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Research Article

Pre and Post Intervention Effects following Neurocognitive Training in an Ongoing Therapeutic Program for Memory and Executive /Neuropsychological Deficits in Children

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Abstract

This is an ongoing study (Fisher and Szokola, May 2018, Fisher and Szokola December 2018) addressing therapeutic intervention for memory and executive reasoning deficits in children. Re-evaluation used to measure the progress of treatment was sufficient to yield a new study reporting pre and post-intervention effects. Children and adolescents are seen two times per week for treatment which consists of cognitive behavioral therapy addressing emotions, social development and social skills as well as the neurocognitive training program that is specifically designed for each patient based upon their specific neuropsychological evaluation test results.

The neurocognitive program consists of well over 200 games and activities that are used to create an individualized protocol that is patient specific based upon neuropsychological evaluation, presenting complaint, parent interview and self-report questionnaires from the teachers, parents and child (depending upon the age). Re-evaluation occurs anywhere from six months to one year. Parents and teachers as well as the children report positive improvement in their everyday functioning. Positive results continue to be seen on pre and post neuropsychological evaluation from this therapeutic program provided in an outpatient treatment setting that provides individual therapy and neurocognitive enhancement.

Keywords: *Neuropsychological Testing; Neurocognitive Intervention; Children and Adolescents*

Introduction

This program has been ongoing for over fifteen years. The current study reflects fourteen years of neurocognitive intervention training pre and post-testing re-evaluation. The program is individually designed based upon neuropsychological evaluation and executed in a therapeutic setting. Neurocognitive therapy occurs alongside conventional cognitive behavioral therapy to address behavioral issues, related neurological and psychological deficits and concerns.

Getting sufficient sleep and good sleep hygiene are continually stressed. Therapy encompasses school and social emotional related needs as well as addressing social emotional events/incidents that may occur during the course of treatment. Contact is maintained with treating pediatricians, primary care physicians and specialists. Parents are integrally involved in the program and encouraged to engage in the activities learned in the clinic setting at home as a carry-over program.

Patients are typically referred by professionals in the medical field given the known status of this facility offering neuropsychological evaluation. It is not uncommon for the primary referral complaint to initiate with the diagnosis of ADHD and continued lack of progress despite the intervention of stimulant medication.

A number of these children have additional emotional issues and entered the facility having unsuccessfully trialed a number of psychotropic medications. The range of neurocognitive deficits is mild to severe with possible causal factors related to either specific neurological disease, sleep apnea (or Upper Airway Resistance Syndrome), concussion or brain injury, birth issues (premature, lowered Apgar scores, loss of oxygen) and/or unknown causal factors. All of the children were diagnosed with memory deficits as well as executive deficits most of the time.

Review of the Literature

The past 25 years have witnessed an evolved field and profound changes in neurocognitive rehabilitation with the realization that medication is not going to solve the problem of deficits related to brain behavior function. Memory deficits and the concept of neuroplasticity is becoming more of a reality than a conceptualization [1]. The development of neuroplasticity has been a significant development to suggest that change is possible. Much of the research to date revolves around the aged population, dementia and stroke. The use of fMRI to assess activation of regions of interest provided the connection between specific types of training and training specific changes, resulting in activated and increased brain activity [2,3]. There has been a focus in the field upon the use of non-invasive brain stimulation techniques to evoke brain changes [4]. Exercise is another focus [5].

As a result of neurocognitive intervention becoming more widely accepted in the search of medication alternatives, programs are evolving. Routine recommendations for dementia prevention are to use the brain and complete daily activities using some type of a brain rehabilitation intervention. The National Institutes of Health (NIH) has been conducting and supporting research to address cognitive disabilities and rehabilitation research, organizing a conference in 2016 with panel findings published in six journals [6]. However, children were found to have little ongoing rehabilitation for traumatic brain injury despite the long-term effects upon educational attainment, vocational and social functioning/success.

Commercial programs have shown efficacy using large scale studies revealing the benefit of cognitive training and stimulation [7,8]. Cognitive training intervention and cognitive enhancement have been found to have positive effects, as well as impacting cognitive decline in the aged population [9,10]. When cognitive training was compared to physical training, improvement was distinct revealing improved executive function with cognitive training and [11] improved memory with physical training [12]. Although a link was not found between short-term physical or cognitive activities and white matter changes, there were positive associations between two target training outcomes and white matter hinting at the potential for long-term activities to impact white matter integrity [13]. Only modest support was shown for the potential of videogame training to improve cognitive function in healthy older adults and another study revealed only specific effects. The transfer of training to real life improvement was seen as offering mixed results [14-16]. Cognitive remediation and vocational rehabilitation were found to have a significantly greater impact upon job attainment rates than playing portable brain games [17].

