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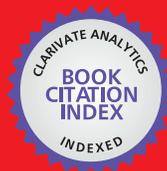
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Chapter

Life Stress and Inhibitory Control Deficits: Teaching BrainWise as a Neurocognitive Intervention in Vulnerable Populations

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Abstract

The chapter describes inhibitory control in the context of broader and related constructs, executive function and self-regulation. We discuss the adaptive functions of inhibitory control, as well as evidence that life stress, such as poverty, maltreatment, homelessness, and mental illness, negatively impacts individuals' inhibitory control and overall self-regulation skills. Moreover, these stressors are known to disrupt the development and functioning of crucial brain systems underlying inhibitory control. Following this review, we discuss a critical thinking skills intervention, BrainWise, which is designed to teach inhibitory and self-regulation skills to children, youth and adults. We describe the implementation of the program, and review evidence for its effectiveness with various populations, including our recent study that demonstrated the success of BrainWise in teaching these skills to homeless men living in transitional housing. Finally, we describe our proposed future applications of this intervention to veterans suffering serious mental health challenges. Our overarching goals are to highlight the importance of inhibitory control and overall self-regulation, the vulnerability of these important skills to life stress, and the promise held by one neurocognitive intervention for improving inhibitory control in high-risk populations.

Keywords: inhibitory control, executive function, self-regulation, stress, poverty, homelessness, childhood maltreatment, mental illness, intervention, BrainWise, veterans

1. Introduction

Inhibitory control, as a key component of goal-directed executive function and overall self-regulation, has implications for a range of adaptive behaviors across development. Individual differences in this self-regulatory ability have implications for accomplishing important life tasks such as educational achievement, securing employment, and establishing successful relationships. Failures to achieve these milestones has enormous personal costs, as well as economic costs to society. The contributions to these individual differences are complex covariations and interactions between biological and environmental forces [1], as is true for the wide swath

of psychological development. How we respond to these individual differences, particularly at the lower end of functioning, with an appreciation of malleable environmental factors and intervention will determine the degree to which we can optimize inhibitory control, benefiting both individuals and the larger society.

The purpose of this chapter is to describe the construct that is the topic of this volume, inhibitory control. We view inhibitory control within the larger contexts of self-regulation, emotion regulation, and executive functions, skills that are all required for adaptive functioning in our increasingly complex world. We will describe the impacts of environmental challenges and life stresses, such as poverty, maltreatment, homelessness, and mental illness on the development and expression of inhibitory control. In addition, we will discuss how the neural mechanisms underlying inhibitory control and related processes are particularly vulnerable to these stressors.

The critical role that inhibitory control plays in adaptive behavior in a wide range of contexts, and its vulnerability to both environmental and biological challenges, has stimulated a diversity of interventions for children, adolescents, and adults in recent years with varying results. We will focus our discussion on one intervention that involves teaching critical thinking skills to promote inhibitory control and overall self-regulation. The BrainWise program will be described in terms of its design and effectiveness in facilitating adaptive decision making and behavior, particularly in high-risk populations. Finally, we will describe the inhibitory control and self-regulatory deficits observed in veterans experiencing mental illness and/or homelessness and a planned application of the BrainWise intervention to this vulnerable population.

2. Importance of inhibitory control to adaptive behavior

2.1 Inhibitory control defined

Inhibitory control is the ability to withhold responses to both internal and external signals when such responses would be maladaptive either for immediate functioning or in service of a future goal. The more adaptive alternative response in these situations involves flexible, reflective “top down” mechanisms that operate to control the “bottom-up” arousal, emotion, and stress responses that are often present in our highly-charged daily activities [2]. Research demonstrates that the development of inhibitory control predicts school readiness and performance in young children [2], as well as a range of academic and cognitive skills [3, 4]. In adolescents and young adults, the inability to control behavior, particularly in affectively- and motivationally-charged contexts, is predicative of maladaptive risk taking [5]. Developmental disorders that have documented difficulties with inhibitory control include: autism [6, 7], ADHD [8, 9], and disruptive behavior disorders [10]. Difficulties with inhibition represent impediments to the normal trajectory of development in social-emotional and academic domains, potentially setting up the individual for struggles in adaptation throughout their lifetime.

Difficulties with inhibitory control may be manifested as maladaptive impulsivity in behavior and is described by Nigg [11] as taking two forms. One form of impulsivity that reflects a non-reflective, immediate reactions to stimuli (either internal thoughts or external events) is often called disinhibition. This can be seen when a 3-year-old overtly expresses a reaction to someone’s appearance in embarrassing fashion, or when an individual with frontal lobe damage continues to make an incorrect decision despite consciously knowing these decisions are wrong. Disinhibition may be a consequence of the life stresses that we will discuss in this chapter, such as extreme trauma or mental illness, particularly when these involve possible brain damage. The second type of impulsivity involves a motivated

preference for an immediate reward over a delayed reward, even if the latter is bigger, better, and ultimately more rewarding [12]. Individual differences in inhibitory control are found in the typically-functioning population, mediated by particular brain regions, and appear to reflect temperamental differences in effortful control [13]. However, this propensity to seek out immediate rewards, even when ultimately maladaptive, also may be impacted by the stressors of poverty, trauma, homelessness, and mental illness, either through learning from one's environment, through subtle brain changes, or through the additive or interactive effects of both pathways.

Inhibitory control, therefore, is a crucial component of adaptive behavior that develops with the contributions of brain maturation and support from the environment. As will be discussed in the next section, it can be viewed as a component of executive functions, the cognitive processes dedicated to accomplishing future-oriented goals, as well as a mechanism for regulating arousal to function adaptively.

2.2 Inhibitory control as part of executive function and overall self-regulation

Nigg [11] developed a hierarchical model of self-regulation that attempted to reconcile several constructs in psychology that have been easily confused and often used interchangeably. Some of these constructs are executive function, effortful control, cognitive control, and emotional regulation. Nigg's model of self-regulation is designed to explain self-regulation in a domain-general manner. This would involve self-regulation over thought, action, and emotions, which fits well with our view of the importance of inhibitory control to all facets of adaptive behavior. The top-down processes of self-regulation are those that are deliberate and under the conscious control of the individual. These include basic executive functions such as inhibition, working memory, and flexibility, as well as effortful control needed to deal with conflicting demands. These top-down processes also include more complex cognitive control processes, such as planning, reasoning, and other coping strategies, particularly those directed to regulating emotional arousal to allow cognitive control processes to be executed.

