Executive Functions: A Discussion of the Issues Facing Children with Autism Spectrum Disorders and Related Disorders

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ABSTRACT

The interest and attention devoted to executive functions has grown steadily in the last several decades. The concept and definitions of executive functions and their association with certain disorders such as autism spectrum disorders (ASD) and overall cognitive, social, emotional, and behavioral functioning are important knowledge areas for those working in education, health, and mental health-related fields. It is particularly important for providers to have an understanding of the basic issues related to assessment and remediation of executive dysfunction. This article briefly addresses the background, current definitions, research, and some intervention options associated with executive functions. The intent is to present a foundation for encouraging additional research on the issues relevant to this important topic.

KEYWORDS: Autism spectrum disorders, executive functions, cognition, remediation

Learning Outcomes: As a result of this activity, the reader will be able to: (1) discuss the definitions, research, assessment practices, and remediation options associated with executive functions and (2) explain the strengths and challenges in executive functions exhibited by children with ASD.

If you have been employed in any field relating to health, human services, or education, you have inevitably come across the term "executive functions." The use of this term has increased exponentially over the last several decades. For example, a search of articles (using "executive functions" as the keyword) within the PsychINFO system revealed a total of 1278 hits. However, when these articles are divided into the decade from which they originated, the numbers reveal an obvious pattern. From 1970 to 1980, two articles were written and from

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1980 to 1990, 35 articles were written. The 1990s revealed a drastic increase in the number of articles to 518. This trend has continued into this millennium and in fact appears to be gaining momentum. In the last 5 years (2000 through 2005) there are already 847 articles referencing this term. The increasing presence of the term "executive functions" is indicative of the growing recognition of its importance in human functioning. However, despite its widespread use, it is still a term that is widely debated. Many authors and researchers[1–4] have sought to increase our understanding of executive functions including its definition, development, measurement, and remediation. This article is a review of the history and current research regarding executive functions and its implications for intervening with children with autism spectrum disorders (ASD) and their families. It should be noted that a detailed analysis of every topic related to executive functions is beyond the scope of this article. The focus will be on what professions in health, human services, and educational settings need to know to build a better understanding of the concept, to explain behavior connections in children with ASD, and to obtain additional information.

BACKGROUND

The study of executive functions began in the field of neuropsychology and specifically in the exploration of frontal lobe dysfunction. As early as 1819,[5] the role of the frontal lobe was seen as essential to cognitive functioning. Many of the early studies began with exploring the impact of lesions to the frontal lobe.[6–9] These studies were most often case studies examining the impact of cranial insult in adults and documenting effects in memory, attention, abstraction, and synthesis of cognitive information. The role of frontal lobe functioning in cognition, however, was not without its critics. Hebb[10] presented information that contradicted the theorized role of the frontal lobe by relaying patient accounts with severe epilepsy. These individuals had portions of their frontal lobe surgically removed, but did not display observable difficulties with social or cognitive functioning. They had high average to superior IQs prior to surgery and experienced no drop in IQ upon retest following surgery.[10,11] This clinical research questioned the role of the frontal lobe in cognitive development and functioning and prompted a general departure from focus for several years.

Since the time of Hebb's[10] report, there has been a gradual return to interest in the frontal lobe, particularly the prefrontal cortex, for understanding cognitive function and dysfunction. Although Hebb's[10] findings suggested a minimal role for the frontal lobe and executive functions in overall cognitive abilities, some studies found significant impairment in areas other than psychometric measures of intelligence.[12,13] An explanation for the minimal correlation between frontal lobe dysfunction and intelligence measures is the content of what is measured when exploring either variable. Essentially, there are areas of convergence (nonverbal processing skills, novel and complex problem-solving, speed of information processing, memory, attention, and concept formation) and divergence (word knowledge, social judgment, and fund of information) between methods of measuring intelligence and executive function. The lack of a significant relationship found by Hebb[10,11] may have been because measures of IQ combine these areas of similarity and difference to provide an overall intelligence score. Gioia and colleagues[4] recommend examining an individual's performance on particular components of an IQ test, for example, the Performance IQ score of the *Wechsler Intelligence Scale for Children* or at the individual subtest level.

Pennington[1] has suggested that one component of intelligence that appears to be implicated in executive dysfunction is fluid intelligence. Fluid intelligence is a component of multiple-factor theories of intelligence[14,15] and can be described as the ability to complete relatively difficult novel tasks. It is associated with one's inductive and deductive reasoning abilities. For example, reproducing a visual/spatial block design, recognizing a visual pattern sequence, and identifying abstract semantic relationships are tasks that tap fluid reasoning. As many widely used intelligence tests are somewhat insensitive to fluid intelligence, it is reasonable to predict that they will

not detect significant discrepancies between executive functions and IQ. In an effort to explore the capacity of individuals with frontal lesions on a measure of fluid reasoning (*Raven's Progressive Matrices* and *Culture Fair IQ test*), Duncan[16] found a significant discrepancy between IQ and the fluid IQ measures. This suggests that, although some intellectual functioning appears to be unaffected by frontal lobe dysfunction, it is more likely that this finding is an artifact of the measures that are used to illustrate intelligence. It should be noted that more recent revisions of popular intelligence measures (the *Wechsler Adult Intelligence Scale—WAIS-III* and the *Wechsler Intelligence Scale for Children—WISC-IV*) are beginning to include more subtests that tap into executive functioning domains.

