Preliminary Analyses of BrainWise—Executive Function Skills
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ABSTRACT

There is substantial interest in understanding the executive function skills (e.g., planning, impulse control, self-monitoring) of children and adolescents, as well as the degree to which "thinking skills" intervention programs can facilitate their acquisition and application in everyday contexts. The Tower of London-Revised (TOL-R) and the Stroop Test were administered to 36 male and female students in fifth grade, middle school, and high school who participated in the BrainWise® intervention during the 2004 – 2005 academic year. During the pretest phase (October-November), both the TOL-R and Stroop test scores were positively correlated with age, and neither test exhibited gender differences. Both the TOL-R and the Stroop test performance demonstrated significant improvements from the pretest to the posttest session (April-May 2005). Neither test showed an Age X Session interaction, suggesting similar improvement across the three groups. Regarding test-retest stability, both the TOL-R (r = .81) and the Stroop (r = .60) demonstrated adequate reliability. Twenty-eight of 34 children (82%) exhibited improved performance on at least one of the measures, and 16 of 34 children (47%) showed improvement on both measures. It is very important to point out that all or some portion of this improvement may be due to maturation and cognitive development presumably occurring during the six months that elapsed between the pre- and posttests. Studies underway include a matched control group to determine the extent to which this improvement is due to maturation, the BrainWise® intervention, or some combination of the two factors.

INTRODUCTION AND PURPOSE

The BrainWise Intervention and Executive Function Skills

Executive functions refer to the set of cognitive processes required for future-oriented, goal-directed behavior (Welsh, 2002) and decades of evidence from clinical neuropsychology (e.g., Luria, 1972) and neuroscience (e.g., Goldman-Rakic, Bourgeois, & Rakic, 1997) have linked executive function processes to the prefrontal cortex of the brain which shows a protracted course of development from the prenatal period through adolescence (e.g., Huttenlocher, & Dabholker, 1997; Welsh, 2001). Executive function involves the process of integrating and combining separate, but collaborative, cognitive abilities in service of a future goal, and is elicited when a person is presented with a novel or challenging task or placed in an unfamiliar situation for which he or she does not have routinized, automatic responses. This construct includes several core cognitive processes, including, but not limited to, attention, working memory, inhibition, and self-monitoring. These core processes work in coordination to allow for the more complex manifestations of executive function, such as planning, inductive reasoning, and flexible, strategic problem solving.

Founded by Dr. Patricia Gorman Barry Ph.D. in 1995, the BrainWise® program represents the several years of research, implemention, and evaluation that has culminated in a curriculum that teaches essential emotional, social, and cognitive skills through an innovative structured approach called the "10 Wise Ways." The philosophy underlying the program is to avoid “quick fixes” such as canned, stereotyped responses to life’s challenges and, instead, to provide individuals with the cognitive, social, and emotional resources to prevent, avoid, and solve problems. Helping individuals learn to make wise, responsible choices requires that certain specific concepts be introduced, applied, used and reinforced, and these critical thinking skills are demonstrated through a series of lessons over a period of months. Individuals learn that they can exert control over their emotional reactions by using analysis, introspection, anticipation, and planning, as well as by recognizing their social support system in the form of teachers, peers, and family. Although BrainWise was initially developed to address high-risk behaviors such as teen pregnancy and substance abuse, it has been used successfully with a range of populations from low-risk kindergarten children, to children with developmental disabilities, to adolescent girls at risk for problem behaviors.

Purpose of this Study

The purpose of this small pilot study was to examine the degree to which exposure to the BrainWise curriculum is related to improvements in executive functions in children and adolescents who are identified “at risk” for academic and or behavioral problems at school. How does the BrainWise program relate to the executive functions previously described? The essence of this intervention is to teach children, adolescents, and adults that they can effectively control their own behavior and make better decisions by acquiring a new set of thinking strategies. Through an explicit, yet engaging, set of lessons individuals are taught how to apply the executive function skills they are learning to control emotions, use social support resources, anticipate the consequences of their actions, plan methods to achieve goals, and communicate their needs and desires in strategic and effective ways. As stated earlier, executive functions are particularly needed when an individual is placed in a novel and/or challenging environment for which automatic responses (at least adaptive ones) are not readily available. For children and adolescents at risk for academic and/or behavioral problems, providing them with a resource of thinking and behavioral control skills via the BrainWise program can be critical to their navigation and ultimate success in meeting the challenges.