In Nigg's model, bottom-up processes include nervous system arousal that may reflect emotion, motivation, or stress responses. Typically, this arousal is adaptively controlled by the top-down regulatory processes, but arousal also may serve to energize self-regulation. As Blair and Raver [2] describe in the case of young children, bottom-up arousal often disrupts goal-directed behavior and, thus, requires top-down regulation. However, they point out that arousal can also facilitate adaptive behavior, as seen when a moderate level of stress improves performance [14] or when emotional tagging of memories improves encoding [15].

Therefore, inhibitory control fits within a complex web of executive function, effortful control and emotion regulation processes that are reciprocally connected to support overall self-regulation in service of adaptive behavior. Depending upon the individual's biological and learning history, and the contextual demands of the environment, inhibitory control and overall self-regulation will be challenged in a variety of ways. Individuals will vary widely in their self-regulatory abilities and these differences may be mediated by neurological differences and/or influenced by a range of life stress factors to which the individual has been exposed.

3. Brain systems underlying Self-regulation and inhibitory control

3.1 Relevant brain networks

The neurophysiological mediation of self-regulation represents the intersection of brain systems activated by bottom-up, "hot" sources of emotional and

motivational arousal and the brain systems involved in “cool” cognitive control over that arousal for adaptive responses and decisions [16]. Emotional arousal is processed in the limbic system, particularly the amygdala, and strong motivational stimuli activates the reward system of the brain comprised of dopamine pathways and the limbic system structure, the nucleus accumbens [17]. The ventromedial portion of the prefrontal cortex serves to modulate the activity of the limbic system under conditions of strong arousal allowing the dorsolateral region of the prefrontal cortex to carry out its “cool” executive functions of planful, organized, and adaptive decision making [18]. Moreover, the right dorsolateral prefrontal cortex appears to be specifically involved in the inhibitory control aspect of executive function [19]. The smooth coordination of these various regions to appropriately react to arousing stimuli with a “fight or flight” response, as well as to mitigate such reactions when necessary to execute adaptive decision making, develops over the childhood and adolescent years [20]. Importantly, the prefrontal cortex shows the most protracted development from birth to adulthood of all cortical areas [21]. Thus, the plastic brain’s vulnerability to biological and environmental insults related to life stress has critical implications for the development of inhibitory control and downstream difficulties with adaptive behavior.

3.2 Impacts of life stress on these brain regions

It is well-documented that chronic stress has deleterious effects on brain development and function, and many of the targets of stress are those networks involved in self-regulation, described above. Animal models, confirmed in human studies, have identified the dorsolateral prefrontal cortex, amygdala, and the ventromedial prefrontal cortex as consistent targets of the negative impacts of chronic stress on structure and function [22]. Stress-induced changes in the ventromedial prefrontal cortex have been specifically linked to cognitive control deficits in both animals and humans [23–25].

Prenatal and early postnatal development of the brain is the consequence of a complex unfolding of genetic and epigenetic mechanisms that can be derailed by adverse biological or environmental forces [26]. There is emerging evidence that poverty—with its many correlated stressors—is related to alterations in a variety of brain regions, including those related to self-regulation, the prefrontal cortex and amygdala [2]. Similarly, there is increasing evidence that childhood maltreatment, again correlated with poverty and other stressors, is related to alterations in the structure and function of brain networks involved in self-regulation. Research has identified the brain networks that differ in maltreated individuals as those that mediate emotional regulation, attention, inhibitory control, and social cognition, particularly in situations of threat or potential reward [27, 28].

Thus, the underlying brain mechanisms of self-regulation and inhibitory control are quite vulnerable to life adversity and stress, and this is likely to be observed in behavioral disruptions in high-risk individuals. In what follows, we discuss the evidence for impairments in inhibitory control, and related constructs of executive functions and self-regulation, that have been linked to four examples of life stress.

4. Life stress impacts on inhibitory control, executive function, and self-regulation

Life stress can include the mild, normative challenges that have been found to fine-tune the stress response system at the brain and behavioral levels to overcome obstacles and build resilience. Evolutionarily, our brains and bodies are equipped

to deal with acute, short-lived stressors without serious negative consequences [29], but chronic, long-lasting, frequent, and/or extreme stress exposure results in what has been referred to as the toxic stress response [30]. Adverse childhood experiences, such as poverty, maltreatment, and parental conflict, are included in the category of toxic stress and have been found to disrupt inhibitory control, emotional regulation, and organized, reflective thinking [31, 32]. Individuals who contend with chronic life stress as adults may have also had exposure to toxic stress in their childhoods during the period of critical brain and behavioral development. As adults, these challenging conditions are likely to continue to impair the brain functions necessary for inhibitory control and overall self-regulation.

It is important to note that where there is risk, there is also substantial evidence of resilience in the face of adverse life circumstances, and this is observed both at the brain and behavioral levels [33]. Our own research has examined young adults with a childhood maltreatment history who manage to enroll in college [34] and homeless men who seek out services such as transitional housing [35]. These groups of adults are demonstrating resilience despite exposure to difficult and sometimes traumatic circumstances. While there is evidence of inhibitory control deficits in these groups, this capacity for resilience is likely to make these groups excellent candidates for interventions to strengthen inhibitory control and a range of related self-regulatory skills.

4.1 Poverty

According to 2017 data, almost 40 million people lived below the poverty line in the United States, and 12.8 million of this group were children [36]. Poverty is not a monolithic factor affecting psychological development; rather, poverty is correlated with numerous risk factors [37] that combine to create a cumulative risk to healthy development. Poverty-related risk factors that have a negative impact on the development of self-regulatory abilities in children include low maternal education, elevated maternal depression, exposure to domestic and neighborhood violence, lower housing quality, exposure to environmental pollutants, and poor access to needed services [38]. A gap in self-regulatory abilities is seen as early as preschool in low-income children [39], and growth in self-regulation is slower in impoverished children with a greater number of cumulative risks [40]. In a large, nationally-representative sample of children in Head Start, Son, Choi and Kwon [41] identified reciprocal associations between inhibitory control and math skills, and the researchers suggest that intervening to improve inhibitory control in low-income children will improve academic abilities, which in turn will improve self-regulation.

Poverty continues to negatively impact self-regulation beyond childhood. Lambert et al. [42] found that poverty was related to cognitive control deficits, while violence exposure was related to emotional dysregulation in a sample of adolescents. In a sample of more than 5000 adults 18–30 years of age, exposure to two decades or more of sustained poverty was related to poorer executive functions, which the researchers suggest have a negative impact on health-related behaviors and ultimately on longevity [43]. Poverty is a complex multifactorial construct that is clearly associated with many other risk factors, including those discussed below, which are themselves predictive of impairments in inhibitory control and related skills.