There has been research with children primarily involving the use of programs on the computer. A systematic literature review of computerized working memory training used with ADHD child population suggested mixed findings regarding the benefit of such training. Critical issues in interpreting existing studies referenced the lack of alignment between demonstrated outcomes and the hypothesized model of therapeutic benefit for a working memory program [18]. A training program used with autism spectrum disorders did not show significant impact and there was a high attrition rate [19]. A twenty-five session home based computer training program aimed at executive function in ADHD children, evaluated on multiple outcome domains, found improvement on inhibition and visuospatial short term and working memory related to the type of treatment received. Transfer effects were found only for nonspecific factors [20]. Another computerized training study addressing working memory in combined subtype ADHD, in a double blind, placebo controlled parallel

group clinical trial, revealed significant improvement and long term far transfer effects [21]. Activities and exercises demanding cognitive control for preschool children comprised of a cognitive training module used to identify sets of socio-environmental predictors was associated with higher pre-intervention and post-intervention cognitive control [22]. Using a randomized control study, effects of one-on-one cognitive training on memory, visual and auditory processing, processing speed, reasoning, attention and general intellectual ability (GIA) for students ages 8 to 14 years were examined finding significant differences on all outcome measures excluding attention [23].

Purpose of the Study

The purpose of this study is to provide ongoing data addressing the efficacy and benefit of a neurocognitive treatment program designed to provide remediation for identified deficits from neuropsychological evaluation using a patient specific individualized program encased in a therapeutic session. Neurocognitive treatment is provided in the context of a therapy session with a therapist to address the neurocognitive and memory deficits as well as related behavioral and emotional issues that typically accompany these deficits. This study represents the goal of establishing ongoing efficacy of a neurocognitive therapeutic intervention program that is individually designed with the goal of improving memory and executive reasoning function in children.

Medications are not providing necessary relief for children with complex deficits beyond that of a genetic attention disorder. Too often these children are diagnosed with ADHD Combined Subtype to explain their symptoms. Symptoms tend to reflect the impact of executive dysfunction upon emotions, cognitive processing and perception of events occurring in their everyday environment. Reactive emotionality, emotional lability and out of control behavior tends to emerge as a result of these variables.

The health field is turning towards a variety of interventions in the hopes of making the difference that medication is not making. Part of the problem is the lack of accurate diagnosis and attempting to treat a condition that has not been properly or completely diagnosed. Neuropsychological evaluation has the scientifically designed ability to fill that gap by identifying the specific deficits of brain behavior function impacting performance. The result is the ability to define specific deficits sufficient to formulate a plan of intervention. Determination of the efficacy of this approach is seen in the post-evaluation results as well as patient, teacher and parent report of observational differences seen in everyday life.

Methods

Children and adolescents in this study are typically referred by their treating pediatrician or primary care physician to address behavioral or emotional complaints, unresolved attention issues and/or ongoing academic difficulties. Evaluation is completed initially addressing the treatment complaint followed by additional testing based upon issues that emerged and/or became apparent from the initial assessment. Children determined to benefit from this treatment program offered at this facility were found to have additional deficits typically involving memory and executive reasoning. These deficits were seen as the primary problem, having a greater impact upon their daily life than identified attention symptoms.

Children and adolescents were placed in a treatment program to address behavioral as well as neurocognitive memory and executive deficits, ages are 5 to 17 years, n = 54. They are seen twice per week for a therapeutic session for approximately one hour consisting of cognitive behavioral intervention and the neurocognitive training program. Training programs are provided for home use to create a carryover program and provide ongoing intervention.

The range of neurocognitive deficits is mild to severe with possible causal factors related to either neurological disease, sleep disorders, brain injury, birth issues and/or unknown causal factors. There were 17 females and 37 males in the study.

All of the children were diagnosed with memory deficits. Slightly more than half (i.e. 55%) were diagnosed with memory, executive reasoning and attention deficits, 11% were diagnosed with memory, executive reasoning, attention deficits and sleep apnea, 3% were diagnosed with attention and executive reasoning deficits, 1% were diagnosed with a TBI, 3% were diagnosed with a TBI, memory and

executive reasoning deficits, 7% were diagnosed with memory and executive reasoning deficits and 12% were diagnosed with memory and attention deficits.

The majority (i.e. 61%) of the children evaluated were not taking any medication at the time of evaluation, 9% were only taking psychotropic medications, 12% were taking only a stimulant medication, 7% were taking a psychotropic medication and a stimulant and 9% were taking other types of medication (e.g. allergy or thyroid medication).

