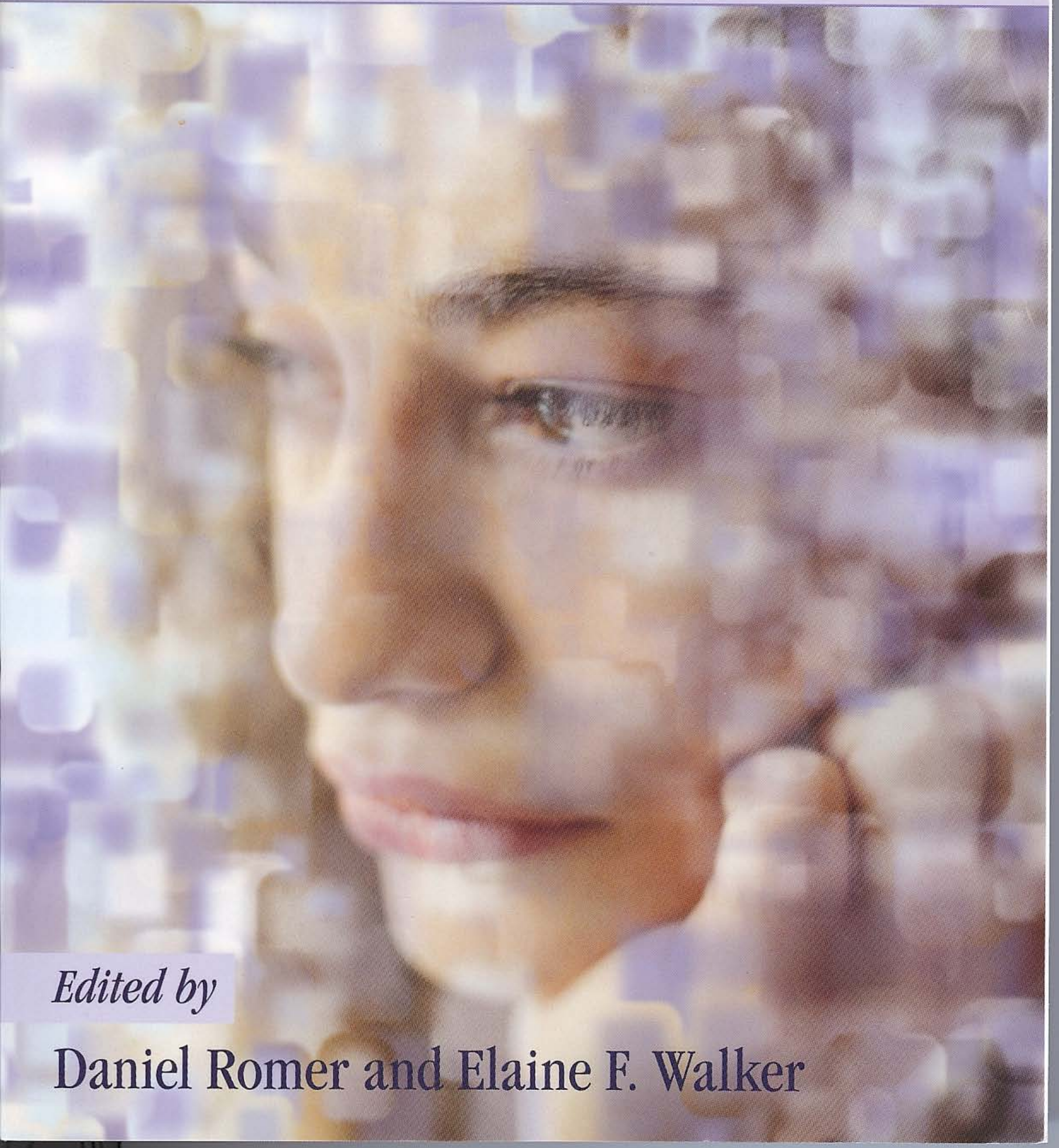
Adolescent Psychopathology and the Developing Brain

Integrating Brain and Prevention Science



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Patricia Gorman Barry and Marilyn Welsh

Searching for "the Green"

David[1] is a slightly built 18-year-old who looks younger than his age. He has an IQ of 50 and attends an urban high school that has contained classrooms for disabled students. He is friends with Ed, another student with disabilities.

Pat Austin, a special education expert and social worker, teaches both boys in a thinking skills course called BrainWise. The BrainWise curriculum provides basic information on the brain and uses this as a framework to teach a series of skills called the "10 Wise Ways." Each wise way builds on another, merging knowledge about the brain with cognitive concepts. When students practice and learn the concepts, they develop problem-solving behaviors.

BrainWise material can be taught in 20 to 30 hours, with an additional 30 or more hours spent reinforcing the skills. However, special needs students require many more hours of instruction and often take the course for consecutive years. David and Ed were completing their second year and had received an estimated 300 contact hours of materials and practice. Still, Mrs. Austin wondered how much they had learned. "It was all I could do to get them to understand the basics," she said.

