11-1-2005

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Published in *Mental Retardation and Developmental Disabilities Research Reviews* 11 (2005), pp. 209–215; doi: 10.1002/mrdd.20075

Research described in this article was sponsored by the National Institute of Mental Health (Contract grant number: 1R01 MH065668), the National Institute on Drug Abuse (Contract grant number: 1R01 DA014661), Southern Illinois University Office of Research Development and Administration (Special Research Program Award), and the Rita Rudel Foundation (two Pediatric Neuropsychology/Developmental Cognitive Neuroscience Awards to Dr. Espy and Dr. Crawford).

Submitted July 11, 2005; accepted July 12, 2005.

Assessment of Executive Function in Preschool-Aged Children

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Abstract

Assessment of the overarching self-regulatory mechanisms, or executive functions, in any age group is challenging, in part due to the complexity of this domain, in part due to their dynamic essence, and in part due to the inextricable links between these central processes and the associated domain-specific processes, such as language, motor function, and attention, over which they preside. While much progress has been made in clinical assessment approaches for measuring executive functions in adults and to some extent in adolescents and school-aged children, the toolkit for the preschool evaluator remains sparse. The past decade, however, has seen a substantial increase in attention to executive functions in very young children from a developmental neuropsychological perspective. With this has come a necessity for better, more specific, and more internally valid performance measures, many of which are now described in the experimental literature. Few such tasks, however, have adequately demonstrated psychometric properties for clinical application. We present two performance tasks designed to tap selective aspects of executive function in preschoolers that are emerging from the experimental laboratory and hold promise of appropriate reliability and validity for the clinical laboratory. Performance tests alone, however, are insufficient to develop a comprehensive picture of a child's executive functioning. Thus, we present a rating scale of preschoolers' executive function in the everyday context, and advocate a model of executive function assessment that incorporates both controlled performance tasks that target specific aspects of executive function and parent/teacher ratings that target more global aspects of self- regulation in the everyday context.

Keywords: Executive function, preschool, developmental neuropsychology

Executive functions are critically important in the overall neuropsychological functioning of the developing child and play a fundamental role in the child's cognitive, behavioral, and social-emotional development. Executive functions can be construed as central or overarching self-regulatory abilities that orchestrate basic or domain-specific cognitive processes (e.g., language, attention, sensory input, motor output) to achieve goal-oriented problem solving [Neisser, 1967] and behavior. Where many definitions and models have been posited [e.g., Stuss and Benson, 1986; Goldman-Rakic, 1987; Welsh and Pennington, 1988; Fuster, 1989; Denckla, 1994; Lyon Krasnegor, 1996; Barkley, 1997; Anderson, 1998], most would agree that the general term "executive function" is an umbrella construct defined as the control, supervisory, or self-regulatory functions that organize and direct all cognitive activity, emotional response, and overt behavior. Given this central role, deficits in various aspects of the executive functions are central characteristics of many acquired and developmental disorders [Pennington and Ozonoff, 1996; Barkley, 1997; Gioia et al., 2002; Gioia and Isquith, 2004]. As such, the typical and atypical development of executive functions in children has become an active topic of discussion and research over the past two decades [e.g., Passler et al., 1985; Welsh et al., 1991; Fletcher et al., 1996; Sonuga-Barke et al., 2003; Espy, 2004; Ewings-Cobbs et al., 2004; Rennie et al., 2004; Senn et al., 2004; Smidts et al., 2004].

