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Walden University

College of Social and Behavioral Sciences

This is to certify that the doctoral dissertation by

Rosemary Akhavan

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Walden University
2018

Abstract

The Efficacy of Neurofeedback in the Treatment of Autism

by

Rosemary Akhavan

MA, Seton Hall University, 1999

BS, University of New Hampshire, 1975

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Psychology

Walden University

November 2018

Abstract

Autism is a disorder that impairs the development of a person's ability to interact with other people and to relate productively with the outside world. There are many types of interventions being used to treat autism, but there are no cures or definitive treatments for this disorder. A biological theoretical foundation was the basis of this study, as recent neuroimaging techniques have demonstrated that autism is a neurological disorder that reveals distinct abnormalities in the brain. The purpose of this study was to examine the efficacy of neurofeedback (NFB) in the treatment of autism. NFB has shown promise of improving the negative symptoms associated with autism, such as repetitive behaviors, aggression, problems with communication, and social ineptness. This study reviewed the results of children diagnosed with autism who were exposed to NFB. Archived data were obtained from a neurofeedback clinic in California. Thirty-eight pre and posttreatment brain maps, collected from individuals treated with NFB, demonstrated that NFB helped brainwaves to settle into a more normalized pattern. Treatment effectiveness was analyzed using binomial expansion (BE), and 9 parents completed the Autism Treatment Evaluation Checklist (ATEC). Clinician notes were also used to provide qualitative information. The findings of this study may impact social change by providing support for NFB as an effective treatment for autism. NFB may be a potential non-medical, noninvasive, and long-lasting approach for those afflicted with autism.

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Dedication

This dissertation is dedicated to my husband, Kourosh Akhavan, who stood by my side through this entire process. I thank him for being my guinea pig, sounding board, and a shoulder to cry on when I was tired and frustrated. Now he is my partner to share my happiness with.

Acknowledgments

First and foremost, I would like to thank my husband and children for their faith and support. They were my cheering squad! Thank-you to Dr. Hanania for being patient with me, and for her guidance and feedback. I would also like to offer special thanks to the people who were generous to share their stories with me. Special thanks go to Dr. Velkoff. Without him this study would not have been possible. And of course, a big thank-you to Walden University whose unique learning environment gave me the opportunity to pursue my dream!

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Chapter 1: Introduction to the Study

According to the American Psychiatric Association's (APA), *Diagnostic and Statistical Manual of Mental Disorders*, Fifth Edition (*DSM-5*), autism is a class of pervasive developmental disorders that manifests in early childhood and are characterized by qualitative abnormalities in language, communication, social interactions, and restrictive and repetitive stereotyped behaviors (Ji & Findling, 2015; Cangialose, 2014; Brasic, 2013; Brasic & Wong, 2010). Autism spectrum disorder (ASD) severely impairs the development of a person's ability to interact with other people, as the autistic individual is self-absorbed and unable to relate normally with the outside world. Researchers have shown that autism is a neurological disorder that reveals distinct abnormalities in the brain including the cerebellum, hippocampus, and the limbic system beginning at a very young age (Brasic, 2013; Grandin, 2006; Kabot, Masi, & Segal, 2003; Ratey, 2001).

This study explored the possible efficacy of neurofeedback (NFB) in the treatment of autism. There are three basic types of NFB treatments: (a) quantitative electroencephalography (QEEG) NFB, (b) hemoencephalography (HEG), and (c) audio-visual entrainment (AVE). A treatment session using QEEG-NFB appears fun and simple. The user is playing a computer game, but instead of moving objects around with a controller, they are using their mind. The NFB equipment analyzes the user's brainwaves through sensors lodged in a cap that is placed on the user's head. Brain waves are mapped and analyzed for deviations from the norm. The practitioner will set parameters for a slightly healthier brain map. While the user is playing a computer game, such as a sports game, their brainwaves are continuously monitored. Each time the brain waves find their way into the optimal state as set by the practitioner, the user is rewarded with positive feedback such as a pleasant tone or interesting picture. After anywhere from 5-40 sessions, the brain seems able to find the optimal state on its own. The user has been taught self-regulation. One of the ingenious aspects of this training is that it is tailored for each individual. Training is always set to be challenging and exciting but not too difficult, so that users can move slowly and steadily into their optimal brain states. QEEG NFB requires active involvement of the individual to interface with the NFB equipment, and requires the person to be aware of the feelings in their body. The individual must also be able to follow directions, to attend to task, and to be able to respond to auditory or visual cues. The ability to adjust specific brainwave activity through kinesthetic awareness and control may be quite daunting for the individual with ASD. As a result, QEEG NFB may not be appropriate for some individuals with ASD who are lower functioning or who have more severe symptoms associated with autism (Coben, Linden, Meyers, 2010).

HEG is a newer treatment modality based on increasing oxygenation and blood flow to the frontal part of the brain. The user is fitted with a headband (spectrophotometer) that is gently placed over the forehead, and runs around the circumference of the head. There are sensors built into the headband to measure the blood flow. Measurements are sent to a computer that measures the light color, calculates their ratio, and graphs the values to determine areas of oxygen deprivation. The user increases brain oxygenation merely by intensely willing it (Limsilla & Toomin, 2003). For instance, the user may see a bar graph on a computer screen and hear a musical tone. To increase oxygenation on demand, the user must attend to the highest note heard, and try to will it to sound higher. Another exercise asks the user to start watching a movie. Suddenly the movie will stop. In order to restart the movie, the user must concentrate to increase brain oxygenation. HEG may be difficult for a child with ASD to implement because they need to be cognizant of their body's feelings in order to increase block flow in the cerebellum, and there are no specific directions on how to do this (Limsila & Toomin, 2003).

AVE is a type of NFB that uses a preprogrammed sequence of lights and sounds to gently guide the brainwaves to fall into a predetermined specific brainwave pattern and to increase cerebral blood flow (Eisenberg, 2010; Siever, 2004). The user puts on a set of glasses and a pair of headphones and simply sits back. The user will then see flashing lights and hear sounds. The user may also listen to music. The program used may be predetermined to treat a specific condition, such as attention deficit hyperactivity disorder (ADHD), depression, or the practitioner can tailor the program to address the particular need of the user. The lights and sounds may be adjusted in volume or intensity. AVE is a passive way to entrain, and it does not make a difference if the user keeps their eyes open or closed. Each session typically lasts about 30 minutes. The AVE unit may be connected to a computer to measure brainwave activity. AVE is a passive approach of NFB that is easy to use and might prove to be more user-friendly to individuals with ASD (Siever, 2004). However, AVE must be used with caution with people who are sensitive to lights and sounds, and it should not be used with people who have a seizure disorder.

Manufacturers of the AVE equipment have certain precautions to avoid this problem, such as using sine wave stimulation instead of square wave stimulation, reducing the amount of red light emitted by using special light bulbs, and by creating a special eye set that provides smooth, even illumination, meaning that as the eyes move about, the brain will not perceive any changes significant enough to alert it (Seiver, 2006).

Statement of the Problem

This study investigated the impact of NFB as a possible treatment for autism. Research seems to indicate that NFB may be helpful in remediating connectivity disturbances and significantly reducing autistic symptoms (Kouijzer, de Moor, Gerrits, Congedo, & van Schie, 2008). In studies and clinical treatment for children with ADHD, improvements have been documented to last for 5-10 years (Kouijzer et al., 2008; Coben, Linden, & Myers, 2010). The success of these studies has formed the foundation for the emergence of applying NFB in the treatment of autism (Coben et al., 2010). If the results of this study indicate a positive direction in the treatment of autism, it could fill the gap in the literature regarding NFB as a viable treatment modality. I hope that future researchers will continue to explore this modality through controlled group studies and that treatment programs will consider adding NFB to their treatment plans.

Research Questions and Hypotheses

The purpose of this study is to examine NFB as a treatment modality for children diagnosed with ASD. The quantitative research question for this study was as follows:

RQ1: Do children treated with QEEG NFB display a significant improvement in normalized brain wave activity after treatment, as demonstrated by pre- and post-brain maps?

$H_0$1: There is no significant difference in brain wave activity as measured by QEEG brain maps pre- and posttreatment.

H_a1: There is a significant difference in brain wave activity as measured by QEEG brain maps pre- and posttreatment.

The qualitative research question for this study was as follows:

RQ2: Do children diagnosed with ASD display a significant reduction of pathological symptoms after treatments with NFB as reported by clinicians? Symptoms to be assessed included speech/language/communication, sociability, sensory/cognitive awareness, and health and physical behavior.

$H_0$2a: There is no difference in social interactions.

H_a2a: There is a difference in social interactions.

$H_0$2b: There is no difference in communications skills.

H_a2b: There is a difference in communications skills.

$H_0$2c: There is no difference in restricted interests.

H_a2c: There is a difference in restricted interests.

$H_0$2d: There is no difference in repetitive behaviors.

H_a2d: There is a difference in repetitive behaviors.

$H_0$2e: There is no difference in eye contact.

H_a2e: There is a difference in eye contact.

$H_0$2f: There is no difference in in tantrums.

H_a2f: There is a difference in in tantrums.

$H_0$2g: There is no difference in display of affection.

H_a2g: There is a difference in display of affection.

$H_0$2h: There is no difference in sleep patterns.

H_a2h: There is a difference in sleep patterns.

$H_0$2i: There is no difference in hypersensitivity.

H_a2i: There is a difference in hypersensitivity.

$H_0$2j: There is no difference in aggressive behaviors.

H_a2j: There is a difference in aggressive behaviors.

The main characteristics of pathological symptoms are impairments in social interaction, impairments in communication, restricted interests, and repetitive behaviors such as hand flapping, head rolling, or body rocking. Additional symptoms may include inability to make eye contact, ignoring other people, failure to show affection, being insensitive to other's feelings, temper tantrums, dislike of being held or cuddled, failure to respond to own name or commands, sleep difficulties, obsessive speech, rigid routines, preference to be left alone, speech that is not meaningful or relevant, lack of understanding or use of proper facial expressions, hypersensitivity to sound or touch, insensitivity to pain, hitting of self or others, loudness, and agitation.

Purpose of the Study

The purpose of this study was to determine if NFB can be considered a possible efficacious treatment modality for patients with ASD. This study focused on NFB, a method of brainwave modulation, as a biological approach in reducing the symptomatology of ASD. NFB is an operant conditioning procedure by which the brain may be accessed directly at the functional level to modify and train brain waves, thereby facilitating new patterns of behavior (Othmer, Othmer, & Kaiser, 1999). The ultimate goal of NFB is to facilitate lasting neurophysiological changes in the brain (Robbins, 2000). This study will add to the body of research regarding NFB as an alternative method of treating ASD.

Theoretical Basis

This study was based on a biological orientation, as research has shown that autism is a biological disorder, not a mental illness (Brasic, 2013; Coben, 2007; Kabot, Masi, & Segal, 2003). Autism is a physical condition that affects the way the brain is structured and functions, and is also a neurological condition that negatively affects the sensory, communicaton, and social capabilities of the child (Brasic, 2013; Coben, 2007; Kabot et al., 2003). The basis for autistic disorders lies in dysregulation of neural connectivity (Coben, 2007). Courchesne reported MRI and autopsy evidence of early abnormailities of the cerebellar vermis and hemispheres of the brain (Courchesne, Townsend, Akshoomoff, Saitoh, Young-Courchesne, Lincoln, James, Haas, Schreibman, & Lau, 1994). Courchesne found that two areas of the cerebellum, lobules VI and VII, were significantly smaller than those in nonautistic children, and a portion of the subjects exhibited lesions in the cerebellum (Courchesne et al., 1994; Edelson, 2000). The children with autism were also reported to have less grey matter, a lower ratio of grey matter to white matter (Kabot et al., 2003). Additionally, a study conducted using positron-emission-topography and found an abnormal capacity for serotonin synthesis in the brains of children with autism (Brasic, 2013; Kabot et al., 2003). These biological defects have been linked to deficits in four areas of social behavior including sharing intentions, joint attention, affective sharing, and the preference for sameness and routine (Kabot et al., 2003). Single-photon emission computed tomography (SPECT) scans of children with autism revealed abnormal cerebral blood flow in the medial prefrontal cortex and anterior cingulate gyrus, negatively impacting communication and social interaction (Coben et al., 2010). Individuals with autism also exhibited less functional connectivity between Broca's area and Wernicke's area, implying a lower degree of information and neural synchronization during language tasks (Coben et al., 2010). Genetic abnormalities have also been discovered making autism the highest estimated heritability disorder (> 90%) among neuropsychiatric disorders (Brkanac, Raskind, & King, 2008). Autism may also be accompianied by other related sensory, motor, and cognitive disorders caused by similar biological conditions such as mental retardation, seizure disorder, Fragile X syndrome, and tuberous sclerosis, a genetic condition that results in abnormal tissue growth in the brain and other organs (Ji & Findling, 2015; Brasic, 2013; Kabot et al., 2003). The American Academy of Child and Adolescent Psychiatry reported on a possible connection between autism and obsessive-compulsive disorder (Kabot et al., 2003). Depression and bipolar disorder is identified in approximately one-third of familes of individuals with autism, and the autistic child may also display symptoms of these disorders (Kabot et al., 2003). It was also reported that these children were responsive to lithium treatment after displaying typical symptoms of bipolar disorder (Kabot et al., 2003).

NFB is based on the concept of neuroplasticity, the idea that the brain is not static, but capable of dramatic and long lasting changes when given the correct stimulation, which has recently been widely accepted as scientific fact (Robbins, 2000; Rosenzweig, Leiman, & Breedlove, 1999). Laibow (1999) described NFB as a "discipline based in neuropsychology, which draws from the multidisciplinary fields of neuroanatomy, pathophysiology, and behavioral medicine" (Coben et al., 2010, p. 92). The brain is at risk of being subject to a wide array of dysfunctions, and it is surmised that approximately 1 in 5 people currently suffers from a neurological or psychological disorder that ranges in severity from complete disability to significant impairments in the quality of life (Edelson, 2000; Rosenweig et al., 1999). The biological theory stresses that autism may be the result of abnormalities of the brain, possibly caused by genetic abnormalities, complications during pregnancy or birth, brain damage, or viral infections (Brasic, 2013; Grandin, 2000; Kabot et al., 2003; Ratey, 2001). The evidence for the biological theory is that autism is often found to be accompanied by neurological symptoms such as difficulty in learning, speech, and sensory processing (Brasic, 2013; Rosenzweig et al., 1999) or mental handicaps such as difficulties in communication, relating to others, or adapting in social situations (Brasic, 2013; Anderson, Nartham, Hendy, & Wrennal, 2001; Grandin, 2000; Kabot et al., 2003; Medical News Today, 2004, Ratey, 2001). Biological psychology can help contribute to the understanding and development of treatments for disorders of the brain. Autism and other brain dysfunctions create an enormous burden in terms of suffering and social costs (Ji & Findling, 2015; Centers for Disease Control and Prevention [CDC], 2000; Rosenweig et al., 1999). Biological researchers are trying to understand the nature of these disorders, and they are continually trying to develop new treatments to prevent, control, or alleviate them, including ASDs (Ji & Findling, 2015; Rosenweig et al., 1999). Biological psychology relates behavior to human bodily processes, and the main goal of this realm of study is to understand the behavior and experiences in terms of their biological substrates (Brasic, 2013; Rosenweig et al., 1999). Biological psychology is committed to improving the human condition and its negative effects on society (Rosenweig et al., 1999). In Chapter 2 I describe in detail the possible causes and abnormalities of the ASD. Brainwave frequencies that are excessive and produce negative symptoms are inhibited, and brainwaves that produce positive symptoms are augmented to achieve desired results (Coben et al., 2010). This study examined whether NFB will prove effective in the treatment of autism by the adjustment of brainwave activity.

Figure 1 displays the main general characteristics of brain mapping for a child diagnosed with autism. The absolute power for delta and theta are increased, but also the power of beta waves is high. In some cases, this can be due to high anxiety. Generally, alpha brain waves are positively related to cortical information processing, that is, cognitive abilities, and that alpha and theta brain waves change with age in a nonlinear and opposite way. Therefore, it is important to note that children with neurological and developmental disorders such as autistic spectrum disorder show significantly more delta and theta brain waves but less alpha power, which correlates with their cognitive impairment (Pop-Jordanova, Zorcec, Demerdzieva, & Gucev, 2010).

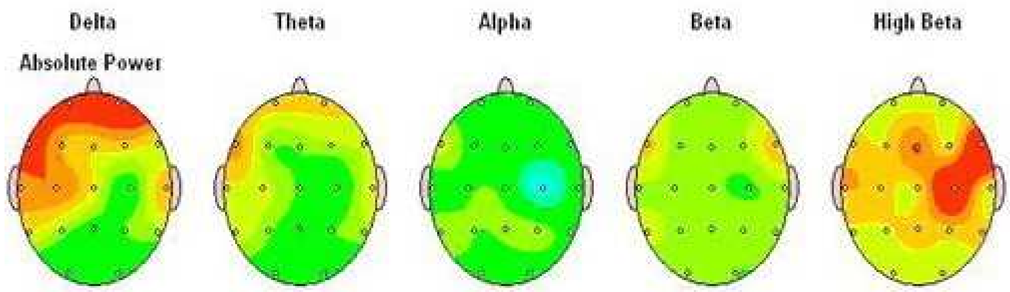

Figure 1. Summary information for main brain waves in 5-year-old autistic child (Drake, 2018).

Assumptions

The following assumptions apply to this study: NFB is not harmful (Coben, Linden, Meyers, 2010; Siever, 2000). To date there have been limited published controlled studies regarding the effect of NFB on the sympoms of autism, although NFB appears to be efficatious in reducing the symptoms of autism in children, such as repetitive behaviors, being fixated on an object, unable to make eye contact, carrying on conversation, ability to follow commands, ablility to interact with other people, being able to dress themselves, feed themselves, and perform other activities of self care, and being injurious to self or others. According to previous researchers of pre- and post-NFB treatments, NFB appears to have a positive outcome (Scolnick, 2005; Sichel, Fehmi, & Goldstein, 1995; Kouijzer et al., 2008; Kouijzer & de Moor, 2009; Jacobs, 2005; Pineda et al., 2008). The behavioral and brain wave changes suggest that NFB can be an effective treatment for some of the symptoms of mild autism, including focusing and reduction of anxiety (Scolnick, 2005; Sichel et al., 1995).

Limitations

NFB is a relatively new modality of treatment for ASD, and the literature supporing the efficacy of NFB and autism is extremely limited, especially because new discoveries and protocols continue to evolve. Therefore, the sample size will be small, and the information gathered will be from archived and secondary sources. Because all participants will be receiving special education services simultaneously, such components could confound the potential treatment effects of NFB, thus challenging the interpretation of outcome and limiting generalization.

Significance of the Study

This study was designed to contribute to the body of knowledge that NFB may be utilized as a treatment modality that may expedite the reduction of symptomatology of those diagnosed with ASD. The implications for social change from this research is the impact that NFB may allow the individual to live a more normal life, and to maintain self-worth and dignity. NFB may allow for long lasting change rather than simply control symptoms. Some of the improvements reported after all types of NFB treatments include (a) decreased stress/frustration; (b) enhanced family participation and increased participation in family activities; (c) an increase in self-expression of emotions, needs, and thoughts; and (d) an increased awareness of self in relation to the external environment (Byrne, 2005). Children have also exhibited an increase in the production of speech and the quality of spoken expression, an improvement in academic performance and increased participation in school activities, improved self-confidence, and an increase in self-esteem (Byrne, 2005). The use of AVE has demonstrated that levels of blood serum and neurotransmitters such as serotonin, endorphin, and melatonin rise significantly after 10 Hz. AVE treatment (Seiver, 2006). Serotonin plays a significant role in a range of bodily processes including sensory gating, behavioral inhibition, sleep, digestion, aggression, and mood regulation; enhanced levels of serotonin result in better mood and sleep, less aggression and impulsivity, stable moods, and more social interaction (Bauman & Kemper, 2004). Children with autism often experience disturbed sleep, wake frequently during the night, wake early, and have nightmares resulting in reduced sleep duration that has a negative impact on daytime behavior (Humphreys et al., 2013). Fifty-three percent of autistic children claim to have sleep difficulties as compared to 32% of children in the normally developing population (Humphreys et al., 2013). Melatonin helps to improve sleep patterns by regulating the circadian rhythm (Humphreys et al., 2013). Increases in endorphins result in increased relaxation, while an increase in norepinephrine, along with a reduction in daytime levels of melatonin, indicate increased alertness (Seiver, 2006). There is also evidence of growth of dendrites and dendritic shaft synapses after mild electrical stimulation in cells being treated (Seiver, 2006). However, studies have not been conducted on the influence of dendritic growth on people with autism, palsy, stroke, and aneurysm, although it has been reported by users with these conditions that they experienced a significant improvement in motor and cognitive functioning after a treatment program of NFB (Seiver, 2006). Increased self-sufficiency with daily living activities and self-care may allow individuals to work and make a living, to live independently and establish a home life, and to develop personal relationships, thus allowing them to become independent, contributing members of society.

Definition of Terms

In this study the following terms are defined as follows:

Alpha: EEG frequencies of 8-12 Hertz (Hz), alpha, a relaxed but alert state (Evans & Abarbabel, 1999).

Autism spectrum disorder (ASD): A class of pervasive developmental disorders that manifest in early childhood and are characterized by qualitative abnormalities in language, communication, social interactions, and restrictive and repetitive stereotyped behaviors (APA, 2013).

Autism Treatment Evaluation Checklist: A one-page checklist that rates the severity of the core symptoms of autism as reported by parents, allowing them to track how well their child is progressing over time (Rimland & Edelson, 2000)..

Beta: EEG frequencies from 12-40 Hz. Beta is the range of normal waking consciousness (Evans & Abarbabel, 1999).

Electroencephalogram (EEG): A test that measures and records the electrical activity of the brain by using sensors attached to the scalp (Robbins, 2000).

Hemoencephalography (HEG): NFB that trains the subject to increase blood flow to targeted areas of the brain (Limsila et al., 2004).

Hertz (Hz): Frequency at which a brainwave repeats its cycle within one second (Evans & Abarbabel, 1999).

Neurofeedback (NFB): An operant conditioning procedure by which the brain may be accessed directly at the functional level to modify and train brain waves, thereby facilitating new patterns of behavior (Othmer et al., 1999).

Neuroimaging: Neuroimaging refers to a series of techniques used to create maps of the brain as it functions. The principal imaging techniques used are electroencephalography (EEG), positron emission tomography (PET), magnetic resonance imaging(MRI), functional magnetic resonance imaging (fMRI), computed axial tomography (CAT), and SPECT (Houde, 2004).

Theta: EEG with frequencies from 4-8 Hz. Theta is referred to as the hypnogogic state and is a type of consciousness twilight that occurs between the state of deep relaxation and sleeping (Evans & Abarbabel, 1999).

Quantitative EEG (QEEG): "QEEG is a type of electrophysiological assessment that applies computerized mathematical analysis to convert the raw waveform data into different frequency ranges including delta, theta, alpha, and beta. Each frequency range is averaged across a sample of data and quantified into mean amplitude (i.e., voltage in microvolts). The absolute power and relative power (i.e., percentage of total power) in each frequency band can be calculated" (Chan, Sze, & Cheung, 2007, p. 74).

Symptoms of autism: Negative symptoms include staring at lights, repetitive blinking, moving fingers in front of eyes, finger-snapping, ear tapping, hand flapping, rubbing skin with objects, rocking, licking of objects, head banging, or sniffing at objects or people. There are serious difficulties in relating to and communicating with other people, including gesturing rather than speaking to indicate needs, averting eye contact, echolalia, unresponsiveness to simple commands, delayed speech, apparent deafness. There may be extreme mood swings for no apparent reason such as uncontrollable crying or laughing, screaming, aggressive behavior, self-injurious behaviors, attachment to unusual objects such as a piece of string, sleep difficulties, and difficulties in changing routines.

Positive symptoms include any improvement in the above symptoms, such as being able to look somebody in the eye and interact with that person, an increase in frustration tolerance, a reduction in tantrums, reduction in stereotypic behaviors, and being able to sleep through the night (Coben, Linden, & Meyers, 2010).

Summary

Autism is a relatively misunderstood disorder, and ongoing research is continually revealing more information related to causes and application of treatments. Chapter 2 includes a comprehensive literature review of ASD regarding possible causes, neuropsychology, descriptive neuroanatomy, treatments available, and the application of NFB as an alternative or complementary therapy. In Chapter 3 the researcher examined data gathered from brain maps and clinicians. Chapter 4 includes a review of the procedures used, and the statistical findings. Chapter 5 provides an overview, interpretation of the findings, implications for social change, as well as recommendations for future research.

Chapter 2: Literature Review

Introduction

Autism is referred to as a spectrum disorder, in which symptoms may occur in any combination, and with varying degrees of severity. According to the CDC, autism is thought to affect one child per 59, making it more common than Down syndrome or childhood cancer (Ji & Findling, 2015; Eisenberg, 2010). Autism attacks without discrimination, afflicting all sectors of society. Nationwide, the demand for human services for childhood autism escalated 556% during the 1990s (National Institute of Child Health [NICH], 2000). This study provides an overview of the complexity of this disability by exploring the major aspects of autism, possible causes for autism, and current treatments for the disorder. In this study I also explore in depth the application of NFB as a treatment tool in the treatment of autism, as well as the implications of NFB for the future. EEG biofeedback, also known as NFB, is a noninvasive computerized exercise for the brain to teach the individual to learn self-regulation by controlling brain waves (Exkorn, 2006). NFB is an operant conditioning procedure whereby an individual modifies the frequency, amplitude, and coherence of the electrophysiological dynamics in the brain (Coben et al., 2010; Othmer et al., 1999). NFB may address the brain directly at the functional or system level, and as the brain responds to the operant conditioning of the audio/visual reinforcement, the functional process may be altered, and new patterns of behavior facilitated (Coben et al., 2010; Othmer et al., 1999). NFB sessions utilize sensors affixed to the child’s scalp and ears to monitor and provide feedback to the child. During a session, the child is seated in front of a computer to play a video game. The game cannot be played unless the child increases or decreases the activity of the frequency bands, or brain wave activity, as shown on the screen.

