The Assessment of Executive Function Using the Cognitive Assessment System: Second Edition

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The purpose of this chapter is to describe how executive function (EF) can be evaluated using the Cognitive Assessment System—Second Edition (Naglieri, Das, & Goldstein, 2013a, 2013b, 2013c). We will begin with a brief discussion of the relevant history of the concept of executive function, the ways it has been conceptualized, and how it has been measured. Next we will describe how the CAS2 can be used as part of the assessment process. Next, a case study will be provided which illustrates how the CAS2 can be integrated with other assessment data for identification and treatment planning. Finally, we will provide a discussion of an executive function intervention method that has been used for improving math and reading comprehension.

The Concept of Executive Function

One of the most remarkable capacities in the human brain is its ability to reflect and direct itself. This ability is often described using the term executive function. Without a well-developed executive function (EF), the human species probably would have remained unevolved and our earliest ancestors would never have been able to develop the tools, arts, and technologies of modern civilization. We owe this amazing ability to a particular part of the brain—the frontal lobes.

The concept of executive function is inextricably linked to the functions of our frontal lobes. Early groundwork for defining the executive function system was put forth by Luria (1966). Luria proposed the existence of a system in charge of intentionality, goal formulation, the action plans leading to these goals, the identification of goal-appropriate cognitive routines, the sequential access to the routines, the temporal ordered transition from one routine to the other, and the evaluation of our actions or the outcome. Following Luria's seminal work, two broad types of cognitive operations associated to the executive system have appeared in the literature: (a) the ability to guide one's behavior by formulating strategies and then guiding our behavior through sequential action plans and (b) the ability to change our plan when the situation requires it. In order to effectively cope with such transitions, mental flexibility is required. Mental flexibility can be conceptualized as the ability to respond efficiently to unanticipated contingencies within our environment. Some researchers refer to this as the ability to shift cognitive set. Goldberg (2009) sees the executive system as critical for planning and generative processes. Fuster (1997) expanded on Luria's original conceptualizations of EF and suggested that the EF system is in charge of both external and internal (such as

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logical reasoning) actions. More recently, McCloskey and Perkins (2013) have offered a model of executive function that goes beyond the generative processes and includes the idea that "trans-self-integration" processes are part of the executive system. The trans-integrative system refers to high levels of intention fueled by the desire to seek out experiences beyond typical perception of self and to experience a subjective sense of interconnectedness with all things.

Whether EF should be conceptualized as a unitary construct or several diverse functions has been a matter of considerable debate. Conceptualizations of executive function have been proposed by many researchers and clinicians. There are now more than 30 definitions for the term EF (Barkley, 2012) and at least as many as different constructs have been placed under its umbrella. For example, the Encyclopedia of Mental Disorders defines the term executive function (EF) as a set of cognitive abilities that control and regulate other abilities and behaviors and are necessary for goal-directed behavior (http://www.minddisorders.com/Del-Fi/Executive-function.html). Lezak, Howieson, Bigler, and Tranel (2012) see EF as consisting of capacities that enable a person to successfully and independently display purposeful, self-serving, and self-directed behavior. Ellioit (2003) described EF as complex cognitive processing requiring the coordination of several subprocesses to achieve a particular goal. The American Heritage Medical Dictionary (2007) defines EF as "cognitive processes that regulate an individual's ability to organize thoughts and activities, prioritize tasks, manage time efficiently, and make decisions. Impairment of executive function is seen in a range of disorders, including some pervasive developmental disorders and nonverbal learning disabilities." Banich (2009) defines EF as "… providing resistance to information that is distracting or task irrelevant, switching behavior task goals, utilizing relevant information in support of decision making, categorizing or otherwise abstracting common elements across items, and handling novel information or situations" (p. 89), and Dawson and Guare (2010) conceptualize it as "… Executive skills allow us to organize our behavior over time and override immediate demands in favor of longer-term goals" (p. 1).

Executive function develops over the course of many years. Some aspects crest in late childhood or adolescence while others advance into early adulthood as the brain continues to mature and establish connections well into adulthood. Executive function is shaped by both physical changes in the brain and by life experiences, in the classroom, and in the world at large. While critical for academic performance (Bull, Espy, & Senn, 2004; Clark, Pritchard, & Woodward, 2010; Willoughby et al., 2012), executive function is also intimately linked to emotional, behavioral, and social functioning (Kochanska, Murray, & Harlan, 2000; Schoemaker et al., 2012). In fact, it has been proposed that the construct can be dichotomized into "cool" processes that are cognitive and tapped during abstract, decontextualized situations or "hot" processes that represent affective responses to situations that are meaningful and involve regulation of affect and motivation (Zelazo, Qu, & Muller, 2004).

Current Assessment Tools for EF

Many tests have been used to evaluate executive function, most of which assess a narrow band of related executive skills. For example it is typical to use neuropsychological tests to evaluate specific topics such as goal-directed attention, impulse control, cognitive flexibility, visual planning and/or organization, and divided attention. Examples include the continuous performance test (Connors, 2000), the Cancellation subtest of the WISC-IV (Wechsler, 2003), visual attention subtests of the NEPSY-II (Korkman, Kirk, & Kemp, 2007), trail making, and the design fluency subtests of the Delis-Kaplan Executive Function System (D-KEFS) (Delis, Kaplan, & Kramer, 2001a, 2001b). Some researchers have suggested that executive functions (EFs) are best conceptualized as distinct abilities that are only loosely related, and many neuropsychologists consider working memory to be one of several disparate EFs that control cognitive performance (Blair, Zelazo, & Greenberg, 2005; Fletcher, 1996; Pennington, Bennetto, McAleer, & Roberts, 1996) while others have argued that all EFs share a common executive attention component (Blair, 2006; Duncan, Emslie, Williams, Johnson, & Freer, 1996).

