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# Context in the Development of Executive Functions in Children

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Assessments of and interventions for executive functions have occupied a central role for neuropsychologists working with children with acquired brain injuries during the past three decades. More recently, awareness has grown about the role that executive functions play for all children and the significant impact they have on behavior and performance in home, school, and community settings. This article posits that demonstration of these functions in a real-world context is the standard by which assessment and intervention strategies should be judged. I then propose that contextually based interventions offer the best probability for meeting this standard. Support for this position is provided by the educational and behavioral literature on learning and transfer and by the neuroscience literature on pattern recognition and embodied cognition.

*Key words: context, embodied cognition, environmental support, executive functions, motivation, training, transfer of learning*



In neuropsychology, during the past 30 years, we have advanced from a situation where the concept of executive function(s) was virtually unknown to the present day, where research and interventions to address typical and atypical development of executive functions occupy a central role in neuropsychology and neuroscience, are acknowledged as increasingly important for parents and teachers to be aware of in the child's development, and indeed have entered the popular consciousness of the general public. One needs to only perform a Google search for "executive functions" to see the voluminous and ever-increasing numbers of research and intervention articles, books, computer and Smartphone applications, and coaching businesses that have sprung up to address these issues.

Despite the level of attention and interest in executive functions, there is as yet no single or predominant model of executive functions and no "gold standard" (Hunter & Sparrow, 2012). In fact, there is as yet no single, universally accepted definition of executive function although a survey of the definitional literature indicates frequent references to some form of self-regulation or control of behavior (Barkley, 1997, 2012b; Fuster, 1997; Koziol, Budding, & Chidekel, 2012; Lezak, 1995; Pennington & Ozonoff, 1996; Roth, Isquith, & Gioia, 2005) either directly or indirectly through examples of how deficits manifest themselves. Additionally, the majority of models refer not to one executive function but rather to "functions" and typically include anywhere from 3 (Fuster, 1997) to 33 components (McCloskey, Perkins, & Van Divner, 2008). For the purposes of this article, I have elected to use Barkley's (2012b) definition of executive functioning as, "*self regulation* [of behavior] *to achieve goals*" (p. 60).

Consensus is more evident, however, when the discussion involves the importance of executive functions. For example, Hunter and Sparrow (2012) summarize the research and clinical work they have reviewed reflecting the necessity of intact executive functions as essential for an individual's independent living as a member of a community, who evidences self-sustaining and socially appropriate behavior. A study for the Gates Foundation (Benson & Scales, 2004) revealed that planning, initiation, goal-directed persistence, emotional regulation,

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and flexibility, among others, are essential life skills for the successful transition to adulthood. The Center on the Developing Child at Harvard University (2011) described executive functions as the foundation for the child's cognitive, social, and moral development, and as critical for success in academic, family, and community settings.

The shared feature of these statements about the critical nature of executive functions, and perhaps an emerging gold standard for judging the efficacy of models of intervention, is the ability to demonstrate acquisition and application of these functions for problem solving and goal attainment in real-life settings. Our model (P. Dawson & Guare, 2009; Guare, Dawson, & Guare, 2012) and those of others (Barkley, 2012b), along with the aforementioned sources, suggest that the importance of executive functions lies in their impact on the individual's capacity for behavioral self-regulation or control. Hence, I would argue that the efficacy of intervention models for executive functions should be judged by their impact on behavioral regulation and resulting day-to-day performance in home, school, and community settings. That "real-world" applications should constitute such a standard would seem a natural and logical outcome for applied neuropsychology. In assessment and intervention, neuropsychologists have endeavored to determine how executive dysfunction impacts the child's or adult's life and what might be done to mitigate these impacts. Throughout their review on research support for interventions to address executive functions, Slomine, Locascio, and Kramer (2012) refer to outcomes that impact the child in his or her everyday environment. Equally interesting in their review is the fact that even in the case of decontextualized interventions such as *CogMed* (Pearson Clinical Assessment Group, 2010), parent and teacher ratings of executive functions in home and school environments are cited as evidence of efficacy. Thus, the objective of these interventions is not simply to improve on the decontextualized task itself, but to demonstrate the transfer of these skills to the real-world stumbling blocks that the child experiences as a result of weaknesses in executive functions. This emphasis on practical application is evident in the marketing of these and other like products, presumably because the developers recognize that real-world application is of most interest to consumers.

However, adoption of a standard of contextual efficacy has significant implications both for assessment of executive functions and for models of intervention to address these functions, including who are or should be the key agents of intervention.