A few months before the school year ended, David started exhibiting signs of schizophrenia, saying he was hearing voices. This was not surprising as his parents were diagnosed with paranoid schizophrenia. One day, David said that he not only heard voices, but saw flying clocks and feared that the voices were going to steal the clocks—and his brain. This happened when David was in the school hallway with Ed.

"Where is the green? Help me find the green," he cried over and over, hitting his forehead with his fist. Students stared as Ed guided his friend through the crowded hallway to Mrs. Austin's office. David entered her office, twisting his body, pounding his forehead, and crying, "I need the green! I can't find the green!"

Mrs. Austin tried to calm him. "You're safe, David. Take some deep breaths."

He wailed, "Where is the green? I can't find the green."

"What is 'the green'?" asked Mrs. Austin.

David did not answer, but moaned, "I can't find the green," and kept hitting his forehead.

Ed answered, "Mrs. Austin, you know! The green's his Wizard Brain. That's why we came to you."

Now Mrs. Austin knew what David was saying. In the BrainWise program, each student receives a picture of the brain, which they label and color as they learn about its different parts. They learn that their senses send signals to the thalamus (also called the brain's relay center), and they color it blue.

The limbic system contains the amygdala (emotions) and the hypothalamus, which houses the fight-or-flight reaction, a response also found in reptiles. Because of this, it is called the Lizard Brain. They learn that the thalamus and limbic system are close to each other and connected, helping the brain send signals to the body so that it responds quickly to protect it from harm. The brain interprets any intense emotion as a threat and will always react without thinking. Because of this, students color the limbic system red.

The prefrontal cortex, or Wizard Brain, is behind the forehead and houses executive functions. Students color it green. Unlike the Lizard Brain, which is connected to the thalamus at birth, connections to the Wizard Brain must be learned. Each time students learn a thinking skill, they draw a line on their picture of the brain showing how the skill connects the thalamus with the Wizard Brain. They learn that thinking skills' connections intercept signals to the Lizard Brain, helping them stop and think before they react.

Mrs. Austin assured David that he had found "the green"—he had used his Wizard Brain to stay low on his emotions elevator and had come with Ed to her office for help. She contacted his parents and helped them make arrangements to get David to his doctor. He was hospitalized and put on new medications.

When David returned to school, Mrs. Austin praised the boys for their use of thinking skills. Ed smiled and said, "I used my Wizard Brain."

David nodded in agreement and pointed to his forehead. "It's here."

The BrainWise Program

How do you help students of all ages and academic abilities understand the brain and how their thinking affects their feelings and behaviors? Helping young people learn how to make good choices is what BrainWise is all about. If David and Ed had not learned skills that underlie the thinking process, this scenario would have been very different. We have found that using mnemonics, drawings, and colors to teach BrainWise concepts engages people of all ages and abilities. Depending on the ages and capability of the students, teachers have the option of adding more information on the brain and explaining the complex relationship between the ventromedial and dorsolateral divisions of the prefrontal cortex, the hippocampus, the amygdala, and the HPA axis and its components, the hypothalamus, the pituitary, and the adrenal-cortex (Bremner, 2003; Davidson et al., 2000; Davidson et al., 2003; Goldsmith & Davidson, 2004; Gunnar, this volume; Teicher et al., 2003). However, the Wizard Brain/Lizard Brain explanation helps students grasp abstract concepts of thinking, emotion, and impulse. The result is a method that helps children and adolescents acquire developmental skills normally found in more mature youth and adults.

Scientifically demonstrating the outcomes of intervention programs is difficult, especially with at-risk populations. In this chapter, we present the theoretical underpinnings of the BrainWise program, as well as research we are conducting using measures of executive function to demonstrate that the program's design and approach help individuals learn and develop thinking skills. Although students may not have much control over what happens to them, we want to teach them that they do have control over how they react.

During the past 15 years, numerous character education, social and emotional learning, and positive youth development programs have been introduced to schools to help students prevent or manage the problems they face (Barry, 1996, 1998, 1999; Benson et al., 1993; Eggert et al., 1995; Elias et al., 1997; Kusché & Greenberg, 1994; Nichols, 1996; Romer, 2003; Shure, 1992; Steinberg, 1996; Zins et al., 2004). In addition, a growing number of programs are available that address specific problems including, but not limited to, AIDS education, anger management, smoking cessation, and prevention of bullying, drug and alcohol abuse, suicide, and teen pregnancy.

All of these programs compete for classroom time, creating a difficult balancing act for teachers who are increasingly under pressure to raise test scores. In addition, many interventions have come and gone, yielding little in the way of positive and lasting change (U.S. Department of Education, 2003). To promote greater success, organizations like the Center for Social and Emotional Education, the Collaborative to Advance Social and Emotional Learning (CASEL), the Center for the Study and Prevention of Violence, the U.S. Department of Education's Institute of Educational Sciences, and the U.S. Department of Health and Human Services are establishing lists and registries that identify evidence-based prevention and intervention programs. However, these lists are meaningless if the curricula are not taught as designed. A random sample of 1,905 middle school teachers found that only 25 percent of the lead staff who taught substance abuse prevention used an evidence-based curriculum and less than one third of them taught the curriculum using best practice standards (Ennett et al., 2003).