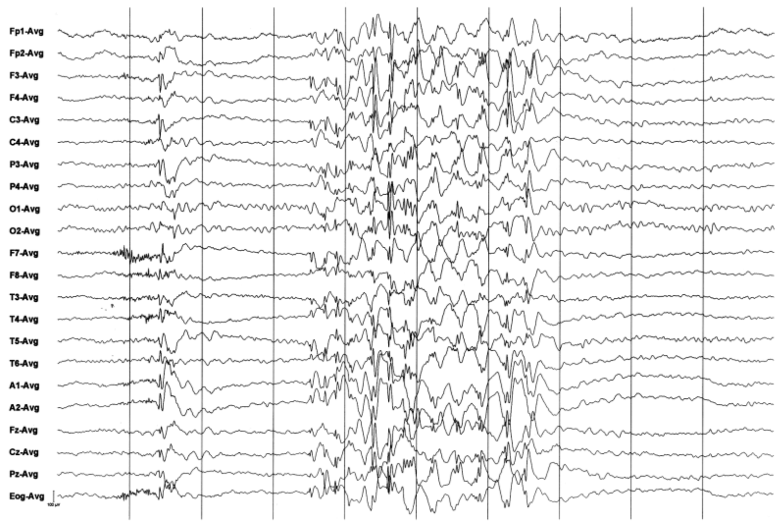

Figure 2: Example of an EEG (Drake, 2018).

The computer provides visual and audio reinforcement. This requires the child to be in an alert and attentive state. When the child ceases to focus, the video game slows down or stops (Exkorn, 2006). Each session may last from 40-60 minutes, and is administered one to five times per week for optimal effectiveness. A therapist monitors the treatment, and may remain in the room, or may monitor the child remotely from another room (Exkorn, 2006). Regular brainwave training improves blood flow to specific targeted regions of the brain, fostering stronger connections between cells, or cell assembly (Exkorn, 2006). After 20-30 sessions, the changes appear to last. However, it should be noted that the frequency specificity of the NFB training, as well as its reversibility, allows the individual to be in control of their own training (Othmer et al., 1999).

Description of the Literature Search

I conducted the literature review for this study digitally through electronic psychology, medical, and educational databases such as Academic Search Premier, MEDLINE, Medscape, PsychARTICLES, PsychINFO, IUCAT, Pub Med, as well as through the Walden University library databases. The sources of articles obtained and reviewed for this study were obtained digitally as well as traditionally from existing versions of professional journals. Journals used for the literature review included, but were not limited to, *Developmental Psychology, Developmental Neuropsychology, Behavioral Neuroscience, Applied Psychophysiology Biofeedback, Journal of Neurotherapy, Professional Psychology: Research & Practice,* and *Journal of Consulting and Counseling Psychology.* Keywords used for this study included: *autism, autism spectrum disorders, autism therapies, ASD, pervasive developmental disorders, neurofeedback, biofeedback, QEEG, brainwaves, neuroanatomy, neuroimaging, neurotherapy, electrode placement,* and *brain functions.* Each of these keywords was searched individually and in combinations. Multiple books provided overviews of autism research. Approximately 1,000 of the articles I identified articles had some relation to an autism, biological, neurological, and NFB focus, and I chose155 to be included in this study. I reviewed all articles that discussed NFB as a treatment for autism; however, I discarded articles that repeated the same studies and chose the most recent and relevant articles. I eliminated articles and books dated before 2000 unless they provided pertinent background information. I discontinued searches when the material in the articles became redundant. One gap that was revealed throughout the literature search process was that research was lacking in the area that overlapped autism and NFB.

Diagnostic Criteria for Autism

According to the APA's *DSM -5*, the following criteria need to be met before a diagnosis for autism can be given:

- Persistent deficits must be present in social communication and social interaction across multiple contexts, as manifested by the following, currently or by history:
  - deficits in social-emotional reciprocity, ranging, for example, from abnormal social approach and failure of back-and-forth conversation to reduced sharing of interests, emotions, or affect to failure to initiate or respond to social interactions; and/or
  - deficits in normal communicative behaviors used for social interaction, ranging, for example, from poorly integrated verbal and nonverbal communication to abnormalities in eye contact and body language or deficits in understanding and use of gestures to a total lack of facial expressions and nonverbal communication; and/or
  - deficits in developing, maintaining, and understanding relationships, ranging, for example, from difficulties adjusting to suit various social context to difficulties in sharing imaginative play or in making friends to absence of interest in peers.

- Restricted, repetitive patterns of behavior, interests, or activities, as manifested by at least two of the following, currently or by history, must be present:
    - Stereotyped or repetitive motor movements, use of objects, or speech (e.g., simple motor stereotypies, lining up toys or flipping objects, echolalia, idiosyncratic phrases);
    - insistence on sameness, inflexible adherence to routines, or ritualized patterns of verbal or nonverbal behavior (e.g., extreme distress at small changes, difficulties with transitions, rigid thinking patterns, greeting rituals, need to take the same route or eat the same food every day);
    - highly restricted, fixated interests that are abnormal in intensity or focus (e.g., strong attachment to or preoccupation with unusual objects, excessively circumscribed or perseverative interests); and/or
    - hyper- or hyporeactivity to sensory input or unusual interest in sensory aspects of the environment (e.g., apparent indifference to pain/temperature, adverse response to specific sounds or textures, excessive smelling or touching of objects, visual fascination with lights or movement).
- Symptoms must be present in the early developmental period (but may not become fully manifest until social demands exceed limited capacities, or may be masked by learned strategies in later life).

- Symptoms must cause clinically significant impairment in social, occupational, or other important areas of current functioning.
- These disturbances are not better explained by intellectual disability (intellectual developmental disorder) or global developmental delay. Intellectual disability and ASD frequently co-occur; to make comorbid diagnoses of ASD and intellectual disability, social communication should be below that expected for general developmental level.

Individuals with a well-established *DSM-5* diagnosis of autistic disorder, Asperger's disorder, or pervasive developmental disorder not otherwise specified should be given the diagnosis of ASD. Individuals who have marked deficits in social communication but whose symptoms do not otherwise meet criteria for ASD should be evaluated for social (pragmatic) communication disorder. (APA, p. 50-51)

The new diagnostic criteria for autism as specified in the *DSM-5* combines the subgroups of Asperger's syndrome, pervasive developmental delay and autism into one broad category, ASD (Glicksm, 2012). The shifting of multicategorical diagnoses into one category reorganizes the symptoms to assess the severity of the disorder and is a guide to provide a uniform language to describe the disorder (Harrison, 2012).

A common characteristic of ASD is the impairment in socialization and communication and repetitive or stereotypic behaviors. However, the conditions that compose ASD differ in the degree that they present clinically. Classic autism manifests at a younger age, shows evidence of a genetic component, and commonly exhibits regression in socialization and communication (Venkat, Jauch, Russell, Crist, Farrell, 2012). Classical ASD is associated with impaired intellectual development and seizures and has a poor prognosis for recovery (Venkat et al., 2012). Asperger's syndrome manifests at a later age and is not commonly associated with impaired intellectual ability or incidence of seizures. Outcomes with therapy are better for those diagnosed with Asperger's syndrome than those diagnosed with classic autism (Venkat et al., 2012). Childhood disintegrative disorder is a rare condition usually seen in males, and the individual exhibits a dramatic loss in communication and socialization skills. It is often associated with seizures and intellectual disability (Venkat et al., 2012). Rett syndrome is associated primarily with females with impairments in communication, socialization, and stereotypic behaviors, and it is associated with the loss of muscle tone and inability to perform normal motor activities (Venkat et al., 2012; Brkanac et al., 2008). Pervasive developmental delay-not otherwise specified is a generalized diagnosis for individuals manifesting a preponderance of ASD symptoms, but who do not clearly fit into the other four classifications due to one or more missing characteristics required for that diagnosis (Venkat et al., 2012). Table 1 describes the clinical and epidemiological characteristics of the diagnoses that compose ASD:

Table 1

Comparison of characteristics in autism.

	Classic autism	Asperger syndrome	Childhood disintegrative disorder	Rett syndrome	Pervasive developmental disorder NOS (not otherwise specified)
Age of onset	0-3 years old	>3 years old	3-4 years old: sudden onset	> 3 years old, regression may manifest sooner (6-18 months)	Variable
Sex ratio	2:1 male to female	4:1 male to female	Male predominance (rare diagnosis)	Female predominance (rare diagnosis)	Variable
Communication impairment	Delayed to nonverbal	Not delayed, but impaired in quality	Delayed to nonverbal	Loss of speech	Variable
Socialization impairment	Poor interactions or reciprocity.	Poor interactions or reciprocity	Abrupt loss of social skills	Loss of speech and motor functioning, extending to gaze and ability to grasp social cues.	Variable
Behavioral impairment	Classic preoccupation with parts of items and stereotyped mannerisms.	Variable: may show only limited interests	Abrupt behavioral change and loss of normal behaviors for age.	Compulsive movements with loss of muscle tone.	Mild to severe disability.
Association with intellectual disability	> 60%	Mild to no association.	Severe disability.	Common association: moderate to severe.	Mild to severe disability.
Clinical functional outcome with current interventions	Poor to fair.	Fair to good.	Poor: by age 10 similar to severe autism.	Unknown given rarity of disease: middle age life expectancy.	Fair to good.

(Venkat et al., 2012, p2)

General Overview and Characteristics

Autism is a class of pervasive developmental disorders that manifests in early childhood and are characterized by qualitative abnormalities in language, communication, social interactions, and restrictive and repetitive stereotyped behaviors (Ji & Findling, 2015; Brasic, 2013; Anderson et al., 2001; Grandin, 2000; Kabot et al., 2003; Medical News Today, 2004, Ratey, 2001). ASD severely impairs the development of a person's ability to interact with other people, as the autistic individual is self-absorbed, and is unable to relate normally with the outside world. Kanner first described this disability in 1943. He believed it to be a brain disorder, and named it autism (Volkmar, & Wiesner, 2009). He observed 11 children that appeared to display "an inborn disturbance of affective contact" (Volkmar, & Wiesner, 2009). Kanner believed that the child's inability to relate socially was cognitive in nature, and that the child was born with this disorder (Volkmar, & Wiesner, 2009). He also noted that these children were resistant to change, insisted on sameness, exhibited stereotypic behaviors, and displayed echolalia (Volkmar, & Wiesner, 2009). The 2007 National Survey of Children's Health, conducted by the CDC's National Center for Health Statistics, autism affects approximately 673,000 children in the United States, or 1.1% of those aged 3 to 17 years old (Anderson, 2009), and also discovered that the frequency of ASD was 1 per 68 children, substantially higher than former estimates (Ji & Findling, 2015; CDC, 2014; Maglione, Gans, Das, Timbie, & Kasari, 2012; Anderson, 2009). The 2010 CDC study also indicated that ASD is four times more common in males than females, and the prevalence is higher among white children (CDC, 2014; Brasic, 2013; Coben et al., 2010;

Eisenberg, 2010; Anderson, 2009). According to the researchers, this higher rate of occurrence than past estimates may be attributed to increased awareness among parents and practitioners, improved identification of the disorder among healthcare providers, and the broadening of criteria for ASD (Kabot et al., 2003). However, whether due to improved diagnostic techniques, or a true rise in incidence, the CDC estimates that up to 1.5 million Americans are diagnosed with ASD with an estimated healthcare services cost of $90 billion in 2011 (Payakachat, Tilford, Kovacs, & Kuhlthau, 2012; Venkat et al., 2012). Consequently, it is surmised that with the aging population of ASD patients, the cost of care is expected to rise to $200 billion (Payakachat et al., 2012; Venkat et al., 2012). The Interagency Autism Coordinating Committee Labeled this increasing prevalence of autism a “national medical emergency” (Payakachat et al., 2012).

Identified Prevalence of Autism Spectrum Disorder
ADDM Network 2000-2010
Combining Data from All Sites

Surveillance Year	Birth Year	Number of ADDM Sites Reporting	Prevalence per 1,000 Children (Range)	This is about 1 in X children...
2000	1992	6	6.7 (4.5 – 9.9)	1 in 150
2002	1994	14	6.6 (3.3 – 10.6)	1 in 150
2004	1996	8	8.0 (4.6 – 9.8)	1 in 125
2006	1998	11	9.0 (4.2 – 12.1)	1 in 110
2008	2000	14	11.3 (4.8 – 21.2)	1 in 88
2010	2002	11	14.7 (14.3 – 15.1)	1 in 68

Figure 3. Identified Prevalence of Autism Spectrum Disorder (CDC, 2014).

The CDC funds a group of programs known as the Autism and Developmental Disabilities Monitoring (ADDM) Network (ADDM). The ADDM Network collects data to estimate the prevalence of children diagnoses with autism living in different areas of the United States. The ADDM collects all information using a surveillance method modeled after the CDC's Metropolitan Atlanta Developmental Disabilities Program. The CDC estimates that 1 in 68 children were identified with autism as reported by the AADM. The AADM Network estimated this from the number of 8-year-old children with autism living in the United States in 2010.

During the 1970’s, it was widely accepted that autism was a result of poor parenting (Edelson, 2000). Behavioral theorists regarded parental failure to reinforce prosocial behavior as a significant causal factor in autism, and the expression “emotional refrigeration” was used to describe child’s early experiences (Edelson, 2000). However, symptoms of autism may be apparent from birth. This emerging awareness has stimulated research in studying infants with autism, probing for insight on symptoms that can aide in early diagnosis and onset of intervention. Most experimental studies have involved children aged 3 years and older because this disorder is rarely detected before then (Coben et al, 2010; Charman, 1999). Azur (1999) indicated that an early diagnosis of autism might be made by observation of infant movement. Autistic infants displayed signs of movement disturbances by the age of 4-6 months. Infants with autism exhibited asymmetries of the arms or legs while crawling or lying down, abnormal rolling over, and an abnormal gait when learning to walk (Cangialose & Allen, 2014; Azur, 1999). Further studies demonstrated that infants with autism were less likely to make eye contact, smile, or to express affect or empathy (Cangialose & Allen, 2014; Charman, 1997; Coben, 2010). They were also relatively unresponsive in imitation or pretend play (Cangialose &

Allen, 2014; Charman, 1997). Autistic infants may stiffen or go limp when being picked up, rather than being clingy or cuddly. These infants are often described as being either passive or overly agitated (Brauser, 2011; Edelson, 2000). They show little or no interest in other people, and lack typical social behaviors, such as smiling when they hear their mother's voice, or making eye contact with others (Bosi, Tierney, Tager-Flushing, & Nelson, 2011; Brauser, 2011; Brkanac et al., 2008).

Kohl has been developing another screening tool for infants based of response to speech. Normal infants prefer "motherese" speech that is expressive slowed speech with the mother carefully enunciating the words. Conversely, autistic infants appear to prefer computerized, warbling, nonspeech sounds to the "motherese" speech (Grandin, 2006). Some infants may display rocking or head banging behaviors. These symptoms continued to be displayed throughout childhood. Confusingly, during the first few years of life, some autistic toddlers may achieve developmental milestones, such as crawling and walking, earlier than the average child may, whereas others may be considerably delayed. Symptoms of autism may begin to emerge for some children during these toddler years from 1-3, and are often referred to as having regressive autism (Brauser, 2011).

Wakefield (1998) theorized that exposure to a virus, vaccine, Candida albicans, or seizures may be responsible for triggering the onset of regression (National Institute of Mental Health [NIMH], 2000). However, the UK General Medicine Council (GMC) recently discounted the 1998 study by British physician Andrew Wakefield and colleagues. The GMC determined the study to be fraudulent and unethical, and that vaccinations are not linked to childhood regressive autism (Brauser, 2011). In another study of regressive autism, preschool children with did not engage in eye gazing or social interaction, but did respond better to a cue that was not a person (Leekman, Lopez, & Moore, 2000).

The autistic child tends to play alone, and fails to establish normal relationships with parents, siblings, or peers. They seem unaware and oblivious to the needs and feelings of others (Cangialose & Allen, 2014; Leekman et al., 2000). School- aged children showed developmental delays, as well as limited gaze following, and infrequent responses to cues, human or non-human (Cangialose & Allen, 2014; Leekman et al., 2000). The inability to understand signs and signals may signify that the child is unable to adequately communicate, thereby rendering the child ineffective in engaging in social interaction (Cangialose & Allen, 2014; Leekman et al., 2000). Older children and adolescents may exhibit more extreme symptomotology, such as aggression, hyperactivity, and anxiety (Kazdin & Weisz, 1998).

Individuals with autism often display repetitious or self-stimulating behaviors. Stereotypic behaviors can involve any one or all senses as shown in Table 2:

Table 2

Stereotypic Behaviors.

Sense	Stereotypic behavior
Visual	Staring at lights, repetitive blinking, moving fingers in front of eyes, hand flapping.
Auditory	Vocal sounds, finger-snapping, ear-tapping.
Tactile	Rubbing or scratching of skin with hands or objects.
Vestibular	Rocking, swaying.
Taste	Licking of objects, placing objects or body parts into mouth.
Smell	Sniffing at objects or people.

(Maglione et al., 2012; Edelson, 2000)

Stereotypic behaviors could also include self-injurious behaviors such as self-mutilation, head banging, sleeping or eating problems, and insensitivity to pain, hypo/hyperactivity, and attention deficits. Researchers have suggested that these repetitious behaviors provide the individual with sensory stimulation, and that the brain craves this stimulation due to some dysfunction in the brain or periphery. Therefore, the autistic individual engages in these actions to excite or arouse their nervous system from the release of beta-endorphins into the body, which provides a sense of pleasure. Others theorize that these behaviors are meant to calm the individual, that they may be hypersensitive, and that the environment is too stimulating, hence, the individual is suffering from sensory overload (Waterhouse, Fein, & Modahl, 1996; Venkat et al, 2012). Consequently, the individual is trying to block out the stimulus by focusing inward. Sensory impairments also make it difficult for the individual to endure normal stimulation. Some are tactilely defensive and avoid all forms of body contact. In contrast, others have little or no tactile sensitivity. Still, others seem to crave deep pressure. About 40% experience hypersensitive hearing, and these individuals will often cover their ears or tantrum after hearing particular sounds, such as a baby crying. Conversely, some children are so unresponsive to sound that they are suspected of being deaf (Edelson, 2000). A common example of a child displaying hypersensitivity to sound, yet displaying a deficit in joint attention would be when the child covers his ears to the sound of water dripping, yet is unresponsive when his mother calls his name loudly (Cangialose & Allen, 2014).

Another common characteristic of autism is the individual's dependence on routine, and the child may become extremely upset at even minor changes in their surroundings or daily schedule. It is hypothesized that the autistic individual insists on "sameness" because they are unable to understand, or cope with novel situations (Cangialose & Allen, 2014). Autistic children may also have difficulties with language development, and some children never learn to speak, or are extremely limited. They may also demonstrate echolalia, which is the mechanical repetition of words or phrases (Edelson, 2000). Approximately 75% of autistic children are classified as mentally retarded, although many show great variability in their skill levels across various aspects of intelligence testing. They will characteristically score higher on tests of visual-spatial skills and rote memory than on tests of verbal and social skills. Individuals who score in the average or high range on intelligence tests are regarded to have high functioning autism. Many autistic individuals have impairment in one or more of their senses that make it difficult to process incoming sensory information properly, which would affect cognitive ability (Brasic, 2013; Edelson, 2000). Another influence on intelligence testing is the inability for the autistic individual to realize that other people have their own unique points of view about the world. They are unable to understand perspectives that are different from their own. Researchers have also noted that their stereotypic behaviors interfere with attention and learning. However, these behaviors can also be utilized as positive reinforcers if the individual is allowed to engage in these behaviors after completing a task (Edelson, 2000).

According to the Centers of Disease Control and Prevention (2000), children with autism require long-term care and services. Special education costs an average of $8,000.00 per child annually. Specially structured programs can cost $30,000.00 per child annually, and care in a residential school escalates to $80-100,000.00 per year. There is no known cure for autism, but early and intensive education can help children develop skills, and medications and therapies can help alleviate symptoms (Ji & Findling, 2015; CDC, 2000).

Syndromes

There are varieties of subclasses. A German doctor, Han Asperger, first diagnosed Asperger’s Syndrome in 1944. Asperger’s syndrome is one form of high functioning autism, and those afflicted may exhibit many odd, idiosyncratic behaviors that can be divided into three categories (Meillo, 2009; Perlman, 2000). The first category is language. Grammar and vocabulary are usually very good, and speech develops before 4 years of age. However, the voice tends to be flat and emotionless, speech patterns are repetitive, and conversation usually centers on the self. The second category is cognition. The individual is obsessed with complex topics such as patterns, weather, and music. They are often described as eccentric, and seem to lack common sense and concrete thinking skills (Brasic, 2014; Meillo, 2009; Perlman, 2000). Their IQ lies within the normal spectrum, but they may have dyslexia, writing problems, and difficulties with mathematics, and score below range in average performance abilities (Brasic, 2014; Meillo, 2009; Perlman, 2000). The third category is behavior. Movements tend to be awkward and clumsy, and the individual may perform the odd forms of self-stimulatory behaviors typically associated with autism. They are socially aware, but may display inappropriate social interactions. The sensory difficulties do not seem to be as severe as in other forms of autism (Brasic, 2014; Meillo, 2009; Perlman, 2000). Presently, there is not a specifically designed treatment for Asperger's syndrome, and many afflicted individuals are suffering from unipolar or bipolar depression (Brasic, 2014; Meillo, 2009; Perlman, 2000). As adults, these individuals are capable of leading productive lives, and live independently (Brasic, 2014; Meillo, 2009; Perlman, 2000). Often called the "little professor syndrome," many hold challenging jobs, such as college professors and computer programmers, get married, and raise families (Brasic, 2014; Edelson, 2000; Meillo, 2009).

Angelman Syndrome; Angelman syndrome was first described by an English physician, Harry Angelman, M.D., in 1965. Although Angelman syndrome is not considered a true subtype of autism, individuals display many similar behaviors such as hand flapping, speech delay, attention deficit, hyperactivity, problems with eating and sleeping, and developmental delays (Edelson, 2000; Meillo, 2009). They may also engage in hair pulling and biting, and are often given a secondary diagnosis of autism. In contrast to autism, these individuals tend to be very sociable and affectionate (Edelson, 2000; Meillo, 2009). Angelman syndrome occurs in approximately 1 in every 25,000 people, and the majority is mentally retarded (Edelson, 2000; Meillo, 2009). They also frequently suffer from epilepsy and demonstrate abnormal EEG's. When they walk, they appear to be stiff-legged, and display jerky body movements. Individuals afflicted share a similar facial appearance, such as a wide smiling mouth, thin upper lip, deep set eyes, as well as low levels of presentation in skin, eyes and hair (Edelson, 2000; Meillo, 2009).

Landau-Kleffner Syndrome usually develops between the ages of 3 and 7, and is more common in males than females (Edelson, 2000; Meillo, 2009). Initially, these children seem healthy and develop normally. Then, they begin to lose their ability to comprehend, followed by a loss of speech. This can occur gradually or suddenly. Parents may suspect that their child is deaf because they fail to respond to sounds (Edelson, 2000; Meillo, 2009). Additional characteristics similar to autism manifest including sleep problems, sameness, pain insensitivity, aggression, and poor eye contact. The cause for Landau-Kleffner syndrome is unknown, although some suspect that exposure to a virus, brain trauma, or a dysfunctional immune system may be culprits (Edelson, 2000; Meillo, 2009). These individuals also display abnormal EEG patterns in the temporal lobe and in the temporo-parieto-occiputal regions during sleep. Approximately 70% develop epilepsy. Prognosis is more optimistic if symptoms are displayed after the age of 6. Anticonvulsant medications and corticosteroids may be prescribed, and occasionally a surgical technique is employed that severs the pathway of electrical brain activity (Edelson, 2000; Meillo, 2009).

Rett syndrome is a pervqasive developmental disorder that presents early in childhood, and is found predominantly in females (Brasic, 2014). Children with Rett Syndrome usually appear to develop normally within the first year of life, but then fail to attain developmental milestones between the ages of 1-6 (Brasic, 2014). These children will display profound mental retardation, and will require assistance in almost all daily living activities (Brasic, 2014). Nearly all individuals with Rett Syndrome show abnormalities of the methyl-CpG-binding protein 2 gene, and almost all women with Rett Syndrome have less acetylcholine in the brain than is found in healthy females (Brasic, 2014). Reduced levels of acetylcholine are correlated with the reduced abilities of women with Rett Syndrome to perform daily living activities (Brasic, 2014).

Autistic Savant: Perhaps the most fascinating syndrome is that of the autistic-savant, who displays an extraordinary skill in one particular area, but is otherwise subnormal in intelligence (Miller, 1999; Edelson, 2000). The estimated prevalence of autistic-savant is 10%. The prevalence in the non-autistic population is less than 1%, including those with mental retardation (Miller, 1999; Edelson, 2000). It is important not to confuse the autistic-savant with the true prodigy who displays exceptional abilities, yet are normal in all other respects. Most often, the savant is not aware of the significance of their ability (Miller, 1999; Edelson, 2000). Common types of savant talents include musical performance, drawing, visual arts, and arithmetic skills, including calendar calculation, and prime number derivation. Less often displayed talents may include sensory sensitivity, mechanical ability, and language aptitude (Miller, 1999). Savant skills appear to be distinctive in several respects, such as constraints on skill expression, inability to reflect on, or inability to describe the performance process. Some suggest that the core savant skill may be rote memory. Others refute this opinion because savant artists and musicians do not identically reproduce what they see or hear- they often apply a different perspective (Miller, 1999; Edelson, 2000). Different cognitive skills may be associated with specific savant skills (Miller, 1999). Ultimately, there are many theories, but not enough concrete evidence to support them, we still do not know why some autistic individuals have savant abilities, and others do not (Miller, 1999; Edelson, 2000).

Social Behavior

The most characteristic symptom of autism is dysfunction in social behavior. There are three groupings: socially avoidant, socially indifferent, and socially awkward (Edelson, 2000).

Socially Avoidant

This category describes those individuals who avoid all forms of interaction, and may tend to tantrum or run away when someone tries to engage them. In infants, this is seen when the child “arches” their back in order to avoid contact, or when they fail to respond to a smile from their mother (Cangialose & Allen, 2014; Edelson, 2000; Charman et al, 1997).