This study is quite preliminary in that involves a small sample size (N=36) of children and adolescents involved in BrainWise, but it did not include a matched control group of students who did not receive this curriculum. Nevertheless, we examined the pre-intervention (i.e., baseline) scores on two executive function (EF) measures, the Tower of London-Revised (TOL-R) and the Stroop test and compared these to performance six months later, after the participants were exposed to weekly sessions of the BrainWise curriculum at school. The following questions were addressed:

- What are the age differences in performance on the two tasks when comparing 5th graders, middle-school students, and high school students (main effect of Age Group)?
- Is there a significant difference in performance from pre-intervention to post-intervention (main effect of Intervention)?
- Are there differences across the three age groups in terms of this pre to post-intervention difference in performance (Age Group X Intervention interaction)?
- What is the test-retest stability of the two EF tasks across a six-month period?

METHOD

Sample

The sample included 36 elementary, middle school, and high school students living in a metropolitan area. The students were almost evenly divided between Caucasians and Hispanics; one third of the sample was male and two thirds of the sample was female. All students were in regular classrooms except a class of special education students (moderately disabled) at one of the high school sites. All students receiving the BrainWise intervention were identified by their classroom teacher and/or the school counselor or social worker as "at risk" for academic and/or behavioral problems in the classroom. The elementary and high-schools represented both low-income and middle to high-income areas of the city. The middle school students were all Hispanic females participating in an afterschool program at a neighborhood church that targeted girls who were at risk for dropping out of school. **Table 1** provides basic demographic information on the three groups. In light of the confounding of age group and gender in this preliminary study, it is important to point out that performance on the two outcome measures did not demonstrate gender differences.

Table 1. *Demographic Information on the Children and Adolescents Participating in the Study*

Age Group	Males	Females	Mean Age (SD)
5th grade	5	6	10.18 (.40)
Middle School	0	14	12.97 (.97)
High School	6	12	15.89 (1.18)

Intervention

The BrainWise curriculum involves a series of lessons in which the trained instructor (often the classroom teacher) teaches the students about the "10 Wise Ways," which stresses control of emotions and effective problem solving by using executive

function skills such as planning, impulse control, and self-monitoring **(see Table 2).** The BrainWise curriculum integrates characteristics found in successful programs: Instructors provide students with 50 or more contact hours, use multiple teaching techniques, and address both risk and protective factors. Additionally, the program can be replicated at multiple sites with demonstrated effects. It involves parents, and its instructors receive ongoing support and training.

Across the four schools, the BrainWise curriculum was taught once to twice a week for 45-50 minute sessions either in the regular classroom or in special pull-out sessions. Typical of schools, the study participants received a wide range of the intervention in both quality and amount, the BrainWise curriculum's ten concepts, lesson plans, order of skill presentation, and ongoing reinforcement provided consistency across the sites. The pilot study gave us information on the viability of this format as well as on the instruments we can use to measure executive function among students taking BrainWise.

Table 2. ***Summary of the BrainWise Curriculum: The 10 Wise Ways***

The 10 Wise Ways to Stop and Think

Wise Way #1: Use your Wizard Brain over your Lizard Brain.
Wise Way #2: Use your Constellation of Support.
Wise Way #3: Recognize Internal and External Red Flags.
Wise Way #4: Exit your Emotions Elevator. (Emotions are compared to a ten story elevator. The higher up they are, the more likely you are to use you Lizard Brain. Techniques to lower the elevator include taking deep breaths, using control self-talk, redirecting your emotions, and using relaxation techniques.)
Wise Way #5: Separate Fact from Opinion.
Wise Way #6: Ask Questions and Gather Information.
Wise Way #7: Identify your Choices (IDC).
Wise Way #8: Consequences of Choices.
Consequences Now and Later (CNL).
Consequences Affecting Others (CAO).
Wise Way #9: Set Goals and Plans for Action.
Wise Way #10: Communicate Effectively.
1. Nonverbal communication.
2. Verbal communication.
    a. I messages.
    b. Recognizing differences.

Outcome Measures

The two executive function tasks below were administered in one, one-hour session before the BrainWise intervention began in October of 2004 and again after the intervention ended in May of 2005.