Neuropsychological assessment was completed using a number of different test measures assessing attention, memory, executive reasoning and visual spatial or visual perceptual deficits. Testing was patient specific, based upon symptom complaint and reason for referral as well as concerns generate by initial attention evaluation. Re-administered tests are based upon the individual program goals for neurocognitive training.

Programs are individually designed based upon patient needs and neuropsychological test findings. Each plan is patient specific and created based upon symptoms presented, deficits impacting daily life and neuropsychological evaluation suggesting a specific focus (e.g. short term memory, verbal versus visual memory, working memory, retrieval versus recognition, word retrieval and the impact of executive deficits. Re-evaluation is completed, using the same testing at the same time of day, after generally six months of treatment to ascertain changes and efficacy of the program. The determination for the time of re-evaluation was based upon treatment lapse of time, when the treating therapist thought there was sufficient improvement to change the program or at the wish of the parent or medical specialist.

Children are used as their own comparison re-evaluation is compared to initial baseline testing. In the use of pre and post-testing, children and adolescents provide their own control. Testing is completed at the same time of day, medication is typically held constant (if tested initially on medication, the child was re-evaluated while on medication).

For this study two batteries of tests were used given that they were common to the patients studied; the Wide Range Assessment of Memory and Learning (WRAML-2) and Cognitive Assessment System (CAS-2). These test measures are used to assess memory, learning as well as the impact of executive processes (planning, simultaneous and successive processive processing as well as attention). These test batteries were administered prior to and following participation in a therapeutic treatment program. Comparison of initial and repeated evaluation over time intervals was assessed, generally six months to one year between pre and post testing.

The WRAML-2 is a memory battery consisting of verbal and visual learning tasks, short term and working memory, assessing retrieval and recognition. The WRAML-2 was designed as a comprehensive tool to be used in the detection of memory throughout the lifespan and is the only memory measure available to provide developmental assessment [24]. Normative profiles of memory were identified using this measure. This measure has been used in developmental research to investigate episodic memory [25-27].

The CAS-2 assess planning, simultaneous and successive processing as well as attention and is clinically seen reflecting the impact of executive deficits of sequential processing, integration, selective attention and cognitive rigidity [28].

The neurocognitive training is integrated into the therapy session that additionally provides treatment of emotional issues, the impact of social and academic factors and ongoing positive and adverse events occurring in daily life. Children and adolescents are generally seen twice per week and encouraged to participate in the overflow program at home during the course of their week to maintain treatment when not in the clinic setting. Each child is assigned a different protocol based upon neuropsychological evaluation and the diagnosis of specific memory types (short term, working, visual, verbal, recognition versus retrieval) as well as the impact of executive reasoning deficits (selective attention, cognitive rigidity, integration, poor sequential processing).

There are over 200 games and activities for the therapist to employ, some of which have been created and others are utilizing available published games. Specific interventions are employed to match the neuropsychological test findings. During the course of therapy, the

use of the game may be continually altered; timing may be added, increasing the number of items to remember, changing the demands of the task (use of color versus black and white) or the pattern of recall for working memory, to cite a few examples. As the individual improves, there are increased levels of the activities. For example, there is a Geoboard that involves the use of patterns created with different colored rubber bands matching a picture presented in black and white or color that provides increasing complexity. The person copies the design and then has to recall it from memory. The task involves the use of planning, memory processes and visual perceptual analysis.

Results

Findings revealed statistically significant differences in scores for initial and re-evaluation testing following treatment. Paired samples t-tests revealed significant differences between initial and re-evaluation scores on the WRAML-2 for verbal memory ($p = 0.039$), screening memory ($p = 0.002$), general memory ($p = 0.016$), general recognition ($p = 0.041$) and working memory ($p = 0.024$). Significant findings also occurred on the CAS-2 for attention functioning ($p = 0.018$), planning abilities ($p = 0.030$), as well as overall functioning ($p = 0.012$).

What is significant in this study is the demonstration of improved functioning across overall index scoring. For this to occur the subtests must be substantially improved that comprises the specific index score. Verbal memory improved which comprises a story recall and list learning task. Screening memory was improved which comprises verbal and visual learning tests (story recall, list learning, recall of five designs shown one at a time and visual recognition). Working memory improved reflecting the impact of verbal and symbolic re-ordering of information (words, numbers and letters). General memory was improved which comprises verbal and visual memory as well as short term attention tasks (recall of nonverbal and verbal sequential tasks). General recognition was improved comprising verbal and visual recognition of the stories, list of words, designs and pictures suggesting that the information was retained and stored.

