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Assessment Protocol for Cognitive and Auditory Processing Skills for Clients Receiving Neurofeedback Treatment for Traumatic Brain Injury & Concussion: Literature Review

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Introduction

According to research conducted by Dr. Tanju Surmeli, "[E]very year, 1.5 million Americans sustain a TBI, with a new case added every 21 seconds, which leads to 80,000 new cases of long-term disability and 50,000 deaths" (T. Surmeli, et. al. p. 3, N/A). The devastating amount of traumatic brain injuries (TBI) cases beckons for more research to formulate newer, more effective treatments and technologies. The search for TBI treatments has progressed within the past decades, opening doors for new research projects and an expansion in knowledge.

The increased research initiatives have improved the technologies and treatments utilized for a TBI or concussion. One technology in particular, neurofeedback, has become increasingly popular. However, there is a lack of a singular, baseline and progression diagnostic tool to measure a client's cognitive and auditory processing skills once they are referred for neurofeedback treatment.

The Brain

Auditory and cognitive processing are a combination of skills that the brain performs to process knowing, perceiving, and remembering stimuli. The auditory system, which is comprised of the outer ear (pinna), middle ear (ossicles and tympanic membrane) and inner ear (cochlea), aids in audition. The pinna acts as a funnel, guiding the sound vibrations through the ear canal to the middle ear. When the sound waves reach the tympanic membrane (eardrum), the ossicles begin to vibrate. These sound vibrations then travel to the cochlea. The cochlea transduces the sound vibrations into electrochemical forms of energy that the brain can understand. This two-part auditory nerve is known as cranial nerve VIII, or the vestibulocochlear nerve. The vestibular part of the nerve is responsible for transmitting changes in equilibrium and head position. The cochlear portion of the nerve accounts for transferring electrochemical neural impulses to the brain. Once the brain receives this communication, it helps the person understand what is being heard through communication in different lobes of the brain (Seikel, Drumright & King, 2014). Therefore, this interpretation of sound vibrations is known as auditory processing. An example of this is that if an individual was asked to touch their nose, the individual would have to understand the direction given and then have the ability to use their motor ability to carry out the function.

Cognitive processing involves not only perception, but also memory and attention (Seikel, et. al, p. 748-49). The main components of the brain that contribute to these cognitive skills are the frontal lobe (Broca's area), parietal lobe (angular gyri) and temporal lobe (Wernicke's area). The frontal lobe is responsible for decision making, as well as planning. Broca's area is one of the major pieces of the frontal lobe. This controls the motor speech planning and production. If this area becomes damaged, a person may have difficulties formulating sentences and producing the actual speech sounds. Since the angular gyri contributes to a person's understanding of written information, when it is damaged, difficulties such as reading, processing and comprehending written information may occur. Finally, Wernicke's area contributes to the comprehension of spoken language (Seikel, et. al, p. 617-19). These sections of these lobes are critical for the maintenance of attention to and perceiving stimuli for recall in the future.

While there are certain areas of the brain that are responsible for cognitive and auditory processing, it is important to note their other physiological functions. It is necessary to understand the brain as a whole, in order to understand the extent of the sustained injuries.

The frontal lobe is the largest, making up one third of the cortex (Seikel, Drumwright, & King, 2014). This area is associated with reasoning, planning, parts of speech, movement, emotions, personality, and problem solving (Martini et al.). This lobe also houses the precentral gyrus, referred to as the motor strip (Martini et al.). This precentral gyrus oversees the voluntary control of skeletal muscles, such as smiling or even walking. If the frontal lobe is damaged, it can have adverse effects on memory, emotions, and the processing of reward and punishment (Seikel et al.). Overall, the frontal lobe sends signals to the other brain lobes in order to process outside stimuli.

Housed just posterior to the frontal lobe is the parietal lobe, which is associated with sensation, orientation, recognition, and perception of stimuli (Martini et al.). The postcentral gyrus (known as the primary sensory cortex) is found here. This gyrus is in charge of touch, pressure, pain, vibration, taste, and temperature (Martini et al.). These sensations are important for perceiving outside stimuli. If this gyrus becomes injured, a person may not understand or process sensory stimuli. An example of this is if an individual is touching something hot and cannot perceive that it is burning through their skin.

Located inferior to the parietal lobe, in the posterior position of the skull, lies the occipital lobe which aids in visual reception and processing. This section allows an individual to understand the outside stimuli being viewed. If this portion of the brain becomes damaged it can lead to an overall sense of blindness or visual processing difficulties.

The temporal lobe, which can be found laterally on either side of the skull, houses specific functions that are related to perception and recognition of auditory stimuli, memory and speech (Martini et al.). All auditory stimuli are processed here. This area of the brain also houses the olfactory cortex. The olfactory tract and bulb, which comprise the olfactory cortex, are located near the frontal lobe. All processing of the stimuli from the olfactory system is deciphered in the temporal lobe (Martini et al.).

The cerebellum, separate from the cerebrum, is comprised of four different lobes. The main function of the cerebellum is to adjust body movements by comparing arriving sensations with previously identified sensations. The cerebellum also accounts for an individual's coordination, posture, and balance (Brain Structures and their Functions, 2012). This structure allows an individual to perform the same movements over and over (Martini et al.). Damage to the cerebellum can cause problems with communication of stimuli to the brain stem, spinal cord, and cerebral cortex (Seikel et al.). Overall, the cerebellum ensures that signals are sent and received properly throughout the entire body.