THE CURRENT STATE OF EXECUTIVE FUNCTIONS

The renewed interest in executive functions has led to its widespread use in many professional journals, books, and workshops addressing the needs of children. This term is described in some detail in many sources, but is only briefly referenced in many more. It is important, therefore, to be familiar with the constructs of executive functions and to be equally aware that the literature is far from a consensus. Several very important issues must be considered in the study of executive functions, including how they are operationally defined, their role in the etiology or maintenance of disorders, measurement issues, and their impact on behavior and social relations in individuals with ASD.

For some, executive function is a broadly defined cognitive skill and perceived as the central orchestrator of tasks focused on self-regulation and goal-attainment. Although few would argue with this description, many have criticized this position as vague and question the ability to draw meaningful conclusions using it.[2] The alternative is a more precise and categorized set of cognitive domains that comprise the executive functions. Pennington[17] identified four variables or cognitive domains most commonly implicated in literature on executive functions: inhibition, cognitive flexibility/shifting of cognitive set, working memory, and planning. Common definitions for these most widely used executive functions are as follows: (1) working memory, the ability to hold information in storage (in some system of short-term memory) while it can be manipulated and compared with information possessed in long-term storage; (2) inhibition, the ability to control a response that will not support goal attainment and instead, activate an appropriate alternative; (3) shifting cognitive set/flexibility, the ability to perceive things in a different manner, respond in unique ways, and/or to make necessary cognitive adjustments to assist goal attainment; and (4) planning, the ability to form a strategy for goal attainment and see it through regardless of the number of required steps. This set of cognitive domains should also include internalized speech.[18,19] The ability to mediate behavior through the process of internal language is an important aspect of self-control, problem-solving, and metacognition. In contrast, the inability to regulate by using internalized self-talk is seen as a barrier to optimal executive functions. This is particularly evident in children with language difficulties such as children with ASD.

The desire to explore executive functioning and, in particular, illuminate the differences between discrete domains has led to a plethora of available measures. Pennington and Ozonoff[2] and Gioia and associates[4] discuss several options for parceling out discrete executive function domains. The measures are all unique depending on the theoretical position of the author or the underlying purpose of the test. However, Pennington and Ozonoff[2] suggest a pattern of commonality, based on the idea that executive dysfunction can be illustrated by tasks that require "planning or programming future actions, holding those plans or programs online until executed, and inhibiting irrelevant actions." Table 1 provides examples of measures used to tap executive function domains.

Despite the availability of so many measures of executive functioning, the process of assigning finite operational definitions endures. This is related to the potential overlap in many discrete executive function domains. It is difficult to determine when one executive function ends and another begins or whether discrete

Table 1 Examples of Measures Tapping into Executive Function Domains

Set-shifting:

Wisconsin Card Sorting.[20] A set of stimulus and response cards in which the individual is required to sort the cards according to different principles to determine perseverative thinking and abstract reasoning skills to help assess brain lesions involving the frontal lobes (appropriate for ages 6.5 and up).

Trailmaking Test, Part B.[21] This test measures attention, visual searching, mental processing speed, and the ability to mentally control simultaneous stimulus patterns.

Planning:

Tower of London,[22] Tower of Hanoi[23] These tests are used for all ages and assess higher-level problem-solving and strategy planning.

Working Memory:

WISC-IV Digit Span.[24] This task requires the individual to repeat numbers in same order and then repeat numbers in reverse order from the presented format.

WISC-IV Letter-Number Sequencing.[24] This task requires the individual to recall a series of numbers in ascending order and letters in alphabetical order.

Inhibition:

Stroop Test.[25] This brief procedure examines attention, mental speed, and mental control by requiring the testee to inhibit an initial response (reading a written word), while focusing attention on another factor presented by the word (its color).

Test of Variables of Attention.[26] A continuous performance test that evaluates four basic measures of arousal and alertness: attention, impulsivity, response time, and variability.

There are also several measures that seek to explore clusters of executive functions for an overall picture of one's abilities. These include:

Behavior Rating Inventory of Executive Function (BRIEF).[27] A questionnaire for parents and teachers of school-age children that enables professionals to assess executive function behaviors of children ages 5 to 18 years in the home and school environments. The BRIEF contains 86 items within eight clinical scales of executive functioning: inhibit, shift, emotional control, initiate, working memory, plan/organize, organization of materials, and monitor.