If we accept that working memory is one of the various constructs that comprise EF, the question still remains as to what role it plays and what other processes it influences. Within the scientific literature, theories of executive function often differ in regard to the role working memory plays in EF. Simply stated, working memory refers to the structures and processes underlying the temporary retention and manipulation of information in support of higher cognitive tasks (Baddeley, 1986; Miyake & Shah, 1999). One known feature of WM is its limited capacity for a reduced amount of information which can be directly accessed during cognitive tasks that require active processing (Cowan, 2005; Szmalec, Verbruggen, Vandierendonck, & Kemps, 2011). Therefore, when working memory demands exceed capacity, a person is restricted to temporarily store subsets of the information and to successively update those representations as new information becomes available. Very often, however, it then becomes hard to distinguish between the older and more recent information, a behavioral phenomenon referred to as proactive interference (e.g., Jonides & Nee, 2006). Given the litany of definitions of executive function, and disagreement within and across disciplines, it is difficult to operationally define the various cognitive constructs that comprise executive function, let alone design instruments to measure them in a standardized, reliable, and valid fashion. Due to this fact, we hypothesize that this also attributes to the shortage of neuropsychological assessment tools that have attempted to measure EF, due in part to the multifactorial nature of most assessment tools currently available. This also explains the paucity of specific test batteries that directly measure executive function. Traditionally, assessment tools for executive function have focused on the adult population and typically measure EF through tasks of fluency (both visual and verbal), trail making, interference, tower, and sorting (Anderson, Northam, Hendy, & Wrennall, 2001; Baron, 2004; Isquith, Roth, & Gioia, 2010; Strauss, Sherman, & Spreen, 2006). These assessments of working memory are basic measures that are not typical of real-life tasks and are not easily generalized across settings, such as in educational environments. This can easily be conceptualized when we consider the nature of the tasks of working memory on more comprehensive assessment batteries, such as Digits Span Backward or Letter-Number Sequencing on the WISC-IV.

Isquith et al. (2010) attempted to develop a standardized measure of executive control processes, specifically working memory and inhibitory control. Their measure, the Task of Executive Control (TEC) uses a computerized, user-friendly format and is built around a cognitive neuroscience framework based upon functional neuroimaging research and the neural basis of working memory. Despite these advances in pediatric neuropsychological assessment tools, the authors of the TEC still point out that their test does not provide scores of working memory or inhibitory control. Rather, they assess these constructs *indirectly* through response accuracy, response time, and response consistency scores by increasing working memory load and inhibitory control demands as the child progresses through the assessment.

One of the best known tests of executive function is the Wisconsin Card Sorting Test (WCST), which has been referred to as a marker of executive function assessment tools (Delis et al., 2001a, 2001b). The WCST was originally developed to measure abstract reasoning and cognitive shifting abilities in response to changing environments through the use of problem-solving strategies to achieve a future goal in neurotypical adults (Berg, 1948; Grant & Berg, 1948; Luria, 1973). Welsh and Pennington (1988) identified the following constructs necessary to successfully perform the WCST: strategic planning, organized searching, utilizing environmental feedback to shift cognitive sets, directing behavior toward achieving a goal, and modulating impulsive responding. One of the best features of the WCST is the fact that it not only provides scores of success but also takes into account areas of difficulty by providing scores that measure difficulty with initiation, concept generation, failure to maintain set, perseveration, and inefficient learning across trials (inability to accept feedback). Over time, the WCST has become an increasingly popular neuropsychological evaluation tool and has been used with both adults and children in various clinical populations to assess neurological dysfunction; traditionally, within the frontal lobes, some clinicians have even referred to the WCST as a measure of frontal lobe functioning at the most primary level.

Although the WCST measures various constructs of EF, noticeably absent is working memory, researchers have been studying the role of working memory in clinical samples using the WCST for decades. This is most evident in the clinical population of schizophrenia. Gold, Carpenter, Randolph, Goldberg, and Weinberger (1997) found that impaired performance on a novel Letter-Number Working Memory Test predicted the WCST category achieved score, whereas measures of set shifting, verbal fluency, and attention were predictive of perseveration errors, suggesting that working memory may be a critical determinant of one aspect of impaired WCST performance in this population. Performance deficits associated with aging have also been identified on the WCST, and working memory is also believed to play a role in these declines over time (Fristoe, Salthouse, & Woodward, 1997). The WCST has frequently been used to assess executive functions in children with attention-deficit/hyperactivity disorder (ADHD). Mullane and Corkum (2007) compared the performance of 15 children with ADHD to 15 children of a control group (age range 6–11) on the WCST and then examined the relationship among working memory, inhibition, age, IQ, and scores from this test. Their study showed that the ADHD group made significantly more set-loss errors, and working memory was significantly correlated with perseverative errors but was also fully mediated by age and IQ.

Another classic neuropsychological assessment of executive function is the Trail Making Test (TMT). The cognitive shifting required by Part B of the TMT is a direct reflection of EF, although other neuropsychological abilities, such as psychomotor speed, visual scanning, and planning, are also required to successfully complete the test (Lezak et al., 2012). Moll, de Oliveira-Souza, Tovar, Bramati, and Andreiuolo (2002) used fMRI to assess neuroanatomical associations of a verbal adaptation of the TMT. Their study found marked asymmetry of activation in favor of the left hemisphere (likely due to the fact that this was a verbal adaptation of TMT), most notably in dorsolateral prefrontal cortex (BA 6 lateral, 44 and 46) and supplementary motor area/cingulate sulcus (BA 6 medial and 32). The intraparietal sulcus (BA 7 and 39) was bilaterally activated. These findings supported previous functional neuroimaging data, which has indicated that the dorsolateral and medial prefrontal cortices and the intraparietal sulci are associated with the regulation of cognitive flexibility, intention, and the covert execution of saccades/antisaccades. Other classic neuropsychological assessments, such as the Stroop test, WCST, and go/no-go tasks, share similar cerebral activation patterns.