Socially Indifferent

One of the most distinguishing characteristics of social deficits in infants and toddlers with ASD is a lack of joint attention (Cangialose & Allen, 2014). Joint attention is a spontaneous behavior that refers to the child looking back and forth between an object of interest and another person, as if to acknowledge a mutually shared experience (Cangialose & Allen, 2014). These individuals characteristically do not seek out interaction, but they also do not overtly avoid social situations. These individuals may not mind being with other people, or to be alone (Edelson, 2000).

Socially Awkward

These individuals may interact with others, but have difficulty in making or keeping friends. This is most common among those with Asperger's Syndrome. Many believe that relationships fail to endure because the autistic individual fails to learn social skills, and is self-centered. They have difficulty relating to another person's point of view, attitude, or emotion. As a result, they may be unable to anticipate what to do when in a social situation, and may react inappropriately (Edelson, 2000). Baron-Cohen (1995) termed this as theory of mind, stating that this mind phenomenon seems to be unique to autism and appears to be independent of intellectual ability. The autistic individual maintains their egocentric view of the world, but does not behave in a superior manner to others (Maglione et al., 2012).

Social dysfunction can also be frustrating to those who need to deal with the autistic person, such as family or coworkers, especially if unrealistic expectations are based on the autistic's intellectual level of functioning (Brasic, 2014; Edelson, 2000).

Social behaviors are exhibited from infancy, and are learned through modeling, interaction, observation, imitation, and play. By age 2, most children will engage in joint, pretend play. However, the autistic child typically participates very little in pretend play with peers, or in symbolic play when left with toys (Cangialose & Allen, 2014; Kavanaugh & Harris, 1994). This observation can be elaborated on by considering the components necessary for pretend play (Kavanaugh & Harris, 1994). Autism may limit the use of some components. The creation and understanding of pretend play relies on "(a) a disposition to set aside the actual situation as a guide for action and speech; (b) the capacity to construct and process pretend stipulations that create a starting point for a given pretend episode; (c) the capacity to construct and process the casual transformations that can occur during a pretend episode, and (d) the capacity to produce actions and remarks appropriate to those stipulations and transformation (Kavanaugh & Harris, 1994)." The autistic child experiences the most difficulty with component a, as well as component d. Although the autistic child may be unable to participate in pretend play, recent research has demonstrated that the autistic child may actually understand the pretend play, and can choose an outcome when prompted This hints that the symptomotology is a barrier to social interaction, not the ability to reason and infer.

Another key characteristic of the autistic individual is the lack of imitation of the actions of others (Smith & Bryson, 1994). The theory of mind philosophy considers the ability to engage in joint attention and imitation as precursors to the development of the capacity to mentally represent the intentions of others. It can be further argued that this corresponds to the development of a foundation for self-awareness, and awareness of others (Smith & Bryson, 1994). The inability to imitate others results in a deficiency to develop a normal theory of mind (Maglione et al., 2012). Piaget (1952) emphasized the importance of imitation as a prerequisite for developmental milestones such as symbolic thought and language. Autistic children demonstrate a nonuniform delay in these achievements. They also show delay in sensorimotor skills, including object permanence. According to Piaget, (1962), these behaviors ultimately culminate in the ability to form mental representations of objects or actions that are not directly accessible to perception. By about 2 years of age, the normal child is able to internalize symbolic capacity, reflecting the idea that language requires abstract, symbolic thinking. Piaget's cognitive stages of development coincide closely with growth spurts identified within the central nervous system (Anderson et al., 2001). In autism, given the delay of language development, prelinguistic skills and sensorimotor abilities develop in an abnormal manner (Smith & Bryson, 1994). Recent studies have suggested that this deficiency might impede the maturity of the autistic individual's awareness of their self, and of their body image (Smith & Bryson, 1994). Consequently, this impairs the ability to imitate others. The unawareness of body image may also contribute to congenital sensory impairment (Smith & Bryson, 1994). Social interaction is further complicated by the difficulty that the autistic individual has in mentally disengaging from a focal object (Hughes & Russell, 1993). A study conducted by Steinmetz implies that an understanding of classical conditioning may hold implications for teaching children with autism how to cope with their disorder. Steinmetz demonstrated that those with autism conditioned more quickly than those without autism, and that they execute early, mistimed responses in reaction to over attending to conditioned stimuli. This research links pathology to classical conditioning, and suggests that the basic mechanism of learning can lead to practical information about the human condition (Azur, 1999). Consequently, a number of impairments that make social interaction extremely difficult plague the autistic person. Splintered sensory awareness, and disordered working memory, inability to understand and respond to verbal and nonverbal messages, and a continuous inability to index sensory and memory information, seriously interferes with the ability to engage in, and maintain conversation.

Autism and the Family

The family with an autistic child is one of the most stressful experiences that a family can endure (Ji & Findling, 2015; Cohen, 2004). Parents are faced with the possibility of a child who may need constant supervision for his or her entire life (Byrne, 2005). Children need to rely on the support and love of their families, and the parents of the autistic child need to provide years of care, and are confronted with many physical, psychosocial, and financial demands (Saunders, Tilford, Fussell, Schulz, Casey, & Kuo, 2015; Byrne, 2005; Retzlaff, 2007). According to 2013 data from the Autism Society, the annual cost to society from this illness is $137 billion, and they estimate that the cost to individuals and families caring for an individual with autism is $3.2 million over their lifetime (Berr, 2013). Behavior therapies for children can cost $40-50,000 per year, and caring for an adult in a supported residential facility can cost $50,000-100,000 per year (Berr, 2013). In order to offset some of these costs, parents have been known to move to states where children with ASD get better benefits for care (Berr, 2013). Parents must often pay for services out of their own expenses (Berr, 2013). Family researchers have consistently demonstrated that many families with a special needs child experience a higher level of stress than families with all healthy children (Saunders et al., 2015; Byrne, 2005; Retzlaff, 2007). The daily challenges of managing the manifest behaviors of ASD are disruptive to the family unit. Family researchers note that families find ways to adapt, not by choice, but through necessity in order to cope with the child's disabilities (Saunders et al., 2015; Byrne, 2005; Retzlaff, 2007). This disability affects the family's participation in daily living activities such as housing, work, education, and care giving (Saunders et al, 2015; Byrne, 2005; Retzlaff, 2007). In order to enhance the effectiveness of interventions that are adapted at home, families need tools and education, and emotional support to maintain emotional strength and reduce burnout (Saunders et al., 2015; Maglione et al., 2012). If these family needs are not addressed, they may hinder the amount of progress made by the child with ASD (Saunders et al., 2015; Maglione et al., 2012). Key factors for adaptation include family cohesion, flexibility, communication, expression of affect, the life cycle phase of the family, transgenerational experiences with illness, and the ability to balance the stresses and resources of the family (Saunders et al., 2015; Byrne, 2005; Retzlaff, 2007). Most parents continually search for the latest information and effective therapies for ASD, visiting an array of professionals in hopes of normalizing their child (Cohen, 2004). Educational researchers report that there are many therapies being used in the treatment for autism (refer to therapies and interventions), and that families were utilizing an average of 7 treatments at the same time, and that the families reported already trying an average of 8 therapies in the past (Heflin, Hess, Ivey, & Morrier, 2008). Parents of a child with ASD experience a divorce rate of 80%, with the highest rate of divorce occurring before the child's teenage years (Barker, Bolt, Floyd, Greenburg, Osmond, & Seltzer, 2010). However, even if the marriage survives through the teenage years, the parents continue to experience the high levels of demands and stress into adulthood. Therefore, the parents experience a prolonged period of vulnerability for divorce (Barker et al., 2010). The risk for divorce is higher if the parents are less educated, were married at a young age, and bore children early in their marriage (Barker et al., 2010). Couples maintain a stronger relationship if they accept their child's disability as a challenge, and learn to appreciate the little things in life. Couples are encouraged to share and pursue common goals and to make a mutual effort to create good moments between them (Retzlaff, 2007). A study of the mothers of a child diagnosed with ASD who participated in a psychoeducational treatment program to help them understand their child's disability, and learn to better learning and behavior problems experienced a lessening of depressive symptoms over an 18-month period of time (Bristol & Hott, 1993). Families that maintained social networks to share ideas, fears, and experiences with other like families appeared to establish greater family resilience (Retzlaff, 2007). Parental initial reactions to the understanding that their child has been diagnosed with ASD include guilt, anger, sadness, and depression (Byrne, 2005). Additional studies reported that when parents were members of a support group for parents of a special needs child, the parents experienced a fluctuation between feelings of anxiety, anger, denial, guilt, depression, and fear (Byrne, 2005). Parents grieved for the loss of their future dreams for their child (Byrne, 2005). In order for a parent to recover from such a loss, they needed to separate from the lost dream, and to formulate new dreams (Byrne, 2005). Additionally, the parent worries that their afflicted child will outlive them, or their primary caregiver (Byrne, 2005). Howlin (1998) reported about the effects that the child with ASD has on their siblings. It was discovered that the normal siblings also exhibited feelings of guilt, and feared that they may have contributed to the condition (Byrne, 2005). The sibling may also secretly fear that they may also be affected by ASD in some way (Byrne, 2005). Siblings may perceive that they receive less attention than the autistic child, as well as believing that they have been treated unfairly by being expected to do more household chores, or to be responsible to help physically care for their handicapped sibling (Byrne, 2005). Normal siblings also reported psychological stress. They reported feeling pressured to over-achieve to make up for the limitations of their impaired sibling, or to provide additional support for their parents, or to care for their impaired sibling as their parents grow older, resulting in feelings of resentment and hostility (Byrne, 2005). In contrast, it has also been reported that the siblings of a child with ASD may exhibit greater maturity and responsibility than their peers (Byrne, 2005). The healthy sibling may possess a positive self-concept, be more altruistic, be more tolerant, and may enter the caring professions when they reach adulthood (Byrne, 2005). The family situation may be greatly affected by the visible extent of the behavior of the child with ASD. If a child displays a visibly identifiable disability, such as Down's syndrome, or behaves badly, bystanders often sympathize with the family. If a child is less visibly impaired, such as the child with ASD, the family is less likely to receive sympathy from others (Byrne, 2005). Not all treatments are covered by health insurance, and consequently, the child may not be able to take advantage of certain interventions. Evaluations and home programs may also deplete family finances, and sometimes one spouse will give up their job in order to care for their child (Byrne, 2005). Families may also need to contend with social stigma. They may be kicked out of restaurants, movies, and public buildings. Strangers accusing them of not being able to control their child may confront them. Many parents have resigned themselves to isolating the family to avoid the negative reactions that they endure (Byrne, 2005). Often, spouses cannot spend quality time together due to the extreme demands of parenting and the lack of qualified and affordable caregivers to take care of the child in their absence (Byrne, 2005). It is often beneficial for the parents or family unit to attend counseling sessions (Hillman, 2006). A therapist can help the family by becoming informed about the etiology of autism, the latest therapies and resources available, and to share this information with the parents (Hillman, 2006). The therapist can help the family to establish an appropriate treatment team, and address barriers to treatment, such as personnel selection, high rate of treatment team turnover, difficulty communicating with school officials, and identify family dysfunction (Hillman, 2006). The therapist can also provide ongoing support for the family (Hillman, 2006). Health services and interventions that are available for the child with ASD may also have the potential to improve the health and wellbeing of the rest of the family due to the "spillover effects" of individual therapy (Payakachat et al., 2012). Spillover effects are determined when the health or wellbeing of others improves because of the improved health of the child (Payakachat et al., 2012). Additionally, interventions that can specifically reduce caregiver burden not only produce an improvement in health for the caregiver, but also extend to the health and wellbeing of the entire family (Payakachat et al., 2012).

Neuropsychology of Autism Spectrum Disorder

It has been 6 decades since autism was formally recognized; yet this disorder remains a profound mystery. Suspected causes range from genetic mutations to viruses and toxic chemicals, but we now know that autism may also be (a) related to abnormalities of brain structure or functionality (Lainhart, 2015; Brasic, 2013; Bosi, et al, 2011; Kabot et al., 2003). Through autopsies of autistic individuals, neuroscientists have discovered that cells in the limbic region of the brain are small and densely packed, suggesting that early development was interrupted (Lainhart, 2015; Edelson, 2000). The underlying causes for these abnormalities are not well understood, although the current literature suggests that there are unidentified factors related to the prenatal and postnatal environment that may trigger the onset of maldevelopment (Brasic, 2013; Bosi et al, 2011; Kabot et al., 2003). Genetic research being conducted by the Collaborative Programs of Excellence in Autism suggests that defective genes may be responsible for autism, or that there may be an autism susceptibility gene, making one person more vulnerable for developing autism (Kabot et al., 2003). It was previously mentioned that autism is more prevalent in males than females. Neuroanatomical studies have suggested that cortical development differs between the male and female brain because of hormonal influences, and that the female brain demonstrates earlier left hemisphere maturation, suggesting more plasticity and greater capacity for transfer of functions. Therefore, the female brain may be better able to sustain early insult then the more lateralized male brain, which may explain the high prevalence of males with autism as compared to females (Anderson et al., 2001). Immaturities were found consistently in the amygdala and hippocampus (Lainhart, 2015). The amygdala is responsible for various aspects of behavior including emotions, aggression, and sensory processing. The hippocampus is responsible for learning, memory, and the integration of sensory information. In summary, these areas of the brain mediate social behavior. Neural imaging studies are demonstrating that there are differences in how the autistic brain responds to social cues (Komeda, Kosaka, Saito, Mano, Jung, Fujii, Hisakazu, Yanaka, Munesue, Ishitobi, Sata, & Okazawa, 2015; Rosenwieg et al., 1999). Images of the brain have also revealed a reduction in size of the corpus callosum and of regions within the cerebellum, a large structure in the brain associated with motor control mechanisms and certain types of learning. Additional magnetic resonance imaging of the brains of autopsied patients revealed evidence of early maldevelopment of the cerebellar vermis and the brain hemispheres (Komeda et al., 2015; Courchesne et al., 1994). Studies have demonstrated this maldevelopment contributes to an inability to execute rapid attention shifts, which in turn undermines social and cognitive development (Komeda et al, 2015; Courchesne et al., 1994). Cerebellar pathology was found to be a consistent factor in infantile autism, and neuroatomic abnormalities were not found in other parts of the brain implicated in models of attention shifting behavior (Courchesne et al., 1994; Bauman, & Kemper, 2004). The mesial frontal cortex and the supplementary motor cortex of the brain are also associated with verbal communication. Most autistic individuals rarely initiate interaction. An impaired amygdala reciprocally connected to an impaired anterior cingulated gyrus, was found in the majority of brains of autistics. This may be directly related to the reduction in drive or desire to communicate (Komeda et al., 2015; Bauman & Kemper, 2004; Waterhouse, Fein, & Modal, 1996). If autistic individuals have no drive to communicate, and have no interest in what others have to say, even in the absence of other neural dysfunctions, they will not communicate (Komeda et al., 2015; Bauman & Kemper, 2004; Waterhouse et al., 1996). Subsequently, they will not learn how to engage in conversation with others, even if they are able to manage to develop a vocabulary and able to understand the speech of others. Even those autistic individuals that are able to converse with others still have difficulty in maintaining a conversation. This abnormal cross processing of information in regions of the brain impairs memory and the ability to record messages and interpret behavior. The change of information and gestures encountered during conversation may generate extreme confusion in the autistic, and may even trigger unpleasant, negative arousal (Komeda et al., 2015; Waterhouse et al., 1996). Other scientists are suggesting that autistic individuals have differences in brain chemistry. Dr. Karen Nelson of the National Institute of Mental Health discovered a chemical marker for autism utilizing blood samples from newborns. Results showed an elevated level of 4 proteins involved in brain development: VIP, CGRP, BDNF, and NT4, suggesting that the disorder is already present at birth. The National Institute of Neurological Disorders and Strokes funded research that exposed impairment in the system of neuropeptides, demonstrating evidence of abnormal elevations of oxytocin, serotonin, and vasopressin (Brasic, 2013; Bauman & Kemper, 2004; Waterhouse et al., 1996) in cerebrospinal fluid of those afflicted with autism. Scientists at Battelle Memorial Institute released information in May 2012 that they have identified a low-cost urine test that potentially predicts the presence of autism in children before the age of 2 (Battelle, 2012). The research conducted at the University of Washington's School of Public Health evaluated the levels of porphyrins in the children with ASD to determine if certain levels of specific porphyrins could predict autism. Urine samples were collected from a group of children diagnosed with ASD and age-matched controls. Results indicated that levels of porphyrins were strong predictors of ASD, and that one-third of children with ASD could be distinguished, and that none of the children in the control group were identified (Battelle, 2012). This development could have strong implications for diagnosis and treatment, as a simple urine test allows for a rapid, low-cost method that can be widely used to identify young children at high risk for developing ASD (Battelle, 2012). Oxytocin and serotonin metabolite levels have been correlated with social behaviors, emotional communication, attachment, imprinting, and contextual memory. Elevated levels of beta-endorphins were also present, and this could contribute to the abnormalities of mood in autism, and the result of an abnormally high pain threshold (Bauman & Kemper, 2004; Waterhouse et al., 1996). Treatments with Selective Serotonin Reuptake Inhibitors (SSRIs) target the serotonin transporter and its primary mechanism is the inhibition of the neural serotonin protein, leading to elevated levels of serotonin (Ji & Findling, 2015; Bauman & Kemper, 2004). Scientists are hoping to develop a prenatal test to screen for autism. Approximately 5% of children diagnosed with autism also have autistic siblings, and the risk of autism is 75% higher among those with afflicted identical twins (Brkanac et al., 2008). A study was conducted on infants who have an older sibling with a confirmed diagnosis of ASD. The infants were administered an EEG on the basis that the resting state EEG data could be used as a biomarker to distinguish typically developing children from a group if infants at a high risk of developing ASD (Bosi, Tierney, Tager-Flusberg, & Nelson, 2011). The results showed that the group of high-risk infants demonstrated an abnormality in EEG signals, with differences being greatest between the ages of 9 to 12 months (Bosi, Tierney, Tager-Flusberg, Nelson, 2011). In the study, researchers compared EEGs from 79 infants aged 6 to 24 months, 46 of which were considered to be at high risk for autism as they had an older sibling with the disorder. The babies wore helmet-like caps studded with electrodes to measure electrical activity while they watched a research assistant blowing bubbles. The tests were repeated, whenever possible, at 6, 9, 12, 18, and 24 months of age. The EEGs were then interpreted using modified multiscale entropy (mMSE) that measures the randomness of an electrical signal. Using algorithms to find distinctive brain patterns in the EEG signals, the researchers were able to identify which children were in the control group, and which children were in the high-risk group. (Bosi, Tierney, Tager-Flusberg, & Nelson, 2011; Bauser, 2011). Infants from families with a history of ASD displayed different EEG patterns that may be indicators of a functional endophenotype associated with the risk for ASD. Differences between the mean mMSE averaged across all channels or in the frontal region of the brain proved significant at all ages except at 9 months. However, machine classification at 9 months based on the mMSE curves in each channel as a feature set was able to determine group membership (Bosi, Tierney, Tager-Flusberg, & Nelson, 2011; Bauser, 2011). Measurements between EEG electrodes also revealed that synchronization was much lower in children with ASD than those of normally developing children, supporting the theory that the autistic brain exhibits low functional connectivity. High local connectivity and low range connectivity in the autistic brain may develop concurrently due to difficulties with synapse pruning or formation (Bosi, Tierney, Tager-Flusberg, & Nelson, 2011; Chan et al., 2007). Estimations of variances in neural connectivity may be an effective diagnostic marker for atypical connectivity development in the brain (Bosi, Tierney, Tager-Flusberg, & Nelson, 2011). Identification accuracy for males was close to 100% at age 9 months, and remained at 70% to 90% at ages 12 to 18 months (Bosi, Tierney, Tager-Flusberg, & Nelson, 2011). For females, the identification was highest at age 6 months, but declined afterwards (Bosi, Tierney, Tager-Flusberg, & Nelson, 2011). Hughes and John (1999) reported the rate of abnormal EEGs in autism ranged from 10 to 83%, with the mean incidence at 50% (Coben et al., 2010). Abnormal EEGs often predict poor performance in intelligence, speech, and educational acquisition (Coben et al., 2010). Rippon (2007) proposed that a reduction in connectivity between specialized neural networks, and overconnectivity within certain neural areas of the autistic brain might be associated with an increased ratio of excitation and inhibition in important neural systems (Coben et al., 2010). Disordered connectivity may be linked to abnormalities in information processing. Children with autism often display deficits of planning, flexibility, and inhibition associated with the frontal lobes and other brain regions. These deficits in executive functioning affect the social, behavioral, and cognitive development of the autistic brain (Coben et al., 2010). Researchers at UCLA and the University of Utah have found evidence of abnormal retinal activity in autistic individuals. Many visual problems have been associated with autism, including reliance on peripheral vision, tunnel vision, hypersensitivity to light and stereotypic behavior near and around the eyes. Scotopic Sensitivity/Irlen Syndrome is a visual-perceptual problem that causes a variety of perceptual distortions when reading, or viewing the environment. Scotopic Sensitivity is triggered by one or more components of light, (e.g., fluorescent lighting, sun), luminance (e.g., reflection, glare), intensity (i.e., brightness), wavelength (i.e., color), and/or color contrast (Waterhouse et al., 1996). As a result, the person may experience:

- Light sensitivity: sensitive to brightness, glare, types of lighting.
- Ineffective reading: letters on a page move, dance vibrate, or jiggle.
- Inadequate background accommodation: difficulty with high contrast.
- Restricted span of recognition: tunnel vision or difficulty reading groups of letters.
- Lack of sustained attention: difficulty maintaining attention (Waterhouse et al., 1996).

A few remedies have been utilized to help alleviate these problems. Helen Irlen, to treat Scotopic Sensitivity, developed the Irlen Lens System that uses 2 methods to treat hypersensitivity. The first is the use of colored transparencies. These colored overlays are used to reduce perceptual stress while reading by reducing the high contrast between white paper and black ink. The second is the use of tinted glasses that improve the visual perception of the environment (Exkorn, 2006; Edelson, 2000).

Hypersensitivity of autistics was addressed in 1987 by Kinsbourne's ascending activation model (Waterhouse et al., 1996). He theorized that autistic individuals experience unstable over and under arousal due to excessive fluctuating ascending activation of the brain, and that since they are easily over aroused, their central nervous system attempts to fend off the sensory stimulation through hyperselective attention. They reduce sensory cues from the environment in order to reduce over arousal. Waterhouse, Fein, and Modahl have since theorized that the source of extended selection is a cortical-amygdala loop rather than the brainstem. The hyperselection that has been described by autistic adults appears not to be dearousing, but instead is reported as being frightingly intense. Autistic adults report that they feel compelled to attend to the single sense stimulus and report that it is the color, sound, or touch itself that frightens them. More research is needed to explore the association between temporal association and selective attention (Waterhouse et al., 1996).

Autism is a behavioral syndrome that has also been associated with many different etiologies. It has been found to be associated with abnormalities of chromosomes 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 21, 22, and Y, and X (Waterhouse et al., 1996). Autism has also been associated with metabolic disorders such as phenylketonuria, purine abnormalities, lactic acidosis, mucopolysaccharidoses, and free fatty acid abnormalities. Autism has also been linked to infectious diseases such as cytomegalovirus, herpes simplex, HIV, rubella, and treponemapallidum. In addition, autism has also been associated to many defined syndromes: Cornelia de Lange, hypomelanosis of Ito, Joubert, Landau-Keffner, Lujan-Fryns, Moebius, neurofibromatosis, Rett, Sotos, Gilles de la Tourette, and tuberous sclerosis (Ji & Findling, 2015; Waterhouse et al., 1996). It must be noted that the appearance of one of these etiologies does not mean that autism is present, as evidence of a chromosomal or metabolic disorder, an infectious disease or known syndrome will only help to identify a case of syndromic autism. Conversely, many autistic cases are idiopathic with a complex genetic basis unique to the autistic syndrome (Kabot et al., 2003). It is recommended that families with a history of ASD seek genetic counseling to determine the risk of transmission of an ASD-associated gene (Geier & Geier, 2008).

A number of comorbid conditions are associated with ASD. Epilepsy and seizure disorders are common neurological conditions associated with ASD, ranging from 22-30 %, the higher rates among those diagnosed with classic autism, and for those who display intellectual disabilities (Ji & Findling, 2015; Venkat et al., 2012). Motor impairments are often observed with deficits and delays in both fine and gross motor skills, including purposeful motor movements, and gait abnormalities (Ji & Findling, 2015; Venkat et al., 2012).

Approximately 85% of individuals with ASD are also are diagnosed with an additional psychiatric disorder requiring acute management (Ji & Findling, 2015; Venkat et al., 2012). The most common condition is anxiety, which occurs in 43-84% of the population. Following anxiety is depression, obsessive-compulsive disorder, and oppositional-defiance disorder and other behavior problems, and psychotic disorders ranging from mild to schizophrenia (Venkat et al., 2012). Substance abuse may also be a problem among adults with ASD, most commonly involving alcohol (Venkat et al., 2012). Patients with Asperger syndrome have been identified as being at risk for suicidal tendencies. A Turkish study conducted in 2010 identified 42% of adolescents with Asperger syndrome also exhibited suicidal ideations, commonly associated with a combination of anxiety disorders and major depression (Venkat et al., 2012). Catatonia syndrome has been shown to appear in 12-17% of adolescents and young adults diagnosed with ASD. Symptoms include decreased speech and mobility, freezing during movements, staring, posturing, and echophenomena (Venkat et al., 2012). Individuals with ASD often complain of sleep disorders including insomnia, restless sleep, and difficulty falling asleep and staying asleep, as well as bedtime resistance (Payakachat et al., 2012; Venkat et al., 2012). If the individual's symptoms worsen to include sleepwalking, increased nightmares, bruxism, thrashing movements, confusion, or agitation the individual should be referred to a physician to ensure that the symptoms are not due to seizure activity (Venkat et al., 2012). Sleep disturbances can be treated with melatonin, or improved sleep hygiene, such as maintaining a bedtime routine, positive reinforcement from parents. A sleep specialist may be recommended for long-term management (Venkat et al., 2012).