There are two reference points that form the backdrop for these implications. One of these reference points is the educational psychology literature and the role that contextual experience can play in *transfer* or *generalization* of executive functions across situations. In terms of models of intervention, if the desired outcome is the child's acquisition and ever-widening contextual application of executive functions, then the notion of transfer or generalization becomes quite important. For the purposes of this discussion, the term transfer will be used although it is similar in its use to the term generalization in applied behavior analysis (Cooper, Heron, & Heward, 2007). Transfer (more specifically, *positive transfer*) refers to the extension of what has been learned in one context to its application in a new context. *Near transfer* refers to extension of knowledge or a skill to a similar but not identical context, whereas *far transfer* refers to extension to a context that is quite dissimilar to the context in which learning originally took place. *Low road transfer* involves automatic, basically reflexive elicitation of well-learned routines when the stimulus setting of the new situation is similar to that of the original learning context. *High road transfer* involves a more deliberate, thoughtful, effortful process that involves abstraction and a search for connections or patterns in the new situation. These terms occupy a central role in instructional design and learning theory (Oregon Technology in Education Council, 2007) and in applied behavior analysis when the term "generalization" is substituted for "transfer."

With regard to transfer, certain conditions have been identified that are important to increase the probability of transfer; they include, among others, the following (Vockell, 2008):

- when the learner is able to recognize common elements in a situation;
- when teaching takes place in a meaningful context;
- when skills are taught in contexts that are similar to those in which the skills are to be employed;
- when the learner is able to practice skills in a range of settings that represent, as much as possible, those future settings where application will be expected or desired;
- when the learner is able to engage in distributed practice after the skills are learned initially—that is, practice during a lengthy period in a range of realistic situations; and
- when the learner acquires positive attitudes about the skill or strategy because this increases the likelihood that the learner will use the skill when it is called for in another situation. Thus, success and reinforcement are important to motivate transfer and use of the skill.

The second point of reference for this focus on context is increasing evidence in the neuroscience literature that indirectly or directly supports contextually based models for development of executive functions. While a number of topics in neuroscience are potentially relevant to development of executive functions, two in particular stand out

for the current discussion—*pattern recognition* and *embodied cognition.* Pattern recognition occupies a central role in learning and involves a significant commitment of neural resources (Goldberg, 2009; Rugg & Yonelinus, 2003). Rose and Dalton (2005) suggests that pattern recognition is one of three broad, integrated neurocognitive components that play a key role in learning and problem solving. He notes that posterior areas of the cortex are devoted to pattern recognition, frontal systems are devoted to generation of action patterns, and extended limbic system networks are devoted to determination of which patterns are important to us. These systems interact continuously to help us determine the action that a particular situation calls for and whether engagement in that action furthers some goal that we have. Embodied cognition speaks more directly to the role of context. While there are a number of definitions of embodied cognition, essentially, the term refers to the proposition that cognition is shaped through the interaction of the body with the world through sensory-motor activities (Damasio, 2010; Wilson, 2002). Glenberg (2012) at the Laboratory for Embodied Cognition and his colleagues have published a number of studies on the implications of embodied cognition for different types of cognitive functions. More directly relevant to the current discussion of executive functions is an article published by Koziol et al. (2012). The authors argue that the brain evolved not for development of cognition per se but for control of action and that executive functions evolved through sensorimotor interactions with the world for the purpose of behavior control. The cerebellum is seen as having a central role in this process, and the authors hypothesize about the possible role of procedural learning in the development of semantic, declarative knowledge. Importantly, they ground this work in functional neuroanatomy.

Given this information from educational psychology and neuroscience, what are the implications? In terms of assessment, if contextual application of executive functions is an important standard for judging the efficacy of interventions, then contextual assessment offers the advantage of establishing baselines of functions in those situations where progress will eventually be judged. In addition, if successful negotiation of problems and attainment of goals in daily living and academic settings is the ultimate standard, an assessment of executive functions in those settings helps to ensure the validity of the intervention. The work of Gioia, Isquith, and Guy (2001) is an example of this type of situational assessment. There are also more recent contextual assessments by Naglieri and Goldstein (2013) and Barkley (2012a). Executive functions are often assessed in the setting of a more traditional neuropsychological evaluation. The *Delis-Kaplan Executive Function System* (Delis, Kaplan, & Kramer, 2001) is one example of an assessment that might be conducted as part of a neuropsychological evaluation. Use of one type of instrument does not preclude use of the other and in fact offers the potential advantage of cross-validation. At the same time, if one of the purposes of assessment is to evaluate the strengths and weaknesses of executive functions and recommend "real-world" interventions, a number of potential concerns arise. See, for example, Dawson and Guare (2010) and Barkley (2012b) for consideration of these issues, which relate to the ecological validity of the measures used, as well as Nikolas and Nigg (2013) for a view on the utility of such measures.