4.2 Childhood maltreatment

Based on data from the Centers for Disease Control and Prevention, approximately 1 in 7 U.S. children experience child abuse and/or neglect in the past year, and this statistic likely underestimates the scope of the problem [44]. Childhood

maltreatment and other adverse experiences have been found to increase risks to physical health and overall adaptive functioning according to the well-known, large-scale Kaiser Foundation study [45]. Given the likely negative impacts on the developing brain and the altered learning environment of the child exposed to maltreatment, cognitive deficits and difficulties with self-regulation will potentially have life-long implications for adaptive behavior.

Evidence suggests impairments in a range of executive functions in childhood samples that have experienced maltreatment [46, 47]. Such deficits are also observed in adolescents and adults reporting a maltreatment history [48, 49]. Inhibitory control is frequently measured by the neurocognitive Go-No-Go task, which requires a response to a specific target and withholding a response (inhibition) to other targets. Adults self-reporting a history of abuse or neglect demonstrate difficulties with this task, particularly in the No-Go condition that demands inhibitory control [50, 51]. Such inhibitory control deficits may manifest as overall difficulties with self-regulation, placing adolescents and adults at risk for maladaptive behaviors and decision making [52].

4.3 Homelessness

As is the case for other adverse environmental conditions already discussed, homelessness is a serious societal problem; in January of 2015, it was estimated that there were 564,708 homeless people in the United States. Executive function impairments, among other cognitive deficits, are observed in youth who have experienced homelessness, foster care, and poverty according to a recent meta-analysis. For children experiencing homelessness, deficits in effortful and emotional control predict academic difficulties [53], and effortful control has also been found to be an individual resource contributing to overall adaptive functioning and resilience among these children [54]. Schmitt et al. [55] demonstrated that difficulties with inhibitory control mediated the relationship between housing insecurity and academic functioning of preschoolers. Thus, homelessness has a deleterious effect on the development of children particularly at a critical milestone of early academic adjustment and achievement, with potential negative impacts on later adaptation.

In adults, executive function skills, including inhibitory control, suffer substantially if a person experiences psychosocial stress [24], social exclusion [56, 57], interpersonal strain [58], or disrupted sleep [59], all of which are common among those experiencing homelessness. It is therefore not surprising that several studies have reported deficits in executive functions among homeless individuals including youth [60], adults [61], and older adults [62]. The experience of homelessness not only appears to put someone at risk for disrupted self-regulatory behaviors, such as executive function and inhibitory control, but these deficits also may result in maladaptive behavior that results in homelessness. Gabrielian et al. [63] compared the problem-solving skills homeless-experienced veterans in a US federal government study who retained (“stayers”) or lost (“exiters”) housing for at least 1 year. Both groups had poor cognition, but there was a trend toward greater problem-solving complexity in stayers as compared to exiters [64]. Similarly, in a study of the influence of cognition on community functioning among formerly homeless persons with mental illness, better executive functions predicted improved self-care and less turbulent behavior [65].

In the United States, the prevalent problem of homelessness among military veterans merits particular attention. Veterans are at particularly high risk of homelessness for several reasons including relatively disadvantaged socioeconomic status and increased risk of mental disorders, both of which are associated with impairments in executive functions (as discussed in Sections 4.1 and 4.4, respectively) [66, 67].

As will be discussed in Section 6, there is a need to carefully consider the role of executive functions in homeless veterans with and without mental illness, both as a potential cause and consequence of these problems, and to develop interventions tailored to the needs of this vulnerable population.

4.4 Mental illness

There is evidence on both brain and behavioral levels that cognitive and emotional regulation deficits may be transdiagnostic symptoms; that is, these difficulties are found across a range of mental illness diagnosis in children and adults. Maladaptive decision-making behavior is observed in youth with anxiety, depression, conduct disorder, and ADHD, though the particular manifestations of these deficits may vary [68]. A meta-analysis by Wright et al. [69] identified small-to-moderate deficits in inhibitory control on tasks such as the Go-No-Go across 11 different mental illness diagnoses in adults. In adolescents with a history of depression, specific deficits in inhibitory control were still observed even after remission of their depression, while other executive functions and cognitive abilities had improved.

Adults with serious mental illness (schizophrenia, schizoaffective disorder, bipolar disorder, major depressive disorder, and posttraumatic stress disorder) frequently exhibit impairments in executive function and cognitive control [70, 71]. Notably, executive functions have been shown to be the most important cognitive domain for a variety of adaptive outcomes for individuals with serious mental illness, including occupational functioning and independent living [72]. Similarly, difficulties with executive functions and overall self-regulation predict maladaptive outcomes in these mentally ill adults, such as treatment nonadherence and violent behavior [72], poor treatment response [73], and overall psychosocial function [74].

In summary, severe life stresses such as poverty, childhood maltreatment, homelessness, and mental illness have adverse effects on the self-regulatory processes such as executive function and inhibitory control. In many cases such stresses co-occur, with cumulative negative effects. Inhibitory control is critical to adaptive functioning across a wide range of domains: academic, employment, interpersonal, and physical and mental health. Stressful life circumstances can create a cascade effect on self-regulatory capacities that may lead to maladaptive behavioral consequences such as risky or antisocial behavior. In turn, maladaptive behaviors place the individual in environments that continue to limit the development of these important skills. For example, an adolescent who engages in delinquent behaviors with peers will not have the role models or the learning experiences to shape appropriate inhibitory control or executive functions in the future. As will be described later in the chapter, US military veterans frequently experience a combination of these stresses when they return home (e.g., homelessness and mental illness) and are at great risk for difficulties with self-regulation. Thus, due to the biological and environmental risk factors that may contribute to deficits in these critical skills in a substantial minority of the population, interventions that can ameliorate these difficulties should hold promise for substantial benefits for both the individual and society.

5. Interventions for inhibitory control and executive function

5.1 Growing interest in prevention intervention

Scientists are using increasingly advanced techniques to study the brain, behavior, and interventions for improving health [75–77]. Findings include

Nobel-prize-winning research that demonstrates how the brain forms synapses when it learns something new [78], the identification of executive functions that are learned through practice [79–81], and research indicating the brain continues to produce neurons well into old age [82].