Aware of these challenges, BrainWise was designed as a universal program that addresses academic standards and can easily be integrated into the classroom. Its 10 skills teach problem-solving strategies that students use to assess and analyze their own problems as well as the problems of others. And because instructors choose to teach BrainWise, there is an increased likelihood that they will closely follow the curriculum.

Originally developed to help high-risk middle and high school students learn to make responsible choices, the program now is taught to children in grades K–12 and to adults. Many schools and agencies use the program solely with risk populations, but it also has been applied universally—for example, integrated into regular classrooms, used in after-school programs, and taught to college students. Girl Scouts can earn a BrainWise badge. Illiterate girls in China are taught thinking skills to resist sex traffickers. Some high school students even wrote a play performed for classes throughout their district that includes a rap song titled "You Gotta Stop and Think." More than 2,000 instructors have been trained to teach BrainWise, including 400 educators in China and representatives from Alaska's seven native reservations. Countless other instructors are self-taught and use the program's scripted lesson plans and online and telephone support for guidance.

Theoretical Foundations of BrainWise

The theoretical foundation of BrainWise is based on research from several disciplines, including neuroscience, the social sciences, and education. Aspects from all of these approaches are integrated into the content and delivery of an intervention used to teach children and youth how to stop and think.

Neuroscience

The brain and body are designed for survival. The body's senses (sound, sight, taste, and touch) act as sentinels, sending signals that warn the brain of danger. These signals trigger fear and the fight/flight/freeze response in the hypothalamic region, releasing glucocorticoids that bring about increased blood pressure, heart rate, and body metabolism (H. Benson, 1975; Cozolino, 2002; van der Kolk, 2003). This reaction places the body in a state of heightened alert, a response that is necessary if someone must jump out of the path of an oncoming car, but that creates problems if someone becomes violent after being accidentally bumped. The brain perceives both the car and the bump as threats, triggering nonthinking emotional and impulsive reactions (Jenson, 2000; LeDoux, 1996).

Goldsmith and Davidson (2004) suggest that chronic exposure to stressful life events that results in elevated cortisol levels may, over time, impair emotion-relevant contextual processing and inhibition. Streeck-Fischer and van der Kolk (cited in Scott et al., 2003) agree, indicating that chronic traumatic experiences affect children's capacity for emotional regulation, causing a negative sense of self, poor impulse control, and distrust of others. Even isolated traumatic incidents tend to produce discrete, conditioned behavioral and biologic responses to reminders of trauma, and chronic incidents (e.g., ongoing abuse or exposure to repeated medical procedures) have a wide range of effects on neurobiological developments (van der Kolk, 2003). Prolonged alarm reactions alter limbic, midbrain, and brainstem functions through "use-dependent" changes (van der Kolk, 2003), which change the degree to which cortical structures help modulate the brain's response to danger (Teicher et al., 2003).

What effect does this have on the large number of children and youth who daily are exposed to stress? At every BrainWise training, we ask teachers, counselors, and social workers to examine a list of 20 risk factors, ranging from "no consistent mealtime or bedtime" to "lives in a constant state of fear or threat," and check which ones their students have. Their responses are the same: "I would check all of them," or "It would be easier to check the ones they don't have." In an era of school violence (Columbine), terrorist attacks (World Trade Center, 9/11), bioterrorism threats (anthrax), random sniper shootings, and natural disasters (Hurricane Katrina), more children fear that they or someone close to them will be harmed.

The media's extensive coverage of terrifying events and the resulting aftermath—school lockdowns, security officers, routine weapon checks, false alarms—contribute to stressful physiological reactions. Research on youth exposed to war and terrorism found that they had difficulty concentrating, were irritable, and were described by teachers as oscillating between apathy and aggressive behaviors in the classroom (Saltzman et al., 2003). Posttraumatic stress research shows that participants have baseline autonomic hyperarousal states and greater resting heart rate variability compared with controls (Cohen et al., 2002), an outcome exemplified by abnormally high resting heart rates recorded in traumatized children (Perry, 1994; Perry & Pollard, 1998).

Unfortunately, many school personnel and youth workers blame the child or youth rather than considering that these young people may not know any other way to react and that their behaviors may be secondary responses to stress, grief, and depression (Saltzman et al., 2003). This is why it is important to teach young people skills that will give them control over how they respond to problems and that show them how to overcome habitual fight/flight/freeze reactions.

Experiences interpreted as traumatic will, during development, determine the functional capacity of the human brain. The same molecular characteristics of nerve tissue that allow the mature brain to store new information are also those for organizing the brain during development (Goelet & Kandel, 1986; Kandel & Schwartz, cited in Perry, 1994.) These findings emphasize how important it is to understand the effect that the external world has on the brain and the body and the impact this has on learning. They also help explain why it is important to teach children skills that will give them control over how they respond to problems.