Finally, there are other accessory brain systems that work automatically to keep an individual fully functional. The brainstem houses the midbrain, pons, and the medulla. The midbrain, referred to as the mesencephalon, contains nuclei for both auditory and visual information (Martini et al.). For example, the midbrain is in use when an individual has an automatic response such as moving the eyes toward an abrupt sound. The reticular activating system is within the midbrain, pons and medulla. The midbrain helps a person maintain consciousness. The pons is the bridge that connects the cerebellum to the cerebrum (Martini et al.). The pons also contains relay centers for somatic and visceral motor control. Visceral controls are involuntary bodily functions, such as blood circulation, which do not require conscious thought (Martini et al.). The conjoining area, before the spinal cord, is the medulla oblongata. The medulla oblongata contains major centers that regulate autonomic functions including heart rate, blood pressure, and the digestion process (Brain Structures and their

Functions). These accessory systems of the brain are important to sustain life and regulatory functions (Seikel et al.). The brain is a delicate and complex organ that controls many of the physiological aspects of the body. A TBI can complicate or interfere with these physiological processes.

Traumatic Brain Injury

Traumatic brain injuries affect nearly 2.5 million people in the United States (Traumatic Brain Injury and Concussion, 2016). According to the Centers for Disease Control and Prevention (CDC), a TBI is caused by a bump, blow or jolt to the head. This may also include penetration of the head during injury that disrupts normal brain functions. An important consideration though, is that not every head injury results in a TBI. Also, not every head injury is the same depending on severity, area that was disrupted and behavioral manifestations.

The brain injuries sustained throughout World War II (WWII) promoted research on brain injuries and rehabilitation. Researchers have shown that a combination of specialists working as a team to help with the cognitive and communication disorders in individuals was the best approach. This community approach helped to combat brain injuries at a faster rate. Medical teams consisted of speech-language pathologists and psychologists, working alongside doctors (High, 2005). This wartime research offered positive support for TBI specialized rehabilitation services. The team approach not only helped TBI patients, but also victims with strokes, amputations, and other conditions that veterans incurred during WWII.

During the 1970's, there was a rapid growth in the number of physicians concentrating on TBI. Brain injuries also became a public health concern with the rise in the number of vehicular crashes. The incidence of vehicular crashes increased due to the increased speed limit on highways (Mendelow & Crawford 1997). During this era, the primary and secondary brain injuries were discovered, along with the ability to issue drugs to control intra-cranial pressure, and standardized guidelines for the treatment of TBIs were written (Mendelow & Crawford). A primary brain injury occurs at the time of impact. This produces clinical effects almost immediately due to the displacement of the physical structures of the brain (Mendelow & Crawford). On the other hand, a secondary brain injury occurs after some time has passed after the initial impact. Secondary brain injuries are largely preventable and/or treatable (Mendelow & Crawford). These types of injuries include hearing loss, tinnitus, headaches, seizures, dizziness, nausea, vomiting, and blurred vision.

In the 1990's, there were significant advancements in technology, treatment, and diagnoses including the use of CT scans, genetic research and, MRIs. President George H.W. Bush signed Presidential Proclamation 6158, which emphasized the importance of the brain and the need for more research (Bush,1990). With this new proclamation, President Bush announced that 1990 was the "Decade of the Brain" in an effort to improve the nation's medical knowledge related to the brain and TBI (Bush).

With the death of Mike Webster, a former National Football League (NFL) athlete, in late September during 2002 brought about more advanced and aggressive research headed by Dr. Bennet Omalu. Dr. Omalu's research discovered that there are many connections between chronic traumatic brain injuries and behavioral/psychological changes that may occur later in an athlete's life (Omalu, DeKosky, Minister, Kamboh, Hamilton, & Wecht, 2005). These symptoms can include cognitive impairment, mood disorders and Parkinson's or Alzheimer's disease (Omalu et al.). These are all problems that NFL players may face during or even after their careers. These symptoms may arise depending on the location of the traumatic impact, severity, and re-injury. However, every individual is different in the way an injury can a person. One single impact may lead to these symptoms, in the same way multiple head injuries can.

The emphasis placed on improving knowledge regarding the brain and TBIs has led to the discovery of three different types of TBIs. The first is a mild traumatic brain injury, which is characterized by a brief period of loss of consciousness and/or dizziness or none at all. This mild concussion may change the mental status of a patient, indicating potential brain function alteration. The next level is a moderate TBI, which is caused by a violent blow to the head or shaking. At first glance, this level may not have apparent consequences. However, some individuals may have lifelong disabilities and impairments after a moderate TBI ("Types and Levels*”*, *n.d.*). Some symptoms may be confusion that lasts for days to weeks; physical, cognitive, and/or behavioral impairments that last for months; and loss of consciousness that may last for a few minutes to hours (“*Types and Levels”*) The worst level is a severe TBI which results from a crushing blow or a penetrating wound to the head. Severe TBIs are the most life altering to a patient (“*Types and Levels”*). Severe TBIs cause a wide range of short-term and long-term changes in overall thinking, sensation, language, and emotions and may also cause epilepsy and other severe conditions (“*Types and Levels”*). Each TBI intensity has important implications that can cause a complete overhaul of an individual’s life.

Traumatic Brain Injury Assessments

Many assessment and screening tools have been created to increase early detection of a TBI or to assess resulting symptoms and difficulties. There are assessments and screening tools that may be utilized by physicians or other medical personnel, or ones that a speech-language pathologist or audiologist may administer.

