of education was high in both groups (i.e., those with ADHD had 17.0 years and those without ADHD had 16.0 years). Finally, the two groups did not differ in their proportions of those with and without meditation experience.

Materials

Materials are divided into those instruments employed to determine inclusion-exclusion in an appropriate grouping (e.g., ADHD vs. no ADHD) and those that served as the experimental instruments from which dependent measures were drawn. Those related to the independent grouping variable included the following.

1. History Questionnaire (Lavoie & Tsukahara, 2000): Constructed for the purpose of this study, the questionnaire asked for demographic, educational, medical, and psychiatric data;

2. Wender Utah Rating Scale (WURS), Abbreviated Form (Ward, Wender, & Reimherr, 1993): The WURS was devised as a diagnostic aid to discriminate the presence and severity of childhood symptoms of ADHD in adults. It is a 25-item self-report measure on which individuals rate behaviors related to possible ADHD symptoms during childhood on a scale of 0 (not at all or very slightly) to 4 (very much) for a total possible score of 100. Wender et al. has suggested a cutoff score of 36 or above to discriminate between adults with ADHD (ADHD+) and adults without ADHD (ADHD-). Internal reliability using a Pearson-Brown correlation was .90. Validity was measured using Pearson correlation coefficients between WURS scores and measures from two entirely different instruments and was found to be moderate (r =.49 and .41, respectively);

3. Beck Depression Inventory-II (BDI-II) (Beck, Steer, & Steer, 1996): The BDI-II was developed for the assessment of symptoms corresponding to the DSM-IV (APA, 1994) criteria for depressive disorders. It is a 21-item

self-report instrument for adults and adolescents 13 years and older on which individuals endorse statements most applicable to themselves. Those scoring 14 or above (0-13 is the normal range) were considered to have a significant number of symptoms related to depression and were, therefore, excluded from the study. Internal consistency of the BDI-II has been demonstrated with a meta-analysis of 9 psychiatric samples. Beck, Steer, and Brown (1988) have reported a mean coefficient alpha of .86. Further, several additional analyses have estimated its convergent validity at .93.

4. Beck Anxiety Inventory (BAI) (Beck, Steer, & Brown, 1998): The BAI is a 21-item scale that measures the severity of anxiety in adults and adolescents. Items consist of descriptive statements of anxiety symptoms rated from "not at all" (1) to "severely, I could barely stand it" (3). Total scores from 0-7 points are considered to reflect a minimal level of anxiety, while scores of 8-15 indicate mild anxiety. Thus, participants scoring above 7 were excluded. Beck has reported that the BAI has high internal consistency reliability (.92) and content validity (.93);

5. Current Symptoms Scale, Self-report Form (Barkley & Murphy, 1998): The 18 symptom items for ADHD are arranged such that the items pertaining to inattention are odd-numbered and those pertaining to hyperactive-impulsive symptoms are even-numbered. Items answered 2 (often) or 3 (very often) were counted. If 6 or more items were endorsed as 2 or 3, it was considered clinically significant and the participant was included in the experimental group; if less than 6 items were endorsed with a 2 or 3, the participant was included in the control group. Barkley's checklist reference norms were derived from Murphy and Barkley's (1996) research on symptoms in an adult community sample of licensed drivers; and

6. Wechsler Adult Intelligence Scale subtests (WAIS-III) (Wechsler, 1999): The Vocabulary and Matrix Reasoning sub-tests of the WAIS-III were used to compare the two groups. The Vocabulary sub-test requires the individual to provide oral definitions of given words; it is a measure of his or her expressive vocabulary, verbal knowledge, and fund of information. Reliability coefficients range from .90 to .98 for Vocabulary. Matrix Reasoning consists of a series of incomplete gridded patterns that the examinee completes by pointing to or stating the number of the correct response from 5 possible choices. Matrix Reasoning is a measure of nonverbal fluid reasoning and general intellectual ability.

The following instruments were used as pre-and post-intervention techniques.

1. Card C of the Clark University Stroop and the 4th card from the California Stroop (Delis, Kaplan, & Kramer, in press). Attention and impulsivity was measured using Card C of the Clark University Stroop and Card 4

of the California Stroop. The Stroop measures the individual's ability to suppress or inhibit habitual responses in the presence of salient conflicting information. The task is assumed to be sensitive to failure to inhibit habitual responses (i.e., to read the color name) and to maintain task focus. Grodzinsky and Diamond (1992) have reported that, relative to controls, boys with ADHD perform more poorly on the Stroop.