NEURODEVELOPMENT OF COGNITIVE SKILLS. The ability to learn new skills is the subject of Eric Kandel's research. The regulation of gene expression by social factors makes all bodily functions, including the brain, susceptible to social influences (Kandel, 1998). All functions of the mind reflect workings of the brain. Thinking must be learned, and the brain does this by forming new synaptic connections. If thinking skills are never learned, not used, or used infrequently, neural connections to the Wizard Brain (prefrontal cortex) are nonexistent or weak, and the brain resorts to its hardwired survival response—responding without thinking.

Kandel won the 2000 Nobel Prize in Medicine for his research showing how this happens. He studied changes that occur in the brain with learning and how that information is retained in memory. By examining nerve cells in the sea snail *Aplysia*, he was able to observe the molecular process of learning.[2] "You can see in front of your eyes that the connections change. When the animal remembers something for the long term, it grows new synaptic connections" (cited in Mirskey, 2000, p. 2).

BrainWise teaches students that new synaptic connections to the prefrontal cortex must be formed in order to regulate the Lizard Brain's strong survival instinct. It ties in the biological explanation of learning by having students draw lines on a picture of the brain, showing how each time they learn a concept, they are building new neural connections. When the skills are used and practiced, the connections are solidified and an "Aha!" experience takes place. They learn the "use it or lose it" mantra of learning—that being aware of these connections is not enough; practice is necessary for thinking skills to be retained.

Learning to modify behaviors is the feature that distinguishes an animal's behavior and reaches its highest form in humans (Kandel, 2000). What better way to demonstrate this feat than to incorporate findings from neurobiology into a curriculum used to teach thinking skills? By breaking down and simplifying key information about learning, the BrainWise program provides a method that works for people of all ages and abilities.[3] Research is beginning to examine the interaction of genes and environment, showing that neural networks underlie thoughts and emotions (Rothbart & Posner, 2005). These findings suggest that training may guide the development of reactive and self-regulatory behavior in children (Reuda et al., this volume).

NEURAL MEDIATION OF EXECUTIVE FUNCTION. The prefrontal cortex integrates sensory information and links it to planned movement. Because of these functions, it is thought to be one of the anatomical substrates of goal-directed action in long-term planning and judgment (Kandel, 1999). These abilities are called executive functions by some researchers (e.g., Welsh & Pennington, 1988), and they do not develop automatically, but must be learned (Greenberg, Kusché, & Riggs, 2004). These skills appear to be substantially influenced by environmental input throughout childhood, although more empirical research on this issue is needed (Welsh, Friedman, & Spieker, in press).

There is general agreement that executive function refers to the cognitive processes that are necessary for purposeful, future-oriented behavior. These include, but are not limited to, regulation of attention; perception; language; inhibition of inappropriate responses; coordination of working memory; and capacities to organize, sequence, and plan adaptive behavior. These skills are necessary for efficient and effective future-oriented behavior, whether that behavior is an infant retrieving a toy or an attorney planning the perfect closing argument (Welsh, 2002). Executive functions are defined in terms of their problem-solving outcomes (Zelazo & Mueller, 2002). BrainWise's 10 Wise Ways (described below) teaches skills that are characteristic of executive functions.

Based on clinical studies with adults who have suffered various forms of brain damage (e.g., Eslinger, 1996; Luria, 1973; Stuss & Benson, 1984; Teuber, 1964), the mediation of executive function processes by the frontal cortex has gained general acceptance (e.g., Tranel, Anderson, & Benton, 1995). It is important to note here that the frontal cortex comprises over one third of human cortical tissue and is composed of a variety of anatomical components, each with specialized cortical and subcortical connections (Damasio & Anderson, 1993). Rather than linking executive function to the frontal lobe en masse, neuroscientific research suggests that it is more accurate to attribute executive processes to the prefrontal cortex and, even more specifically, to two regions within the prefrontal cortex: the dorsolateral and orbital-frontal areas (Iversen & Dunnett, as cited in Barkley, 1997). More recently, the underlying neural mediation of executive functions has been viewed from a "systems perspective," implicating the involvement of entire fronto-subcortical circuits (Banfield et al., 2004; Heyder, Suchan, & Daum, 2004; Roth & Syakin, 2004). For example, Banfield et al. (2004) suggest that the connections between the dorsolateral prefrontal cortex and subcortical structures, such as the basal ganglia and thalamus, mediate the so-called "cold" executive functions, such as planning, conceptual reasoning, strategic behavior, flexibility, and working memory. In contrast, the circuit that involves the ventromedial/orbitofrontal prefrontal cortex and basal ganglia and thalamic structures underlies what might be called "hot" executive functions, such as self-monitoring and regulation of emotion processing and emotional response. This new direction for research in executive function and its neural correlates has direct relevance to goals of the BrainWise program given that this curriculum focuses on improving both "cold" executive functions (e.g., planning, effective communication) and "hot" executive functions (e.g., controlling one's emotions, recognizing "red flags" in one's environment).