Dental problems associated with ASD are often a combination of prescribed medications and stereotypic behaviors. Dry mouth is the most common side effect of medications prescribed for ASD, and self-injurious behaviors such as bruxism and destructive chewing habits may cause dental pain, and dental damage. Regular dental check-ups and treatment is recommended (Venkat et al., 2012).

Therapies and Interventions

Medical Treatments

Pharmacological and biomedical treatments can be utilized for the treatment of autism. The objective for pharmacological treatment is to decrease the core symptoms of autism, to decrease anxiety and overfocus, improve social skills, reduce aggressive and self-injurious behaviors, increase the effectiveness of other interventions, and to improve the quality of life for the child and their family (Ji & Findling, 2015; Coben et al., 2010; Exkorn, 2006). Medications focus on the management of aggressive, self-injurious and repetitive behaviors, irritability, and deficits in socialization (Venkat et al., 2012). The most commonly used medications are antidepressants, stimulants, and neuroleptics. It is important to note that there is no medication that works equally well with all children, and that no specific medication has been developed exclusively for the treatment of autism (Ji & Findling, 2015; Coben et al., 2010; Exkorn, 2006). However, a new class of neuroleptic, known as atypical antipsychotics has been used to improve social interaction, and decreases aggression, irritability, agitation, and hyperactivity. Risperidone and aripiprazole are the only two U.S. Food and Drug Administration (FDA)-approved medications in this class, with Risperidone being the most studied drug that demonstrates the best evidence of providing benefit to those with ASD in reducing irritability and aggression (Ji & Findling, 2015; Payakachat et al., 2012; Venkat et al., 2012, Coben et al., 2010; Brkanac et al., 2008). Side effects include weight gain and elevated lipid levels; however, there is evidence to suggest that Risperidone may be effective for periods of up to one year (Ji & Findling, 2015; Payakachat et al., 2012; Coben et al., 2010; Brkanac et al., 2008). In a random controlled study comparing risperidone to placebo in treatment of children aged 4-7 resulted in a 69% improvement in the risperidone cohort in measurements of behavior including irritability, social withdrawal, and communication, as compared to 12% improvement in the placebo group (Payakachat et al., 2012; Venkat et al., 2012). Methylphenidate appears to modestly improve irritability, and Valproate also shows moderate improvement in reducing repetitive behaviors (Venkat et al., 2012). Another anti-psychotic medication, Abilify (Aripiprazole), has also been used with autistic patients with success, reducing aggression, agitation, and self-injurious behaviors, with minimal side effects including mild somnolence, weight gain, or weight loss (Ji & Findling, 2015; Coben et al., 2010). The overlapping repetitive stereotypical and perseverative behaviors that are exhibited in both autism and obsessive-compulsive disorder (OCD) have led to the use of selective serotonin uptake inhibitors (SSRIs) for treatment of autism based on the success of the drug for OCD (Coben et al., 2010; Exkorn, 2006). Studies have demonstrated these drugs to be beneficial, reducing repetitive thoughts and behaviors, repetitive language use (Coben et al., 2010). Despite the common use of SSRI's, there is little evidence to support their ability to manage core symptoms of ASD, such as aggression or self-injurious behaviors (Ji & Findling, 2015; Venkat et al., 2012). SSRI's appear to be more beneficial in adults with ASD in the management of anxiety, aggression, and obsessive-compulsive behaviors (Ji & Findling, 2015; Venkat et al., 2012). However, the side effects associated with SSRI’s may be significant, causing some to discontinue treatment with SSRIs. Side effects included restlessness, agitation, nausea, insomnia, anxiety, and increased appetite (Ji & Findling, 2015; Coben et al., 2010). Melatonin may aid with insomnia (Venkat et al., 2012). In summary, pharmacological treatments appear to demonstrate limited benefits, adverse side effects, and the rebound of aggressive behavior when the drug is discontinued. Many children require multiple drugs to address the multiple symptoms of autism, and often the benefits do not outweigh the detriment of their side effects (Ji & Findling, 2015; Coben et al., 2010). There have been increasing efforts to find novel pharmacotherapy agents based on molecular and cellular biomarkers, however recent trials that displayed promising outcomes from animal studies did not show efficacy when used in clinical trials (Ji & Findling, 2015). This can be attributed to the difficulty of heterogeneity of autism as a spectrum disorder and imprecise diagnostic and outcome measures, as well as high placebo response rates (Ji & Findling, 2015). These contribute to the difficulty in capturing medication benefits, and it is recommended that larger clinical trials are needed before more definitive conclusions can be reached (Ji & Findling, 2015).

Dietary Treatments

Dietary treatments have been reported to improve cognitive function, language and social skills (Coben et al., 2010; Exkorn, 2006; Edelson, 2000). Research has suggested that individuals with autism may not be able to properly metabolize the proteins in casein (dairy), and gluten in wheat and other grains, resulting in an opioid effect on the brain as they are introduced into the bloodstream (Coben et al., 2010;

Exkorn, 2006; Edelson, 2000). Autism may also be comorbid with metabolic abnormalities including the failure of the digestive tract to metabolize the casein and gluten into amino acids, as well as leaky gut syndrome that allows undigested peptides to pass into the bloodstream (Coben et al., 2010; Exkorn, 2006). Studies have shown that when children with autism were placed on a gluten-casein free diet, 81% of parents reported an improvement in symptoms within a 3-month period (Coben et al., 2010). Problems associated with this diet include lack of knowledge by the parents as to what foods are beneficial or not, and that some studies have shown that this diet may lead to a reduction in bone cortical thickness (Coben et al., 2010). Additionally, this diet may place the individual at risk for vitamin and nutritional deficiencies, including vitamins A, B12, and thiamine. (Vankat et al., 2012, Adams, Audhya, McDonough-Means, Rubin, Quig, Geis, Gehn, Loresto, Mitchell, Atwood, Barnhouse, & Lee, 2011; Coben et al., 2010; Exkorn, 2006). One classic symptom associated with Rett syndrome is weight loss, and a decrease in muscle mass can contribute to a cause of death in this population. Therefore, it is imperative that the physician be aware that nutritional deficiencies in the ASD population may cause these individuals to present with unusual conditions not usually apparent in the general population (Vankat et al., 2012; Adams et al., 2011; Coben et al., 2010; Exkorn, 2006).Vitamin supplements and enzymes may prove to be beneficial in the treatment of autism, as it has been suggested that there is an association between gastrointestinal functioning and brain functioning in autism (Coben et al., 2010; Rimland, 1996). Research has shown that secretin, a gastrointestinal hormone may help improve the autistic child’s gastrointestinal symptoms. In addition, within five weeks, some parents have reported improvements in eye contact, alertness, and increased expressive language (Coben et al., 2010; Ratliff-Schaub, Carey, Reeves, & Rogers, 2010). In addition to secretin, it has been proposed that the addition of omega-3 fatty acids to the diet may have a positive effect on the symptoms of autism (Adams et al., 2011; Coben et al., 2010; Ratliff-Schaub et al, 2010). Omega-3 fatty acids are essential for normal brain development and functioning, and some research studies have found fatty acid deficiencies in autistic children (Adams et al, 2011; Coben et al., 2010). In May 2002, Dr. James Neubrander accidentally discovered that following injections of the enzyme Methyl-B12 (Methylcobalamin) in a child patient with autism, that his mother began reporting improvements in the child's behavior (Coben et al., 2010). He then began using this treatment on other autistic children, and parents anecdotally reported dramatic improvements in behavior. Dr. Neubrander reported improvement in executive functioning, speech and language, and socialization and emotion (Coben et al., 2010). While the treatment may appear promising, there are very few published studies to support this claim (Coben et al., 2010).

The Table 3 below outlines outpatient pharamalogical and alternative management of ASD utilizing medications or dietary therapies:

Table 3

Medications and alternative therapies.

Medication	Symptom targeted	Side effects
Risperidone	Irritability, social and communications impairment	Weight gain, xerostomia (dry mouth), elevated prolactin level, somnolence, tremor, gait abnormality.
Methylphenidate	Hyperactivity.	Decreased appetite, insomnia, irritability, abdominal discomfort, xerostomia.
Valproate	Mood stabilization.	Aggression, liver enzyme elevation, sedation, xerostomia.
Selective serotonin reuptake inhibitors	Obsessive-compulsive symptoms, stereotyped behaviors, self-injurious behaviors.	Agitation, suicidal ideation, tardive dyskinesia, xerostomia.
Secretin	Social, behavioral, communications impairment-poor evidence of efficacy.	Minor irritability, hyperactivity, vomiting.
Gluten-free and casein-free diets	Social, behavioral, communications impairment-limited evidence of efficacy.	Expensive, potential for nutritional deficiencies, constipation.
Probiotics	Social, behavioral, communications impairment-no evidence of efficacy.	None reported, anecdotal interaction with antibiotics.
Chelation therapy	Social, behavioral, communications impairment-no evidence of efficacy.	Stevens-Johnson syndrome, low levels of calcium.
Vitamin therapy	Social, behavioral, communications impairment-no evidence of efficacy.	Vitamin toxicity in elevated doses.
Melatonin	Insomnia.	None reported.
Clonidine	Tic disorders, irritability.	Hypotension, sedation.

(Venkat et al, 2012, p.4)

Behavior Modification

Intensive, home- based behavior modification is recommended for the treatment of autism (Payakachat et al., 2012; Kazdin & Weisz, 1998). Treatment should start at as early an age as possible, preferably during toddler and preschool years, involve parental training of at least 5 hours per week, and include at least 20 hours of intervention from clinicians (Payakachat et al., 2012; Kazdin & Weisz, 1998). Skill deficits can be addressed through operant procedures, and an individualized treatment plan should be designed for use in the child's everyday environment (Kazdin & Weisz, 1998). Therapists work as part of the treatment team, and children typically receive about 40 hours per week of intervention. Utilizing this intensive type of treatment plan can result in an increase of IQ scores, and higher placement in regular classes at school (Coben et al., 2010). These effects were maintained up to 12 years after intervention (Kazdin & Weisz, 1998). Combinations of treatments have also showed promise for use with autistic youngsters (Payakachat et al., 2012; McIntosh, 1999; Kazdin & Weisz, 1998). Children who received therapy at home, as well as at school, demonstrated three to four times greater progress than those who received therapy only in school (Payakachat et al., 2012; McIntosh, 1999; Kazdin & Weisz, 1998). Therapies should be devised to make the most of the child's environment, and to address the individual needs of the child. Child psychiatrist Stanley Greenspan of the George Washington University Medical School labels this as the DIR approach: "developmental, individual-difference, relationship based" approach. DIR focuses on the child's developmental needs, individual differences in neuro-system capacities and relationships with therapists. In this approach, community resources are also utilized, such as speech and occupational therapists, counselors, parental support groups, school aides, and special needs classes (Exkorn, 2006; Greenspan & Weider, 2006).

Social Engagement

Researchers at the University of Maryland have tested an intervention to trigger the child's social engagement system, which includes such behaviors as listening, looking, facial expressions and vocalizations that support social interaction, improving the autistic child's ability to interact with others, and thus making them more receptive to other therapies (McIntosh, 1999). The intervention is based on the supposition that tensing the muscles of the middle ear enables the person to discriminate the human voice from the lower frequency sounds in the environment. As a result, this stimulates the entire social engagement system, and the child demonstrates an improvement in listening, language, and other communication skills (McIntosh, 1999).

Physical Environment

Additionally, a variety of factors should be considered in the treatment of autism, including the physical environment. Autistic individuals can be extremely sensitive to chemicals, such as those used in cleaning products. Even if the smell of the product has dissipated, chemical residue may remain. This residue may eventually enter the individual's body and alter brain functioning and behavior (Edelson, 2000). Fluorescent lighting, the most common lighting used in classrooms, may also affect behavior. Researchers observed an increase in repetitive, self-stimulatory behaviors under fluorescent lighting compared to incandescent lighting (Edelson, 2000). Behavioral problems can also be linked to problems in language and communication. Communication skills can be improved with the use of pictures, and by using sign and verbal language simultaneously. Behavior problems often occur because the individual is over excited. Strategies should be targeted at keeping the individual calm, and to reduce stimulators in the environment. Calming techniques that seem to work with autistic individuals include vigorous exercise that would act as a release of the high excitement level, vestibular stimulation, as in slow swinging, and deep pressure, as in the use of the hug. The ultimate goal of behavior therapy is to allow an individual to learn to live and work independently within their environment. Self-management is a term used to describe the process of achieving personal autonomy, and the goal for self-management is to shift supervision and control of the individual from the parent, caregiver, therapist, or employer, to the individual (Edelson, 2000). There are 3 components to self-management:

- Self-monitoring: The aim for self-monitoring is for the people to become more aware of their own behavior, and then to prompt the person to stop the behavior before it escalates. With practice, the individual should be able to recognize and manage the behavior on his or her own.
- Self-evaluation: The person determines whether he/she engaged in the desired behavior in relation to the goals that have been set. If it was, then the person will proceed to the next stage of self-reinforcement. If not, the person may need to revise and remonitor.

- Self-reinforcement: Reinforcement refers to the self-delivery of rewards for reaching the goals that were set.

Self-regulation is difficult and time consuming. Additional techniques may be implemented such as modeling, rehearsal, shaping, feedback, fading, and generalization. If the self-management program is successful, it is important to incorporate a maintenance program, and follow up sessions should be scheduled. Allowing the autistic individual to actively participate in their own therapy plan may be a reinforcer itself to help maintain appropriate behaviors. Once the person can monitor, evaluate, and regulate his/her own behavior, everyone benefits (Edelson, 2000).

Applied Behavior Analysis

Applied Behavior Analysis (ABA) is not an analysis, but a treatment developed in 1987 by Dr. Ivar Lovaas, and is based on the theory of operant conditioning by B.F. Skinner (Exkorn, 2006). Small units of behavior are measured, and through behavior modification behaviors that are more complex and adaptive are developed, stressing imitation, attention, motivation, and compliance (Coben et al., 2010). ABA methods are used to support the autistic child through reinforcement procedures to increase on-task interactions, systematic instruction and reinforcement procedures to enhance communication and social skills, teaching self-control and self- monitoring, to generalize or transfer behavior from one situation to another, to restrict conditions of interfering conditions, and to reduce interfering behaviors such as self-injury or stereotypy (Exkorn, 2006). ABA is the method of treatment that yields the most empirical support to date (Coben et al., 2010). Additionally, Joseph Ducharme developed a new behavioral treatment called errorless compliance training (Coben et al., 2010). This therapy is a non-coercive approach, involving parents to teach their child to comply with requests in a systematic and gradual manner (Coben et al., 2010). Errorless compliance training was applied to three boys with Asperger's +Syndrome, with great improvement in the children's compliance being reported by the parents. Furthermore, observational data demonstrated durable effects at 2 months' post treatment, with parents reporting being satisfied with the intervention (Coben et al., 2010). The New York State Department of Health Early Intervention Program recommends that ABA and other behavioral interventions be included in their treatment of autism (Coben et al., 2010). However, a strong commitment by parents is necessary to achieve positive outcomes (Coben et al., 2010). Although behavioral treatment programs receive strong support, it is recommended that additional therapies be used in conjunction with the behavioral methods (Coben et al., 2010; Kabot, Masi, & Segal, 2003; Meyers, & Young, 2012).

The Son Rise Program

Barry and Samahria Kaufman, who had a child diagnosed with autism, developed the Son Rise program in 1983. Dissatisfied with available treatments, they developed a home-based treatment program combining traditional educational principles with nontraditional disciplines of treatment aiming at turning the child's repetitive behaviors into a method of building connections and communications (Kaufman, 1994). The parent is recognized as the most important resource, and they are taught to empower themselves to the child's advantage. The home is regarded as the ultimate teaching environment. The Son Rise program's philosophy is based on the premise that the most effective way to teach children is to draw information and insight from them, and to help the child develop and build on their talents, skills, and interests (Kaufman, 1994). Varieties of situations are introduced in which the child can explore concepts and materials freely, with trainers assisting them. A specially designed playroom is constructed in the family's home, and is designed to eliminate over stimulation by filtering out 95% of the most common distractions. The playroom allows the child to heighten their learning curve, and to increase their ability to relate socially to their trainers (Kaufman, 1994). The Son Rise program encourages parents and therapists to imitate the child's behaviors. Rather than reinforcing the behaviors, they believe that by joining in a connection can be made between trainer and child. The Son Rise developers claim that joining in has demonstrated that repetitive behaviors decrease rather than increase (Kaufman, 1994). The Son Rise program also encourages children to learn at their own rate and pace, and employs games to motivate and teach the autistic child (Kaufman, 1994).

The Denver Model

Dr. Sally Rogers, a developmental psychologist also developed a family-oriented form of intervention called the Denver Model in the 1980's. The Denver Model combines intensive teaching of cognitive and communication skills, as well as focusing on social skills. The Denver Model emphasizes relationship building, and is based on the premise that optimal development occurs when a child is able to form emotional connections with others. The model is family based, with the parents taking charge of their child's treatment objectives. The parents also participate in all treatment team meetings, and receive support from the team to help the child achieve their treatment goals (Exkorn, 2006).

Deep Pressure Stimulation

Another form of therapy was developed by Temple Grandin, a PhD in Animal Science who had a successful career designing livestock equipment. She was also diagnosed with autism at the age of 2. Temple Grandin suffered from sensory overload, and developed the "hug machine," which is a deep squeezing machine that is used with autistic individuals to calm the nerves, and to build a tolerance to touch (Grandin, 2000; Grandin, 2006). The device is completely lined with foam rubber, and the user has complete control of the amount of pressure applied. The machine provides comforting pressure to large areas of the body. Temple Grandin claims that autistic individuals prefer deep pressure stimuli, and prefer proximal sensory stimulation to distal sensory stimulation such as hearing or seeing (Grandin, 2000; Grandin, 2006). Weighted blankets have also been shown to help the autistic individual sleep (Grandin, 2000). Autistic individuals may also wear tight wristbands on their watches, tight belts, tight shoes, or pressure suits to calm the hyperaroused nervous system (Grandin, 2006). Deep pressure stimulation, like that of the hug machine also appears to reduce the urge to pull away (Grandin, 2000). Based on the research of Temple Grandin, Tom McKean developed a pressure suit that can be monitored and adjusted, and is commercially available through the Therafin Corporation (Grandin, 2006).

Brain Balance System

Dr. Robert Meillo developed the Brain Balance System based on the belief that the autistic child suffers from Functional Dysconnection System (FDS), where the 2 hemispheres of the brain are not electrically synchronized, interfering with the brain's ability to share and integrate information properly (Meillo, 2009). It is theorized that there is a hormonal imbalance in the brain resulting in an imbalance in maturation of the two hemispheres of the brain that becomes more significant as the child becomes older. The Brain Balance System provides stimulation to activate slow areas of the brain through exercises that assist the brain in integrating and working as a whole (Meillo, 2009).

Play Therapy

Play therapy is an effective intervention as it helps children who have difficulty in expressing their feelings, needs, and thoughts through verbal language (Mastrangelo, 2009). Play provides an arena in which those feelings can be expressed, and communication is enhanced through play since it is the most natural form of self-expression for children (Mastrangelo, 2009). On a conscious level, play allows the individual to enact thoughts and feelings of which they may be aware, but are unable to express in words. Developmentally, play is considered a natural expression for young children. Play bridges the gap between concrete experience and abstract thought (Landreth, 2001). Because of the pleasure inherent in play, it can be self-motivating and may satisfy the child's need to explore and master their environment. Winnecot described playing as doing, and that through doing one learns to control their outside environment. Piaget (1962) defined play as assimilation, or the child's effort to make a connection between the outside environment and his/her own concepts (Mastrangelo, 2009; Fox, 1996). The stereotypic movements of the autistic child cannot be defined as play as they lack symbolic capacity (O'Connor & Braverman, 1997). The developmental deficits of the autistic child are reflected in play that is poorly elaborated and poorly structured, and are narrow in terms of fantasy (Mastrangelo, 2009; O'Connor & Braverman, 1997). Vygotskian theory states that play allow children to practice what they already know, and allows the child to assimilate new concepts. Vygotsky concluded that play facilitated cognitive development (Fox, 1996). Steven Siviy (1998) found that rough and tumble play among children helps to wire the brain's pleasure and reward centers. The neocortex is the section of the brain that denotes reasoning, and that humans are the largest species to participate in social play, thereby developing the social brain (Schaefer, 2003).

Music Therapy

Music therapy works by radiating genuine energy frequencies, thereby stimulating areas of the brain (Meillo, 2009). Music therapy encompasses a wide variety of performance experiences, and listening and movement exercises. In clinical settings, music therapy has been known to reduce blood pressure, alleviate pain, ease muscle tension, and promote physical rehabilitation (Exkorn, 2006). Music may promote emotions such as serenity, and help to counteract depression. Music therapies may be instructional or child directed, and may help to improve coordination skills, attention, and focus (Exkorn, 2006). Music therapy has been used for individuals with and without disabilities, including autism. The rhythm in music can help structure behavior by simultaneously generating emotions directly, and by influencing physiological functioning such as, heart rate, muscle tone, blood pressure, and respiration. Music therapy provides a comfortable, nonthreatening environment to encourage interaction, thereby enhancing social skills (Durrani, 2014; Nayak, Wheeler, Shiflett, & Agostinelli, 2000). Music therapy activities can include singing, playing of instruments, improvising, performing, and listening, based on the interest and abilities of the participants. The use of music as an intervention can be of great appeal to children who do not find toys interesting, but who do respond to music. Because music can function as a universal language, music can provide an alternative to verbal forms of communication (Durrani, 2014; Carmichael, Hairston, & Atchinson, 1997). The primary goal of music therapy is to provide children with an outlet for the expression of their emotions through a safe and socially accepted medium. Secondary gains include an increase in self-esteem, as well as the skills developed from playing, singing, and performing. Additionally, gains may include discipline, patience, and appreciation (Carmichael, et al, 1997). Researchers have suggested that the child with autism may be more likely to respond to auditory stimulus than visual stimulus, especially when the auditory stimulus is musical (Lim, 2008). Music therapy has been suggested as an effective intervention for children with autism for the several reasons. First, some children have sensitivity to music, including auditory acuity such as superior discrimination abilities, and a strong memory for music. Some children with ASD have a perceptual preference for music, and some children with ASD are able to produce musical patterns (Lim, 2008). Music may be employed for development in several areas including fine and gross motor coordination, attention span, social skills, and concept of self and nonverbal communication (Durrani, 2014; Lim, 2008). A number of studies have been conducted using music therapy with children diagnosed with autism. Kaplan and Steele (2003) conducted a study of 40 autistic children treated over a period of 2 years. It was demonstrated that sessions of interactive singing and instrument playing was effective across a variety of treatment goals, including an improvement in behavior, psychosocial skills, motor skills, cognitive processing, and an improvement in language and communication. Parents reported that their children applied and generalized skills acquired in music therapy to non-music environments. Whipple (2004) compared music to non-music interventions. Music therapy included singing, background music, social stories set to music, and directions followed with music. According to the analysis, the use of music therapy contributed to an increase in socially accepted behaviors, increased vocalizations, gestures, vocabulary comprehension, and echolalia with the intention to communicate. Lim (2005) conducted a study to examine how musical stimuli might impact the production of speech in children with ASD. Lim examined 50 children, ranging in age from 3-5 years. The children had been previously evaluated on standard tests of language and functioning. The children were divided into 3 groups, and each group received 6 sessions of training. The first group watched a video containing 6 songs, and pictures of 36 target words. The second group received speech therapy, and watched a speech video containing 6 stories and pictures of targeted words. The third group did not receive any training. The results of the study showed that the children who received both music and speech training significantly increased their production of speech. This study supported the theory that children with ASD appeared to perceive linguistic information, such as the targeted words that were embedded in the music stimulus, could then verbalize the words as functional speech. These studies reinforced the assumption that music therapy can be beneficial to children with autism.

Art Therapy

Art therapy assists children with communication skills, relationship building, sensory stimulation, and development of a sense of self (Exkorn, 2006). Art therapy is a multisensory, multifaceted medium that can be tailored to the particular needs of the child with ASD (Durrana, 2014). Art therapy can provide insight to the child's emotional state, and helps the child to express feelings and ideas. This therapy can be extremely beneficial to the autistic child that has difficulty with verbal expression (Exkorn, 2006; Oster & Gould, 1987; Rubin, 1984). Art therapy is a way to arouse the desire to communicate within the autistic child who may find it easier to process objects easier than words (Durrani, 2014). The use of nonverbal expression through the creation of art encourages the child to begin to represent their experiences (Durrani, 2014). A therapist provides a wide array of art materials, and encourages the child to use them in any way they desire. Once the project is completed, the therapist asks the child to reflect on their creation, and may probe its significance and meaning. In doing so, the therapist might ask questions like, "What does the person in the drawing want to say to you?" Art is a universal language, as it allows one to tell a story without speaking (Provencal, Gabor, 2007). The use of art therapy is well suited for the child with ASD because they are often concrete, visual thinkers (Epp, 2008). The use of art therapy in conjunction with social skills training may increase the willingness of the child to participate in activities (Epp, 2008). Art offers a way to solve problems visually. It forces the child to be less literal and concrete in self-expression, and it offers a nonthreatening way to deal with rejection (Epp, 2008). It replaces the need for tantrums or acting out, because it allows for an acceptable method of discharging aggressions, and enables the child to self-soothe (Epp, 2008). The use of icons and symbols helps the child remember what they are taught. When children and therapists work together to create custom made symbols, icons, and stories for the child's individual challenges and goals (Epp, 2008). The child takes ownership of these creations and integrates them into their internal experience (Epp, 2008). Another popular form of art therapy that is used with children with ASD is the use of comic strips as teaching tools. The therapist may draw a comic strip, and then discusses the illustrated event with the child. Children who are visual learners benefit greatly from this approach, and are less intimidating than role-playing (Epp, 2008). The therapist may also invite the child to draw their own comic strip, and then use this medium as a means of expression, especially for those with language skills difficulties. Additionally, the therapist may also gain insight into what the child is experiencing (Epp, 2008). The characteristics of art allows for the children, who often suffers from social anxiety, to relax and enjoy themselves, while learning in a controlled and therapeutic setting (Epp, 2008).