Another example of an executive function assessment that does not include measures of working memory is the D-KEFS. The D-KEFS comprises nine individual assessment instruments designed to comprehensively assess higher-order cognitive functions in children and adults. These higher-order abilities are dependent on more primary neuropsychological abilities and are dependent upon attention, language, and perception and provide a foundation for more advanced cognitive processing such as problem-solving, cognitive flexibility, and abstract reasoning (Delis et al., 2001a, 2001b). Two of the nine subtests on the D-KEFS are novel and were developed by two of the test authors, while the other seven subtests were adapted from previously established clinically valid instruments or employed in prior experimental studies, such as the TMT, Stroop test, or tower tests. The D-KEFS isolates fundamental skills that may negatively impact higher-order cognitive skills and helps delineate skill deficits more precisely by identifying more clearly why examinees cannot perform the EF tasks. Similar to the WCST, no mention of working memory or its role in EF is made mention of in the examiner manual. Without working memory, however, the majority of the tasks on the D-KEFS cannot be completed successfully.

Engle (2002) discussed how measures of working memory consistently show higher correlations with measures of higher-level cognitive functions than do simple memory span tasks. He proposed that working memory is related to general fluid intelligence and executive attention. If we follow this line of thinking, then individuals with high working memory capacity should perform better on tasks requiring the inhibition of distracting information. This has been supported through various domains. Melby-Lervåg and Hulme (2012) provided several examples of this theory. These examples included research on high working memory capacity and improved performance on antisaccade tasks (Kane, Bleckley, Conway, & Engle, 2001) and high working memory capacity leading to better inhibition in the more difficult condition on a Stroop task with adults when such incongruent trials were relatively infrequent and the participant may detract attention to the goal of the task (Kane and Engle, 2003). Marcovitch, Boseovski, and Knapp (2007) found the same results on the Stroop task with children. High working memory capacity also appears to help inhibit distractions on dichotic listening tasks (Conway, Cowan, & Bunting, 2001).

Neuroimaging studies have consistently shown widespread activations in the prefrontal cortex during various forms of working memory tasks. The anterior prefrontal cortex plays a specific role in the ability to distinguish between target and nontarget stimuli during recognition and delayed working memory tasks (Leung, Gore, & Goldman-Rakic, 2005). The prefrontal cortex is also adapted to generate persistent activity that outlasts stimuli and resists distractors and has long been presumed to be the basis of working memory (Wang et al., 2006). Lesions to the frontal cortex have been believed to result in an inability to use complex information stored in working memory (Goldman-Rakic, 1991).

Deficits in executive functioning, including working memory, have also been proposed as playing an important role in ADHD and are especially related to impairments of behavioral regulation, task planning, and selective attention within this population (Klingberg et al., 2005; Mezzacappa & Buckner, 2010). Working memory also contributes to cognitive deficits observed in children with autism spectrum disorders (Kenworthy, Yerys, Anthony, & Wallace, 2008) and specific language impairments (Archibald & Gathercole, 2006).

Despite the fact that the majority of tests of executive function do not measure working memory directly, this construct is still necessary to successfully complete the majority of these tasks. Neuroimaging data clearly indicates the association between activation in the prefrontal cortex and various executive function constructs. The prefrontal cortex is also clearly associated with working memory, and it appears likely that it influences performance on assessments measuring executive function, despite the fact that this construct is often absent from definitions of EF and the assessment tools that measure it. Impaired working memory has negative influences on performance on such tasks, as shown in the examples of the WCST described above. This indicates that as new assessment tools are developed, researchers must provide clinicians with an opportunity to assess WM when examining EF, ideally in a manner that is generalizable to real-world settings. Table 12.1 provides a sample of neuropsychological measures with and without working memory requirements.

Regardless of how executive function is conceptualized, Lezak et al. (2012) and Dawson and Guare (2010) cautioned that the way tests of executive function are constructed and the demands of the instructions can limit the degree to which findings of these measures can be generalized beyond the testing situation, and several examples have been provided above. This concern raises two important topics. First, it is important that measures of executive function evaluate behaviors relevant to real-world functioning should play a role in assessment. Second,

Table 12.1 Sample neuropsychological measures of Executive Function purporting to require or not require Working Memory

Test	Example	Executive components	Involves Working Memory
Continuous performance tests	Conners' Continuous Performance tests (Connors, 2000)	Goal directed attention	No
Cancellation Tests	Visual attention subtest of the NEPSY-II (Korkman et al., 2007)	Goal directed, attention, impulse control	No
Color-Word Interference Test	Stroop Color-Word Interference Test (Golden, 1978)	Goal directed attention, set shifting, cognitive flexibility, impulse control	No
Attention Tasks	Expressive Attention subtest from the CAS2 (Naglieri et al., 2013a, 2013b, 2013c)	Focused attention, impulse control, working memory	No
Complex Figure Drawing Test	Rey Complex Figure Tests (Meyers & Meyers, 1995)	Visual planning, organization	No
Mazes	Elithorn Mazes subtest of the WISC-IV Integrated (Kaplan et al., 2004)	Visual planning, cognitive flexibility, impulse control	No
Tower Tests	Tower subtest of the NEPS and Tower of Hanoi	Visual planning, cognitive flexibility, impulse control	No
Trail Making Tests	Trail Making Subtest from the Delis-Kaplan Executive Function System (Delis et al., 2001a, 2001b)	Visual planning, goal directed attention, divided attention, set shifting	No
Planning (Planned Connections)	Planned Connections subtest from the CAS2 (Naglieri et al., 2013a, 2013b, 2013c).	Visual planning, goal directed attention, divided attention, set shifting	No
Wisconsin Card Sorting Tests	WCST 128 and 64-card versions (WCST; Grant & Berg, 1948)	Goal directed attention, set shifting, cognitive flexibility, working memory	Yes
Tasks of Executive Control (TEC)	Isquith et al. (2010)	Working memory, inhibitory control	Yes
Simultaneous Processing Tasks	Verbal-Spatial Relations subtest from the CAS2 (Naglieri et al., 2013a, 2013b, 2013c)	Simultaneous processing, working memory	Yes
Successive Processing Tasks	Sentence Repetition or Questions subtest from the CAS2 (Naglieri et al., 2013a, 2013b, 2013c)	Maintenance of order, working memory	Yes

it is also important that formal tests of executive function *should not* be highly structured, predictable, and directed by the examiner which reduces, and sometimes even eliminates, the need for planning and organization on part of the examinee. Similarly, Naglieri (1999) proposed that tests should be designed to encourage self-directed cognition and the selection, implementation, and evaluation of strategies. This was the goal of subtests designed to measure aspects of executive function on the Cognitive Assessment System (Naglieri & Das, 1997).