Tower of London-Revised (TOL-R; Schnirman, Welsh, & Retzlaff, 1998): This 30-item test requires that the participant create a goal-configuration of colored balls on up to three pegs from a start configuration. A correct solution is executed in the designated number of moves (4, 5, or 6) while following three rules: (1) move one ball at a time; (2) balls must be moved to a peg; (3) only one ball may be moved to shortest peg, two balls may be moved to medium-sized peg, and three balls may be moved to tallest peg. The score (number correct) can range from 0 to 30 points.

Stroop Test (Golden, 1978): Partipants were presented with three tasks in a consistent order; each task consisted of an 8.5" X 11" sheet of white paper on which was printed 100 stimuli. Task One: the participant reads the words on a page consisting of the words "RED," "BLUE," and "GREEN" printed in black ink; Task Two: the participant names the colors on a page consisting of sets of four Xs that were printed in red, blue, or green ink; Task Three: the participant names the colors of conflict stimuli in which the word (eg. "RED") was printed in a conflicting color of ink (eg., blue ink). The participants were told to name the color of ink or read each word, moving down the column as quickly as possible and correcting their errors before continuing and the number correctly named or read in 45 seconds are recorded. The interference score was calculated in order to adjust the conflict condition score for reading and color naming speed. This interference score reflected the resistance to interference or the ability to inhibit the reading response in the conflict situation, and negative scores reflect poor inhibition, while positive scores reflect good inhibition.

RESULTS

See Table 2 for descriptive statistics. Thirty-four participants had pretest and posttest scores on the TOL-R; all 36 participants had pretest and posttest scores on the Stroop.

Tower of London-Revised

Main Effect of Age Group was significant, $F(2,31) = 6.95$, $p=.003$. Tukey HSD post-hoc comparisons indicated that the high-school students had higher scores than the elementary school students, but middle school students did not differ from either group.

Main Effect of Intervention (pre-intervention vs post-intervention) was significant, $F(1,31) = 4.69$, $p=.03$. The mean score was higher in the posttest than in the pretest.

Age Group X Intervention Interaction was not significant, $F(2,31) = 1.36$, $p<.05$, suggesting similar improvement from pre-intervention to post-intervention in all three age groups. [NOTE: the almost identical pretest and posttest means for the high school group is the result of a few outlier participants who either scored at ceiling at both test sessions or who went down dramatically from pretest to posttest. Seven of fourteen students improved their score on the test, and four of fourteen remained the same]

Comparison with "expected change": a rough estimate of expected change over six months was calculated by regressing age onto the pretest TOL-R scores in the cross-sectional data. The slope indicated that an increase of .70 would be expected by

maturation, while the average change from pre- to posttest was 1.40 points **(see Figure 1).**

Test-retest reliability: The stability of the TOL-R scores across the six-month interval was **.81.**

Stroop

Main Effect of Age Group was significant, $F(2,33) = 6.18$, $p = .005$. Tukey HSD post-hoc comparisons indicated that high school students had higher scores (i.e., better inhibition) than both middle school and elementary school students, but that the latter two groups did not differ from each other.

Main Effect of Intervention was significant, $F(1,33) = 7.74$, $p = .009$. Scores were higher (better inhibition) in the pretest as compared to the posttest.

Age Group X Intervention Interaction was not significant, $F(2,33) = .39$, $p>.05$, suggesting similar improvement in Stroop score from pretest to posttest across the three age groups.

Comaprison with "expected change": the estimate of expected change from the regression line of age and pretest Stroop scores was .48, which is greatly exceeded by the average observed change from pre- to posttest of 2.99 **(see Figure 1).**

Test-retest reliability: The stability of the Stroop scores across the six-month interval was **.60.**