Aquatic Therapy

The American Recreation Association recommends aquatic therapy as many ASD children suffer from sensory difficulties, and are easily distracted. The surrounding hydrostatic pressure of the water has a calming effect on the child while simultaneously providing sensory stimulation (Exkorn, 2006). Often, children with ASD are unable to join in play, but aquatic therapy allows the child to work on physical impairments while having fun. Aquatic exercises may also help to improve sensory integration, body awareness, and balance, mobility skills, along with cognitive and psychosocial benefits (Lo, 2008). Aquatic therapy also assists the individual in the performance of activities that may be difficult to implement on land (Exkorn, 2006). Aquatic exercise targets sensory and physical impairments while having fun. Often children have difficulties participating with other children and/ or sports because of difficulties in communication, sensory integration, balance, and coordination. The pool acts as an equalizer where the child with ASD can participate in a sport activity while socializing with other children (Lo, 2010). A typical aquatic therapy session begins with the therapist leading the children in warm up exercises. Then the children may swim laps. Strength training involves the use of foam-float barbells, and aquatic noodles for arm and leg exercises. The therapist may also have the children jump rope using the noodles to speed up movement, and increase heart rate. Most aquatic therapy sessions end with a group game activity. Constant routines have been reported to promote independence with self-care skills, to boost confidence, and improve endurance (Lo, 2008).

Canine Therapy

Canine companions are trained assistance dogs used to provide support for the child with disabilities. Working with a canine companion allows an opportunity for the child to establish an emotional connection with the dog, thereby helping to establish a sense of security, and confidence and independence (Exkorn, 2006). Additional benefits include the teaching of responsibility, a source of unconditional love and acceptance, and the importance of a shared experience (Dilts, 2008). It is surmised that being able to form a relationship with a dog may help to facilitate the child with forming relationships with people (Exkorn, 2006). A canine companion as an adjunct has the ability to decrease the shock of meeting new people (Dilts, 2008). Simply petting a dog distracts the child from their own anxiety, and provides the comfort from touch that therapists cannot give (Dilts, 2008). Having a pet has also been shown to reduce blood pressure and heart rate for medical purposes (Dilts, 2008). The canine may also be helpful in allowing children be expressive, to release emotions, overcoming inhibitions, and allowing therapeutic changes to occur (Dilts, 2008). Since children with ASD appear estranged from life, and alienated from others, animals may also serve as a way to connect with nature, thereby leading to a more balanced and relaxed state (Dilts, 2008). Martin and Barnum (2002) reported that animals might be one method to increase attachment between children with ASD and their social environment. Animals seem to act as transitional objects, allowing children to first develop bonds with the dogs, and then extend these bonds to humans (Dilts, 2008). Children diagnosed with autism have significant difficulty in their ability to communicate (American Psychological

Association, 1994), especially in the area of joint attention, a prerequisite for communication (Welsh, 2009). Therefore, it is difficult to teach the autistic child to read (Welsh, 2009). Studies on the effects of canine therapy have demonstrated positive outcomes, including better eye-to-eye contact, and improved verbal or gestured interaction (Welsh, 2009). Kaymen (2005) explored the use of animal therapy by having children read to dogs, and it was found that the reading levels of the children improved. The most common way canine therapy is implemented is with therapeutic visitation dogs (Welsh, 2009). These dogs are often pets that have been volunteered by their owners for therapy. These therapy dogs are used in homes and residential settings, hospitals, nursing homes, rehabilitation facilities, as well as in educational settings, and other settings where therapy is provided (Welsh, 2009). In 2002, Priscilla Taylor founded a non-profit community-based organization called Autism Service Dogs of America to provide families with specially trained dogs for children with autism. Their service dogs provide physical safety and an emotional anchor for children with ASD. With a permanent service dog family are able to participate in activities liking going to the park, or going out to eat. The service dog helps to calm the child, enabling the child to participate in more activities, and in some cases the dog can accompany the child to school, helping with transitions between activities and locations. The service dog also increases opportunities for the child to develop social and language skills with others. Information about this organization is available on their website; http://autismservicedogsofamerica, or by joining them on Facebook.

Chiropractic Treatment

Chiropractic treatment has been shown to improve the behavior of the ASD child by restoring optimal functioning to the nervous system through adjusting and manipulating parts of the body where bones are connected, emphasizing the spinal column (Exkorn, 2006). Treatments may also include heat and ultrasound. Chiropractic treatments are directed to the imbalances in the nervous system that inhibits sensory processing. Chiropractic treatment has been shown to improve tendon reflexes, increase range of motion, reduce hyperactivity and aggressiveness, and improve control of bladder and bowel movements (Jennings & Barker, 2006). There are several guidelines that the chiropractor follows when working with a child with ASD: establish consistent routines, avoid loud disturbances during treatments, use distraction techniques, be alert for nonverbal cues, and question parents about any changes in behavior patterns. Significant changes may include the cessation of stereotypic behaviors such as headstands, spinning objects, or tugging at clothing (Jennings & Barker, 2006). Positive change may also be indicated by an increase in the variety of foods that the child will eat, or an improvement in vocabulary. Many children with ASD are tactile defensive and crave deep pressure, and the chiropractor may apply deep pressure when manipulating the spine. This technique can have a calming effect on the child (Fallon, 2011). Chiropractic adjustment can also help the child to feel where their body ends, and where the rest of the world begin, and can interrupt the feedback loop associated with repetitive movements (Fallon, 2011).

Dolphin Therapy

Psychologist David Nathanson and dolphin expert Horace Dobbs, along with a Dutch therapist named Richard Griffioen who discovered that the gentle and playful nature of the dolphins helped the child to increase their functional skills, introduced dolphin therapy in the 1990's. The child is able to swim and play with the dolphins, and they are able to touch them. They are also shown how to instruct the dolphins, and learn from them. These exercises benefit the child in concentration, retaining of information, and development of communication skills (Exkorn, 2006). A study conducted in the Ukraine with 40 parents of children diagnosed with autism utilized dolphin therapy over a 2-week period. A parent report scale using the Behavior Dimensions Rating Scale (BDRS) was administered pre and post therapy. Results support previous positive evidence that dolphin therapy is effective with children with special needs (Dilts, 2008). Smith (2003) used dolphins in her treatment of autistic children, and found that these children exhibited dramatic, observable behavioral improvements. For example: two children were able to hold each side of a bucket containing water, lift it together, and then pour the water over the dolphin demonstrating interactive, mutually cooperative play. The temperament of the dolphin makes this therapy easy to implement, as the dolphins enjoy attention, and enjoy human contact (Dilts, 2008). Swimming with dolphins is considered less dangerous and more acceptable than interactions with other wild animals (Dilts, 2008).

Energy Therapy

Energy therapies include psychic therapy, crystal healing, and therapeutic touch. These are noninvasive techniques meant to balance the child's energy on a physical, emotional, and psychic level. There is no solid scientific evidence that supports the effectiveness of these therapies (Exkorn, 2006).

Floortime: Developmental/Individual Difference/Relationship Therapy

The Floortime approach, also known as the Developmental, Individual Difference, Relationship (DIR) therapy was developed by child psychologist Stanley Greenspan. Floortime is a one on one intervention that focuses on the individual strengths of the child, and their relationship to others (Mastrangelo, 2009; Exkorn, 2006: Greenspan, 2006). Floortime is founded on the principle that children learn best when they are emotionally engaged. Parents, family members, and the therapist get down on the floor and follow the child's lead to encourage paying attention and communicating by capitalizing on the child's interests, skills, and motivations (Mastrangelo, 2009; Exkorn, 2006; Greenspan, 2006). Floortime sessions are typically 20-30 minutes long, and are unstructured and spontaneous (Mastrangelo, 2009; Exkorn, 2006; Greenspan, 2006). Floortime was designed specifically to educate and involve parents on strategies to improve the social, emotional, and communicative relationship between parent and child (Mastrangelo, 2009). Parents are more likely to provide enhancing, developmental learning opportunities to the child when they feel empowered about their parenting capabilities (Mastrangelo, 2009). Parents also reported that they are happier, less stressed, and more able to meet their child's needs when they can involve their child in a rich, interactive, home based program (Mastrangelo, 2009). Floortime is an approach designed to be used with children with ASD. Treatment plans are based on each child's unique abilities, and interventions are based on DIR characteristics. "D" represents the developmental capabilities of the child, and includes shared attention, engagement, interactions, problem solving, creating play ideas, and abstract thinking. "I" represents the individual differences in sensory motor processing and regulation. "R" represents the relationship and environment necessary to provide the interactions needed for emotional, social, and cognitive development. The key elements of Floortime are divided into 6 stages:

1. Self-regulation and shared attention focus on senses and motor capacities to help the child stay calm and regulated. This includes looking at faces, hearing voices, and movement.
2. Two-way intentional communication challenges the child to communicate through gestures and emotional signals.
3. Purposeful complex problem-solving communication involves the parent and child to work up to 30+ circles of communication. For example, the child takes the parent by the hand and walks them to the door, points to go outside, or vocalized the desire to go out. The parent reciprocates by expanding the conversation, perhaps by asking the child where they want to go, or who will come along.
4. Engagement and relating refer to encouraging the child to engage positively, and to encourage growth of intimacy.

5. Creating and elaborating symbols or ideas refers to inviting the child to relate to sensations, gestures, and pretend play.
6. Building bridges between symbols challenges the child to connect ideas together, and to create connections between feeling states. This ability is essential for the child to separate reality from fantasy, to modulate mood, and to concentrate and plan. (Mastrangelo, 2009).

During spontaneous Floortime play sessions, the adult follows the child's lead by using appropriate affect and tone during interactions, along with gestures and words paired together with exaggerated affect. Floortime enables the parent to establish a foundation of shared attention, engagement, simple and complex gestures, and problem solving as a means to introduce the child to ideas and abstract thinking (Mastrangelo, 2009).

Equestrian Therapy

Equestrian therapy, also known as hippotherapy, teaches children how to ride horses to improve motor skills, coordination, and to improve muscle tone (Exkorn, 2006). Equestrian therapy operates from the premise that introduction of an animal into the life of a person helps to enhance their emotional well-being (Dilts, 2008). Equestrian therapy can be used for children with psychological and emotional problems as bonding with the horse gives the child an outlet for their fears and anxieties, while promoting leadership skills and responsibility (Kern, Fletcher, Garver, Mehta, Grannermann, Knox, Richardson, & Trivedi, 2011). However, the most common use for equestrian therapy is for physical therapy. A study conducted in 2008 by the Washington University Program in Occupational Therapy found that equestrian therapy had a positive impact on children diagnosed with cerebral palsy (Horses and Humans Research Foundation, 2008). The study showed that the rhythmic movement of the horse improved both head and trunk stability, and upper extremity function, and that the children were able maintain a continuum of measurable improvement months after therapy ended (Horses and Humans Research Foundation, 2008). This study demonstrated that equestrian therapy might be a therapeutic tool that can make a measurable difference in the basic skills that form the foundation of most functional activities of everyday living (Horses and Humans Research Foundation, 2008).

Holding Therapy

Dr. Martha Welch, a child psychiatrist who theorized that a bond could be developed between the child and another through close physical contact, and comforting talk (Exkorn, 2006), introduced holding therapy. The technique is encouraged when the child throws a tantrum. The child is held until they relax and establish eye contact. Holding therapy has opponents who contend that forced holding could be considered as abuse, and that it may actually instill feelings of fear, anger, and confusion (Exkorn, 2006).

Hyperbaric-Oxygen Therapy

Hyperbaric-oxygen therapy (HBOT) is the treatment of the body with 100% oxygen at higher than normal atmospheric pressures in an enclosed, airtight, pressurized chamber. HBOT has also been used in the treatment of brain injuries, stroke, cerebral palsy, and multiple sclerosis (Coben et al., 2010; Exkorn, 2006). Brain imagings, including Positron Emission Tomography (PET) and SPECT have indicated cerebral hypoperfusion in autism, and it has been suggested that the increased oxygen delivered by HBOT may counteract the hypoxia created by hypoperfusion, thus leading to a reduction in symptoms of autism (Coben et al., 2010).

Some studies have claimed that the use of HBOT has enhanced the cognitive functioning of healthy adults and elderly patients (Rossignol, Rossignol, James, Melnyk, & Mumper, 2007). The studies claimed that the patients demonstrated improvement in attention, reaction time, and word recall (Rossignol et al, 2007). A study utilizing HBOT was conducted in 2007 with 18 children diagnosed with autism, ranging in age from 3-16 years old produced mixed results (Rossignol et al, 2007). The children underwent 40 sessions of HBOT, each lasting 45 minutes. Blood samples were drawn before and after treatments. Parents also assessed changes in clinical symptoms. The results showed that inflammation in the children improved, but that efficacy in other areas, such as cognition, could not be determined (Rossignol et al, 2007).

Learning and Developmental Disorders Evaluation and Rehabilitation Services

The Learning and Developmental Disorders Evaluations and Rehabilitation Services (LADDERS) therapy is a comprehensive treatment and evaluation program that uses a multidisciplinary team approach (Exkorn, 2006). The program is affiliated with the Massachusetts General Hospital for children, and the Spaulding Rehabilitation Center. The program is strongly committed to family involvement, and provides parents with training and education to help them to transfer learned skills to the home environment (Exkorn, 2006).

The Miller Method

Arthur Miller and Eileen Miller designed the Miller Method as a cognitive developmental approach toward play therapy for children with ASD (Mastrangelo, 2009). They theorized that some children with ASD have system disorders that impair the child's ability to organize, understand, and engage in their environment (Mastrangelo, 2009; Exkorn, 2006). Using special equipment such as large swinging balls, the Miller square, and Swiss cheese boards, the children are encouraged to be more focused, and are assisted in converting stereotypical behaviors into functional behaviors (Mastrangelo, 2009: Exkorn, 2006).

Occupational Therapy

Occupational therapy is utilized to aid children achieve competence in all areas of their lives, including play, social interactions, self-help, and communication. Occupational therapy provides support for those who have difficulty with sensory, motor, neuromuscular, and/or visual skills. Through occupational therapy, children are able to learn how to balance, communicate, respond to touch, and how to complete daily tasks (Exkorn, 2006). Depending on the child's needs, the therapist may include a variety of techniques including, trampolines, swings, writing, and drawing (Exkorn, 2006). Occupational therapy with the autistic child focuses on the development of skills needed for daily living, such as dressing, eating, grooming, bathing, and toileting (Robinson, 2008). Occupational therapy was built on the premise that the child's sensorimotor performance components, such as manual dexterity, hand manipulation, strength. mobility, and tactile processing are important for the development of specific skills of daily living (Robinson, 2008). Difficulty in sensory processing is also believed to impede functioning by limiting skill development. An example of this would be pencil grasp (Robinson, 2008). Occupational therapy focuses on patterns of sensory processing including, avoidance of sensory input due to hypersensitivity, sensation seeking behavior due to under-responsiveness, and low registration that includes a failure to register sensory input from the environment (Robinson, 2008). Studies of children with ASD continually confirm the presence of motor difficulties during development (Robinson, 2008). Studies have also correlated significant delays in motor development with a delay in early language and perceptual development (Robinson, 2008). Even simple activities require executive control, including anticipating movement, adjusting movement in reaction to external feedback, and coordinating movement in a goal directed sequence (Robinson, 2008). Additionally, many children with ASD may present with features such as poor muscle tone, oral-motor problems, and stereotypy impairing the child's ability to perform daily living tasks. Example of occupational activities may include threading of beads, catching a beanbag, and balancing on one foot. Other activities may be using a butter knife to butter bread, cutting of soft foods, putting on and removing a shirt, using utensils while eating, managing shoes and socks, and doing/undoing buttons, snaps, zippers, and fasteners. Self-care exercises may include exposure to varying food textures, tooth brushing, hair brushing, and washing of face and body.

Physical Therapy

Physical therapy enhances physical abilities by treating impairment of movement that interferes with developmentally appropriate functioning. Some children with ASD have poor muscle tone, as well as poor posture, balance, and coordination (Exkorn, 2006). Physical therapists exercise the children to increase endurance to develop motor control (Exkorn, 2006). Physical therapists may work with the child with ASD on basic motor skills such as sitting, rolling, standing, and playing. Physical therapists may also work with the school's special education teachers and aides to educate them on the tools needed for building physical and social skills (Lo, 2010). Physical therapy helps the child with transitioning between activities, and with motor planning skills. Site-specific training is important, as while the child may be able to learn a specific skill, they may not be able to generalize it to other related skills, contexts, or environments (Lo, 2010). Physical therapy also aids the child with following directions, responding to verbal cues, and physical prompts and demonstrations (Lo, 2010). The autistic child requires much repetition to reinforce skills.

Social Stories

Carol Gray created social stories in 1991. Social stories are used as a vehicle to teach social skills to children with ASD by telling stories about specific situations or events. The child is given as much information as possible to enable them to understand the situation, and then to figure out the expected or appropriate response (Exkorn, 2006; Goldstein & Schneider, 2010). Pictures, photographs, or music may accompany social stories. Additional supports include picture prompts, activity schedules, checklists, and videotape modeling. An adult typically reads an illustrated story that identifies a situation or behavior, and describes acceptable social cues, and appropriate responses. Social stories are thought to be effective as they address specific behaviors that the child with ASD needs to learn, such as initiating conversation, responding to conversation, changing a routine, understanding of how other people think and feel, or how to behave appropriately in a social situation (Goldstein & Schneider, 2010; Scarpinelli, 2009). Some of the challenging behaviors addressed by social stories include tantrums, aggression, interrupting, screaming, and hitting. Relatively few research studies have been conducted where social stories have been the sole intervention, yet they appear to be effective when used in conjunction with other therapies (Goldstein & Schneider, 2010; Scarpinelli, 2009). Therefore, it is unclear if the improvements in behavior are accounted by social stories alone, or to the use of social stories in combination with other therapies (Goldstein & Schneider, 2010; Scarpinelli, 2009). During treatment in a recent study, a social story was read to a child each day immediately before a daily routine at school, such as circle time. The story highlighted a targeted behavior. The child was then asked questions regarding what the child would do next. If the child answered correctly the reader stated, "That's right." If the child did not answer correctly, the reader opened the story to the correct response, and then orally stated that response. The reader then observed the child, and it was noted that the child responded in a more appropriate manner (Goldstein & Schneider, 2010; Scarpinelli, 2009). The child sat during circle time for a longer period, and raised his hand to be called on. In the following weeks, the child was able to maintain some of the appropriate behaviors. Results appeared to indicate that social stories might help facilitate the development of self-management (Goldstein & Schneider, 2010; Scarpinelli, 2009).

Speech and Language Therapy

Speech and language therapy is designed to help a child communicate verbally and nonverbally by using words or body language (Exkorn, 2006). The speech pathologist provides appropriate interventions that teach the child how to establish words or communication systems, process information, and how to express themselves (Exkorn, 2006). The child may also be taught how to read body language and recognize facial expressions. For nonverbal children, alternative treatments such as American Sign Language or communication boards may be included. For the autistic child, impairment in speech is a core symptom of autism (Dawson, 2010). Language deficits are variable among those with ASD, ranging from complete loss of functional language, to impairments in language processing, language production, or language comprehension (Dawson, 2010). Research has indicated that some children with ASD also suffer from other impairments that interfere with speech development, such as fine and gross motor skills, oral-motor impairment, and motor imitation skills (Dawson, 2010). It may be recommended that speech therapy be implemented in conjunction with other therapies. Speech therapy utilizes sensory and tactile cues, together with physical manipulation of the speech mechanism to produce the correct production of sounds. The therapist encourages the child with daily practice, timing, and gradual shaping of skills. Therapists also encourage the child to imitate sounds. For children who are nonverbal, utterances are paired with gestures. Sequenced play and the use of musical tones and rhythm also help to motivate the child to imitate sounds (Dawson, 2010).

Virtual Reality

Virtual Reality (VR) is a computerized intervention and assessment toll that utilizes a computer and interactive programs. The programs are categorized into 3 groups: promoting independent living skills, improving cognitive performance, and improving social skills (Standon & Brown, 2005). VR provides a safe environment for the child to practice skills, as the virtual world can be manipulated in ways that cannot be done in the real world (Standon & Brown, 2005). The virtual world can convey concepts without the use of language and symbols (Standon & Brown, 2005). VR can be advantageous for those with ASD because it allows for producing a variety of versions of a learning environment, each with minimal modification of a similar scene. Flexibility and generalization can be encouraged by gradually increasing the difference between the different versions of the learning environment (Standon & Brown, 2005). These virtual environments can present an opportunity to learn basic skills and rules that could be repeatedly practiced before entering the real world where these skills are required (Standon & Brown, 2005). VR can also help the child with ASD compensate for the lack of theory of mind by causing them to consider the implications of their thoughts, and how others (Standon & Brown, 2005) may see their behavior. In addition, training with the computer may also improve motor control, and eye-hand coordination (Standon & Brown, 2005). It has been reported that children with autism are enthusiastic when working on the computer, probably because the computer can reduce stimulation to a level of input tolerable to the individual (Standon & Brown, 2005). Examples of virtual worlds include grocery shopping, preparing of food, orientation, road safety, and manufacturing skills. When buying groceries, children shop in a virtual supermarket, choose foods from the shelves, and then proceed to checkout. Food preparation is based in a virtual kitchen where the individual is taught a food preparation task, and is oriented to food and kitchen safety. Orientation refers to spacial recognition. The child is placed in a virtual house, is asked to follow a route through the house, and is then asked to identify objects seen on the way. Road safety refers to learning to navigate crossing the road, identifying safe places to cross, and judging of speed and distance of oncoming vehicles. Vocational training teaches the child how to assemble parts of an object. Variations of these tasks appear to maintain the learner's interest and motivation (Standon & Brown, 2005). Evaluations have demonstrated some transfer of learning to the real world (Standon & Brown, 2005). The ultimate intent of VR is to enable the individual to have, as much control as possible over their own life, be able to make choices, be involved in their communities, contribute to that community through work, and to be able to live as independently as possible (Standon & Brown, 2005).

In 2012, a Technical Expert Panel (TEP) in conjunction with UCLA and other universities, including experts in psychology, developmental pediatrics, child psychiatry, educators, and parents of children diagnosed with ASD (Maglione et al., 2012), released a set of guidelines addressing nonmedical interventions. They rated and compared the efficacy of various interventions using guidance suggested by the US Agency for Healthcare Research and Quality. Applied behavioral analysis, the Picture Exchange Communication System, and various social skills interventions including video monitoring and peer monitoring were rated as moderate, meaning that showed evidence of efficacy (Maglione et al., 2012). Theory of Mind and other cognitive interventions also demonstrated evidence of effectiveness (Maglione et al., 2012). The panel did not rate any intervention as strong. The TEP recommended starting treatment early as timely treatment appears to maximize the impact of treatment on the young child's development and prevent ongoing developmental delay or deterioration. The panel recommended staring treatment within 12 months of diagnosis. The TEP also reported that greater intensity and duration of treatments resulted in better outcomes (Maglione et al., 2012). The TEP recommended that children with ASD should receive at least 25 hours per week of comprehensive therapy to address target social skills development, communication, play skills, and integrated behavioral and developmental programs. One-on-one approaches appeared to prove most effective with young children, and group programs involving peers proved more effective for older children (Maglione et al., 2012). Programs should be tailored to the individual need of each child to be successful, and to avoid the financial and emotional costs of inappropriate intervention methods. An intervention program should also address the needs and concerns of the family, and offer opportunities for their direct participation. Therapies should continue throughout the individual's life span, and should vary depending on the individual's chronological age and specific developmental needs (Maglione et al., 2012).

Neurofeedback and Autism

EEG Biofeedback as a treatment for autism is a relatively new frontier, with most of the treatments being utilized primarily with higher functioning individuals, as the participant needs to be able to engage their attention on a specialized computer program during each session (Jarusiewicz, 2002). Autistic children are often averse to having monitor wires placed on their heads during sessions, however, some companies that produce NFB equipment have developed helmets that eliminate the need for the positioning of electrodes on the scalp, making NFB more user friendly (Jarusiewicz, 2002; Play Attention 2009).

Another variation utilizing a user-friendly application is NFB using HEG, developed by Hershel Toomin. HEG trains the subject to increase blood flow to targeted areas of the brain (Limsila et al., 2004). A headband called a spectrophotometer is placed around the forehead of the user, and is attached by wires to a computer. Red and infrared lights on the spectrophotometer flash as an optode, and the light collecting amplifier is a different type of optode that reacts to the returned light that is reflected and refracted by the targeted tissue (Limsila et al., 2004). The optodes are placed three centimeters apart to insure optimal conduction of light through the cortical tissue. The computer program receives reflected light and spectrophotometric measurement of blood oxygenation through the headband, and displays feedback in a visual and auditory form to the user (Limsila et al., 2004). The user is able to see a moving bar graph on the left side of the screen. The bar lasts a few seconds, and is then replaced with a bar showing the average position (Limsila et al., 2004). A histogram is then generated that continuously judges the current varying lights against the average value. Additionally, each increment is accompanied by a variably pitched tone keyed to the current height (Limsila et al., 2004). This tone was developed to increase in pitch, and to signify blood oxygenation (Limsila et al., 2004). The user can increase blood oxygenation on demand by attending to the highest note in each trill and will the note to the next higher sound. This type of NFB exercises selected areas of the brain, and increases blood flow to the chosen brain regions. Consequently, capillaries and dendrites grow with this brain exercise (Limsila et al., 2004). HEG treatment is usually broken down into ten-minute segments, with two segments constituting a user's treatment session (Limsila et al., 2004). HEG has been supported by studies using Single Photon Emission Tomography (PET) that can observe deeper structures in the brain, and have discovered reduced blood flow in the frontal area and the limbic system in autistics. These areas are important for impulse inhibition. PET scans have also revealed abnormally low blood flow in the area of the stratum, as well as in the temporal and parietal regions of the brain (Limsila et al., 2004; Waterhouse et al., 1996).