These and other studies support and complement research showing that thinking skills are learned behaviors and that when they are not developed, are only partially learned, or are compromised by adversity and stress, they negatively impact the physical and mental health of individuals, families, and communities [26, 75, 77, 83]. We know that most mental health disorders and problems are largely preventable. This knowledge underlies requests from health providers, educators, and concerned citizens for access to research and prevention programs [76, 84]. In the last two decades, a greater number of scientific papers has been published on prevention programs [85], biological and social behavior interventions [76], and self-control and intertemporal choice in economics [86]. They reflect the diverse and valuable advances in research on a wide range of approaches that address prevention to promote healthy life choices.

5.2 BrainWise program

The BrainWise program is a prevention curriculum that uses a multidisciplinary approach to teach 10 thinking skills that include inhibitory control and other executive functions [35]. The program focuses on neurocognitive development and integrates findings from social science, education, and neuroscience. It integrates the roles that the prefrontal cortex and limbic system play in decision making, explains them simply, and provides a template for teaching thinking skills.

Program participants are students and clients of diverse ages, backgrounds, and abilities. The program uses nonscientific terms to explain basic brain processes and provides scripted lessons, making the material easy to understand and remember by children, youth, and adults, including individuals with disabilities and mental health challenges [87, 88]. BrainWise instructors can adapt scientific terms to fit their students' and clients' level of understanding whether the individuals are learning disabled or high performers.

The curriculum uses activities that combine kinesthetic, sensory-motor, visual, auditory, cognitive, and socioemotional techniques instructors can adapt and customize as needed. Its approach includes teaching basic brain concepts using activities that engage participants of all ages, helping them understand why learning and practicing enables them to stop and think before they act. The program can be adapted to address a wide range of teaching situations and can be taught in classes, small groups, and one-on-one. This flexibility appeals to instructors and helps ensure they will teach and reinforce the lessons with fidelity [89, 90]. Instructors learn how to integrate the lessons into daily activities, providing opportunities to use examples that are specific to problems faced by their clients and students.

Reinforcement is key to retention [76, 91–94]. Instructors have access to several BrainWise teaching aids and create their own. These include problem-solving worksheets, checklists, reinforcement games, and support activities that sometimes call for older students to teach and reinforce lessons with younger students. Depending on the site and instructor, text messages, apps, telephone, emails, and other devices are additional reinforcement strategies. For example, instructors may randomly send customized text messages to remind a participant to “Exit Your Emotions Elevator” or “Use Your Wizard Brain!”. Course instructors also have access to a “members-only” BrainWise network where they share teaching strategies and techniques and receive a monthly online newsletter containing research updates, teaching tips, and instructors' stories.

BrainWise is taught in schools, clinics, faith-based organizations, agencies, worksites, homeless shelters, hospitals, and households throughout the United States and in Canada, China, India, and 17 other countries [95]. U.S. Indian Health Services (IHS) has recognized BrainWise as a program that benefits Native Americans and Alaska natives, and the University of Tennessee Extension has trained its agents to teach BrainWise throughout the state [96]. The advocacy of program users underlies this growth, and a future direction for application of BrainWise will be to incarcerated youth and adults.

5.3 The 10 Wise Ways

BrainWise starts with four tenets: (1) everyone has problems; (2) people who have fewer problems use thinking skills; (3) the brain can help prevent problems; and (4) the 10 Wise Ways teach thinking skills. This section presents the lessons and research supporting each one (**Figure 1**).

5.3.1 Wise Way 1: use your Wizard Brain over your Lizard Brain

This statement lays the foundation for the nine lessons that follow. Participants learn how the body's five senses act as sentinels and send signals to the brain's thalamus, which is also called the relay center because it collects sensory information and sends it to the limbic system to be processed.

The limbic system is located beneath the relay center and contains the amygdala (where fear and any intense emotion are triggered) and the hypothalamus (which sets off the fight or flight reaction; [97]). These survival responses are also found in reptiles, leading us to call this section the Lizard Brain. Instructors use this information to discuss the history and importance of survival instincts and how the amygdala (emotion center) and hypothalamus (fight or flight reaction) contribute to impulsive reactions, such as maladaptive road rage [98].

Participants receive worksheets with age-appropriate pictures of brains and label the parts as they learn about them. They see the Lizard Brain's proximity to the brain stem. They learn that the part of the brain behind the forehead contains the thinking area known as the prefrontal cortex. For simplicity, we call it the Wizard Brain and point out that all of us are born with only rudimentary connections from the relay center to the Wizard Brain. These connections develop as we learn, Sapolsky [76] discusses the neurobiological stages involved in top-down, Wizard Brain decision-making.

Wise Way #1 <i>Wizard Brain Over Your Lizard Brain</i>	Wise Way #2 <i>Build a Constellation of Support</i>	Wise Way #3 <i>Red Flag Warnings</i>	Wise Way #4 <i>Exit the Emotions Elevator</i>	Wise Way #5 <i>Fact vs Opinion</i>
Wise Way #6 <i>Ask Questions and Gather Information</i>	Wise Way #7 <i>Identify Choices (IDC)</i>	Wise Way #8 <i>Consider Consequences Now and Later</i>	Wise Way #9 <i>Set Goals and Plans for Action</i>	Wise Way #10 <i>Communicate Effectively</i>

Figure 1.
The 10 Wise Ways.

This sets the stage for presenting a powerful piece of information. The skills participants learn in BrainWise help them build connections to their Wizard Brain so that when signals are sent to the relay center, they are diverted away from the Lizard Brain and to the Wizard Brain. This simplified explanation is easy for almost anyone to understand [35]. Each time participants learn a wise way, they draw a line from the relay center/Lizard Brain to the Wizard Brain. This process helps participants of all ages and abilities form a clear picture of how different parts of the brain respond to a stimulus.

Wise Way 1 lays the foundation for the remaining skills by helping participants learn how the brain is involved in behaviors and what they can do to prevent and manage problems. As discussed in the previous section, the hierarchical model of self-regulation developed by Nigg [11] describes these processes as “top-down” and “bottom-up.” The top-down processes are Wizard Brain responses that include executive functions and the complex planning, reasoning, and other coping strategies taught throughout the remaining Wise Ways. The bottom-up processes are all Lizard Brain reactions to events that arouse strong emotions. These will be addressed in Wise Ways 2–10.

The lesson ends with participants drawing a line on the brain worksheet to show that Wise Way 1 helps them make a connection. Sapolsky [76] presents this process in a discussion about how the ventromedial prefrontal cortex forms connections with the limbic system, and the biological processes underlying such neuroplasticity are presented by Kandel [78].