More specifically, the third card of the Clark University Stroop (color names printed in different colored inks) requires the participant to name the color of the ink and not to read the words. The California Stroop offers a fourth, more demanding condition. Participants are asked to name the color of the ink and inhibit reading the words; however, they are also instructed that, if a word is inside a little box, they should read the word and not name the ink color. Each card was administered for a period of 45 sec. The number of items on each card was 100. For each card, number of items completed (of 100) and number of errors served as the primary measures (4 measures in total).

2. VIGIL Continuous Performance Task (VIGIL; Psychological Corporation, 1998): VIGIL is a version of the Continuous Performance Test (CPT) developed by Rosvold, Mirsky, Sarason, Bransome, and Beck (1956) for the assessment of brain damage. Today, the test is used frequently as a measure of sustained attention in individuals with and without organic dysfunction. Specifically, the VIGIL program uses a computer display to present a random sequence of individual letters to the participant. Dispersed among these random letters are the target symbols, the letter K and a sequence of letters (A, K) presented one at a time. The individual is instructed to press the space bar as quickly as possible every time the target stimuli are observed. The test lasts approximately 12 min. Reaction times, hit rates, omission errors (misses), commission errors (false alarms), and total errors served as the primary measures for each set of target symbols, namely, K and A, K (10 measures in total).

3. Dichotic Listening Task (DLT): (Kimura, 1967): The DTL was designed to measure auditory recognition capacity. Clinically, however, it has also been observed to be sensitive to disturbances in complex attention and executive functioning (Tsukahara, 1999, personal communication). Using stereophonic headphones and an audiotape, the individual is simultaneously presented with two sets of numbers (3 digits in one ear and 3 different digits in the other) and asked to report as many of the 6 digits as possible. A recorded voice prompts the participant to report either "right ear first" or "left ear first" before the numbers are presented. Measures culled from this instrument included: total left; total right; total both; total right ear first; total left ear first; right ear second; and left ear second. Thus, the total number of measures from this task was 7. Since this instrument is comprised of two identical halves (24 items per half), the first half was used as a pre-test and the second half as a post-test measure.

4. Group Embedded Figures Test (EFT) (Witkin, Oltman, Raskin, & Karp, 1971): This task examines visual search and tracing of figures embedded within a background. On a paper-and-pencil task, the individual is asked to disembed simple geometric figures from complex designs; the measure is number correct (out of 18). A split half approach was utilized here (9 as a pre-test and 9 as a post-test). Witkin et al. (1971) have demonstrated that field independent boys have better control over their impulses than field dependent boys. Campbell (1969) has found that, relative to normals, hyperactive individuals found fewer figures. Finally, Pelletier (1974) has found that meditators demonstrate a shift toward increased field independence following meditation.

Thus, taken together, there was a total of 22 primary measures used in this pilot study.

Design and Procedure

Individuals were recruited either by telephone calls or letters sent by a referring psychiatrist, neurologist, or psychologist. On arrival to the session, potential participants were asked to sign informed consent. The examiner then reviewed the history questionnaire with each participant via a brief interview. He or she was then given a packet of questionnaires including the WURS, the Beck Depression Inventory, the Beck Anxiety Inventory, and the Barkley Behavior Rating Scale. Participants who scored 36 or higher on the WURS and who met the study requirements were invited to participate (ADHD+). Individuals who did not meet the inclusion criteria were thanked for their time and their participation was discontinued. Thirty additional individuals without the diagnosis of ADHD, a WURS score below 36, and a Barkley Behavior Checklist score below 6 were also invited to participate as part of the normal control group. Within each group, participants were randomly assigned via a Latin Squares design either to a relaxation group (meditation+) or a non-relaxation group (meditation-).

All participants were then administered the Weschler Adult Intelligence Scale-III sub-tests followed by the Stroop tasks, the Embedded Figures Test, the Dichotic Listening Test, and the computerized VIGIL Continuous Performance Test. Participants in the meditation+ group were trained on the relaxation response and then asked to elicit the relaxation response (below). Participants in the meditation- group were asked to read leisure material that was not work related, obligatory, or difficult (placebo intervention) until told to stop. Finally, all participants were re-administered the entire battery of experimental tasks.