As discussed above, the notion that learning new skills and information results in the development of new synaptic connections in the brain is generally well accepted (e.g., Kandel, 2000). However, it has also been proposed by Changeux and colleagues (Changeux & Danchin, 1976; Changeux, Heidmann, & Patte, 1984) that during development, millions of excess, redundant connections are created between neurons in the brain and, through interactions with one's environment, these excess connections are "pruned down" to more manageable and efficient levels. That is, repetitive stimulation from and interactions with the environment should functionally stabilize networks of neuronal connections that are necessary for adaptive behavior, whereas unnecessary connections are eliminated. Examinations of the synaptic density in the prefrontal cortex suggest that there are a tremendous number of excess synaptic connections, referred to as "exuberant connectivity" by Chugani (1994), in the brains of children from about 3 years of age through adolescence and, in fact, this synaptic density far exceeds that of adults (Huttenlocher & Dabholker, 1997). The sharp increase and high point in synaptic contacts occurs at an age when executive function processes are only just beginning to manifest in a child's behavior. In contrast, the protracted period of improvement in executive processes that is apparent across the school age and adolescent years actually parallels a gradual *decline* in synaptic density in the prefrontal region. It may be precisely this *decrease* in synaptic number that reflects the stabilization of the functional networks underlying advances in cognitive processing, as proposed in Changeux's theory of stabilization. Therefore, as early as age 5 and as late as age 16, the prefrontal cortex may be particularly "primed" and ready to be exposed to the BrainWise lessons that are taught, repeated, and reinforced over time, potentially creating functional networks of connections not only within the prefrontal cortex, but between the prefrontal cortex and critical subcortical structures, such as the limbic system.

Social Science

BrainWise adopts many of the premises that define cognitive restructuring. Cognitive models include teaching specific techniques designed to help people change distorted patterns of thinking (Beck et al., 1979; Ellis, 1985; Ellis & Harper, 1975). Cognitive restructuring has successfully been used to promote optimism, enhance personal control, increase performance, and boost self-esteem (Burns, 1980; Seligman, 1991). The theory of learned optimism has grown, helping launch a movement toward positive psychology devoted to fostering factors that allow individuals to flourish as decision makers with choices, preferences, and the possibility of becoming masterful (Seligman & Csikszenmihalyi, 2000). In BrainWise, mastery of thinking occurs when individuals are able not only to apply the 10 Wise Ways to themselves and to others, but to apply them to themselves and others simultaneously.

Bandura's (1977a, 1977b, 1986) social learning theory addresses how children learn appropriate responses through the observation of others' behavior and the subsequent consequences (outcome and efficacy). This theory is at the center of entertainment education programs designed to promote literacy, empower women, prevent pregnancy, and halt the spread of HIV. Offered in developing countries, social learning programs reach millions around the world, helping people learn from role models whose behavior they wish to emulate (Smith, 2002). By fostering the belief that individuals have control over their choices and decisions, they increase their self-efficacy. BrainWise applies this concept by having students use the 10 Wise Ways to analyze popular television shows, movies, and song lyrics. They may learn how to teach thinking skills to members of dysfunctional families found in television shows like *The Simpsons,* analyze the bad and good choices of celebrities, or discuss the thinking skills behind sports figures who use talent, not drugs, to advance their performance.

Education

The theory of multiple intelligences says that intelligence entails the ability to solve problems and that problem-solving skills allow one to approach a situation in which a goal is to be obtained and to identify the appropriate route to that goal (Gardner, 1993). Certain habits of thought, such as taking one's time, considering alternatives, sharing one's work with others, and assuming the perspective of another person, are habits of the mind—characteristics that should be cultivated early and widely (Gardner, 1993). BrainWise was designed to develop good habits in students by helping them learn how to use the Wise Ways to solve problems.

Sternberg's (2001) balance theory of wisdom complements the preceding theories, including Kandel's research on learning and memory. To make wise judgments requires combining explicit knowledge (the knowledge one learns directly in school and life) with implicit knowledge (informal knowledge more likely to be picked up through life experience than through formal classroom teaching). He sees educators as providing learning experiences that will help the individual make his or her own wise decisions (Sternberg, 2001). BrainWise does this and more—it provides specific tools, the 10 Wise Ways, to guide young people to make wise choices.

Optimal learning occurs in predictable sequences, and BrainWise incorporates its five stages: preparation (prime and preexpose); acquisition (use teaching strategies that involve direct and indirect learning); elaboration (give students opportunities for experimentation and feedback); memory formation (encode learning); and functional integration (extend usage of materials; Jenson, 2000).

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 (Bartlett, 1985; Elliot, 2001; Hawkins et al., 1992; Payton et al., 2000; Steinberg, 1996).

Description of the BrainWise Intervention

The BrainWise curriculum consists of an instructor's manual that contains 17 scripted lessons and a set of reproducible student worksheets, a poster set of the 10 Wise Ways, bookmarks, supplemental lessons, and a companion book for parents. To address teacher resistance to "another new program," it is taught by instructors who want to teach it. Although the program's lesson plans contain many examples, instructors are encouraged to customize the lessons to fit the age, sex, culture, ability, and specific needs of their students or clients. The program's language and terminology make it easy to integrate and generalize its 10 lessons into activities inside and outside the classroom.

