Defining and Measuring Executive Functions in Adults:

Applications for Practice and Policy

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Introduction

For much of the last century, social policy has aimed to build human capital by increasing knowledge in children and adults through education and workforce development programs. Often the underlying assumption of these programs has been that human capital derives from concrete knowledge and repeatable skills relevant to success in particular professions. After half a century of application, conventional programs to build human capital have produced only mediocre results. Recent research on executive brain functions illuminates new horizons for social policy that could transform human capital development to create capacity to solve novel problems in real-life contexts and enable self-regulation vital to social and occupational success. Education and workforce development programs that build executive function (EF) could improve in effectiveness and efficiency, creating greater prosperity for program participants and the societies of which they are a part.

Executive functions underlie complex behaviors such as making decisions to attain pre-determined goals, applying past learning to novel contexts, regulating behavior, solving novel problems, interacting in social environments, and orienting to the future (Diamond, 2006; Mezzacappa, 2004; Stuss & Benson, 1984; Stuss & Alexander, 2000). These discoveries have informed effective interventions in early childhood education (Barnett, Jung, Yarosz, Thomas, Hornbeck, Stechuk, & Burns, 2008) and programs to assist adults with dysexecutive function resulting from cognitive disorders such as ADHD, traumatic brain injury, and multiple sclerosis (Parker & Boutelle, 2009; Kennedy, Coelho, Turkstra, Ylvisaker, Sohlberg, Yorkston, Hsin-Huei, & Pui-Fong, 2008; Fink, Rischkau, Butt, Klein, Eling, & Hildebrandt, 2010). The concept of EF could be applied more broadly to social policy and practice to improve outcomes for children and adults participating in a variety of social programming. An understanding of the cognitive psychology and neuroscience literature on the definition and measurement of EF will inform discussions of how it may be applied to systems of human capital development.

A Brief History of Executive Function Research

The study of EF began 150 years ago with a railroad worker named Phineas Gage. In a construction accident, the frontal lobe of Gage’s brain was pierced by a metal rod and this changed his behavior in unexpected ways. While Gage’s intelligence and other brain functioning remained intact, he became more impulsive, less organized, and nearly incapable of keeping plans. The case became a media sensation and sparked discussion of the importance of the frontal lobe to organizing and planning in daily life. The underlying processes and anatomy of these functions remained elusive to understanding for decades to come (Harlow, 1868; Miyake, et al., 2000).

In the 20th century, a myriad of case studies underscored the importance of the frontal lobe to higher order brain functions. Patients with frontal lobe damage experienced difficulties in “attention…planning, and monitoring of performance (Stuss & Benson, 1984, p. 17). They also showed difficulty engaging in social interaction and adapting to changes in the environment. This led researchers to posit the existence of a central executive in the frontal lobe that organized other brain functions. They theorized the central executive as a type of memory, or a supervisory attentional system that monitored all incoming sensory information in the brain (Baddely & Hitch, 1974; Norman & Shallice, 1986).

In the last two decades, neuroscientists and cognitive psychologists have expanded EF research beyond atypical populations marked by deficits to include typical adults and children encountering everyday environments. These studies, aided by advancing in neural imaging technology and new methods of statistical analysis, have allowed researchers to describe the neurological basis of and developmental influences on EF in childhood, adolescence, and adulthood (Huizinga, Dolan, & Molen, 2006). More recent findings show that there is not one central executive function, but rather a group of closely related yet distinct EFs that share brain structures in and surrounding the prefrontal cortex (Pfc) of the frontal lobe (Stuss, & Alexander, 2000). The distinct executive functions best understood and measured are inhibition, working memory, and cognitive adaptability or shifting (Friedman, Miyake, Corley, Young, Defries, & Hewitt, 2006; Huizinga, Dolan, & Molen, 2006; Miyake, et al., 2000). These operations are the basic building blocks of higher brain functioning like planning and goal orientation. Understanding their relationship to everyday behaviors sets a foundation for a new understanding of the role of education and experience in building human capital.

The Importance of Executive Functions

Executive functions are related to many behavioral outcomes that are the goals of human capital development programs that strive to foment productive participation in the socioeconomic system. EF enables prosocial behavior linked to morality, ethics and effective social interaction; creative problem solving important to job performance and solving life challenges; and identification of and perseverance toward goals that benefit individuals, families, and communities. EF not only supports academic success and educational attainment, but also social cooperation and family cohesion. The social and academic behaviors that arise from EF are essential to supporting outcomes that are the focus of human capital development from early childhood programs to Adult Basic Education (ABE).

