Neuro Therapeutics

Focus on What Matters

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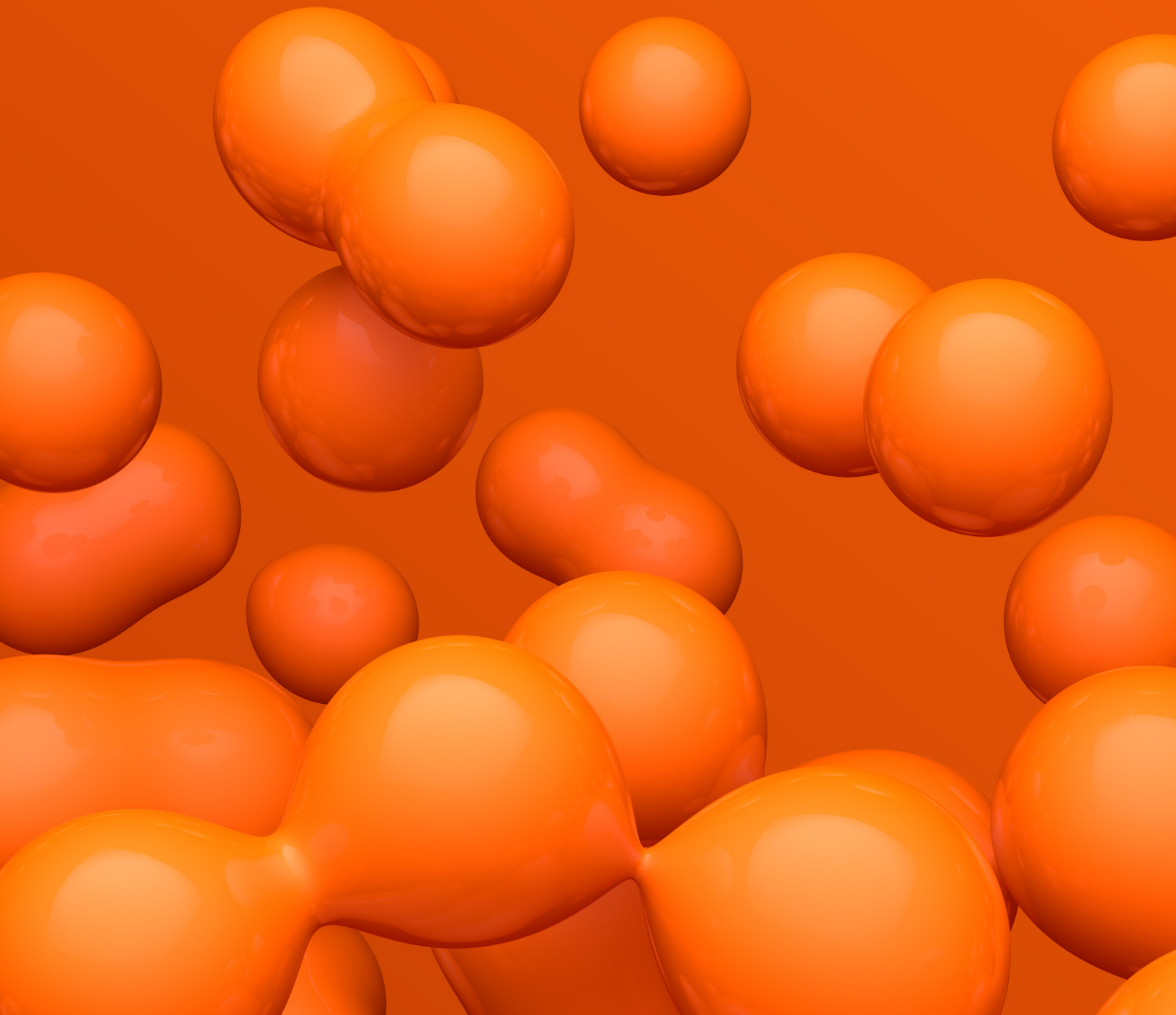