Experimental Manipulation: Relaxation Response

The experimenter was trained on the RR and an audio-tape of a mock RR training session was made to demonstrate the examiner's expertise. The treatment with each participant began with a pre-control for

approximately 3 min during which he or she was asked to sit quietly in a chair and to become accustomed to simple diaphragmatic breathing techniques. Instructions were provided verbally. Researchers (e.g., Hillenberg & Collins, 1982; Israel & Beiman, 1977; Paul & Trimble, 1970) have found live relaxation instruction provided by a therapist to be more effective than tape-recorded instructions.

Before formal training in the 9 steps (below), each participant's heart rate was measured manually with the experimenter counting his or her pulse at his or her wrist for 10 sec. The participant was then asked if he or she had any questions concerning what he or she was being asked to perform. Training on the RR then included instruction on the following 9 (verbatim) steps: (a) sit quietly in a comfortable position; (b) close your eyes; (c) relax your muscles; (d) breathe slowly and naturally and, as you do, repeat the word "one" silently to yourself as you exhale; (e) assume a passive attitude (don't worry about how well you're doing. when other thoughts come to mind, internally say , "oh, well" and return to the repetition of the word "one"); (f) continue for 15 min after I leave the room; (g) I will inform you when the 15 minutes is up; and (h) do not stand immediately when I re-enter the room (continue sitting quietly for a minute or so, allowing other thoughts to return. then open your eyes and sit for another minute before rising). Participants were then asked the following questions and their responses were recorded: (a) in general, how do you feel?; and (b) do you think you were able to elicit the relaxation response?

Post-measures were then administered. Upon completion of these measures, participants were debriefed and thanked. Specifically, they had the opportunity to discuss the RR or their symptoms of ADHD more generally. At that time, ADHD participants were given a fact sheet developed by Barkley and Murphy (1998). Upon request, some were also given the business card of a local psychiatrist as well as additional written information regarding the RR.

Statistical Analysis

The parametric data were treated by three-way analyses of covariance with group (ADHD vs. no ADHD) and intervention (RR vs. no RR) as between-subjects variables, test occasion (pre- vs. post-intervention) as a within subject, repeated measures variable, and age as a covariate; in addition, planned comparisons were employed following these overall analyses. Further, secondary analyses (e.g., on inclusion-exclusion criteria) employed *t*-tests and chi-square tests to determine differences between groups.

Results

Findings are presented with respect to the two preliminary hypotheses: (a) overall differences between those with and without ADHD; and (b) differential effects of the RR training on those with versus without ADHD (three-way interactions for presence vs. absence of ADHD, presence vs. absence of intervention, and pre vs. post test occasion). Means for other main effects and interactions may be calculated by the interested reader (Table 2).

Overall Differences Between Those With and Without ADHD

As Table 1 illustrates, those with ADHD differed from those without ADHD on 5 of the 22 outcome

---

insert Table 1 about here

---

measures, namely, one on the Clark University Stroop (number correct) and four on VIGIL: A, K (errors, omissions, comissions, hits). In all cases, those without ADHD out-performed those with ADHD. This is more than might be expected (5 of 22 vs. 1 of 20) by chance alone. Further, there were 4 additional trends (number of errors on the Clark University Stroop, reaction time on VIGIL K, and left first and left second on the Dichotic Listening Task).

Effects of the RR

As Table 2 demonstrates, there were trends toward significant three-way interactions on 4 of the 22

---

insert Table 2 about here

---

measures. These occurred on: VIGIL K (hits); VIGIL A K (reaction time); and the Dichotic Listening Task (total right, left second).

Discussion

The present exploratory study has implications for problem, theory, method, and practice. For problem, it appears that the effects of the RR on the attentional functioning of those with ADHD is worthy of further empirical investigation and has the potential to contribute to the empirical data base in this area. That is, the RR has been shown effective in reducing symptoms of hypertension, anxiety, depression, insomnia, AIDS, infertility, cancer, and now, in a suggestive manner, ADHD in adulthood. Future research should qualify this finding with larger samples of men as well as extend these notions to the attentional functioning of women with ADHD and children of both

genders with ADHD. Further, that the RR demonstrated trends toward improving attentional functioning in our participants with ADHD, future research would do well to assess the effects of the RR on additional aspects of cognitive functioning such as intelligence, memory, problem solving, language, and the like. In this manner, we will ultimately come to understand whether the RR has the potential to impact all aspects of cognitive functioning or simply the attentional aspects such as those documented here. That other aspects of cognitive functioning are involved in ADHD gains support from perusal of other DSM-IV-TR (2000) symptoms relevant to ADHD, namely, impulsivity, hyperactivity, distractibility, etc.