The intervention involves a series of skills called the 10 Wise Ways (as displayed in table 19-1). These skills are designed to help young people to cope with problems, especially those that create stress and heightened emotional reactions. The following example demonstrates this aspect of the curriculum:

Table 19-1 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. (In BrainWise, emotions are compared to a ten-story elevator. The higher up you are, the more likely you are to use your 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.
   c. Avoid using double messages.
3. Assertive communication
   a. Aggressive communication
   b. Passive communication
   c. Passive aggressive communication
   d. Assertive communication

A Denver kindergarten teacher described how her 5-year-olds used skills they learned in BrainWise after the killings at nearby Columbine High School. The children talked about how Eric Harris and Dylan Klebold used their Lizard Brain, did not use their constellation of support, were high on their emotions elevators, and made bad choices that had consequences for many people. The children pointed out that the grownups did not recognize the boys' red flags and didn't ask the right questions to find out about their problems and talk with them. The teacher said what others have said about BrainWise: It gives words to talk about problems, and the concepts help them understand what happened and how to react to the events calmly, not with fear. "I get goose bumps when I tell the story," she said.

BrainWise skills also help inhibit the emotional and impulsive behaviors of teenagers, the population for whom the curriculum was originally developed. When talking about BrainWise, their conversations are filled with terms they learned in the curriculum—for example, "I used to be a Lizard Brain," "My new friends help me solve problems and my old friends created problems," "Being aware of red flags helps me stay low on my emotions elevator," "Now I think about my choices and the consequences," "I know what it means to set goals," "I try to separate fact from opinion," "It helps when I take other people's points of view," "*I messages* have helped me solve problems," and "I notice who is being aggressive, passive, and passive aggressive and use my thinking skills to be assertive." Statements like these are consistent across all program sites, even programs in China.

Evidence of Program Effectiveness: Research on Program Outcomes

Study of Urban Middle School Students

This study evaluated the effects of the BrainWise curriculum in a sample of 113 middle school students in regular classrooms at posttest (51 intervention and 62 comparison students). Two schools participated in the study; seventh graders from School A received the intervention, and those in School B did not. The sample included 65% Hispanic, 27% Caucasian, 4% American Indian, 2% African American, 1% Asian American, and 1% children from other ethnic minority populations (OMNI Research and Training, Inc., 2001).

Students at both schools were administered pretests and posttests containing several scales predicted to measure BrainWise outcomes. The central research question addressed was whether changes in the attitudes and behaviors of seventh-grade students could be observed after they completed the BrainWise course.

In addition, 42 students participated in three focus groups conducted at the experimental and comparison schools at the beginning of the spring semester and again at the end of the semester. The students were shown a video clip with four brief scenarios of typical situations they face—stealing, rumors, not turning in homework, and relationships. Discussion questions were designed to probe their understanding and use of the concepts behind the 10 Wise Ways. Students in School A were also asked to describe key BrainWise concepts.

At posttest, students who had received BrainWise demonstrated significant improvements on three of the scales: decreased physical aggression, reduced negative affect (feelings of loneliness, sadness, and being upset), and increased peer acceptance. Two other scales, social skills and belief in moral order, also showed differences. Students at the comparison school showed no change and scored worse on the belief in moral order scale.

Results from pre- and postprogram focus groups indicated that intervention students improved in communication and information gathering, assertiveness, honesty, deescalation of emotions, and recognizing consequences; and they showed decreased lying, fighting, and disrespecting others. In describing BrainWise, one student summarized the program by saying, "It doesn't change the person, it changes how the person thinks."

Study of Elementary, Middle, and High School Students

The evolving study of executive function provides what may be a more comprehensive way to measure the neurocognitive changes that occur with the BrainWise intervention. Two instruments, the Tower of London-Revised (Schnirman, Welsh, Retzlaff, 1998) and the Stroop Test (Stroop, 1935), were selected to measure executive function in BrainWise students. Because it was a pilot study, no control group was used. 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, and one third was boys and two thirds were girls. All students were in regular classrooms except a class of special education students at one of the high school sites.[4]

In High School A, BrainWise was taught to regular students for two semesters, 45 minutes one day a week. At High School B, BrainWise was integrated into a special education classroom, where it was taught for two semesters, 50 minutes twice a week. The two elementary schools taught BrainWise to regular students for two semesters, pulling selected students out of other classes, 30 minutes one day a week. Middle school students in the after-school program were taught BrainWise for 24 weeks, one hour one day a week. Teachers, school social workers, and parents selected participating students as youth who would benefit from the skills taught in BrainWise.

Typical of schools, the study participants received a wide range of the intervention in both quality and amount. The BrainWise curriculum's 10 concepts, lesson plans, order of skill presentation, and ongoing reinforcement provided consistency across the sites. The pilot study gave us information on the feasibility of this format as well as on the instruments we can use to measure executive function among students taking BrainWise.

Two outcome measures of executive functions were included in this preliminary study. The Tower of London–Revised (TOL–R) measures executive function skills such as planning, working memory, and inhibition (Schnirman et al., 1988). The Stroop test measures executive processes such as interference control, inhibition, and cognitive flexibility and, according to the test authors, performance reflects an individual's ability to cope with cognitive stress and process complex input (Western Psychological Services, 2004). Both tests were administered to male and female students in fifth grade, middle school, and high school who participated in the BrainWise intervention during the 2004–2005 academic year. Thirty-four students were tested twice on the TOL–R, and 36 students were tested twice on the Stroop. The pretests took place during October and November 2004, and the posttests were administered during April and May 2005.