Relatively, less attention has been devoted to the structure, organization, and development of executive functions in infants and preschool-aged children [Espy and Kaufmann, 2001]. One prominent view of preschooler's behavior is that young children are not able to exert higher order control of pertinent cognitive processes, emotional responses, and behavioral impulses, as lack of inhibitory control, significant distractibility, cognitive inflexibility, and lack of organized or planful strategic behavior and self-monitoring are hallmarks of this age range. This "dysexecutive" behavior suggests that the study of executive functions in preschool-aged children may not be particularly fruitful, given the potential for a broad range of normal variability in these functions. However, the developmentally oriented neuropsychologist, whether focused on clinical service delivery or research investigation, has an inherent interest in the earliest roots of disorders that are evident in later childhood and adolescence. Through careful explication of developmentally based techniques to capture emergent executive functions in preschoolers, the earliest forms and/or precursors of executive regulation can be defined and described. For example, better understanding of the roots of poor inhibitory control, later manifested in attention-deficit/hyperactivity disorder [ADHD; e.g., Mariani and Barkley, 1997; Brophy et al., 2002; Sonuga-Barke et al., 2003], has potential implications for early detection and intervention of this disorder. Furthermore, a variety of disorders also involve executive dysfunction that manifests first in the preschool years, for example, autism spectrum disorders (ASD), and prematurity, where there might be similar yield in early detection and intervention.

In the context of a burgeoning literature on executive function in children, several assessment tools have been developed to enable measurement of executive functions in children and adolescents. The majority of such tools are adaptations or applications of measures originally developed for adults, for example, the recently introduced Delis–Kaplan Executive Function System [Delis et al., 2001], includes versions of many tasks thought to tap aspects of executive function. Where the application of "adult" oriented measures to school-aged children in many cases is possible and can be informative, young children do not possess the linguistic, motor, or sustained attention skills necessary to achieve rudimentary success on such tasks. Their "failure " on adult-oriented tasks has historically been viewed as evidence that young children do not possess executive functions. Indeed, the lack of developmentally appropriate measures has hampered the clinical assessment of executive function in young children until recently, with the development of executive tasks as part of larger preschool-oriented batteries with well-developed normative bases and psychometric properties [e.g., Korkman et al., 1998]. Such tasks may measure more global aspects of cognition and self-regulation, however, rather than specific facets of executive control. Thus, there remains a relative paucity of measures available by which to assess executive skills in the preschool period, despite the emergence of several psychiatric and neurodevelopmental disorders in this age range. Because children affected with these disorders are considered to have unique profiles of executive dysfunction [e.g., Pennington, 1997], tasks to measure discriminable executive processes are essential.

To address the lack of extant instruments, developmental neuropsychologists have been actively developing new performance measures tapping executive functions specific to preschool- aged children [e.g., Diamond et al., 1997; Espy et al., 2001]. In typically developing preschool children, normative executive ability development has been studied with several paradigms-rule governed, attribute-based sorting tasks [Hughes, 1998; Espy et al., 1999], including the Dimensional Change Card Sorting task (see Zelazo et al., 1996], manual selection or verbal naming of stimuli that conflict or interfere on the basis of natural associations [e.g., Day-Night Stroop; Gerstadt et al., 1994; Carlson and Moses, 2001; Diamond et al., 2002; Wright et al., 2003; Diamond et al., 2004], manual search tasks with working memory demands [Diamond et al., 1997; Hughes, 1998; Espy et al., 2001] and inhibiting prepotent or prohibited somatic motor responses [Reed et al., 1984; Diamond and Taylor, 1996; Kochanska et al., 1996; Korkman et al., 1998; Espy et al., 1999; Carlson and Moses, 2001].

A challenge in assessing executive function at any age is not only to find appropriate performance-based measures, but also to evaluate the functional, real-world impact of executive dysfunction expressed in everyday activities. In this context, increasing attention in the assessment literature is being paid to the ecological validity of neuropsychological assessment tools, including those targeted toward executive function [Lezak, 1982; Shallice and Burgess, 1991; Roberts et al., 1995; Wilson et al., 1998]. Ecological validity in the assessment context refers to the "functional and predictive relation between the patient's behavior on a set of neuropsychological tests and the patient's behavior in a variety of real-world settings" [Sbordone, 1996; p 16]. Thus, an ecologically valid assessment tool is one that has characteristics similar to a naturally occurring behavior and has value in predicting everyday function [Franzen and Wilhelm, 1996]. By their very nature as performance-based tests designed with high internal validity in mind, many existing neuropsychological tests assess more narrow, situationally constrained processes in contrast to real-world, adaptive executive functions, as a result, the obtained data may not document fully the essence of strengths and weaknesses in the array of executive functions across contexts [Goldberg and Podell, 2000].

