Assessing the Behavioral Aspects of Executive Functioning across the Lifespan: Review of Rating Scales and Psychometric Derivation of a Screener for Young Adults

by

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BA, Boston University, 2009

A Thesis Submitted in Partial Fulfillment
of the Requirements for the Degree of

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in the Department of Psychology

Supervisory Committee

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Abstract

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Executive functioning skills are paramount to our ability to purposefully and successfully mediate our actions within our day-to-day environment. Dysfunction of the executive system can result in a multitude of behavioral manifestations in all stages of life. Increasing evidence supports the use of rating scales to obtain a more comprehensive and ecologically valid understanding of an individual's executive functioning. The current thesis involves two articles examining the use of behavioral rating scales in the assessment of executive functions. **Study 1:** In response to a recent proliferation of executive functions rating scales, this article reviews and discusses currently available scales for the assessment of executive functions across the lifespan. **Study 2:** This study derived an executive functions screener from the Behavioral Assessment System for Children (BASC-2-SRP-COL) for use in young adults and evaluated it against a well-known executive function rating scale (the Behavior Rating Inventory of Executive Function-Adult Version).

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Dedication

To Jane Duggan, Michael Duggan, and Michael Mann,

your love and support mean the world to me.

Prologue

The following thesis consists of two related, but distinct, articles examining the use of behavioral rating scales in the assessment of executive functions. The first article is a critical review of behavioral rating scales for the assessment of executive functioning across the lifespan, targeted towards a clinical audience (to be submitted to *Archives of Clinical Neuropsychology*). The second article involves an empirical study designed to derive and assess the convergent validity of a screener for the behavioral assessment of executive functions in young adults (to be submitted to *Psychological Assessment*).

Though these two articles have been prepared as autonomous manuscripts, together they meet the following research aims related to the behavioral assessment of executive functions: (a) reviewing and synthesizing the current methodological approaches and issues relating to executive functions rating scales; (b) deriving an executive functions screener based on empirically supported conceptual and methodological evidence; and (c) evaluating the convergent validity of the derived screener and its potential as a new behavioral rating measure for executive dysfunction in young adults. The autonomous nature of the articles introduces some redundancies within the thesis as a whole, including the reviewed literature and to a lesser extent the individual discussions and conclusions provided; however the articles are written to complement one another and to both contribute to current and future research pertaining to the behavioral assessment of executive functioning.

Chapter 1.

Assessing the Behavioral Aspects of Executive Functioning Across the Lifespan: A Current Review of Rating Scales*

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[*]Adapted from an in preparation manuscript to be submitted to *Archives of Clinical Neuropsychology.*

All work in this chapter was conceived of and carried out by me, with the exception of the critical feedback incorporated into the execution of this review and the writing of this manuscript by my committee members.

Abstract

Executive functioning skills are paramount to our ability to purposefully and successfully mediate our actions within our day-to-day environment. Dysfunction of the executive system can result in a multitude and variety of behavioral manifestations in all stages of life. Increasing evidence supports the use of rating scales, in addition to traditional performance-based measures, to obtain a more comprehensive and ecologically valid understanding of an individual's executive functioning. Growing awareness of the utility and importance of rating scales, as well as increased general interest in executive functioning, has led to a recent proliferation rating scales in this domain. This article provides an up-to-date review of these rating scales for the assessment of executive functions. Additionally, this review seeks to emphasize two aspects of rating scales critical to the interpretation of executive functioning as it changes across the lifespan: (1) the conceptualization of executive functioning serving as the foundation of each scale; and (2) issues surrounding selection of the individual providing the ratings within the lifespan context. This article concludes with a discussion of the clinical implications surrounding the use of rating scales for the assessment of executive functioning.

Keywords: executive function, rating scales, assessment, ecological validity, lifespan

Introduction: The Contributions of Rating Scales to the Assessment of Executive Functioning Across the Lifespan

Executive functions are unique to our experience as human beings and are critical to successful and adaptive everyday functioning. Executive functions support us throughout our lives, helping us navigate academic, workplace, and interpersonal environments and they have been suggested to lie at the heart of all constructive, socially useful, personally enhancing, and creative activities (Lezak, 1982). Furthermore, executive dysfunction can manifest at virtually any point across the lifespan and have profound functional consequences for the day-to-day environment. As a result, improving the operationalization and assessment of executive functions have become essential to capturing behavioral manifestations of executive function or dysfunction (Toplak, West, & Stanovich, 2013).

Historically, assessment of executive function has been limited to laboratory-based tests. Over time, however, clinicians and researchers have come to find that these tests do not always indicate impairments in patients who have clear executive dysfunction in their everyday lives, while at other times they indicate impairments in patients with no evidence of executive problems outside of the test setting (Pennington & Ozonoff, 1996). In an effort to produce a more complete and ecologically valid understanding of executive functioning, a number of rating scales have been developed to assess the behavioral aspects of executive function within an everyday real-world context and potentially serve as an ecological validity index for clinical or laboratory findings (Isquith, Roth, & Gioia, 2013; Silver, 2014; Meltzer & Krishnan, 2007).

In this sense, executive function rating scales were originally intended to serve as complementary measures to traditional assessment methods; however research has since shown that performance-based and rating-based measures assess different aspects of executive functioning and provide important complementary information to clinicians and researchers (Isquith et al., 2013; McAuley, Chen, Goos, Schachar, & Crosbie, 2010; Silver, 2014; Toplak et al., 2013). As a result, executive function rating scales have become useful measures in their own right and are now a typical addition to neuropsychological assessment batteries (Silver, 2014).

While traditional, gold standard laboratory-based tests of executive function (e.g., the Wisconsin Card Sorting Test) have numerous advantages, assessments relying solely on their use run the risk of inaccurately identifying real executive impairments (as alluded to above) or drawing conclusions from findings that may not be representative of the executive functioning in real-life situations (Barkley, 2011, 2014; Stein & Krishnan, 2007). Here, executive function rating scales offer many advantages, but they too are characterized by a series of strengths and limitations.

Some of the primary strengths of executive function rating scales lie in their ability to assess application of executive skills (rather than the functionality of their components), their capacity to capture executive characteristics of everyday functioning in clinical populations, their contributions of distinct information to executive function assessment, and their potential correlations with expected biological markers (Gioia, Kenworthy, & Isquith, 2010; Isquith et al. 2013; Toplak et al., 2013; also see Silver, 2014 for a discussion on the differences between rating scales and performance-based measures). While use of informant reports is common among rating scales, one must recognize that these reports can be influenced by a number of factors, including bias as well as personal, cognitive, or other characteristics of the informants themselves (Grace & Malloy, 2001; Silver, 2014; Gioia, Isquith, & Kenealy, 2008). Additionally, evaluators "have limited control of environmental influences that may affect ratings on behavioral scales [… and it is] more difficult to parse deficits in specific executive functions via reported behaviors in [an] everyday context than via more narrowly focused performance measures" (Isquith et al., 2012, p. 3).

Considering the balance between the strengths and weaknesses of laboratory-based and rating scale measures, neuropsychologists are now recommended to include both in their evaluations as a means of capturing a diversified yet comprehensive range of quantitative and qualitative aspects characteristic of the multidimensional nature of executive function (Cripe, 1996; Gioia et al., 2008; Stein & Krishnan, 2007). Some even conjecture that neuropsychologists have an ethical responsibility to include more ecologically valid tasks and behavioral ratings in a neuropsychological assessment in order to relate results "more closely to the actual day-to-day behavior and functioning [of a] patient" (Moberg & Kniele, 2006, p. 106).

Since executive function rating scales were developed with ecological validity and practical utility in mind, it is perhaps surprising that the various scales available for assessment across the lifespan have been largely developed for specific age ranges and subsequently extended in an upward or downward fashion for use at different points in the lifespan. This narrow approach is not exclusive to executive function rating scales, or even executive function assessment; rather, researchers recognize that there is limited integration between methods and theories from the disciplines of cognitive development and cognitive aging (Craik & Bialystok, 2006).

With the recent proliferation of executive function rating scales, as well as the increasing general interest in both executive function and ecologically valid assessment approaches, it is important to critically review these measures in order to facilitate selection of the most appropriate assessment measures in clinical and research settings, to encourage continuity of knowledge and practice, and to identify potential limitations and areas for future improvement. As such, this article starts with a brief overview of current conceptualizations of executive function and its development. The remainder of the article is dedicated to a review of a selection of executive function rating scales. These include scales with versions for children and adults: the Barkley Deficits in Executive Function Scales (BDEFS-CA and the BDEFS), the Behavior Rating Inventory of Executive Functions (BRIEF-P, BRIEF, BRIEF-SR, and BRIEF-A), and the Dysexecutive Questionnaire (DEX-C and DEX); scales just for use with children and adolescents: the Behavior Assessment System for Children (BASC), the Childhood Executive Functioning Inventory (CHEXI), the (CEFI), and the Delis-Rating of Executive Function (D-REF); and scales for use with adults only: the Executive Function Index (EFI) and the Frontal Behavioral Inventory (FrSBe). The article concludes with a discussion of the current and future clinical and research implications surrounding the use of these scales and their continued development.

Conceptualizing Executive Functions Across the Lifespan

Defining Executive Function

Fundamentally, executive functions enable purposeful, goal-directed, and problem-solving behavior in the everyday, “real world” environment (Goldstein, Naglieri, Princiotta, & Otero, 2014; Gioia et al., 2008). Although successful executive functioning appears to manifest itself in successful problem solving, executive function is now widely understood as an umbrella term used for a diversity of self-regulatory functions that control, organize, and direct cognitive ability, emotional responses, and behavior (Anderson, 2008; Duggan, & Garcia-Barrera, 2014; Miyake et al. 2000). As such, executive functions are complex, difficult to define and notoriously challenging to assess and experimentally characterize. Numerous theoretical models have been proposed, some of which have garnered empirical support; however, none have been unanimously accepted.

Theories of executive functioning can be characterized broadly as falling into one of several main categories. In terms of the neural basis of executive functioning, some theories focus on the organization of the prefrontal cortex and the top-down organization of its networks (e.g., Miller & Cohen, 2001), while others describe the hierarchical and temporal organization of information processing involved in volitional behavior (e.g., Koechlin & Summerfield, 2007). Another category of theories concentrate on the basic cognitive operations of executive functioning (e.g., Friedman & Miyake, 2004; Miyake, Friedman, Emerson, Witzki, Howerter, & Wager, 2000), which has been useful in investigating the neural correlates (e.g., Collette et al., 2005) and genetics of executive functions (e.g., Friedman, Miyake, Young, DeFries, Corley, & Hewitt, 2008). There are some theories, which are more process-oriented (e.g., Zelazo & Carlson, 2012); and those, which are more clinically oriented, exploring, for example, how executive behavior is affected after brain damage (e.g., the work of Donald Stuss) or in the presence of a neurodevelopmental disorder (e.g., the work of Russell Barkley). Additional theories and conceptualizations of executive function emphasize behavior that is "executive" in nature (e.g., Denckla, 1996; Jurado & Rosselli, 2007). It is perhaps this latter category that best describes what executive functions rating scales attempt to capture. Jurado and Rosselli (2007), for example, aptly describe executive functions as follows:

> In a constantly changing environment, executive abilities allow us to shift our mind set quickly and adapt to diverse situations while at the same time inhibiting inappropriate behaviors. They enable us to create a plan, initiate its execution, and persevere on the task at hand until its completion. Executive functions mediate the ability to organize our thoughts in a goal directed way and are therefore essential for success in school and work situations, as well as everyday living. (p. 214)

Overall, most categories of theories suggest that a definition of executive function should reflect the integrated (unitary), yet multidimensional (diverse) interactions between cognitive and emotional control processes that result in behavioral outcomes (Garcia-Barrera, Frazer, & Areshenkoff, 2012; Garcia-Barrera, Karr, & Kamphaus, 2013), aimed at the production of volitional, purposeful, and efficient behavior (Lezak, 1982).

Over the last 15 years, significant progress in the conceptualization and operationalization of executive functions has been accomplished through the application of latent variable analysis (Miyake et al., 2000). In their seminal study, Miyake et al. (2000) used confirmatory factor analysis to examine the composition of executive functions. Overall, they extracted three correlated latent variables that contributed differentially to performance on several executive function tasks: mental shifting of attention towards goal-relevant representations (*shifting*), inhibition of goal-irrelevant representations (*inhibiting*), and fluid updating and monitoring of mental representations in working memory as a goal is planned and executed (*updating*). While Miyake, Friedman and colleagues have been clear in noting that these three components are neither exclusive (Miyake et al., 2000), nor fundamental to executive functioning as a whole (e.g., recent work questions the distinctiveness of inhibition; Miyake & Friedman, 2012), their approach helped demonstrate that executive functions are distinguishable, yet share some underlying commonality.

A considerable amount of research has since been dedicated to examining the latent structure (and isolating other components) of executive abilities, and the latent variable approach continues to serve as a mainstay for advancing knowledge about the structure and development of executive functions (Best & Miller, 2010; Duggan & Garcia-Barrera, 2014; Naglieri & Goldstein, 2014b). Furthermore, the latent variable approach has been integral to the process of developing executive functions rating scales. Development of the scale items should be initially guided by a careful conceptualization and definition of executive function and observable executive function behaviors, with appropriate consideration of the targeted age span and instrument purpose (e.g., assessing executive dysfunction versus normative executive functioning; Naglieri & Goldstein, 2014a). The psychometric properties (e.g., the factor structure of the item set, or the correlations of items designed to measure the same construct) of a scale should correspond with the definition used in its development (Naglieri & Goldstein, 2014a), as well as the (relatively) consensus conceptualization of executive functioning as an integrated but multidimensional construct.

The Development of Executive Function Across the Lifespan

Executive abilities are now known to develop and change over the lifespan and consideration of the developmental trajectories of these abilities from childhood to adulthood is of great relevance in research and in assessment (Barkley, 2014; Salthouse, 2011; Salthouse, Atkinson, & Berish, 2003; Zelazo, Craik, & Booth, 2004). Despite the publication of an estimated 3000 scientific articles addressing aspects of executive functioning over the last 15 years (Wasserman & Wasserman, 2013), numerous limitations, including the absence of a consensus definition of executive function, the lack of agreement about its specific components, and the difficulty associated with its reliable measurement, have contributed to the challenges associated with understanding humans' ability to exert self-regulatory, goal-oriented, conscious control over action. Furthermore, when defined as outcomes, executive functions are highly variable across subjects and overtime, and much research examining the development of executive functions has been restricted to narrow age ranges and disproportionately focused on the preschool/early childhood years (Best & Miller, 2010). Consequently, we do not currently have an integrated empirical characterization of executive function development across the lifespan.

Just as there are various approaches to conceptualizing executive functions, so too are there various approaches to investigating the development of executive functions. Numerous studies, for example, have related the emergence of executive capacities, as well as age-related improvements in executive functioning, to the ongoing maturation of the frontal lobes, and in particular, the prefrontal cortices, which are considered to play an integral role in subserving and coordinating executive abilities (Alvarez & Emory, 2006; Hughes, 2011; Jurado & Rosselli, 2007; Romine & Reynolds, 2005; Yuan & Raz, 2014). Some findings from the neuroimaging literature also indicate that executive function may recruit different brain regions over time, suggesting that executive function may operate differently at discrete developmental periods (Moran & Gardner, 2007). Furthermore, as individuals age, reduction in neuronal network connectivity and structural atrophy progression, beginning primarily with the frontal regions, is associated with patterns of cognitive decline, including decline in executive function (Craik & Bialystok, 2006; Jurado & Rosselli, 2007).

A significant proportion of studies examining the development of executive functioning employ a components or latent variable approach in order to determine when specific executive functions emerge, show greatest improvements, and reach maturity (Best & Miller, 2010). Overall, research indicates that the development of the executive function system follows an inverted U-shaped developmental trajectory, which varies individually across executive abilities, but generally follows a unitary to multidimensional gradient (Balinsky, 1941; De Luca & Leventer, 2008; also discussed in Anstey, Hofer, & Luszcz, 2003; Duggan & Garcia-Barrera, 2014). Briefly, empirical evidence indicates that executive functioning emerges early in life. Executive functioning skills have been reported as early as 1 year of age, can be reliably elicited in children as young as 3 years (Anderson, Anderson, Jacobs, & Spencer Smith, 2008; Zelazo, Craik, et al., 2004), and show major advances during the preschool period (Espy, Bull, Martin, & Stroup, 2006; Espy & Cwik, 2004; Müller, Kerns, & Konkin, 2012). Early in development executive functions are essentially a unitary system (Hughes, Ensor, Wilson, & Graham, 2009; Wiebe, Sheffield, Nelson, Clark, Chevalier, & Espy, 2011), which develops and refines throughout childhood (Best & Miller, 2010; Willoughby, Writh, Blair, & The Family Life Project Investigators, 2012). Specifically, they differentiate into a multidimensional system (e.g., factor structures of multiple components) throughout childhood and into adolescence and early adulthood, with some executive abilities reaching full maturity and developmentally plateauing in the teenage years, and others unfolding well into young adulthood (Best, Miller, & Naglieri, 2011; Brocki & Bohlin, 2004; Garon, Bryson, & Smith, 2008; Huizinga, Dolan, & van der Modlen, 2006; Lee, Bull, & Ho, 2013; McAuley & White, 2011; Rose, Feldman, & Jankowski, 2012; Shing, Lindenberger, Diamond, Li, & Davidson, 2010). While the multidimensionality of executive functions appears to remain somewhat stable throughout earlier adulthood (McAuley & White, 2011; Testa, Bennett, & Ponsford, 2012), little is established about their potentially interesting changes in middle age (Garden, Phillips, & McPherson, 2001; Stevens, Skudlarski, Pearlson, & Calhoun, 2009), and patterns of decline in later adulthood (Jurado & Rosselli, 2007; Gregory, Nettelbeck, Howard, & Wilson, 2009; Nettelbeck & Burns, 2010).

This inverted U-shaped trajectory is consistent with recent models of higher-order cognitive functions indicating neural specialization and fractionation during early neurodevelopmental stages (Tsujimoto, 2008), as well as Werner's (1957) orthogenetic principle, which states that development proceeds from a state of lack of differentiation to one of increasing differentiation, articulation, and hierarchical integration. It is important to keep in mind that executive function "starts as much as infrastructure for other cognitive systems as overseer thereof; [executive function] develops in a constant back-and-forth, up-and-down, interactive, looping fashion involving other cognitive domains" Denckla, 2007, p.7). Interactions between neurophysiologic and cognitive changes, however, are nonlinear, dynamic, and significantly moderated by genetic, environmental and social factors (Baltes, 1987). For example, "emotional executive functions (such as attentional control" appear to emerge earlier in life than "metacognitive executive functions (such as planning and verbal fluency)" (Ardila, 2013, p. 82); yet maturation of emotion regulation processes may developmentally lag behind others, such as those associated with abstract problem solving (Zelazo & Carlson, 2012). In addition to quantitative changes to the executive system (i.e., strategies and processes that improve with age), development of executive functions also undergoes qualitative functional changes (e.g., cognitive processes and strategies supported with different neural activation patterns or shifts in organization; Best & Miller, 2010; Chevalier, Huber, Wiebe, & Espy, 2013).

Few studies have examined the developmental trajectory of executive functions as measured with rating scales. In most instances, information regarding differences across ages is limited to details provided in the various rating scale manuals regarding the development of their norms, or through studies examining rating scale measurement-invariance (e.g., Fournet et al., 2014; Garcia-Barrera, Karr, & Kamphaus, 2013). While executive functions research has generally been limited to narrow age ranges, executive functions rating scales have been developed for use across broad age ranges. Given this difference and the lack of an integrated developmental account across the lifespan, it is not clear if executive function rating scales adequately capture or address issues of developmental significance to everyday executive functioning.