5.3.2 Wise Way 2: build a Constellation of Support

Research supports the importance of human connection [99–102] and identifies how support systems can be lifelines out of loneliness, helplessness, sadness, and other feelings of being isolated. Wise Way 2 helps people learn how to create and use an effective support network by teaching about resources for different types of support, as well as how to find and access dependable support sources.

Participants learn to identify a wider range of sources they can go to for help, a process that increases their awareness of the benefits of sources they previously may not have considered. This includes learning that valued help takes many forms—human, animal, spiritual, and inanimate—and that we all need to identify and access different types of support for our various problems [103, 104].

The Constellation of Support shows that we connect with the “stars” in our constellation in three ways: (1) Broken Line (not helpful), (2) Single Line (not unhelpful, but not helpful either), or (3) Double Lines (helpful). This activity creates awareness that broken lines may include unthinking friends and family, members with their own set of problems who do not realize that alternative help is available or how to access it. The course instructor is always a double line for the client or student and is a resource for other support sources. This lesson and visual teaching activities are valuable tools that help participants assess the degree of help a support resource provides.

The science of social support is complex and involves many biological pathways, including neuropeptides, genes, and hormones [76, 105]. These studies are consistent with the advantages of utilizing resources and support, a concept that is taught as a key connection to the Wizard Brain. Participants learn that the Constellation of Support is complicated, and resources can be deceptive, potentially causing problems instead of preventing them if one is not careful. The lesson makes individuals aware that help is always available and the skills they are learning will help them access the most useful sources.

5.3.3 Wise Way 3: Red Flag Warnings

Teaching about Red Flag Warnings builds on what participants learned about the Lizard Brain's bottom-up arousal. The body's five senses continuously receive sensory cues, and this lesson creates awareness of signals that warn "something is going to happen." Individuals learn about their unique sensations warning of problems and the importance of recognizing two types: External Red Flags and Internal Red Flags.

External Red Flags are audio signals, such as a siren, or visual cues, such as gang colors or empty beer cans on the front porch. Participants learn to identify how they react to red flags, especially in problem situations. This recognition creates an awareness of maladaptive behaviors. For example, one client realized that he would turn his head and spit immediately before he lost his temper. When he recognized this as an external warning signal, he was able to control his behavior.

Internal Red Flags are what a person feels inside, a key component of emotion regulation. Participants may say, "I feel mad," or name emotions such as frustration, sadness, loneliness, and unhappiness. Instructors ask them to describe what they feel inside, probing to identify physical sensations such as tight muscles, hot flashes, and upset stomach. Helping them become aware of internal red flags is as important for 5-year-olds as it is for older youth and adults. Instructors and parents find that students with ADHD and autism can learn to identify internal sensations they may feel before an emotional or physical incident.

The Red Flag Warnings content includes teaching aids and activities that promote reinforcement. Participants, including adults, make personalized red flags and list their Internal Red Flags on one side and External Red Flags on the other. Young children complete Red Flag Buddy worksheets, marking areas where they feel red flags. This awareness helps prepare them for times when sensory information streams toward their brains and rapidly, powerfully, and automatically triggers behaviors [85].

After they learn the lesson, they draw a line on the brain worksheet showing that they are building another connection to their Wizard Brain. This seemingly simple process puts into practice the neuroscience behind emotions and impulse [76] and gives instructors a segue to the next lesson on emotions and how to control them.

5.3.4 Wise Way 4: exit the Emotions Elevator

The Constellation of Support and Red Flag Warnings lessons prepare participants to learn about their emotions and techniques to control them using their Wizard Brain. The first part of the lesson explains emotions by using the metaphor of an elevator, but instructors can use metaphors that may be more familiar to their students; e.g., instructors in rural China and India use fires and volcanoes, so participants create individualized Emotions Elevators.

In the context of teaching Wise Way 4, participants learn the following: (1) Emotions are cumulative and have a range of intensity [22]. BrainWise teaches that the first floor is low emotion and the higher floors are out of control. (2) Multiple emotions are experienced simultaneously, e.g., one can be enraged but also feel admiration for a worthy adversary. Additionally, participants learn that emotions can be on different floors of the Elevator—one can be scared, but also extremely curious and excited; extreme emotions, from one to many, hijack Wizard Brain thinking and replace it with Lizard Brain impulse. (3) Any emotion that is high on the elevator triggers Lizard Brain reactions, from being "crazy in love" to taking a selfie in a dangerous location [76].

They also learn that it is difficult to impossible to stop emotions when they hit the high floors of the Emotions Elevator. Lizard Brain reactions are swift, from uttering hateful words to acting in anger. Participants learn to distinguish between helpful emotions and toxic emotions and are taught that skills help them control their emotions to decrease stress and promote healthy behaviors [24, 31].

The second part of the lesson teaches them how to stay off their Emotions Elevators or how to stay on the lower floors, so they can access the Wizard Brain. These techniques include strategies that help control emotions such as control self-talk, stop talking, leave the situation, redirect your emotions, and control relaxation. Instructors are encouraged to add any number of interventions that will help their clients and students regulate inhibition and improve self-control [85, 106, 107]. BrainWise helps participants recognize that many strategies are available and use the Wizard Brain to find what works best for them.

Skills to exit the Emotions Elevator are taught as behaviors used to promote Wizard Brain thinking and help participants build neural pathways to reroute Lizard Brain impulses. This process builds on Wise Ways 1–3 and lays a foundation for subsequent lessons.

5.3.5 Wise Way 5: Fact vs. Opinion

Fake news has existed for a long time. Parkinson [108] describes the propaganda, cooked-up stories, and hoaxes deliberately planted by Benjamin Franklin, John Adams, Nathaniel Hawthorne, and other Revolutionary leaders to instill fear in colonists against the British, Indians, and African Americans. Instructors have no shortage of examples of falsehoods and half-truths from past and present history as well as daily events in the participants' lives.

Research conducted by the Stanford History Education Group (SHEG) with 7804 middle school, high school and college students in 12 states found that students have a “dismaying” inability to tell fake news from real news [109]. SHEG is working with educators to create materials that help young people navigate the fake news they encounter online. These are the kinds of resources BrainWise instructors use to teach and reinforce Fact vs. Opinion.

These lessons promote awareness of the role emotions play in fostering Lizard Brain actions and spark discussion on how using Wise Ways 1–4 puts questionable information into perspective. At the end of the lesson, participants draw a line on the brain worksheet to show they have learned another skill to help them use their Wizard Brain to prevent and solve problems. Instructors encourage them to reinforce the lesson by applying the skill to relationships, work, and current events.