EF promotes achievement and attainment in education by enabling attentional focus, prospective memory, planning, organization, and adaptability in novel situations. Working memory is particularly important to children's math and reading performance, and inhibition is related to success in math, science, and reading (St Clair-Thompson, & Gathercole, 2006; Bull & Scerif, 2001). Bilingual children score higher on EF tests than monolingual peers, suggesting that language learning and EF are also connected (Carlson & Meltzoff, 2008). The link between EF and educational success is explained in part by goal orientation. Students with strong EF skills are able to apply themselves better to their studies. For example, the cognitive behavior of “prospective memory” is enabled by EF. This type of memory reminds a student to do something he or she had earlier planned on doing, such as beginning to work on an essay due the following week (Wilson, 1998). The three particular executive functions of shifting, working memory, and inhibition each contribute to academic achievement in different ways. Shifting and working memory allow students to organize time and apply the knowledge they’ve acquired to novel problem sets. Inhibition allows students to focus attention in learning environments.

Executive functions also allow adults and children to regulate emotion and interact positively in complex social environments. The areas of the prefrontal cortex associated with EF are vital for exerting top-down control over emotions and also influence economic decision-making, risk-taking behavior, and levels of social trust between partners. This has implications for relationships in families and working environments. In a study of the willingness of people to enter into economic deals with one another, researchers found that patients with impaired prefrontal cortex functioning were less likely to engage in deal making. Prefrontal functioning influenced participants’ judgments of the intentions of others. Those with Pfc impairment tended to impute negative intentions to potential partners in proposed economic deals. This propensity to read negative intent and mistrust others resulted in missing economic opportunities (Koenigs & Tranel, 2007). Prefrontal cortex functioning also influences decision-making in which individuals must weigh risks and benefits (Llewellyn, 2008). Mistrustful behavior or the inability to cooperate with others or weigh the relative benefits of risky behaviors could have impacts on social cohesion and economic development at the levels of family and community.

The complex social cognition associated with EF enables management of everyday life challenges. A parent dealing with a 2-year-old throwing a temper tantrum may respond in two starkly different manners depending on executive function deployment: coolly and rationally through inhibition of anger and frustration; or angrily, and perhaps violently, if executive control systems are inadequate to inhibit prepotent responses of anger. A parents' EF at any moment may be influenced by a number of variables, e.g. development of EF, stress level, educational history. The emotional self-regulation enabled by EF plays a critical role in parenting and navigating other complex relationships such as those that develop in the workplace (Koenigs & Tranel, 2007; Miller & Cohen, 2001).

The importance of prefrontal executive functioning to social trust is related to EF's role in social cognition, or perspective taking. Perspective taking allows people to imagine what another person's perspective is in a given situation. This activity is vital for the successful navigation of social environments that require viewing the world through others' eyes and using these alternative perspectives to make good decisions. The ability to judge how others see the world or how they feel is a lower-level brain function, but applying this knowledge to guide one's own behavior is enabled by EF (Qureshi, Apperly, & Samson, 2010). This ability influences behavior as diverse as empathizing with a child, making a strong offer in a business negotiation, or creating a new product or work of art that satisfies an audience. EF also enables the complex social cognition required when interacting in an intercultural or multilingual environment (Richeson & Shelton, 2003).

Perhaps the greatest contribution of executive functions to the well-being and success of individuals is its enhancement of locus of control, a well-studied psychological concept that encompasses self-esteem and the general feeling of being in control of one's life. Neuroimaging and theoretical evidence show that the supervisory functioning of the prefrontal cortex exerts the kind of top-down control that makes people feel as though they can modify their own actions to create different life outcomes (Declerc, Boone, & Brabander, 2006). People with a strong internal locus of control see the outcomes of their lives as connected to their own actions. Those with an external locus of control view their lives as products of outside forces. In an academic setting, a student with an external locus of control will view a poor test score as a result of an unfair teacher or test, rather than a reflection of his or her own time studying. An external locus of control is associated not only with poor academic performance, but also depression and substance abuse (Declerc, Boone, & Brabander, 2006). Students with internal loci of control will attribute poor test performance to their own behavior, and be more likely to change study habits to improve for the next test.