Review of Rating Scales

The primary goal of this article is to provide readers with a review of measures that were specifically developed to assess everyday behavioral manifestations of executive functions in children and adults. This includes the review of several recently published and commercially available rating scales that were not available at the time of previous reviews (i.e., Barkley Deficits in Executive Function Scale (BDEFS); Childhood Executive Functioning Inventory (CHEXI); Comprehensive Executive Function Inventory (CEFI) Delis Rating of Executive Functions (D-REF); and Dysexecutive Questionnaire for Children (DEX-C)). This review also includes some information that is repetitious with other recently published reviews (see Malloy & Grace, 2005; Gioia et al., 2008; Naglieri & Goldstein, 2014b); however, it is included here in the interest of providing a comprehensive review and to aide in making comparisons between scales.

Each review is conducted, in particular, to assist clinicians and researchers in addressing two issues key issues. First, how does each scale operationally define executive function? Given the variety of theoretical frameworks defining the construct, it is important to understand how each scale defines and measures executive functioning. This not only guides appropriate instrument selection, but also facilitates informed comparisons between measures. Second, what rating scales are available to particular ages and to what extent does each scale take developmental considerations into account? Executive functioning is changing over the course of the entire lifespan and executive dysfunction can be developmental (e.g., relating to neurodevelopmental and clinical disorders such as ADHD or FASD) or acquired in nature (e.g., relating to acquired brain injury, neurodegenerative processes, or environmental factors). Thus executive dysfunction is often slow to fully express behaviorally, is inherently chronic, or is more likely to emerge at particular points across the lifespan than others.

With regard to these two issues, the following reviews are organized under the headings: *Rating Scales for Children and Adults*, *Rating Scales for Children and Adolescents*, and *Rating Scales for Adults*. The reviews also include two sections (*Conceptual framework* and *Selection of raters*) that are intended to provide the reader with information in line with the goals articulated above. To the authors' knowledge, this is the first executive function rating scale review integrating measures for use across the lifespan, and providing discussion about the conceptual framework of each reviewed scale. All rating scales reviewed below are summarized in Table 1.1.

Rating Scales for Children and Adults

Barkley Deficits in Executive Function Scale (BDEFS) and Barkley Deficits in Executive Functioning Scale—Children and Adolescents (BDEFS-CA)

Description The Barkley Deficits in Executive Function Scale (BDEFS; Barkley, 2011) is designed to capture executive function deficits in daily life activities for adults ages 18 to 81. The BDEFS was developed for clinical use and is intended for the evaluation of executive dysfunction symptoms in high-risk or clinic-referred adults, rather than for the assessment of normative executive functioning in the general population. The BDEFS includes a long form consisting of 89 items and a short form consisting of 20 items (selected from the long form), all scored on a 4-point Likert scale:

rarely or not at all, sometimes, often, and *very often*. Self-report and informant report versions are available for both forms, and an interview form, based on the short form, is also available.

The Barkley Deficits in Executive Functioning Scale—Children and Adolescents (BDEFS-CA; Barkley, 2012) was recently developed to evaluate clinically significant dimensions of executive functioning in children and adolescents ages 6 to 17. The BDEFS-CA was created as a downward extension of the adult BDEFS and includes a long form (70 items) and a short form (20 items) scored on the same 4-point Likert scale as the BDEFS. Both forms are available in parent-report format only, and an interview form (based on the short form) is available for cases in which a parent is unable to complete the rating scale.

The long forms of the BDEFS and the BDEFS-CA are scored by calculating the totals for each of the five scales: Self-Management to Time, Self-Organization and Problem-Solving, Self-Restraint, Self-Motivation, and Self-Regulation of Emotion. Additionally, the instrument yields a total executive functioning summary score (the total of the five scales), symptom count (number of items rated as occurring *often* or *very often*), and an ADHD-executive function index score (with higher score indicating greater likelihood for a clinical diagnosis of ADHD). The short form versions of the BDEFS, intended for quick screening, are scored to yield a total executive functioning summary score. The manuals indicate that results from the BDEFS and BDEFS-CA can be interpreted using four different approaches by: 1) interpreting the meaning of each scale separately by identifying high subscale scores and individual items; 2) making normative comparisons (percentile scores based on sex and age group; 3) conducting risk analysis to aid in clinical interpretation with respect to major domains of life activity beyond the BDEFS subscales; and 4) assessing change in patients resulting from treatment. All of the BDEFS materials are provided in the manual and the publisher of the BDEFS has provided individual purchasers limited permission to photocopy the scales and score sheets for clinical or research practice.

Conceptual Framework. The BDEFS is principally developed from Barkley's model of executive functioning (1997a, 1997b), which conceptualizes executive functioning as self-regulation (goal-directed actions altering individual behavior) directed towards future consequences. More specifically, Barkley proposes five self-regulatory actions that comprise the component functions of executive functioning: self-inhibition, self-directed sensory-motor action, self-directed private speech, self-directed emotion/motivation, and self-directed play (reconstitution). Barkley also indicates that his conceptualization of executive functioning has been developed in consideration of and conjunction with the "larger literature on the nature of executive functioning (e.g., Denckla, 1996; Fuster, 1997; Lyon & Krasnegor, 1996; Stuss & Benson, 1986) and the rich and lengthy history of descriptions of the symptoms of patients with [prefrontal cortex] injuries (Luria, 1996)" (original citations, Barkley, 2014, p. 249).

Barkley's model of executive functioning was largely developed through his work examining and characterizing executive function deficits in individuals with ADHD (Barkley, 2011, 2012, 2014). As such, the BDEFS was originally developed to evaluate executive dysfunction in daily life activities in adults and children with ADHD. The BDEFS item pool was developed to reflect the interrelated constructs (which were subsequently supported through factor analysis) that contribute to the temporal self-organization of behavior for the attainment of future goals central to Barkley's model: "inhibition, nonverbal working memory (self-directed private speech, verbal contemplation of one's behavior before acting, etc.), emotional-motivational self-regulation (inhibiting emotion, motivating one's self during boring activities, etc.), and reconstitution (generativity, planning, problem-solving, and goal-directed inventiveness)" (Barkley, 2014, p. 249).

Selection of Raters. Aside from the typical standard of practice for the administration of rating scales, specific considerations for the selection of raters is not provided for any of the versions of the BDEFS and BDEFS-CA.

Norms. Norms for the BDEFS were developed using a sample of 1,249 adults ages 18 to 81, representative of the US general population (relative to the 2000 US Census), with equal (or nearly equal) representation of males and females, and age groups (generally stratified by decade). Norms (percentiles) in the BDEFS manual are provided for men and women in four age ranges: 18-34 years (n=305), 35-49 (n=316), 50-64 (n=322), and 65-81 (n=275; Barkley, 2011). Interestingly, age correlated to a small but significant degree (*r*'s = -0.13 to -0.08) with all the scores (Self-Management to Time, Self-Restraint, Self-Regulation of Emotion, Self-Motivation, and Total EF Summary Score) except one (Self-Organization). In relation to these findings, Barkley notes "there is a decline of about 10% in EF deficits across the six age groups between the youngest and oldest [and this decline] could reflect merely cohort effect, true developmental decline in such deficits, or differential survival rates in which individuals with higher EF deficits die younger than those with lower levels" (Barkley, 2014, p. 251).

Similarly, norms for the BDEFS-CA were developed based on a nationally representative sample of 1,800 children with equal representation of mothers and fathers and boys and girls, and proportional representation of geographic regions (relative to the 2000 US Census). Norms (percentiles) in the BDEFS-CA manual are provided for boys and girls in two age ranges: 6-11 years and 12-17 years (Barkley, 2012).

The normative samples for both the BDEFS and BDEFS-CA were “not filtered to remove individuals with developmental, learning, psychiatric, or medical disorders or [in the case of the BDEFS-CA] those children receiving psychiatric medication or special education services, as has been reportedly done with other EF rating scales (Gioia et al, 2000)” in order to ensure representation of the general US population (Barkley, 2014, p. 252). Norms are not available for the interview versions of the scale; however, in studies with the adult BDEFS, interview and ratings results were highly correlated (Barkley, 2011, 2014).

Reliability. Support for the reliability of the BDEFS is provided through high internal consistency of scale scores (Cronbach’s alpha ranging from 0.91 to 0.95), adequate interobserver agreement (0.66 to 0.79), and adequate test-retest reliability (0.62 to 0.90 across scales, 0.84 for the Total EF summary score over a 2-3-week interval) (Barkley, 2011; Barkley & Murphy, 2011). Similarly, reliability of the BDEFS-CA is evidenced through high internal consistency of scale scores (0.95 to 0.97), and high test-retest reliability (0.73 to 0.82 across scales, 0.82 for the Total EF summary score over a 3-5-week interval; Barkley, 2012, 2014).

Validity. Support for the validity of the BDEFS and BDEFS-CA scale scores is provided through factor analysis, correlations with other executive function rating scales, regression analyses, group comparisons regarding disorder discrimination, and concurrent validity with various measures of functional impairment in major life activities such as family functioning, educational functioning, occupational functioning, social relationships, marriage, driving, financial management, crime and drug use, parenting stress, and offspring psychopathology (Barkley, 2011, 2012, 2014). Recent research provides some evidence that the BDEFS may predict symptom dimensions and relationship, professional, and daily living impairments over and above executive function tasks performance in adults with ADHD (Kamradt, Ullsperger, & Nikolas, 2014). Further evidence for the validity of the BDEFS and BDEFS-CA—particularly through replication—is limited, likely due to the relatively recent publication of these scales. An additional review of the BDEFS is provided elsewhere (Allee-Smith, Winters, Drake, & Joslin, 2013); however, this review does not contain any information about the BDEFS-CA.

Behavior Rating Inventory of Executive Function (BRIEF)

Description. The Behavior Rating Inventory of Executive Function (BRIEF) is a family of four different rating scales designed to examine behavioral manifestations of executive dysfunction in individuals ranging from 2 to 90 years of age. The four versions of the BRIEF are: the BRIEF-Preschool (BRIEF-P) for ages 2 to 5 (Gioia, Espy, & Isquith, 2003), the original BRIEF (BRIEF) for ages 5 to 18 (Gioia, Isquith, Guy, Kenworthy, 2000b), the BRIEF-Self Report (BRIEF-SR) for ages 11 to 18 (Guy, Isquith, & Gioia, 2004), and the BRIEF-Adult (BRIEF-A) for ages 18 to 90 (Roth, Isquith, & Gioia, 2005). The BRIEF-P has one report form for parents and teachers, the BRIEF two forms—one for parents and another for teachers, the BRIEF-SR one self-report form, and the BRIEF-A two forms—an informant and a self-report form.

The BRIEF-P consists of 63 questions scored on a 3-point Likert scale: *Never, Sometimes,* and *Often*. The instrument yields *T*-scores for 5 executive domains— inhibit, shift, emotional control, working memory, and plan/organize—loading on 3 factors: emergent metacognition, flexibility, and inhibitory self-control, and a composite—the Global Executive Composite score.

The BRIEF consists of 86 questions scored on a 3-point Likert scale: *Never, Sometimes,* and *Often*. The instrument yields *T*-scores for 8 domains (3 behavioral, 5 cognitive), 2 indexes, and a composite: the inhibit, shift, and emotional control domains (Behavioral Regulation Index), the initiate, working memory, plan/organize, organization of materials, and monitor domains (Metacognitive Index), and the Global Executive Composite score (composite of the two indexes).

The BRIEF-SR consists of 80 questions scored on a 3-point Likert scale: *Never, Sometimes,* and *Often*. The instrument yields *T*-scores for 8 domains (4 behavioral, 4 cognitive), 2 indexes, and a composite: the inhibit, shift, emotional control, and monitor domains (Behavioral Regulation Index), the working memory, plan/organize, organization of materials, and task completion domains (Metacognitive Index), and the Global Executive Composite score (composite of the two indexes).

The BRIEF-A consists of 75 questions scored on a 3-point Likert scale: *Never, Sometimes,* and *Often*. The instrument yields *T*-scores for 9 domains (4 behavioral, 5 cognitive), 2 indexes, and a composite: the inhibit, shift, emotional control, and self-monitor domains (Behavioral Regulation Index), the initiate, working memory, plan/organize, task monitor, and organization of materials domains (Metacognitive Index), and the Global Executive Composite score (composite of the two indexes).

Overall, the individual scales and indices across all versions of the BRIEF are based on their factor structure. Additionally, the BRIEF provides three different validity scales: the Negativity scale (all versions), the Inconsistency scale (all versions), and the Infrequency scale (BRIEF-A).

Conceptual Framework. The original BRIEF was developed as a way to reconcile conflicting information regarding parent and teacher anecdotal reports of children's everyday functioning with their performance on laboratory-based measures of executive functioning. Influenced by their training under a neuropsychological assessment model "articulated by [Holmes-]Bernstein and Waber (1990) that views executive function as a broad umbrella term within which a set of interrelated subdomains could be defined via behavioral manifestations," the authors of the BRIEF developed the instrument by using a guiding framework based on a review of the literature on executive functions across the lifespan (Roth, Lance, Isquith, Fischer, & Griancola, 2013, p. 301). "The resulting model defined executive functions as a collection of interrelated functions, or processes, responsible for goal-directed and cognitive activity, or as the "conductor of the orchestra" that controls, organizes, and directs cognitive activity, behavior, and emotional responses" (p. 302). In their review, most models of executive function included some variants of inhibition, shifting, initiation of goal-directed behavior, planning and organizing, and monitoring; and they posit that these behaviors are supported by working memory capacity (Pennington &

Ozonoff, 1996; their citation) and are reflected in cognition *and* behavior and emotional control (Zelazo, Qu, & Müller, 2004; their citation; Roth et al. 2013, p. 302).

Selection of Raters. Aside from the typical standard of practice for the administration of rating scales, specific considerations for the selection of raters is not provided for any of the versions of the BRIEF. Numerous translations of the BRIEF, for languages and dialects on six continents and for all four of its versions, are currently available and additional translations are in development (Roth, Isquith, & Gioia, 2014).

Norms. Each of the four versions of the BRIEF was normed on a large sample approximated to the US population on key demographic variables including age, gender, ethnicity, geographical population density, and for some of the scales socioeconomic status and parental education. Although the norms for the original BRIEF have drawn some criticism based on the limited geographic representation of the normative sample, Roth et al. respond that "studies including typically developing children from around the world over the past decade have yielded scores consistent with the [original] normative sample" (2014, p. 307). A comprehensive review of the standardization samples for each form of the BRIEF is provided by Roth et al. (2014).

Reliability. Each version of the BRIEF has been shown to demonstrate appropriate internal consistency (BRIEF-P $\alpha = .80$ to .97; BRIEF $\alpha = .80$ to .98; BRIEF-SR $\alpha = .75$ to .96; BRIEF-A $\alpha = .73$ to .98), test-retest reliability (BRIEF-P $r = .65$ to .94; BRIEF $r = .72$ to .92; BRIEF-SR $r = .59$ to .89; BRIEF-A $r = .82$ to .96), inter-rater reliability, and stability over time (BRIEF-P $r = .86$; BRIEF $r = .82$ to .88; BRIEF-SR $r = .77$; BRIEF-A $r = .90$ to .92; Gioia et al., 2003; Gioia et al., 2000b; Guy et al., 2004; Roth et al., 2005 respectively). Mean inter-rater reliability coefficients were low: BRIEF-P (parent-teacher) $r = .19$; BRIEF (parent-teacher) $r = .32$; BRIEF-SR (self-parent) $r = .47$; BRIEF-SR (self-teacher) $r = .28$; and BRIEF-A (self-informant) $r = .57$.

Validity. Several-hundred research articles over the last 20 years have explored the validity and utility of the various forms of the BRIEF. Numerous lines of evidence supporting the validity of the BRIEF have been reported on the basis of content, internal structure, convergence, divergence, and concurrence. Although beyond the scope of this article, recent reviews on the validity of the BRIEF are provided elsewhere (Strauss, Sherman, & Spreen, 2006; Roth et al., 2014).

Dysexecutive Questionnaire (DEX) and the Dysexecutive Questionnaire for Children (DEX-C)

Description. The Dysexecutive Questionnaire (DEX) is part of the Behavioural Assessment of the Dysexecutive Syndrome (BADS; Wilson, Alderman, Burgess, Emslie, & Evans, 1996) in adults (presumably 16 to 87 years old, based on the BADS normative sample), and is designed to gather information on four dimensions of problems typically associated with the Dysexecutive Syndrome: emotional or personality changes, motivational changes, behavioral changes, and cognitive changes. Within these four dimensions, 20 characteristics (corresponding to the 20 DEX items) are measured that the authors submit as being particular to the Dysexecutive Syndrome. The overall aim of the BADS is to predict everyday functional problems arising from the Dysexecutive Syndrome. The DEX consists of 20 items scored on a 5-point (0-4) Likert scale ranging from *Never* to *Very often*. The DEX is intended to provide information that supplements the primary BADS (which consists of six cognitive tests) and it is not factored into the

BADS profile calculation. Two forms, self- and informant reports, of the DEX are available.

More recently, the Behavioural Assessment of Dysexecutive Syndrome has been adapted for children (Behavioural Assessment of Dysexecutive Syndrome Test Battery for Children; BADS-C; Emslie, Wilson, Burden, Nimmo-Smith, & Wilson, 2003) and includes the Dysexecutive Questionnaire (DEX-C). The DEX-C is designed to assess dysexecutive features across four domains: behavioral, motivational, emotional/personality, and cognitive. It consists of 20 items scored on the same 5-point Likert scale as the DEX. The DEX-C an informant report, and is intended to be filled out by teachers and parents of children 7 to 16 years old.

Conceptual Framework. The BADS was developed under the framework of the Dysexecutive Syndrome and aims to improve upon cognitive measures of executive function/dysfunction. The authors of the BADS state that it assesses individual component skills of executive functioning without necessarily tapping into the true nature of the Dysexecutive Syndrome—described as "the ability to initiate [the use of executive skills], monitor their performance and use this information to adjust their behavior" (Burgess & Alderman, 1990, p. 183 as cited in Wilson et al., 1996). Wilson et al. cite two theoretical models as influencing their development of the BADS: 1) the working memory model, which includes the hypothetical construct of a central executive, which has been suggested defective in some patients with executive dysfunction (Baddeley & Hitch, 1974; Baddeley, Logie, Bressi, Della Sala, & Spinnler, 1986; Hartman, Wilson, & Pickering, 1992); 2) the Attentional Control System (Shallice, 1982), which is comprised two attentional mechanisms—a contention scheduling system and a supervisory attentional system, the later of which has been implicated in the Dysexecutive Syndrome. The authors primarily cite the work of Stuss and Benson (1984, 1986) to support the choice of the content of their questions and their sampling of the four broad areas listed above.

The BADS-C, which includes the DEX-C, is a downward extension of the adult BADS and thus draws from the same conceptual models discussed above. Both the BADS and the BADS-C examine the executive functioning areas of flexibility and perseveration, novel problem solving, sequencing, using feedback, planning, impulsivity, and following instructions.

Selection of Raters. Aside from the typical standard of practice for the administration of rating scales, specific considerations for the selection of raters is not provided for any of the versions of the DEX and DEX-C.

Norms. The authors indicate that the DEX is intended to supplement the results of the BADS cognitive battery primarily through the additional provision of qualitative information. Normative data for the DEX are quite limited. The manual provides percentile scores (based on the sum of the 20 items) for the DEX based on a sample of 216 normal subjects and 78 patients with acquired brain damage (in which the structural characteristics and localization of brain damage was not reported). Subsequently, non-clinical samples have been shown to demonstrate (to some degree) behavioral problems captured by the DEX, highlighting the need for normative base rates for the DEX (Chan, 2001).