5.3.6 Wise Way 6: ask questions and gather information

Asking the right questions helps people separate facts from opinions. Participants recognize that learning to ask good questions involves using their Wizard Brain, being off (or low on) their Emotions Elevators and accessing reliable sources in their Constellation of Support. Participants may have little or no experience stopping to think about the information they need. The lesson is a primer on obtaining facts and helps individuals practice gathering them effectively. This skill strengthens the neural networks that help the Wizard Brain to regulate the emotional arousal of the Lizard Brain transition [76]. At the conclusion of the lesson, participants add another line to their brain worksheet, creating a visual reminder that the skills they are learning will help divert Lizard Brain impulses.

5.3.7 *Wise Way 7: Identify choices (IDC)*

Individuals dependent on their Lizard Brain often feel victimized. They are clueless about other choices because the limbic system's rapid-fire reactions drive their behavior and blind them to other choices they could make. The high intensity of their anger, sadness, despair, hopelessness, or other emotions they experience overcomes them, making it impossible to consider other choices [22]. Even if they want to make good choices, they fail to follow through [110].

Exploring all of one's choices is a new concept for participants who rely mainly on their Lizard Brains. To bolster awareness of identifying and making choices, instructors ask participants to generate as many choices as they can, positive and negative, for problem situations. They are reminded to include "not making a choice." This activity helps change myopic perceptions that cause problems. Ericson and Laibson [107] discuss how myopic behavior creates "cognitive noise" that causes perceptual limitations. *Wise Way 7* helps participants expand their thinking about choices and prepares them for the next skill—considering the consequences of making a choice.

5.3.8 *Wise Way 8: consider consequences*

For many participants, considering consequences is a missing step. Learning the skill and using it can be an "Aha!" moment for them. People who have never learned consequential thinking fall back on Lizard Brain impulses. Being aware not only that they have choices, but that they can determine the best choice by considering the consequences now and later (CNL) and the consequences affecting others (CAO) gives them options they never knew they had.

Thinking about the outcomes of choices is complicated [2, 76, 107]. This lesson teaches consequential thinking in the context of the seven preceding skills. It provides a framework that helps individuals put the lessons together as part of the Wizard Brain thinking that usurps harmful Lizard Brain reactions. Considering the impact of choices involves future thinking (i.e., executive functions) and inhibitory control, instructors may use this introduction to expand the lesson to discussions of mental health, diets, the environment, relationships, education, and finances.

One teenager referred to CNL as the "thinking skill that saved my life." She said she was considering committing suicide and did not follow through because she thought about the consequences her death would have on her mother. She wrote her teacher a testimonial about the incident. Another student at her school had recently committed suicide, and we are grateful she did not repeat the act. Her positive choice is supported by research showing that people who are suicidal or self-injure have decreased neurocognitive functions and an absence of inhibitory control [111].

Lizard Brain dominance eliminates consequential thinking as emotions hijack thinking. Sadly, we know that even strong Wizard Brain connections are not a guarantee against harmful behaviors, but they are helpful for prevention and intervention. When participants draw lines on their brain worksheets indicating they have learned another connection, they know that practice strengthens the connections. They also begin to recognize positive results they attribute to using their Wizard Brain.

5.3.9 *Wise Way 9: set goals and plans for action*

Translating goals to behaviors requires using multiple *Wise Ways*. People who have never been taught how to apply goal setting to achieve success—graduating, losing weight, making friends, getting sober—often rely on Lizard Brain reactions

that sabotage their good intentions and lead to failure. Their high Emotions Elevator excitement may not be directed in an adaptive manner to get sober, lose weight, exercise, or achieve whatever goal they set, and instead it fuels a greater desire to drink, eat, and give up.

Industries have been built around goal setting and ways to motivate people to change and sustain behaviors. Even people who have thinking skills are stymied by powerful emotions that destroy goals. This lesson creates awareness of the delicate balance between the Wizard Brain and Lizard Brain. Our brains can be tricky, and it helps when people understand how to obtain resources, why Lizard Brain responses can dominate, and what boosts Wizard Brain thinking. Participants learn that people who achieve their goals know how to manage the bottom-up Lizard Brain urges with top-down Wizard Brain skills. These lessons, activities, and problem-solving worksheets are additional tools that help participants use their brains to make good choices.

5.3.10 Wise Way 10: communicate effectively

This skill is taught at the end of the course because its successful implementation requires knowledge and use of the preceding nine Wise Ways. It is divided into three sections: verbal communication, nonverbal communication, and assertive communication.

The teaching activities include participant role plays that demonstrate using “I” messages, sending double messages, taking other people’s point of view, and discussing the simultaneous use of communication with other Wise Ways. Participants learn to differentiate between assertive communication behaviors and passive, aggressive, and passive-aggressive behaviors. The lesson includes discussions about replacing Lizard Brain reactions with Wizard Brain behaviors, using support resources, recognizing red flag warnings, understanding the role emotions play, separating fact from opinion, asking questions, identifying choices, and setting goals.

Participants draw the tenth line on their brain worksheet to show that they have learned how to build another brain connection. They know that if they do not practice and use the skills, the links to the Wizard Brain weaken and disappear and are quickly replaced by Lizard Brain reactions.

The BrainWise curriculum was developed for nonscientists—the children, youth, and adults who take the course to learn skills that will help them make healthy decisions. It presents information in an easily understood format, so that it will be practiced until the skills and behaviors are automatic and retained [112]. Retention indicates mastery of the 10 Wise Ways. Program graduates are aware of the difference between Lizard Brain and Wizard Brain behaviors and have skills that make it easier to choose healthy behaviors.

5.4 BrainWise efficacy with populations exposed to childhood maltreatment and poverty—research with schools and families

Consistent, positive results have been reported on evaluations conducted across a variety of populations by different researchers. Participants in these studies include children living below the poverty line who have experienced multiple Adverse Childhood Experiences (ACEs), including maltreatment. A primary context for studying the effectiveness of BrainWise has been in schools identified as “at-risk.” One study compared a group of inner-city middle school students who were taught BrainWise with a matched control group. The results found that students who took BrainWise demonstrated significant changes in decreasing physical

aggression, reducing negative feelings, and increasing peer acceptance. They also showed improvements on a belief scale and moral order scale. The control group showed no changes. A student described the program by stating, "It doesn't change the person. It changes how the person thinks" [113]. In another study described by Barry and Welsh [95], students given the BrainWise curriculum in schools in a large metropolitan district were administered executive function tasks, Tower of London and Stroop, in a pre-post design. The findings indicated students who learned BrainWise showed improvements on the measures, and knowledge of the 10 Wise Ways also was related to self-reported executive function skills [113]. Pre- and post-data also were collected on 539 K-5 students who took BrainWise. Teachers rated the children on goal-oriented behavior, decision-making, emotional regulation, self-management, self-awareness, and relationship skills. Significant improvements were noted on all measures [114].