Assessments such as the NFL Sideline Concussion Assessment Tool: Baseline Test, Acute Concussion Evaluation (ACE), Rivermead Post-Concussion Symptoms Questionnaire, Glasgow Coma Scale, Rancho Los Amigos Scale, and Cognitive-Communication Checklist for Acquired Brain Injury (CCCABI) are among a wide range of tools for general physicians and medical practitioners to use. These assessments provide a broad overview of physical symptoms one may experience following a concussion or TBI. For example, the NFL Sideline Concussion Assessment Tool: Baseline Test targets the athlete's physical symptoms and equilibrium. This allows for a quick, game-time decision regarding the athlete's ability to continue play (NFL Head, Neck and Spine Committee, 2013). In comparison, the CCCABI hones in on the daily functioning of the client. This screening tool examines the client's auditory comprehension and information processing, expression, discourse and social communication, reading comprehension, written expression, and thinking, reasoning, problem solving, executive functions, as well as self-regulation (MacDonald, 2015).

There are many screening and assessment tools used by speech-language pathology and audiology professionals, as well. The screening tools include, but are not limited to, the Language/Cognitive-Communication Evaluation, Speech Audiometry, Otoacoustic Emissions, Pure Tone Exam and Auditory Brainstem Response (American Speech-Language Hearing Association, 2017). Some assessment batteries for speech-language pathologists are the Assessment of Language-Related Functional Activities (ALFA), Communication Activities of Daily Living (CADL-2), Behavior Rating Inventory of Executive Function (BRIEF), Burns Brief Inventory of Communication and Cognition (Burns Inventory), Cambridge Test of Prospective Memory (CAMPROMPT), Comprehensive Trail-Making Test (CTMT), Behavioral Assessment of the Dysexecutive Syndrome (BADS), Speed and Capacity of Language Processing Test

(SCOLP), Delis-Kaplan Executive Function System (D-KEFS), Wessex Head Injury Matrix (WHIM), and Test of Memory Malingering (TOMM) (Ferrell, N/A). These testing instruments analyze and collect data revolving around cognitive functioning skills. Some of the many cognitive functioning skills that are tested include memory, executive functioning, spatial awareness, and organization. Audiologists may use the Frequency Pattern Sequence Test, Duration Pattern Sequence Test, Synthetic Sentence Identification Test, and Staggered Spondaic Word Test (American Academy of Audiology, 2011). These collective audiological assessments allow the assessor to administer different tones, while speaking at the same time. The assessment batteries evaluate a client's ability to filter outside stimuli, in order to focus on the pertinent information. Altogether the testing tools are only a few of the many assessments that may be used by speech-language pathologists and audiologists to evaluate a client with a TBI.

The general and specific assessments are essential tools that aid in understanding a client's symptoms. These assessments allow for the professionals to formulate treatment plan, make referrals, and gather baseline data. However, one problem with many of these speech-language pathology and audiology tools is that they are not comprehensive. Many do not account for the person's physical or mental symptoms. Also, each of these assessments focuses on a specific concept rather than gathering information regarding cognitive processing, auditory processing and physical and mental symptoms. As a result, clinicians often must administer more than one test instrument in order to assess a variety of cognitive functions and auditory processing ability. Alternatively, clinicians may need to "pick and choose" which sections from these tools to administer during baseline and therapy progression data collection, in order to gather the types of data that are required for planning treatment for the clients.

Neurofeedback

Around the 1970s, treatments such as neurofeedback and biofeedback were being formulated under the primary guidance of Hershel Toomim. His idea catapulted the creation of the brain mapping cap as well as neurofeedback (Siever, N/A). Since the beginning prototype, neurofeedback has evolved. Today's neurofeedback devices are utilized to measure the brainwaves, as well as train the brain to strengthen certain areas based on the recorded data.

Neurofeedback stems from the original therapeutic process of biofeedback, which is "…a mind-body therapy using electronic instruments to help individuals gain awareness and control over psychological processes (Gilbert & Moss, 2003; Moss, 2001; Schwartz & Andrasik, 2003)" (Baskin, Kirk, Gilbert, Leher, Lubar, Moss, & La Vaque, p.ii, 2004). Biofeedback focuses on the physiological processes of the body, such as heart rate, respiration, sweat production, blood pressure, and muscle activity. Neurofeedback focuses more on the brainwave functioning and electrical brain currents, such as slow cortical potentials. "During typical training, one or more electrodes are placed on the scalp and one or two are usually put on the earlobes. Then, high-tech electronic equipment provides real-time, instantaneous feedback (usually auditory and visual) about your brainwave activity. The electrodes allow us to measure the electrical patterns coming from the brain… Your brain's electrical activity is relayed to the computer and recorded" (Hammond, p.306).

There are five specific brainwaves that are monitored through neurofeedback devices: delta, theta, alpha, beta, and gamma (Hammond, 2011). Delta brainwaves can be extremely slow, being recorded as .5 to 3.5 Hertz (Hz). If delta brainwaves are the strongest on the neurofeedback data sheet, then the person is usually in a state of "…deep, restorative sleep…" (Hammond, p.

306). Theta brainwaves, on the other hand, register at approximately 4 to 8 Hz. When these brainwaves are recorded, people are in a state of relaxation. While we are preparing to sleep, or even daydreaming, the theta brainwaves are the strongest. "…[A]ctivity generally represents a more daydream-like, rather spacey state of mind that is associated with mental inefficiency…" (Hammond, p. 305). Relaxed states, where a person is still aware of their surroundings, are known to exhibit strength in the alpha brainwaves. These brainwaves tend to measure at 8 to 12 Hz. The person will be free from pressing matters and not particularly focused on one specific matter. The last two brainwaves depend on faster brain functioning that may be triggered by stress or anxiety. Beta brainwaves, measured at approximately 13 to 30 Hz, represent an elevated state of alertness. These waves are "…associated with a state of mental, intellectual activity and outwardly focused concentration…" (Hammond, p. 305). Lastly, gamma brainwaves are recorded at 30 Hz and above. Gamma brainwaves are heightened when people are task-driven (Hammond).