Abstract

Across the lifespan, problems in attention can negatively impact an individual and interfere with their quality of lives. Impact can be seen from reduced productivity at work, difficulties with education, and emotional control issues caused by lack of attention (Barkley & Murphy, 2010). Additionally, these issues have a large impact on the US economy as the total cost of illness ranges between $36-52 billion annually (Pelham, Foster, & Robb, 2007). There are many ways attentional issues can be assessed, however, there is no single intervention that is the answer for every individual and good treatment plans will include close monitoring, follow-ups and changes needed along the way. We highlight here some of the methodologies that are currently being utilized with maximal potential for positive impact as awareness and consumption of services and products continues to increase.

Introduction to Attention

Attention refers to the mental ability of an individual to focus or narrow awareness on selected stimuli from the external environment or internal moods, thoughts, memories, and physical sensations that are behaviorally relevant from those that are behaviorally irrelevant (Raz, 2004). Several models of attention have emerged within the domains of cognitive psychology, neuro/psychophysiology, and psychometric testing. While a comprehensive review is beyond the scope of this manuscript, a brief description of fundamental components of attention, associated deficits, related assessment tools, and interventions are provided in the following sections.

The attention system is a complex and unique system but can be broken down into fundamental components that include focused attention, selective attention, sustained attention, divided attention, and alternating attention (Sohlberg & Mateer, 2001).

- Focused attention refers to an individual's ability to respond to specific visual, auditory or tactile stimuli and is assessed by simple orienting and tracking measures (Sohlberg & Mateer, 2001) or event-related potential (ERP) task paradigms (Woodman, 2010).

- Selective attention is the ability to maintain attention on the current task even when competing stimuli are present and can be assessed by the d2 test. Individuals that struggle with this component are easily distracted by external or internal stimuli (Sohlberg & Mateer, 2001).

- Sustained attention (vigilance) involves maintaining the focus of attention on determined stimuli and is key to successful information processing. Deficits in sustained attention are linked to mind-wandering, lapses in attention and a decline in performance efficiency, especially when required to attend to a task for long periods of time. Sustained attention can be assessed using continuous performance tasks (CPT) or the Brief Test of Attention (BTA; Sohlberg & Mateer, 2001).

- Divided attention is the ability to manage more than one task demand at a time and often requires continuous alternating of attention. This can lead to the loss of information, as attention is divided by two competing sources of information with limited attentional resources. This attentional domain can be assessed with the paced auditory serial addition test (Sohlberg & Mateer, 2001).

• Alternating attention refers to an individual's ability to switch attention between tasks that have contrasting cognitive requirements and can be assessed with WAIS-III or trails B. Those that struggle with mental flexibility may have difficulty switching between tasks once a goal has been set (Sohlberg & Mateer, 2001).

Problems with Attention

Both children and adults experience attention issues. Across the lifespan, problems of attention impact educational, occupational, neuropsychological, and social functioning (Rostain, 2008). In the academic domain, the inability to attend to tasks may lead to poor grades, poor reading and math standardized test scores, a lower intelligence quotient (IQ), lower grade point averages, an increase in school dropout (van der Kolk, van Agthoven, Buitelaar & Roijen, 2015). In the United States alone, more than one-third of children diagnosed with an attention related disorder also experience high levels of emotional difficulties contributing to low self-esteem and social rejection which may result in a distorted sense of self and a decrease in self-confidence. Additionally, the lack of emotional regulation may result in comorbid behavior issues including opposition and/or aggression which may increase the number of family conflicts (Wehmeier, Schacht, & Barkley, 2010). Due to the lack of appropriate communication skills associated with attention issues and disruptive behaviors, individuals may experience difficulty establishing and maintaining relationships, which also negatively impacts self-esteem and self-confidence, further hindering the drive to explore additional life challenges (Wehmeier, Schacht, & Barkley, 2010).