The BADS-C (including the DEX-C) was normed on a final sample of 265 control children ages 8 to 16 years (and subsequently supplemented with an additional small sample of healthy 7-year olds) balanced for gender across eight age bands, and with consideration for general ability and socioeconomic group representativeness. Additionally, the BADS-C (with DEX-C) was administered to a sample of 114 children with developmental or neurological disorders. Teacher- and parent-ratings were collected for both samples and age-scaled scores and percentiles are provided for each year band.

Reliability. Reliability measures are not reported in the BADS manual. Bennett, Ong, & Ponsford (2005) recently reported high internal consistency ($\alpha = .93$) for family member informant ratings of individuals in an acute rehabilitation setting and reasonable inter-rater reliability (between expert informants); however it should be noted that the investigators used a self-modified version of the questionnaire referred to as the extended-DEX. A subsequent study in neurologic patients reported only moderate correlations between independent, non-clinician raters (Barker, Morton, Morrison, & McGuire, 2011). Independent studies on the reliability and validity of the BADS-C and the DEX-C are sparse (Engel-Yeger, Josman, & Rosenblum, 2009; see validity below).

Validity. The BADS manual reports moderate correlations of informant (but not patient) ratings with individual BADS tests scores. Factor analysis of the BADS indicated three factors: behavior, cognition, and emotion (all of which correlated with the Total BADS score and the two former correlated with various BADS subtests). Subsequent factor analysis revealed five factors: three cognitive factors (Inhibition, Intentionality, and Executive Memory) and two emotion factors (Burgess, Alderman, Evans, Emslie, & Wilson, 1998). Similarly, a study of normal participants and clinical patients with various diagnoses (e.g., stroke, traumatic brain injury, dementia) also found five factors: inhibition, intentionality, knowing-doing, dissociation, "in-resistance" (related to “abstract-thinking problems, confabulation, and perseverance”), and social regulation (Chan, 2001, p. 557).

The DEX has been employed in numerous studies of a wide range of disorders and conditions of clinical interest, and comparisons of informant and expert ratings, as well as evidence for content validity have been mixed, with some studies providing support and others failing to provide support or replicate findings. Recent examination of the factor structure of the DEX in two larger community-dwelling samples (n=468 and n=669, ages 18-97 years) using self-report data revealed that while the three-factor solution reported by Wilson, Evans, Emslie, Alderman, and Burgess (1998) provided relatively the best fit, extremely high factor intercorrelations led the researchers to question their uniqueness and validity, and instead led them to conclude that executive problems were parsimoniously described with one underlying factor (Gerstorf, Siedlecki, Tucker-Drob, & Salthouse, 2008). Additionally, reports of executive dysfunctioning in everyday life was associated with individual differences including age, cognition, education, subjective health, personality and affect. Reports of executive dysfunctioning were moderately frequent throughout adulthood and younger age groups reported more problems than older groups (an effect partially mediated by negative affect), despite executive functioning being known to decline with advancing age.

Using Rasch analysis, Simblett and colleagues found that self- (Simblett & Bateman, 2011) and informant-ratings (Simblett, Badham, Greening, Adlam, Ring, & Bateman, 2012) of executive dysfunction in individuals with acquired brain injury did not perform as a unidimensional, interval-level scale of executive functioning. The findings reported by Simblett et al. (2011, 2012) and Gerstorf et al. (2008) raise some questions about the validity of the DEX and indicate that item content and subscale conceptualization can be improved and that age-related differences in the experience of executive functioning problems are an important consideration for this and likely other executive function rating scales. Additional reviews of the BADS and the DEX are provided elsewhere (Gioia et al., 2008; Chamberlain, 2003; Malloy & Grace, 2005).

The BADS-C manual reports significant correlations ($p < .001$) between the BADS-C total, the DEX-C total scores, and all measures from the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1999). Significant correlations ($p < .001$) were also reported between the DEX-C and all of the BADS-C subtest scores except one (the Water Test). Overall, children from the normative sample with developmental or neurologic disorders were rated significantly higher than controls in number and severity of executive functioning problems. Engel-Yeger et al. (2009) have recently provided support for the construct validity of the BADS-C in a sample of Israeli children aged 8-16 years; however their study does not report any data on the DEX-C. Additional reviews of the BADS-C are available elsewhere (Baron, 2007; Henry & Bettenay, 2010).

Rating Scales for Children and Adolescents

Behavior Assessment System for Children (BASC)

Description. Although the Behavior Assessment System for Children as a whole (BASC; Reynolds & Kamphaus, 1992; BASC—second edition (BASC-2); Reynolds & Kamphaus, 2004) is not an executive function rating scale *per se*, it is worth discussing here for two reasons. First, the BASC-2 includes a content scale for the measurement of executive functioning (referred to as the Executive Functioning content scale; derived from the Frontal-Lobe/Executive Control scale developed for the original BASC;

Reynolds & Kamphaus, 2002), which is designed to identify individuals who experience self-regulation difficulties (see Barringer & Reynolds, 1995, and Reynolds & Kamphaus, 2002, for a complete description of how this scale was developed), Second, there is a growing body of research supporting an additional utility of the BASC in the assessment of executive functioning (see section below).

Briefly, the BASC is an omnibus system for the evaluation of the behaviors and self-perceptions of children. Some of the strengths of the BASC include its multimethod and multidimensional conceptualization, its norms and standardization across different versions, and the utility of its composite scores and scales. As a multimethod system, the BASC gathers information from multiple viewpoints (self- and informant ratings) and it is multidimensional in that it gathers information regarding numerous aspects of behavior and personality including adaptive behaviors (e.g., leadership, social, and study skills), internalizing problems (e.g., anxiety, depression, and withdrawal) and externalizing problems (e.g., conduct, hyperactivity, and aggression). As such, the validity of the BASC for the assessment of symptoms frequently associated with executive dysfunction has been the focus of several studies, particularly for the diagnosis of attention-deficit/hyperactivity disorder (see Garcia-Barrera, Duggan, Karr, & Reynolds, 2014 for an overview).

The Executive Functioning content scale is available for the Preschool (2 to 5), Child (6 to 11), and Adolescent (12 to 21) forms of the BASC-2 Teacher Rating Scales (TRS) and Parent Rating Scales (PRS); however it is unavailable for the Self-Report of Personality (SRP) forms. The Executive Functioning content scale is derived from 7 to 8 items from the TRS (of the 100-139 items total) and 10 to 13 items from the PRS (134-

160 items total) and high Executive Functioning content scale scores (reported as *T*-scores) are more indicative of potential self-regulation difficulties.

Conceptual Framework. The Executive Functioning content scale was originally developed as an 18-item supplemental scale to assist the clinical identification of frontal lobe functioning and executive control problems by measuring behaviors commonly associated with executive dysfunction, such as those frequently observed post brain injury (Reynolds & Kamphaus, 2002). According to the BASC-2 manual, this scale is currently conceptualized as measuring "the ability to control behavior by planning, anticipating, inhibiting, or maintaining goal directed activity, and by reacting appropriately to environmental feedback in a purposeful, meaningful way" (Reynolds & Kamphaus, 2004, p. 87). Additionally, the authors point out that elevated Executive Functioning content scale scores may also be present for individuals with ADHD symptoms (due to their association with frontal-lobe arousal and functional deficits) and/or depression (due to the dopaminergic system's association with frontal-lobe dysfunction).

Selection of Raters. The BASC-2 manual does not provide any guidance on the selection of raters in terms of eliciting a more reliable or valid Executive Functioning content scale score; however it does provide ample discussion of standard procedures appropriate for the consideration and selection of raters and issues that may affect the ratings provided by teacher, parents and child raters.

Norms. The BASC-2, including the Executive Functioning content scale, was normed using a total sample of over 13,000 measures (TRS, PRS, and SRP combined) and developed to reflect the general US population, while clinical norms were developed using samples of children who were diagnosed with, or classified as having, one or more behavioral, emotional, or physical problems.

Reliability. The BASC-2 manual reports internal consistency (coefficient alpha reliabilities) for the Executive Functioning content scale for the general norm samples (Preschool ages 2-3, Preschool ages 4-5, Child ages 6-7, Child ages 8-11, Adolescent ages 12-14, and Adolescent ages 15-18) ranging from .81 to .90 for the TRS and .78 to .85 for the PRS. Internal consistency (coefficient alpha reliabilities) for the Executive Functioning content scale for the clinical norm samples (Preschool-all clinical, Child-all clinical, Child-learning disability, Child-ADHD, Adolescent-all clinical, Adolescent-learning disability, Adolescent-ADHD) ranged from .80 to .89 for the TRS and .81 to .87 for the PRS. Test-retest reliabilities (by age level) ranged from .84 to .91 for the TRS (other-teacher) and .73 to .83 for the PRS (cross-parent).

Validity. When the Executive Functioning content scale (TRS-Child, TRS-Adolescent, PRS-Child, PRS-Adolescent) was compared with the Conners' Teacher and Parent Rating Scales-Revised (Conners, Erhardt, & Sparrow, 1999) correlations were consistently high (.57 to .87) for the Conners' oppositional scale, hyperactivity scale, ADHD Index, and all three Global Indices. The Executive Functioning content scale was also consistently correlated with DSM-IV inattentive, hyperactivity/ impulsivity, and combined subtypes (.42 to .86). Correlations were higher for TRS than PRS.

The PRS was found to strongly correlate with the BRIEF parent form as well (PRS-Child/PRS-Adolescent adjusted correlations): .69/.73 Inhibit, .64/.67 Shift, .69/.74 Emotional Control, .50/.83 Initiate, .60/.68 Working Memory, .54/.74 Plan/Organize, .44/.70 Organization of Materials, .51/.42 Monitor, .75/.69 BRI, .51/.74 MI, .70/.81 GEC.

Alternative Approaches to Executive Function Assessment using the BASC. A series of studies have recently contributed to the development of an alternative approach to assessing executive function using the BASC. These studies derived an executive functioning screener using 25 items on the original BASC-TRS (Garcia-Barrera, Kamphaus, & Bandalos, 2011). This screener differs from the BASC EF content scale in that it is comprised of a wider pool of items that robustly define the behavioral manifestation of executive functioning as the outcome of four latent executive constructs: problem solving, attentional control, behavioral control, and emotional control.

The consistency of this four-factor model has been established across gender, time and different ages (i.e., preschoolers; Karr, Garcia-Barrera, Kerns, Müller, Baron, & Litman, 2013; kindergarteners; Sadeh, Burns, & Sullivan, 2012; and children; Garcia-Barrera et al. 2011). There is also preliminary support for its validity in clinical and cross-cultural samples (i.e., ADHD, Colombian children; Garcia-Barrera, Karr, Duran, Direnfeld, & Pindea, 2014). Although still in development, this approach offers the advantage of providing a statistically and theoretically based measure of executive functions that is embedded within one of the most widely utilized instruments for the behavioral assessment of children.

Childhood Executive Functioning Inventory (CHEXI)

Description. The Childhood Executive Functioning Inventory (CHEXI; Thorell & Nyberg, 2008; Thorell, Eninger, Brocki, & Bohlin, 2012; Thorell & Catale, 2014) is a screening instrument designed for the assessment of everyday executive functioning in children ages 4 to 15. The CHEXI consists of 24 items scored on a 5-point Likert scale (1-5) ranging from *Definitely not true* to *Definitely true*, with higher scores indicating more executive dysfunction. There is one form of the CHEXI, to be completed by parents or teachers. It is available for free on the CHEXI website (www.chexi.se) and comes in several different languages (English, Swedish, French, Spanish, Chinese, and Farsi). The CHEXI includes four subscales—working memory, planning, inhibition, and regulation—which can be examined using the means of their contributing items. An adult version of this instrument (the Adult Executive Functioning Inventory; ADEXI) is currently in development but unpublished as of this date (Thorell & Catale, 2014).

Conceptual Framework. The central aim in the development of the CHEXI was to create an instrument for the behavioral assessment of executive functioning in children that improved upon on some weaknesses the authors identified in other rating scales. Chiefly, Thorell & Nyberg (2008) note that many rating scales, such as the BRIEF, include several items significantly related to the principal symptoms of ADHD (i.e., hyperactivity and inattention). They further discuss that since not all individuals with ADHD have executive function deficits, this "semantic overlap between […] measures of [executive functions] and ADHD symptoms" has the potential to be problematic, particularly in the case of trying to determine how specific dysexecutive behaviors relate to developmental or acquired disabilities associated with executive dysfunction (p. 538). Therefore, the CHEXI was developed to assess executive functioning in a way that does not include content related to ADHD symptoms. The authors accomplished this by initially structuring and developing the CHEXI around four a priori subscales (working memory, planning, inhibition, and regulation) that were created based on Barkley's (1997) model that posits these same four constructs as constituting the key executive function deficits in children with ADHD. Factor analysis on the CHEXI, however, appears to consistently identify two general factors (working memory and inhibition), and additional research is needed for this instrument (Thorell & Catale, 2014).

Selection of Raters. As many currently available rating scales are rather long (containing more than 75 items), the CHEXI is geared to be a quick screening instrument (24 items estimated to take 5 to 10 minutes). This is a potential advantage of the CHEXI; however, the authors note that the CHEXI currently has more utility as a research tool than as a clinical instrument.

Norms. Normative data is not currently available for the CHEXI.

Reliability. Two studies describe the test-rest reliability of the CHEXI using parent ratings collected 3-10 weeks apart. Thorell & Nyberg (2008) reported correlations ranging between .75 and .94 for the total CHEXI score and the four a priori subscales in a sample of 65 five-year olds; and Catale et al. (2013) reported correlations between .98 and .99 for the total score and the two broad factors. Reliability coefficients of the working memory factor (.92) and the inhibition factor (.89) provide initial support for internal reliability (Catale et al., 2013).

Validity. As stated above, factor analysis of the CHEXI has failed to support the four a priori subscales, but instead most studies to date have identified two broad factors which are referred to as working memory (a combination of the working memory and planning a priori subscales) and inhibition (a combination of the inhibition and regulation a priori subscales; Thorell & Catale, 2014). The CHEXI appears to discriminate between children meeting the diagnostic criteria for ADHD and normally developing children (Thorell, Eninger, Brocki, & Bohlin, 2010). One study reports modest correlations between the CHEXI and laboratory measures of executive functioning (Thorell &

Nyberg, 2008), and a subsequent study reports low and nonsignificant correlations (Catale et al., 2013). Current reliability and validity evidence for the CHEXI is limited, but can be bolstered through additional study, particularly with samples of older children.

Comprehensive Executive Function Inventory (CEFI)

Description. The Comprehensive Executive Function Inventory (CEFI; Naglieri & Goldstein, 2013) is designed to evaluate everyday behaviors associated with executive function in children and adolescents ages 5 to 18 years. The CEFI consists of 100 items scored on a Likert scale. The measure yields a full scale and nine CEFI scales reported as standard scores (mean = 100, sd = 15; high scores implying good executive functioning): *Attention*, *Emotion Regulation*, *Flexibility*, *Inhibitory Control*, *Initiation*, *Organization*, *Planning*, *Self-Monitoring*, and *Working Memory*. The CEFI also provides a Consistency Index, Negative Impression Scale, and Positive Impression Scale. The CEFI has three forms—parent (5-18 years), teacher (5-18 years) and self (12-18 years), can be administered in paper or online format, and is available in English and Spanish.

Conceptual Framework. The authors of the CEFI report that the content of the inventory was initially guided by a comprehensive literature review and their clinical and research experience regarding the conceptualization and assessment of executive functions. Instead of adopting a particular orientation on the unity or diversity of executive functioning, or creating groupings of items *a priori* (e.g., cognitive, behavioral, emotional), the authors wrote a large number of items which they believe capture the key behavioral aspects of executive function, including: “time management, working memory, decision making, goal-directed behavior, planning, resistance to distraction, persistence, attention to detail, perspective taking, sustained attention, cueing, shifting, stopping and starting, motor inhibition, motivation, flexibility, regulation, and stress tolerance” (Naglieri & Goldstein, 2014c, p. 224). The authors go on to state that they “decided to include many aspects of executive function and let the results of [their] analyses determine the structure of the final scale” (p. 224). Those analyses indicated “executive function as measured by the behaviors included in the CEFI should be considered a unidimensional construct for parent, teacher, and self-ratings” (p. 225).

Selection of Raters. The CEFI has a reading level of 3.7. The inclusion of the Consistency Index, Negative Impression Scale, and Positive Impression scale facilitates an objective assessment of the accuracy of a respondent’s ratings.

Norms. The CEFI was normed using a US population representative sample (within 2% of the population targets) of 3,500 ratings (1,400 parent, 1,400 teacher, and 700 self-report forms), stratified based on age, gender, race/ethnicity, region, and parental education level. Eight-hundred seventy-two ratings of children with various clinical diagnoses were also collected. The authors of the scale report that their use of a sample closely representing the US population is a strength of the CEFI.

Reliability. CEFI internal reliability coefficients were very high for the CEFI Full Scale (.97 to .99), high for the nine scales for the parent form (.84 to .93) and teacher form (.90 to .96), and moderately high for the self-report form (.74 to .86). Test-retest reliability, assessed over a 1 to 4 week interval, was high for all forms of the CEFI (coefficients ranging from .74 to .91). Adequate inter-rater reliability was reported across all CEFI Scales for parent raters (.73 to .88) and teacher raters (.54 to .68).

Validity. Construct validity is provided through factor analysis, which indicated one factor best describes the behaviors measured by the CEFI. Inter-rater reliability also provides support for the construct validity of the CEFI because the parent, teacher, and self-report forms contain the same items. Naglieri and Goldstein (2013, 2014c) report that item-level and factor-level factor analyses indicated a one-factor solution best explained the data and support that the behaviors rated on the CEFI represent a single construct interpreted as executive function. In their test of criterion validity, the authors found moderate to large effect sizes across all three forms and three groups of children and youth diagnosed with a clinical disorder (ADHD, Autism Spectrum Disorder, Mood Disorder), which they indicate supports their conclusions that the CEFI is sensitive to differences in behaviors associated with executive function for these groups. Criterion validity was established by a comparison of the CEFI with the BRIEF, in which CEFI Full Scale and BRIEF Global Executive Composite scores for parent, teach and self-ratings were highly correlated.

Delis Rating of Executive Function (D-REF)

Description. The Delis Rating of Executive Function (D-REF; Delis, 2012) is designed to measure executive function problems in children and adolescents ages 5 to 18 years. The D-REF consists of 36 items (available for online or paper administration) scored on a 4-point Likert scale: *Seldom/Never*, *Monthly*, *Weekly*, or *Daily*. The measure yields three core indexes—behavioral functioning, emotional functioning, and cognitive functioning—and a total index (calculated from the three core indexes), as well as four second level index scores—attention/working memory, activity level/impulse control, abstract thinking/problem solving, and compliance/anger management—purported to identify patterns of clinically relevant symptoms. The D-REF includes parent, teacher and self-ratings forms.

Conceptual Framework. The D-REF manual provides further information about the overall conceptualization of the scale with its descriptions of the core and clinical indexes (D-REF, 2012; as cited in Rueter, 2014). The behavioral functioning (the ability to regulate one's own behavior and meet the demands of the environment) index is indicated to measure impulsivity, hyperactivity, insufficient self-monitoring, poor organization, and difficulty following rules. The emotional functioning (the ability to regulate one's own behavior to the demands of the environment) index is indicated to measure poor frustration tolerance, emotional instability, anger control problems, sensitivity to criticism, and interpersonal issues. The executive functioning (the ability to effectively adapt and function within the demands of the environment) index is indicated to measure poor attention and working memory, deficient problem-solving and decision-making skills, cognitive rigidity, disorganization, and difficulty initiating/sustaining behavior. The total composite score is indicated to assess the ability to plan, execute, and regulate cognitive, emotional and behavioral functions to adapt to the demands of the environment.