Description of the CAS2

The CAS2 (Naglieri et al., 2013a, 2013b, 2013c) was specifically designed to measure four neurocognitive abilities defined by the PASS theory of intelligence. Because this test was built explicitly on a specific theory of intelligence, we will briefly describe that theory and then how the CAS2 measures the PASS theory as described by Naglieri and Otero (2011).

The PASS theory of intelligence is based on a fusion of cognitive and neuropsychological constructs originally described by A.R. Luria in works such as *Higher Cortical Functions in Man* (1966, 1980) and *The Working Brain* (1973). Luria viewed the brain as a functional mosaic, the parts of which interact in different combinations to subserve cognitive processing (Luria, 1973). There is no area of the brain that functions without input from other areas. This means that cognition and behavior result from an interaction of complex brain activity across various areas. It was Luria's (1966, 1973, 1980, 1982) understanding of the functional aspects of brain structures which formed the basis for the PASS theory (Planning, Attention, Simultaneous, Successive processing), initially described by Das, Naglieri, and Kirby (1994) and operationalized by Naglieri and Das (1997) in the first and Naglieri et al. (2013a, 2013b, 2013c) in the second editions of the *Cognitive Assessment System*. These four manifestations of intelligence are more fully described in the sections that follow.

The prefrontal cortex "plays a central role in forming goals and objectives and then in devising plans of action required to attain these goals. The cognitive processes required to implement plans, coordinate these activities, and apply them in a correct order are subserved by the prefrontal cortex. Finally, the prefrontal cortex is responsible for evaluating our actions as success or failure relative to our intentions" (Goldberg, 2009, p. 23). Planning helps one to achieve goals through the development of strategies necessary to accomplish tasks for which a solution may not be initially apparent. The broad term of Planning is seen as an essential ability to all activities that require someone to figure out how to solve a problem. This includes self-monitoring and impulse control as well as making, assessment, and implementation of a plan. Thus, Planning allows for the generation of solutions, discriminating use of knowledge and skills, as well as control of Attention, Simultaneous, and Successive processes (Das, Kar, & Parrila, 1996). The essential dimension of the construct of Planning as defined by Naglieri and Das (1997) is very similar to the description of executive function provided by others (see other chapters in this volume). For example, O'Shanick and O'Shanick (1994) describe executive functions as including the abilities to formulate and set goals, assess strengths and weaknesses, plan and/or direct activities, initiate and/or inhibit behavior, monitor current activities, and evaluate results. Executive function includes abilities to formulate a goal, plan; to carry out goal-directed behaviors effectively; and to monitor and self-correct spontaneously and reliably (Lezak, 2004).

Attention is an ability that is closely connected to the orienting response. Brain structures within Luria's first functional unit, the reticular formation, allow one to focus selective attention toward a stimulus over a period of time without the loss of attention to other competing stimuli. The longer attention is needed, the more the activity necessitates vigilance. Goals and intentions related to plans provide control of Attention, while knowledge and skills play an integral part as well, especially when a learned solution to a problem is employed. In such instances, executive function is reduced and action with less cognition results. Schneider, Dumais, and Shiffrin (1984) and the attention selectivity work of Posner and Boies (1971), which relates to deliberate discrimination between stimuli, are similar to the way that the Attention process was conceptualized and measured in the CAS and CAS2. That is, tasks were designed to require focused cognitive activity and resistance to distraction over time.

Simultaneous processing is an ability that is used for organizing information into groups to form a coherent whole and seeing patterns as interrelated elements. This ability is made possible by the parieto-occipital-temporal brain regions. There is a visual-spatial dimension to tasks that demand most Simultaneous tests, but not all. In the CAS and CAS2, Simultaneous processing is measured using tasks that have a strong visual-spatial component such as that found in progressive matrices tests like those developed by Penrose and Raven (1936) and Naglieri Nonverbal Ability Test (2008). Simultaneous processing is not, however, limited to nonverbal content, as demonstrated by the important role it plays in the grammatical components of language and comprehension of word relationships, prepositions, and inflections (Naglieri, 1999). This is most apparent in the inclusion of the Verbal-Spatial Relationship subtest in the CAS (Naglieri & Das, 1997) and CAS2 (Naglieri, Das, & Goldstein, 2013a). Similarly, visual-spatial tests that use the progressive matrix format have been included in the so-called nonverbal scales of intelligence tests such as the *Wechsler Nonverbal Scale of Ability* (Wechsler & Naglieri, 2006), the perceptual reasoning portion of the *Wechsler Intelligence Scale for Children-IV* (WISC-IV; Wechsler, 2003), the *Stanford-Binet-Fifth Edition* (SB5; Roid, 2003), the *Naglieri Nonverbal Ability Test-Second Edition* (NNAT2; Naglieri, 2008), the *Kaufman Assessment Battery for Children-Second Edition* (K-ABC2; Kaufman & Kaufman, 2004), and a Simultaneous processing test (Naglieri & Das, 1997).