On the cognitive battery there was improvement in overall functioning representing the combined impact of planning, simultaneous processing, attention and successive processing for memory of words and sentences. Attention functioning improved indicating a positive impact upon traits of inhibition and selective attention seen clinically on tasks of interference and number detection. Planning was improved suggesting the benefit to processes of cognitive flexibility and problem solving as well as clinically seen integration and ability to assess the whole picture.

		Pre-Testing	Post-Testing
WRAML-2 Verbal Memory	Mean± SD	95.02 13.16	99.69 14.95

Table 1: *Effect of cognitive training on verbal memory performance.*

		Pre-Testing	Post-Testing
WRAML-2 Screening Memory	Mean± SD	99.29 14.26	106.36 18.04

Table 2: *Effect of cognitive training on screening memory performance.*

		Pre-Testing	Post-Testing
WRAML-2 General Memory	Mean± SD	97.0 6.74	105.2 8.74

Table 3: *Effect of cognitive training on general memory functioning.*

		Pre-Testing	Post-Testing
WRAML-2 General Recognition	Mean± SD	99.5 20.46	108 6.02

Table 4: *Effect of cognitive training on general recognition functioning.*

		Pre-Testing	Post-Testing
WRAML-2 General Recognition	Mean± SD	91.66 7.37	103.33 8.50

Table 5: *Effect of cognitive training on working memory functioning.*

		Pre-Testing	Post-Testing
CAS-2 Attention Functioning	Mean± SD	92.24 15.71	97.21 12.94

Table 6: *Effect of cognitive training on attention functioning.*

		Pre-Testing	Post-Testing
CAS-2 Overall Functioning	Mean± SD	97.60 17.30	106.60 14.97

Table 7: *Effect of cognitive training on planning abilities.*

		Pre-Testing	Post-Testing
CAS-2 Overall Functioning	Mean± SD	92.36 14.52	96.15 13.05

Table 8: *Effect of cognitive training on overall cognitive functioning.*

Conclusions

This study demonstrated improved functioning across overall index scoring for memory evaluation as well as reflecting substantially improved subtest scoring that comprised the specific index score. Improvement was seen for tasks of verbal learning, working memory as well as short term memory reliant upon attention. Recognition improved suggesting that the information was retained and stored. There was overall improvement on the cognitive assessment involving executive reasoning processes of planning (cognitive flexibility, integration and problem solving) simultaneous processing, attention (inhibition and selective attention) and successive processing seen on neuropsychological evaluation.

The tests in the cognitive assessment reflected specific improvement in areas of attention (suggesting the possible application of improved inhibition as well as selective attention processes and ability to tolerate more stimuli in the environment or learning situation) and planning (suggesting the possible application of improved problem-solving skills and cognitive flexibility).

Improved functioning for verbal memory learning as well as recognition of verbal and visual information following a delay of time was seen. Visual memory by itself did not reveal significant improvement and improved only with delayed recognition assessment. Hypothetically, this may be the result of the clinically seen impact of executive function that tends to affect the tasks involved with the assessment of visual memory using this specific test battery. The lack of visual memory improvement by itself did not impact the scre-

ening and general memory scores which significantly improved. Positive changes in working memory for verbal and nonverbal stimuli provides the potential for improved functioning in a number of real-life areas such as the ability to take notes in class, hold conversations and use in everyday learning situations.

Efficacy was demonstrated in this continuing study of using a neurocognitive program within a therapeutic session to address neuropsychological and behavioral/emotional issues for children and adolescents suffering from memory and executive reasoning deficits. Findings indicate that therapeutic intervention has been beneficial in recovering a range of memory and executive functioning in a clinic population of children with deficits documented on neuropsychological evaluation. Improvements in the areas of overall memory, verbal, working and recognition memory, as well as attention, planning and overall cognitive functioning were seen between six months and one year of treatment.

Limitations of the Study

This study lacks a matched patient control group. This is a clinical study completed in an outpatient setting using a clinical population. Almost twice as many males were included in the study relative to females (17 females and 37 males). However, this may be reflective of the well documented tendency for males to be diagnosed with an attention disorder given that attention was the typical entryway to neuropsychological evaluation.

Six months is the general rule with regard to practice effects although familiarity with the test measure providing an additive impact cannot be ruled out. Medication was not separated out in stratified groups although medication provides the ability to rule out inattention as a variable in testing and typically those children on stimulant medication had more of an impact of attention deficits to warrant medication intervention. Information from the school setting was not obtained as part of the follow up testing due to reevaluation being done at different times of the year including the summer.

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