With regard to the implications of contextual efficacy for intervention, I propose, as we have in our writings (Dawson & Guare, 2010; Guare et al., 2012), that there are three factors that need to be considered in the development of models of intervention: *motivation, environmental supports*, and *explicit instruction.*

## MOTIVATION

Hunter and Sparrow (2012), in discussing models of executive function, observe that discussions of emotion and motivation have been left out of much of the executive function literature, and instead, there has been a focus on the so-called "cool" executive functions, which hypothetically can be decontextualized and more readily engaged by abstract tasks. Rossano (2011) and Barkley (2012b) echo this observation about the "dearth of attention" (Barkley, 2012b, p. 25) given to the role of emotion and motivation in executive functions and self-regulation. Historically, some models and conceptualizations of executive function (Damasio, 1994; Stuss & Benson, 1986) see emotion and motivation as playing a central role in executive functions. From Barkley's (2012b) perspective, the ascendance of cognitive psychology and information-processing models in descriptions of executive functions are part of the reason for this divide. However, in the research and theoretical literature on executive functions, there are indications that this may be changing. In the neuroscience literature on the teen brain, for example, references are often made to both "cool" and "hot" executive functions, with the latter strongly associated with emotion and motivation (Prencipe, Kesek, Cohen, Lamm, & Zelazo, 2011). Pessoa (2009) proposes a framework to describe how emotion and motivation directly interact with and direct executive functions, and he suggests that motivation and emotion may impair or enhance behavioral regulation, contingent on how they interact with key executive control functions. Taylor et al. (2004), in a neuroimaging study of motivation and executive function, found a significant relationship between motivation and working memory and suggested that motivation may integrate information about the value of an activity involved in

executive functions and, beyond that, may have the general effect of enhancing neural effort.

In terms of developing a contextually based intervention model, I agree with Solanto (2011) and Barkley (2012b), among others, that motivation plays a central role in the acquisition and practice of executive functions. Motivation is viewed as facilitating behavior in the service of obtaining a reward or avoiding a punishment. Thus, motivation plays an essential role in the activation of behavior. As noted, P. Dawson and Guare (2012) and Guare et al. (2012) have proposed that motivation and strategies to enhance motivation are an essential part of intervention models to help children develop and practice executive functions. These authors also propose that goal setting can be a key component of motivational strategies. In the "definitional" references, a number of the authors cited (Barkley, 2012b; Gioia et al., 2001; Pennington & Ozonoff, 1996; Stuss & Benson, 1986) suggest that self-regulation occurs in the service of goal attainment. In our model, the value of goal setting is based, in part, on a theory of goal setting proposed by Locke and Latham (2002). These authors propose that goals serve four primary functions. First, they *direct* behavior—toward goal-relevant activities and away from goal-irrelevant activities. Second, they *energize*—high goals lead to greater effort than do low goals. Third, they encourage *persistence*. Finally, they *motivate* individuals to discover or use task-relevant knowledge or strategies. Thus, goals are potentially an important motivational component for children and adolescents. When a child has a goal that is important to her, behavior in the service of obtaining that goal can increase the likelihood of learning and practicing goal-relevant skills. Moreover, achieving the goal may well involve the use of what we consider to be executive functions, such as working memory, flexibility, and response inhibition, among others. Thus, to the extent that they are important to the child, goals offer a vehicle for the acquisition and practice of executive functions. At the same time, it is important to note that children may be faced with problem situations and/or goals that their teachers or parents have set for them that they do not see as important. Hence, there is no internally generated motivation to activate and sustain goal-directed behavior. Barkley (2012b), among others, has noted that in the absence of internal motivation, it is important to externalize motivation. This means utilizing some artificial means to create an extrinsic source of motivation. Barkley (2012b) observes that strategies utilized in applied behavior analysis, particularly those related to the principles of reinforcement, are especially well suited to developing externalized sources of motivation. As Guare et al. (2012) have noted, whenever possible, it is preferable to rely on the internally generated motivation of the child's own goals, particularly as the child approaches adolescence. Given the adolescent's desire to establish autonomy and independence and to be responsible for the self-regulation of his or her own behavior, goals on which the adolescent and the parent can agree (e.g., obtaining a driver's license or a job) facilitate the acquisition and use of executive functions in the attainment of these goals. But when the child does not have a goal, these authors propose a range of externalized sources of motivation. Contextually based intervention models thus should address what role motivation plays in the development of executive functions and also should address how motivational strategies need to be modified during the course of the child's development.