Successive processing ability is used when working with stimuli arranged in a defined serial order such as remembering or completing information in compliance with a specific order. Successive processing is involved with the serial organization of sounds, such as learning sounds in sequence and early reading which is an underpinning of phonological analysis (Das et al., 1994). When serial information is grouped into a pattern, however (like the number 553669 organized into 55-3-66-9), then successful repetition of the string may be a function of Planning (i.e., using the strategy of chunking) and Simultaneous (organizing the numbers into related groups). This method is often used by older children and can be an effective strategy for those who are weak in Successive processing (see Naglieri & Pickering, 2010). The concept of Successive processing ability from PASS is similar to the concept of Sequential processing included in the K-ABC2 (Kaufman & Kaufman, 2004) and tests that require recall of serial information such as Digit Span Forward on the WISC-IV (Wechsler, 2003).

The PASS theory provided the basis upon which the CAS and CAS2 were built. These basic psychological processes are measured using 4 (CAS2:Brief; Naglieri et al., 2013a, 2013b, 2013c), 8, or 12 (CAS2; Naglieri et al., 2013a, 2013b, 2013c). Additionally, the 12-subtest Extended Battery of the CAS2 provides several supplementary scales which includes measures of Executive Function more distinctly (see Table 12.2). For this reason, the CAS2 Extended Battery will be emphasized and more fully described below.

The Planning Scale

The subtests which comprise the Planning scale evaluate a students' ability to create a plan of action, apply the plan, verify that the action taken conforms with the original goal, and modify the plan as needed. It is formed by combining the results of the Planned Number Matching, Planned Codes, and Planned Connections subtests.

- *Planned Number Matching*. Each Planned Number Matching item presents the student with a page of eight rows with six numbers on each row. The student is required to find and underline the two numbers in each row that are the same within the 180 s limit per page. The numbers were written so that they can be more efficiently examined using a strategy. For example, some of the numbers are similar at the beginning, others at the ending.
- *Planned Codes*. In Planned Codes, students are provided with a legend at the top of each page that shows a correspondence of letters to specific codes (e.g., A, B, C, D to OX, XX, OO, XO, respectively). The page contains four rows and eight columns of letters without the codes which are arranged in some systematic manner the child can use to complete the page more efficiently. The student is required to write the corresponding codes in each empty box beneath each of the letters. Students have 60 s per item to complete as many empty code boxes as possible.
- *Planned Connections*. The Planned Connections subtest requires the student to connect a series of

stimuli (numbers and then alternating numbers and letters) in an order as quickly as possible. Students have between 60 and 180 s to complete each item. Students who carefully examine the task note that the lines they draw never cross and that strategies such as looking back to the previous number or letter make completion of the task more effective.

The Attention Scale

The subtest on this scale is designed to measure a students' ability to focus their cognition to detect particular stimuli and inhibit response to irrelevant competing stimuli. The CAS2 Attention scale comprises the Expressive Attention, Number Detection, and Receptive Attention subtests.

- *Expressive Attention*. The Expressive Attention subtest consists of two age-related sets of three items. Students between age 5 and 7 are presented with three items consisting of seven rows of six pictures of common animals that are depicted as either big (1 in. by 1 in.) or small (1/2 in. by 1/2 in.) for each item. In each of three items, the student is required to identify whether the animal depicted is big or small in real life ignoring the relative size of the picture on the page. In Item 1, the pictures are all the same size. In Item 2, the pictures are sized appropriately (i.e., big animals are depicted with big pictures and small animals are depicted with small pictures). In Item 3, the realistic size of the animal often differs from its printed size. Students between age 8 and 18 are presented with three items consisting of eight rows of five pictures. In Item 1, students are asked to read four black-and-white colored words (BLUE, YELLOW, GREEN, and RED) that are presented in random order. In Item 2, students are asked to name the colors of four colored rectangles (printed in blue, yellow, green, and red) that are presented in random order. In Item 3, the four colored words are printed in a different color ink than the colored word name and are presented in random order. In this item, students are required to name color of the ink in which the word is printed rather than read the word. Completion of the task demands considerable focus of attention on the critical attributes of the stimuli and resisting distractions created by stimuli that are only partially like the targets.
- *Number Detection*. Each Number Detection item presents the student with a page of approximately 200 numbers. Students are required to underline specific numbers (ages 5–7) or specific numbers in a particular font (ages 8–18) on a page with many distractors. Completion of the task demands considerable focus of attention on the important attributes of the stimuli (the number in the correct font) and resisting distractions created by stimuli that are only partially like the targets (the correct number but the incorrect font).
- *Receptive Attention*. The Receptive Attention subtest consists of two age-related sets of four items containing 180 picture or letter pairs. Both versions require the student to underline pairs of objects or letters either that are identical in appearance or that are the same from a lexical perspective (i.e., they have the same name). Completion of the task demands considerable focus of attention on the critical attributes of the stimuli (two letters that are the same but look different such as R and r) and resisting distractions created by stimuli that are only partially like the targets (letter pairs such as B and r).

The Simultaneous Scale

The Simultaneous scale evaluates a students' ability to synthesize separate elements into a cohesive whole or interrelated group. This CAS2 scale comprises the Matrices, Verbal-Spatial Relations, and Figure Memory subtests.

- *Matrices*. Matrices is a multiple choice subtest that utilizes shapes and geometric elements that are interrelated through spatial or logical organization. Students are required to analyze the relationship among the parts of the

Table 12.2 CAS2 subtests on the Core and Extended Batteries and supplemental scales

	Core and Extended Battery composites					Supplemental scores				
CAS2 subtests	Planning	Simultaneous	Attention	Successive	Full Scale	Executive Function without Working Memory	Executive Function with Working Memory	Working Memory	Verbal content	Nonverbal content
Planned Codes	x				x					x
Planned Connections	x				x	x	x			
Planned Number Matching	*				*					
Matrices		x			x					x
Verbal-Spatial Relations		x			x		x	x	x	
Figure Memory		*			*					*
Expressive Attention			x		x	x	x			
Number Detection			x		x					
Receptive Attention			*		*				*	
Word Series				x	x					
Sentence Repetition or Questions				x	x		x	x	x	
Visual Digit Span				*	*					

Note. x = Core Battery subtest; * = Extended Battery subtest item and solve for the missing part by choosing the best of six options.