To address the issue of ecological validity in capturing school-aged children's executive function, Gioia et al. developed a rating scale to assess the behavioral manifestations of a range of executive functions, the behavior rating inventory of executive function [BRIEF; Gioia et al., 2000]. This measure efficiently gathers parent and teacher observations of children's everyday self-regulatory behaviors in a number of related subdomains, including their ability to inhibit impulses, shift flexibly from situation to situation or task to task, modulate emotions, initiate, plan and organize problem solving activity, monitor their task performance and behavior, and hold information in working memory. This measure and its approach to assessing executive function should not be viewed as an alternative to performance-based assessment, but rather as complementary. The two methods should be combined for a more comprehensive understanding of the child's executive function. Where traditional test-based measures of executive function are given to assess more specific components of executive function such as working memory, inhibition, and organization at the molecular level, the rating scale method measures the broader, molar level of function in the child's everyday context. In this model, the ecologically valid assessment of executive dysfunction provides an important bridge toward understanding the impact of the component-level (i.e., test- based) deficits on the child's everyday adaptive functioning. Gioia and Isquith [2004] advocate for an ecologically valid model of executive function assessment that explicitly incorporates two levels of information: (a) specific process components typically defined by clinical tests, and (b) real-world behavioral manifestations of the specific cognitive processes.

In keeping with this model and the need for tools with which to assess executive function in preschool-aged children, we describe the development of three new instruments designed with these demands in mind. First, we present TRAILS-P [Espy and Cwik, 2004], a substantial modification of the traditional trail making test [Reitan, 1971] used commonly to evaluate an individual's ability to shift cognitive set. Second, the Shape School [Espy, 1997] is discussed, a task designed to allow for separation of inhibitory processes, namely response suppression, from cognitive switching while remaining sensitive to developmental maturation in the preschool child. Finally, we present the behavior rating inventory of executive function, preschool version [BRIEF-P; Gioia et al., 2002] as an ecologically valid measure of preschool children's executive function in the everyday, real-world context.

TRAILS-P

The objective of the TRAILS-P was to develop a task to assess ability to shift cognitive set in preschool children based on the widely used TMT [Reitan, 1971]. The TMT has been used extensively in adult neuropsychological research as an assessment of psychomotor speed, complex attention, and executive functions. In adult and school-aged child versions, the individual first connects numbered circles in connect-the-dots fashion as rapidly as possible. The individual then connects numbered and lettered circles in alternating fashion while keeping both numbers and letters in sequences (i.e., 1-A-2-B-3-C, etc.), requiring the respondent to change or shift cognitive sets from well-rehearsed, or automatized, sequences (i.e., numbers and letters). In both conditions, time to complete the sequence is the dependent measure, including time for error correction. This commonly used executive task, however, is of limited utility with preschool children, as the number and letter sequences are not sufficiently automatic. By using creative, colorful stimuli in a storybook format that is appealing to young children, the TRAILS-P can be a useful tool in young children.

In the TRAILS-P, children are presented with a book with colorful dog characters. The children are told, "Here is a family of doggies. The littlest one is the baby dog, then the sister dog, then the brother dog. The Mommy dog is here, and the biggest dog, the Daddy dog, is right here. This dog family lives in this house." The children are instructed to identify all of the dogs, in order of size, to ensure adequate understanding. Children are provided an inked stamp with a child size handle for easy gripping. In Condition A (Control), the children are instructed to stamp the dogs in order of size, starting with the "Baby" through to the "Daddy." Condition B (Switch) involves the introduction of like-sized bones, which the child has to "match" to the dogs, that is, flexibly shift among the like-sized stimuli, in order. To assess the effects on task performance of reversing response contingencies, in Condition C (Reversal), the child stamps the dogs in order of size, but now has to ignore the previously presented salient stimuli, the bones. Condition D (Distraction) assesses the effects of distraction by intermixing cat stimuli as distractors with the target dogs and bones. Again, the child has to alternate stamping the dogs and then the relevant bones, in size order, while ignoring the cats. For each condition, the latency to stamp all stimuli (with correction for wrong stamps as in the original TMT) and the number of errors are scored.