For theory, the present study has implications in several respects. First, in light of recent theorizing that ADHD and ADD may represent two qualitatively distinct disorders, future research would do well to consider this distinction. In fact, because our participants were screened on the WURS that has items related to both attention and to hyperactivity, subsequent analyses of our own data might further contribute to the literature in this area. That is, more refined analyses, in this and future research, might reveal differential effects of the RR dependent on whether the individual has symptoms predominantly of attention or predominantly of hyperactivity. Further, a third group, namely, those with symptoms of both inattention and hyperactivity, might be assessed toward ascertaining whether this sub-group is more similar to one of the other two sub-groups or constitutes sub-group unto itself. The issue of whether ADHD consists of distinctly different sub-groups or one basic group (with symptomatology manifest in different ways) has obfuscated the research to date and revealed conflicting findings that may ultimately be reconciled in this manner. Second, that our participants with and without ADHD showed differences in some aspects of attentional functioning (e.g., selective attention, sustained attention) but not others (e.g.,complex attention, executive function, cognitive disembedding) reinforces the notion that it is worthwhile to consider attention as a multidimensional construct with various dimensions that may or may not be related to one another. Future research, as well as more refined analyses of the pilot data obtained here, have the potential to answer longstanding questions about the interrelations of aspects of cognitive functioning that have intrigued cognitive psychologists and neuropsychologists for some time now.

The present pilot work also has significant implications for several aspects of method. First, that the trends though suggestive found herein were obtained with only a minimal intervention (15 min on 1 occasion) suggests that even more pronounced effects of the RR on improving attention might be obtained through more powerful manipulations. For example, more extensive training on one occasion, multiple trainings on multiple occasions,

and/or a combination of trainings (e.g., with respect to both form and content) may ultimately reveal the most efficacious means to improve attentional functioning in those with ADHD. Such possibilities are clearly worthy of further empirical investigation. Second, that our participants performed differentially on Card C of the Clark University Stroop versus the California Stroop suggests that the two tasks may assess differential aspects of attentional functioning and that, in contrast to what some have recommended in the literature, the two tasks should not be used interchangeably. Further, researchers should acknowledge that variants of the classic version of this task (Clark University Stroop Color-word Test) need to be considered in terms of the specific norms generated by the specific task rather than in terms of the totality of data collected on this and other tasks.

Finally, the present exploratory study has strong implications for practice. If our preliminary findings are corroborated with and verified on larger samples of individuals, on individuals with ADHD and other disorders, on children as well as on adults, on males as well as on females, and with respect to other meaningful comparisons, we will then be in a position to generate standardized training manuals for both patients and therapists, which might be incorporated into the armamentarium of clinical psychologists and related professionals. While significant controversy ensues as to the most efficacious forms of intervention (and the underlying processes that make them so), a robust finding within the treatment literature has concerned the additive effects of therapy, that is, three treatments appear to lead to better outcome than two and one treatments, respectively. Finally, that this particular treatment is relatively straightforward and may ultimately be easily administered by the patient himself or herself, the present pilot data in and of themselves make a contribution and suggest directions for related avenues of research, which have powerful application for those suffering from ADHD and related disorders.

References

American Psychiatric Association. (1980). Diagnostic and statistical manual of mental disorders (3rd ed.). Washington, DC: American Psychiatric Association.

American Psychiatric Association. (1987). Diagnostic and statistical manual of mental disorders (3rd ed., rev.). Washington, DC: American Psychaitric Association.

American Psychiatric Association (1994). Diagnostic and statistical manual of mental disorders (4th ed.), Washington, DC: American Psychiatric Association.

American Psychiatric Association (2000). Diagnostic and statistical manual of mental disorders (4th ed., text revision). Washington, DC: American Psychiatric Association.

Baird, J., Stevenson, J., & Williams, D. (2000). The evolution of AD/HD: A disorder of communication? Quarterly Review of Biology, 75, 17-47.

Barkley, R. A. (1991). Diagnosis and assessment of attention deficit-hyperactivity disorder. Comprehensive Mental Health Care, 1(1), 27-43.

Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: constructing a unifying theory of AD/HD. Psychological Bulletin, 121, 65-94.

Barkley, R. A. (1998).

Barkley, R. R. & Murphy, K. R. (1998). Attention-deficit hyperactivity disorder: A clinical workbook. New York: Guilford.

Beck, A., Steer, R. A. & Brown, G. (1988). Beck Depression Inventory Manual. San Antonio, Texas: Psychological Corporation.