If left unresolved, attention problems may proceed into adulthood and become a lifelong issue impairing overall educational level and academic success (Halmøy, Fasmer, Gillberg, & Haavik, 2009) and job performance and career opportunities (Barkley & Murphy, 2010), with affected individuals reporting histories of academic failures, employment problems, and traffic accidents (Faraone et al., 2006). Poor time management, organizational and problem-solving skills, and low attendance or consistently arriving late to work, along with inability to follow directions and attend to tasks ultimately result in unsatisfactory job performance (Barkley & Murphy, 2010) and further lead to higher levels of unemployment and increased disability claims (Halmøy, Fasmer, Gillberg, & Haavik, 2009). In addition to education and work performance, it is common for additional components of an individual's life, such as recreational outlets and particularly performance to be affected by the issues associated with attention problems. Performance is hindered when certain components of attention, particularly selective attention, alertness, and information-processing are diminished (Tenenbaum & Eklund, 2007). Selective attention allows the individual to attend to relevant information while omitting distractions. Alertness refers to a state of readiness which enables the individual to respond to a particular stimuli as it occurs. Finally, information processing determines if an individual can effectively assign the appropriate level of attention to the current task as well as the ability to switch focus between concurrent tasks (Tenenbaum & Eklund, 2007).

When attention issues severely impact daily routines causing disruption and chaos to the individual's life, a medical diagnosis may be determined through use of the Diagnostic and Statistical Manual, Fifth edition (DSM-5; American Psychiatric Association [APA], 2013) and the International Classification of Diseases, 10th Edition (ICD-10; World Health Organization [WHO], 1992). The most common attention issue clinically diagnosed is ADHD (CDC, 2015). The worldwide-pooled prevalence of childhood attention-deficit/hyperactivity disorder (ADHD) is 5.29% (Polanczyk, de Lima, Horta, Biederman, & Rohde, 2007), with 30-65% of children re-

porting symptoms into adulthood (Faraone, Biederman, & Mick, 2006). According to the DSM-5, to be accurately diagnosed with ADHD, children up to the age of 17 must experience six or more symptoms of inattention, hyperactivity and impulsivity, while individuals 17 and older must experience five or more symptoms. Symptoms must be present for at least six months with an onset before the age of 12. The ICD-10 utilizes the same criteria as the DSM-5, however it requires more details regarding impairment in social, academic, or occupational settings, such that specific symptoms occur in at least two separate domains. Additionally, the ICD-10 combines all symptoms of inattention, impulsiveness and hyperactivity into a single diagnosis of hyperkinetic conduct disorder where the DSM-5 splits inattention and hyperactivity-impulsivity to allow for multiple diagnoses of ADHD (Lee et al., 2008).

The high rate of Americans experiencing ADHD has a large impact on the US economy. More than $2 billion a year is spent on medication for the treatment of ADHD (Bloomberg Business, 2003). The total cost of treatment which includes medication, additional therapies, and production and income losses, ranges between $36-52 billion annually (Doshi et al., 2012; Pelham, Foster, & Robb, 2007). Alternative treatments, including psychotherapy and physiological monitoring, are also utilized, especially when there is a concern for potential side effects from medication.

Assessments of Attention

Psychological Assessments

Rating scales, like most assessment instruments measure different components of attention. They are used to assess the presence and/or severity of attention difficulties and can also be utilized to determine the effectiveness of interventions. These assessments are easy to administer, low in cost, and typically require minimal time to complete. Some assessments are administered by an observer, such as a parent or teacher, and others are completed by the individual. Scores are quantified and compared to a normative sample (Kaplan, 2012). The Conners 3rd Edition (Conners-3; Conners, 2008) rating scale focuses on the assessment of ADHD and common associated difficulties in children and adolescents ranging from 6 to 18 years of age including the following; inattention, hyperactivity/impulsivity, learning problems/executive functioning, aggression, peer relations, and family relations. The assessment includes a self-report, parent report and teacher report. Respondents rate the occurrence of the behavior for the past month according to a Likert scale ranging from not true at all/never/seldom to very much true/very often/very frequently (Conners, Pitkanen, & Rzepa, 2008).