Espy and Cwik [2004] examined the temporal stability of the TRAILS-P. Thirty children were retested within 1 month of completing the TRAILS-P to determine test–retest reliability. There was evidence for good test–retest reliability, with correlations between test and retest administrations ranging from 0.45 to 0.77, with a mean value of 0.64 averaged across the four test conditions. The reliability of the latency to complete condition B (Switch) was lower than that of all other conditions. Although shifting between extra-dimensional sets develops rapidly in this age range [e.g., Jacques and Zelazo, 2001; Espy et al., submitted], it is unlikely that significant cognitive development occurred in the 30 children during the average 2 week interval. An alternative explanation is that the small item set contributed to greater variability in temporal stability.

Initial data from Espy and Cwik [2004] show that there are substantive differences in latencies to complete each of the TRAILS-P conditions, and that these latency differences are greater for younger preschool children than those for older preschool children. This pattern suggests that there are measurable developmental differences in the cognitive processes required to meet the differing task demands of the conditions. When comparing simple stimulus identification (Condition A, Control) from that requiring simple shifting among sets (Condition B, Switch), it was found that the youngest children took more time to complete the conditions than middle age groups who, in turn, took more time than the 5-year-olds. There was, however, a general reduction in latency to complete the Control vs. Switch Conditions, suggesting that practice effects from the Control condition may have attenuated potential cognitive "costs" associated with shifting.

In Condition C, Reversal, children have to inhibit stamping the previously salient target class (i.e., Cats instead of Dogs). Espy and Cwik found that, regardless of age group, children were able to respond to the simple change in response contingencies, suggesting that the Reversal task is too simple or that this ability develops much earlier and is mature by preschool. The impact of distraction in Condition D was limited largely to the youngest of children, who took disproportionately longer to complete Condition D relative to Condition B.

In terms of errors, Espy and Cwik found no consistent differences in the number of errors among TRAILS-P conditions. The oldest children in that study made fewer errors than the younger children, with no differences between 3- and 4-year olds. Given the strong relation between speed and accuracy, this finding suggests that 4-year-old children are actively learning to modulate their responding, and that the improvement in speed at this age comes with a cost of accuracy. It is only at age five that children can progressively stamp quickly and accurately, switching between relevant sets, reversing response contingencies, and maintaining focus in light of distraction.

Although the TRAILS-P appears to have good psychometric properties and performance varies as a function of condition task demands and child age, evidence for convergent and discriminant validity with other standardized instruments must be demonstrated before more widespread clinical application is undertaken. Further, a different developmental pattern might emerge on a different shifting task. Development in task performance is a function of the child's abilities and cognitive proficiencies, as well as variations in task demands. What might appear to be growth in discrete cognitive abilities may actually be changes in task demands as a function of age.

Initial findings with the TRAILS-P demonstrate the feasibility of adapting prototypical executive function tasks, such as the TMT, for use in young children. The TRAILS-P is unique in this regard, using engaging stimuli with an age appropriate manual response. Based on its psychometric properties, the TRAILS-P may offer a promising tool to assess the processes involved in executive control in young children with neurological, psychiatric, and developmental disorders.

Shape School

Executive tasks, by their very nature, require the control of other more discrete cognitive processes, for example, memory, language, manual coordination, or visual-spatial skills. Most of the executive tasks developed for younger children to date are nonverbal, that is, utilize pictures of objects and a manual response—an advantage for assessing young preschool children with more limited verbal facilities relative to adults. However, with the rapid increase in verbal proficiency in this age range, and the importance of executive skills in the more verbally laden academic context that marks the end of the preschool period as they transition to formal schooling, it would be useful to have tools to assess individual variances in executive abilities that utilize verbal information. It may be that performance on such tasks may be more highly related to outcomes of interest that load heavily on verbal skills, such as reading and mathematics. The purpose of the Shape School was to develop an executive function task for use with preschool children, sensitive to maturation, but where inhibition and switching processes were separated, given that cognitive processes differ maturationally and contribute uniquely to executive skill development.