The attention/working memory (related to sustained attention, shifting attention, multitasking in working memory, distractibility, and forgetfulness) clinical index is indicated to measure symptoms of inattention, poor working memory, deficient multitasking, forgetfulness, and disorganization. The activity level/impulse control (related to impulsivity, hyperactivity, and disorganization) clinical index is indicated to measure symptoms of impulsivity, hyperactivity, and poor self-monitoring. The compliance/anger management (related to poor self-monitoring, problems following rules, poor frustration tolerance, poor anger control, and sensitivity to criticism) clinical index is indicated to measure symptoms of mood lability, frustration tolerance, sensitivity to criticism, and rule breaking. Finally, the abstract thinking/problem solving is indicated to measure symptoms of poor decision-making and problem solving skills, cognitive rigidity, and concrete thinking.

Selection of Raters. The D-REF manual indicates that any parent or primary caregiver who lives with the child and has the opportunity to observe his or her behavior may be selected as a respondent for the Parent Rating From. The child's primary teacher, or teacher with the most current and extensive interactions with the child, may be selected to as a respondent regarding the child's behavior and activities in a structured school (or similar) environment. The D-REF is designed to be easily read and understandable; it is written at a fourth-grade reading level for the parent and teacher rating forms and at a third-grade level for the self-rating form, and a text-to-speech function for the online version allows items to be read to the rater.

Norms. Norms for the D-REF are available using the computerized scoring program, which yields *T*-scores for all index and composite scores and statistical comparisons of multi-rater forms. The D-REF was normed using a US population representative sample of 1,062 individuals (500 parent, 342 teacher, and 220 self-ratings) and it provides age- or age and gender-adjusted norms. The normative sample was stratified according to parent education (0-11 years, 12 years, and 13 plus year) and age (i.e., 5-6, 7-8, 9-10, 11-2, 13-14, and 15-18) and only self-ratings forms were collected for ages 11-18. The norms are limited by inadequate representation of certain geographic, race/ethnicity, and parental education cases and inconsistent with the characteristics of the 2011 US Census (Rueter, 2014).

Reliability. The D-REF provides reliability information regarding internal consistency and stability measures; however interrater or inter-scorer reliability is not reported (Rueter, 2014; Delis, 2012). Overall, the D-REF was found to have adequate consistency for the three primary indexes and composite index for the Parent Rating Form (good to very good; reliability coefficients ranging from .86 to .97), Teacher Rating Form (good to very good; reliability coefficients ranging from .80 to .99), and Self-Rating Form (moderate to good; reliability coefficients ranging from .77 to .96), with the Total Composite Score and the Executive Functioning Index consistently having the highest reliability coefficients (Rueter, 2014). The reported reliability information obtained for the clinical group samples indicates the D-REF is sensitive to common developmental disorders (e.g., ADHD-combined type, ADHD-inattentive type, Autistic Disorder, learning disorder). Test-retest stability shows that the D-REF is consistent over time; however the D-REF is a new instrument and test-retest stability was examined with 50 participants across two occasions ranging from 7 to 56 days apart.

Validity. The content validity of the D-REF was established through extensive literature reviews, linking items content to specific executive functions while maintaining their representation of general issues associated with behavior, emotions, and cognitive functions, pilot and standardization of the scale, and incorporating clinical experience and client feedback. Intercorrelations of index scores were moderate to high for the Parent Rating Form (.71 to .88), the Teacher Rating Form (.67 to .87), and moderate for the Self-Rating Form (.67 to .81). Across form comparisons indicated low to moderate correlations. Convergent validity is evidenced through comparison of the D-REF with the BRIEF (D-REF manual). In this comparison, higher correlations were found between the

D-REF and the BRIEF Parent and Teacher Rating forms than the BRIEF Self-Rating form (.75 for Parent, .82 for Teacher, and .72 for Self-Rating Forms), and the highest observed correlations were between D-REF Total Composite score and the BRIEF General Executive Composite.

Rating Scales for Adults

Executive Function Index (EFI)

Description. The Executive Function Index (EFI; Spinella, 2005, 2009) is a short, non-commercially published, self-report rating scale designed to provide a measure of an individual's perception of his or her own executive functioning. The EFI is designed for use in an adult population (age unspecified) and consists of 27 items scored on a 5-point Likert scale: *Not at all (1), Somewhat (3),* and *Very much (5)*. The EFI yields a total score, derived by summing the totals of the five subscales: Motivation Drive, Organization, Strategic Planning, Impulse Control, and Empathy. Higher scores indicate more positive executive functioning.

Conceptual Framework. The EFI was developed in an effort to improve some limitations of other self-report executive function scales by creating a measure sampling a wide array of executive functions in healthy individuals (as opposed to clinical populations). Items for the EFI were developed through a literature review of executive functions mediated by prefrontal-subcortical systems (Tekin & Cummings, 2002; Stuss & Levine, 2002; Faw, 2003; Miller & Cohen, 2001; Fuster, 2000; Chow, 2000; original citations provided by Spinella, 2005). As a result, items were generated in several conceptual domains of executive functioning (motivation, impulse control, empathy, planning, and social conduct) and subsequent factor analysis was used to reduce the number of items within the five current scales: Motivational Drive, Organization, Strategic Planning, Impulse Control, and Empathy.

Selection of Raters. The EFI was developed as a self-report scale for non-clinical populations; specific considerations for the selection of raters are not provided.

Norms. The EFI was developed using a community sample of 188 healthy adults (ages 17 to 60 years). Current normative data are limited to means and standard deviations for scale and total scores based on a sample of 701 participants from a community sample (ages 15 to 83 years; Spinella, 2009). Based on this sample, higher EFI scores are associated with female participants, and with higher age and education. Formal representative norms or specific stratified norms have not yet been reported for the EFI.

Reliability. Cronbach's alpha for the five subscales were in the acceptable to good range (0.69 to 0.76) and good for the total score (0.82). Test-retest reliability was not reported (Spinella, 2005, 2009). In a recent study examining the psychometric properties of the Dutch version of the EFI (EFI-NL) in a college student sample (n=376), Cronbach's alpha for the EFI total score was acceptable (0.73) and lower for the five subscales (0.41 to 0.69; Janssen, De Mey, & Egger, 2009).

Validity. Exploratory factor analysis indicated a 5-factor structure (Empathy, Strategic Planning, Organization, Impulse Control, and Motivational Drive) for the EFI accounting for 29.7% of the total variance. Spinella (2005, 2009) also reports a second-order factor analysis confirming an a priori three-factor solution corresponding to functions associated with three principle regions of prefrontal systems per Cummings (1993): Orbitofrontal (Impulse Control and Empathy), Dorsolateral (Strategic Planning and Organization), and medial prefrontal (Motivational Drive). Convergent validity has been demonstrated through correlations with the Frontal Systems Behavioral Scale (FrSBe), the Interpersonal Reactivity Scale (Davis, 1980), and the Interpersonal Impulsiveness Scales (Patton, Stanford, & Barratt, 1995).

An attempt to replicate the EFI structure proposed by Spinella (2005) using the Dutch version of the EFI (EFI-NL) yielded a similar five factor structure, replicating the Empathy, Organization, and Motivational Drive factors but resulting in the Strategic Planning and Impulse Control scales loading on two and four factors, respectively (Janssen, De Mey, & Egger, 2009). The findings reported by Janssen and colleagues also highlight the need for further replication in additional samples.

A recent study by Miley and Spinella (2006) indicated positive correlations between three EFI scales (Motivational Drive, Empathy, and Strategic Planning) and two positive personality attributes (satisfaction with life and gratitude) and inverse correlations between Impulse Control and forgiveness. Although the authors offer several plausible explanations for these findings (e.g., effective executive functioning may support positive psychological attributes), they also raise concern about the validity of the scale and again highlight its current restrictions (i.e., exclusively self-report and non-clinical populations; similar to the findings described above regarding the relation between the DEX and affect).

Frontal Systems Behavior Scale (FrSBe)

Description. The Frontal Systems Behavior Scale (FrSBe; Grace & Malloy, 2001) is designed to measure and provide clinically useful information about behaviors associated with damage to the frontal systems of the brain (e.g., apathy/akinesia, disinhibition/emotional dysregulation, and executive dysfunction) in adults ages 18 to 95 (upper bound based on the normative sample). The FrSBe can either be used to compare baseline/premorbid behaviors with those post-injury/illness, or the column labeled "at the present time" can be used to track a patient over time. The FrSBe consists of 46 items scored on a 5-point Likert scale ranging from *Almost Never* to *Almost Always*. Two forms of the FrSBe are available: a self-rating form and a family rating form. Both baseline and current ratings yield three subscale scores measuring Apathy, Disinhibition, and Executive Dysfunction and a Total (composite) score for which *T*-scores can be derived. The manual also provides a discussion of specific items that may be useful for (cautious) qualitative analysis.

Conceptual Framework. The FrSBe was developed to capture frontal systems dysfunction that is not captured with traditional neuropsychological measures but does result in disordered behavior in the natural setting. Grace and Malloy (2001) indicate the development of the FrSBe was guided by Cummings (1993) and Mega and Cummings (1994), in which they present a model linking "three clinically observable frontal behavioral syndromes to the three fronto-striato-thalamic circuits": (1) the dorsolateral prefrontal circuit with executive cognitive dysfunction; (2) the orbital prefrontal circuit with disorders of self-regulation (e.g. the syndrome of frontal disinhibition); and (3) the anterior cingulate circuit with disorders of activation, spontaneous behavior, and motivation (e.g., syndromes such as apathy or frontal abulia; Grace & Malloy, 2001, p. 2).

The three FrSBe subscales are based on this model. Specifically, the Executive Dysfunction Subscale may indicate problems with "executive functions such as sustained attention, working memory, organization, planning, future orientation, sequencing, problem solving, insight, mental flexibility, self-monitoring of ongoing behavior, and/or the ability to benefit from feedback or modify behavior following errors;" the Disinhibition Subscale may indicate problems with inhibitory control (e.g., impulsive, hyperactive, socially inappropriate, or poor conformity to social conventions) and poor emotional control (e.g., emotional lability, explosiveness, irritability, and easily provoked positive and negative emotions); and the Apathy Subscale may indicate problems with "initiation, psychomotor retardation, spontaneity, drive, persistence, loss of energy and interest, lack of concern about self-care, and/or blunted affective expression" (Grace & Malloy, 2001, pp. 16-17).

Selecting Raters. The FrSBe manual provides an excellent discussion of the factors and limitations that should be considered when selecting individuals to provide ratings of behavior. Individuals completing the Family Rating Form should be the family member or caregiver with the most recent and most extensive contact (at least weekly) with the patient. The FrSBe is written at a 6^{th} grade reading level, and the authors advise administrators to use their clinical judgment about raters' cognitive ability to ensure reliable and valid behavioral ratings.

Additionally, the authors suggest using the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 2001) or the Dementia Rating Scale-2 (DRS-2; Jurica, Leitten, & Mattis, 2001) to evaluate the cognitive functioning of patients with neurological conditions to ensure sufficient cognitive functioning prior to administering the FrSBe. Severely demented patients (MMSE total = 0-10 and/or DRS-2 scaled score = 2-3) should not complete the Self-Rating Form, it will likely yield unreliable ratings. Moderately demented patients (MMSE total = 11-20 and/or DRS-2 scaled score = 4-5) may be capable of completing the self-rating form with extensive guidance from the examiner. Mildly demented patients (MMSE total = 21-26 and/or DRS-2 scaled score = 6-8) should be able to complete the self-rating form with some guidance from the examiner. Finally, the authors caution "because the base rates for dementia in individuals over 80 years of age are high, some spouses, relatives, and/or caregivers who may be asked to complete the Family Rating Form have cognitive limitations" (Malloy & Grace, 2001, p.6).

Norms. Norms are provided in the Professional Manual and are stratified by gender, age (18-39, 40-59, ≥ 60 years old), education level (≤ 12 and >12 years), and rater (self and informant), with higher *T*-scores indicating greater degrees of symptomatology and clinical significance. The normative sample included 436 Caucasian men and women ranging from 18 years to 95 years of age and 10 to 20 plus (doctoral) years of education. The norms provided for the FrSBe have three primary limitations: 1) the restriction of the normative sample to only Caucasian individuals; 2) the relatively high education level of the normative sample (with most of the sample having greater than 12 years of education); and 3) the grouping of individuals 65 to 95 years old into one normative category ("≥ 65").

Reliability. High internal reliability has been reported in both normal and clinical samples with reliability estimates being slightly better in clinical samples than in a sample of normal controls. The FrSBe manual reports alpha coefficients ranging from .78

to .92 (family rating form) and .72 to .88 (self-rating form) for the Total, Apathy, Disinhibition, and Executive scales (Grace & Malloy, 2001). Additional evidence for the reliability of the FrSBe is provided elsewhere (Stout, Ready, Grace, Malloy, & Paulsen, 2003; Velligan, Ritch, Sui, DiCocco, & Huntzinger, 2002).

Validity. The FrSBe has been shown to demonstrate construct (Azzara, 2005; Grace, Stout, & Malloy, 1999; Lane-Brown & Tate, 2009; Paulsen et al., 2000; Stout et al., 2003; Velligan et al., 2002; Verdejo-Garcia, Bechara, Recknow, & Perez-Garcia, 2006), convergent (Norton, Malloy, & Salloway, 2001; Spinella & Lyke, 2004; Velligan et al., 2002; Verdejo-Garcia et al., 2006a), ecologic (Boyle et al., 2003; Chio et al., 2010; Reid-Arndt, Nehl, & Hinkenbein, 2007; Rymer, Salloway, Norton, Malloy, Correia, & Monast, 2002), and discriminant validity in patients with different types of pathologies (Cahn-Weiner, Grace, Ott, Fernandez, & Friedman, 2002; Chiaravalloti & DeLuca, 2003; Malloy, Tremont, Grace, & Frakey, 2007; Paulsen et al., 1996). Additional reviews on the FrSBe and its reliability and validity are provided elsewhere (see Grace & Malloy, 2001; Malloy & Grace, 2005; and Gioia et al., 2008).

Discussion

A variety of measures are now available for the behavioral assessment of executive function across the lifespan including scales for the assessment of children and adolescents (BASC, CEFI, CHEXI, D-REF), adults (EFI, FrSBe), and both children and adults (BRIEF, BDEFS/BDEFS-CA, DEX/DEX-C). It is worth noting a number of additional proprietary and non-proprietary scales are available but have been excluded here after being determined to fall outside the scope of this review. This includes scales requiring the use of an expert interviewer (e.g., Frontal Behavior Inventory; Kertesz, Davidson, & Fox, 1997), scales primarily developed for other purposes but contain specific executive function indicators or sets of items executive in nature (e.g., Working Memory Rating Scale; Alloway, Gathercole, & Kirkwood, 2008); scales with limited research support (e.g., Children's Executive Functions Scale; Silver, Kolitz-Russell, Bordini, & Fairbanks, 1993); and scales in development with limited publication of new research evidence since last reviewed elsewhere (e.g., Iowa Rating Scales of Personality Change; Barrash, Tranel, & Anderson, 2000). See Table 1.2 for a brief review of some of these measures.

The underlying conceptualization of executive function used in the development of rating scales is critical to understanding what information executive function rating scales provide; comparing findings between rating scales (which will be a more common need with the recent proliferation of commercially available rating scales); and relating behavioral measures of executive functioning to the cognitive assessments of executive functioning (particularly as higher order cognitive functions are more clearly distinguished and the ecological validity of such assessment tools improves over time). Overall, most scales reviewed here take into account a strong theoretical framework and are supported by empirical evidence demonstrating both the unity and diversity of executive function. While reviewing the factor structure (e.g., as determined by principal components analysis, exploratory factor analysis, or confirmatory factor analysis) of each instrument and its supporting evidence (e.g., fit indices) is beyond the scope of this review, it is important to note that not all instruments reviewed here adequately provide this information in their manuals. Carefully examining this information and its consistency with each scale's theoretical foundation and body of related empirical research is an area that should be addressed, and can likely continue to be improved upon overtime within the field of executive function assessment.

While all of the rating scales described here can be repeatedly used to longitudinally track changes in behavioral manifestations of executive function (or dysfunction), the information about the reliability of these instruments in the measurement or detection of normative, disrupted, or potentially emergent/divergent properties executive functioning throughout the span of their purported age range is limited. Additionally, the current literature suggests that executive function in adults is not necessarily as stable or homogenous as previously theorized, but is instead characterized by a more normative decline and defractionation in individuals as they age (Adrover-Roig et al., 2012; Craik & Bialystok, 2006). This is particularly disconcerting for two reasons. First, with regards to the use of behavior rating scales first, because norms for older individuals are typically formulated using smaller samples and are grouped together into very large age spans (e.g., 65 to 90). Second, informant raters (often spouses) are also subject to an increased risk for executive function and cognitive capacity decline. Similarly, it may be useful to more thoroughly investigate executive functioning in parent or family informants of children's behavior, as evidence suggests that much variability in executive functioning is genetic in origin (Friedman, Miyake, Young, DeFries, Corley, & Hewitt, 2008).

The utility of the pre-/post-illness or injury aspect of the FrSBe is particularly useful within the clinical setting; however a scale that incorporates such a format has yet to be developed for use in child and adolescent populations, but could potentially assist with tracking or qualifying various types of executive behavior changes (e.g., those associated with traumatic brain injury).

Interestingly, there is now a greater selection of empirically supported executive function rating scales for children and adolescents than adults. Much of the recent studies and reviews of executive function assessment has also been in the context of child assessment (e.g., Anderson, Anderson, et al., 2008; Silver, 2014; Isquith et al., 2013; Toplak et al., 2013; McAuley et al., 2010; Gioia et al., 2010). This is not surprising. Laboratory-based executive function tests were traditionally developed for the assessment of adults, and as interest increased in learning more about the development and disruption of executive functioning throughout development, it became readily clear that 'gold standard' executive function tasks cannot merely be adapted or extended downward for use in children and adolescent populations (Isquith et al., 2013; Silver, 2014; Welsh, Pennington, & Grossier, 1991). At the same time there is significant risk associated with the downward- or upward-extension strategies being implemented in the development of executive function rating scales for use across the lifespan (Bernstein & Waber, 2007). In particular, while executive function follows an inverted U-shaped developmental trajectory, executive functions do not reflect the maturation of specific neural "regions or functional modules so much as the assembly, integration, and refinement of functional networks" (Bernstein & Waber, 2007, p. 45), and executive deficits may be primarily or secondarily reflective of a heterogeneity of neuropathological processes or environmental factors.

Surprisingly, through this review the authors were unable to identify any rating scale that was initially developed with the specific intent of assessing executive behaviors in the mid-adolescence to early adulthood period. In fact, scales appear to be developed for the 5-to-18 and the 18-and-older age groups and then subsequently up- or downwardly extended to other age groups. Given the continued development of the prefrontal cortex and peak levels of executive skills not being reached until the mid-20s to late 30s (De Luca & Leventer, 2008), it may be beneficial to investigate the unique manifestation of executive behaviors during the late-adolescence to early adulthood period and to ensure that executive function (or dysfunction) is accurately defined and operationalized with respect to this developmental period. For instance, the transition from adolescence into adulthood is characterized by increased social exploration, sensation and novelty seeking, and risk taking along with the final maturation of complex adult behaviors (Crews, He, & Hodge, 2007). Everyday executive functioning during this period should be considered relative to a number of specific factors, including: educational attainment and social development (Blakemore & Choudhury, 2006); exposure to alcohol and drug use and vulnerability for addiction (Crews et al., 2007), and emergence of psychopathologies associated with executive dysfunctioning (e.g., schizophrenia, obsessive-compulsive disorder; Herson & Beidel, 2012).