The Brief Test of Attention (BTA) is a standardized test used to assess auditory divided attention in individuals ages 17-82 years (Schretlen, 1989). The test consists of 2 tasks, each which require less than 5 minutes to complete. An audio CD is played and an individual is instructed to distinguish between spoken numbers and letters of the alphabet. First, 10 lists of letters and numbers (e.g., "M-6-3-R-2") are read aloud, or played through the audio CD. This list increases in length from 4 to 18 items. The individual is to disregard the letters and count how many numbers are read aloud. Each list is followed by 5 seconds of silence, during which the subject reports how many numbers were recited. The same 10 lists are presented in the second task, in which the individual is to disregard the numbers and count how many letters are read aloud. The number of correctly monitored lists is summed across both forms, with raw scores ranging from 0 to 20 (Schretlen, Bobholz, & Brandt, 1996).

The d2 Test of Attention (Brickenkamp, 2002) is commonly used to measure an individual's ability to identify relevant stimuli while distracting stimuli is presented (Wassenberg et al., 2008). The individual is presented with 14 independent lines of alphabetic character strings with 47 letters in each row (e.g., d, p - with a combination of zero, one, or two strokes above and/or below the letter) and instructed to select each of the target character (e.g., d with two strokes above) as fast as possible within 15 seconds (Krumm, Schmidt-Atzert & Eschert, 2008).

Continuous Performance Tasks/Tests (CPT) such as the Test of Variables of Attention (T.O.V.A; Greenberg, 2011), the Integrated Visual and Auditory CPT (IVA-2; Sandford & Turner, 2004), and the Conners' CPT-II (Homack, 2006), are generally composed of a presentation of stimuli (characters, shapes and sounds) on a computer screen and are used to aid in diagnosis or as a milestone in determining treatment efficacy. They measure commission errors, omission errors, reaction time and reaction time variability and the results can be compared to well established databases for further insight. Additionally, these tests have the advantage of being free from biases of self-reporting tests mentioned above.

Psychophysiological Assessments

In addition to standardized psychological assessments that focus on measuring cognitive performance and outcome, physiological assessments have been conducted to measure and assess the internal processes which as a component of bodily functioning (Schwartz & Schwartz, 2003), including heart beat, pupil dilation, and blood pressure. Psychophysiological assessments, therefore, assess the interaction between an individual's psychological state (mind) and the physiological reaction (body) (Schwartz, 2003). Therefore, physiological constructs of arousal to psychological constructs such as emotions, attention, memory, and decision making are some of the areas that can be analyzed (Roth, Dawson & Filion, 2012). Common measurements utilized to assess physiological responses associated with attention problems include electrodermal activity (EDA), heart rate variability (HRV), and electroencephalography.

Electrodermal Activity (EDA) relates to the electrical changes recorded at the surface of two points of the skin by applying an electrical potential between them, resulting in current flow that can then be measured non-invasively. Sweat acts as natural conductor of electricity. Therefore, changes in sweat gland activity naturally occurs during physiological arousal. These changes may be measured through use of the EDA sensors which are typically attached to the individual's fingertips. EDA has been used to assess the relationship between cognitive states, arousal, emotion and attention. In addition, EDA has also been used to examine implicit emotional responses that may occur without conscious awareness or are beyond cognitive intent (i.e., threat, anticipation, salience, novelty). Therefore, EDA may a useful indicator of attentional processing, where salient stimuli and resource demanding tasks evoke increased EDA responses (Braithwaite, Watson, Jones & Rowe, 2013).

Heart rate variability (HRV) measures the inter-beat intervals within the heart beat and is used to determine the functional state of the individual in terms of physiological arousal. Heart rate should change with each beat in a coherent manner, fluctuating with inhalation and exhalation. When an individual is in a state of physiological arousal, very low variability occurs in heart rate. Therefore, there is little change among heart rate within each heartbeat and less coherence, which results in an unbalanced autonomic nervous system

(ANS) which may further lead to both physical and psychological issues (Gervitz & Lehrer, 2003). By measuring HRV, research indicates individuals with attention disorders exhibit an imbalance in their ANS which correlates with low motivation and poor test scores (Börger, et. al, 1997).