Each level of brainwave activity and function is unique to each individual. However, based on the above information, those with anxiety disorders may be more inclined to experience prominent beta brainwaves over the others. On the other hand, theta brainwaves may be heightened for someone who experiences bouts of depression. However, each individual who experiences anxiety and depression will still have different brainwave measurements (Hammond).

The prefrontal cortex and motor strips can affect what is known as slow cortical potentials. According to research by D. Corydon Hammond, slow cortical potentials are "the positive or negative polarizations of the EEG in the very slow frequency range from .3 Hz to usually 1.5 Hz…" (p. 308). In essence, slow cortical potentials should shift negatively while performing tasks. These negatively shifted potentials create “excitatory effects” (Hammond, p. 308). Slow cortical potentials account for the electrical currents in the brain. These currents are driven by the level and intensity of processing in which a person is engaging. There are two reactions that occur with slow cortical potentials, negative shifts and positive shifts. The negative shifts are task-driven, leaving an individual’s brainwaves in an excitatory state during the duration of the task. On the other hand, positive shifts result in a much slower rate of brainwave function. Positive shifts are the consequence of little to no activity. When the brain is in a relaxed or inattentive state, these positive slow cortical potentials are more apparent (Albrecht, Auer, Dewiputri, Gevensleben, Heinrich, Lutcke, Moll, Rothenberger, & Schweizer, 2014).

Essentially, the negative shifts and positive shifts in the slow cortical potentials can be observed in a variety of situations, as well as being paired with the different types of brainwaves. Negative shifts will be paired more often than not with beta and gamma brainwaves, while delta and theta brainwaves would be associated with positive slow cortical potentials. Therefore, anxiety and stress levels could elevate the negative shifts. These negative shifts may occur if a person is having difficulties processing information, which in turn causes stress and anxiety. In comparison, the positive shifts would occur more with a person who could be experiencing depression or impaired/decreased brain functioning. Neurofeedback is a treatment method that has been developed to manage these shifts in brainwave functioning.

This process of measuring neurological responses allows for the professional to monitor either the progression or regression of certain ailments. Trackable disorders/conditions utilizing neurofeedback include, but are not limited to: anxiety, chronic pain, depression, insomnia, post-traumatic stress disorder, stroke, temporomandibular disorders, and traumatic brain injury (TBI). For the purpose of this paper, the main focus will be on the use of neurofeedback with TBIs. The purpose of neurofeedback is to identify the triggered areas and the responses that are produced, and then to modify the brain's activity, which is the "feedback" part of the therapy. (Baskin, et. al.).

Brain mapping, Neurofeedback, and Traumatic Brain Injuries

The use of neurofeedback to treat TBIs has grown in recent decades. For this method, the neurofeedback measurement device can record the areas of the brain that seem to have irregular brainwaves. This allows for the clinician to document the findings. The data collected may help the clinician choose certain therapeutic tasks that target the specific brain area and also help understand how the therapy is working by looking at feedback.

The Quantitative Electroencephalogram (qEEG) is one type of device that records the monitored brainwaves. This tool usually takes approximately 60 to 75 minutes to collect enough data. During this process, the brainwaves are visually recorded in order for analysis of normal and abnormal brainwaves. The results are recorded on a brain map, which is color coded based on the severity of damage to the specific area of the brain (Warner, 2013). The important aspect of the qEEG is the objectivity of the results, which is highly important for an accurate treatment plan surrounding the damaged brain areas (Hammond). The right and left hemispheres of the brain are specifically targeted and analyzed during neurofeedback. The right hemisphere is responsible for synthesizing information, thinking spatially (puzzles or brain teasers), perceiving, comprehending and expressing based on visual and auditory cues, and experiencing and expressing emotion. Conversely, the left hemisphere houses: analyzing complex concepts, thinking sequentially, thinking linguistically, storing memories, and thinking logically (Warner).

Neurofeedback is essentially used to train the brain. The data collected from the brain map, in unison with knowledge of what each brain lobe and hemisphere is responsible for, greatly affects how therapy is conducted. The clinician uses this data and creates treatment plans for the client to enhance those damaged brain areas through the feedback process (EEG Institute, 2017).

Recently, NeurOptimal Advanced Brain Training Systems has contributed to the research and development of a neurofeedback device. This system, produced by Zengar, is aimed at providing real-time results of how the brainwaves are functioning throughout treatment sessions, giving instantaneous feedback automatically. The clinician does not need to first interpret an EEG and then devise a treatment plan for the "faulty" brainwaves; the system automatically does the interpretation and feedback. Its portability makes it easy for the clinician to use in a variety of settings. Also, many professionals, such as speech-language pathologists, psychologists, and neurologists, may all be trained in using this system to administer neurofeedback therapy (NeurOptimal Advanced Brain Training Systems, 2016).

The device works by placing a set of wires containing the electrodes into the amplifier box, which is connected to a laptop (containing the Zengar NeurOptimal software), and the headphone jack is connected into an extended adapter with headphones. The sensors are then attached to the client: one electrode on each ear, one electrode on each side of the head, and one electrode, or "grounding" electrode, on the right ear lobe (NeurOptimal Advanced Brain Training Systems).

Once the client is connected to the device, he/she will then put on the headphones, which play a recording of relaxing music. This ensues for approximately 30 minutes. The person does not have to do anything but sit and relax. If the Zengar device detects an abnormal brainwave function, the relaxing sounds will subtly skip a beat, or sound “scratched”. After the 30 minutes of neurofeedback training is completed, the Zengar software records the data, which appears on the laptop screen within minutes. The data will illustrate the normalcy of brainwave functioning. (NeurOptimal Advanced Brain Training Systems).