Beck, A. T., & Steer, R. A. (1993). Beck Anxiety Inventory Manual. San Antonio, Texas: Psychological Corporation.

Benson, H. (1974). The relaxation response. New York: Avon.

Benson, H., Beary, J. & Carol, M. (1974). The Relaxation Response. Psychiatry, 37,37-46.

Benson, H., Rosner, B. A., & Marzetta, B. R. (1974). Decreased blood pressure in hypertensive patients who regularly elicited the RR. Lancet, 1, 289-291.

Benson, H & Wallace, R. K. (1972) Decreased blood pressure in hypertensive patients who practice meditation. Circulation, 46(4),131.

Biederman, J., Newcorn, J., & Sprich, S. (1991). Comorbidity of attention deficit disorder with conduct, depressive, anxiety, and other disorders. American Journal of Psychiatry, 148, 564-577.

Blanton, J. B. (1990). Effects of computer-assisted biofeedback on relaxation and on-task behavior of children with attention deficit disorder. Dissertation Abstracts International, 51, 1572.

Borgeat, F., Stravynski, A., & Chaloult, L. (1983). The influence of two different sets of information and suggestions on the subjective effects of relaxation. Journal of Human Stress, 9,40-45.

Bronowski, J. (1967). Human and animal languages: To Honor Roman Jakobson. The Hague, Netherlands: Mouton and Co.

Campbell, S. (1969). Cognitive styles in normal and hyperactive children. Unpublished doctoral dissertation, McGill University.

Cannon, W. B. (1914). The emergency function of the adrenal medulla in pain and the major emotions. American Journal of Physiology, 33, 356-371.

Cantwell, D. (1985). Hyperactive children have grown up: What have we learned about what happens to them? Archives of General Psychiatry, 42, 1026-1028.

Castellanos, F., Giedd, J., Marsh, W., Hamberger, S., Vaituzis, A., & Dickstein, D. (1996). Quantitative brain magnetic resonance imaging in attention deficit hyperactivity disorder. Archives of General Psychiatry, 53, 607-616.

Chelune, G., Ferguson, W., Koon, R., & Dickey, T. (1986). Frontal lobe disinhibition in attention deficit disorder. Child Psychiatry and Human Development, 16, 221-234.

Delis, D., Kaplan, E., & Kramer, J. H. (in press). Executive Function Scale. (1997) San Antonio, Texas: The Psychological Corporation.

Domar, A., Seibel, M., Benson, H. (1990). The mind/body program for infertility: A new behavioral treatment approach for women with infertility. Fertility and Sterility, 53,246-249.

Donney, V. K., & Poppen, R. (1989). Teaching parents to conduct behavioral relaxation training with their hyperactive children. Journal of Behavior Therapy and Experimental Psychiatry, 20, 319-325.

Douglas, V. I. (1972). Stop, look, and listen: The problem of sustained attention and impulse control in hyperactive and normal children. Canadian Journal of Behavioral Science, 4, 259-282.

Douglas, V. I. (1983). Attention and cognitive problems. In M. Rutter (Ed.), Developmental neuropsychiatry (pp. 280-329). New York: Guilford Press.

Elia, J., Ambrosini, P., & Rapoport, J. (1999). Treatment of Attention-Deficit/Hyperactivity Disorder. The New England Journal of Medicine,780-788.

French, A. P., & Tupin, J. P. (1974). Therapeutic application of a simple relaxation method. American Journal of Psychotherapy, 28, 282-287.

Giedd, J., Castellanos, F., & Casey, B. (1994). Quantitative morphology of the corpus callosum in attention deficit hyperactivity disorder. American Journal of Psychiatry, 151, 665-669.

Glanz, R. (1992). The effect of the RR on complex cognitive processes (meditation). Dissertation Abstract Internations, 53,2088.

Golden, C. J. (1978). Stroop color and word test: A manual for clinical and experimental use. Chicago: Stoelting.

Goleman, D. (1977). The varieties of meditative experience. New York: Dutton.

Grodzinsky, G., & Diamond, R. (1992). Frontal lobe functioning in boys with attention deficit hyperactivity disorder. Developmental Neuropsychology, 8, (4)427-445.

Hall, P. (1999). The effects of meditation on the academic performance of African American college students. Journal of Black Studies, 29, 408-425.

Harmon, R., & Myers, M. (1999). Prayer and meditation as medical therapies. Physical Medicine and Rehabilitation Clinics of North America, 10 (30),651-663.