Electroencephalography (EEG) measures the electrical activity in the brain utilizing electrodes placed on the scalp at standardized locations according to the International 10-20 system (Klem, Lüders, Jasper, & Elger, 1999). These assessments can be conducted during a variety of tasks including resting state eyes-open and eyes-closed conditions, CPT performance, math and reading tasks. EEG characteristics related to attention have been well studied and documented (Table 1). Individuals that are on the extreme/clinical end the spectrum with attention problems tend to exhibit elevated theta power, reduced relative alpha and beta power and consequently higher theta/alpha and theta/beta ratios mainly observed over the frontal and central midline regions (Barry, Clarke, & Johnstone, 2003). A small percentage of individuals with attention issues exhibit widespread hyperarousal state where beta power is elevated and theta and alpha have reduced relative power (Clarke, Barry, McCarthy, & Selikowitz, 2001). Increased slow wave activity and cortical underarousal has been associated with inattention, hyperactivity and impulsivity. Conversely, lower beta frequencies, including sensorimotor rhythm (12-15 Hz) have been found to be associated with calm immobility in experimental animals, whereas the higher beta frequencies (>15 Hz) are associated with focusing on a task or other situation requiring attention (Lofthouse, Arnold, Hersch, Hurt, & DeBeus, 2011).

Table 1: Basic frequency bandwidths and associated states*

Frequency Name	Bandwidth Range	General Description
Delta	1.5-3.5 Hz	Deep Sleep, Repair
Theta	4-7.5 Hz	Drowsy, Daydreaming
Alpha	8-12 Hz	Relaxed, No Visual Processing
SMR	12–15 Hz	Motor Relation, Alert
Beta	13–30 Hz	Cognitive Processing
Gamma	35–45 Hz	Problem Solving

Note. *review see, Niedermeyer (1999)

Event-related potentials (ERPs) measure brain responses that are a direct result of a specific sensory, cognitive or motor event. This measurement is taken during an EEG recording allowing the administer/researcher to observe a series of cognitive operations, both prior to the presentation of sensory stimuli and after a behavioral response has been made. This is executed through measurement of ERP waveforms across many different timepoints within millisecond precision (Woodman, 2010). This high temporal resolution lends itself well to the study of the earliest stages of information processing and the subsequent transitions from sensory-based perceptual processing to the higher cognitive operations that are necessary to successfully navigate through the complex stimulus-laden environment of everyday life (Light et al., 2010). ERP research in children with inattention and hyperactivity indicate reduced cortical negativity (i.e., a deviant CNV) during cognitive preparation (e.g., Banaschewski et al., 2004; Rockstroh, Elbert, Lutzenberger, & Birbaumer, 1990), as well as reduced posterior P300 activity (Barry, Johnstone, & Clarke, 2003).

Interventions

Whether a healthy individual is seeking increases in attention performance or has a diagnosed attention disorder and is under the supervision and direction of health care provider, there are a variety of interventions and delivery formats that have demonstrated efficacy in regulating components of the attention system. More severe attentional problems, including ADHD, require a more comprehensive treatment which may include behavioral, psychological, educational, and sometimes medical evaluation (Olfson, Gameroff, Marcus & Jensen, 2003). After an individual has been evaluated, the individual and family members are educated on the nature of the issue and methods proven to assist with managing the symptoms. Treatment is typically multidisciplinary, requiring the assistance of the mental health, educational, and often medical professionals at various points along the course (Ramsay & Rostain, 2005). The intensity and duration of the intervention in either case of healthy or clinical condition, often depend on the severity of the presentation, therefore, the more severe the symptoms the longer the individual may undergo interventions (Barkley & Murphy, 1998). Individuals diagnosed with attentional disorders who are motivated to better manage their symptoms may seek help from mental health providers in the form of psychotherapy or psychopharmacology. Often, a combination of psychotherapy and psychopharmacology is an effective form of treatment. In addition, alternative forms of therapy, such as biofeedback and neurofeedback, have also been reported effective for helping individuals acquire skills to combat symptomatology (Berntson et al., 1994; Schwartz & Schwartz, 2003).