According to the article, “Efficacy of QEEG and Neurofeedback in the Assessment and Treatment of Post-Concussive Syndrome: A Clinical Case Series,” Dr. Tanju Surmeli states:

> “Approximately two-thirds of mildly injured patients will regain 80% of their functioning with the first six months of recovery and continue to improve over the next one and one half years. Treatment [neurofeedback] therefore, should be relegated to those patients who are not improving, whose improvement has reached a plateau, or who after six months still have significant dysfunction” (p.8).

This 40-subject case series led to the conclusion that neurofeedback can improve cognitive functioning, and overall somatic symptoms. According to this study’s data, neurofeedback should be fully completed (20, 60-minute sessions) in order to see lasting effects. The study conducted had an adequate number of subjects, however, it did not test the effects of neurofeedback on auditory processing skills. The long-term effectiveness data collected was also based on phone conversations with the subjects after approximately a 3-year period post-treatment. Unfortunately, another flaw in the research regarding the effectiveness of neurofeedback was the amount of assessment and screening tools that Surmeli used. Surmeli utilized The Symptom Assessment-45 Questionnaire, The Positive Symptom Index, Hamilton Rating Scale for Depression, Test of Variable Attention, and Clinical Global Impressions.

Combined, these assessment and screening tools account for the somatic and emotional symptoms a client may face following a concussion or TBI. The tools do not collect data regarding cognitive or auditory processing skills. The Test of Variable Attention is the closest tool that examines a person's ability to focus and respond to cognitive processing tasks that involve shapes (the TOVA Company, 2015). This study exhibits the need for a singular baseline assessment tool.

The Zengar Company has created their own set of screening measures. The following forms are provided with the purchase of the NeurOptimal device: Checklist of Client Concerns, Pre- and Post-Session Evaluation, Tracking Your Progress, and a goal setting form. The Pre- and Post-Session Evaluation and the Tracking Your Progress forms account for the client's somatic symptoms and are intended to assign a qualitative measure, via rating scales, to the client's reported symptoms. These forms also ask the frequency of the symptoms. Clinicians can use these data tools to measure changes in the client's somatic symptoms over time. The Checklist of Client Concerns contains 101 somatic symptoms that a client may experience. The client can circle any of the symptoms that he/she may be experiencing as baseline data is collected, and periodically throughout ongoing therapy (NeurOptimal Advanced Brain Training Systems). However, the downside with this specific NeurOptimal data collection sheet is that out of 101 items there are only 16 that account for cognitive skills and 3 that account for auditory processing skills. The other forms provided by the Zengar company do not account for anything but somatic symptoms, such as fatigue, mood swings, panic attacks, and nausea to name a few.

The Future of Assessment and Neurofeedback

There is a lack of comprehensive assessments, making the actual baseline and therapy progression data collection more difficult. For instance, clients A and B may come to a clinic for similar cognitive processing issues. Neither client is administered the same assessment, because there is a lack of a comprehensive assessment protocol. While both clients have cognitive processing difficulties, the clinician may be unsure of where the problem lies. Therefore, he/she cannot place the electrode sensors on to the areas of the skull thought to be abnormal. A clinician may become frustrated because while client A is progressing, client B is not. If the clinician was able to administer a comprehensive assessment battery, he/she may have been able to detect the problematic areas quicker and with much more ease.

A concern revolving around the use of neurofeedback as a therapeutic approach is the lack of a standard assessment protocol to test a baseline for cognitive and auditory processing skills. Clinicians may use an abundance of different test batteries to gather data, but at this time there is a lack of a singular standard or recommended assessment protocol to measure a patient's baseline cognitive and/or auditory processing abilities prior to beginning neurofeedback treatment for these deficits. The use of existing assessment batteries and screening tools may take extended time to administer, taking away time from the client's treatment. In addition, while the aforementioned assessments and screenings may be widely used in other treatment contexts, they may not provide standard or consistent baseline data for neurofeedback, due to the fact that clinicians may utilize different portions of these tools in order to obtain the necessary baseline measurements. For this reason, an assessment tool should be developed for neurofeedback treatment, which is quick to administer and will establish objective baselines for cognitive and auditory processing skills. This will ensure effective neurofeedback treatment and provide the ability to document response to treatment in a more objective manner.

The Neurofeedback Assessment for Cognitive and Auditory Processing is a proposed new tool that creates an objective and consistent approach to collecting baseline data for clients referred for neurofeedback treatment, who exhibit cognitive and/or auditory processing deficits following a TBI. It allows the clinician to test both cognitive and auditory processing skills. The tool collects data on client and family history, symptoms (before the session, during the task and after the tasks are completed), as well as the specific cognitive and auditory processing tasks. These sections involve concentration, memory (recall), attention to detail, comprehension, orientation, and audition. Included in this new assessment are sections that assess the patient's background history, symptoms, memory, concentration, senses, hearing and auditory processing. These different sections allow a wide variety of skills and abilities to be evaluated. The assessment battery can be completed in about 30 minutes. This new method would allow clinicians to complete the pre-treatment assessment in a relatively short period of time. Treatment plans and referrals can be created and the neurofeedback treatment started more quickly, since the client will only need the duration of one session to complete the assessment.

This method can also serve as a way to assess the client's progress after a course of therapy. However, this assessment has not been tested to gather information concerning the validity and reliability since it is a newly developed assessment. Once this tool has been tested, it can be implemented in clinics as a singular baseline and progression assessment tool.