- *Verbal-Spatial Relations*. Verbal-Spatial Rela tions is a multiple choice subtest in which each item consists of six drawings and a printed question at the bottom of each page. The examiner reads the question aloud and the child is required to select the option that matches the verbal description.
- *Figure Memory*. For each Figure Memory item, the examiner presents the student with a two- or three-dimensional geometric figure for 5 s. The picture is then removed and the student is presented with a response page that contains the original figure embedded in a large, more complex geometric pattern. The student is required to trace the original figure with a red pencil in the response book.

The Successive Scale

The Successive scale evaluates students' ability to recall or comprehend a verbal statement based upon the serial organization of information. All of the Successive subtests require the student to deal with information that is presented in a specific order. The CAS2 Successive scale is composed of the Word Series, Sentence Repetition or Sentence Questions, and Visual Digit Span subtests.

- *Word Series*. The Word Series subtest utilizes nine single-syllable, high-frequency words: book, car, cow, dog, girl, key, man, shoe, and wall. The examiner reads aloud a series of these words ranging in length from two to nine words, read at the rate of one word per second. The student is required to repeat the words in the same order as stated by the examiner.
- *Sentence Repetition*. The Sentence Repetition subtest (only administered to 4–7 year olds) requires the student to repeat syntactically correct sentences containing little meaning such as "The blue is yellowing."
- *Sentence Questions*. The Sentence Questions subtest (only administered to 8–18 year olds) requires the student to listen to sentences that are syntactically correct but contain little meaning and answer questions about the sentences. For example, the student reads the sentence "The blue is yellowing" and then is asked the following question: "Who is yellowing?"
- *Visual Digit Span*. Visual Digit Span subtest requires the student to recall a series of numbers in the order they were shown using the stimulus book. Each item with from two to five digits in length is exposed for the same number of seconds as digits. Items with six digits or more are all exposed for a maximum of 5 s.

Brief, Core, and Extended CAS2 Versions

There are three configurations of the CAS2. First is a four-subtest Brief; second is the eight-subtest Core, and third is the 12-subtest Extended Battery. Regardless of which version is administered, all yield PASS Scale and Full Scale standard scores score (mean of 100 and standard deviation of 15), but only the Extended Battery has supplemental scales which includes subtests specifically used to measure Executive Function. The configuration of the subtests and the scales for the Core and Extended CAS2 Batteries are shown in Table 12.1.

The CAS2 supplemental scores are provided to extend interpretation beyond the PASS scales to concepts such as Executive Function and Working Memory that may be especially helpful when interpreting CAS2 within the context of a comprehensive evaluation. The supplemental scales are also set to have a mean of 100 and standard deviation of 15 like all the other scales of the CAS2.

Executive Function scales. As described earlier in this chapter, views of executive function often differ in regard to whether working memory should be included or not. For this reason, the CAS2 provides two scales of executive function: Executive Function without Working Memory and Executive Function with Working Memory.

The Executive Function without Working Memory scale comprises the Planning Connections and Expressive Attention subtests. We chose these subtests because Weyandt, Williis, Swentosky, Wilson, Janusis, Chung, and Turcotte (this volume) found that the Stroop test (Expressive Attention on the CAS2) and TMT (Planned Connections on the CAS2) are among the most widely used tests utilized to evaluate executive functioning. These subtests address shifting and inhibition, two important components of executive function. These subtests fall on the Planning and Attention scales of the CAS2.

The Executive Function with Working Memory scale comprises Planning Connections, Verbal-Spatial Relations, Expressive Attention, and Sentence Repetition (ages 5–7) or Sentence Questions (ages 8–18) subtests. This addresses the working memory aspect of executive functioning that is central to the view of executive function described by Baddeley and Hitch (1974). That is, the Working Memory scale comprises the Verbal-Spatial Relations and Sentence Repetition (ages 5–7) or Sentence Questions (ages 8–18) subtests because they require the examinee to store information for a short amount of time and manipulate it using a phonological loop and visual-spatial sketchpad described by Baddeley and Hitch (1974). Engle and Conway (1998) describe the visual-spatial sketchpad as mental image of visual and spatial features. The phonological loop refers to retention of information from speech-based systems that are important when retention of the order of information is required (Engle & Conway, 1998). Because the CAS2 Verbal-Spatial Relations and the Sentence Repetition/Sentence Questions subtests have similar cognitive demands as the visual-spatial sketchpad and phonological loop, respectively, they were selected to evaluate Working Memory and added to the subtests used to evaluate Executive Function.

The values used to create the Executive Function scales included in the CAS2 were normed using a sample of 1,342 individuals aged 5–17 years who were representative of the US population on a number of important demographic variables. The sample is nationally representative, stratified sample based on gender, race, ethnicity, region, and parental education (see Naglieri et al., 2013a, 2013b, 2013c). Using those data, the internal reliability coefficients for the CAS2 Executive Function scales were reported in the Manual. The median reliability across ages 5–18 years was .87 and .90 for the CAS2 Executive Function with and Executive Function without working memory scales, respectively.

The next issue to be discussed is how to use this score within the larger context of a comprehensive evaluation. We will illustrate how the CAS2 PASS and Executive Function supplemental scales can be interpreted and combined with the Comprehensive Executive Function Inventory (CEFI; Naglieri & Goldstein, 2013). We will only present relevant aspects of this case to illustrate how the CAS2 Executive Function scales and the CEFI data can be integrated and a treatment plan selected.