In a randomized control study of mothers in a welfare-to-work program, participants with internal loci of control performed significantly better than those with external loci of control, even when controlling for IQ scores and other factors (Leininger & Kalil, 2008). A feeling of control over one's life was more important than any other factor, including prior educational attainment, in determining how successful low-income women were in adult education programs. Locus of control has great power to explain differential life outcomes and is directly related to EF development. In programs designed to transform participants' lives, applying curriculum and pedagogy that develop EF skills will play a central role in a successful theory of change.

Understanding Specific Executive Functions

Cognitive scientists have best understood and measured three executive functions that serve as essential building blocks for many of the other supervisory systems in the prefrontal cortex: inhibition, working memory, and shifting. Each of these functions works in coordination with the others, and accordingly shares some brain structures with other EFs; however they are distinct enough to be measured separately and describe different abilities (Huizinga, et al., 2006). The simultaneous unitary and diverse nature of EF arises in part because of its supervisory role. Each EF must be connected to other areas of the brain in order to monitor and shift behavior according to information from multiple sources. Just as an effective CEO and CFO should have connections to the broad workings of a company and to each other, so must EFs connect to other parts of the brain to share information. The following section will describe the most commonly studied of the executive functions and give examples of how they operate in real world contexts.

Type of Executive Functions	**Description**	**Psychometric Assessments**
Inhibition	Inhibition occurs when a person ignores a prepotent response to reach a goal. A prepotent response is one that arises without conscious thought, i.e. out of habit, reflex, or immediate desire.	The Stroop Task The Stop-Signal Task The Happy-Sad Task The Tower of London Task The Go No-Go Task The Day/Night Task
Working Memory	Working memory, sometimes referred to as updating, is the running record of experience and information the brain holds in consciousness to help decide on behavior.	The Keep-Track Task The Letter Memory Task The Wisconsin Card Sorting Task (WCST)
Shifting	Shifting, also known as cognitive adaptability or attentional flexibility, describes the process of selecting and implementing strategies to complete tasks or solve problems.	The Number-Letter Task The Plus-Minus Task The Wisconsin Card Sorting Task (WCST)

Table 1: Types of Executive Functions

Inhibition

Inhibition occurs when a person ignores a prepotent response to reach a goal. A prepotent response is one that arises without conscious thought, often out of habit, as when a person in the U.S. looks left and then right to check for traffic before crossing a street (Miller & Cohen, 2001). Inhibition plays a role in conduct disorders and Attention Deficit Disorder (ADHD), and enables many positive behaviors in everyday life (Logan, Schachar, & Tannock, 1997). A person may have a natural proclivity for sugary foods, for example, but at a doctor's visit discovers she is at risk for diabetes. When she passes her favorite pastry shop, she has a sudden, prepotent urge to buy a chocolate donut, but as she begins to turn toward the shop, she pauses, then turns away. The action of inhibiting lower order brain functions such as hunger or habit is itself a brain function that engages the prefrontal cortex.

Inhibition also plays an important role in social cognition. A myriad of cultural norms and assumptions require humans to navigate complex social terrain with serious consequences for misbehavior. A waiter at a restaurant who encounters rude customers may have a sudden urge to attack an offensive client, or at least to express anger in an outpouring of insult. This prepotent urge may have negative repercussions on the waiter's employment if carried out, so the waiter keeps his indignation to himself. In this way, inhibition allows emotional regulation to navigate social interaction.

Working Memory

Working memory, sometimes referred to as updating, is the constant running record of experience the brain retains in consciousness to decide on behavior. The "working" part of working memory derives from its importance in planning and goal-oriented decision making. While general memory may be stored out of consciousness for long periods, working memory plays a role in active decision-making in the present moment, fostering perseverance in surmounting short or long-term challenges by enabling focus on present tasks associated with goals. In short, working memory unites future goals with past learning and present action. Individuals with poor working memory find it difficult to adhere to previously made plans and as a result become distracted easily. Working memory also assists in reading comprehension, since it allows for interpretation of text based on a conscious record of previous material (Baddeley, 1986; Bunting, & Cowan, 2005). These abilities are imperative for an effective parent or employee, e.g. keeping a doctor's appointment or remembering a job interview.