A third form of NFB is called audio-visual stimulation (AVS), also known as photic stimulation or AVE, which unites three modalities, the auditory, visual, and vestibular, into a singular intervention, gently training brainwaves to fall into a predetermined specific brainwave pattern (Eisenberg, 2010). The individual being treated wears a device attached to glasses and earphones. Flashing lights are coupled with intermittent rhythmic pulsating tones. This has a synergistic effect, compounding the training benefits (Eisenberg, 2010). The lights and sound stimulate the neocortex creating an imprint known as the cortical evoked response (Siever, 2002). The cortical evoked response (CER) is the brain's response to a single stimulus. When this stimulus is introduced more frequently than 4 times per second, a new response engraves itself on the tail of the previous stimulus. It is at this point that the cortical evoked responses become known as the “frequency following response”, and this is now referred to as brain wave entrainment (BWE), where the brain begins to reverberate with the stream of stimuli, and the resulting brainwave becomes the same frequency as the stimulus (Siever, 2002). AVE creates brain wave entrainment by delivering pulses of sound and light in accordance with the rules of BWE. Brief, intense flashes of light produce harmonic activity in the brain, and photic induced seizures have been reported in approximately 1: 10,000 adults, and 1: 4,000 individuals aged 5 to 24 years old. Therefore, care must be used when delivering photic stimulation, especially to children (Siever, 2006). Takahasha and Tsukahara (1976) measured induced photic seizures with 14 individuals under controlled lighting conditions. In all 14 cases generalized PCRs of sharp and wave and spike and wave complex were induced using a brief, intense flash pulse. They observed that photo convulsive responses (PCRs) were most likely to occur with red light stimulation at 15-20 Hz, and that it was more apt to trigger seizures than white light (Siever, 2006). Ruuskanen-Uoti (1994) reported on an individual who developed a seizure while using a “light & sound” machine employing square wave simulation delivered by red light emitting LEDs. To address this concern, it was discovered that sine-wave modulated light eliminated the problem of light intensity from Xenon strobe increasing with frequency, and that the harmonics generated within the neo-cortex were also eliminated despite the fact that frequency multiples were at times much higher than the fundamental frequencies (Siever, 2006). These findings were supported by findings of Van der Tweel (1965), Townsend (1973), Donker (1978), and Regan (1965). It was observed that a square was LED light flashing at 7 Hz can produce strong harmonics between 20 and 40 Hz. In sine-wave stimulation studies the concern of inducing seizures was completely eliminated. In the raw EEG shown in the studies, there were no signs of epileptiform activity (Siever, 2006). AVE appears to influence and train brainwaves in a noninvasive manner using frequencies that are similar to those frequencies used with other NFB techniques (Eisenberg, 2010; Siever, 2004). The AVE machine used by the practitioners in this study is called the DAVID Paradise XL system manufactured by the Mind Alive Corporation in Canada. The Mind Alive Corporation has created the Omniscreen eyeset to address the concern of PCRs. The wave form for the DAVID system uses sine wave stimulation for frequencies from 10 and below, and it has a slowed turn-on and turn-off time of approximately 15 msec. Therefore, the sine wave stimulation used in the DAVID system does not produce the harmonics that square wave stimulation, and as demonstrated in the studies noted above, sine wave stimulation has been shown not to produce seizures (Siever, 2006). The DAVID eyeset is also tinted in a blue overlay to filter out red light, and uses incandescent bulbs, and blue-tinted white LEDS (Siever, 2006). Earlier eyesets were manufactured to illuminate 0.5 square inches per eye (3.2 cm), a small part of the visual field that makes a bright spot in the middle of the user's vision. This bright spot triggered the brain to become alert in response to this stimulation, and in turn tries to reduce the meditative, relaxed state of the user, and interferes with brain wave entrainment. The Omniscreen eyeset uses a reflective incandescent system that illuminates 2 square inches (13 square cm) per eye, which provides smooth, even illumination. As a result, when the eyes move about the brain will not perceive any changes significant enough to arouse it (Siever, 2006). These eyesets also utilize split field stimulation that allows a different frequency to be stimulated into each side of the brain which is important for treating conditions such as depression, ADD, and cognitive decline in seniors (Siever, 2006). It should be noted that there are no other studies to confirm these findings.

Children with autism have also been found to have greater coherence between hemispheres in the beta band than typically developing children (Coben & Myers, 2010). Children with autism have also displayed higher coherence in the alpha band, and a reduction of inter- and intrahemispheric asymmetry than children who are developing normally, or who are mentally handicapped (Coben & Myers, 2010). These findings reinforce the theory of weak connectivity between the frontal area of the brain, and other portions of the brain (Coben & Myers, 2010). Recent studies have shown that significant changes in brain plasticity have occurred after alpha brainwave training (University of Goldsmiths London, 2010). Researchers at the University of London demonstrated that 30 minutes of NFB is sufficient enough to induce a lasting shift in cortical excitability and intracortical function (University of Goldsmiths London, 2010). Research has shown that autism is a neurological disorder that reveals distinct abnormalities in the brain including the cerebellum, hippocampus, and the limbic system beginning at a very young age (Grandin, 2006; Kabot et al., 2003; Ratey, 2001). It has been demonstrated that there is a poor migration of neurons within the brain of the autistic individuals, and proper migration of neurons is imperative for the normal development of brain functioning (Ratey, 2001). Sensory information coming at the autistic individual from the outside world appears to be too fast for the brain to process, and they are simply overwhelmed by the stimuli (Ratey, 2001). The typical reaction is to shut down or attempt to escape from the stimuli. This is compounded by an inability to pay attention because the sensory information that is received comes in fragments or pieces (Ratey, 2001). Brain autopsy research conducted by Bauman demonstrates that individuals with autism have an immature development of the cerebellum and the limbic system (Grandin, 2006). Low functioning children with autism ages 4-12 have EEG readings that resemble the brain of a 2-year-old, and that the autistic infant brain has shown that there is an excess of brain overgrowth that causes the brain to grow abnormally large between the ages of 1 and 2. However, the brain returns to normal size due to later undergrowth of the brain (Grandin, 2006). Additional research by Minshew demonstrated that normal brains tend to ignore details, while the autistic individual focuses on details instead of the whole picture (Grandin, 2006). To view this phenomenon Minshew had normal and autistic individuals, along with those diagnosed with Asperger's syndrome read sentences while they were in a brain scanner. The autistic brain was the most active in the region of the brain that analyzes individual words. The normal brain was more active in the area of the brain that analyzed the entire sentence, and those with Asperger's syndrome were active in both areas (Grandin, 2006). Courchesne believes that autism may be a disorder of brain circuit disconnections (Grandin, 2006). This would affect the brain's ability to integrate detailed data from lower parts of the brain where the sensory based memories are stored, with higher level information processing occurring in the frontal cortex (Grandin, 2006). Courchesne determined that the only parts of the brain that appear to be normal in the autistic brain are the visual cortex, and the areas in the rear of the brain that stores memories and supports visual thinking (Grandin, 2006). Courchesne theorized that during early development of the child, neuroinflammatory reactions may have resulted in a malfunction of the frontal minicolumnmicrocircuitry, resulting in brain overgrowth that hinders connectivity between units of cerebral processing (Coben, 2007). This would then result in excessive connectivity within the frontal lobes, and restricted connectivity between the frontal cortex and other areas of the brain (Coben, 2007). Furthermore, brain scans have uncovered that the white matter in the frontal cortex is overgrown and abnormal (Grandin, 2006; Kabot et al., 2003). White matter connects input through the different regions of the brain, while grey matter forms the information processing circuits. Rather than growing together at a normal rate, the autistic frontal cortex has an excessive amount of overgrowth much like tangled connector cables (Coben & Myers, 2010; Grandin, 2006). While those with Asperger's syndrome have more neural connections, it has been shown that the development is uneven, thereby resulting in uneven skills (Grandin, 2006). Functional neuroimaging and electroencephalography have supported that the symptoms of autism disorder are the result of brain dysfunction in multiple regions of the brain, and have been shown to be related to abnormal neural connectivity problems where certain areas of the brain are displaying excessively high connectivity, and deficient connectivity (Coben & Meyers, 2010: Kouijzer, 2008).

NFB appears to be helpful in remediating connectivity disturbances, and significantly reducing autistic symptoms (Kouijzer et al., 2008), as demonstrated by Cowen and Markham (1994), Sichel et al. (1995), Jarusiewicz (2002), Ibric and Hudspeth (2003), Scholnick (2005), Kouijzen and deMoor (2008, 2009), Thompson, Thompson, and Reid (2010b), Limsila, Toomin, Kijvithee, Bunthong, PookJinda, and Utairatanakit (2004), Coben (2006, 2007), and Coben and Padolsky (2007). These studies will be discussed in depth. Additionally, NFB seems to have lasting effects in children with ADHD, with improvements documented to for 5-10 years (Coben& Myers, 2010; Coben et al., 2010). In this first formal study utilizing AVE it is theorized that AVE NFB will yield positive results. It is hoped that if this study demonstrates the AVE yields positive results, researchers will continue to monitor children with ASD to determine if the results of NFB are also long lasting, like those of the children with ADHD.

Review of Studies Involving Neurofeedback as a Treatment Modality for Autism Spectrum Disorder

The first case conducted for the treatment of autism with NFB was conducted in 1993 by Cowan and Markham (1994) on an eight-year-old girl diagnosed with high functioning autism (Coben & Myers, 2010). A QEEG analysis indicated an unusually high amount of alpha and theta activity, primarily in the parietal and occipital lobes. NFB treatment focused on reducing the alpha/beta ratio. The girl displayed substantial improvement on the Test of Variables of Attention (TOVA) between her initial assessment on 4/19/1993, and follow up assessment on 5/22/1993 (Cowan & Markham, 1994). The TOVA is a 22-minute continuous performance assessment where the patient attempts to remain focused on a computer display. Every two seconds a “target,” or “nontarget” appears, and the patient is instructed to click a trigger every time that the target appears (Cowan & Markham, 1994). After 21 sessions, the child displayed increased attention span, decreased stereotypic behaviors, and improved socialization as reported by parents and teachers. A 2-year follow up indicated that the improved attention span remained, as assessed by the TOVA (Coben & Myers, 2010).

NFB has been documented with positive results in the case of a child with mild autism (Sichel et al., 1995). The child displayed classic symptoms of autism. He was disinterested in those around him, and did not make social contact or engage in play with his siblings. Vocalization was extremely limited, and he displayed stereotypic behaviors. Brain imaging revealed high theta/beta ratios, which were highest in the parietal and central regions of the brain. The child received neurotherapy treatments, based on collecting the EEG signal, and using this signal as a feedback medium (Graham, 2002). The underlying principle of neurotherapy is to use self-management strategies to help the patient take control of problematic symptoms, cognitive patterns, or behavior (Graham, 2002). Emphasis was placed on the sensory motor strip and the parietal lobe to raise his SMR, and to decrease his theta. After 31 sessions, the child displayed significant behavioral changes. His mother reported that he talked more, and even displayed affectionate behaviors, such as hugging and kissing. He began to attend to, and react to other people, and made more eye contact. He noticed distress in his sibling for the first time, and seeks comfort when he is upset. He imitates and plays with his siblings. He falls asleep easily and appears less anxious, as well as being less shy and withdrawn. Verbalizations remain slow and limited. These findings support the hypothesis that the individual benefits from the therapy by paying attention to the experience of the body, and by learning how to teach his own body to attend to and respond to stimuli (Sichel et al., 1995).

A study conducted by Jarusiewicz in 2002 investigated group differences in the efficacy of NFB for children with autism. Twenty-four children were divided into two groups. They were matched by age, sex, and severity of their disorder. One group received NFB training, and the other was the control group. The children received between 20 and 69 sessions, each thirty minutes in length. All children displayed an abnormal amount of delta and theta. NFB was used to inhibit delta and theta, although adjustments to protocols were made on an individual basis as needed. All twelve children who received NFB demonstrated improvement in their condition based on parental feedback on the Autism Treatment Evaluation Checklist (ATEC). ATEC levels improved significantly after treatment, rising from 8% to 56%, (Jarusiewicz, 2002) or an average 26% reduction in symptoms (Jarusiewicz, 2002).

Ibric and Hudspeth presented another case of an 8-year-old autistic boy treated with NFB in 2003. The boy underwent 40 sessions of NFB training that included theta suppression and alpha enhancement (Coben et al., 2010). The result was improved sleep patterns, aggressive behavior, obsession, and involuntary movements (Coben et al., 2010).

Scolnick conducted a study in 2005 with 10 autistic boys diagnosed with Asperger's syndrome. Five of the boys dropped out of the study before completion. However, the remaining five boys completed twenty-four sessions of NFB, and demonstrated improved behavior as rated by parents and teachers. Yet, the pre- and post-intervention quantitative EEGs indicated a trend toward normalization; the result did not show statistical significance. Scolnick attributed this to the small sample size, and the fact that there was no control group. Scolnick also points out that the subjects were boys approaching puberty, therefore maturation could not be ruled out as a cause for improvement (Scolnick, 2005).

A study conducted in 2007 compared the use of QEEG NFB with individuals with Asperger's Syndrome to individuals with ADD. Initial observations of the EEG in Asperger's revealed showing (theta and alpha) in the right and temporal areas (P4, T6), and sometimes frontally at F3 and F4 (Thompson & Thompson, 2007). Differences were also noted of hypercomodulation between P4, C4, and F4. The children with Asperger's also displayed characteristic patterns as seen in ADD with slowing at C3, Cz, and C4, and/or at F3 and Fz with a "dip" in 13-15 Hz (SMR) across the central region of C3, Cz, and C4 (Thompson & Thompson, 2007). Fifty individuals with Asperger's ranging in age from 5-51 received NFB training, and their results were compared against a group of 100 individuals with ADD to determine if these individuals benefitted to the same extent from NFB as the ADD clients did. Training protocol was for both groups were to decrease the dominant slow wave frequencies while enhancing the 12-15 HZ or 13-15Hz activity. Electrodes were placed at Cz or C4. However, when a full cap was used with Asperger client's assessments also showed excessive slow wave activity at P4, T6, Fz, F3, Fp1. For these profiles, additional training was included at these sites (Thompson & Thompson, 2007). EEG patterns of the Asperger clients resembled patterns of the ADD clients in the central areas, but amplitudes were more extreme. Training for the ADD individuals took between 40-60 sessions, but the training for Asperger's clients averaged 100 sessions. In both groups NFB training produced a consistent decrease in theta/beta ratios with the predominant change being an increase in SMR. Among both groups social interactions improved with the Asperger's children initiating and maintaining some friendships. An increase in IQ of about 10 points was also observed (Thompson & Thompson, 2007). The Asperger children also displayed a reduction in fidgety and impulsive behaviors, tactile sensitivity, and alertness to the outside world (Thompson & Thompson, 2007).

In 2008, a study was conducted with fourteen children aged from 8 to 12 years old, diagnosed with autism. The children received 40 sessions of NFB, and results were compared with a waiting list group. NFB following a training protocol also used to treat ADHD, of reducing theta and increasing beta in the low end of the band. After treatment was completed, children displayed improvements in attentional control, cognitive flexibility, and goal setting (Kouijzer et al., 2008). Results of parent rating scales also identified improvements in social interactions and social skills (Coben, 2010; Kouijzer et al., 2008). This same group received a 12 month follow up by researchers, and it revealed that the changes in executive functioning and behavior were maintained, suggesting that NFB may have long-lasting effects for children diagnosed with autism (Coben, 2010).

Thompson, Thompson, and Reid (2010b.) reviewed the data from a review of 159 individuals who were treated with NFB over a 15-year period. One hundred fifty individuals were diagnosed with Asperger's Syndrome, and 7 were diagnosed with Autistic Spectrum Disorder. The protocol used for most of the participants included decreasing slow wave activity, reducing beta, and increasing fast wave sensotimotor rhythm. The positive outcome included a decrease in difficulties with attention, anxiety, aprosodias, and social functioning. It was also found that there was an increased in academic and intellectual functioning (Thompson, Thompson, & Reid, 2010b). These finding also lend support to the belief that NFB can be a useful and long-lasting component in the treatment of autism (Thompson et al., 2010b). Thompson, Thompson, and Reid (2010a) also support of using biofeedback in conjunction with NFB training, including that learning diaphragmatic breathing of about 6 breaths per minute, (faster in children) gives those individuals with autism a portable stress management technique, and leads to improved heart and breath coherence, influencing the nervous system to seek it's on balance and equilibrium (Thompson et al., 2010a). It should be noted that these case studies were not controlled in any way, and more detailed information is not available (Coben et al., 2010).

The largest case series study was conducted in Thailand with 180 children aged from 3 to 18 (Limsila et al, 2004). The study included a form of NFB called HEG, or cerebral blood flow biofeedback. Following 40 sessions of training over frontal sites, HEG readings indicated an increase in blood oxygenation by 53% (Limsila et al, 2004). Eighty-six percent of the 81 school aged children increased their grade point average (GPA) more than 0.5 points, while only 4% decreased their GPA by more than 0.5%. It should be noted that there were no control groups or assessment for outside interventions (Limsila et al, 2004). This study demonstrated that HEG was easy to use for the children (Limsila et al, 2004). The children appeared to be more comfortable wearing a headband than having electrodes or a helmet placed on their head, or having their eyes and ears covered (Limsila et al, 2004). Sessions were short, starting at 5 minutes and gradually increasing to 20 minutes, and the children were asked to look at pictures or books that they liked, all contributing to the user-friendly atmosphere of using HEG (Limsila et al, 2004).

The largest controlled study was conducted in 2007 by Coben and Padolsky (Coben, 2010). Forty-nine children diagnosed with autism were studied. Thirty-seven children received 20 sessions of QEEG connectivity guided NFB, and the wait-list control group received a broad variety of assessments, including parental rating scales, neuropsychological tests, QEEG analysis, and infrared imaging. The group that received the NFB demonstrated an 89% success rate, based on parental feedback (Coben, 2010). Significant improvements were also noted in comparison to the control group in areas of neuropsychological assessment of attention, executive functioning, visual-perceptual processing, and language functions (Coben, 2010).

Another controlled study was conducted by Coben in 2006 using HEG (Coben, 2010). Forty individuals with autism were non-randomly assigned to one of three groups, and all had previously completed 20 sessions of EEG Biofeedback. Group one consisted of 10 subjects that received near infrared HEG (nirHEG), group two of 18 subjects received a passive infrared treatment (pirHEG), and group three was the wait-list control group consisting of 12 subjects (Coben, 2010). All participants were identified as having frontal system dysfunction based on neurobehavioral, neuropsychological testing, infrared imaging, and QEEG data (Coben, 2010). After HEG treatment, parental ratings indicated an average success rate of 90% (Coben, 2010). There were statistically significant improvements in neurobehavioral and neuropsychological functioning, as these improvements were based on enhancement of brain thermal regulation and reduction in abnormal EEG findings (Coben, 2010). Each type of HEG resulted in different results, with the nirHEG influencing attention, and the pirHEG having more positive impact on emotional control and social skills (Coben, 2010). Additional improvements were reported in communication and social interactions, and a reduction of autistic symptoms.

In 2007, Coben conducted a controlled study of 50 individuals, with 25 randomly assigned to a treatment group and 25 to a wait-list control group. This study focused on intervention for prominent social skill deficits based on a facial-processing model (Coben, 2010). All subjects had previously received some sort of NFB training, and the groups were match for sex, age, handedness, and medication, severity of symptoms, social skills, and visual-perceptual levels. Subjects received QEEG connectivity guided NFB and coherence training, with emphasis over the right posterior hemisphere of the brain. The group that received the NFB demonstrated improvement in visual-perceptual abilities, and significant progress in social skills. EEG analysis of the brain also showed improvements in connectivity, and resulted in improvements associated with visual, facial, and emotional processing (Coben, 2010).

Two studies focused on abnormal Mu rhythms. Pineda et al. (2008) studied 27 children diagnosed with high functioning autism. The study divided 8 children into 2 groups; and experimental group and a control group. The experimental group received 30, 30-minute sessions of NFB with rewards for mu (8-13 Hz), and inhibits for EMG of

30-60 Hz. Parents completed the ATEC that revealed a small improvement (9-13%) in 2 of the participants (Coben et al., 2010). The second study divided 19 children into 2 groups; an experimental group and a control group. NFB treatment was similar to study 1, except that the mu reward was adjusted to 10-13 Hz. The ATEC was again completed by the parents, and the result showed a small improvement in overall ratings (Coben et al., 2010). However, individual participants exhibited improvements in some areas, and a worsening in other areas (Coben et al., 2010). Another study related to mu rhythms was conducted in 2006 by Coben and Hudspeth with 14 children who were identified with having an abnormally high level of mu rhythm. They all received assessment guided NFB that placed emphasis on Mu power and connectivity. QEEG assessment demonstrated that all participants improved significantly on neurobehavioral and neuropsychological measures. Diminished levels of mu were also associated with increased coherence and social functioning (Coben et al., 2010).

A less formal, qualitative study was conducted in 2005 with 8 children. Mothers added NFB to their child's treatment program without making any other changes. The children lived in different states, and treatment was administered by trained NFB practitioners. The number of sessions ranged from "a few" to 40 sessions. Parents were then asked to complete a questionnaire that asked "Did the neurofeedback treatment make a difference? If so, what specifically is different? How is it different?" (Byrne, 2005). Common themes were reported by the families:

1. Decreased stress/frustration, and increased calm.
2. Enhanced family participation and increased participation in family activities.

3. An increase in self-expression of emotions, needs, and thoughts.
4. Increased awareness of self in relation to the external environment.
5. Improved ability and/or quality of verbal expression.
6. Improved scholastic performance or ability in school-based activities.
7. Improved self-confidence in social interactions and situations, and an increase in self-esteem.
8. Increased self-sufficiency with daily living activities and self-care.
9. Others also noticed changes and improvements.

The results of this study demonstrated positive effects of NFB, and parents also reported that it helped to alleviate the level of stress for the parents and other family members (Byrne, 2005).

As discussed in this Literature Review, the protocol used during most of the studies includes decreasing slow theta wave activity, reducing beta, and increasing fast wave sensorimotor rhythm (Kouijzer et al., 2008; Thompson, Thompson, & Reid, 2010). The usual protocol for practitioners utilizing NFB with autistic individuals is to inhibit theta and beta, and to increase alpha brainwaves (Kouijzer et al., 2008; Thompson, Thompson, & Reid, 2010). Children with autism have been found to have greater coherence between hemispheres in the beta band than typically developing children (Coben & Myers, 2010). Children with autism have also displayed higher coherence in the alpha band and a reduction of inter- and intrahemispheric asymmetry than children who are developing normally, or who are mentally handicapped (Coben & Myers, 2010). A 2010 study that analyzed the QEEG findings of 9 children aged 5 years old with ASD showed generally increased delta-theta activity in the frontal area of the brain. More specifically, the brainwave rate measured at location CZ displayed 5.8 which is significantly lower than normal readings, and is attributed to low general mental arousal Hz which is lower than normal and belongs to low theta waves. The slow activity did not change with eyes closed, or eyes open. Also noted was high beta activity (21, 48 Hz) in the central-temporal regions (Pop-Jordanove et al., 2010). These findings reinforce the theory of weak connectivity between the frontal area of the brain, and other portions of the brain (Coben & Myers, 2010). Recent studies have shown that significant changes in brain plasticity have occurred after alpha brainwave training (University of Goldsmiths London, 2010). NFB treatment is focused on reducing the ratio of alpha and theta (Coben & Myers, 2010). Functional neuroimaging studies revealed high theta/beta ratios, which were highest in the parietal and central regions of the brain (Coben & Myers, 2010). Thompson and Thompson (2007) targeted NFB training on sites P4, T6, F3 and F4 where there appeared to excess theta and slowing alpha, and at C3, Cz, C4**.**

Summary

The review of the literature presented NFB as an alternative or complementary treatment for ASD. Through a review of the literature it was hypothesized that there would be a reduction in symptomatology of ASD within or across groups. In summary, 14 studies have been conducted involving NFB as a treatment modality for ASD, and only 5 were controlled studies. Thirteen studies used QEEG connectivity guided NFB, and 2 of the studies utilized HEG. There are no formal studies involving the application of AVE. Of the controlled studies, a total of 180 subjects diagnosed with autism reported positive results as demonstrated by QEEG analysis, parental observations, rating scales, and neuropsychological evaluation. In the noncontrolled studies, all reported positive results ranging from slight to significant based on parental observations, QEEH pre and posttest comparisons, rating scales, as well as the use of the Test of Variable Attention (TOVA), and the ATEC. The protocol for all of the studies included an inhibition of theta and beta, and an increase of alpha. Jarusiewicz (2002) also suppressed delta. Coben (2000) did a 2- year follow-up of his study, and Kouijzer (2009) conducted a 12-month follow-up. Both groups reported maintenance of improved symptoms suggesting that there is preliminary evidence that the effects of NFB on the treatment of autism may be long-lasting (Coben et al., 2010). Positive results or improvement of symptoms referred to a reduction of stereotypic behaviors, an increase in attention, a reduction of stress, anxiety, aggression, obsession, and involuntary movements. The children also displayed an increase in social interactions, greater cognitive flexibility, an increase in communication and eye contact, and an increase in physical contact, such as seeking out a hug when in distress. The Limsila study (2004) in Thailand reflected an increase in school grades, and there were no other measurements or controls.

While these studies appear encouraging, there are a number of limitations that need to be considered before definite conclusions can be made. There are a limited number of studies, lack of controls, limited attempts to control for placebo effects, and a lack of researchers who were blind to the conditions of the studies (Coben et al., 2010). Additionally, sample sizes varied. Three of the studies had only one subject, 3 had less than 10 subjects and 4 more had 14-24 subjects. Five more studies had groups of 24, 40, 29, 50, and 180 subjects. Many of the participants were diagnosed with Asperger's syndrome, with a minority of subjects representing with the more severe symptoms of ASD. In regard to applying these results to the general population, it should be noted that most of the subjects were 6-12 years old, and that there is a lack of representation of subjects who were very young, or adult. Some studies had no controls, and all studies relied heavily on parental observations rendering these studies as symptom based. Future research might focus on measuring brain related changes that may occur as a result of NFB. This would help to substantiate the efficacy and mechanisms of NFB. Additionally, longer follow-up periods should be included to measure the durability of the results.