Executive function rating scales have the potential to provide additional assessment information beyond their current scope of application. For example, a recent study using self-ratings and laboratory measures of executive functioning found that executive function problems in everyday life (as measured through a preliminary version of the BDEFS), but not executive functioning tests, were predictors of depression (Knouse, Barkley, & Murphy, 2012). While the results of this study have many limitations, executive dysfunction is implicated in neurobiological and cognitive processing theories of depression and measures of everyday executive functioning may serve as an important tool for this and other disorders associated with executive function deficits.

Despite a large body of literature supporting and promoting the use of more ecologically valid measures of executive functioning (such as rating scales) in conjunction with traditional executive function tests, a recent review of the literature on acquired brain injury revealed a clear majority of results were derived from standardized measures and few studies use ecological ones (Chevignard, Soo, Galvin, Catroppa, & Eren, 2012). Similarly, Chan, Shum, Toulopoulou, and Chen (2008) identified that the overwhelming trend in the assessment of executive functions in research and clinical settings is focused on the functionality and ecological validity of laboratory-based tests. Overall, these and other researchers advocate for a broadband approach (i.e., combining performance-based measures and rating scales) to the assessment of executive functioning in order to obtain more accurate, sensitive, and specific information about executive function. Although further research is necessary for all scales, there are several empirically supported measures available for the evaluation of executive function deficits in everyday life.

Chapter 2.

Derivation and Convergent Validity of a Screener for the Behavioral Assessment of Executive Functions in Young Adults*

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Abstract

Objective: Ecologically valid indicators of executive functioning are designed to capture dysfunction not easily measured in a lab setting. A four-factor executive functions screener (problem solving, attentional control, behavioral control, emotional control) has been derived previously from the Behavior Assessment System for Children (BASC) in preschoolers (Karr et al., 2013), kindergarteners (Sadeh et al., 2012) and children (Garcia-Barrera et al. 2011, 2013). This study derived a similar screener for use in young adults and evaluated against a well-known executive function rating scale (the Behavior Rating Inventory of Executive Function-Adult Version; BRIEF-A). **Participants and Methods:** 197 undergraduates (ages 18-25) completed the BASC-2-Self-Report Form-College, and a subset (n=97) completed the BRIEF-A. The screener was derived using 23 BASC items assigned *a priori* to each executive function component. Confirmatory factor analysis was used to evaluate the screener. Each factor was also evaluated against target and non-target scales from the BRIEF-A using Pearson and Spearman correlations, as well as latent mean correlations, obtained through structural equation modeling. **Results:** Acceptable internal consistency was obtained within each factor (α = .647 to .660, and .799 for the whole screener). The target, four-factor model fit the data the best and demonstrated adequate fit (RMSEA= .046, CFI = 0.913, TLI = 0.902). All four BASC factors were significantly correlated with their target BRIEF-A scales using simple correlations and latent mean correlations, and these correlations were stronger than the observed correlations between the BASC and BRIEF-A non-target factors. **Conclusions:** These findings support the four-factor model measured through the screener in a young adult population and contribute to accumulating evidence in favor of the BASC executive functions screener. Significant correlations between executive function components and BRIEF-A scales provide additional support for the validity of the screener. Continued development of the BASC executive functions screener is warranted.

Keywords: executive function, behavior rating scale, confirmatory factor analysis, convergent validity

Introduction

Executive control is essential to normative individual functioning throughout life and any disruption of the executive system can have negative implications for adaptive and successful everyday functioning. While researchers and clinicians acknowledge that early detection of executive function impairments is crucial for successful treatment or remediation (Torralva, Roca, Gleichgerrcht, Bekinschtein, & Manes, 2009; Zelazo, Müller, Frye, & Marcovitch, 2003), effective detection of such disruption remains a significant challenge in neuropsychology (Gioia & Isquith, 2004; Garcia-Barrera, Karr, Kamphaus, 2013).

Currently, two general approaches are available for the assessment of executive functions: laboratory performance tests and rating scales. Laboratory-based tests have served as the traditional method for assessing executive functions. While these tests have numerous advantages, they are not always sensitive to everyday manifestations of executive dysfunction outside the test setting, or they sometimes indicate executive impairments in individuals not demonstrating any day-to-day functional difficulties (Pennington & Ozonoff, 1996). In response to the limitations of traditional approaches, researchers have developed several different behavioral rating scales, designed to capture everyday executive functioning in a more ecologically valid way (Isquith, Roth, & Gioia, 2013; Meltzer & Krishnan, 2007; Silver, 2014). Although rating scales were initially intended to complement traditional laboratory tests, recent research indicates rating scales have their own value, providing unique, but complementary information about different aspects of executive functioning (Isquith et al., 2013; McAuley, Chen, Goos, Schachar, & Crosbie, 2010; Silver, 2014; Toplak, West, & Stanovich, 2013).

Executive function rating scales remain in their early development compared with other neuropsychological assessment measures, having only gained a strong body of research support and considered as an integral component of executive functions assessment within the past decade (Gioia, Kenworthy, & Isquith, 2010; Silver, 2014). Despite this support, assessment of executive functions via rating scales is still associated with a number of challenges including individual bias, personal and cognitive characteristics of raters, environmental influences affecting ratings, inconsistent conceptualizations and definitions of the construct, and difficulty in parsing out specific executive function deficits (for a discussion, see Chapter 1; Gioia et al., 2008; Grace & Malloy, 2001; Isquith et al., 2013). While some of these challenges are inherently associated with the rating scale approach, others may be more readily addressed and ameliorated (e.g., definition and operationalization of executive function).

One approach consists of improving the underlying definition of executive functions itself. Inconsistent definitions of executive functions have hindered our understanding of the construct and its development across the lifespan (Jurado & Rosselli, 2007). Generally, executive functions are now regarded as the product of numerous complex within and between prefrontal-parietal and corticothalamic-striato-cerebellar interactions (Duggan & Garcia-Barrera, 2014; Fuster, 2000; Miller & Cohen, 2001; Otero & Barker, 2014). The combination and integration of these interactions gives rise to socially appropriate behavior that can perhaps best be characterized as volitional and planned, resulting in purposeful action and effective performance (Lezak, Howieson, Bigler, & Tranel, 2012). With respect to behavior rating scales of executive functioning, underlying conceptualizations of executive functioning should capture: (a) the diversity of its interrelated functions (b) the unity of these interactions—organizing, controlling, and directing cognitive activity, behavior, and emotional responses; and (c) the environmental context of everyday life (Roth, Isquith, & Gioia, 2014; Gioia et al., 2008). Considering these features, Jurado and Rosselli (2007) offer perhaps the most pragmatic and conceptually complete definition of executive functions:

> In a constantly changing environment, executive abilities allow us to shift our mind set quickly and adapt to diverse situations while at the same time inhibiting inappropriate behaviors. They enable us to create a plan, initiate its execution, and persevere on the task at hand until its completion. Executive functions mediate the ability to organize our thoughts in a goal directed way and are therefore essential for success in school and work situations, as well as everyday living. (p. 214)

Despite considerable overlap between executive function definitions and agreement on its general attributes, elucidating the specific component structure of this construct remains unresolved (Goldstein, Naglieri, Princiotta, & Otero, 2014). One of the most influential approaches in response to this challenge arose from a study that applied latent variable analysis to demonstrate both the integration (unity) and multidimensionality (diversity) of three theorized components of executive functioning: inhibitory control, updating working memory, and mental shifting (Miyake, Friedman, Emerson, Witzki, Howerter, & Wager, 2000). As a result, this study has significantly contributed to our understanding of the nature and development of executive functions, and provided a key framework for subsequent research and the development of improved assessment instruments (Frazer, 2012; Miyake & Friedman, 2012).

A growing body of literature has investigated the development and latent structure of executive abilities across the lifespan. Overall, the development of executive functioning appears to follow an inverted U-shaped trajectory (Juardo & Rosselli, 2007). Research indicates that executive functioning emerges as a one- or two-dimensional structure in the toddler and preschool years (Miller, Giesbrecht, Müller, McInerney, & Kerns, 2012; Wiebe, Sheffield, Nelson, Clark, Chevalier, & Espy, 2011). Throughout childhood and adolescence, executive functioning appears to increase in structural complexity; studies provide evidence for a more differentiated factor structure, with 2- and 3-factor models best fitting data with these age groups (Huizenga, Dolan, & van der Molen, 2006; Lee, Bull, & Ho, 2013; Lehto, Juujärvi, Kooistra, & Pulkkinen, 2003; Rose, Feldman, & Janowski, 2012). In late-adolescence to early-adulthood, empirical support for a 3-factor (Miyake et al., 2000) to 5-factor (Frazer, 2012) models suggests that executive functioning may peak and plateau as a multidimensional structure, and then decline or defractionate later in adulthood (Adrover-Roig, Sesé, Barceló, & Palmer, 2012). The peak of executive development, which occurs in late-adolescence to early-adulthood (typically during the university years), is perhaps one of the most studied periods in psychology. Much of this research, however, has been limited to a laboratory-based setting (e.g., Friedman & Miyake, 2004; Friedman, Miyake, Young, DeFries, Corley, & Hewitt, 2008; Frazer, 2012; Miyake et al., 2000), and greater consideration should be given to the assessment of executive functioning in everyday contexts.

A number of instruments are now available for the behavioral assessment of executive functions; however different definitions and approaches underlie their development, and rating scales “may not measure the appropriate number of factors underlying executive functioning” (Garcia-Barrera, Karr, & Kamphaus, 2013, p. 1301). Furthermore, a recent review of executive function rating scales (Chapter 1) was unable to identify a measure specifically developed for the assessment of executive functions in the mid-adolescence to early-adulthood period. Instead, scales appear to have been developed for age groups either younger or older than 18 years, and then subsequently extended in an up- or downward fashion. While these scales typically provide norms for the late-adolescent/early-adulthood age groups, the content of their items is not generally tailored to encompass variables uniquely associated with this developmental period, and which may have significant bearing on executive functioning (Chapter 1). These include behavioral factors such as increased novelty and sensation seeking, social exploration, and risk taking (Crews, He, & Hodge, 2007); environmental factors such as educational attainment and increased risk for substance abuse (Blakemore & Choudhury, 2006; Crews et al., 2007); and clinical factors such as the emergence of psychopathologies associated with executive impairments (e.g., schizophrenia, obsessive-compulsive disorder; Hersen & Beidel, 2012).

One approach to address some of these issues has been proposed by Garcia-Barrera, Kamphaus, and Bandalos (2011) with the development of a behavioral screener for the assessment of executive functions derived from the Behavioral Assessment System for Children (BASC; Reynolds & Kamphaus, 1992). The BASC, currently in its second edition (BASC-2; Reynolds & Kamphaus, 2004), is a multidimensional broad-band rating scale designed for the assessment of the behaviors and self-perceptions of preschoolers (ages 2 -5), children (age 6-11), adolescents, (ages 12-21) and college students (ages 18-25). Garcia-Barrera et al. (2011) originally developed their BASC executive functions screener by selecting 25 items from the BASC teacher ratings scale-child (BASC-TRS-C) form that were related to four executive factors: Problems Solving, Attentional Control, Behavioral Control, and Emotional Control. The Problem Solving factor refers to “the ability to plan, problem-solve, make decisions, and organize information towards the execution of a goal,” and it includes eight items (Cronbach’s α = .805; Garcia-Barrera et al., 2011, p. 67). The Attentional Control factor refers to “the ability to focus, sustain, and shift attention systems according to task demands,” and it includes seven items (α = .890; p. 67). The Behavioral Control factor refers to the self-regulation of behavior, including inhibition/impulse control, and it includes six items (α = .842). Finally, the Emotional Control factor refers to “the ability to self-regulate emotional response to environmental and internal cues,” and it includes five items (α = .845).

This multidimensional model demonstrated adequate fit, over and beyond a unidimensional model, and demonstrated invariance for both age (6-8 years versus 9-11 years) and gender (Garcia-Barrera et al., 2011). A number of subsequent studies have replicated the derivation of this behavioral screener for executive functions, providing support for its reliability and validity. Specifically, Garcia-Barrera et al. (2013) were able to replicate the screener and provide evidence for its measurement reliability across time using longitudinal invariance analyses and latent growth modeling in a large sample of children (*N*=1,237). Sadeh, Burns, and Sullivan (2012) were able to independently replicate and demonstrate adequate fit for the four-factor model in a sample of kindergarteners at risk for developing behavior disorders (*N*=220). Preliminary research support has also been provided in preschoolers (Karr, Garcia-Barrera, Kerns, Mueller, Baron, & Litman, 2013) and in clinical and cross-cultural samples (i.e., ADHD, Colombian children; Garcia-Barrera, Karr, Duran, Direnfeld, & Pineda, 2014). Garcia-

Barrera et al.'s (2011) executive functions behavioral screener may offer an effective and practical method for the screening of executive functioning. Further research, however, is needed to replicate and evaluate this instrument in adolescents and young adults. Additionally, prior studies have not examined how this instrument compares to other executive function behavioral rating scales; therefore analysis of its convergent validity is necessary to make such comparisons, as well as to better understand its potential utility.

The BASC-2 Self-Report of Personality-College (BASC-2-SRP-COL) form contains 185 items, 68 of which consist of dichotomous items to be rated either *true* or *false*, and 117 items to be rated on a four-point Likert scale ranging from 1 (*never*) to 4 (*almost always*; Reynolds & Kamphaus, 2004). While most other ratings scales for individuals ages 18 to 25 are designed for use in all adults (e.g., 18 to 90), the items on the BASC-2-SRP-COL are specifically designed to capture many behavioral, emotional, self-concept formation issues that are specific to this developmental period (representing the transition from adolescence into early adulthood) and are highly relevant to normative executive functioning (Chapter 1). Given the support for Garcia-Barrera et al.'s (2011) four-factor model (as derived from other forms of the BASC), a similar screener derived from the BASC-2-SRP-COL may serve as an effective executive functions measure for young adults.

Considering the variability of executive function structures reported across ages and the absence of rating scales with content specifically designed to capture the unique factors critical to the transition between adolescence and adulthood, we were led to the present two-part study. First, we wanted to determine if an executive functions screener for young adults could be derived from the BASC-2-SRP-COL using the model and methods outlined by Garcia-Barrera et al. (2011). Given that this approach has been successful in the derivation of an executive functions screener with other versions of the BASC (Garcia-Barrera et al., 2011, 2013; Karr et al., 2013; Sadeh et al., 2012), we anticipated that we would in fact be able to derive the target instrument of this study. In conjunction with this process, we aimed to evaluate the statistical properties of the derived screener and to determine which factor structure (i.e., a unidimensional or a particular multidimensional model) best explained the data. Based on previous research with the BASC executive functions screener, we hypothesized that a four-factor model would provide the best fit to the data and yield an instrument with the strongest statistical properties. Second, we examined the convergent validity of the BASC executive functions screener by comparing it with a well-established rating scale for executive function, the Behavior Rating Inventory of Executive Function—Adult Version (BRIEF-A; Roth, Isquith, & Gioia, 2005). We hypothesized that our analyses would yield moderate to strong correlations between the BASC and the BRIEF-A and provide evidence for the convergent validity of the derived BASC-2-SRP-COL executive functions screener.

Methods

Participants and Measures

A total of 199 university students between the ages of 18 and 25 were recruited through a psychology research participant pool at the University of Victoria to take part in a larger study evaluating the convergent validity of several executive measures. The present study reports the results from a subsample of the data (described below). Participants were screened and excluded from enrollment if they were not between the ages of 18 and 25 (inclusive) or if they reported a significant history of neurologic or psychiatric disturbance (e.g., traumatic brain injury, seizures, mental illness), developmental disorder (e.g., Attention Deficit Hyperactivity Disorder, Fetal Alcohol Spectrum Disorder, Autism), learning disability, or substance abuse. The study was approved by the Human Research Ethics Board at the University of Victoria (Protocol Number 12-466). All participants were informed of the study's procedures, risks, and benefits and provided written consent before participating.

In this study, all participants completed the BASC-2-SRP-COL (described above); however two participants were excluded because the last page of the BASC was not completed (52 of 185 items missing). This resulted in a total of 197 participants for the analyses with the BASC. A subset of 100 participants was randomly assigned to complete the Behavior Rating Inventory of Executive Function—Adult Version (BRIEF-A; Roth et al., 2005). Of these 100 participants, 97 completed the both BRIEF-A and the BASC; thus the data acquired from these 97 was used for analyses with the BRIEF-A. The BRIEF-A is the most commonly used and empirically supported rating scale for the assessment of behavioral manifestations of executive dysfunction in adults ages 18 to 90 (Isquith et al., 2013). The BRIEF-A contains 75 items rated on a three-point Likert scale (*Never*, *Sometimes*, and *Often*), which contribute to nine scales: inhibit, shift, emotional control, self-monitor, initiate, working memory, plan/organize, task monitor, and organization of materials. A summary of the demographic characteristics of the total BASC sample (*N*=197) and the BRIEF-A subsample (*n*=97) is provided in Table 2.1.

Statistical Analyses

Descriptive statistics, frequency distributions, correlations, tests for multivariate normality, and reliability coefficients were calculated using IBM SPSS Version 18, and all analyses of factor structure and latent means were conducted using Mplus Version 7.11 (Muthén & Muthén, 1998-2012). Since the BASC-SRP-COL and the BRIEF-A consist of Likert-type items, all indicators were treated as polytomous by using the specification for categorical data in Mplus for each analysis. While Mplus uses the maximum likelihood method of estimation for continuous data by default, in the case of categorical data, Mplus employs the weighted least squares with mean and variance adjusted estimator (WLSMV). Specifically, the WLSMV assumes an underlying unobserved normally distributed continuous latent variable for each observed categorical variable (including binary and ordered categorical variables), with threshold estimates distinguishing between levels of categorical responses (Muthén & Muthén, 1998-2012; Wang & Wang, 2012). Overall, 3 missing data patterns were identified for the confirmatory factor analysis conducted with the BASC data (N=197), 1 missing data pattern was identified for the replication of the four-factor model with the BRIEF-A data only (N=97), and 3 missing data patterns were identified in the analyses using the BASC and the BRIEF-A (N=97). The missing completely at random assumption was applied to each analysis.

Screener derivation process. The entire set of 185 items from the BASC-2-SRP-COL was carefully reviewed and items potentially ‘executive’ in nature were isolated. This was based on the four-factor conceptualization of executive function providing the framework for the screener: Problem Solving, Attentional Control, Behavioral Control, and Emotional Control. Overall, 50 items were initially extracted, serving as latent indicators of the construct. It is important to note that, while large, this number reflects several sets very similar or near-duplicate items (e.g., *I have trouble paying attention to what I am doing* and *I have trouble paying attention to lectures*), which were optimally refined during the item screening process (as follows).

Item screening included tests for multivariate normality, analysis of frequency distributions, as well as examination of item correlations and item content. The data were screened for significant outliers using Mahalanobis distance. Item means, standard deviations, skewness, and kurtosis were analyzed. The critical values were set to |2.0| for skewness and |7.0| for kurtosis, in accordance with the methods outlined in the original BASC executive functions screener derivation study (Garcia-Barrera et al., 2011). This was done in order to adequately screen for any significant nonnormality amongst the categorical data yielded by the BASC-2-SRP-COL (using binary and four-point Likert scales), which often presents in a nonnormal distribution (Finney & DiStefano, 2006). Potential collinearity effects were examined through the generation of a correlation matrix. While moderate correlations are expected between items serving as latent indicators of the same construct (here executive functioning), high correlations suggest collinearity and potential redundancies between items. Finally, the wording and content of each item was reviewed to ensure that items potentially too ambiguous were removed (i.e., the wording of an item should make it clearly apparent which factor an item belongs to) and that the groupings of items adequately captured the constructs of each of the four factors.