Delis-Kaplan Executive Function Scale (D-KEFS).[28] Assesses key areas of executive function (problem-solving, thinking flexibility, fluency, planning, deductive reasoning) in both spatial and verbal modalities, normed for ages 8 to 89.

NEPSY.[29] Assesses neuropsychological development in children ages 3 through 12. It detects strengths as well as subtle deficiencies in five functional domains that facilitate or interfere with learning attention and executive function, language, memory and learning, sensorimotor functions, and visuospatial processing.

executive functions operate in isolation or always collaborate as components of a larger coordinated system. This confounds the efforts to obtain universal operational definitions of the particular executive functions by making discrete measurement very difficult. For example, Ozonoff and colleagues[30] discuss many interpretive cautions in their analysis of inhibition of prepotent responses versus flexibility. They indicate that there are many aspects of inhibition and their design only addresses one aspect, which limits the ability to generalize. These researchers also discuss the difficulty the measures used in their design had in separating out inhibition from flexibility. Further, Ozonoff and colleagues[30] indicate that these executive functions share many common variables/demands.

The second central issue in executive functions is their role in specific disorders. One major question is whether delays in executive functions cause a particular disorder or are merely symptoms of the disorder. One aspect of the etiology issue is the lack of discriminatory ability of executive dysfunction. Research has shown that many

disorders are affected by insufficient executive functioning. Autistic spectrum disorders,[2,30] attention deficit hyperactivity disorder (ADHD),[26,31–33] conduct disorder,[34–36] phenylketonuria (PKU),[23,37] Tourette's syndrome,[38] and brain injury[39] have all implicated executive functions in some way. Gioia and coworkers[4] also discuss the intimate association between executive dysfunction and language disabilities. It has been posited by many, and reasonably so, that this lack of discriminatory capacity reduces the appropriateness of viewing executive dysfunction as a primary condition leading to a particular disorder. Instead, it reinforces the concept of executive dysfunction as being symptomatic of another underlying neurobiological or neurodevelopmental mishap.

Research has also been conducted to explore the role of the discrete executive function domains in specific disorders. The analysis of these domains in individuals with particular disorders, such as autism, ADHD, and conduct disorder has yielded mixed outcomes. Some variables appear to be more evident than others when researching particular disorders. For example, it has been hypothesized that the particular executive function that discriminates ADHD from other disorders is the area of inhibition. Individuals with ADHD are consistently found to have more struggles inhibiting behavior than individuals with other disorders.[26,31,32,40,41]

The research related to executive dysfunction in individuals with ASD has also yielded some significant trends. Bennetto and associates[42] and Russell and coworkers[43] suggested deficits in verbal working memory for individuals with ASD. Specifically, Russell and colleagues[43] found differences in the performance of individuals with ASD when compared with neurotypical controls on measures requiring working memory, but found no difference on tasks requiring short-term verbal memory. Deficits in shifting cognitive set or flexibility were purported by Hughes et al,[44] McEvoy and associates,[45] Ozonoff,[46] and Ozonoff and Strayer.[47] McEvoy and colleagues[45] found that preschool participants with ASD displayed more inflexibility and perseverative responses than matched controls on measures of executive function. Hughes and colleagues,[44] Ozonoff and associates,[48] and Prior and Hoffman[49] also identified deficits in planning. Prior and Hoffman[49] explored individuals' abilities to profit from feedback in goal-directed problem-solving. Individuals with ASD had difficulties with strategic sorting—even when they knew they were incorrect, they could not modify their strategy. The performance variables that discriminated them from others in this study were planning and response to feedback. The generation of novel thoughts and actions (generativity)[50] is another area that has been proposed to be deficient in autism.

This leads us to a discussion of how the common areas of executive dysfunction identified in ASD impact social and behavioral functioning. The difficulties related to working memory, shifting cognitive set/flexibility, planning, and generating novel thoughts and actions may be implicated in the deficits displayed by individuals with ASD. However, more comprehensive research is needed to firmly establish the extent of the relationship. Therefore, the following information is based on the available research and hypothesis.

EXECUTIVE FUNCTIONS AND CHILDREN WITH ASD

The diagnostic criteria for ASD include deficits in communication, social interactions, and the presence of restricted interests and repetitive behaviors. Executive dysfunction has been proposed to potentially explain restricted interests and repetitive behaviors.[51–54] Lopez[52] found restricted interests and repetitive behavior to be highly related to working memory and cognitive flexibility. It appears that the interaction of these executive functions presents the most impact. Likewise, Turner[53,54] indicated that cognitive flexibility and generativity are associated with repetitive behavior.

It is possible to speculate how an individual with ASD's restricted interests and repetitive behaviors are related to the ability to shift cognitive set–cognitive flexibility. A particular topic or object becomes the focus of intense interest and attention often to the detriment of alternative topics. Consideration of novel topics or objects is not readily available to

the individual and, therefore, new interests progress slowly or not at all. The inability to shift cognitive set would also help to explain the need for sameness in individuals with ASD.