During the pretest phase, both the TOL–R and Stroop test scores were positively correlated with age, and neither test exhibited gender differences. On the TOL–R, the high school students outperformed the middle school and elementary school students, and these latter two groups did not differ from each other. Regarding the Stroop test score, both the high school and elementary school students exhibited inhibition scores that were superior to those of the middle school students.

During the posttest phase, the scores on the TOL–R and Stroop tests again correlated in the expected direction with age of the student. Consistent with the pretest phase, the average TOL–R score of the high school students was superior to that of the middle school and elementary school students, and these groups did not differ from each other. With regard to the Stroop test, the high school students demonstrated better inhibition scores than the middle school and elementary school students, who did not differ from each other.

In terms of the change in the scores on the two tests, the data from 34 students who had pretest and posttest scores for both tests were analyzed, and these mean scores and standard deviations are presented in table 19-2. Regarding the TOL–R, there was a significant increase from pretest (mean of 17.91 out of 30 points) to posttest (mean of 19.12). There was also a significant effect of Age Group with the mean performance of each age group as follows: elementary school, 14.5; middle school, 17.75; high school, 21.93. Pairwise comparisons indicated that the high school group was superior to both the middle school and elementary school groups, which did not differ. The Intervention by Age Group interaction was not significant; thus, the age groups demonstrated similar improvement from the pretest to posttest sessions. However, an inspection of the means demonstrates that, as a group, the high school students did not change in the TOL–R mean score. This unexpected results appears to be the consequence 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. The TOL–R scores were highly positively correlated ($r = .81$) from the pretest to the posttest sessions, indicating good test–retest reliability.

Table 19-2 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.

Age Group	Pretest TOL–R	Posttest TOL–R	Pretest Stroop	Posttest 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.

With regard to the Stroop test, a positive score indicates better inhibition during the conflict task, and a negative score indicates poor inhibition. There was a significant increase from the pretest (mean of .369) to the posttest (mean of 3.36). There was also a significant effect of Age Group, with the mean performance of each age group as follows: elementary school, .376; middle school, –.813; high school, 6.032. Again, the high school group's inhibition was superior to that of both the middle school and elementary school groups, which did not differ. The Intervention by Age Group interaction was not significant, consistent with the results for the TOL–R test. The Stroop scores were also positively correlated from the pre- to posttest sessions ($r = .60$), indicating adequate test–retest reliability.

Given the wide individual differences in performance, both across and within age groups, a preliminary examination of within-person change in scores was conducted. An improvement in number correct on the TOL–R and a change in a more positive direction in the Stroop inhibition score were examined for each student. Of the entire sample of 34 students, 16 showed improvement on both tests; 6 showed improvement in the TOL–R only; 6 showed improvement in Stroop only; 2 showed decline in the Stroop only; and 4 showed decline in both tests. Therefore, 28 of 34 (82%) demonstrated improved performance on at least one of the measures, and 16 of 34 (47%) showed improvement on both measures.

It is important to point out that all or some portion of this improvement may be due to maturation and cognitive development that occurred during the 6 months that elapsed between the pretests and posttests. In light of the absence of a matched control group in this preliminary study, the degree to which maturation accounted for the significant changes in performance could not be examined directly. However, an estimate of the change that might be expected to occur in 6 months was calculated by regressing age onto the pretest score of each measure and determining the slope of each line. The slope provides an estimate of the change in the TOL–R and Stroop preintervention scores with an increase of one year in the cross-sectional data. One-half of this number would provide an estimate of the increase in performance on these two tests in a 6-month time period (the time between the preintervention score and the postintervention score).

For the TOL–R test, the expected increase in the score for 6 months was .70 points, and this can be compared to an actual increase of 1.40 points from pretest to posttest in the entire sample. A statistical comparison of the actual difference scores and the expected difference scores was not significant, paired samples $t(33) = .803, p > .05$. For the Stroop test, the expected improvement in the inhibition score was .48, and this can be compared to an actual increase in the inhibition score of 2.9 from pretest to posttest. The paired t-test between the actual and expected difference scores was significant, $t(35) = 2.4, p = .022$. It's important to note that these rough estimates of expected "change" in the scores over a period of six months are derived from cross-sectional data, which informs us about developmental differences and not developmental change. However, if these estimates are relatively close to what would be expected to occur with maturation alone, the observed improvements in executive function performance over the course of a 6-month exposure to the BrainWise program appear to exceed these levels (see figure 19-1). In this preliminary study, a significant change was only observed in the Stroop interference score, which presumably reflects improvements in impulse control.