Internal consistency reliabilities for each group of items (factors) were estimated using Cronbach's α. Although .8 typically is deemed as the acceptable cut-off value for Cronbach's α, in the case of complex psychological constructs values of .7 and even below can more realistically be expected (Hair, Black, Babin, & Anderson, 2010; Kline, 2013). Additionally, it is important to consider that the value of Cronbach's α depends of the number of items in the scale, with α increasing with the number of items included (Cortina, 1993). In consideration of the complexity encompassed within each of the four executive function factors, along with the small number of indicators being used to estimate each factor, internal-consistency reliability values greater than 0.6 were established as acceptable and values greater than 0.7 established as good (Hair, Black, Babin, & Anderson, 2010; Kline, 2013). These criteria are also supported by the findings from a recent review of executive functions rating scales, which indicated that self-report data from such instruments typically have lower reliabilities than informant ratings (between the .6 to .8 range; Chapter 1).

Confirmatory factor analysis was used to evaluate the adequacy of the four-factor model and the selected indicators. This model was also compared to a unidimensional (one-factor) and several multidimensional (two- and three-factor) unnested variations (see Figure 1). The χ^2 test, which indicates the difference between the observed and expected covariance matrices, is considered an index of goodness of model fit. Nonsignificant *p*-values indicate adequate model fit, with χ^2 values closer to zero indicating better model fit. The χ^2 test, however, is particularly sensitive to large sample sizes and tends to be significant due to increased power to reject the null hypothesis (Marsh, Balla, & McDonald, 1988). Therefore, additional fit indices were assessed in order to evaluate model quality more accurately. The comparative fit index (CFI) and the Tucker-Lewis Index (TLI) are two recommended incremental fit indicators that resolve some of the issues inherent in the χ^2 test of model fit (Jackson, Gillaspy, & Purc-Stephenson, 2009). For both the CFI and the TLI, a score of 1.0 represent perfect fit (but is statistically rare in practice), scores above .95 demonstrate optimal model fit, scores above .90 are deemed as reasonable or acceptable, and scores below .90 can be improved substantially (Hu & Bentler, 1999). Finally, the root-mean-square-error of approximation (RMSEA) approximates how well a model with optimally chosen (but unknown) parameter estimates would fit the observed covariance matrix, with a value of zero representing exact fit. The RMSEA is generally regarded as a measure that favors parsimony and is relatively independent of sample size. Hu and Bentler (1999) suggest a RMSEA cutoff criterion of less than .06. More specific recommendations consider RMSEA values of less than .05 as good fit, less than .08 as acceptable fit, less than .10 as mediocre fit, and greater than .10 as not acceptable (Browne & Cudeck, 1993 as cited in Schermelleh-Engel, Moosbrugger, & Müller, 2003). For this study, an RMSEA of .05 (optimal bound) to .06 (upper bound) was set as the criterion.

Evaluating convergent validity. Convergent validity concerns the degree to which two measures of the same underlying construct relate to one another. While there are no universally adopted methods for establishing convergent validity, traditionally this process is guided by the principle that measures of a construct should be strongly associated with each other. Researchers commonly evaluate the interconnections between measures and constructs by evaluating the patterns of their correlations—an approach rooted in the classic conceptual framework developed by Cronbach and Meehl (1955) and methodologically outlined by Campbell and Fisk's (1959) multitrait-multimethod matrix. According to these methodological guidelines, a key indicator of convergent validity is strong monotrait-monomethod correlations. For the purpose of this study, monotrait- (executive function) monomethod (self-rating scale) correlations were examined by evaluating the four BASC executive function factors (Problem Solving, Attentional Control, Behavioral Control, and Emotional Control) with their corresponding scales from the BRIEF-A.

The conceptualization and item content of the BRIEF-A scales were carefully reviewed and the scales determined to be most similar to the four BASC executive function factors were isolated as "target" scales. The Plan/Organize scale, which measures the "ability to manage current and future-oriented task demands within the situational context" including planning, implementing and achieving goals, and organizing to achieve an objective, was selected as the scale best representing Problem Solving (Roth et al., 2005, p. 22). The Working Memory scale, which examines the "capacity to actively hold information in mind for the purpose of completing a task or generating a response…[and] the ability to sustain attention and performance over time," was selected as the one most similar to Attentional Control (pp. 21-22). The Inhibit scale, which measures "inhibitory control…and the ability to stop one's own behavior at the appropriate time," was isolated as most closely representing Behavioral Control (p. 20). Finally, the Emotional Control scale, which measures the "ability to modulate emotional responses," was selected as best representing Emotional Control (p. 21).

In addition to these four target scales, the BRIEF-A also contains five other "non-target" scales, considered less similar to the four BASC factors: Organization of

Materials, Shift, Initiate, Task Monitor, and Self-Monitor. The Organization of Materials scale "measures organization in the adult's everyday environment with respect to orderliness of work, living, and storage spaces" (p. 22). The Shift scale "measures the ability to move freely from one situation, activity, or aspect or a problem to another, as the circumstances demand… [it] is composed of items reflecting the ability to shift behaviorally and to shift cognitively" (p. 20). The Task Monitor scale measures "the extent to which the individual keeps track of his or her own problem-solving success or failure" (p. 22), and the Self-Monitor scale measures "the extent to which the adult keeps track of his or her own behavior and the effect of his or her behavior on others" (p. 21).

Correlational comparisons between the BASC factors and the BRIEF-A scales were made using the following steps. First, raw item scores of each of the four BASC executive function factors and the nine total BRIEF-A scales were converted into *T*-scores. Next each BASC factor was evaluated against its corresponding BRIEF-A target scale using pairwise correlations (i.e., BASC Problem Solving with BRIEF-A Plan/Organize; BASC Attentional Control with BRIEF-A Working Memory; BASC Behavioral Control with BRIEF-A Inhibit; and BASC Emotional Control with BRIEF-A Emotional Control). Next, each BASC factor was evaluated against the eight remaining BRIEF-A scales (e.g., BASC Problem Solving with BRIEF-A Working Memory, Inhibit, Emotional Control, Organization of Materials, Shift, Initiate, Task Monitor, and Self-Monitor). These comparisons were made in an effort to assess the specificity of the relations between the BASC factors and their target scales. Since ordinal data often result in nonnormal distributions (Finney & DiStefano, 2006), both Pearson's r and Spearman's ρ correlations are reported (see Table 2.5).

While examining patterns of correlation coefficients is one of the most common approaches to evaluating validity, it is limited by several factors. First, this approach is highly subjective; the observed magnitudes of correlations and their statistical significance are essentially "eyeballed" and judged on the degree to which they conceptually fit with the hypothesized patterns of association (Furr & Bacharach, 2014). Additionally, the correlation between two measures reflects both the extent to which they share an underlying construct and the extent to which they covary on other factors (e.g., measurement error, reliability; Campbell & Fiske, 1959). Here, structural equation modeling approaches offer an advantage over traditional correlational analysis in that they require formal hypotheses about within- and between-construct relations and they disattenuate correlations for the effects of potential sources of error (Hoyle & Smith, 1994). In this regard, the structural equation modeling approach provides a more sophisticated method of obtaining clearer estimates and making statistical comparisons between measures.

In this study, structural equation modeling was used in a series of steps (as outlined by Hoyle & Smith, 1994) to further evaluate the construct validity of the derived four-factor BASC executive functioning screener. The first step involved obtaining support for the measurement model of the latent variables underlying the scale; this was accomplished by using confirmatory factor analysis and examining the internal consistency reliabilities (see *Screener Derivation Process* above). Next, the target and non-target variables from the BRIEF-A (i.e., Plan/Organize, Working Memory, Inhibit, Emotional Control, Organization of Materials, Shift, Initiate, Task Monitor, and Self-Monitor) were modeled as latent variables within a separate nine-factor model, also using confirmatory factor analysis. Finally, the focal latent variables (Problem Solving, Attentional Control, Behavioral Control, and Emotional Control) were correlated with the target and non-target variables using their latent means, and the standardized covariance (i.e., Pearson correlation coefficients) between the corresponding pairs of focal (BASC) and criterion (BRIEF-A) latent variables were inspected.

Although the target BRIEF-A scales utilized in these analyses were selected based on the similarity in their conceptualization and item content to the four BASC factors, there are nevertheless concept and content differences. Therefore, we expected a strong correlation between the Problem Solving (BASC) and Plan/Organize (BRIEF-A) factors, based on the greatest similarity in conceptualization and content, and moderate to strong correlations between Attentional Control (BASC) and Working Memory (BRIEF-A), Behavioral Control (BASC) and Inhibit (BRIEF-A), and Emotional Control (BASC) and Emotional Control (BRIEF-A). With regards to the latter two factors, one might expect high correlations based on their names (i.e., both sharing the same name "emotional control"). It is important to note, however, that the content of the BRIEF-A Emotional Control scale captures additional aspects of emotional control behaviors not represented in the BASC Emotional Control items. Therefore the correlation between these two factors was predicted to be in the moderate range.

Results

Screener Derivation

The first main objective of the present study was to answer the following questions: Can an executive functions screener for young adults be derived from the BASC-2-SRP-COL using the methods previously applied in the derivation of different versions of the BASC for younger populations (Garcia-Barrera et al., 2011, 2013, Karr et al., 2013; Sadeh et al., 2012)? What are the statistical properties of the BASC-2-SRP-COL executive functions screener and what model best describes the data (e.g., a unidimensional model or a different multidimensional model)?

Data and item screening. The data were first inspected for multivariate normality. No significant outliers were identified using Mahalanobis distances ($\alpha = .05$). Review of the validity indexes derived from the BASC (i.e., the *F* index, which detects excessively negative responses; the *V* index, which detects responses to nonsensical items; the *L* index, which detects excessively positive responses; the *Response Pattern* index, which detects potentially patterned responding; and the *Consistency* index, which identifies cases of inconsistent responses to similar items) and the BRIEF-A (i.e., the Negativity scale, the Infrequency scale, and the Inconsistency scale) did not indicate any cases that should be excluded from further analyses. Next, the preliminary pool of 50 potential indicator items (14 Problem Solving items, 10 Attentional Control items, 15 Behavioral Control items, 11 Emotional Control items) was refined during a series of item screening steps. Four items exceeded the established skewness and kurtosis criteria (|2.0| and |7.0| respectively) and were removed (items 42, 45, 54, and 58). Review of intra- and inter-factor item correlations resulted in the removal of seven items due to poor correlations (items 7, 49, 120, 136, 149, 151, and 178).

The remaining pool of items was then refined again to include the best set of indicators by reviewing again item content and optimizing the reliability coefficients for each factor. Several general principles guided decisions made during this stage. First, each factor should be represented by a set of items that captures both the underlying core construct, as well as the complexity each construct is theorized to represent. Second, factors should comprise of a balanced item set, limiting the effects of collinearity and equally weighting the key aspects of each construct. Finally, when possible, items should represent a diversity of original BASC scales membership as to ensure factors are not merely abbreviated BASC scales. A total of 15 items were removed during this final process (items 57, 66, 88, 98, 101, 102, 105, 108, 109, 113, 117, 128, 129, 137, and 179). Table 2.2 summarizes the final set of 23 items (6 Problem Solving items, 6 Attentional Control items, 6 Behavioral Control items, and 5 Emotional Control items) and their original BASC-2-SRP-COL scale membership. Although the Attentional Control factor was the only factor that did not represent a diversity of original BASC scales, only items considered as latent indicators of Attentional *Control* (and not simply "Attentional Problems" as indicated by the original BASC scale) were included.

Internal consistency reliability. The internal consistencies (Cronbach's α) for the four executive function factors were in the acceptable range. Specifically, the alpha coefficients were: .658 for Problem Solving, .664 for Attentional Control, .647 for Behavioral Control, and .660 for Emotional Control. An alpha coefficient of .799 for the whole screener was obtained. To determine whether the removal of any items would lead to improvements in the scale, we examined the SPSS output specifying the change that would be observed in each alpha if an item were to be deleted. Alpha coefficients were not improved with the deletion of any items; therefore all of items were retained. While these values fell below those reported on previous studies of the executive functions screener using different versions of BASC (Garcia-Barrera et al., 2011, 2013; Sadeh et al., 2012), they are still deemed to be in the acceptable range based on the criteria outlined above. Additionally, it is worth noting that the BASC-2-SRP-COL is unique in its inclusion of items with dichotomous *true/false* response choices; the inclusion of several of these items in the scales may explain the lower alpha coefficients observed in the present study.

Confirmatory factor analysis. Confirmatory factor analysis (CFA) was used to evaluate the a priori four-factor model of executive functioning serving as the target model for this study (referred to as Model 4 below). This included both an evaluation of the model's fit to the observed data, as well as an evaluation of the model in comparison with a series of three alternative CFA models (referred to as Models 1-3; see Figure 1). The alternative CFA models were chosen based on the strongest theoretical variations consistent with the current conceptualization of executive functioning, in consideration of the item content of the selected indicators, and in line with the alternative models evaluated by Garcia-Barrera et al. (2011). The first alternative model (Model 1) evaluated was a one-factor (unidimensional) model with 23 indicators. Since this model contained all of the isolated executive function indicators (conceptualized as contributing to one unitary construct), the latent construct was called Executive Function. The second alternative model (Model 2) was a two-factor model comprised of a Problem Solving latent construct (6 items) and a Behavioral Self-Regulation latent construct (17 items), which combines items originally comprising the Attentional Control, Behavioral Control, and Emotional Control factors. The third alternative model (Model 3) was a three-factor model, corresponding to three latent constructs: Problem Solving (6 items), Attentional Control (6 items), and Behavioral/Emotional Control (11 items; formerly Behavioral Control and Emotional Control).

All models converged normally and the fit indexes for each are reported in Table 2.3. Overall, each model (Model 1 to Model 4) demonstrated increasingly better model fit in terms of all selected fit indicators. Larger CFI and TLI values were observed with each model, and Model 4 was the only model to demonstrate acceptable fit (above .900) using these metrics (CFI = 0.913, TLI = 0.902). Although all χ^2 values had significant *p*-values (p = .0000), this was anticipated due to the large sample size; therefore, χ^2 values were evaluated on a qualitative basis. Each subsequent model demonstrated lower (less-inflated) χ^2 values, with Model 4 having the best fit of the four evaluated models (χ^2 = 316.867). Likewise, each model demonstrated improved (lower) RMSEA values; and Model 4 was the only model to have an RMSEA falling below the optimum cutoff criterion of .05 (RMSEA = 0.046), which is desirable. These results indicate that the BASC executive functions screener derivation process and the four-factor BASC executive functions screener (Garcia-Barrera, 2011) are replicable using the BASC-2-SRP-COL. Additionally, these results provide further support that the BASC executive functions screener yields information about more than one component of executive functioning. The statistical properties of the four-factor model (Model 4) in comparison to those of the alternative models (Models 1-3) indicated that the data were best explained by the four-factor model, and this model was the only to demonstrate adequate fit across the selected fit indicators.

Potential model modifications. After the four-factor model had been confirmed, the model modification indexes were examined to determine if any additional analyses were warranted. Three potential model modifications were identified. Item 107 (*I can solve difficult problems by myself*; a Problem Solving indicator) was suggested to load onto the Attentional Control factor for an expected drop of 15.936 in χ^2. Item 107 was also suggested to load onto the Behavioral Control factor for an expected drop of 17.174 in χ^2. Finally, item 156 (*When I get angry, I can't think about anything else*; an Emotional Control indicator) was suggested to load onto the Attentional Control factor for an expected drop of 17.174 in χ^2. Even though item 107 likely reflects, to some extent, an aspect of Attentional Control and/or Behavioral Control, the degree to which it would reflect Attentional Control and/or Behavioral Control processes over Problem Solving is assumed to be relatively small. An alternative would be to allow this item to load on all three factors (Problem Solving, Attentional Control, and Behavioral Control), reflecting an item that potentially captures a more unitary aspect of executive functioning. Again, however, the theoretical justification for this adjustment is not strong. Considering the relatively small size of the expected drop in the χ^2 parameter with these potential changes, parsimony was favored and the modification was not pursued. Correspondingly, while item 156 likely incorporates an element of Attentional Control, this item was theoretically considered to capture Emotional Control processes over and beyond Attentional Control ones. Thus, a modification with item 156 was also not pursued.

Parameter estimates. The individual item factor loadings for the final model configuration (Model 4) are summarized in Table 2.4. Factor loadings represent the strength of the association between the indicator item and the factor; in this case the squared factor loadings signify the proportion of variance a factor explains for the given indicator variable. The higher a loading is, the more it contributes to defining a factor's dimensionality. Standardized factor loadings of .30 to .40 are typically considered reasonably strong, loadings of .70 to .80 are commonly considered very strong, and values of 1.0 represent an optimal level, but are unlikely in ‘real-life’ data (Furr & Bacharach, 2014). However, sample size should also be taken into consideration when interpreting factor loadings. For instance, factors with four or more loading values of |.60| or greater are deemed reliable, regardless of sample size (Guadagnoli & Velicer, 1988 as cited in Stevens, 2002). The factor loadings for Model 4 ranged from 0.363 to 0.724 overall; 0.468 to .719 for Problem Solving (with 3/6 above |.60|), 0.584 to 0.700 for Attentional Control (with 5/6 above |.60|), 0.363 to 0.690 for Behavioral Control (with 4/6 above |.60|), and 0.598 to 0.724 for Emotional Control (with 4/5 above |.60|). The strength of these factor loadings explains the overall fit of the model and the quality of the selected indicators.

Figure 2 depicts the configuration of the final model (Model 4) as well as its inter-factor correlations. All correlations were significant (p = .002 for Problem Solving with Behavioral Control, and p = .000 for all others), ranging from r = 0.292 (Problem Solving with Behavioral Control) to r = 0.683 (Problem Solving with Emotional Control). Given the moderate-to-significant correlations reported between the screener’s four factors in prior studies (Garcia-Barrera et al., 2011, 2013, Karr et al., 2013), similar patterns of correlations were expected for this study. While the screener’s observed correlations do generally suggest moderate relationships between its underlying latent constructs, these correlations were weaker than expected.

Convergent Validity of the BASC Executive Functions Screener

The second primary objective of this study was to answer the following question: What is the evidence for the convergent validity of the four-factor BASC executive functions screener? To answer this question, this screener (Model 4) was compared to the most widely used and researched executive functions self-rating scale—the BRIEF-A.

Convergent validity: correlations between the BASC and the BRIEF-A. The convergent validity of the BASC executive functions screener was first investigated by evaluating the correlations between the *T*-scores of its four composite scores (Problem Solving, Attentional Control, Behavioral Control, and Emotional Control) and the *T*-scores of the BRIEF-A target scales. The strongest correlation was between the Problem Solving factor and the Plan/Organize scale (r = 0.652, p = 0.000; ρ = 0.650, p = 0.000). Moderate correlations were observed between the Attentional Control factor and the Working Memory scale (r = 0.615, p = 0.000; ρ = 0.622, p = 0.000) and the Emotional Control factor and the Emotional Control scale (r = 0.588, p = 0.000; ρ = 0.520, p = 0.000). The weakest correlation was between the Behavioral Control factor and Inhibit scale (r = 0.489, p = 0.000; ρ = 0.480, p = 0.000). Correlations between BASC factors and non-target scales were all lower than the target scale correlations, with the exception of one Spearman correlation that was equal to the target correlation (i.e., Attentional Control with Inhibit). Specifically, non-target correlations ranged from r = 0.146 to 0.567 and ρ = 0.142 to 0.572 for Problem Solving, r = 0.075 to 0.585 and ρ = 0.091 to 0.622 for Attentional Control, r = 0.146 to 0.465 and ρ = 0.142 to 0.473 for Behavioral Control, and r = -0.057 to 0.505 and ρ = -0.050 to 0.456 for Emotional Control. These results are summarized in Table 2.5. Overall, the observed target correlations were lower than the anticipated correlations—hypothesized to be in the moderate-to-high range based on other studies examining the convergent validity of well-known executive functions rating scales (Delis, 2012; Gioia, Isquith, Guy, & Kenworthy, 2000; Grace & Malloy, 2001;

Roth et al., 2005). The specificity of each target correlation was largely supported by the lower non-target correlations.