Medication

Medication management has been an effective form of treatment for diagnosable attention issues (Spencer et al., 1996; Weiss & Murray, 2003). Typically, either psychostimulants or antidepressants are prescribed to decrease symptoms. Psychostimulants are prescribed to temporarily decrease fatigue and increase alertness and wakefulness while improving motor control (Ng & O'Brien, 2009). Side effects associated with psychostimulants may include but are not limited to insomnia, stomachache, headache, appetite suppression, increased blood pressure, nervousness and jitteriness. These side effects are often mild and short-lived. The greatest concern is that stimulants often become dependant and abused by users; especially those with ADHD (Goldman, Genel, Bezman, & Slanetz, 1998). Due to some of the adverse reactions and the lack of response to stimulants, antidepressants have been prescribed as an alternative medication to assist people in better managing symptoms of attentional issues. Antidepressants typically serve as second-line treatments for ADHD and may often be used as an additional medication taken with a psychostimulant (Verbeeck, Tuinier & Bekkering, 2009). While medication management has been effective in treating ADHD symptoms, many individuals will seek additional therapies in conjunction to assist in gaining further skills to attain personal goals (Ramsay & Rostain, 2005).

Psychotherapy

Individuals often seek psychotherapy or counseling techniques (e.g. Cognitive Behavioral Therapy) to help alleviate symptoms, work through barriers, and process emotional turmoil they may be experiencing (Howard, Kopta, Krause, & Orlinsky, 1986). Psychotherapy has been identified as an effective form of treatment for attentional issues (Hesslinger et al., 2002). Therapists assist individuals in identifying personal goals and

appropriate steps to attain these goals and establish healthier lifestyles (Corey, 2012). The process of psychotherapy involves guiding the individual to develop tools and strategies to effectively meet and defeat everyday challenges. The role of the therapist is to help the individual maximize their strengths while developing needed skills to minimize difficulties and enhance self-confidence. For example, individuals experiencing attentional issues may often become distracted with external stimuli and lose focus on the task at hand (Hesslinger et al., 2002). As a result, tasks may be identified but never completed, which may cause the individual to feel frustrated with themselves and further lead to negative self-talk, or negative thoughts about oneself. Often therapists incorporate strategies associated with cognitive behavior therapy to help individuals learn to identify and change negative self-talk and improve self-esteem. With an enhanced self-esteem, individuals are more apt to approaching tasks (Corey, 2012). In addition, self-monitoring or management allows individuals to effectively regulate attention, take corrective actions if needed, and evaluate progress (Hesslinger et al., 2002).

Therapists may implement mindfulness training to help individuals gain additional skills (Hamilton, Kitzman & Guyotte, 2006; Kabat-Zinn, 2003). Mindfulness is a form of meditation which is often implemented to enhance one's ability to engage in a present focused stated with a nonjudgemental attitude. Individuals are instructed to become aware of their current thoughts and feelings, embracing a calm state of simply being in the present as opposed to perseverating over the past or becoming anxious about the future (Kabat-Zinn, 2003). Maintaining a present focused state is the most challenging component of mindfulness training. Although attention regulation skills may be crucial for optimal functioning, the ability to exercise control over attention may be even more critical for those persons who are vulnerable to affective dysregulation. Empirical evidence documents that mindfulness meditation enhances emotional regulatory skills (Hamilton et al., 2006).