The connection between executive function domains and the social or communication deficits of ASD has been less well established. Stimulus overselectivity was a term used by Lovaas[55] in the 1970s to describe the tendency of individuals with ASD to focus inordinately on irrelevant stimuli during learning situations. This inappropriate focus was believed to impact an individual's ability to successfully navigate social situations and proved resistant to corrective feedback. However, other research indicated that stimulus oversensitivity occurred in individuals with mental retardation, brain injury, and learning disabilities, undermining its prominence in explaining the social deficits in ASD.[56,57] Recent research on ASD also explored the impact of focusing on less useful stimuli in social situations. Klin et al[58] conducted research to explore the point of focus of individuals with ASD during contrived social situations. They determined that individuals with ASD focused disproportionately on the mouths of social contacts and objects within the scene. This was in contrast to the tendency of controls to focus most often on the eyes of social contacts. Furthermore, Klin and colleagues[58] found that the tendency to focus more on the mouths of social contacts than on arbitrary objects predicted better social competence. Hughes and associates[59] and Russell and coworkers[60] suggested that individuals with ASD have difficulties in social situations because they cannot disengage from an object and shift from an external to an internal point of reference. Their focus is the observable aspects of an interaction, leading to difficulty with theory of mind and deception tasks. While it has been established that individuals with disabilities other than ASD may display stimulus oversensitivity and inappropriate social focus, it is perhaps an interaction of the unique cognitive and metacognitive deficits of ASD that leads to less social competence.

Overall, the connection between social deficits and executive function is a developing area in ASD research. It is perhaps useful to hypothetically explore this connection from the perspective of the social information-processing model proposed by Crick and Dodge.[61] They contend that social information is processed through a variety of simultaneously occurring steps that culminate in a behavioral enactment. Essentially, an individual perceives a social stimulus and encodes it—processes particular internal and external components of the situation (visual, auditory, etc.). An interpretation of the situation is then generated focusing on attributions of intent and causation, goal assessment, and self-efficacy assessment. Next the individual determines the goals involved in responding to the social situation and identifies alternatives for attaining this goal. Lastly, before behavioral enactment, the individual must determine the most effective response option based on availability, efficacy, and potential success. As an illustration, consider the following:

An individual is walking down the hallway at school and is bumped by a classmate; he scans the classmate's face and behavior to pick up cues to aide in interpreting the situation. He also processes internal information such as agitation; the initial information from the current incident and information regarding the individual's past encounters with the classmate provide the basis of an assessment of intent (was the behavior an accident or intentional); the individual establishes the goals of a response (e.g., retaliation or acceptance) and regulates arousal accordingly; possible corresponding responses to achieve the goal are identified (hit back, accept apology); the list of responses is evaluated based on factors such as effectiveness, consequences, and the ability to perform, and one is selected (hitting may lead to a fight and suspension); and the identified behavior is enacted. It is important to remember that this exchange is done in a matter of seconds.

There are several potential points within the Crick and Dodge[61] model that challenge individuals with ASD based on their executive dysfunction. The difficulty with stimulus oversensitivity and inappropriate focus (details such as facial features and external versus internal) could account for problems with encoding social information. It is important to consider

that difficulty within the early steps of social information processing undoubtedly impairs the subsequent steps. The steps of social information processing rely on an individual's ability to hold information online, while manipulating it or retrieving other relevant information (working memory) that will aid in navigating the social situation. The deficits in working memory displayed by individuals with ASD may invariably impact their ability to process social information at every stage. Channon et al[62] explored the social information processing in individuals with Asperger's syndrome. They indicated that their participants showed less skill in the ability to identify relevant social aspects, sufficiently retrieve useful information from memory, and generate appropriate solutions (generativity) to a problem illustrated in a social scenario. Again, the information reported by Channon and associates[62] has implications for many of the social information steps outlined by Crick and Dodge.[61] Finally, Channon and colleagues[62] indicated that individuals with Asperger's did not display differences in their ratings of satisfaction with the solutions they had generated, which contrasts with the quality of their social solutions. Therefore, not only was the ability to identify prosocial solutions to problems impaired, the individuals in this study were unaware of their difficulty in this area. Thus, not only early difficulties, but difficulties during most of the social information steps of the Crick and Dodge[61] model may account for the social deficits often observed in ASD in relation to executive function.

The impact of executive functions in ASD and the role of specific executive function domains are in their infancy and require comprehensive research before more definitive statements can be offered. Evidence suggests a connection between executive functions and restricted, repetitive behavior, but the relationship between executive functions and social/communication deficits is less clear. Some initial research on establishing this connection has been promising.[45,63] Ozonoff et al[64] indicated a significant relationship between a measure of planning and the social communication skills of individuals with ASD, but no relationship with a measure of shifting cognitive set. Pennington[51] suggests a theory of mind perspective sheds light on the social struggles of an individual with ASD. Others[65] propose a review of the manner in which the executive function and theory of mind perspectives could be connected to explain the unique pattern of symptoms characteristic of ASD.