The Shape School includes four conditions: A, B, C, and D. It also uses the familiar and appealing storybook format to build conflict between the stimulus properties and the response demand. The story begins with a depiction of a school yard, with colorful circle and square figures playing. In the A "Control" condition, the child is told that the pupil's name is the figure color (i.e., red, yellow, or blue). The story continues with the pupils "lining up" to go into school from the play yard. The child is instructed to name the pupils in order (i.e., name the figures' colors) as fast as possible without making any errors. The Control condition establishes the relation between stimulus properties (color) and response (naming stimulus color). Although the conflicting shape information is present in each stimulus, it is not yet identified as relevant to naming. An advantage of this condition is the potential to disambiguate the contribution of basic psychomotor speed from executive abilities. In the B condition, the figures have two facial expressions, either happy or frustrated, depending on whether the pupil "is ready for lunch." The child is instructed, in this condition, to name the pupils who were ready for lunch (i.e., happy-faced) and not to name those frustrated-faced pupils who were not ready. This condition is meant to measure a type of inhibitory process, namely response suppression.

In Conditions C and D, another classroom was added to the story. These pupils wear hats, where their name is the figure shape. In Condition C, all the pupils have neutral faces as in the Control condition. The child is told that pupils are going to story time, and the child is instructed to name the pupils (i.e., color for pupils without hats, shape for pupils with hats). In Condition C, the child must utilize the second conflicting dimension (shape) to name the relevant cued stimuli, which are intermixed with stimuli that are named by the first dimension (color), to assess cognitive shifting. The final condition, D, includes pupils with happy and with frustrated faces, and with and without hats. The child is told that not all pupils are ready for art. The child is instructed to name the happy-faced pupils who are ready for art (i.e., the appropriate color or shape name) and not to name those with frustrated faces, thereby invoking both response suppression and cognitive switching concurrently with the interleaved stimuli.

Because both conditions, B and C, require a relatively constant working memory load of maintaining two rules in mind with overt cues present that signal the correct stimulus-response mapping, and include proactive interference from the same previously active response set, comparing performance on these two conditions among young children of varying ages allows determination of whether the pattern of development of these inhibitory processed is consistent with shared, or unique, inhibitory processes. In like fashion, comparing Conditions B, C, and D to that of A yields a comparison of the cognitive "costs" of executive processing, relative to baseline naming speed assessed in Condition A.

Response time and number of stimuli correctly identified (according to the pertinent rule) in each condition from when the child begins naming the first figure to when they finish naming the figures in the array are recorded. For each condition, an efficiency score can also be calculated by dividing the number of stimuli correctly named by the latency to complete each condition [Efficiency = (the number of correct – the number of errors)/total time].

Evidence for reliability was examined by calculating the test–retest reliability coefficients for each Shape School Condition from data of 18 young children who were administered the Shape School twice, and by calculating the internal consistencies (Cronbach's α coefficients) for each Shape School condition using naming accuracy on each of the 15 figures in the conditions [Kaiser et al., 2004). To minimize restrictions on the underlying latency-based variable distributions, Spearman correlations were used for test–retest reliability. The test–retest correlations for completion time range from 0.65 to 0.78. Using the efficiency scores resulted in similar values, with the exception of that for Condition C, which was below acceptable test standards. Given the unique relation between speed and accuracy in this condition (evidenced by the positive correlation, rather than the commonly observed negative relation for the other conditions), the test–retest correlation between the Condition C efficiency scores might not be an accurate reflection of true reliability. Cronbach's α coefficients for each condition exceeded 0.71 for the B, C, and D conditions, where for Condition A, α was 0.56, likely attenuated because of the very high level of naming accuracy in this simple condition. Particularly given the young age of the sample, the magnitudes of these relations suggest good evidence for reliability [Espy et al., in press].