## ENVIRONMENTAL SUPPORTS

A second factor that needs to be considered in the development of contextually based interventions for executive functions involves environmental supports. Although there is evidence that what will become executive functions is evident, in rudimentary form, in infancy (Barkley, 1997), executive functions are thought to continue developing into young adulthood (Anderson, Jacobs, & Anderson, 2008). That being the case, throughout the course of the child's development, executive functions will require "surrogate assistance" in the form of environmental supports or *scaffolding* (Center on the Developing Child at Harvard University, 2011). This support might involve changes in the physical or social environment, modification in the tasks that children are expected to perform, or changes in the way that parents and teachers interact with the child (Dawson & Guare, 2010). There are three intended objectives for such supports.

The first objective is to allow the child to practice emerging executive functions in environments that facilitate success through support that decreases the initial skill demand, followed by gradual fading of that level of support as the child demonstrates increasing independent use of executive functions and transfer of these skills to other environments and situations. Two factors impact the type and degree of support needed, the task/situational demand, and the skill level of the child. Although normative information such as that offered by Anderson et al. (2008) can help to establish expectations for children at particular age ranges, individual differences in the development of executive functions preclude absolute rules for the types of supports that need to be provided at any particular age. To help manage this individual variability, behavioral analysis can be of assistance because the types of supports that are developed are predicated on observations of the child's behavior in a particular situational context to determine the degree of support needed to facilitate successful execution of the behavior. In applied behavior analysis, this is comparable to an *antecedent intervention* (Cooper et al., 2007). As noted, success is a key factor in facilitating transfer of learning because success motivates the child to utilize the skill again.

The second objective of environmental supports is to arrange or construct situations or tasks in such a way, over time, as to elicit executive functions from the child. There are both situational and instructional components that will facilitate this objective. The situational component will be considered here and the instructional component will be discussed later in the article. The situational component involves three of the characteristics of near transfer—extension of knowledge or a skill to a similar but not identical context, the learner's ability to recognize common elements across contexts, and learning and practice in contexts in which those skills will be applied in the future. If parents and teachers can use these contextual characteristics along with the learning strategies, then the probability increases that executive functions will be elicited by the stimulus characteristics of the situation, therefore freeing the child from dependence on adult prompts.

A third objective in the use of environmental supports is to present them to the child as a set of tools that can reduce demands on executive functions, which relates to the idea of *off-loading*. Off-loading is defined by Shapiro (2011) as "a way of simplifying the cognitive routines that otherwise would require a lot of memory and a lot of reasoning ... you can think of off-loading as involving structuring your environment in a certain way" (p. 14). Shapiro gives as an example organizing books in a particular way such as by subject. Technology such as Smartphones represents another type of environmental support or tool that can be utilized for off-loading. In cognitive rehabilitation for executive functions, these types of tools are referred to as cognitive orthotic devices (LoPresti, Mihailidis, & Kirsch, 2004). If over time and through contextual application parents and teachers are able to introduce, help the child utilize, and demonstrate the benefit of these tools, then regular pairing of these tools across similar situations increases the probability that the situation will elicit tool use. As with the second objective, both situational and instructional components are needed to meet this objective.

## TRAINING

The third element necessary for contextually based interventions for executive functions involves instruction in or training of those functions. The variables that need to be considered in training include where the training will take place, what the training involves, and who carries out the training. Regarding where training takes place, the premise of much of this article is that if real-world use of executive functions is the goal, then acquisition and application of executive functions by children in real-world settings provides the best opportunity for success. Ylvisaker, Turkstra, and Coelho (2005) have argued that interventions for executive dysfunction are best carried out through the context of everyday functional activities using everyday routines and people. They suggest that teaching cognitive processes in entirely decontextualized settings is ineffective, and recent evidence regarding one of the more publicized computer programs for training executive functions supports this contention (Shipstead, Hicks, & Engle, 2012). In addition, attempts to teach executive functions in decontextualized settings meet few of the conditions that favor transfer of learning. On the other hand, Feeney and Ylvisaker (2008) and Feeney (2010), working with children with self-regulatory problems secondary to acquired brain injury, demonstrated the efficacy of contextually based behavioral and cognitive -behavioral strategies. Slomine et al. (2012) similarly favor contextualized interventions that take place in the child's home and school settings, but they also note that although holistic, complex interventions are preferable, the multiple components inherent in such interventions create research challenges for isolation of the most important variables. For a detailed review of the efficacy of various interventions, the reader is referred to their chapter.