INTERVENTION

Setting aside the difficulties and confusion related to executive functions in general and, in particular, their connection to ASD, it is universally agreed that executive dysfunction leads to a myriad of difficulties. Therefore, it is important to develop intervention methods to address problems with executive functions at any age. The first step in determining the appropriate direction for intervention is obtaining useful assessment data. In addition to the assessment options discussed earlier, evaluators may also employ direct observation of an individual in a natural setting. This will provide a comprehensive view of the unique set of strengths and weaknesses and inform the focus of intervention. Although the specific intervention format for children with executive function challenges will be determined through individual assessment, some general interventions are offered here that may be particularly useful to children with ASD.

Barkley[66] discussed teaching delayed responding as a way to improve an individual's executive functioning. Essentially, it involves delaying a response to a situation to increase the time devoted to objective goal-setting, systematic screening for appropriate responses, and response selection and enactment. Delayed responding is a skill that must be overtly taught through discrete instruction and modeling and be reinforced in natural settings. It is consistent with many interventions focusing on decreasing impulsive actions and reinforcing a brief "think time" before enacting a response.

One method that can be used to encourage delayed responding and improve social functioning is Plan-Execute-Repair (P-E-R). This format involves three overlapping steps. The planning phase entails analyzing a task to determine the goals, isolating the required steps, and developing a plan to accomplish the goal.

In the execution phase, the focus is on when and how to start and sustain adequate effort. In the repair phase, the process and steps are evaluated and necessary modifications are considered. There are many ways to use graphic illustrations and visually represent the P-E-R process. This would be particularly helpful in supporting individuals with ASD in overcoming their social challenges. For example, in the instance of and individual with ASD being bullied, a plan could be developed to address the potential goal of the bully, to identify options for approaching the problem, and to select an appropriate alternative. The process could be practiced in a controlled environment and practiced in contrived settings. This would allow for evaluation and modification of the plan before implementation in the natural setting. The plan could then be re-evaluated and appropriate modifications could be identified and incorporated.

Many individuals with executive dysfunction struggle with organizational skills. Methods for addressing these issues typically begin with extensive external support and gradually work toward increased autonomy. Organization is a set of skills that must be taught and reinforced. An individual struggling in this area will need a consistent system of external reminders to support his or her ability to self-organize. Other supports include commercial organizers such as folders and portfolios, journals, and planners. Color coding materials may also be beneficial. The use of the graphic organizers is best used in everyday life and reviewed/evaluated by the individual with assistance from a support person. The visual schedules and prompts that are commonly used to support children with ASD are a good example of a graphic organizer. Being able to visually and physically add to and subtract from a daily schedule is a useful organizing strategy. This strategy can begin fully supported and gradually move toward independent use. One example of a visual organizer that is focused on facilitating social connections is the use of comic strip conversations.[67] This intervention involves developing a graphic for characterizing a specific social situation. It allows individuals with ASD the opportunity to access the thoughts, intentions, and feelings of others. It also offers a forum for generation of appropriate social communication and problem-solving.

David Hyerle[68] has developed the Thinking Maps (Thinking Maps, Inc., Cary, NC) model for enhancing organization skills using visual graphic organizers. This model allows an individual to design useful schematics that aid in developing thinking skills and organizational strategies. Thinking maps can be applied to tasks related to academics (reading, writing, math); social interactions (conversations, relationships, problem-solving); or concept development (part/whole relationships, cause/effect, and so on). For the individual with ASD, thinking maps can support the ability to analyze social situations, teach abstract language or temporal concepts, and address restricted interests. For example, a thinking map could be developed that encapsulates a topic of particular interest in an individual with ASD. The map could be used to visually illustrate the relationship/connection of the topic to other topics and support the evolution of the restricted interest. An intense interest in the Titanic could be expanded to explore other sea tragedies and define the commonalities, such as experiences of passengers and crew. This would support the individual's examination of social connectedness.

There have also been several models developed that focus on building self-talk skills and executive functions. These models are largely based on the earlier work of Meichenbaum and Goodman.[69] Kamann and Wong,[70] Prins and Hanewald,[71] and Shure[72] offer intervention options for using self-talk as a means to teach and enhance skills related to inhibition and stress/anxiety and anger management, appropriate goal setting, and social interaction. The goal is to teach children to use self-talk to coach themselves through problem-solving events. Like many of the other interventions, this is a skill that needs to be taught and reinforced. It requires an initial system of external support to move a child toward independent use of self-talk. An example of this technique for an individual with ASD would be to develop a menu of internal statements that he or she could use in response to certain situations. When faced

with a frustrating situation the individual may be coached to say "It is not worth getting upset about and risking getting in trouble." These statements are often developed in social stories.[67] They can become a simple mantra to remind an individual with ASD of appropriate social behavior and problem-solving in times of stress and distraction.