Shifting

The executive function of shifting, also known as cognitive adaptability or attentional flexibility, describes the process of selecting and implementing strategies to complete tasks or solve problems. The tasks we complete on a day to day basis, from making a phone call or mailing a letter to exercising or choosing to eat fish, arise in part due to habit and in part due to conscious choices we make. Shifting exerts top-down, conscious control on cognitive processes to move from one behavior to another (Monsell, 2003). People with impairment in shifting find it difficult to change tasks, and are apt to continue using a strategy to solve a problem even after it is clear the strategy is not working.

A simple example of a situation requiring shifting is a person from the United States visiting England who must cross the street safely. The typical, habitual strategy of looking left, then right, to watch for oncoming traffic does not work in the new environment. The visitor must recognize the novel context, choose a new strategy, and implement it in order to cross the street safely (Miller & Cohen, 2001).

Shifting is also required for successful social interactions in families and the workplace. Employees must shift from behaviors that would be appropriate in the home environment to a different set of behaviors appropriate for the workplace. This type of code-switching may be employed in language as well, as when a bilingual person decides which language to use according to context. Parents use shifting when adopting a strategy to pick up a child from an after-school program after unexpected car trouble. Shifting enables adaptation to new environments and the selection of appropriate behavior to overcome quotidian and long-term challenges.

Coordination of the Executive Functions

Although cognitive scientists have isolated the executive functions of inhibition, working memory, and shifting, in the many challenges that surface in everyday life these functions are not isolated, but rather coordinate with each other and myriad other cognitive processes to solve problems. In the very simple case of crossing the street in a foreign country, for example, all three functions are employed. Before crossing the street, one must inhibit the prepotent response of looking left, then right; engage working memory to access relevant information from past street-crossing episodes to formulate a new strategy; then use shifting to implement the new strategy. If such a simple problem requires coordination of multiple executive functions, one can imagine the complex manner in which they work together to solve problems such as completing a career education program or changing parenting behaviors. For this reason EF can be considered a unitary construct for the purpose of designing programs and policies that build EF skills. Human capital development programs that use EF as a base for design and implementation should empower participants to solve life challenges that engage the coordination of multiple executive functions.

Measuring Executive Functions

To broadly incorporate EF into interventions, policy, and human capital development, measurement must capture its impact. Many existing programs for children and adults may already impact EF, and an important innovation will be using measurement to identify programs, refine them, and deploy them to the right people at the right time.

Measuring EF has not been a simple process, but tools have improved significantly in recent years. EFs control other brain functions, so any test of EF also measures the brain functions that EF organizes. This task confusion makes it difficult to use typical psychometric tests to measure EF as a pure construct. These difficulties notwithstanding, researchers have developed a wide array of psychometric EF tests, some of which measure specific executive functions, and others that tap into multiple executive functions. The psychometric tests that have been developed are often not considered ecologically valid, however, since it is possible for participants to score high on these tests and still show impairment when solving problems that require EF skills in the real world (Barkley & Murphy, 2010; Lamberts, Evans, & Spikman, 2010; Wilson, Evans, Alderman, & Burgess, 1998). Just as a driver may pass a written driving test and fail the road exam, participants may demonstrate EF skills on a psychometric test, but be incapable of coordinating these skills to solve problems outside of the testing environment. This does not mean that psychometric tests cannot be used as part of a greater program to evaluate the effectiveness of interventions, but they should not be considered by themselves sufficient to determine a program's effectiveness.

In order to address the challenges of ecological validity in measuring EF researchers have developed rating-scale assessments that are global measures of the unitary aspects of executive functions. These global assessments of EF predict with greater accuracy the abilities of participants to solve real-world problems requiring EF skills. Drawbacks of these measures include a longer administration time and less precision in identifying specific deficits or strengths in specific executive functions. Most rating scales have also been designed to measure deficits in clinical populations, and would need to be adapted for use with typical groups.

Another challenge to measuring EF is creating assessments that remain valid for children and adults. While some psychometric tests retain validity across the developmental spectrum, many are too complex for children or too easy for adults, and thus cannot be used to make comparisons across development. Tests that have varying levels difficulty can be adjusted for different populations to ensure validity across a larger developmental spectrum (Lindqvist & Thorell, 2009). Researchers continue to address challenges of developing EF measures that have wider applicability across age and clinical and non-clinical populations. For now, however, evaluators must choose between measures that capture EF specific to the characteristics of participants in the program being evaluated (Sayfan & Monsour, 2011).