Hart, E., Lahey, B., Loeber, R., Applegate, B., & Frick, P. (1995). Developmental change in Attention-Deficit Hyperactivity Disorder in boys: A four-year longitudinal study. Journal of Abnormal Child Psychology, 23,729-749.

Heaton, R., Chelune, G., Talley, J. Kay, G., & Curtiss, G. (1993). Wisconsin Card Sort Test Manual: Revised and Expanded. Odessa, FL: Psychological Assessment Resources.

Hillenberg, J. B., & Collins, F. L. (1982). A procedural analysis and review of relaxation training research. Behavioral Research Therapy, 20, 251-260.

Hynd, G. (1990). Brain morphology in developmental dyslexia and attention deficit hyperactivity disorder. Archives of Neuorlogy, 47, 919-926.

Irvin, J., Domar, A., Clark, C., Zuttermeister, P., & Friedman, R. (1996). The effects of RR training on menopausal symptoms. Journal of Psychosomatic Obstet Gynecology, 17,202-2-7.

Israel E., & Beiman, I. (1977). Live verses recorded relaxation training: A controlled investigation. Behavioral Therapy, 8, 251-254.

Kabat-Zinn, J. (1982). An outpatient program in behavioral medicine for chronic pain patients based on the practice of mindfulness meditation. General Hospital Psychiatry, 4, 33-47.

Kimura, D. (1967). Functional asymmetry of the brain in dichotic listening. Cortex, 3, 163-178.

Kutz, I., Borysenko, J., & Benson, H. (1985). Meditation and psychotherapy: A rationale for the integration of dynamic psychotherapy, the RR and mindfulness meditation. American Journal of Psychiatry, 142, 1-8.

Kratter, J. (1983). The use of meditation in the treatment of attention deficit disorder with hyperactivity. Dissertations Abstracts International,44,1965.

Lavoie, T., & Tsukahara, R. (2000). Unpublished History Questionnaire.

Leuzzi, R., & Spandorfer, J. (2000). Some individuals never outgrow AD/HD, says DSM-IV. Internal Medicine, 4, 44.

Lev, D. (1994). Focused attention: The impact of concentrative meditation on cognitive control and altered states of consciousness. Dissertation Abstracts International, 55, 3618.

Levy, F. (1991). The dopamine theory of Attention Deficit Hyperactivity Disorder. Australian and New Zealand Journal of Psychiartry, 25,277-283.

Lezak, M. D. (1995). Neuropsychological assessment, 3rd Ed. New York: Oxford University Press.

Lindsay, W. R., & Morrison F. M. (1996). The effects of behavioral relaxation on cognitive performance in adults with severe intellectual abilities. Journal of Intellectual Disability Research, 40, 285-290.

Lou, H., Henriksen, L., Bruhn, P., Borner, H., & Nielson, J. (1989). Striatal dysfunction in attention deficit and hyperkinetic disorder. Archives of Neuology, 46, 48-52.

Lovejoy, D., Ball, J., Keats, M., Stutts, M., Spain, E., Janda, L., & Janusz, J. (1999). Neuropsychological performance of adults with attention deficit hyperactivity disorder: Diagnostic classification estimates for measures of frontal lobe/executive functioning. Journal of the International Neuropsychological Society, 5, 222-233.

Maharishi, M. (1969). On the Bhagavad Gita. Baltimore: Penguin Books.

Margolis, H. (1990). Relaxation training: A promising approach for helping exceptional learners. International Journal of Disability, Development and Education, 37,215-234.

Mattes, J., & Gualtiri, A. (1980). The role of frontal lobe dysfunction in childhood hyperkinesis. Comprehensive Psychiatry, 21, 358-369.

Newcorn, J., Halperin, J., Healey, J., O'Brian, J., Pascualvaca, D., Wolf, L., Morganstein, A., Sharma, V., & Young, G. (1987) Are ADDH and AD/HD the same or different? Meeting of the American Academy of Child and Adolescent Psychiatry, Washington.

Otis, L.S. (1974). If well integrated but anxious, try TM. Psychology Today, 7,(11) 45-46.

Patel, C. H. (1973). Yoga and biofeedback in the management of hypertension Lancet, 2, 1053-1055.

Paul. G., & Trimble, R. (1970). Recorded vs "live" relaxation training and hypnotic suggestion: Comparative effectiveness for reducing physiological arousal and inhibiting stress response. Behavioral Therapy,1, 285-302.

Pelletier, K. (1974). Influence of transcendental meditation upon autokinetic perception. Perceptual and Motor Skills, 39, 1031-1034.