Studies of Shape School performance suggest that the executive functions of response suppression and cognitive shifting may be differentiated in even very young children, but that performance on the Shape School conditions varies somewhat with age group. In a recent analysis of 219 children who completed the Shape School [Espy et al., 2004], there were developmental differences in performance on the control Condition A, where the time to complete Condition A, B, C, and D varied by child's age group, but not the number of stimuli correctly named. Of note is the high degree of naming accuracy across conditions across ages, suggesting that the basic verbal demands of the task were not sufficiently challenging as to impair the measurement of the executive components of task performance. In the planned contrasts between adjacent age groups, differences in completion time were evident between the middle (children between than 4.5 and 5.0 years) and older (children older than 5.1 years) groups for both Conditions B and C. This pattern of performance differences across age groups and conditions is evident in Table 1. For Condition B, there was a progressive decrement in completion time across age groups, as older children took less time to complete the condition than those in the middle age group, who, in turn, took less time than the youngest age group. For Condition C, the middle age preschool children took more time on average to complete the condition than the youngest children, but completed the condition in less time than older children.

Although it is tempting to conclude from these findings that response suppression and cognitive switching skills have somewhat differing developmental timetables, further longitudinal studies are needed to adequately address this question. Furthermore, evidence for validity is sorely needed to better establish

Table 1. Normative Performance on Shape School by Age Group and Condition

Variable	Younger (n = 78)		Middle (n = 66)		Older (n = 75)	
	M	SD	M	SD	M	SD
Condition A						
Correct	14.94	0.27	14.88	0.48	14.95	0.28
Time (sec)	25.11	9.95	22.77	7.87	20.38	9.15
Efficiency	0.68	0.23	0.72	0.22	0.82	0.23
Condition B						
Correct	14.18	1.50	14.26	1.38	14.59	0.99
Time (sec)	30.74	16.16	27.59	16.71	21.89	9.70
Efficiency	0.58	0.26	0.67	0.30	0.78	0.30
Condition C						
Correct	11.60	3.24	12.00	2.86	12.37	2.88
Time (sec)	49.12	20.37	51.58	18.43	41.96	17.26
Efficiency	0.26	0.10	0.26	0.10	0.34	0.15
Condition D						
Correct	11.83	2.56	12.30	2.25	12.68	2.21
Time (sec)	52.17	26.17	46.98	19.55	39.96	20.64
Efficiency	0.29	0.17	0.31	0.14	0.39	0.17

Efficiency = Number of correctly identified stimuli/completion time. Younger, ≤ 4.6 years; middle, > 4.6 years and ≤ 5 years; and older, > 5.1 years.

differential sensitivity and basis for measurement. It would be useful to determine whether the Shape School captures performance differences in children with neurological, medical, psychiatric, and developmental disorders relative to those who are typically developing. The ability to reveal different executive processing profiles in response suppression and cognitive shifting may shed light on important and dynamic brain-behavior relations in this developmental period. Although there are emerging novel approaches to measuring executive control in this age range, there remains comparatively few tasks for which the psychometric properties have been explored [e.g., Espy and Cwik, 2004] or that utilize verbal responses. Critically, it will also be important to determine whether the executive aspect of performance on the more verbally based Shape School task is related to that of those tasks that utilize visual stimuli and manual responses, and whether Shape School performance relates to other important outcomes. Taken together, these findings suggest that the Shape School may be an effective measure of executive function in preschool children, particularly to distinguish among differing inhibitory processes and demand costs of executive processing more broadly.