Convergent validity: structural equation modeling approach. Next, the four target BRIEF-A scales were modeled as a four-factor model with 36 indicator items using confirmatory factor analysis. The model converged normally and the following fit indexes were observed: $\chi^2 = 773.174$, $p = 0.000$, *df*, = 588, CFI = 0.884, TLI = 0.876, RMSEA = 0.057. Next the nine BRIEF-A scales were modeled as a nine-factor model with 71 indicator items. This model also converged normally: $\chi^2 = 5296.967$, $p = 0.000$, *df*, = 2485, CFI = 0.876, TLI = 0.871, RMSEA = 0.039. While these models do not provide acceptable fit by the established criterion standards, their statistics are fairly decent considering the current restricted sample (both in terms of size and variability) and the BRIEF-A was originally modeled in a 2 factor-, 9 scale-fashion (Roth et al., 2005). The convergence of these models provided the support needed to continue with the final set of analyses.

A structural equation modeling approach was used to examine the correlations between the latent factors of the BASC and BRIEF-A models. The four factors of the BASC executive functions screener were modeled simultaneously with the four target factors of the BRIEF-A (see Figure 2.3 and Table 2.6). All observed focal variable-target criterion variable latent mean correlations were high: Problem Solving with Plan/Organize, $r = 0.896$; Attentional Control with Working Memory, $r = 0.850$; Behavioral Control with Inhibit, $r = 0.779$; and Emotional Control with Emotional Control, $r = 0.768$ (all $p = 0.000$; reported in Table 2.6). These latent mean correlations are higher than the correlations between the factor/scale *T*-scores, yet generally more consistent with the anticipated correlations.

Next, the four factors of the BASC executive functions screener were modeled simultaneously with the nine factors of the BRIEF-A in order to put the specificity of the correlations reported in Figure 2.3 and Table 2.6 into context, and to more broadly examine the convergent validity of the derived BASC screener. All latent mean correlations are reported in Table 2.7. It is important to note that the target mean correlations reported in Tables 2.6 and 2.7 differ slightly as a result of increasing model complexity by moving from a 4-factor BASC model *versus* a 4-factor BRIEF-A model to a 4-factor BASC model *versus* a 9-factor BRIEF-A model. The latent mean correlations between Problem Solving and its eight non-target BRIEF-A scales were all significant ($p = 0.000$ to 0.001), yet lower than its target latent mean correlation ($r = 0.289$ to 0.789). The same trend was observed for Attentional Control ($r = 0.327$ to 0.666, $p = 0.000$ to 0.001). All latent mean correlations between Attentional Control and its non-target BRIEF-A scales were lower than the target correlation ($r = 0.124$ to 0.831), and all correlations, with the exception of one, were significant (all $p = 0.000$ except Organization of Materials, $p = 0.267$). Similarly, all non-target latent mean correlations for Emotional Control, except one, were significant ($p = 0.000$ to 0.004 except Organization of Materials, $p = 0.727$). With the exception of Shift ($r = 0.769$), all non-target latent mean correlations were lower than the target correlation (all others $r = -0.036$ to 0.446). The results from both sets of analyses support the convergent validity of the derived BASC-2-SRP-COL executive functions screener with the BRIEF-A.

Discussion

Executive functions research has been limited by the immense variability in the conceptualization of this elusive construct. Particular challenges in relation to this variability include inconsistency in measurement approaches, variation in the proposed structure of executive functions, and a limited understanding of the development of executive functions across the lifespan (Chapter 1). While late-adolescence has been established as a critical period of neural development for executive functioning, limited data on its behavioral correlates are available (Taylor, Barker, Heavey, & McHale, 2013) and no prior executive functions behavior rating scale has been developed to specifically measure executive functioning in this developmental context (Chapter 1). In response to these challenges, the present study had two primary objectives.

First, we developed an executive functions screener from the BASC-2-SRP-COL (Reynolds & Kamphaus, 2004), which was conceptually and methodologically based on the previously derived BASC-TRS-C executive functions screener for children (Garcia-Barrera et al., 2011). Using the four-factor model of executive functioning, the screener was developed to capture behaviors related to planning and goal initiation (Problem Solving); focusing, sustaining, and shifting attention (Attentional Control); behavioral self-regulation (Behavioral Control); and emotional self-regulation (Emotional Control; Garcia-Barrera et al., 2011). A total of 23 items from the BASC-2-SRP-COL were isolated as indicators of these four components, serving as latent constructs of executive functioning.

Results from the construct validity analyses, in which unidimensional and multidimensional models of the screener were tested using confirmatory factor analysis, indicated that the four-factor model (Model 4) best explained the data and had significantly better fit than the other models. While all models did converge normally, each subsequent multidimensional model showed substantial improvements in model fit (sequentially moving from Model 1 to Model 4) and the four-factor model was the only model to demonstrate acceptable fit. The strength of this multidimensionality is consistent with the developmental literature; specifically, with other studies using a latent variable approach, in which executive functioning appears to be unidimensional early in development, and continues along an inverted-U shaped trajectory, fractionating into more distinct components throughout childhood and adolescence, and reaching its peak in early-adulthood (Casey, Tottenham, Liston, & Durston, 2005; Huizinga, Dolan, & van der Molen, 2006; Lee et al., 2013; Lehto, et al., 2003; Willoughby, Blair, Wirth & The Family Life Project Investigators, 2012). Considering this developmental trajectory, it is interesting to note that while other executive functions rating scales (e.g., Egeland & Fallmyr, 2010; Fournet et al., 2014; Garcia-Barrera et al., 2011; Roth, Lance, Isquith, Fischer, & Griancola, 2013) typically have stronger fit indices than those reported here, their reported fit statistics are specific to different developmental contexts (i.e., younger and older age groups). Since this is the first study to examine the psychometric properties of an executive functions instrument targeted for the early-adult period (ages 18 to 25), the relatively lower fit indices reported here could be interpreted as reflecting the difficulty associated with attempting to measure the construct at its period of greatest structural complexity. Additionally, the lower inter-factor correlations reported in this study may indicate more differentiation between executive function components in young adults. It could also be that, when attempting to capture both the unity and diversity of executive behaviors, greater psychometric rigor can be achieved in samples of younger or older individuals, or in samples of wider age ranges that encapsulate the narrower early-adulthood period (e.g., the BRIEF-A; Roth et al., 2005; the FrSBe, Grace & Malloy, 2001). At the same time, the generally high loadings of the indicators on the latent factors and the acceptable model fit described here contrasts with Willoughby, Blair, Pek, and The Family Life Project Investigators' (2013) discussion that single-factor models tend to provide the best relative fit to data in early childhood and the observed discrepancy between better global model fit and poorer quality measurement may not be specific to a particular age period.

When moving from a three-factor model to a four-factor model (in which Behavioral and Emotional Control are separated into distinct factors), the BASC-TRS-C executive functions screener demonstrated little difference in model fit (ΔCFI = -.012; Garcia-Barrera et al., 2011, p. 71), whereas the present study demonstrated a more substantial gain in fit (ΔCFI = -.100). This comparison indicates that Behavioral Control and Emotional Control processes may fractionate more robustly in adolescence (i.e., between the age ranges of 6-11 and 18-25). Components of executive functioning have been shown to follow unique developmental trajectories (Anderson, Anderson, et al., 2008; Huizinga et al., 2006; Reynolds & MacNeil Horton, 2008; Romine & Reynolds, 2005; Garcia-Barrera et al., 2013). While research suggests that development of executive control over emotion regulation processes (e.g., Emotional Control) initiates early on, in terms of maturity, it may lag behind others, such as those executive control associated with abstract problem solving (i.e., problem solving; Zelazo & Carlson, 2012). This is consistent with neurophysiological evidence that implicates the orbitofrontal cortex, a key structure associated with emotion regulation and reward-related behavior, in this developmental lag as well (Happaney, Zelazo, & Stuss, 2004; Rolls, 2004; Zelazo & Carlson, 2012). As for the instrument as a whole, the obtained inter-factor correlations (ranging from .292 to .683) were all lower than the absolute values of inter-factor correlations on the BASC-TRS-C executive functions screener (ranging from .502 to .875; Garcia-Barrera et al., 2011) except for the correlation between Problem Solving and Emotional Control (negative inter-factor correlations were not observed in the present study due to reverse scoring of positively worded items). These findings support both the scale's internal convergent validity (measuring four constructs unified by the same latent construct of executive functions) and divergent validity (each construct is unique and not better explained by another construct). Additionally, when considered in the context of the BASC-TRS-C screener, these findings are consistent with the developmental fractionation of executive functions theory, which would predict lower correlations between components of executive functions over time until peak executive functions development is achieve early in adulthood. Furthermore, experimental studies examining the structure of executive functioning across different ages using factor-analytic approaches have reported lower intercorrelations with increasing age (Lee, Bull, & Ho, 2013; Lehto et al., 2003).

Given the apparent stability of the four-factor model across different samples and different age ranges, the BASC executive functions screener may serve as a useful instrument for further investigating the developmental trajectories of its constructs—particularly Behavioral Control and Emotional Control. Measurement invariance was not examined in the present study due to skewness of the sample and limited sample size;

however, future research examining the measurement invariance of this screener across ages (18 to 25) and between genders would contribute to improved understanding of the scale's psychometric properties and may further inform our understanding of the development of executive functions.

While it is plausible that the acceptable, but not optimal, fit indices reported in this study may be indicative of challenges associated with measuring a complex and fractionating system of functions at or near their developmental peak, an alternative explanation may lie in one or more shortcomings of the instrument itself. First, although the internal consistency reliabilities (ranging from .647 to .664) fell just above the acceptable range, higher values (above .70 or .80) are generally recommended and seen as ideal (Naglieri & Goldstein, 2014a). These reliabilities are also lower than those obtained in studies with other versions of the BASC executive functions screener, which ranged between .805 and .890 for the original screener derivation (Garcia-Barrera et al., 2011). Unsurprisingly, these same studies also report slightly higher factor loadings for the selected indicators than the ones we obtained here (Garcia-Barrera et al., 2011, 2013).

These findings, again, could be interpreted as indicators of the challenges associated with attempting to measure an increasingly multidimensional construct. Alternatively, these findings could reflect the limitations associated with our sample, which is relatively homogenous and geographically limited in comparison to the sample used by Garcia-Barrera et al. (2011), which was much larger and representative of the population of U.S. children (the original BASC-TRS-C standardization dataset; Reynolds & Kamphaus, 1992). These findings could also indicate some room for improvement of the instrument itself. For example, during the initial phases of item extraction and screening, we noted several differences between the BASC-2-SRP-COL and the BASC-TRS-C that made it challenging to develop an executive functions screener that captured the breadth and depth of the targeted constructs. These challenges include the addition of *true/false* items, the removal of certain items previously included in the BASC-TRS-C executive functions screener, and the inclusion of items that assess developmentally unique aspects of executive functions not previously addressed. Ultimately, many of these more unique items were screened out due to their weak psychometric properties and due to their infrequency, as underrepresentation of particular aspects of a construct reduce the quality of the measure. Additionally, the small number of indicators selected for each factor (ranging from 5 to 6 for each factor) also likely contributes to the low internal consistency reliabilities reported in the current study.

Of further note, most rating scales include clinical populations within their data collection samples, and the exclusion of clinical groups from the present study may have contributed to the low internal consistency estimates (see Chapter 1). Internal consistencies of other executive functions rating scales have been shown to improve in mixed clinical/healthy adult samples and are higher in informant-report samples than in self-report samples (i.e., BRIEF-A, Roth et al., 2005; FrSBe, Grace & Malloy, 2001). While the BASC-2-COL does not have an information version available to compare the self-report version to, the child and the adolescent versions of the BASC (BASC-2-C and BASC-2-A) have informant and self-report forms, and further investigation of the BASC executive functions screener across these forms may provide more information and context to interpret the low internal reliabilities reported here. Yet another factor to consider is that younger adults have been shown to report more executive function difficulties than older adults (i.e., individuals ages 18-29 on the BRIEF-A and ages 18-39 on the FrSBe; Roth et al., 2005 and Grace & Malloy, 2001 respectively).

Overall, it is important for future research to more carefully examine these factors in larger samples of clinical and healthy individuals, as well as across the span of developmental periods. Furthermore, all psychological constructs are complex. As such, one could argue that as construct complexity increases, so does the need for higher internal consistency estimates. Given the elusive nature of executive functions and the challenges associated with psychometrically characterizing them (Jurado & Rosselli, 2007), further research is needed to determine the extent to which we can realistically expect to capture them through psychometric instruments and how those expectations may vary with developmental considerations.

The second main objective of this study was to investigate the convergent validity of the derived BASC executive functions screener by comparing it with the BRIEF-A (Roth et al., 2005)—one of the most popular instruments for the behavioral assessment of executive functions in individuals over the age of 18. Although accumulating research has supported the reliability and validity of the BASC executive functions screener, one lingering issue concerns its convergent validity with other executive functions behavior rating scales. Furthermore, the widespread variability in the conceptualization and measurement of executive functions has made it particularly difficult to establish convergent validity for all executive functions rating scales (Naglieri & Goldstein, 2014a), and attempts to do so have generally been restricted to simple correlations (e.g., Delis, 2012; Gioia, Isquith, Guy, & Kenworthy, 2000b; Grace & Malloy, 2001; Roth et al., 2005).

Results from the first set of convergent validity analyses, which examined correlations between the BASC factors and BRIEF-A scales, demonstrated significant target correlations generally in the moderate range. Since previous studies examining the correlations between established behavior rating scales for executive functions have reported moderate-to-high correlations, we hypothesized that a similar pattern of correlations would be observed here. Although the observed correlations were lower than expected, they were still quite strong considering the differences between the instruments. While the isolated BRIEF-A scales were the closest in content and conceptualization to the BASC factors, they are not facsimiles. For example, the Plan/Organize scale measures aspects of organizing (e.g., with items such as *I have problems organizing activities*) that are not conceptualized or captured in the Problem Solving factor. Thus, it would have been potentially more realistic to expect moderate correlations that reflect both the similarities and differences in content and conceptualization between the measures. Additionally, previous convergent validity analyses of correlations tend to compare composite scores; since the present correlations were based on direct factor-to-scale comparisons, the original hypothesized correlations were likely too ambitious. Directly correlating BASC factors with BRIEF-A scales may have also been complicated by the more general differences between the scales. Although both are self-ratings instruments, the BRIEF-A exclusively contains negatively worded executive function items measured on a three-point Likert scale, while the BASC screener contains items imbedded in a much broader behavior rating scale comprised of positively and negatively worded items scored on dichotomous and four-point Likert scales.

In an effort to address the observed weakness of the correlation analysis, as well as some of the general weakness associated with the correlation approach to convergent validity, we used structural equation modeling to examine relationships between the latent means of the BASC factors and select BRIEF-A scales. Interestingly, this approach yielded high and significant correlations for each factor/scale pair, suggesting that the BASC executive functions screener has strong convergent validity with the BRIEF-A when the effects of error are disattenuated from the model. The success of this approach suggests that a similar methodology may be helpful in addressing the challenges associated with establishing convergent validity for other executive functions ratings scales. The approach could also be used to more clearly examine the convergent validity of executive functions rating scales in the context of multitrait-multimethod relationships (e.g., with laboratory-based tests of executive functioning, or with interview-based instruments such as the Frontal Behavioral Inventory, Kertesz, Davidson, & Fox, 1997), and it has shown to be a successful approach in other fields (for example, see Bryant, King, & Smart, 2007).

Overall, the selection of target scales, as well as the specificity of the correlations between the BASC factors and their target scales, was supported by the data. Nearly all target correlations and latent mean correlations were higher than their non-target counterparts. Interestingly, the latent mean correlation between BASC Emotional Control and the non-target Shift scale was slightly higher than the target correlation ($r = 0.769$ versus $r = 0.768$). Although this finding was not anticipated, it was not surprising considering the Shift scale contains several items that relate closely with those of the BASC Emotional Control factor (e.g., *After having a problem, I don't get over it easily*).

This suggests that ability to shift focus from one mindset to another may be closely tied to emotional control processes. Alternatively, it suggests that the Shift scale on the BRIEF-A may be more measuring shifting in an emotional context (i.e., emotional shifting).

The significant correlations across nearly all of the BRIEF-A scales indicate that the BASC factors have a cohesive structure that represent executive functioning. Additionally, these correlations are consistent with the correlations between the BRIEF-A scales and the DEX, which were all significant and ranged from 0.38 to 0.80 (Roth et al., 2005). Only the non-target scale Organization of Materials had insignificant correlations with some of the BASC factors and it was the lowest of all the correlations for nearly all factors. This finding is also consistent with Roth et al.'s (2005) findings in which Organization of Materials had the lowest correlation with the DEX ($r = 0.38$). The pattern of strong correlations between the BASC factors and the BRIEF-A scales represent clear and consistent pattern of convergence between the instruments and specificity of the BASC factors. Overall, this provides strong evidence of the validity of the BASC four-factor executive functions screener.

In summary, the present study successfully derived an executive functions rating scale for young adults from the BASC-2-SRP-COL, and was the first to examine the convergent validity of the BASC executive functions screener. Analyses of the instrument's psychometric properties support its construct validity, indicate that it is acceptably reliable, and suggest that this measure has strong convergent validity with the BRIEF-A. It is important to note that a number of factors limit the interpretations that can be made from this study, as well as limit the potential implementation of the BASC-2-

SRP-COL executive functions screener in the future. First, the screener should be replicated in a larger sample and analyses of measurement invariance conducted in order to further investigate and adequately augment support for its psychometric properties. Second, further analyses of the screener's convergent validity should be conducted using other executive functions ratings scales, as well as traditional performance-based tests. Although correlations between executive functions rating scales and performance-based measures have been low (Silver, 2014), use of latent variable approaches similar to those described here and elsewhere (e.g., Miyake et al., 2000; Bryant, King, & Smart, 2007) may contribute to improved understanding of the development and measurement of executive functioning. Deriving norms and a composite measure for the screener would also facilitate additional convergent validity analyses and making comparisons between instruments. Finally, analyses examining the clinical validity of the screener would improve its assessment utility and potentially contribute to promoting an improved understanding of the development of executive functions in early-adulthood, as well as the emergence of related executive dysfunction and psychopathologies. Overall, these findings support the model serving as the foundation of Garcia-Barrera et al.'s (2011) BASC executive functions screener. These findings also contribute to a growing body of research, which demonstrates that this instrument may inform our understanding of the development of executive functions throughout childhood and into early adulthood. Although future research is needed, this study provides support for a behavioral screener for executive functions in young adults between the ages of 18 and 25.