Graham and Harris[73] discuss the self-regulated strategy development (SRSD) intervention model for supporting executive function. SRSD was designed to build higher-order cognitive skills, enhance self-regulation and generalization of these skills, and increase positive self-concept. This model has been used to address academic difficulties in reading, math, and writing. Essentially, the SRSD program involves analysis of existing skills, identifying targets for change, teaching a related strategy, modeling the strategy along with the appropriate use of self-talk, engaging in collaborative and independent practice, and promoting generalization and autonomous use of the strategy. This model could be a valuable method for addressing the multitude of challenges that an individual with ASD faces, particularly in the social realm. The first step would be to conduct an assessment (standardized measures and naturalistic observation) of the social skills an individual possesses. A list of crucial social skills could be generated and prioritized (e.g., expanding the repertoire of conversational topics). The individual could identify many familiar social discourse topics and be taught to recognize nonverbal cues signaling the need to change a topic. Next, the sequence of social behavior would be modeled and practiced in a safe and controlled environment. Finally, efforts would begin to encourage the use of the learned strategies outside the controlled situation, perhaps first in staged scenarios and then in typical social forums. The intent would be to ensure early success and reinforce the use of the newly acquired social strategies.

The intervention options discussed above are by no means a complete or comprehensive listing of those available to address executive functions. They are merely a representation of interventions currently being applied to address executive dysfunction in ASD and other disorders. It is essential that the reader pursue a more in-depth review of the available interventions that acknowledge the unique cognitive presentation and intervention needs of each child with ASD.

CONCLUSION

Regardless of the controversies, discrepancies, and ambiguity, it is essential to continue work to refine our definition of executive functions and enhance our ability to determine the presence of unique patterns of dysfunction characterizing ASD and other specific disorders. It will also be important to explore further the connection between unique executive functions displayed in specific disorders and particular symptoms. This may lead to a more informed selection of intervention options and, therefore, enhanced ability to meet the diverse needs of individuals with ASD.

REFERENCES

1. Pennington BF. The working memory function of the prefrontal cortices: implications for developmental and individual differences in cognition. In: Haith MM, Benson JR, Roberts R, Pennington BF, eds. The Development of Future Oriented Processes. Chicago, IL: University of Chicago Press; 1994:243–289
2. Pennington BF, Ozonoff S. Executive functions and developmental psychopathology. J Child Psychol Psychiatry 1996;37:51–87
3. Lyon GR, Krasnegor N. Attention, Memory, and Executive Function. Baltimore, MD: Brookes; 1996
4. Gioia GA, Isquith PK, Guy SC. Assessment of executive functions in children with neurological impairment. In: Simeonsson RJ, Rosenthal SL, eds. Psychological and Developmental Assessment. New York, NY: Guilford Press; 2001:317–356
5. Rylander G. Personality changes after operations of the frontal lobes. Acta Psychiat et Neurol Scand 1939;20(suppl):327
6. Harlow JM. Recovery from the passage of an iron bar through the head. Pub Mass Medical Soc 1868;2:327–347
7. Bianchi L. The Mechanism of the Brain and the Function of the FrontalLobes. Edinburgh, UK: Livingstone; 1922
8. Brickner RM. An interpretation of frontal lobe function based upon the studyof a case of partial bilateral frontal lobectomy. In: Orton ST, Fulton JF, Davis TK, eds. Localization of Function in