BRIEF-Preschool Version

The BRIEF-P was developed to capture executive function as manifested in the everyday behavior of preschool-aged children, based on the premise that measurement of executive functions is possible when a developmentally appropriate behavioral repertoire is sampled [Wellman, 1988]. Examination of everyday behavior is a complementary approach to performance test assessment of executive functions in preschool children. The child's everyday environments, both at home and at school/ or daycare, are important venues for observing routine manifestations of the executive functions. This methodology has been employed in the measurement of executive function in school-aged children and adolescents with the development of the BRIEF[Gioia et al., 2000]. The original BRIEF is a parent- and teacher-completed rating scale tapping eight theoretically and empirically derived subdomains of executive function as observed through everyday behaviors in children aged from 5 to 18 years. Studies to date suggest that the BRIEF exhibits appropriate internal consistency, temporal stability, and evidence of validity based on convergence/divergence with a variety of measures and on internal factor structure [Gioia et al., 2000]. The instrument also captures profiles of executive functions that differ across common developmental and acquired disorders including ADHD, ASD, TBI, and reading disorders [Gioia et al., 2002]. Such rating scale methodology adds a complementary ecological validity dimension to clinical assessment of executive function [Silver, 2000; Gioia and Isquith, 2004]. Capitalizing on parents and teachers as valuable sources of data high in ecological validity, we explored modification and application of the original BRIEF for assessing executive functions in preschool-aged children.

The BRIEF-P [Gioia et al., 2002] is a 63-item parent/ teacher completed rating scale for children aged from 2 to 5 years with items composing five executive domains: Inhibit (16 items), Shift (10 items), Emotional Control (10 items), Working Memory (17 items), and Plan/ Organize (10 items). The scales are summarized in three overlapping indexes: Inhibitory Self-Control (Inhibit and Emotional Control), Flexibility (Shift and Emotional Control), and Emergent Metacognition (Working Memory and Plan/Organize). The BRIEF-P requires an approximately fifth-grade reading level and 10–15 minutes to complete. Parents, teachers, daycare providers, or other caregivers are asked to rate each item as to whether it is never, sometimes, or often a problem for the child (e.g., "Is impulsive"). Responses to items comprising each scale are summed (*never* = 1, *sometimes* = 2, *often* = 3) and compared with normative values in tables for two age groups (2–3-year-olds and 4–5-year-olds) separately by gender (boys and girls). Indexes are calculated and referenced to normative values in a similar fashion. The manual provides T scores, percentiles, and 90% confidence intervals for scales and indexes. The BRIEF-P can be administered by technically trained individuals, but should be interpreted in the context of an assessment by appropriately trained professionals, including psychologists, neuropsychologists, and psychiatrists.

Gioia et al. [2002] report internal consistency (Cronbach's α's) for parent ratings on the preschool BRIEF scales and total score as follows: Inhibit α = 0.90, Shift α = 0.85, Emotional Control α = 0.86, Working Memory α = 0.88, Plan/Organize α = 0.80, Global Executive Composite α = 0.95. Cronbach's α's for teacher ratings were: Inhibit α = 0.94, Shift α = 0.90, Emotional Control α = 0.91, Working Memory α = 0.94, Plan/ Organize α = 0.97, Global Executive Composite α = 0.97. Pearson correlations were calculated to examine the temporal stability of parent ratings on the preschool BRIEF over an average interval of 4.5 weeks (range 1–9 weeks). Correlations were: Inhibit r = 0.90, Shift r = 0.88, Emotional Control r = 0.87, Working Memory r = 0.85, Plan/Organize r = 0.78, total score r = 0.90. Teacher ratings over an average of 4.2 weeks (range 2–6 weeks) resulted in similar test–retest stability: Inhibit r = 0.94, Shift r = 0.65, Emotional Control r = 0.83, Working Memory r = 0.88, Plan/ Organize r = 0.85, Global Executive Composite r =

0.88. These findings suggest appropriate internal consistency and temporal stability for the BRIEF-P scales.

Evidence of validity is based on factor analysis of clinical and normative samples, convergence/discriminance with several preschool rating scale measures including the Child Behavior Checklist [Achenbach and Rescorla, 2000] and Behavior Assessment System for Children [Reynolds and Kamphaus, 1992], and on ability to detect executive function deficits in children with risk factors or disorders. The factor analytic studies [Isquith et al., 2004] support the index structure of the BRIEF-P (i.e., Inhibitory Self-Control, Flexibility, and Emergent Metacognition). The BRIEF-P scales correlate logically and coherently with other measures of behavior and attentional functioning. Isquith et al. [2004] found large effect sizes for all BRIEF-P scales comparing both teacher and parent reports in a mixed group of clinically referred preschool children. Executive behaviors in the clinical group were rated consistently as more problematic than in the normative sample, across all domains assessed by the preschool BRIEF.