Case of Dennis

Dennis was referred for a psychological evaluation by his physician to assist with planning for current and future high school needs given inconsistent academic performance and problems in school and at home with distractibility, forgetfulness, and inattention. Teachers reported that Dennis does not always follow directions, appears forgetful, and does not stay focused. At home, Dennis often misses cues and details, has trouble with his chores, is easily distracted, and does not follow through with instructions. He has particular trouble shifting from one uncompleted activity to another. Dennis loses things all the time and does not appear to learn well from experience, doing something the same way even though it did not work the first, or second, or third time. All of these concerns were first apparent when he was about 8 or 9 years old. At that time, ironically, there was discussion about possible placement in the gifted and talented program after he earned a very high score on a screening test. His grades varied but overall they were about average throughout his years in school but earned a very high score on his college entrance exam.

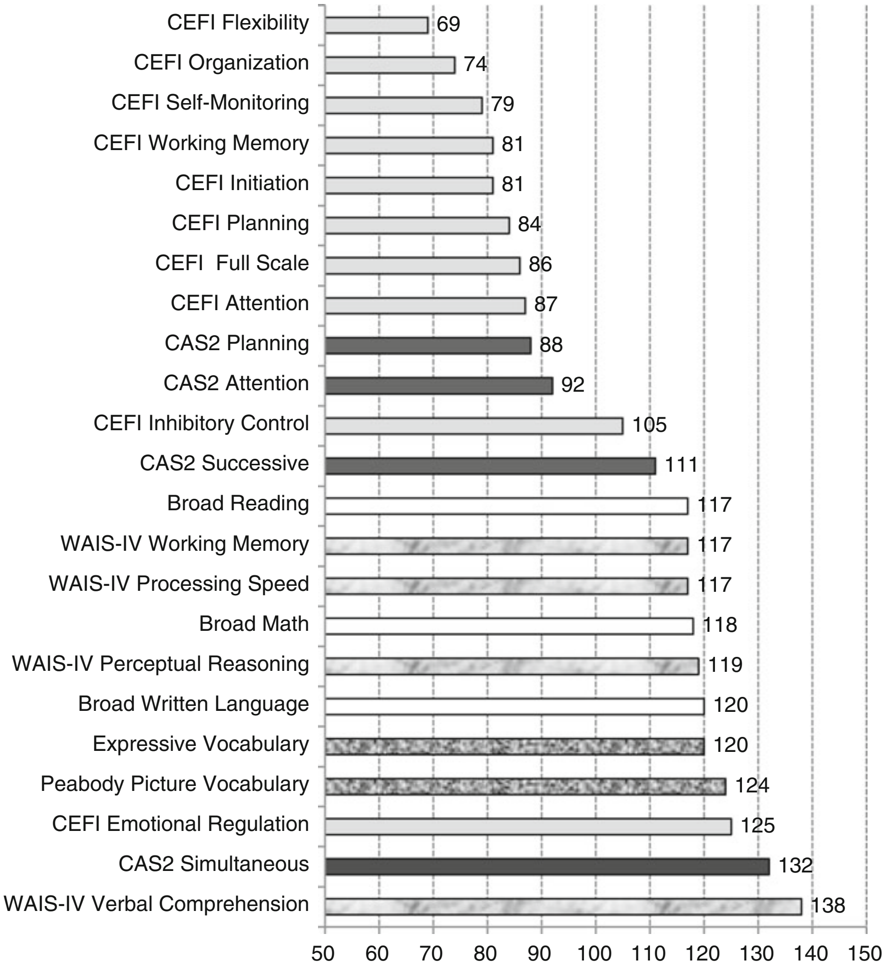

Fig. 12.1 Graphic representation of scores Dennis earned on the CAS2, CEFI, WAIS-IV, and achievement tests

Dennis earned high scores on tests that require verbal knowledge. He earned scores of 124 (95th percentile) and 120 (91st percentile) on the Peabody Picture Vocabulary Test-Fourth Edition and the Expressive Vocabulary Test-Second Edition, respectively (see Fig. 12.1). He earned an even higher score on Wechsler Adult Intelligence Scale-Fourth Edition on the Verbal Comprehension scale (138, 99th percentile) which measures general ability through tasks that require verbal knowledge and communication. Dennis' scores on the other portions of the WAIS-IV were about 20 points lower. He earned a Perceptual Reasoning score of 119 (90th percentile) and 117 (87th percentile) on both the Working Memory and Processing Speed scales. Taken as a whole, these scores suggest that Dennis earned very high scores on measures of general ability and particularly when general ability was measured using tasks that require verbal knowledge. These scores do not, however, help us understand the reported difficulties he has experienced in school and at home.

The scores Dennis earned on the CAS2 provide an understanding of this young man's abilities that are sometimes consistent and at other times very inconsistent. Dennis earned high scores on the CAS2 Simultaneous, Attention, and Successive scales. He earned a score of 132 (98th percentile) on the CAS2 Simultaneous scale of ability. This means that he is excellent at understanding interrelationships whether the task involves verbal concepts or the spatial organization of objects. This ability was also reflected in his high score on the WAIS-IV Similarities subtest on the Verbal scale which demands that he explain how seemingly different objects (e.g., a flea and a tree) are alike as well as his excellent performance on the various WAIS-IV Perceptual Reasoning score. Dennis also earned a high score on the CAS2 Attention scale (109; 73rd percentile) which demonstrates, contrary to reports of teachers and his parents, that he can focus his attention and resist distraction. In addition, Dennis is very capable of remembering sequences of words and sounds as well as working with information in order as demonstrated by his score of 111 (77th percentile) on the CAS2 Successive processing ability scale. The results of the CAS2 and the CEFI do suggest cognitive and behavioral limitations that are related to his behavioral and academic problems.

Dennis earned a score of 88 (21st percentile) on the CAS2 Planning Scale and a score of 91 (27th percentile) on the CAS2 Executive Function scale. These scores indicate that he has trouble on cognitive tests that require strategies for solving problems, control of his actions, monitoring the effectiveness of his solutions, and self-correction. The cognitive score on the CAS2 is consistent with the reports of his behavior provided by his mother's ratings on the CEFI. Her ratings yielded a total CEFI score of 86 (18th percentile). Of particular note were his very low scores on the CEFI treatment scales Flexibility, Organization, Self-monitoring, Working Memory, Initiation, and Planning and good scores on Inhibitory Control and Emotional Regulation. From both a cognitive ability (CAS2) and behavioral (CEFI) perspective, Dennis shows considerable variability and it is this pattern of strengths and weakness which explain his academic and behavioral problems at home and at school. The next important topic is what can be done to help him.