NFB is presented as an alternative or a complementary treatment for autism. With more research NFB may be viewed as an intervention that may prove to be as efficacious as other therapies, such as ABA, diet, and medications, and should be included in treatment plans. Future clinical work and research might stress the possible synergistic effects between NFB and other interventions.

The majority of the studies employed connectivity guided NFB. This study will contribute to the gap in the literature regarding the use of QEEG NFB, or connectivity guided NFB. QEEG NFB requires active involvement of the individual to interface with the NFB equipment, and requires the person to be aware of the feelings in their body. Electrodes are placed on specific areas of the child's head that measure the child's brainwave activity. The individual is then asked to follow directions, to attend to task, and to be able to respond to auditory or visual cues. Another form of feedback, HEG trains the subject to increase blood flow to targeted areas of the brain (Limsila et al, 2004). A headband called a spectrophotometer is placed around the forehead of the user, and is attached by wires to a computer. The computer program receives reflected light and spectrophotometric measurement of blood oxygenation through the headband, and displays feedback in a visual and auditory form to the user (Limsila et al., 2004). A tone was developed to increase in pitch, and to signify blood oxygenation (Limsila et al., 2004). The user can increase blood oxygenation on demand by attending to the highest note in each trill and will the note to the next higher sound. This type of NFB exercises selected areas of the brain, and increases blood flow to the chosen brain regions. Consequently, capillaries and dendrites grow with this brain exercise (Limsila et al., 2004). HEG may also be difficult for the child to adapt to since they need to be cognizant of their body's feelings in order to increase block flow in the cerebellum. Lastly, AVE unites three modalities, and auditory, visual, and vestibular into a singular intervention gently training brainwaves to fall into a predetermined specific brainwave pattern (Eisenberg, 2010). The individual being treated wears a device attached to glasses and earphones. Flashing lights are coupled with intermittent rhythmic pulsating tones. This has a synergistic effect, compounding the training benefits (Eisenberg, 2010). The lights and sound stimulate the neocortex creating an imprint known as the cortical evoked response (Siever, 2002). AVE appears to influence and train brainwaves in a noninvasive manner using frequencies that are similar to those frequencies used with other NFB techniques (Eisenberg, 2010; Siever, 2004). AVE is a passive form of NFB that does not require any user interaction making it simple to use, and possibly easier to tolerate

(Siever, 2004). AVE could also be used in the treatment of nonverbal or preverbal children, as there are few studies that address the needs of these children (Maglione, et al, 2012). This study will investigate the use of QEEG NFB in the treatment of autism.

Chapter 3: Research Method

Introduction

This chapter explored the possibility that NFB could provide an efficacious alternative or complementary therapy in the treatment of autism. Although formal research has been limited, Chapter 4 of this study reviewed archived brain maps and clinician notes to determine whether NFB resulted in a positive direction in the treatment of autism. Significant results would suggest that NFB could be a viable biological approach for the treatment of autism. The Walden IRB approval number for this study is: 06-08-17-0012761.

Setting

A neurofeedback clinic in Southern California provided archived data for 38 cases of completed courses of treatment, accompanied by a pre- and posttreatment brain maps that were able to quantitatively support the efficacy of NFB as a treatment modality. The clinic was founded in 1980 to provide NFB as a drug-free alternative treatment for ADHD, ASD, depression, anxiety, closed head injuries, and stress-related disorders. They utilize the disciplines of medicine, neuroscience, psychology, and computer science, and has treated over 12,000 patients, claiming that approximately 80% of patients treated achieve significant clinical improvement (Drake, 2018). The key to treatment is to first obtain a brain mapping or QEEG of the patient. The QEEG acts as a guide to identify the specific areas of dysregulation in the brain from which NFB protocols are then developed to enable the patient to strengthen and improve their brain functioning (Drake, 2018).

The students being treated continue to participate in their special education programs as usual. The treatments used in the special education classes include applied behavior analysis (ABA), positive reinforcement, psychology assessments and Individualized Education Programs (IEPs), occupation therapy, speech therapy, and adaptive physical education. Detailed explanations of these interventions are described in Chapter 2. Children diagnosed with autism are protected under the Individual with Disability Education Act (IDEA). IDEA was implemented in 1973 and was amended in 1997 and is a federal law governing all special education services within the United States (deBettencourt, 2002). IDEA cites autism as a qualifying condition for special education programs. IDEA requires that public school districts provide a free, appropriate education for students with disabilities (deBettencourt, 2002). IDEA also requires that measurable annual goals and objectives be written into a student's Individual Education Program. (IEP) (deBettencourt, 2002).

Instrumentation and Materials

The brain map, or QEEG, is a noninvasive test where scalp sensors record the brain wave activity in several ways: timing, amplitude, asymmetry, coherence, and phase. This information is sent through a software program that converts the brain wave activity into numbers. These numbers are then statistically analyzed and transposed into corresponding color codes onto brain images. The program compares the data to averages in a FDA database that represents the normal population (Rodrak, & Wongsawat, 2013).

According to Dr. Velkoff, brain mapping of autistic patients has shown an abnormal pattern of connectivity or coherence in the areas of the brain that support language, typically a core deficit in autism. Dysfunctional patterns are also often found in the right posterior region of the brain that is involved in understanding nonverbal social cues. For patients diagnosed with autism, these regions are a high priority for analysis, and brain map-guided treatment programs are key to strengthening these imbalances. The brain map allows the clinician to truly know if the symptoms are neurologically based or psychological or behavioral (Drake, 2018).

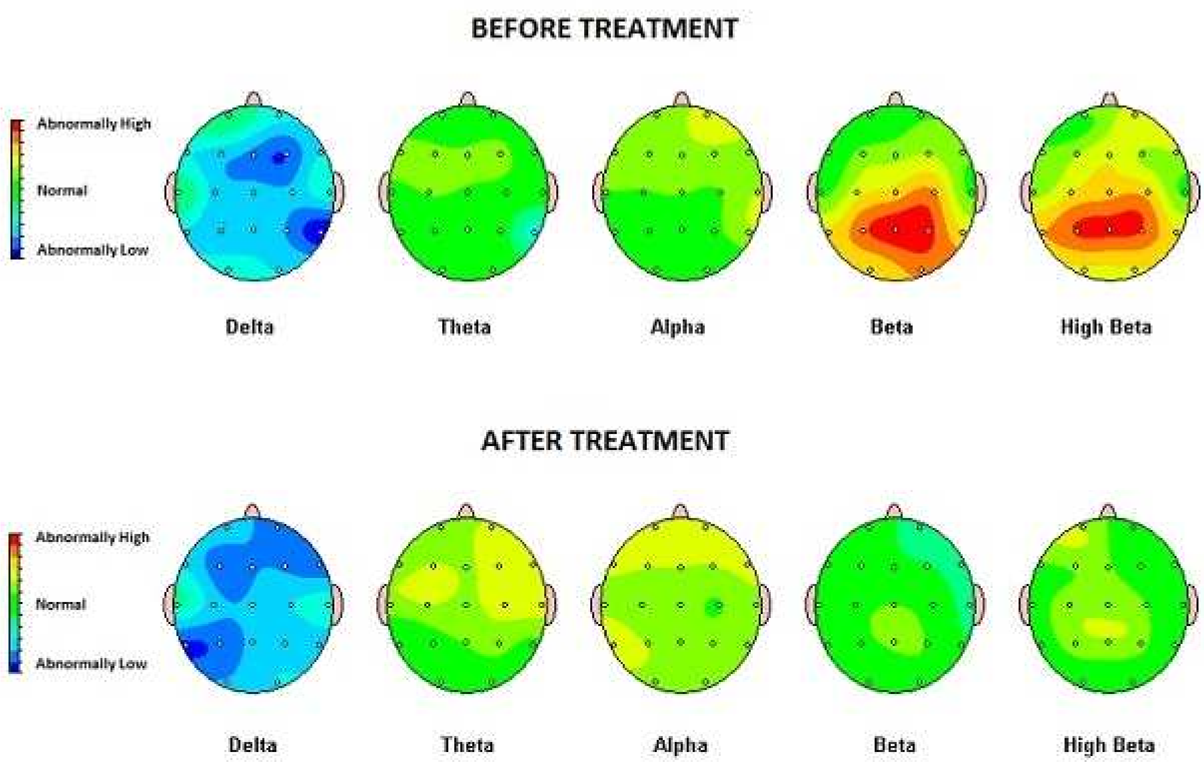

Figure 4. Brain mapping of a patient diagnosed with autism spectrum disorder before and after treatment. The pretreatment brain map shows the hyperarousal of the language area of the brain (left posterior), and the right posterior of the bran that is associated with understanding social cues. (Drake, 2018).

The children diagnosed with autism received 42 QEEG NFB treatment sessions using equipment and software that provides both auditory and visual feedback. Brain wave patterns are transmitted by electrodes placed on certain areas of the scalp, and these sensors are then connected to the computer. The child pays attention to their own brain wave activity by playing a game and responding to the reward or inhibiting feedback provided by the computer. The child learns to change their brain wave patterns and eventually control them. Dr. Orlando of the Tampa Bay Institute for Autism Research and. Rivera, M.A., also from the Institute for Autism Research, report that the more successful the child is while playing the games, the more control they gain in changing their brain wave patterns. Brain maps were collected before treatments began and after treatments ended. The NFB equipment collected the raw EEG patterns and compared them to validated norms to compose the brain maps. The brain maps then served as a guide to establish protocols of where to place electrodes on the scalp to attempt to normalize brain wave patterns (Orlando & Rivera, 2004). Their progress can be tracked through the use of pre- and post-NFB brain maps.

Figure 5. A patient during a neurofeedback session. Electrodes are placed on the scalp over the abnormal areas recording brainwaves, and then displaying them on the computer screen in the form of a game. Here, the brainwaves are converted into a computer game of a car driving down a road. When the brainwaves shift into a faster, healthy frequency, the car begins to speed up and an auditory sound is heard. This feedback is triggered every half second the patient maintains this improved response. With continued practice, the patient will be able to integrate this behavior into their everyday life until it becomes their natural state. Neurofeedback can lead to long term improvement by using a learning process that strengthens and develops the synaptic connections in the brain (Drake, 2018).

Research Design

This study entailed utilization of a mixed method sequential explanatory design that reviewed two types of archived data: quantitative data gathered from pre- and post-brain maps, and qualitative data gathered from clinician notes and interviews. Mixed methods research allows for the collecting and analysis of statistical data and narrative data to arrive at a more complex understanding of the research question (Creswell & Plano Clark, 2007). In 2006, the APA Presidential Task Force on Evidence Based Practice supported a policy of endorsing the value of using a diversity of research methods, both quantitative and qualitative (Wiggins, 2011). In a sequential model the researcher advocates which method will be the primary in the study and then determines if the complementary method will support and supplement the research data of the primary method (Wiggins, 2011). Additionally, the explanatory and confirmatory method fosters a less polarized view toward the laws and principles of research (Wiggins, 2011). In this study, the brain mapping quotients were the quantitative elements of the study, and the qualitative part of the study included clinician notes and information obtained through clinician interviews.

Research Questions and Hypotheses

The quantitative research question and hypotheses were as follows:

RQ1: Do children treated with QEEG NFB display a significant improvement in normalized brain wave activity after treatment, as demonstrated by pre- and post-brain maps?

$H_0$1: There is no significant difference in brain wave activity as measured by QEEG brain maps pre- and posttreatment.

H_a1 There is a significant difference in brain wave activity as measured by QEEG brain maps pre- and posttreatment.

The qualitative research question and hypotheses were as follows:

RQ2: Do children diagnosed with ASD display a significant reduction of pathological symptoms after treatments with NFB as reported by clinicians?

$H_0$2a: There is no difference in social interactions.

H_a2a: There is a difference in social interactions.

$H_0$2b: There is no difference in communications skills.

H_a2b: There is a difference in communications skills.

$H_0$2c: There is no difference in restricted interests.

H_a2c: There is a difference in restricted interests.

$H_0$2d: There is no difference in repetitive behaviors.

H_a2d: There is a difference in repetitive behaviors.

$H_0$2e: There is no difference in eye contact.

H_a2e: There is a difference in eye contact.

$H_0$2f: There is no difference in in tantrums.

H_a2f: There is a difference in in tantrums.

$H_0$2g: There is no difference in display of affection.

H_a2g: There is a difference in display of affection.

$H_0$2h: There is no difference in sleep patterns.

H_a2h: There is a difference in sleep patterns.

$H_0$2i: There is no difference in hypersensitivity.

H_a2i: There is a difference in hypersensitivity.

$H_0$2j: There is no difference in aggressive behaviors.

H_a2j: There is a difference in aggressive behaviors.

Data Collection and Analysis

Information was gathered from archived data including brain mappings and clinician case notes, as well as clinician interviews. The data gathered from the brain mappings from the participating clinic were statistically compared for treatment significance. Examples of feedback gathered from clinician interviews or notes focused on behavior changes that occurred during or after NFB treatment. Examples of changes included whether children were better able to interact with others, improvements in speech and communication, a change in frequency and recover times from tantrums, a change in stereotypic behaviors, and whether or not there was a change in academic performance. Treatment effectiveness was analyzed using binomial expansion (BE), as BE offers the ability to assess individuals, small groups, and programs, and it makes no assumptions in reference to underlying distributions (Chynoweth, Blankinship, & Parker, 1986).

Participant Safety

Information for this study was gathered from archived data and clinician reports. Therefore, there are no risks or adverse effects associated with this study. The participating clinic signed a consent form to allow use of their archived records. Patients' identities are protected by using a number to identify each patient.

Summary

Chapter 3 provided research method information including specific measures used during the study regarding the efficacy of AVE in the treatment of autism.

The research question for this study was: Do children diagnosed with ASD display a significant reduction of pathological symptoms after treatments with AVE as reported by practitioners, parents, and/or teachers? All children were also receiving other therapies, with the most common therapy being ABA. Due to the lack of prior research it is impossible to isolate the effect of AVE and there are no control groups. Children are being compared to the parental report of improvement before and after AVE. Symptoms to be assessed are categorized into four areas including; speech/language/communication, sociability, sensory/cognitive awareness, and health and physical behavior.

Null Hypothesis: There will be no difference in pathological symptoms of autism after AVE treatments as reported by practitioners, parents, and/or teachers? The main characteristics of pathological symptoms are impairments in social interaction, impairments in communication, restricted interests, and repetitive behaviors such as hand flapping, head rolling, or body rocking. All children participating in this study also attend special education classes, however, this is not being considered as part of this study. Special education treatments include: Applied Behavioral Analysis (ABA), positive reinforcement, psychology assessments and IEPs, occupation therapy, speech therapy, and adaptive physical education.

Alternative Hypothesis: There will be a reduction in pathological symptoms associated with autism. Pathological symptoms include impairments in social interaction, impairments in communication, restricted interests, and repetitive behaviors such as hand flapping, head rolling, or body rocking. All children participating in this study also attend special education classes. Special education treatments include: Applied Behavioral Analysis (ABA), positive reinforcement, psychology assessments and IEPs, occupation therapy, speech therapy, and adaptive physical education.

Chapter 4 will present the data and testimonials collected for this study, and Chapter 5 will include an overview of the study, the interpretations of the results, including implications for social change and recommendations for future studies.

Chapter 4

The purpose of this mixed method study was to ascertain whether exposure to NFB has efficacy as a therapeutic modality with children diagnosed with ASD to reduce pathological symptoms associated with the condition. Negative symptoms include staring at lights, repetitive blinking, moving fingers in front of eyes, finger-snapping, ear tapping, hand flapping, rubbing skin with objects, rocking, licking of objects, head banging, or sniffing at objects or people. These children may have serious difficulties in relating to and communicating with other people, including gesturing rather than speaking to indicate needs, averting eye contact, echolalia, unresponsiveness to simple commands, delayed speech, and apparent deafness. There may be extreme mood swings for no apparent reason such as uncontrollable crying or laughing, screaming, aggressive behavior, self-injurious behaviors, attachment to unusual objects such as a piece of string, sleep difficulties, and difficulties in changing routines (National Institute of Health, 2011). Data and feedback for this study was shared with this researcher in the form of practitioner reports, parental feedback, and teacher reports from a mental health clinic in Southern California. Ten parents completed the ATEC pre- and posttreatment and shared their experiences with me. One ATEC was not used because the evaluation was incomplete. This researcher contacted parents by phone or e-mail asking if they would be willing to share the results of their treatments. This researcher also examined pre- and post-brain maps from 38 former patients. Brain maps were provided from archived records along with clinician notes. Patients received 25 to 206 sessions. The sessions lasted approximately 30 minutes each. The clinic recommends a minimum of 42 treatment sessions to obtain clinical improvement.

The Autism Evaluation Checklist

ATEC was developed in 1999 to assess the effectiveness of treatments for autism (Rimland & Edelson, 2000). The ATEC is a one-page checklist that rates the severity of the core symptoms of autism as reported by parents, allowing them to track how well their child is progressing over time. Unlike other assessments that simply diagnose autism, the ATEC is sensitive enough to measure changes in the child's condition to determine the efficacy of the treatment being utilized. The ATEC scores 77 items and is divided into four sections consisting of (a) speech/language/communication, (b) sociability, (c) Sensory/Cognitive Awareness, and (d) health/physical/ behavior. The Autism Research Institute developed an Internet scoring procedure that computes the scores for each subset and then computes a total ATEC score indicating the severity of the disorder. The ATEC was normed in 2000 based on the first 1,358 forms that were submitted to the Autism Research Institute by mail, fax, or online. The Pearson split-half coefficients reflecting internal consistency of each subscore was reported as follows: (a) speech/language/communication, .920; (b) Sociability, .836; (c) sensory/cognitive awareness, .875; and (d) health/physical/ behavior, .815, with a total ATEC score of .942. This demonstrates that the ATEC is a reliable measure with strong internal consistency indicating that the items measure the same realm of behavior, and that pretreatment scores may be reliably compared with posttreatment scores. Although the ATEC is not nationally normed, the validity of the ATEC is supported by a number of studies related to autism and NFB, including Jarusiewicz (2002), Pineda et al. (2008), Coben and Myers (2009), and Coben and Padolsky (2010). A more recent 2013 study compared the Childhood Autism Rating Scale (CARS) with the ATEC. The CARS is a well-established instrument with good psychometrics, and the study revealed a significant correlation between the CARS and the ATEC (Geier, Kern, & Grier, 2013). Independent studies revealed that the CARS correctly identified 98% of the children in the study, and that it correlated (r = .67) with the Autism Behavior Checklist (Greier et al, 2013).

Scoring of the Autism Evaluation Checklist

The ATEC is a one-page checklist that is very simple to fill out. The person completing the checklist will simply check off for some questions whether a statement is "not true," "somewhat true," or "very true." For other conditions such as bed-wetting or aggressive behavior, the person completing the checklist would indicate if this condition is "not a problem," a "minor problem," a "moderate problem," or a "serious problem." The scores range from 0-180, and the lower the score indicates a better outcome (Rimland & Edeleson, 2000). The scores of the response and corresponding subscale are weighted, and the higher subscale and total score indicates that the child is more severely impaired, whereas the lower the subscore and total score indicates that the child is less impaired (Geier et al, 2013). Table 4 describes the meaning of the scores:

Table 4

Meaning of ATEC scores.

Percentile	ATEC score
mild autism 0 – 9	0 – 30
10 – 19	31 – 41
20 – 29	42 – 50
30 – 39	51 – 57
40 – 49	58 – 64
50 – 59	65 – 71
60 – 69	72 – 79
70 – 79	80 – 89
80 – 89	90 – 103
90 – 100 severe autism	104 – 180

(Rimland & Edelson, 2000)

The important benchmarks in scoring are as follows:

- ATEC < 30. This level places the child in the top 10th percentile. A child with score of less than 30—or, better still, less than 20—would have some ability to conduct normal, two-way conversations and more or less behave normally. Such children have high chances of leading normal lives as independent individuals.
- ATEC < 50. This places the child in the 30th percentile level. The child has good chance of being semi-independent. More importantly, the child will not likely need to be placed in an

institution. For many parents of autistic children, being able to achieve improvement up to this level is already considered very significant.

- ATEC > 104. Even though the maximum score is 180, any person with a score of more than 104 would already be in the 90th percentile and be considered very severely autistic." (Rimland & Edelson, 2000).
- Note that the scores are not evenly distributed, indicating that the scores for improvement are not as indicative as the final score. Therefore, a child diagnosed as moderately autistic whose scores improve from 45 to 5 is preferable to a severely autistic child whose scores improve from 180 to 80 (Autism Research Institute, 2014). The ATEC is not copyrighted and is available without charge from the Autism Research Institute website: http://www.autism.com/ind_atec_survey.sap (Autism Research Institute, 2014; Greier et al, 2013).

These score distributions demonstrate normative data that allow comparison of baseline scores from scores obtained later, or from one individual to another. The lower the scores, the better the efficacy of treatment (Rimland & Edelson, 2000).

Procedure

The completed before and after ATEC forms were scored on-line by the Autism Research Institute at www.autism.com/ari.

Table 5

ATEC: Autism Evaluation Checklist: Prescores and Postscores

Name	Pre	Post	
JP	69	16	+53
ER	84	41	+43
AL	50	27	+23
HA	55	23	+32
AG	60	32	+28
JC	48	43	+5
ES	45	43	+2
RS	86	25	+61
DV	68	47	+21

JP		Pre	Post
I	Speech/lang/commun	12	2
II	Sociability	21	3
III	Sensory/cognitive aware	16	4
IV	Health/physical BX	20	7
	Subscale totals	69	16

ER		Pre	Post
I	Speech/lang/commun	6	3
II	Sociability	24	8
III	Sensory/cognitive aware	20	15
IV	Health/physical BX	34	15
	Subscale totals	84	41

AL		Pre	Post
I	Speech/lang/commun	6	0
II	Sociability	15	9
III	Sensory/cognitive aware	16	10
IV	Health/physical BX	13	8
	Subscale totals	50	27

(table continues)

HA		Pre	Post
I	Speech/lang/commun	8	3
II	Sociability	9	4
III	Sensory/cognitive aware	16	5
IV	Health/physical BX	22	11
	Subscale totals	55	23
AG		Pre	Post
I	Speech/lang/commun	9	2
II	Sociability	11	6
III	Sensory/cognitive aware	13	6
IV	Health/physical BX	27	18
	Subscale totals	60	32
JC		Pre	Post
I	Speech/lang/commun	5	5
II	Sociability	10	10
III	Sensory/cognitive aware	13	12
IV	Health/physical BX	20	16
	Subscale totals	48	43
ES		Pre	Post
I	Speech/lang/commun	6	4
II	Sociability	16	16
III	Sensory/cognitive aware	20	20
IV	Health/physical BX	3	3
	Subscale totals	45	43

(table continues)

RS		Pre	Post
I	Speech/lang/commun	22	4
II	Sociability	18	3
III	Sensory/cognitive aware	22	9
IV	Health/physical BX	24	9
	Subscale totals	86	25

DV		Pre	Post
I	Speech/lang/commun	2	1
II	Sociability	17	10
III	Sensory/cognitive aware	14	11
IV	Health/physical BX	35	25
	Subscale totals	68	47

The above table conclusively shows that there was a marked increase in all levels of functioning among all participants. In Subscale I, speech/language/communication, eight participants demonstrated improvement, and one remained unchanged. In Subscale II, sociability, seven participants showed improvement, and two remained unchanged. In Subscale III, sensory/cognitive awareness, eight participants demonstrated improvement and one remained unchanged, and on Subscale IV, health/physical/behavior, eight participants showed improvement and one remained unchanged.

Brain Mappings

Information about an individual's brain waves are gathered through a quantitative electroencephalogram (QEEG) that measures the electrical activity of the brain. A QEEG is an FDA approved, evidence based diagnostic tool that evaluates a person's brain waves. A brain mapping is conducted by having the individual wear a cap that has sensors attached to it. These sensors measure the electrical current in various parts of the brain. The procedure is non-invasive and painless. The brain waves are then compared to a normative database to determine where there may be differences as compared to the normal sample (Denver Center of Psychotherapy, 2018).

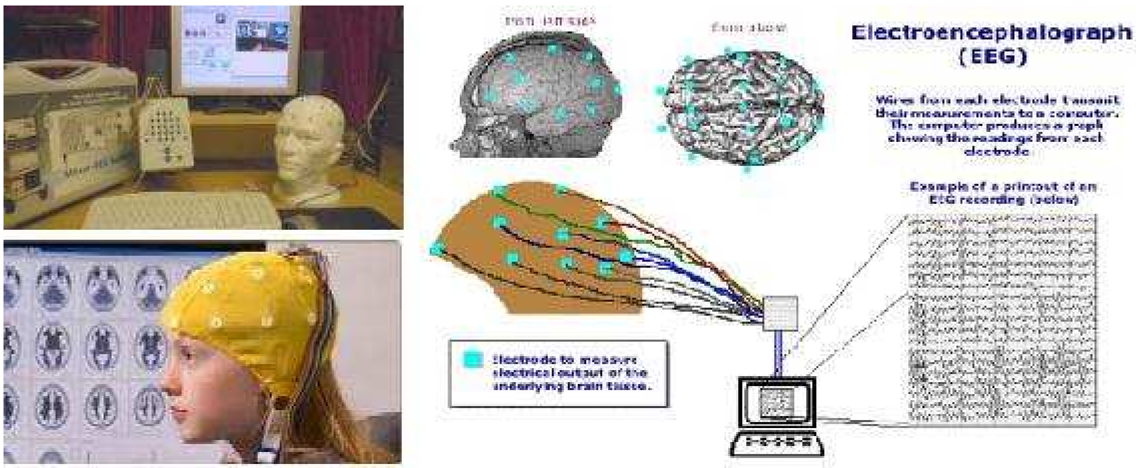

Figure 6. Picture of person undergoing brain mapping. (http://www.edmontonneurotherapy.com/Edmonton_Neurotherapy_QEEG_brain_mapping.html). The computer analysis of the brain wave activity allows it to identify areas of the brain that may be under functioning or are overactive. These areas are further identified by indicating the standard deviation of that area.

Thirty-eight brain maps were used for this study. Patients ranged in age from 5 to 21 years-old, and the number of treatment sessions ranged from 25 to 206. Treatment sessions averaged 30 minutes in length. Patients averaged 3 sessions per week. Protocols for treatment were prescribed by the medical director and were based on the individual’s brain mapping. Treatments included NFB, and some patients received a form of neuromodulation based on NFB called Neurofield.