The study showed that the Stroop in particular, and potentially the TOL–R, may capture cognitive and behavioral characteristics that are targeted for change in the course of the BrainWise intervention. We plan to conduct follow-up research with a larger sample and a matched control group to see to what extent this improvement is due to maturation, the BrainWise intervention, or some combination of the two factors. Our current research is based on the assumption that some individuals have relatively weak executive skills and the BrainWise intervention is designed to bolster executive functions in general. Although this may be true for a subset of individuals, others may have adequate executive functions under "normal circumstances," but they have difficulty recruiting and executing these skills under conditions of high stress. Many of the lessons included in the BrainWise curriculum involve making good decisions, controlling emotions, and communicating effectively in situations that are characterized by high levels of stress and tension (e.g., peer pressure, bullying). Therefore, another interesting avenue for research will be to examine the degree to which the BrainWise intervention is particularly effective in helping children and adolescents exercise their executive function skills while under stress. That is, it

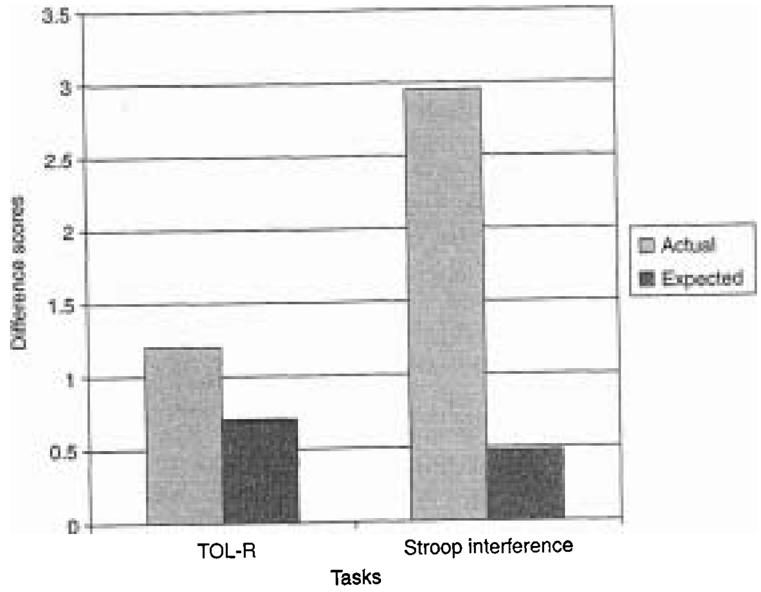

Figure 19-1 A comparison of actual and expected difference scores for Tower of London–Revised (TOL-R) accuracy and Stroop interference.

may be the case that the more sensitive test of the effectiveness of BrainWise is not in terms of changes in executive functions as seen under "normal" testing conditions, but in terms of changes in executive skills under "stressful" testing conditions (e.g., conditions more stressful than the time limits required by the Stroop).

Future research involves evaluating BrainWise as a school- and family-based intervention to improve school adaptation, performance, and achievement in low-income children. Evidence suggests that programs designed to alter parenting attitudes and practices result in improved school readiness, literacy, and academic achievement (Brooks-Gunn & Markman, 2005; Olds et al., 2004). The target children will receive BrainWise at school, and their caregivers will be taught BrainWise at home. Outcomes of this group will be compared with matched groups who receive BrainWise only in school and not at home, and children and parents who do not receive BrainWise. This "double dose" of the BrainWise intervention will allow pairwise comparisons to determine whether enhancing cognitive stimulation at school or the school and home is sufficient to produce improvements in child outcomes, as well as the attendant effects of teaching caregivers new thinking skills.

Conclusion

The classroom is not a scientific laboratory. It is difficult to control the quality and amount of BrainWise material that students receive, just as it is difficult to control other variables that can jeopardize the effective delivery of a program or a study's internal and external validity. We are beginning to gather data that show how teaching children about the brain helps them learn skills to make good decisions.

As we gain a better understanding of the neurodevelopment of the frontal cortex and how it complements skills that are called executive function, we will be able to integrate brain research into helping individuals learn how to replace impulse and emotions with a thinking process. The BrainWise curriculum uses a simple explanation of this process to help students understand that how they think affects how they act, and provides a framework to teach skills that promote positive youth development.

Educators, psychologists, and sociologists need to work closely with scientists studying the biology of learning so their discoveries can be applied to programs taught in schools, communities, and homes. Emotion and cognition once were considered independent and separate, but now can be understood as intricately bound and inseparable (Bell & Wolfe, 2004). We are getting closer to the day when scientific evidence will explain how the *Aha!* of learning takes place in everyone, including at-risk adolescents, kindergartners, and developmentally disabled youth like David and Ed.

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Notes

1. The students' names have been changed.
2. Nerve cells of the sea snail were easier to study than those of a mammalian brain, as *Aplysia* has 20,000 central nerve cells clustered around 10 ganglia, each of which contains 2,000 cells, versus a "million-million" nerve cells in a human (Kandel, 2000).
3. Kindergartners and developmentally disabled children take longer to learn the concepts. It's important not to equate knowing the BrainWise terminology (e.g., Wizard Brain, Lizard Brain, emotions elevator, and so on) with understanding the concepts. That is like expecting a child who knows the alphabet to be able to read. Demonstrating knowledge of the skills through behavior indicates that the skills have been learned.
4. These were high performing special education students, different from David and Ed's class for profoundly disabled students.

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