The efficacy of the BrainWise curriculum also has been demonstrated in public health contexts. Research was conducted on BrainWise by public health nurses working with at-risk families at a state agency. All the families had more than one child and presented risk behaviors and health problems: some had histories of child abuse, 75% were single parents with less than 12 years of education, and 61% were unemployed. The nurses visited the families a minimum of four times and measured outcomes using a Life Skills Progression checklist. Following each visit, the nurse used the checklist to measure parental behaviors. Data collected on 112 families found improvement on all 39 life-skill variables and significant improvement on 24 variables [115].

5.5 BrainWise efficacy with homeless men

There is a small, emerging literature on the effect of homelessness on neuropsychological impairment, including the evidence discussed in Section 4.3, but studies with comparison groups are rare [116]. We conducted a study of the BrainWise program delivered to homeless men at a transitional housing facility [35]. The homeless organization serving the men in our study presented a rare opportunity to conduct research with a comparison group. The men in both groups had progressed from the intake phase to transitional housing, indicating high motivation to change the behaviors that contributed to their homelessness.

The treatment group (N = 210) was taught BrainWise in Phase 1 of the treatment that included services such as counseling and case management, along with classes in life skills, career training, education, and spiritual development. The control group (N = 66) received all the services and classes with the exception of BrainWise. A staff counselor taught BrainWise and customized the examples using problems and situations typical of those the men faced. She consolidated the lessons and taught them during the first week of the men's placement. She reinforced the concepts outside the classroom during her daily interactions with the men. Other staff and volunteers received training in BrainWise and reinforced the lessons during their interactions with the men.

The men completed pretests and posttests on validated instruments that included eight scales measuring executive functions (Behavior Rating Scale for Executive Function, or BRIEF), one scale measuring coping self-efficacy (Coping Self-Efficacy Scale, or CSES), a self-report on problem solving skills (Wasik Problem Solving Rating Scale, or WPSRS), and a scale that measured participants' knowledge of the thinking and emotional skills taught in BrainWise (BrainWise Knowledge Survey, or BKS). These instruments were found to be reliable for a sample unaccustomed to taking such measures. They were administered the post-test 4 months after learning the 10 Wise Ways.

The results demonstrated that the men in the treatment group improved on a much wider range of executive functions (including inhibitory control), coping self-efficacy, and BrainWise knowledge than the men in the comparison group. This provided evidence that BrainWise positively influences critical skills for adaptive functioning and resilience. These improved skills and knowledge will likely help them better face the many daily challenges, such as maintaining healthy relationships, holding jobs, and becoming productive members of society [35].

6. Vulnerable veteran populations and the BrainWise intervention

6.1 Veteran homelessness and serious mental illness

The promising results of the preceding study have given rise to an effort to study the implementation of BrainWise within the U.S. Department of Veterans Affairs (VA). Homelessness among veterans is a sizeable and urgent problem and addressing it is a high priority for VA. According to the 2018 Annual Homeless Assessment Report (AHAR) to Congress, nearly 38,000 Veterans in the U.S. were experiencing homelessness on a single night, of whom roughly 14,500 were completely unsheltered [115]. The cornerstone of the VA's efforts to reduce veteran homelessness is the Housing and Urban Development–Veterans Affairs Supported Housing (HUD-VASH) program, which provides housing subsidies and case management services to eligible veterans. HUD-VASH has been instrumental in reducing the nation's homeless veteran population, which dropped by 52% from 2009 to 2018 [117]. However, many veterans in the program fail to obtain housing, and many who do subsequently return to homelessness [118]. Clearly, despite access to similar resources, many veterans are not succeeding. While the reasons for this are complex, individual characteristics account for some of these disparate outcomes. In particular, serious mental illnesses such as schizophrenia and bipolar disorder [119, 120] and substance use disorders [121] are major risk factors for homelessness among veterans.

6.2 Combat-related risk factors for executive dysfunction

Given disproportionate rates of mental illness among Veterans, the impairments in executive functions related to a variety of psychiatric conditions discussed in Section 4.4 are especially relevant to this population [67]. In addition, veterans are at unique risk for combat-related posttraumatic stress disorder (PTSD) and traumatic brain injury (TBI). PTSD and TBI, which frequently co-occur, are considered signature conditions of the wars in Iraq and Afghanistan due to their high prevalence among this cohort [122]. PTSD is associated with impaired executive function irrespective of current symptom severity [123]. Similarly, because the frontal lobes are particularly susceptible to traumatic injury, deficits in executive function are common sequelae of TBI, even in mild cases [124]. Rabinowitz and Levin highlight the negative impact of moderate to severe TBI on judgment and everyday decision making, suggesting a possible role for the BrainWise program given its emphasis on and approach to decision making skills [125]. Specifically, TBI can disrupt the process of associating visceral emotional responses with positive and negative outcomes. TBI impacts several aspects of decision making, including impulsivity, risk adjustment, and rational choice, owing to abnormalities in the anatomic regions responsible for each of these functions [126]. Although untested in this regard, the BrainWise program's emphasis on strengthening systems of emotional control and reinforcing neural pathways involved in adaptive decision making may be well suited as a rehabilitative strategy for persons with TBI.

6.3 Conceptual model of executive functions and veteran homelessness

As previously discussed in Sections 4.1–4.4, homelessness itself, predisposing factors for homelessness such as poverty and childhood maltreatment, factors resulting from homelessness such as stress and social exclusion, psychiatric illness in general, and veteran-specific conditions such as combat PTSD and TBI are all associated with impairments in executive functions. Many individuals are burdened by several of these factors. In turn, there is evidence that executive functions mediate several processes which impact a person's ability to obtain housing and remain housed, such as risk-taking behaviors, conduct problems (e.g., violent behavior), and aspects of self-care. Taken together, a conceptual model begins to emerge by which we can represent some of the relationships between executive function, factors that impact it, and its effect on housing outcomes (**Figure 2**).