the Cerebral Cortex. Baltimore, MD: Williams Wilkins; 1934:259–351
9. Goldstein K. The mental changes due to frontal lobe damage. J Psychol 1941;17:187–208
10. Hebb DO. Intelligence in man after large removals of cerebral tissue: report of four left frontal lobe cases. J Gen Psychol 1939;21:73–87
11. Hebb DO. Man's frontal lobes: a critical review. Arch Neurol Psychiatry 1945;54:10–24
12. Fuster JM. The Prefrontal Cortex: Anatomy, Physiology and Neuropsychology of the Frontal Lobe. 2nd ed. New York, NY: Raven; 1989
13. Kolb B, Wishaw IQ. Fundamentals of Human Neuropsychology. New York, NY: WH Fremont; 1990
14. Cattell R. Theory of fluid and crystallized intelligence: a critical experiment. J Educ Psychol 1963; 54:1–22
15. Carroll J. Human Cognitive Abilities: A Survey of Factor Analytical Studies. New York, NY: Cambridge University Press; 1993
16. Duncan J. Attention, intelligence, and the frontal lobes. In: Gazzaniga MS, ed. The Cognitive Neurosciences. Cambridge, MA: MIT Press; 1995:721–733
17. Pennington BF. Dimensions of executive functions in normal and abnormal development. In: Krasnegor N, Lyon GR, Goldman-Rakic PS, eds. Development of the Prefrontal Cortex: Evolution, Neurobiology, and Behavior. Baltimore, MD: Brookes; 1997:265–281
18. Vygotsky L. Thought and Language. Cambridge, MA: MIT Press; 1962
19. Luria AR. The Role of Speech in the Regulation of Normal and Abnormal Behavior. Tizard J, trans. New York, NY: Liveright; 1962
20. Milner B. Some effects of frontal lobectomy in man. In: Warren J, Akert K, eds. The Frontal Granular Cortex and Behavior. New York, NY: McGraw Hill; 1964:601–618
21. Reitan RM. Validity of the trail making test as an indicator of organic brain damage. Percept Mot Skills 1958;8:271–276
22. Shallice T. From Neuropsychology to Mental Structure. Cambridge, UK: Cambridge University Press; 1988
23. Welsh MC, Pennington BF, Ozonoff S, Rouse B, McCabe EBR. Neuropsychology of early-treated phenylketonuria: specific executive function deficits. Child Dev 1990;61:1697–1713
24. Wechsler W. Wechsler Intelligence Scale for Children. 4th ed. WISC-IV Manual. San Antonio, TX: Psychological Corporation; 2003;167
25. Cohen JD, Servan-Schreiber D. Context, cortex, and dopamine: a connectionist approach to behavior and biology in schizophrenia. Psychol Rev 1992;99:45–77
26. Greenberg LM, Kindschi CL. TOVA Clinical Guide. Los Alamitos, CA: Universal Attention Disorders; 1996
27. Gioia GA, Isquith PK, Guy SC, Kenworthy L. Behavior Rating Inventory of Executive Function. Odessa, FL: Psychological Assessment Services; 2000
28. Delis DC, Kaplan EF, Kramer JH. Delis-Kaplan Executive Functional Scales (D-KEFS). San Antonio, TX: Psychological Corporation; 2001
29. Korkman M, Kirk U, Kemp S. NEPSY: A Developmental Neuropsychological Assessment. San Antonio, TX: Psychological Corporation; 1998
30. Ozonoff S, Strayer DL, McMahon WM, Filloux F. Executive function abilities in autism: an information processing approach. J Child Psychol Psychiatry 1994;35:1015–1031
31. Fischer M, Barkley RA, Edelbrock CS, Smallish L. The adolescent outcome of hyperactive children diagnosed by research criteria: II. Academic, attentional and neuropsychological status. J Consult Clin Psychol 1990;58:580–588
32. Weyandt LL, Willis WG. Executive functions in school-aged children: potential efficacy of tasks in discriminating clinical groups. Dev Neuropsychol 1994;10:27–38
33. Barkley RA. Attention Deficit Hyperactivity Disorder: A Handbook for Diagnosis and Treatment. 2nd ed. New York, NY: The Guilford Press; 1998
34. Moffitt TE, Silva PA. Self-reported delinquency, neuropsychological deficit, and history of attention deficit disorder. J Abnorm Child Psychol 1988; 16:553–569
35. Moffitt TE, Henry B. Neuropsychological assessment of executive functions in self-reported delinquents. Dev Psychopathol 1989;1:105–118
36. Hurt J, Naglieri JA. Performance of delinquent and nondelinquent males on planning, attention, simultaneous, and successive cognitive processing tasks. J Clin Psychol 1992;48:120–128
37. Pennington BF, Van Doorninck WJ, McCabe LL, McCabe ERB. Neuropsychological deficits in early treated phenylketonurics. Am J Ment Defic 1985; 89:467–474
38. Watkins LH, Sahakian BJ, Robertson MM, et al. Executive function in Tourette's syndrome and obsessive-compulsive disorder. Psychol Med 2005; 35:571–582
39. Ylvisaker M, ed. Traumatic Brain Injury Rehabilitation: Children and Adolescents. 2nd ed. Boston, MA: Butterworth-Heinemann; 1998
40. Grodzinsky GM, Diamond R. Frontal lobe functioning in boys with attention deficit hyperactivity disorder. Dev Neuropsychol 1992;8:427–445