Intervention Design

There are two intervention methods that are needed for Dennis. First is to address his cognitive weakness in Planning (CAS2) and second is to improve his behaviors described by the seven low scores on the CEFI. These will require two different types of interventions. We will address the cognitive weakness in Planning from the CAS2 first, then provide a group of interventions for the seven scales of the CEFI. A brief review of the intervention research related to PASS theory will be presented first, then implementation described.

Intervention for CAS2 Planning scale. Naglieri and Otero (2011) summarized the research on Planning scores from the CAS and academic interventions in math and reading which demonstrated that students can be taught to better use their planning ability and in so doing improve in classroom work and standardized test scores. This research, which compared student with low Planning scale scores to those with high scores on the CAS, began with two published studies by Naglieri and Gottling (1995, 1997). Both studies involved students who attended a special school for those with learning disabilities. In these investigations, students completed mathematics work sheets in sessions over an approximately 2-month period. The method designed to indirectly teach skills such as strategy use, self-monitoring, and self-correction was applied in individual one-on-one tutoring sessions (Naglieri & Gottling, 1995) or within the entire classroom by the teacher (Naglieri & Gottling, 1997) about 2–3 times per week in half-hour blocks of time. During the intervention sessions, the students were encouraged to use good executive function skills when completing math work sheets. The teachers provided probes that facilitated discussion and encouraged the children to consider various ways to be more successful (see Naglieri & Gottling, 1995, 1997 for more details). The results from both these studies showed that the students with low Planning scores on the CAS improved considerably more than those with high Planning scores on the CAS.

The next study that examined PASS scores from the CAS to instruction involved students with learning disabilities and mild mental impairments (Naglieri & Johnson, 2000). They implemented the same method, called Planning Facilitation (Naglieri & Pickering, 2010), but compared students with cognitive weaknesses in each of the four PASS processes and students with no cognitive weakness. They showed that children with a cognitive weakness in Planning improved considerably over baseline rates, while those with no cognitive weakness improved only marginally. Similarly, children with cognitive weaknesses in Simultaneous, Successive, and Attention showed substantially lower rates of improvement. The importance of this study was that the five groups of children responded very differently to the same intervention. Thus, the PASS processing scores were predictive of the children's response to this math intervention (Naglieri & Johnson, 2000).

Iseman and Naglieri (2011) further demonstrated that teaching students with learning disabilities and ADHD executive function skills improves academic performance. In this randomized control study, students in the experimental group were encouraged to use good executive function skills such as planning, strategies, self-monitoring, and self-correction in math. A comparison group received additional math instruction by the regular teacher. Following the intervention, the control group outperformed significantly on math work sheets as well as standardized math test scores, illustrating the value of teaching executive skills.

Importantly, students with a Planning cognitive weakness in the experimental group improved considerably on math work sheets, but those with a Planning cognitive weakness in the comparison group did not improve. This study strongly supported the view that teaching students to better utilize Planning strategies—executive function skills, had a positive and significant influence on their academic performance in math. This finding was extended to reading comprehension by Haddad et al. (2003) with the same results. The results of these studies using academic tasks suggest that teaching cognitive skills related to Planning on the CAS should be implemented.

Interventions for low CEFI scales. Interventions that can be used to help Dennis improve on the CEFI Flexibility, Organization, Self-monitoring, Working Memory, Initiation, and Planning scales are provided in the CEFI computerized report.

Interventions for the first scale, Flexibility, should address the behaviors measured by that sale. These include how Dennis adjusts his behavior to meet circumstances, including coming up with different ways to solve problems, having many ideas about how to do things, and being able to solve problems using different approaches. These needs are also addressed by the intervention provided for the CAS2 Planning Scale.

Interventions for Organization, Self-monitoring, and Planning in the CEFI computerized report include methods from Naglieri and Pickering's (2010) *Helping Children Learn* book. The interventions are designed to provide instruction about strategies for specific instructional areas (e.g., decoding, reading comprehension, writing, math) using two basic steps. First, the teacher tells the student that a plan is a method for how to do something that involves thinking about how to solve a task. Second, using a plan means you have to (a) ask what do I want to do and what is my goal, (b) choose a plan, (c) begin work on the task using that plan, (c) see if the plan is working, (d) change the plan if necessary, and (e) evaluate the solution vis-a-vis the goal.

Interventions for Working Memory also summarized in the CEFI computerized report include an intervention handout entitled "Focusing Strategies to Improve Memory" (Naglieri & Pickering, 2010, p. 125). The goal of this intervention is to teach the student to be aware of the need to pick a good environment to work. That means being physically comfortable in a location with adequate light and temperature, working in a location with minimal visual and auditory distractions, and using self-talk strategies to control any internal distractions. Another important intervention for working memory is to use mnemonics (e.g., rhymes, acronyms, visual images) for various academic and nonacademic tasks (Naglieri & Pickering, 2010, p. 101).

Conclusions

In this chapter, we have provided a summary of the concept of Executive Function and two ways to measure the concept. The first way is to use the CAS2. This nationally standardized individually administered test can be used to measure a child or adolescent's ability to make decisions about how to complete a task, implement the solution, monitor the effectiveness, modify the solutions as needed, and recognize when the goal has been achieved adequately. These activities are the hallmark of executive function that are also evaluated by observations of the child in the natural environment using the CEFI. The case study we presented is an actual one (the name has been changed) that illustrates how the CAS2 and CEFI data can be used to understand the cognitive and behavioral manifestations of the concept of executive function and empirically supported interventions which can be applied to address the need for improvement.

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