Assistive Software/Games

Assistive technology and computer games may be used as an aid to help individuals better manage symptoms associated with attention issues. For example, individuals who experience attention problems are more likely to find reading challenging as opposed to those without attention issues. Distractibility often causes an individual to focus on unimportant stimuli or daydream, negatively impacting one's short-term memory. Therefore, an individual may find himself reading the same sentence or paragraph multiple times or missing pertinent information completely. Assistive reading technology has the capability to present text both visually and audibly. Through use of this software, individuals may find it easier to keep track of what they have read by highlighting the text. This feature assists individuals to decrease the tendency to impulsively jump around in the text and skip over important information (Hecker, Burns, Katz, Elkind, & Elkind, 2002). Assistive technology may be used to help individuals improve attention. Research has also indicated playing computer games has a positive effect on attention primarily due to the high level of continuous interest, concentration, endurance, and cognitive ability needed for strategic problem solving (Roh & Lee, 2014).

Virtual Reality

Virtual reality exposure therapy (VRET) utilizes virtual reality to immerse an individual in a simulated environment similar to a real life setting in which the individual experiences challenges (Rizzo, Buckwalter, & van der Zaag, 2002). For individuals experiencing ADHD enrolled in VRET, often a classroom environment is sim-

ulated. Once immersed, a therapist will incorporate various cognitive and behavioral techniques to assist the individual in acquiring or enhancing effective skills to better manage the symptoms associated with ADHD (Wann, Rushton, Smyth, & Jones, 1997). Outcomes indicate not only are individuals engaging in VRET able to increase the ability to identify relevant information and attend to a task with distractions, this type of therapy is appealing to individuals with ADHD as most are interested in stimulation associated with video games (Rizzo et al., 2004).

Biofeedback

Biofeedback, is a tool used to measure, monitor, and display physiological information of the person through use of noninvasive sensors (Schwartz & Schwartz, 2003). With the information provided from the biofeedback training, individuals may gain the ability to self-regulate certain physical or biological functions. Often sensors utilized include but are not limited to the following; eye tracker, kinect (monitors body movement), pulsometer (HR), respirometer (breathing rate), electromyography (EMG) and electrodermal activity (EDA). Training targets both direct functioning, identified as intentional body movements, and indirect functioning identified as unconscious physiological functioning. Monitoring these functions and displaying progress in the form of visual and auditory cues allows individuals to gain an awareness of physiological functioning and eventually, with training, control over these processes (Ortiz-Vigon Uriarte et al., 2015). Gaining control of physiology has been known to help individuals better manage symptoms of attention issues and improved motor control associated with ADHD (Bakhshayesh, Hänsch, Wyschkon, Rezai, & Esser, 2011; Maurizio et al., 2014).

Heart Rate Variability

The purpose of HRV training is to decrease over-activation of physiological responses to stress and achieve a state of balance in the autonomic nervous system by increasing the variability in heart rate (Berntson et al., 1994; Gevirtz & Lehrer, 2003; Gevirtz & Dalenberg, 2008). Training HRV involves slow diaphragmatic breathing exercises. During the breath cycle the heartbeat intervals increase (speed up) during inhalation and decrease (slow down) during exhalation. The difference between the increase maximum and the decrease minimum is the variance of the heart rate (Zucker et al., 2009). Decreasing breathing rate slows the beating of the heart. Ultimately, a decrease in heart rate will increase the variability, allowing the individual to achieve what is known as respiratory sinus arrhythmia (RSA), or the synchronization of the heart rate with breath pace. As a result, an individual may create an overall balance within the ANS (Gevirtz & Dalenberg, 2008; Zucker, Samuelson, Muench, Greenberg, & Gevirtz, 2009), further improving physical ailments (Sutarto et al., 2010; Wheat & Larkin, 2010), as well as mood, cognition and mental clarity (Gevitz & Dalenberg, 2008; Sutarto et al., 2010). In addition, HRV training has lasting effects (Wheat & Larkin, 2010).