Regarding what the training involves or should involve is determined, in part at least, by the setting (e.g., school or home) and situational demands, the age and developmental level of the child, the state of his or her executive functions and the desired outcome. For example, Jacobson and Mahone (2012) present a thorough case for the importance of executive functions throughout the child's school experience, and they note how the demands on these functions change over time. These authors note that with this universal need for executive functions and research that teacher training in specific skills can positively impact children's self-regulatory behavior, curricula in the preschool and elementary school settings have been developed with a view toward promotion of executive functions for all students. They give as examples *PATHS* (Promoting Alternative Thinking Strategies; Kusche & Greenburg, 1994) and *Tools of the Mind* (Bodrova & Leong, 1996). Jacobson and Mahone cite research evidence for the effectiveness of these curricula in improving self-regulatory behavior for some populations of children. At the same time, recent research regarding *Tools of the Mind* (Willingham, 2012) questions some of the claims for efficacy in addressing executive functions. Nonetheless, the outcome research reported by Jacobson and Mahone for these and other classwide or schoolwide intervention programs offer promise for addressing executive functions on a wide-scale basis. Prepared, evidence-based curricula, when faithfully implemented, offer the advantage of consistency in application and time savings for teachers, and potentially provide continuity for students across grades. In addition, some of these programs include a parent component, which can promote consistency of approach across environments.

A different and perhaps more grassroots approach to what training in executive functions involves addresses directly the presumed agents of change, parents, and teachers. This approach is reflected in the work of Meltzer (2010) for teachers, Cooper-Kahn and Dietzel (2008) for parents, and Dawson and Guare (2010, 2012) and Guare et al. (2012) for parents and teachers. Whereas prepared classwide curricula take a "one-size-fits-all" approach, the approach of these authors is focused on individual differences in executive functions and on children who evidence weaknesses in these functions. They have also made an effort to address the needs of children across a broad age range, an element that Jacobson and Mahone (2012) note is lacking in the more programmatic interventions, especially for older children. In addition, the focus is on individual, discrete functions or skills and strategies for intervention that vary according to the age, setting, and profile of strengths and weaknesses evidenced by a particular child. This approach is predicated on the idea that the potential for widespread intervention depends on parents and teachers understanding what these functions are and what impact they have on their children's academic achievement, social interactions, and behavior. Thus, there is a motivational component in that parents and teachers develop an investment in improving the performance of their children and students. If parents and teachers are to apply these strategies on an individualized, differentiated basis, then there are a number of steps that need to be introduced to them. The first step is to introduce and define the specific functions or skills that are addressed in the model. The second step is to give home and school examples of how these skills manifest themselves in daily living and give examples with enough specificity for people to "see" them in what they observe in their own experience. The third step is to provide assessment tools keyed to the specific executive functions in the model. For high school students, for example, P. Dawson and Guare (2012) provide both an adult version of a questionnaire for parents or teachers as well as a separate student version. They also have developed a checklist based on parent, teacher, and student feedback that is designed to identify how the skill weakness is reflected in a specific behavior. For example, they have defined *sustained attention* as, "The capacity to continue paying attention to a situation or task in spite of distractibility, fatigue or boredom" (P. Dawson & Guare, 2012, p. 8). The corresponding checklist behaviors for *sustained attention* include the following (P. Dawson & Guare, 2013):

____ Takes frequent breaks when working
____ Takes breaks that are too long
____ Internally distracted—thoughts, states, moods, daydreams. Please specify:
____ Externally distracted—sights, sounds, technology such as phone, internet, TV. Please specify:
____ Rushes through work—sloppy/mistakes
____ Does not know limits (how long can sustain attention) or when best study/work time is
____ Does not recognize when off-task
____ Trail off frequently, not just in talking but in texting
____ Work where distractions are present (e.g., TV) with rationale that you can both work and watch

In discussing contextually based models, I have now suggested where the training interventions need to take place and what tools and techniques the training should involve. The last component is who are or should be the agents of training. Along with others (Feeney & Ylvisaker, 2008; Jacobson & Mahone, 2012), I have tried to make the case that based on evidence from the learning and transfer literature and the literature on embodied cognition, executive functions are best trained and practiced in the natural context of the child's life. If that is the case, then the natural agents of training are parents and teachers, and if widespread intervention is the goal, then it is to that audience that our insights and interventions need to be directed. In their working paper, authors from the Center for the Developing Child at Harvard University (2011, p. 13) clearly note the following policy implications of behavior intervention: "Early care and educational professionals—as well as kindergarten and early elementary teachers—would be better equipped to understand and adjust behavioral and learning challenges in their classrooms if they had professional training (and easy to use tools for) the development of executive function skills ... [and] ... Parents would benefit from greater access to tools and approaches that provide useful knowledge in ways of supporting the early development of executive function skills."

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