Conclusions

Neurofeedback, a branch of biofeedback, has created opportunities for concussion and TBI intervention. This technology has also prompted more TBI and concussion research. The newer Zengar neurofeedback system can provide the clinician with quick, real-time results regarding abnormal brainwave functioning. However, the effectiveness of this therapeutic intervention for cognitive and auditory processing disorders can be difficult to determine. Clinicians have the option of a multitude of assessment and screening tools. Currently, there is no one recommended protocol for assessing clients' pre-treatment cognitive and auditory processing skills. The data collection tools provided by Zengar concentrate on subjective reporting of somatic symptoms. A standard, consistently-used, and more objective assessment protocol that collects data on cognitive and auditory processing skills, in addition to somatic symptoms, should be developed.

The goal of the proposed Neurofeedback Assessment for Cognitive and Auditory Processing is to provide the practitioner with just that – a singular diagnostic tool. This assessment can be performed to collect baseline data, as well as track progress throughout therapy. It relieves the clinician of lengthy assessments that surpass 30-60 minutes to administer. It also helps the clinician save time before and after sessions, because he/she only has to use one assessment battery to collect data, rather than select portions from other assessment and screening tools. Thorough research needs to be conducted on this proposed tool, to determine the quality of this tool. This is the first step to developing a tool that can be used consistently for measuring both baseline status and progress after neurofeedback treatment for clients experiencing cognitive and auditory processing difficulties after a concussion or TBI.

The Neurofeedback Assessment for Cognitive and Auditory Processing

CLIENT NAME: ______________________________ D.O.B: ____________ GENDER: ____
Assessor: ____________________________________ Date of Assessment: ______________

PATIENT HISTORY

Have you suffered an injury to your head? If so, what was the course of treatment you and/or your physician decided to take?		Was your head injury ever severe enough to be hospitalized overnight?	
How many times have you suffered an injury to your head? Was the injuries in the same area/spot?		Were any MRIs or CT scans performed due to your injury?	

FAMILY HISTORY

Has anyone in your family or yourself been diagnosed with any of the following?	Y/N?	Explain the diagnosis and when you were diagnosed with any of these:
○ Migraines		
○ ADD/ADHD		
○ Depression, anxiety		
○ Any mood or psychiatric disorder that may affect personality changes including but not limited to: ▪ Dissociative identity disorder ▪ Bipolar disorder ▪ Schizophrenia ▪ Antisocial personality disorder ▪ Conduct disorder ▪ Histrionic personality disorder ▪ Narcissistic personality disorder ▪ Paranoid personality disorder		
○ Epilepsy		
○ Learning disabilities		

○ Alzheimer's or Dementia		
○ Hearing loss due to: ▪ Congenital ▪ Acquired or noise exposure ▪ Ear infections (otitis media) ▪ Medications		

SYMPTOMS CHECKLIST

At this moment, are you experiencing any of the following, if so mark the level of severity:	Y/N?	Circle one of the numbers. 1 = highly bothersome 2 = bothersome 3= bearable 4 = no problem at all
– Headache		1 2 3 4
– Head pressure or throbbing		1 2 3 4
– Nausea/vomiting		1 2 3 4
– Dizziness or spinning		1 2 3 4
– Fatigue		1 2 3 4
– Sleeping more than usual, list how much sleep you usually had before injury and then after injury : ______________________________________		1 2 3 4
– Confusion		1 2 3 4
– Vision problems		1 2 3 4
– Tinnitus (ringing in ears)		1 2 3 4
– Reduced hearing		1 2 3 4
– Balance problems		1 2 3 4
– Sensitivity to noise or light		1 2 3 4
– Difficulty reading, problem solving, writing, etc.		1 2 3 4
– Paranoia		1 2 3 4
– Personality changes post injury (i.e., more irritable, loss of enjoyment)		1 2 3 4
– Numbness or tingling		1 2 3 4
TOTAL:	_________/64	

MEMORY EVALUATION: *ASK THE PATIENT TO REMEMBER A LIST OF FIVE RANDOM WORDS. THESE WORDS WILL BE ASKED AGAIN LATER TO TEST SHORT TERM MEMORY*: BALL, GIRL, FOOTBALL, SCHOOL, AND MONKEY.

ORIENTATION EVALUATION:

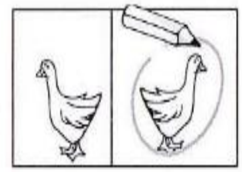
Interviewer questions:	**Client Responses:**	**Accuracy based on a 0-3 scale. 0= completely wrong, 1 = three to five mistakes, 2 = less than two mistakes, 3 = no mistakes**
– What is the month, date today and the year?		0 1 2 3
– Name the President at this time		0 1 2 3
– Where do you currently reside?		0 1 2 3
– What is your phone number?		0 1 2 3
– How many U.S. states are there?		0 1 2 3
– What are the colors of the U.S flag?		0 1 2 3
– What is your date of birth (spell out the month)?		0 1 2 3
TOTAL:	________/21	