Neurofeedback

Research indicates that neurofeedback (NFB) is an effective intervention for helping individuals gain control over symptoms associated with attention issues. NFB is a nonpharmacologic, non-invasive, treatment strategy that monitors and trains the electrical activity (EEG) of the brain using sensors placed on the scalp (Hammond, 2011). Over multiple training sessions, an individual learns volitional control of specific EEG components through visual or auditory feedback, reward, and operant conditioning (Sherlin et al., 2011). Based on

neuroimaging research, clinical presentation and evaluation, and provider experience, NFB protocols are developed to target specific EEG activity in particular regions of the brain in order to produce specific results. For instance, protocols for ADHD generally target theta and beta activity over the frontocentral cortex to enhance attention. Protocols for major depression target alpha asymmetry over the frontal cortex to improve affect. Protocols for generalized anxiety disorder target alpha and beta activity over the occipital cortex to reduce arousal. Protocols for insomnia target rolandic mu activity over the sensorimotor cortex to promote sleep (review see, Micoulaud-Franchi et al., 2015).

Several meta-analyses have assessed the efficacy of NFB for the reduction of self-reported ADHD symptoms, indicating medium effect sizes for overall symptom reduction (Lofthouse, Arnold, Hersch, Hurt, & DeBeus, 2012; Micoulaud-Franchi et al., 2014), and medium (Micoulaud-Franchi et al., 2014) to large (Arns, de Ridder, Strehl, Breteler, & Coenen, 2009) effect sizes on inattention and impulsivity. Review of individual studies indicate that NFB is also effective for improving various aspects of attention. For sustained attention, NFB has consistently led to improvements on CPT performance assessed with the T.O.V.A. (Fuchs, Birbaumer, Lutzenberger, Gruzelier, & Kaiser, 2003; Kaiser & Othmer, 2000; Monastra, Monastra, & George, 2002; Rossiter, 2005; Rossiter & La Vaque, 1995), and IVA CPT (Lévesque, Beauregard, & Mensour, 2006; Xiong, Shi, & Xu, 2005). Gains in focused attention, indexed by improvements on specific ERP tasks including contingent negative variation (CNV) (Heinrich, Gevensleben, Freisleder, Moll, & Rothenberger, 2004; Mayer, Wyckoff, Schultz, & Strehl, 2012; Wangler et al., 2011) and P300 (Arns, Drinkenburg, & Leon Kenemans, 2012; Bakhtdadze, Dzhanelidze, & Khachapuridze, 2011; Egner & Gruzelier, 2004), have also been observed. Finally, improvements in selective attention have been evidenced by improvements on the d2 test (Fuchs et al, 2003; Keller, 2001).

Discussion

An amazingly high number of individuals report challenges in attention, with 5.29% of children worldwide having issues severe enough to necessitate a diagnosis for ADHD, and 30-65% of those children likely to carry symptoms into adulthood. These challenges negatively influence productivity at work, lead to difficulties in education, and problems in emotional control. There are many components that make up the attention system, however those components are reasonably understood and can not only be measured but influenced in a positive direction by interventions. If left unaddressed attention problems may become a lifelong issue contributing to decreased educational and academic performance, as well as diminished career opportunities and job performance. In addition to education and work performance, it is likely that there is a negative contribution in recreational outlets and family life.

A number of described assessment and intervention techniques have been demonstrated to have an effective and positive influence on attention processes and increased performance on associated attentional measures. Most of the interventions described (sans medication) have been shown to be effective in healthy and even elite performers as well as clinical populations. This suggests that creating easier access to assessment and intervention techniques may have the opportunity to increase the quality of life for many individuals who otherwise may not be compelled to seek intervention because the deficit experienced doesn't reach the severity of a clinical presentation.

A large number of individuals seek to increase their attention abilities, whether they are healthy individuals seeking increases in performance or are those who suffer an attention disorder under the supervision and

direction of health care provider. By creating tools and instruments that are easy to access, cost effective, efficacious and can be seamlessly integrated into already existing daily behaviors or delivered through mobile devices the consumption, compliance and ultimately efficacy may be increased.

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