The symbols indicate positive (+) and negative (–) associations. As shown in the model, executive functions appear to have both direct and indirect effects on housing stability. For example, poor planning can lead directly to loss of housing (e.g., via failure to pay rent), and poor inhibitory control can lead to behaviors such as substance use and conduct problems which then lead to housing loss. Of note, a number of possible points of intervention within the model are addressed by existing VA services—treatment of mental illness, TBI, and substance use, provision of housing services, and case management to address psychosocial needs—but a focus on executive functions is not among these. The possibility of intervening to improve executive functions presents an opportunity to augment existing VA services with the aim of improving housing outcomes for homeless veterans. BrainWise was selected for this purpose because it is the only program known to have evidence for improving executive functions in homeless individuals.

6.4 Adaptation of BrainWise for homeless veterans with serious mental illness

The chapter authors, working with other investigators at VA, have developed a proposal to adapt the BrainWise curriculum for use with homeless and recently homeless veterans diagnosed with serious mental illness, using input from VA staff and veterans themselves. The initial pilot study would be carried out at the Greater Los Angeles VA Medical Center, in an integrated care clinic for homeless veterans called a Homeless Patient-Aligned Care Team (HPACT). HPACT services include primary care, mental health and substance use treatment, and case management, with care tailored to the unique needs of homeless veterans. The HPACT model has resulted in a number of positive outcomes [121, 127] and presents an opportune

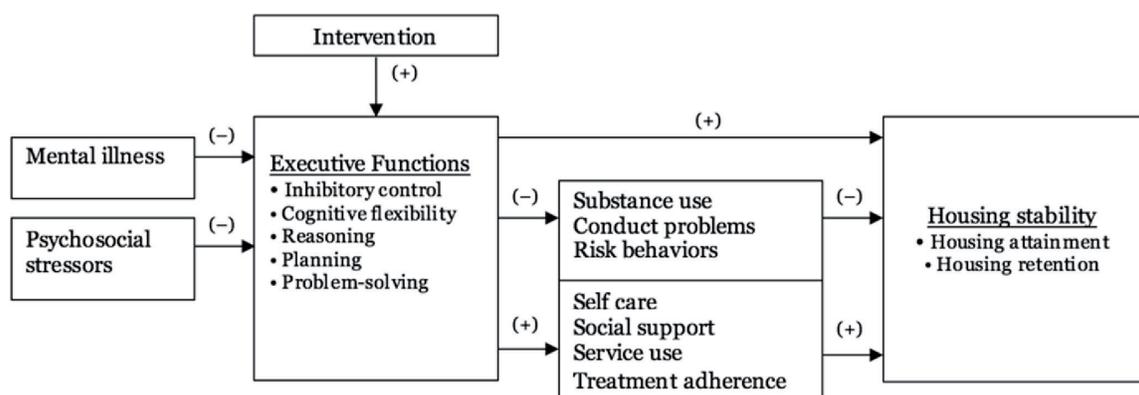


Figure 2.
Conceptual model of life stress, executive functions and housing stability.

venue for implementation of innovations that fill service gaps. The design and procedures of this proposed pilot study are described, below.

During an initial adaptation phase, the research team interview key stakeholders consisting of clinicians and administrators in the HPACT clinic and HUD-VASH program, as well as homeless veterans from an established Veteran Engagement Group. The BrainWise program and materials are described and shown to the stakeholders, who are then asked to provide input regarding aspects of the curriculum that appear most and least relevant, barriers or problems they anticipate in delivering the intervention, situations homeless veterans face which could be used as teaching examples, and other suggestions or thoughts they may have. The interviews are recorded, transcribed, and analyzed using qualitative research methods in order to identify salient themes and extract information to be used to guide the initial adaptation of the BrainWise materials.

The adapted curriculum is taught in a series of weekly sessions to two groups of approximately 8–12 HPACT patients diagnosed with schizophrenia or other forms of psychosis, with or without a substance use disorder. Immediately following each intervention session, participants provide feedback on the session, and this information is recorded, analyzed, used to conduct further modifications of the curriculum based on input from participants. At the same time, the research team monitors the fidelity of the adapted curriculum to assure that core BrainWise elements are retained.

In addition to the development of content and format tailored to this population, the key outcomes of interest for this pilot study are the feasibility and acceptability of the intervention for the population of homeless veterans with psychotic disorders. We would also gather preliminary data on the effects of the intervention on executive functions, BrainWise content knowledge, substance use, and housing trajectory, by assessing these variables prior to and immediately following the intervention course. Although such results are not intended to be conclusive due to the lack of a control group and the small number of participants planned for the initial study, conducting these assessments would provide valuable information about the feasibility of the data collection methods in this population. It would also yield descriptive statistics that would assist in planning a larger controlled trial of the adapted BrainWise curriculum. Our hope is that this work may form the foundation for the wide-scale incorporation of BrainWise programming into homeless services throughout VA, and more importantly that the tools gained from the program can help these vulnerable veterans emerge from homelessness and more successfully navigate their everyday lives.

7. Conclusions

Researchers continue to explore the diverse manifestations of inhibitory control across development, as well as its importance to the adaptive domains of executive functions and self-regulation. The brain systems critical to the normal development of these skills are guided by genetic and epigenetic phenomenon, as well as supported by an environment that provides learning opportunities and age-appropriate challenges. However, it is also clear that the brain systems underlying inhibitory control are vulnerable to a variety of stressors, which can result in differences in developmental trajectories and functioning. Research also confirms that such life stressors as poverty, childhood maltreatment, homelessness, and mental illness, are associated with impaired functioning in inhibitory control, executive functions, and overall self-regulation.

In this chapter, we introduced the BrainWise program as a universal curriculum that translates basic biological science to prevention skills taught by educators and

health providers. We discussed how its approach optimizes findings on effective interventions, simplifies their delivery, and integrates them with brain science. The section described the 10 skills instructors teach to students and clients and the scientific support for each one, and presented research that had been conducted with children, adolescents, and adults.

We gave examples of how the program has been successfully used with elementary, middle, and high school students as well as families on welfare and homeless-experienced men, shared research on the program's outcomes, and provided access to additional resources. The information provided a template showing how science can be scaled to develop lessons that teach thinking skills to diverse populations and reach individuals who will benefit from learning executive functions, including inhibitory control and emotional regulation.

Finally, we suggest an application of the BrainWise curriculum to a very vulnerable population of veterans with serious mental illness, and potential TBI, who have experienced homelessness. The simplicity and accessibility of this intervention to a wide range of circumstances, as well as its focus on some key executive function impairments in this population make this a promising direction for inquiry. At-risk and high-risk populations of individuals incur personal and societal costs of poor decision making and impulsive behaviors which may be ameliorated by appropriate, targeted, and flexible neurocognitive interventions.

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