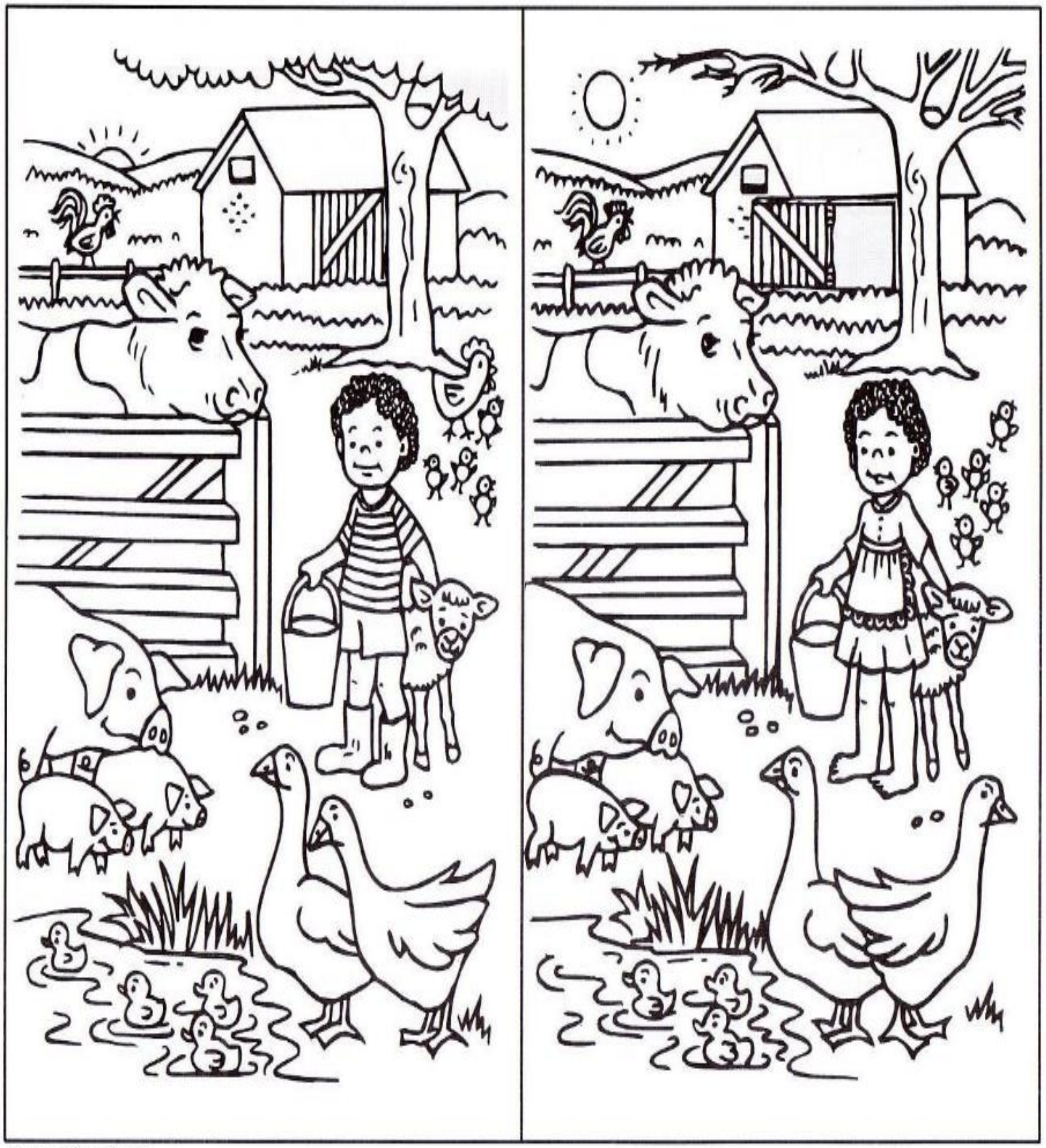
WORD RECALL: *WITHIN ONE SECOND INTERVALS, SAY EACH WORD TO THE CLIENT – ALLOW THE CLIENT FIVE SECONDS BEFOE REPEATING THE WORDS BACK TO THE INTERVIEWER. MARK THE NUMBER IN WHICH THE CLIENT RECALLS THE WORDS. FOR EXAMPLE, CIRCLE A '2' NEXT TO THE WORD 'BALL' IF THE CLIENT SAYS IT SECOND IN THEIR SEQUENCE. IF THE CLIENT EXEMPTS A WORDS, MARK A '0'.*

Word list:	**Trial #1:**	**Trial #2:**	**Trial #3:**
– Ball	0 1 2 3 4 5	0 1 2 3 4 5	0 1 2 3 4 5
– Girl	0 1 2 3 4 5	0 1 2 3 4 5	0 1 2 3 4 5
– Football	0 1 2 3 4 5	0 1 2 3 4 5	0 1 2 3 4 5
– School	0 1 2 3 4 5	0 1 2 3 4 5	0 1 2 3 4 5
– Monkey	0 1 2 3 4 5	0 1 2 3 4 5	0 1 2 3 4 5
TOTAL:	________/15		

CONCENTRATION TASKS		
Interviewer questions:	**Client Responses:**	**Accuracy based on a 0-3 scale. 0= completely wrong, 1 = three to five mistakes, 2 = less than two mistakes, 3 = no mistakes**
– Name the ABC's in order.		0 1 2 3
– Count by even numbers starting with '0' and ending with '20'		0 1 2 3
– Name as many differences in the picture as possible: (following page, can tear out of booklet)		0 1 2 3

67





Taken from Bridging with a Smile

TOTAL:	________/9

SYMPTOMS CHECKLIST

At this point in time, are you experiencing any of the following?	Y/N?	Circle one of the numbers. 1 = highly bothersome 2 = bothersome 3= bearable 4 = no problem at all
– Headache		1 2 3 4
– Nausea/vomiting		1 2 3 4
– Dizziness or spinning		1 2 3 4
– Difficulty concentrating		1 2 3 4
– Anxiety, if so, is it caused by not knowing how to answer the questions?		1 2 3 4
– Difficulty recalling information		1 2 3 4
– Vision problems (trouble focusing your eyes)		1 2 3 4
– Tinnitus (ringing in ears)		1 2 3 4
– Trouble hearing conversations and understanding instructions		1 2 3 4
– Sensitivity to noise or light		1 2 3 4
– Difficulty reading, problem solving, writing, etc.		1 2 3 4
TOTAL:	__________/44	