Neurofield

Neurofield is a specialized form of neurotherapy that combines neurostimulation modalities such as pulsed electromagnetic field stimulation, transcranial direct current stimulation (tdcs), transcranial alternating stimulation (tacs), and transcranial random stimulation (trns) with EEG NFB (Oberman, Rotenberg, & Pascual-Leon, 2015). The mild electromagnetic stimulation assists the brain waves in moving from abnormal patterns to healthier and more stable patterns, as well as enhancing neuroplasticity (Drake, 2018). Neurofield can be very beneficial for people who find it difficult to generate normal brain wave patterns on their own. Neuromodualtion is a passive application that can bypass this difficulty by stimulating brain functioning into a healthier balance that can be reinforced by NFB to stabilize improvements (Drake, 2018).

This researcher counted the number of abnormalities revealed in the pre-treatment brain mapping to the number of imbalances indicated on the post brain mapping. The difference as a group was evaluated with the Binomial Expansion (BE), as BE offers the ability to assess individuals, small groups, and programs, and it makes no assumptions in reference to underlying distributions (Chynoweth et al., 1986).

Table 6

Brain Mappings: Pre and post treatment scores.

	ID #	Age	Level	# TX	NFD	Before	After	Difference	Reversal?
1	808	8	3	58	no	323	115	208	No
2	128	5	1	49	Yes	47	53	-6	Yes
3	011	5	2	40	no	79	145	-66	Yes
4	807	6	2	173	Yes	183	132	51	No
5	876	6	2	61	Yes	47	132	-85	Yes
6	811	6	1	37	no	239	263	-24	Yes
7	901	8	3	42	No	167	52	115	No
8	305	8	3	206	No	287	158	129	No
9	314	8	2	38	Yes	103	37	66	No
10	141	8	2	104	No	23	96	-73	Yes
11	194	8	3	42		75	72	3	No
12	721	8	2	64	Yes	199	97	102	No
13	960	9	2	47	Yes	44	102	-58	Yes
14	085	10	1	48	No	25	36	-11	Yes
15	239	10	2	42	No	89	145	-56	Yes
16	105	11	2	50	Yes	37	27	10	No
17	131	11	1	46	Yes	460	276	184	No
18	972	11	2	42	Yes	186	53	133	No
19	042	13	2	32	No	102	39	63	No
20	101	13	1	67		178	161	17	No
21	124	13	1	48	No	304	490	-186	Yes
22	735	13	3	38	Yes	154	66	88	No
23	741	14	3	48	Yes	532	186	346	No
24	948	14	1	47	yes	161	63	98	No
25	125	15	2	56	Yes	113	85	28	No
26	494	15	3	34	no	98	40	58	No
27	855	18	1	42	no	26	44	-18	Yes
28	996	18	1	48	No	229	101	128	No
29	890	18	2	54	Yes	412	141	271	No
30	071	21	3	49	No	149	154	-5	Yes
31	712	5	1	42	Yes	142	67	75	No
32	562	10	1	32	Yes	18	25	-7	Yes
33	405	8	2	42		88	58	30	No
34	096	10	2	84	Yes	171	120	51	No
35	186	15	2	48	Yes	13	233	-233	Yes
36	799	9	2	47	yes	32	69	-37	Yes
37	267	21	2	25	Yes	123	12	111	No
38	469	12	3	47	Yes	250	204	46	No
									14 reversals

Thirty-eight brain maps were evaluated pre and post NFB treatment. Twenty-four individuals showed a reduction in dysregulated brain waves, and 14 individuals did not show an improvement after treatment. Using a binomial on-line calculator, we can calculate the binomial probability of getting successes in a specific number of trials. The binomial expansion formula:

$$P(X = x) = {}^{n}C_{x}\, p^{x}(1-p)^{(n-x)}$$
$$x = 0, 1, 2, .., n$$

Where *n* = Number of events, *x* = Number of success, *p* = Probability (Stattrek.com, 2018).

The binomial expansion looks at whether reversals took place, regardless of their size. In this case we count 14 reversals out of 38 cases. We ask ourselves the question about the chance that 14 or less reversals would have been observed in the case that every single reversal is just due to the chance. Using a calculator for binomial expansions and probabilities, we find that under the assumption that a reversal is simply due to chance (p=0.5, coin tossing), then the probability of 14 or less reversal out of 38 subjects = 0.0717 or 7.17% (Stat Trek, 2018).

In conclusion, the probability of seeing at most 14 reversals, if each reversal is simply due to chance and the treatment were irrelevant, would be just a little more than 7%. Therefore, NFB appears to have a significant impact as a treatment for autism.

Clinical Reports

Twenty-four brain maps showed improvement post treatment. Practitioners and parents reported observing significant improvements in their children after treatments.

Practitioners claimed that NFB worked more quickly and was more effective on the children who had Asperger's syndrome, or were higher on the autism spectrum. This observation has been noted for all therapies, and outcomes for therapy for those diagnosed with Asperger's syndrome are better than those diagnosed with classical autism (Venkat et al., 2012). The most common problems that parents complained about were anxiety, aggressive behaviors, sleep disturbances, language difficulties, and a lack of social awareness. The first area where all described significant improvement was a decrease in worry and anxiety. Before treatments practitioner notes, and parents and teacher testimonies described aggressive behavior, anger, tantrums, screaming, hyperactivity, and anxiety and obsession with objects. After NFB children exhibited a decrease in hyperactivity, less oppositional behavior, and a decrease in tantrums. Parents also stated that their children appeared to be happier and were able to transition easier from one activity to another. Parents also reported less screaming, a decrease in fearfulness. They stated that their children were better able to slow themselves down and recover from fits of anger. They also reported less fixation on objects for hours on end. Nine children exhibited violent behaviors and had caused damage by throwing things and breaking things, hitting, kicking, pinching, and scratching. Some parents reported that were afraid their children would seriously hurt them, or their siblings. After treatment, all nine children were calmer. Reports of continued aggressive behavior were rare. Children who experienced daily tantrums and meltdowns now ranged from no meltdowns to 2 or 3 per week. The remaining meltdowns were reported to be less intense, shorter in length, and the children were able to recover more quickly.

The next area of improvement that parents cited most was an improvement in sleep. A study supported that children with ASD are more likely to have sleep disturbances than typically developing children (Humphreys et al., 2013). The study reported that these children slept 17 to 43 minutes less each night, starting at the age of 30 months, and lasting throughout childhood (Humphreys et al., 2013). Children with ASD also experienced significantly more episodes of frequent wakening of more than twice per night from the age of 30 months and this also lasted throughout childhood (Humphreys et al., 2013). Other sleep problems reported by parents included early morning wakening, lack of sleep routine, nightmares, and reduced sleep duration. Sleep disorders have been linked to increased autistic symptoms and have a negative effect on daytime behavior and learning (Humphreys et al., 2013). Parents reported that after exposure to NFB their children were able to fall asleep more easily and were able to sleep through the night. Parents also reported a decrease in sleep walking and sleep talking, fewer nightmares, and increased dream awareness. Since children were sleeping better they had more energy during the day.

There were also reported improvements in health. A few parents reported that their children experienced sensory deficits, and some had a high tolerance for pain. After NFB parents reported more pain and body awareness. Children appeared less sensitive to lights and sounds. Parents also stated that their children's appetite improved, that they were aware of the feeling of hunger, were less picky about foods, and that they exhibited a decrease in involuntary regurgitation. Other improvements in health included decrease in self-injurious behaviors, less teeth-grinding and nail biting, and an improvement in balance and coordination.

The greatest area of improvement after NFB treatments were in the areas of sociability and behavior. Most often reported by parents was a decrease in social isolation, and ability to sit for longer periods of time, talking more and sharing in conversation about daily activities. Children who were previously unwilling or unable to remember activities were actually initiating conversations. Parents and teachers stated that their children were making better eye contact, appeared to be more socially aware, displayed an increase in emotional tolerance, and were better able to interpret feelings and emotions. The children appeared happier and more motivated and were seeking out activities and play dates. A few parents cited specific improvements such as less running away from staff at school, having an easier time getting on and off the school bus, less stealing, and being less grabby and huggy with people. One parent reported that her child now always had someone to sit with at the lunch table, and always had someone to play with on the playground. Another parent reported that she witnessed her child comfort another crying child on the playground. In general, parents and teachers reported being able to correct, criticize, or give instructions to the children without triggering a tantrum.

All children displayed an improvement in academics, specifically related to impaired abilities to concentrate and focus. Parents reported that their children were less distracted, had better visual tracking and clearer thinking. Their language abilities also improved. Children not only spoke more clearly, but they also formed longer sentences, had better speech annunciation, and appeared to better process information. Twenty-two children in this study were reported to have difficulty in participating in a reciprocal conversation. After treatment, 18 children were able to carry on a conversation with others. Two of these children were able to give presentations to their classes. Four children who were Level 3 reported an increase in words but were still not able to converse. Two of these children learned sign language and used writing to help them express themselves. In reading, children were better able to remember sight words, and better able to decode words, all of which resulted in an improvement in reading ability. Parents also reported an improvement in handwriting, as well as an ability to do touch addition. They also reported improved cognitive flexibility, an increased ability to follow instructions in a small group, and improved cooperation in the classroom. One boy displayed an increase in creativity as he began to play with Legos and started to conceive his own designs. All children experienced an improvement in grades. Three children improved so much that they were mainstreamed in regular classes and were taken out of class a couple of hours each day for remedial instruction.

There were 14 brain maps that did not show improvement post-treatment. However, the parents of all 14 children reported clinical improvements.

No. 141. This child was an 8-year-old male diagnosed with ASD Level 2. The child received 104 treatments. Primary concerns before treatment included poor social interaction, lack of interactive play, robotic behaviors and vocal tone, lack of expressive language, inability to have a reciprocal conversation, a preference for sameness, repetitive behaviors, and rigid attitude. After treatment the child I reported to be calmer, happier, and more emotionally stable. Before treatment the child would experience bouts of unprovoked laughing or crying 4-5 times per week. After treatment they reduced to one per week. The child interacted more with others, would greet people appropriately without being prompted, and started communicating more. The child was able to engage in conversation with others, using more words, and speaking in complete sentences. The child's voice also lost its robotic tone. The child also seemed to comprehend more when people were speaking to him. Additionally, the child was less fidgety, was more willing to try new foods, and was able to pick out his own clothes.

No. 239. This is a 10-year-old female diagnosed with ASD Level 2. Primary concerns before treatment included poor social skills, difficulty with expressive language, including stuttering, anxiety, lack of focus, and fixations. After treatment the child was calmer and less anxious, more expressive, and stuttered less. The child was also more independent and was doing her homework on her own and was easier to redirect.

No. 071. Parents brought their 26-year-old son in for treatment because he was becoming violent. Their son would hit, throw things, and break things when upset. The parents were afraid for their safety, and their doctor recommended that they institutionalize their son. Their son was diagnosed as Level 3, and was nonverbal, demonstrated stereotypic behaviors such as hand flapping, was rigid, had obsessions, and ha meltdowns when upset. He would also bite himself when frustrated. After 49 treatment sessions the son was calmer and was no longer violent. He was able to say some words but learned to communicate through sign language and writing. His father taught him mechanics, and he was able to work in his father's business. He was also able to take care of his basic needs, such as showering, dressing himself, and preparing simple meals.

No. 799. This child is a 9-year-old male who was diagnosed with ASD Level 1. Before treatment he had little social awareness. He did not make eye-contact with people, did not engage in conversations, preferred to isolate himself, fails to say “hello” or “good-bye,” disliked being held or cuddled, and was not aware of his environment. After treatment he was playing more with his siblings, talking more, more aware of his environment, and seemed to be comprehending better.

No. 128. This was a 5.5-year-old male who was diagnosed ASD Level1, and was presenting with aggression, hyperactivity, impulsivity, and poor social skills. After 49 treatment sessions the child stopped having violent episodes at home and in school. His frustration tolerance also increased. The child was also more focused and was learning to write his name.

No. 085. Parents brought their 10-year-old son in for treatment to address anxiety, hyperactivity and impulsive behaviors, stereotypic behaviors, and lack of social awareness. The child had echolalia, poor language skills, and was unable to engage in a reciprocal conversation. After 48 treatments the child was calmer, had less anxiety and was pacing less, was listening better, and seemed more aware of his surroundings. He was also repeating less and was able to engage more in conversations. He was sharing more, and able to express his emotions. Additionally, he was able to focus better, and was putting things away, and cleaning up after himself.

No. 876. This child was 6-years-old, and was diagnosed with ASD Level 2, and a sensory processing disorder. He completed 61 sessions of NFB. Primary concerns included anxiety, aggressiveness, hyperactivity and impulsivity, difficulty with expressive language, and the child was not able to engage in a reciprocal conversation. He had meltdowns, eloped from his classroom, had limited food choices, and would scream when frustrated. After treatment parents reported that the child was calmer, less impulsive, less aggressive, and was having fewer meltdowns. He was focusing better, and able to follow verbal directions with multiple steps. The child started to socialize with other children, and his language skills improved. The child was able to speak in full sentences, but still had difficulty engaging in conversations. The child's fine motor skills improved, and he was able to hold and cut with scissors in school. The child still continued to scream when frustrated.

No. 124. This child was 13-years-old and completed 25 treatment sessions. He did not recognize social cues, did not have any friends, and would invade people's personal space by getting within 2 inches of their faces. He also had stereotypic behaviors and anxiety. After treatment the child was less anxious and was pacing less and stimming less. His sleep improved, and he had more energy and enthusiasm. His parents also reported that his expressive language skills improved, and he was starting to engage in reciprocal conversations.

No. 960. This male was 9-years-old and was diagnosed with ASD Level 2. This child was defiant, had anxiety, sensory issues, poor eye-contact, lack of social interaction, and had meltdowns. After 47 treatment sessions his tantrums decreased from daily to once per week, and they were less intense and shorter in duration. The child was chewing less on his clothes. The child was getting along better with his brother, and he made a friend at school. Parents also reported that he was more compliant and had a more positive attitude.

No. 011. This child is a 5-year-old female diagnosed with ASD Level 2, and she completed 40 treatment sessions. Primary concerns included tantrums, hyperactivity and impulsivity, difficulty with focus and attention, and problems with receptive and expressive language. After treatment the child was calmer, having fewer tantrums, and was more compliant. She was able to understand more, and her expressive language skills were improving as she was demonstrating spontaneous speech. She was also able to focus better and learned how to tie her shoelaces with less frustration. She was engaging in imaginative play and was easier to redirect. Parents reported that she continued to scream when frustrated and would elope from school.

No. 855. This is an 18-year-old male diagnosed with ASD Level 1. This individual was presenting with anxiety, an inability to understand social cues, ritualistic behaviors, isolating from others, echolalia, an inability to sustain a reciprocal conversation, poor eye contact, motor tics (skin picking), and vocal tics. After completing 42 treatments the pt was less anxious, was able to maintain eye contact, was more verbal, more aware of his surroundings, his tics were reduced, and he was more organized. A few months after completing the treatment the mother called the clinic to tell them that her son graduated high school, had given a business presentation and won an award for his business concept, and was accepted at college as a math major. They went on a trip to China where her son socialized with family members, tried new types of foods, and initiated conversations with others.

Summary

The research questions for this study were:

RQ1: Do children treated with QEEG NFB display a significant improvement in normalized brain wave activity after treatment, as demonstrated by pre- and post-brain maps?

RQ2: Do children diagnosed with ASD display a significant reduction of pathological symptoms after treatments with NFB?

Thirty-eight brain maps were evaluated pre and post NFB treatment. Twenty-four individuals showed a reduction in dysregulated brain waves, and 14 individuals did not show an improvement after treatment. According to the theory of binomial expansion, the probability of seeing at most 14 reversals, if each reversal is simply due to chance and the treatment were irrelevant, would be just a little more than 7%. Therefore, NFB appears to have a significant impact as a treatment for autism.

RQ2: Do children diagnosed with ASD display a significant reduction of pathological symptoms after treatments with NFB as reported by clinicians?

$H_0$2a: There is no difference in social interactions. The null hypothesis is rejected.

H_a2a: There is a difference in social interactions. The alternative hypothesis is accepted.

$H_0$2b: There is no difference in communications skills. The null hypothesis is rejected.

H_a2b: There is a difference in communications skills. The alternative hypothesis is accepted.

$H_0$2c: There is no difference in restricted interests. The null hypothesis is rejected.

H_a2c: There is a difference in restricted interests. The alternative hypothesis is accepted.

$H_0$2d: There is no difference in repetitive behaviors. The null hypothesis is rejected.

H_a2d: There is a difference in repetitive behaviors. The alternative hypothesis is accepted.

$H_0$2e: There is no difference in eye contact. The null hypothesis is rejected.

H_a2e: There is a difference in eye contact. The alternative hypothesis is accepted.

$H_0$2f: There is no difference in in tantrums. The null hypothesis is rejected.

H_a2f: There is a difference in in tantrums. The alternative hypothesis is accepted.

$H_0$2g: There is no difference in display of affection. The null hypothesis is rejected.

H_a2g: There is a difference in display of affection. The alternative hypothesis is accepted.

$H_0$2h: There is no difference in sleep patterns. The null hypothesis is rejected.

H_a2h: There is a difference in sleep patterns. The alternative hypothesis is accepted.

$H_0$2i: There is no difference in hypersensitivity. The null hypothesis is rejected.

H_a2i: There is a difference in hypersensitivity. The alternative hypothesis is accepted.

$H_0$2j: There is no difference in aggressive behaviors. The null hypothesis is rejected.

H_a2j: There is a difference in aggressive behaviors. The alternative hypothesis is accepted.

The alternative hypothesis is accepted as this study supplies supporting feedback from practitioners, parents, and teachers that children exposed to NFB benefitted with improvement in physiological symptoms, neuropsychological behaviors, and neurocognitive abilities. Furthermore, NFB depicted a favorable side effect profile with no adverse effects in neurological or psychological functioning. The ATEC indicates that changes have continued for more than one year may indicate the possibility that improvements may be long lasting since NFB is based on the concept of neuroplasticity, the idea that the brain is not static, but capable of dramatic and long lasting changes when given the correct stimulation (Robbins, 2000; Rosenzweig et al., 1999).

Chapter 5 discusses the limitations and strenghts of the study, implications for social change, recommendations for action, and suggestions for future research.

Chapter 5

Introduction

The purpose of this study was to better understand and increase awareness about NFB and the possible efficacy that it may have in the treatment of autism. Autism is considered to be a developmental disorder with continuous delays in social interactions, communication, and difficulties related to obsessive interests or repetitive behaviors (APA, 2000). Autism has been shown to have a biological basis. It is considered to be a neurological disorder with distinct abnormalities in the brain (Kabot et al., 2003; Edelson, 2000). Recent research has shown that the prospect of using NFB to significantly ameliorate pathological symptoms appears to be extremely promising (Kouijzer et al., 2008). The improvement demonstrated through NFB as a treatment for autism is based on the fact that NFB takes advantage of a learning process that both develops and strengthens the synaptic connections in the brain (Kouijzer et al., 2008). Recent studies have also supported the possibility of neuroplasticity of the brain through NFB, and displaying improvement in neurocognitive abilities, reduction of pathological neuropsychological symptoms, and improved neurophysiological functioning (Allen Press, 2000). Most therapies currently being used focus on cognitive-behavioral interventions. Presenting reports that NFB can be beneficial may convince providers to implement NFB as an adjunctive therapeutic modality.

Limitations and Procedures

The use of NFB as a treatment for autism has been evolving over recent years. The number of formal studies on the effect of NFB in the treatment has been limited.

This researcher scoured the internet and visited numbers of clinics to gather data as well as contacting companies who made NFB equipment, but results were few. Some practitioners who did use NFB to treat autism claimed that they did not keep good notes, and others stated that they did not want to share information. A behavioral health clinic in Southern California was willing to share information. They also provided NFB-based brain mappings, something that few other practitioners were doing. However, it was discovered that many patients did not have post treatment brain maps done, bringing down the number of cases to be analyzed. This researcher gathered 38 pre- and post-brain maps, as well as archived notes and information from practitioners and parents. Ten parents completed the ATEC, but one was not used because it was incomplete. Forty-two sessions are recommended for the treatment of autism, and the subjects in this study ranged from having had 27 to 106 sessions. Therefore, the children did not all receive the same number of treatment sessions making it impossible to ascertain the potential differential effect due to the range of training sessions. Subsequently, children were compared to their rate of progress prior to NFB training.

Implications for Social Change

The results of this study may be used to advance social change by helping children diagnosed with ASD and their families improve their overall quality of life. Behavioral therapies can cost $40,000-$50,000 per year (Berr, 2013). Many families have tried up to 40 different interventions, and educational researchers report that many families were utilizing an average of 7 treatments at the same time (Heflin et al., 2008). These costs can be extremely burdensome for families, and with the exception of behavior modification interventions, there are few established efficacious treatments (Thompson et al., 2010b; Coben, et al., 2010). Families with an autistic child who needs significant help often becomes overwhelmed (Jarusiewicz, 2002). One desperate family whose child screamed at the top of his lungs all day long decided to handle the problem by submitting him to a surgical procedure where an opening was made in the child's vocal chords to widen the gap thereby providing a larger space for the air to pass through, thus reducing and softening the sound of his screaming (Caplan, 2013). AVE is simple to use and appears to achieve the same results as EEG NFB with less cost and time (Siever & Joyce, 2000). Children exposed to NFB have not reported any adverse effects and can be an excellent alternative for those who cannot tolerate drug therapy (Siever & Joyce, 2000). Another way to reach more children and relieve familial stress would be to incorporate AVE into the school setting. Most communities that need neurotechnologies are often those that can least afford it (Siever & Joyce, 2000). Benefits include continuous scheduled treatment sessions, immediate and ongoing feedback, and random on-site observations (Siever & Joyce, 2000).

Recommendations for Future Research

Future clinical research may consider focusing on the possible synergistic effects between NFB and other interventions commonly used with this population (Coben et al., 2010). Recent research has shown that one cause of autistic disorder is a disturbance of neural connectivity, and NFB may be capable of remediating these disturbances; therefore, it should be included as part of treatment planning (Coben, 2007). However, the general population has limited knowledge about the use of NFB. Therefore, any literature, supporting or not, increases the probability that information becomes mainstream and introduces this topic to future researchers (Coben, 2007). Future studies are needed to provide and replicate data by other clinicians (Jarusiewicz, 2002; Coben et al., 2010; Maglione et al., 2012). NFB remains elusive not only to the general population, but also to other clinicians because it does not fit into the traditional medical model (Robbins, 2000). Past brain research has focused on neurotransmitters and psychotropic drugs, not about brainwave frequencies (Robbins, 2000). To date, sample sizes have been small, and as a result, the findings may not be truly representative of this population. The addition of pre- and post-QEEGs may also lead to greater understanding of brain mechanisms that can result in better training methods (Jarusiewicz, 2002). I also suggest that there be randomized controlled trials in order to demonstrate the efficacy of NFB as a valid intervention. Future research is needed to track the efficacy according to current research standards (Coben & Myers, 2010). Research should include random assignments, blinding of participants, procedures to control for placebo effects, studies replicated in a minimum of two independent settings, and continued improved protocol development generated in part by new software and technological advances (Coben & Meyers, 2010; Jarusiewicz, 2002). Long term follow-up with NFB has often been neglected due to time and financial constraints (Kouijzer, de Moor, Gerrits, Buitelaar, & van Schie, 2008). Research should also include the use of neuromodulation in the treatment of autism. A recent study conducted by Dr. Tsai at The University of Texas Southwestern Medical Center in Dallas showed that the RCrusl, located near the brain stem, has been found to correlate with some core symptoms of ASD (Anderson, 2017).

Dr. Tsai and his team of researchers conducted a study using mice. They inhibited the RCrusl, which led to social impairments, and stimulation of this region restored the normal social behaviors of the mice (Anderson, 2017). The participating clinic for this study already uses a form of neurostimulation called Neurofield. Neurofield is a specialized form of neurotherapy that combines neurostimulation modalities such as pulsed electromagnetic field stimulation, transcranial direct current stimulation, transcranial alternating stimulation, and transcranial random stimulation with EEG NFB (Drake, 2018). The mild electromagnetic stimulation assists the brain waves in moving from abnormal patterns to healthier and more stable patterns, as well as enhancing neuroplasticity (Drake, 2018). These forms of neuromodulation can be very beneficial for people who find it difficult to generate normal brain wave patterns on their own through classic NFB.

The field of NFB needs more longitudinal studies to measure the durability of the effects, to achieve mainstream acceptance, and to achieve insurance coverage (Gerrits et al., 2008; Coben et al., 2010). It is possible that NFB could change the direction of future research beyond cognitive behavioral therapies and medications. Researchers need to determine if NFB benefits achieved in childhood will continue to be associated with neuropsychological changes in adulthood (Coben et al., 2010).

Conclusion

Families require tools and education to enhance the effectiveness of treatments used when treating their child for autism. They need support to maintain emotional strength, to guard against being overwhelmed, and to reduce burnout (Maglione et al., 2012). Society also needs tools to help those with ASD become productive citizens, and further research is needed. University of California-Davis (UC Davis) health economists reported that ASD-related medical, nonmedical, and productivity losses in 2015 were $268 billion, and they predict that number to rise to $1 trillion by 2025 (UC Davis Health, 2015). Abbeduto, director of the UC Davis MIND Institute, an internationally recognized autism treatment and research center, stressed the need for additional funding and research to understand the causes of ASD and to develop treatments for ASD (UC Davis, 2015). Society needs to ensure that all children have access to intensive early interventions, school-based interventions to support academics and social and language skills, and supports to ensure better post-secondary and vocational options for adults. Investing in these areas could actually reduce the costs to society (UC Davis Health, 2015).

NFB is a hopeful intervention with beneficial effects achieved without being invasive or resulting in negative side effects (Thompson et al., 2010b). NFB has profound implications for treatment in a field with few low risk alternatives (Sichel et al., 1995). NFB is worth considering as a part of a multimodal treatment plan by clinicians and schools for individuals with ASD.

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