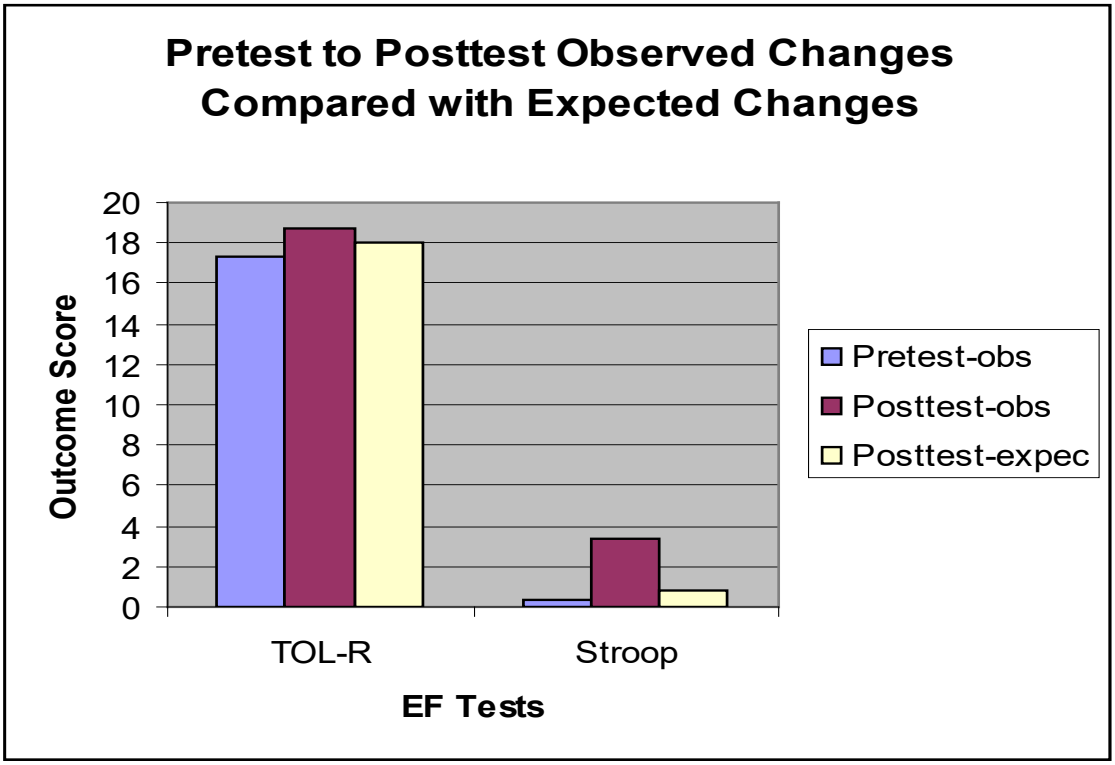
Table 2. ***Means and Standard Deviations for Performance on the TOL-R and Stroop Tests for Three Age Groups and for the Pre-Intervention and Post-Intervention Sessions***

	Pre-test	Post-test	Pre-test	Post-test
Age Group	TOL-R	TOL-R	Stroop	Stroop
5th Grade	13.60	15.40	-.56	1.31
N= 10	(4.72)	(5.02)	(7.44)	(4.26)
Middle School	16.60	18.90	-2.98	1.35
N=10	(5.85)	(6.57)	(7.80)	(4.25)
High School	21.93	21.93	4.65	7.42
N=14	(4.43)	(4.80)	(5.72)	(6.75)

NOTE: The TOL-R score is number correct out of possible 30 points. The Stroop score reflects the degree to which the individual can inhibit the reading response in order to make the color naming response. As the score increases in a negative direction, this indicates increasingly poor inhibition (a longer time than would be predicted by reading

and naming speeds alone). As the score increases in a positive direction, this indicates increasingly effective inhibition.

Figure 1.



DISCUSSION

This preliminary study of 36 children and adolescents ranging in age from 10 to 18 who received the BrainWise intervention at school for a period of six months was designed to examine the degree to which we would observe positive changes on two executive function measures from the pre-intervention period to the post-intervention period. All children were receiving the BrainWise intervention because they were identified by school personnel as potentially "at risk" for academic and/or behavioral problems. There was no attempt to match the three age groups (5th grade, middle-school, high-school) on gender distribution, SES, or other variables. In addition, there was no matched control group (i.e., not receiving BrainWise) in this preliminary study. Therefore, the results must be viewed cautiously at this point.

The analysis indicated that there were overall age group differences on the two measures of executive function, the TOL-R and Stroop, as well as a session (pre to post-intervention) effect. Given the lack of a control group, an estimate of the expected performance change over six months was derived from the slope of the regression line between age and pretest score. For both tests, but especially for the Stroop inhibition score, the improvement from pre-intervention to post-intervention was greater than would be expected by maturation alone.