SENSORY EVALUATION: *RATE THE RESPONSES FROM 0-3. CIRCLE ONE OF THE NUMBERS. 0= NO RESPONSE, 1= SLIGHT RESPONSE (BARELY NOTICEABLE), 2 = DELAYED RESPONSE, 3 = FULL RESPONSE*

Smell: ***Have the patient relax in their chair with their eyes closed; after they seem to be completely relaxed wave the cotton ball just below their nostrils. They should be able to identify these smells verbally. Circle '0' for a no response.***	**Trial #1**	**Trial #2**	**Trial #3**
– Lemon	0 1 2 3	0 1 2 3	0 1 2 3
– Peppermint	0 1 2 3	0 1 2 3	0 1 2 3
– Lavender	0 1 2 3	0 1 2 3	0 1 2 3
– Basil	0 1 2 3	0 1 2 3	0 1 2 3
TOTAL:	________/36		

Auditory Processing: ***Have the patient relax in their chair; after they seem to be completely relaxed. Explain to them that they need to follow the directions that are going to be read aloud.***	**Trial #1**	**Trial #2**	**Trial #3**
– Touch your nose	0 1 2 3	0 1 2 3	0 1 2 3
– Show me your smile	0 1 2 3	0 1 2 3	0 1 2 3
– Lift your right arm	0 1 2 3	0 1 2 3	0 1 2 3
– Wiggle your fingers	0 1 2 3	0 1 2 3	0 1 2 3
– Point to the door	0 1 2 3	0 1 2 3	0 1 2 3
– Stand up	0 1 2 3	0 1 2 3	0 1 2 3
– Point to me	0 1 2 3	0 1 2 3	0 1 2 3
– Touch your toes	0 1 2 3	0 1 2 3	0 1 2 3
TOTAL:	_________/44		

Hearing*: Have the patient sit across from you and cover your mouth with either a dark paper or a Speech Hoop. Proceed through the following words at different intensities, while having the client repeating what word was said. Mark an 'X' by the words that were repeated wrong. Put a '~' by the words that were hesitated and leave the words that were correct blank.*				
– Week _______	– Home _______	– Tooth ______	– Jar ______	– Note ______
– Ditch ______	– Team _______	– Mop ______	– Cab ______	– Germ ______
– Tough _______	– Yes _______	– Chair ______	– Hush ______	– Search ____
– Bean ______	– Sub _______	– Soup ______	– Room _____	– Ring ____
– Size _______	– Life _______	– Death ______	– Whip _____	– Goal _____
TOTAL CORRECT:	_________/25			

WORD RECALL: *THE PATIENT WAS ASKED TO REMEMBER FIVE WORDS AT THE BEGINNING OF THE ASSESSMENT. THE CORRECT SCORE WILL BE MARKED AS A PERCENT CORRECT OUT OF THE TOTAL WORDS.*

What were the five words that you were asked to remember at the beginning of the assessment?	**Y/N?**	**Observations (articulation errors, hesitation, etc.)**
– Ball		
– Girl		
– Football		
– School		
– Monkey		
TOTAL CORRECT:	______/5 : ________%	

SYMPTOMS CHECKLIST

After completing this assessment are you experiencing any of the following?	Y/N?	Circle one of the numbers. 1 = highly bothersome 2 = bothersome 3= bearable 4 = no problem at all			
– Headache		1	2	3	4
– Nausea/vomiting		1	2	3	4
– Dizziness or spinning		1	2	3	4
– Difficulty concentrating		1	2	3	4
– Anxiety, if so, is it caused by not knowing how to answer the questions?		1	2	3	4
– Difficulty recalling information		1	2	3	4
– Vision problems (trouble focusing your eyes)		1	2	3	4
– Tinnitus (ringing in ears)		1	2	3	4
– Trouble hearing conversations and understanding instructions		1	2	3	4
– Sensitivity to noise or light		1	2	3	4
– Difficulty reading, problem solving, writing, etc.		1	2	3	4
TOTAL:	_________/40				

Symptom checklist overall total: _____/148

Memory evaluation total: _____/21

Word recall overall total: _____/20

Combined score: ______/303

Concentration total: _____/9

Sensory overall total: _____/105

Finals comments or observations:	Date:

________________________________ ________________________________

Assessor signature Date Client signature Date

Score:	Explanation of results:	Plan of action moving forward:
303-270	Based on the results, the client's cognitive and/or auditory functioning was not greatly impacted by the injury.	
269-240	Based on the results, the client's cognitive and/or auditory functioning was slightly impacted due to the injury.	
239-213	Based on the results, the client's cognitive and/or auditory functioning was impacted due to the injury.	
212-199	Based on the results, the client's cognitive and/or auditory functioning was greatly impacted due to the injury.	
198-173	Based on the results, the client's cognitive and/or auditory functioning was significantly impacted due to the injury.	
172>	Based on the results, the client's cognitive and/or auditory functioning was immensely impacted due to the injury.	

The equivalency for the scoring was based on a random number out of 303 to provide us with a percentage. Assuming that this assessment is seen as an academic exam, we wanted the scoring to be as similar to academic grading scales. The following are the scoring ranges as percentages for a better understanding of why these scores would be concerning to the assessor: 303-270 = 100%-89%, 269-240 = 88.7%-79%, 239-213 = 78.8%-70%, 212-199 = 69%-65.6%, 198-173 = 65%-57%, 172> = 56.7%>. The scoring is a guideline of how to proceed following this assessment, not a perfect solution. The score should be a baseline measurement of cognitive and auditory processing skills, for use in measuring future progress, after treatment.

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