In essence, the preschool adaptation of the original BRIEF everyday behavior rating methodology for the measurement of executive behavior of preschoolers yielded an internally consistent, temporally stable instrument, with an internal structure consistent with the multi-domain construct of executive functioning in preschool-aged children [Hughes, 1998; Espy et al., 1999] that was sensitive to atypical variations in executive function development.

Conclusions

Clinical assessment of executive function in preschool-aged children remains challenging for several reasons, including the more limited and more variable development of verbal, motor, attentional, and likely executive functioning in this age group, but also an historical view of younger children as lacking in executive capacity. As with much of psychological assessment, methods and tools for measuring executive functions were first developed for adults, then applied in original form or modified somewhat for adolescents and eventually children in a "top down" approach. More recently, developmental neuropsychologists have provided an increasing array of experimental assessment tools designed from the "bottom up," that is, measurement from a developmental perspective.

Although this increasing menagerie of assessment tools designed to assess executive control in young children shows promise in experimental studies, normative data are typically scant and evidence for reliability and validity is limited, rendering such tests less useful in the clinical context where interpretation of findings is paramount. Such evidence is emerging, however, for the measures presented here. For both the Shape School and Trails-P, there was evidence of good reliability, based both on coefficient α's showing appropriate internal consistency and on the correlation between performance at test and retest administrations, ~2 weeks apart, showing adequate temporal stability. These reliability indicators are on a par with extant clinical measures, such as those reported for the NEPSY executive/attention subtests designed for this age range [Korkman et al., 1998]. Temporal stability for neuropsychological instruments versus cognitive or academic batteries is inherently lower, given the greater practice effects particularly for executive measures versus more crystallized abilities such as vocabulary and knowledge base as measured via cognitive batteries. Although early evidence of reliability and validity for preschool executive function measures is encouraging, more work is needed with clinical groups of preschool children with known risk factors such as severe prematurity, early central nervous system infections, or neural tube defects. It may be particularly informative to examine performance on these measures in preemies with intraventricular hemorrhages given the greater likelihood of localization, thus increasing the potential for teasing apart neuroanatomical contributions to different inhibitory processes.

As a complement to the developing toolkit of performance tasks designed to assess executive functions with high internal validity and experimental control, parent, teacher, or caregiver reports of the preschool child's everyday, real-world functioning add a high degree of ecological validity to understanding behavioral manifestations of executive dysfunction. The BRIEF-P provides a convenient means of capturing children's executive function in an ecologically valid fashion, and demonstrates appropriate evidence for reliability and validity for use in the clinical context. On the other hand, this rating scale method also carries limitations, as the focus is on a more global view of executive function in the everyday context with less process-specific information. This behavioral rating methodology is viewed best as a tool that is complementary to developmentally appropriate cognitive performance tests that measure the specific executive function processes. Furthermore, rating scale methods depend on informant ratings, and therefore may be affected by rater biases, including atypical developmental expectations of behavior by parents or teachers.

Given the hypothesized multifaceted or fractionated models of executive functioning in the developing child, no single measure is likely to be adequate in assessing this complex but critical domain. Further, we would suggest that no single method, such as performance tests or rating scales, is adequate in isolation. Instead, we advocate for model of neuropsychological assessment that explicitly incorporates both the specific process components typically defined by laboratory or performance tests and the more broad real-world behavioral manifestations of the specific processes or components. Any such data must, of course, be interpreted in the context of the environmental factors that impact on the child's function. As new measures of executive function become available for preschool children in the clinical context, this method of balancing internal validity and ecological validity considerations would better guide assessment and the subsequent intervention planning and monitoring. ■

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