What follows is a list of the most common assessments of EF and the particular executive functions they measure. This list informs the use of measurement in evaluating and refining programs that intend to build human capital through EF development.

Assessments of Executive Function	**Type of Executive Function Measured**	**For Children or Adults**
The Stroop Task	Inhibition	Adults
The Stop-Signal Task	Inhibition	Adults
The Happy-Sad Task	Inhibition	Both
The Flanker Task	Inhibition	Both
The Go/No-Go Task	Inhibition	Both
The Tower of London Task	Inhibition	Adults
The Keep-Track Task	Working Memory	Both
The Letter Memory Task	Working Memory	Both
The Wisconsin Card Sorting Task (WCST)	Working Memory, Shifting	Both
The Number-Letter Task	Shifting	Both
The Plus-Minus Task	Shifting	Adults
Rating Scales	All	Both
The Executive Secretarial Task (EST)	All	Adults
The Behavioral Assessment of Dysexecutive Syndrome (BADS)	All	Adults

Table 2: Assessments of Executive Function

Psychometric Tests of Executive Tasks

These tests measure the most basic components of EF and can be performed quickly in laboratory settings. They have easily quantifiable results and can be analyzed and compared with other tests using statistical analysis.

The Stroop Task

The Stroop Task is one of the oldest and most common measures of EF. Participants name the color of a symbol or word in three trials. In the first trial, participants name the color of a symbol, such as an asterisk. In the second, they name the color of a word that spells a different color, e.g. BLUE written in red letters. In the final trial, the participants name the color of a word printed in the same color (Stroop, 1935). The Stroop Task taps the executive function of inhibition as participants must inhibit their prepotent response to read the word, rather than the color of its letters (Miyake, et al., 2000). The difference in performance on the first and third tasks from responses on the second task measures the functioning of participants' inhibitory control.

The Stop-Signal Task

The Stop-Signal Task also taps inhibition. In this task, participants must discriminate between an X and an O when they appear on a computer screen. When the participant sees the letter, he or she taps the corresponding letter on the keyboard. On 25% of the letter appearances, a tone sounds, indicating that the participant should *not* press a button to distinguish between the letters. The stop-signal reaction time measures inhibitory control as the participant must inhibit the prepotent response of responding to the letter (Logan, et al., 1997).

The Go No-Go Task

This task measures is similar to the Stop-Signal task and also measures inhibition. Participants must press a button only when the letter X is presented on a computer screen. Fifteen other letters are presented in addition to the letter X, and the participants must refrain from pressing the button. Go stimuli (X's) are presented on 80% of the trials, and no-go stimuli (other letters) are presented in the remaining 20%. Variations in difficulty on this task may be introduced by reversing the response stimuli, so that participants must press a button in response to all non-X letters after having completed the first trial of responding only to X (Redick, Calvo, Gay, & Engle, 2011).

The Flanker Task

This task measures inhibition through a subject's ability to inhibit a prepotent response and also to ignore distracting stimuli. A line of arrows is projected across a computer screen, and the subject must respond only to the middle arrow. If the middle arrow points to the left, the subject presses a button to the left. If the middle arrow points to the right, the subject presses a button to the right. When the middle arrow is in the same direction as the other arrows, called flankers, this is called a congruent trial. When the middle arrow points in a different direction, it is called an incongruent trial. The average difference in response time between congruent and incongruent trials measures inhibition and the ability to ignore distractions. The difficulty of this task may be varied by changing the size and number of the flanker arrows (Lindqvist & Thorell, 2009).

The Happy-Sad Task

This task focuses on measuring inhibition. Similar to the Stroop Task, participants must inhibit a prepotent response, but rather than responding to words, the participants respond to images of happy and sad faces. Participants must name the opposite emotion portrayed on a simple image of a face. Experiments show that this test does not suffer from a ceiling effect for adults, and remains accessible to younger children, so retains validity across the developmental spectrum. The Stroop Task does not benefit from this same validity, as young children's reading fluency is not yet well enough developed for the task to measure only inhibition. (Sayfan & Monsour, 2011).