Pennington, B., Grossier, D., & Welsh, M. (1993). Contrasting cognitive deficits in attention deficit disorder verses reading disability. Developmental Psychology, 29, 511-523.

Porter, S. S., & Omizo, M. M. (1984). The effects of group relaxation training/large muscle exercise, and parental involvement on attention to task, impulsivity, and locus of control among hyperactive boys. Exceptional Child, 31, 54-64.

Quay, H. (1988). Attention deficit disorder and the behavioral inhibition system: The relevance of the neuropsychological theory of Jeffrey A. Gray. In L. M. Bloomingdale & J. Sergents, Attention deficit disorder: Criteria, cognition, intervention (pp. 117-126). New York: Pergamon.

Quay, H. (1997).Gray's behavioral inhibition in AD/HD: An update. Paper presented at the annual meeting of the International Society for Research in Child and Adolescent Psychology, Los Angeles, CA.

Rey. A. (1941). L'examen psycholoique dans les cas d'encephalopathie traumatique. Archives of Psychology, 28, 286-340.

Rosvold, Mirsky, Sarason, Bransone, & Beck (1956).

Roush, W. (1997). Herbert Benson: Mind-body maverick pushes the envelope. Science, 276, 357-359.

Schaughency, E., & Hynd, G. (1989). Attentional control systems and the attention deficit disorders. Learning and Individual Differences,1,(4),423-449.

Seidman, L. (1999). Attention Deficit Hyperactivity Disorder across the life span. Massachusetts General Hospital-Harvard Medical School Psychiatry Continuing Education Handout.

Seidman, L., Faraone, S. Biederman, J., & Waber (1997). Toward defining a neuropsychology of Attention Deficit Hyperactivity Disorder: Performance of children and adolescents from a large clinically referred sample. Journal of Consulting and Clinical Psychology, 65, 150-160.

Shapiro, D. H., & Giber, D. (1978). Meditation and psychotherapeutic effects. Archives of Psychiatry, 35, 294-302.

Spencer, T., Biederman, J., Wilens, T., & Faraone, S. (1994). Is attention-deficit hyperactivity disorder in adults a valid disorder? Harvard Review Psychiatry, 326-335.

Spencer, T., Wilens, T, Biederman, J., Faraone, S., Ablon, S, & Lapey, K. (1995). A double blind, crossover comparison of Methylphenidate and placebo in adults with childhood-onset Attention-Deficit Hyperactivity Disorder. Archives of General Psychiatry, 52,434-443.

Still, G. F. (1902). Some abnormal psychical conditions in children. Lancet, 1, 1008-1012, 1077-1082, 1163-1168.

Trennery, M., Crosson, B., DeBoes, J., & Leber, W. (1988). Stroop neuropsychological screening test manual. Odessa, FL: Psychological Assessment Resources.

Troller, J. N. (1999). Attention deficit hyperactivity disorder in adults: conceptual and clinical issues. Medical Journal Aust, 171, 421-5.

VIGIL: Continuous Performance Test, user's guide. (1998). San Antonio Texas: The Psychological Corporation.

Voeller, K. (1990). The neurological basis of attention deficit hyperactivity disorder. International Pediatrics, 5,171-176.

Ward, M. F., Wender, P. H., & Reimherr, F. W. (1993). The Wender Utah Rating Scale: An aid in the retrospective diagnosis of childhood attention deficit hyperactivity disorder. American Journal of Psychiatry, 150, (6) 885-890.

Wechsler, D. (1999). Weschler Abbreviated Scale of Intelligence. San Antonio, Texas: Psychological Corporation.

Witkin, H., Oltman, P., Raskin, E., & Karp, S. (1971). Manual for embedded figures test, children's embedded figures test and group embedded figures test. Palo Alto, CA: Consulting Psychologists Press.

Wishart, H., Keyes, B., Flashman, L., Riordan, H., Macallister, T., Sparling, M., Huey, L., & Saykin, A. (2000). Multidimensional models of Attention-deficit/hyperactivity disorderin adults: Implications of the factor structure of neuropsychological test results. International Journal of the Neuropsychological Society, 6 (2).124.

Zametkin, A. J., & Liotta, W. (1998). The neurobiology of attention-deficit/hyperactivity disorder. Journal of Clinical Psychiatry, 59, 17-23.

Zametkin, A., Nordahi, T., Gross, M., King, C., Semple, W., Rumsey, J., Hamburger, S., & Cohen, R. (1990). Cerebral glucose metabolism in adults with hyperactivity of childhood onset. The New England Journal of Medicine, 323, 157-162.