41. Pennington BF, Groisser D, Welsh MC. Contrasting deficits in attention deficit hyperactivity disorder versus reading disability. Dev Psychol 1993;29:511–515
42. Bennetto L, Pennington BF, Rogers SJ. Intact and impaired memory functions in autism. Child Dev 1996;67:1816–1835
43. Russell J, Jarrold C, Henry L. Working memory in children with autism and with moderate learning difficulties. J Child Psychol Psychiatry 1996;37: 673–686
44. Hughes C, Russell J, Robbins TW. Evidence for executive dysfunction in autism. Neuropsychologia 1994;32:477–492
45. McEvoy RE, Rogers SJ, Pennington BF. Executive function and social communication deficits in young autistic children. J Child Psychol Psychiatry 1993;34:563–578
46. Ozonoff S. Reliability and validity of the Wisconsin Card Sorting Test in studies of autism. Neuropsychology 1995;9:491–500
47. Ozonoff S, Strayer D. Inhibitory function in nonretarded children with autism. J Autism Dev Disord 1997;27:59–77
48. Ozonoff S, Pennington BF, Rogers SJ. Executive function deficits in high functioning autistic individuals: relationship to theory of mind. J Child Psychol Psychiatry 1991;32:1081–1105
49. Prior M, Hoffmann W. Brief report: neuropsychological testing of autistic children through an exploration with frontal lobe tests. J Autism Dev Disord 1990;20:581–590
50. Jarrold C, Boucher J, Smith PK. Generativity defects in pretend play in autism. Br J Dev Psychol 1996;14:275–290
51. Pennington BF. The Development of Psychopathology: Nature and Nurture. New York, NY: Guilford Press; 2002
52. Lopez BR. An examination of the relationship between executive function and restricted, repetitive symptoms in high functioning individuals with autism. Dissertation Abstracts Int 2001;62:555
53. Turner M. Towards an executive dysfunction account of repetitive behaviour in autism. In: Russell J, ed. Autism as an Executive Disorder. London. UK: Oxford University Press; 1997:57–100
54. Turner M. Repetitive behaviour in autism: a review of psychological research. J Child Psychol Psychiatry 1999;40:839–849
55. Lovaas OI, Koegel RI, Schreibman L. Stimulus oversensitivity in autism: a review of research. Psychol Bull 1979;86:1236–1254
56. Bailey SL. Stimulus overselectivity in learning disabled children. J Appl Behav Anal 1981;14: 239–248
57. Gersten R. Stimulus overselectivity in autistic, trainable mentally retarded, and non-handicapped children: comparative research controlling chronological (rather than mental) age. J Abnorm Child Psychol 1983;11:61–75
58. Klin A, Jones W, Schultz R, Volkmar F, Cohen D. Visual fixation patterns during viewing of naturalistic social situations as predictors of social competence in individuals with autism. Arch Gen Psychiatry 2002;59:809–816
59. Hughes C, Russell J. Autistic children's difficulty with mental disengagement from an object: its implications for theories of autism. Dev Psychol 1993;29:498–510
60. Russell J, Mauthner N, Sharpe S, Tidswell T. The "windows task" as a measure of strategic deception in preschoolers and autistic subjects. Br J Dev Psychol 1991;9:331–349
61. Crick NR, Dodge KA. A review and reformulation of social information processing mechanisms in children's social adjustment. Psychol Bull 1994; 115:74–101
62. Channon S, Charman T, Heap J, Crawford S, Rios P. Real-life-type problem-solving in Asperger's syndrome. J Autism Dev Disord 2001;31:461–469
63. Ozonoff S, McEvoy RE. A longitudinal study of executive function and theory of mind development in autism. Dev Psychopathol 1994;6:415–431
64. Ozonoff S, Cook I, Coon H, et al. Performance on Cambridge Neuropsychological Test Automated Battery Subtests sensitive to frontal lobe function in people with autistic disorder: evidence from the Collaborative Programs of Excellence in Autism network. J Autism Dev Disord 2004;34:139–150
65. Ozonoff S. Components of executive function in autism and other disorders. In: Russell J, ed. Autism as an Executive Disorder. London, UK: Oxford University Press; 1997:179–211
66. Barkley RA. Linkages between attention and executive functions. In: Lyon GR, Krasnegor NA, eds. Attention, Memory, and Executive Functions. Baltimore, MD: Brookes; 1996
67. Gray CA. Social stories and comic strip conversations with students with Asperger's syndrome and high-functioning autism. In: Schopler E, Mesibov GB, eds. Asperger's Syndrome or High-Functioning Autism? New York, NY: Plenum Press; 1998:167–198
68. Hyerle D. Visual tools for constructing knowledge. Alexandria, VA: Association for Supervision and Curriculum Development; 1996
69. Meichenbaum DH, Goodman J. Training impulsive children to talk to themselves: a means of developing self-control. J Abnorm Psychol 1971; 77:115–126
70. Kamann MP, Wong BYL. Inducing adaptive coping self-statements in children with learning disabilities through self-instructive training. J Learn Disabil 1993;26:630–638

71. Prins PJM, Hanewald GJFP. Coping self-talk and cognitive interference in anxious children. J Consult Clin Psychol 1999;67:435–439
72. Shure MB. I Can Problem Solve: An Interpersonal Cognitive Problem-Solving Program—Intermediate Elementary Grades. Champaign, IL: Research Press; 2001
73. Graham S, Harris KR. Addressing problems in attention, memory, and executive functions: an example from self-regulated strategy development. In: Lyon GR, Krasnegor NA, eds. Attention, Memory, and Executive Functions. Baltimore, MD: Brookes; 1996