The Keep-Track Task

This task focuses on working memory. Participants must hold information in their working memory and update the information based on experience during the test. Six categories, such as animals, vegetables, and colors are presented to a participant along with a series of words that fit each category. In the trial, the participant is given three categories and presented with a series of words. The participant must mentally place each of the words into one of the three categories. Fifteen words are presented to the participant in random order. At the end of the trial, the participant must write down the last word from each of the three categories (Yntema, 1963).

The Letter Memory Task

This task is a tool to measure working memory. Participants listen to the test administrator read a series of letters. When the test administrator stops reciting the letters, participants must recall the last four letters. In order to ensure the task is measuring working memory, test administrators ask the participant to update mentally the last four letters after each additional letter is read (Morris & Jones, 1990).

The Number-Letter Task

This task measures shifting. Pairs of numbers and letters appear in one of four quadrants on a computer screen. When these pairs appear in the top two quadrants, participants must identify the number as odd or even. When they appear in the bottom two quadrants, they must identify the letter as a vowel or consonant. In the first trial, the pairs appear only in the top quadrant. In the second, they appear only in the bottom, and in the third the pairs appear in all four quadrants following a clockwise pattern. The average difference in response time in the third trial measures the cost of shifting and therefore the participants' shifting acuity (Rogers & Monsell, 1995).

The Plus-Minus Task

This task measures shifting using three simple calculation trials. In the first trial, participants add the number three to a series of numbers. In the second, they subtract three from a different series of numbers. In the third, they must alternate between adding and subtracting with a third series of numbers. The additional "cost" of shifting between adding and subtracting relative to the average time on the other two trials measures shifting ability (Jersild, 1927).

The Tower of London Task

This task is purported to measure more unitary constructs of executive functioning such as planning and problem solving. Participants must arrange three differently colored balls in a particular arrangement while following a set of rules. The balls can be placed on three different pegs, and each peg can hold three, two, or one ball respectively. Participants are instructed to match the pictured arrangement of balls in the least number of moves (Berg & Byrd, 2002). In a statistical analysis, Miyake et al. (2000) found that the Tower of London Task measured inhibition more than other executive functions.

The Wisconsin Card Sorting Task (WCST)

The WCST is one of the most common of all psychometric tests used to measure executive functions, and purports to be a global task that measures general frontal lobe functioning. Participants must sort cards that can be categorized by number, shape, or color. The test administrator decides which category is correct and tells the participant yes or no if they have categorized correctly. After a time, the administrator changes the correct rule for categorization. Participants are measured on how fast they learn the rules and how fast they switch to new rules (Berg, 1948). In a statistical analysis, Miyake et al. (2000) found that the WCST correlated most with shifting and working memory executive functions.

Ecologically Valid Assessments of Executive Function

These scales and tasks assess EF as a unitary construct and attempt to reflect the functioning of participants in real-life settings that require EF. These assessments often take longer to administer than individual task-based psychometric tests; however they also provide greater ecological validity and thus predict with greater accuracy occupational capacity and other skills associated with human capital development.

Rating Scales

Rating scales measure a person's executive functioning through structured questionnaires. Self-ratings are filled out by the participants themselves; however parents or teachers may be able to rate the behavior of children as well. Rating scales use Likert scales to rate perception of characteristics or abilities associated with EF. Questionnaires may ask participants to rate their organization, planning, and goal-setting by asking about personal habits or daily routines, for example. In a study of adults with ADHD, self-ratings were found to be much better predictors of occupational functioning difficulties associated with EF impairment (Barkley & Murphy, 2010).

The Executive Secretarial Task (EST)

Lamberts et al. (2010) developed this task to ameliorate the dearth in ecologically valid assessments with comparability across measures. The executive secretarial task requires participants to organize a set of upcoming events in the way that a secretary may organize meetings using a calendar. The task taps into the organizing and planning components of frontal lobe functioning and has shown reliability and validity in predicting difficulties in everyday life resulting from frontal lobe impairment. The EST also correlates well with other ecologically valid tests of EF such as the Behavioral Assessment of Dysexecutive Syndrome (BADS) and the Dysexecutive Questionnaire (DEX) (Lamberts et al., 2010).

Behavioral Assessment of the Dysexecutive Syndrome (BADS)

Wilson et al. (1998) developed the Behavioral Assessment of the Dysexecutive Syndrome (BADS) as an ecologically valid test of EF in the frontal lobe. The BADS attempts to tap into higher level EF such as planning and organization in a battery of tests with the intention of predicting real-world functioning. The BADS uses rating scales and tasks in a composite assessment designed to emulate the types of tasks requiring EF in everyday life. The BADS has shown better ability to predict EF difficulties than typical psychometric EF tests.