Table 1

Similarities and Differences Between Those With (ADHD+) and Without (ADHD-) ADHD on Major Outcome Measures

Dimension	Task	Measure	AD/HD+	AD/HD-
Selective Attention	Clark University	1. No. correct (of 100)	44.1	52.6 *
	Stroop (Card C)	2. No. errors	1.2	0.6 †
	California Stroop	3. No. correct (of 100)	45.4	47.4
	(Card C)	4. No. errors	0.7	0.4
Sustained Attention	VIGIL (K)	5. Errors	4.7	4.2
		6. Omissions	2.4	1.6
		7. Commisions	2.4	2.5
		8. Hits	1.0	1.0
		9. Reaction Time	432.4	400.4 †
	VIGIL (A, K)	10. Errors	15.7	8.0 *
		11. Omissions	8.1	3.7 **
		12. Comissions	7.5	4.3 *
		13. Hits	0.9	1.0 *
		14. Reaction Time	394.9	382.2
Complex Attention	Dichotic Listening	15. Total Left	0.8	0.9
and Executive	Task	16. Total Right	0.5	0.7
Function		17. Total Both	0.8	0.8
		18. Right First	0.5	0.6
		19. Left First	0.8	0.8 †
		20. Right Second	0.8	0.9
		21. Left Second	0.5	0.7 †
Cognitive	Embedded	22. No. Correct (of 9)	4.7	4.8
Disembedding	Figures Test			
Ability				

** $p<.01$, * $p<.05$, † $p<.10$

Table 2

Three-way Interactions of Group (ADHD+, ADHD-), Treatment (RR+, RR-), and Test Occasion (PRE, POST) on Major Outcome Measures

Dimension	Measure [1]		AD/HD+/RR+	AD/HD+/RR-	ADHD-/RR+	ADHD-/RR-
Selective Attention	1	PRE	44.5	53.3	44.1	40.0
		POST	50.7	61.9	48.1	44.3
	2	PRE	1.0	0.5	1.1	1.7
		POST	0.8	0.1	0.6	1.3
	3	PRE	42.9	46.8	42.1	38.8
		POST	50.1	50.9	48.4	45.8
	4	PRE	0.5	0.5	0.5	1.2
		POST	0.6	0.1	0.6	0.6
Sustained Attention	5	PRE	5.1	4.1	4.4	6.1
		POST	4.5	3.1	2.8	5.5
	6	PRE	2.0	0.9	2.1	2.4
		POST	2.6	1.0	1.5	3.2
	7	PRE	3.1	3.2	2.4	3.6
		POST	1.9	2.1	1.3	2.3
	8	PRE	1.0	1.0	1.0	1.0
		POST	1.0	1.0	1.0	1.0 †
	9	PRE	406.8	401.8	440.4	420.2
		POST	391.9	400.9	437.9	431.0
	10	PRE	6.6	8.7	11.3	14.2
		POST	6.3	10.2	17.3	19.9
	11	PRE	3.3	4.3	6.2	7.9
		POST	2.9	4.3	8.4	10.0

[1] Measure number corresponds to previous page

	12	PRE	3.3	4.4	5.1	6.4
		POST	3.4	5.9	8.9	9.9
	13	PRE	1.0	1.0	1.0	1.0
		POST	1.0	1.0	0.9	0.9
	14	PRE	373.9	367.0	336.7	373.6
		POST	386.4	400.9	437.9	431.1 †
Complex Attention	15	PRE	0.8	0.9	0.8	0.8
and Executive		POST	0.8	0.9	0.8	0.9
Function	16	PRE	0.6	0.7	0.5	0.5
		POST	0.6	0.8	0.6	0.5 †
	17	PRE	0.9	0.8	0.8	0.8
		POST	0.8	0.9	0.7	0.8
	18	PRE	0.6	0.7	0.6	0.5
		POST	0.6	0.8	0.6	0.5
	19	PRE	0.8	0.9	0.8	0.8
		POST	0.8	0.9	0.9	0.8
	20	PRE	0.8	0.9	0.8	0.8
		POST	0.8	0.9	0.8	0.9
	21	PRE	0.6	0.7	0.5	0.5
		POST	0.6	0.8	0.6	0.5 †
Cognitive	22	PRE	3.1	3.3	2.7	2.4
Disembedding		POST	2.6	2.9	2.9	2.4
Ability						

† $p<.10$