Recommendations for Practice and Policy

Policymakers and practitioners may incorporate EF into existing programs or design new strategies using EF to build the human capital of adult participants. When adapting or designing programs to build EF skills in adults, practitioners and policymakers should take into account guidelines that ensure effective participation and use measurement to identify and scale successful programs.

Motivation

EF skills build capacity in planning, organizing, and regulating behavior to attain goals; however program participants must first have goals in order to practice and develop EF skills applied to goal orientation. To leverage participants' motivation to develop EF skills, programs should not impose pre-determined goals upon participants, but rather incorporate client-centered approaches to help participants identify personal goals that may guide organization of their behavior. Without motivation to apply EF skills to personal outcomes, participants will not pursue activities necessary to develop EF and programs will be less effective.

Mitigating Factors

A variety of mitigating factors may disrupt the effectiveness of an EF development program. Many adults who have the most to gain from EF development also face a wide array of other challenges that contribute to chaotic home environments resulting from many factors: unemployment, poverty, mental or physical health problems, disability, or toxic levels of adversity-related stress. In order to engage the pre-frontal cortex region responsible for executive functioning, some level of basic stability must exist in a person's environment. Moments of high-stress and crisis trigger responses from other regions of the brain that may help a person respond to immediate threat, but do not allow for careful reflection, inhibition, or long-term planning associated (Caine & Caine, 2006). In order to develop executive functioning in adults, programs must first work to bring stability to participants' lives. Once stability is reached, a program may guide students through the process of careful, reflective planning and evaluation that leads to future orientation and engages the executive functions (Barnett, et al., 2008; Diamond, Barnett, Thomas, & Munro, 2007). If programs do not address these mitigating factors prior to or in conjunction with EF development, participants will not be able to engage in EF developing activities and programs will be unsuccessful.

Measurement

The array of EF measurements presents a challenge to policymakers and practitioners considering how to evaluate an EF development program. No single measurement provides sufficient evidence to determine a program's effectiveness, but tools may be used in combination to monitor and evaluate a program's progress. The first consideration for program designers is how to use EF measures to screen possible participants to identify those who would benefit most from the program. Psychometric tests such as the Go/No-Go task are inexpensive, rapid assessments that may be applied to large groups. These tests could form part of a screening mechanism to identify adults who need support in developing EF skills to improve parenting and occupational capacity. These psychometric tests should not be used in isolation to measure an EF program for adult's progress, however, as these tests may not register the changes in behavior that adults undergo in EF programs. To measure progress, EF measures that use rating scales or testing batteries to capture individual changes in behavior, rather than underlying brain processes, should be used in conjunction with psychometric tests to learn if programs have an impact on participants' EF skills. Practitioners and policymakers could work with researchers to develop new ecologically valid measures of EF skills tailored to non-clinical populations found in adult human capital development programs.

Conclusion

In the last decade, a surge of research in cognitive psychology and neuroscience has led to great advances in understanding and measuring the higher order brain functions known as EF. These functions are centered in the prefrontal cortex of the frontal lobe and exert top-down control over other brain operations in the way an executive leads an organization by determining goals and strategies. EF enables complex behavior such as planning, problem-solving, strategizing, organizing, and orienting present action to future goals based on past learning. EF is distinct from the analytical intelligence measured by IQ tests that has dominated much of pedagogy and curriculum in human capital development systems. Such systems that focus only on developing analytical intelligence or knowledge retention elide a number of supervisory executive skills vital for academic achievement, social cognition, occupational capacity, and effective parenting. Researchers have developed a variety of tools measure specific executive functions such as inhibition, working memory, and shifting, and recently have developed comprehensive assessments to measure EF as a unitary construct that predicts the ability to resolve real-life problems requiring frontal lobe functioning.

Policy makers and practitioners may use an understanding of EF and its measurement to design, refine, and deploy effective human capital development systems that go beyond building on analytical intelligence to creating capacity to solve complex real-world problems. Early childhood programs, bigenerational interventions, adult education, and workforce development all stand to improve efficiency and effectiveness by incorporating the development of EF into their theories of change.

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