Tables

Table 1.1

Summary of executive function rating scales included in review

Measure	Age (in years)	Rater	Number of items	Components	Norms
Scales for Children and Adolescents					
Barkley Deficits in Executive Function Scale-Children and Adolescents (BDEFS-CA; Barkley, 2012)	6 to 17	Parent report form	Long form (70-items), Short form (20-items), Interview (20-items)	Total executive functioning summary score Self-management to time Self-organization and problem solving Self-restraint Self-motivation Self-regulation of emotion Symptom count ADHD-EF index score	Available (percentiles)
Behavior Assessment System for Children-2 (BASC-2; Reynolds & Kamphaus, 2004; Garcia-Barrera et al., 2011)	2 to 21	Parent and teacher report forms	Teacher (100-139 items), Parent (134-160 items), Revised executive function screener (subset of ~25 items; Garcia-Barrera et al. 2011)	Executive functioning content scale Revised executive function screener (in development)	Available (T scores and percentiles)
Behavior Rating Inventory of Executive Functions-Preschool (BRIEF-P; Gioia et al., 2003)	2 to 5	Parent/teacher report form	63-items	Global executive composite Inhibit Shift Emotional control Working memory Plan/organize	Available (T scores and percentiles)
Behavior Rating Inventory of Executive Functions (BRIEF; Gioia et al., 2000b)	5 to 18	Parent and teacher report forms	86-items	Global executive composite Behavior regulation index Inhibit Shift Emotional control Metacognition index Initiate Working memory	Available (T scores and percentiles)

Table 1.1

Summary of executive function rating scales included in review

Measure	Age (in years)	Rater	Number of items	Components	Norms
				Plan/organize Organization of materials Monitor domains	
Behavior Rating Inventory of Executive Functions-Self report (BRIEF-SR; Guy et al., 2004)	11 to 18	Self-report form	80-items	Global executive composite Behavior regulation index Inhibit Shift Emotional control Monitor Metacognition index Working memory Plan/organize Organization of materials Task completion	Available (T scores and percentiles)
Childhood Executive Functioning Inventory (CHEXI; Thorell & Nyberg, 2008)	4 to 15	Parent/teacher report form	24-items	Total score Working memory Planning Inhibition Regulation	Unavailable
Comprehensive Executive Function Inventory (CEFI; Naglieri & Goldstein, 2013b)	5 to 18 (informant) 12 to 18 (self)	Parent/teacher and self-report forms	100-items	Total (scale) Attention Emotion regulation Flexibility Inhibitory control Initiation Organization Planning Self-monitoring Working memory	Available (standard scores)
Delis Rating of Executive Function (D-REF; Delis, 2012)	5 to 18		36-items	Total index Core indexes Behavioral functioning Emotional functioning Cognitive functioning	Available (T-scores)

Table 1.1
Summary of executive function rating scales included in review

Measure	Age (in years)	Rater	Number of items	Components	Norms
				Secondary indexes Attention/working memory Activity level/impulse control Abstract thinking/problem solving Compliance/anger management	
Dysexecutive Questionnaire for Children (DEX-C; Emslie et al., 2003)	7 to 16	Parent/teacher report form	20-items	Each item is developed to address a certain aspect of executive functioning	Available (age-scaled scores and percentiles)
Scales for Adults					
Barkley Deficits in Executive Function Scale (BDEFS; Barkley, 2011)	18 to 81	Self- and informant report forms	Long form (89-items), Short form (20-items, Interview (20-items)	Total executive functioning summary score Self-management to time Self-organization and problem solving Self-restraint Self-motivation Self-regulation of emotion Symptom count ADHD-EF index score	Available (percentiles)
Behavior Rating Inventory of Executive Functions-Adult (BRIEF-A; Roth et al., 2005)	18 to 90	Self- and informant report forms	75-items	Global executive composite Behavior regulation index Inhibit Shift Emotional control Self-monitor Metacognition index Initiate Working memory Plan/organize Task monitor Organization of Materials	Available (T scores and percentiles)
Dysexecutive Questionnaire (DEX; Wilson et al., 1996)	16 to 87	Self- and informant report forms	20-items	Each item is developed to address a certain aspect of executive functioning	Limited (percentiles)
Executive Function Index (EFI, Spinella, 2005, 2009)	Unspecified adults (15 to 83)	Self-report form	27-items	Total score Motivation drive	Limited (means and

Table 1.1
Summary of executive function rating scales included in review

Measure	Age (in years)	Rater	Number of items	Components	Norms
				Organization Strategic planning Impulse control Empathy	standard deviations)
Frontal Systems Behavior Scale (FrSBe; Grace & Malloy, 2001)	18 to 95	Self- and informant report forms	46-items	Total (composite) Apathy Disinhibition Executive dysfunction	Available (T-scores and percentiles)

Table 1.2

Additional executive function rating scales excluded from review

Measure	Citation	Age/Scale Description	Executive Functioning Measures
Apathy Evaluation Scale (APS)	Marin et al., 1991	Adult scale. Clinician, informant, and self-report forms.	18-items evaluating emotional, cognitive, and behavioral aspects of apathy ; Significant correlations with tests of executive functions (Anderson & Bergedalen, 2002)
Barratt Impulsiveness Scale (BIS)	Patton et al., 1995	Adult scale. Self-report form.	34-items, some executive in nature.
Brown Attention-Deficit Disorder Scales for adolescents and adults	Brown, 1996	Adolescent and adult scale. Self-report form.	40-items grouped into 5 clusters: Organizing and activating to work, sustaining attention and concentration, sustaining energy and effort, managing affective interference, and utilizing working memory and accessing recall.
Children's Executive Functions Scale	Silver et al., 1993	Adolescent scale. Parent report form.	5 executive domains: social appropriateness, inhibition, problem solving, initiative, motor planning; See also Molho, 1996; Greenaway, 2004; and Goulden & Silver, 2009
Cognitive Failures Questionnaire	Broadbent et al. 1982	Adult scale. Self-report form.	25 items, some executive in nature; See also Larson et al. 1997; Wallace et al., 2002
Conners' Adult ADHD Rating Scales (CAARS)	Conners et al.,	Adult scale. Self-report form.	Long, short, and screening versions, some items executive in nature.
Frontal Behavior Inventory (FBI)	Kertesz et al., 1997	Adult scale. Structured clinical interview with informant.	24-items, some executive in nature.
Iowa Rating Scales of Personality Change (IRSPC)	Barrash et al., 2000	Adult scale. Self-report form.	27-items assessing behavioral control, emotional functioning, social and interpersonal behavior, and higher-order cognitive abilities; See also Barrash et al. 2011; Nguyen et al. 2013
Key Behaviors Change Inventory	Kolitz et al. 2003	Adult scale. Informant report form (individuals with TBI).	8 scales: inattention, impulsivity, unawareness of problems, apathy, interpersonal difficulties, communication problems, somatic difficulties, and emotional adjustment
Metacognitive Awareness System (MetaCOG)	Meltzer et al., 2004	Adolescent scale. Self- and teacher report forms.	Multiple surveys and questionnaires assessing perceptions of strategy use, metacognitive awareness, motivation, and effort; See also Meltzer & Krishnan, 2007
Neurobehavioral Inventory	Kreutzer et al. 1996	Adult scale. Self- and Informant report form (individuals with TBI).	70-items, some executive in nature
Neurobehavioural Rating Scale-Revised (NRS-R)	Levin et al. 1987; Levin et al. 1990;	Adult scale. Semi-structure clinical interview.	29-items, some executive in nature.

Table 1.2

Additional executive function rating scales excluded from review

Measure	Citation	Age/Scale Description	Executive Functioning Measures
	Vanier et al. 2000		
Situational Self-Awareness Scale	Govern & Marsch, 2001	Adult scale. Self-report form.	31-items, some executive in nature.
Working Memory Rating Scale (WMRS)	Alloway et al., 2008	Adolescent scale. Teacher report form.	20-items evaluating learning difficulties associated with working memory deficits.

Table 2.1
Demographics

	BASC-2-SRP-COL sample	BRIEF-A subsample
Sample size	197	97
Age (M±SD in years)	20.46 ± 1.80	20.58 ± 1.81
	Representation by developmental age (%)	
18	15.74	15.46
19	18.78	15.46
20	17.77	19.59
21	20.81	18.56
22	12.69	15.46
23	7.11	8.25
24	5.58	6.19
25	1.52	1.03
	Representation by sex (%)	
Female	79.19	73.20
Male	20.81	26.80

Note. BASC-2-SRP-COL = Behavior Assessment System for Children, 2nd edition, Self-Report of Personality, College version; BRIEF-A = Behavior Rating Inventory of Executive Function, Adult version; M = mean; SD = standard deviation

Table 2.2
Distribution of the final set of BASC-2-SRP-COL executive function items per scale

Item	Original scale membership
Problem Solving	
Item 56	Sense of Inadequacy
Item 87	Sense of Inadequacy
Item 95	Test Anxiety
Item 107	Self-Reliance
Item 118	Sense of Inadequacy, Test Anxiety
Item 138	Self-Reliance, Ego-Strength
Attentional Control	
Item 5	Attention Problems
Item 36	Attention Problems
Item 67	Attention Problems
Item 125	Attention Problems
Item 148	Attention Problems
Item 160	Attention Problems
Behavioral Control	
Item 97	Hyperactivity
Item 144	Hyperactivity, Mania
Item 155	Mania
Item 159	Hyperactivity
Item 174	Mania
Item 175	Hyperactivity
Emotional Control	
Item 16	Anxiety
Item 47	Anxiety
Item 126	Anxiety
Item 156	Anger Control
Item 171	Anxiety, Anger Control

Note. BASC-2-SRP-COL = Behavior Assessment System for Children, 2nd edition, Self-Report of Personality, College version.

Table 2.3

Model variation analyses for the BASC-2-SRP-COL executive functions screener

Model	WLSMV χ^2	*df*	CFI	ΔCFI	TLI	RMSEA (90% CI)
Model 1: 23 items, 1 factor	514.426*	230	0.734		0.708	0.079 (0.070-0.088)
Model 2: 23 items, 2 factors	483.857*	229	0.762	-0.028	0.737	0.075 (0.066-0.084)
Model 3: 23 items, 3 factors	427.422*	227	0.813	-0.051	0.791	0.067 (0.057-0.077)
Model 4: 23 items, 4 factors	316.867*	224	0.913	-0.100	0.902	0.046 (0.034-0.057)

Note. BASC-2-SRP-COL = Behavior Assessment System for Children, 2nd edition, Self-Report of Personality, College version; WLSMV χ^2 = weighted least squares with mean variance adjusted chi-square; *df* = degrees of freedom; CFI = comparative fit index; ΔCFI change in comparative fit index between models; TLI = Tucker-Lewis index; RMSEA = root-mean-square error of approximation; * indicates *p* = 0.000.

Table 2.4

Factor loadings for the BASC-2-SRP-COL four-factor model of executive functions

Variable and factor	Unstandardized factor loading	Standardized factor loading	Standard error	R^2
Problem Solving				
Item 56	1.000	0.602	0.088	0.637
Item 87	1.193	0.719	0.064	0.484
Item 95	0.828	0.499	0.070	0.751
Item 107	0.778	0.468	0.068	0.781
Item 118	1.086	0.654	0.067	0.572
Item 138	0.974	0.587	0.069	0.656
Attentional Control				
Item 5	1.000	0.698	0.076	0.512
Item 36	0.954	0.666	0.084	0.556
Item 67	1.002	0.700	0.082	0.511
Item 125	0.836	0.584	0.067	0.659
Item 148	0.947	0.661	0.072	0.563
Item 160	0.941	0.657	0.063	0.568
Behavioral Control				
Item 97	1.000	0.525	0.064	0.725
Item 144	0.692	0.363	0.077	0.868
Item 155	1.203	0.631	0.063	0.601
Item 159	1.315	0.690	0.069	0.524
Item 174	1.206	0.633	0.071	0.599
Item 175	1.209	0.634	0.073	0.598
Emotional Control				
Item 16	1.000	0.645	0.101	0.584
Item 47	0.982	0.633	0.071	0.599
Item 126	0.927	0.598	0.061	0.642
Item 156	1.028	0.663	0.064	0.560
Item 171	1.123	0.724	0.061	0.475

Table 2.5

Correlations between the BASC factor T-scores and BRIEF-A scale T-scores

BASC Factor			*r*	*p*	*ρ*	*p*
Problem Solving	Target BRIEF scale:	**Plan/Organize**	**0.652**	**0.000**	**0.650**	**0.000**
	Non-Target BRIEF scales:	Working Memory	0.433	0.000	0.439	0.000
		Inhibit	0.330	0.001	0.368	0.000
		Emotional Control	0.434	0.000	0.424	0.000
		Organization of Materials	0.178	0.081	0.208	0.041
		Shift	0.496	0.000	0.455	0.000
		Initiate	0.463	0.000	0.469	0.000
		Task Monitor	0.567	0.000	0.572	0.000
		Self-Monitor	0.397	0.000	0.379	0.000
Attentional Control	Target BRIEF scale:	**Working Memory**	**0.615**	**0.000**	**0.622**	**0.000**
	Non-Target BRIEF scales:	Plan/Organize	0.384	0.000	0.432	0.000
		Inhibit	0.585	0.000	0.622	0.000
		Emotional Control	0.265	0.009	0.299	0.003
		Organization of Materials	0.075	0.467	0.091	0.373
		Shift	0.261	0.010	0.307	0.002
		Initiate	0.420	0.000	0.476	0.000
		Task Monitor	0.542	0.000	0.558	0.000
		Self-Monitor	0.274	0.007	0.246	0.015
Behavioral Control	Target BRIEF scale:	**Inhibit**	**0.489**	**0.000**	**0.480**	**0.000**
	Non-Target BRIEF scales:	Plan/Organize	0.260	0.010	0.322	0.001
		Working Memory	0.465	0.000	0.473	0.000
		Emotional Control	0.270	0.008	0.237	0.020
		Organization of Materials	0.238	0.008	0.261	0.010
		Shift	0.280	0.006	0.327	0.001
		Initiate	0.286	0.004	0.299	0.003
		Task Monitor	0.203	0.046	0.216	0.034
		Self-Monitor	0.380	0.000	0.318	0.002
Emotional Control	Target BRIEF scale:	**Emotional Control**	**0.588**	**0.000**	**0.520**	**0.000**
	Non-Target BRIEF scales:	Plan/Organize	0.256	0.011	0.275	0.006
		Working Memory	0.261	0.010	0.265	0.009
		Inhibit	0.188	0.065	0.188	0.066
		Organization of Materials	-0.057	0.579	-0.050	0.626
		Shift	0.505	0.000	0.456	0.000
		Initiate	0.274	0.007	0.273	0.007
		Task Monitor	0.246	0.015	0.243	0.017
		Self-Monitor	0.220	0.029	0.159	0.119

Note. Pearson (*r*) and Spearman's (ρ) correlations are each followed by their respective *p* values.

Table 2.6

Latent factor mean correlations between the BASC and BRIEF-A target scales, derived from the BASC 4-factor model with the BRIEF-A 4-factor target scale model

BASC Factor	BRIEF-A Scale	*r*	*p*
Problem Solving	Plan/Organize	0.896	0.000
Attentional Control	Working Memory	0.850	0.000
Behavioral Control	Inhibit	0.779	0.000
Emotional Control	Emotional Control	0.768	0.000

Note. The values in this table correspond to those depicted in Figure 2.3.

Table 2.7
Latent factor mean correlations between the BASC and BRIEF-A, derived from the BASC 4-factor model with the BRIEF-A 9-factor target and non-target scale model

BASC Factor			r	p
Problem Solving	Target BRIEF scale:	**Plan/Organize**	**0.891**	**0.000**
	Non-Target BRIEF scales:	Working Memory	0.647	0.000
		Inhibit	0.544	0.000
		Emotional Control	0.590	0.000
		Organization of Materials	0.289	0.001
		Shift	0.770	0.000
		Initiate	0.710	0.000
		Task Monitor	0.789	0.000
		Self-Monitor	0.637	0.000
Attentional Control	Target BRIEF scale:	**Working Memory**	**0.840**	**0.000**
	Non-Target BRIEF scales:	Plan/Organize	0.497	0.000
		Inhibit	0.831	0.000
		Emotional Control	0.359	0.000
		Organization of Materials	0.124	0.267
		Shift	0.407	0.000
		Initiate	0.628	0.000
		Task Monitor	0.673	0.000
		Self-Monitor	0.450	0.000
Behavioral Control	Target BRIEF scale:	**Inhibit**	**0.769**	**0.000**
	Non-Target BRIEF scales:	Plan/Organize	0.390	0.000
		Working Memory	0.666	0.000
		Emotional Control	0.401	0.000
		Organization of Materials	0.327	0.001
		Shift	0.521	0.000
		Initiate	0.444	0.000
		Task Monitor	0.360	0.000
		Self-Monitor	0.631	0.000
Emotional Control	Target BRIEF scale:	**Emotional Control**	**0.768**	**0.000**
	Non-Target BRIEF scales:	Plan/Organize	0.376	0.000
		Working Memory	0.395	0.001
		Inhibit	0.331	0.004
		Organization of Materials	-0.036	0.727
		Shift	0.769	0.000
		Initiate	0.446	0.000
		Task Monitor	0.420	0.000
		Self-Monitor	0.396	0.000

Note. The values of the target correlations reported in this table differ from those reported in table 2.6 and in figure 2.3 as a result of moving from a 4-factor BASC model : 4-factor BRIEF-A model to a 4-factor BASC model : 9-factor BRIEF-A model.

Figures

Figure 1.1. *Schematic of reviewed executive function rating scales across the lifespan by self-report and informant report*

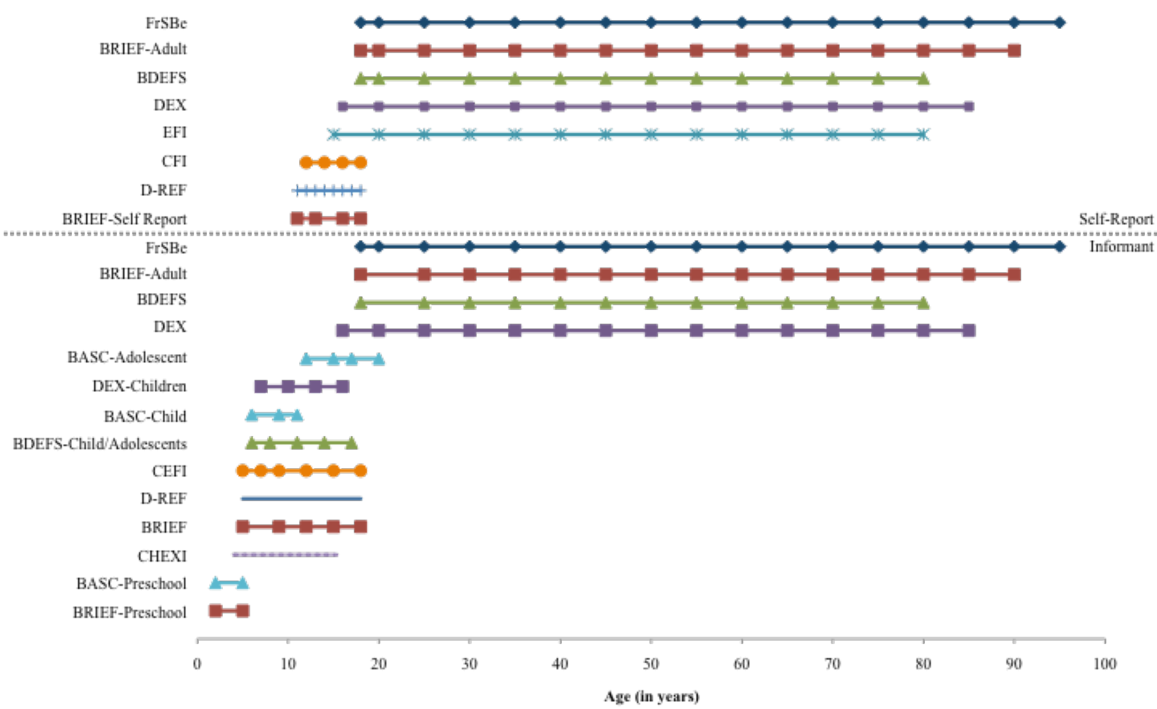
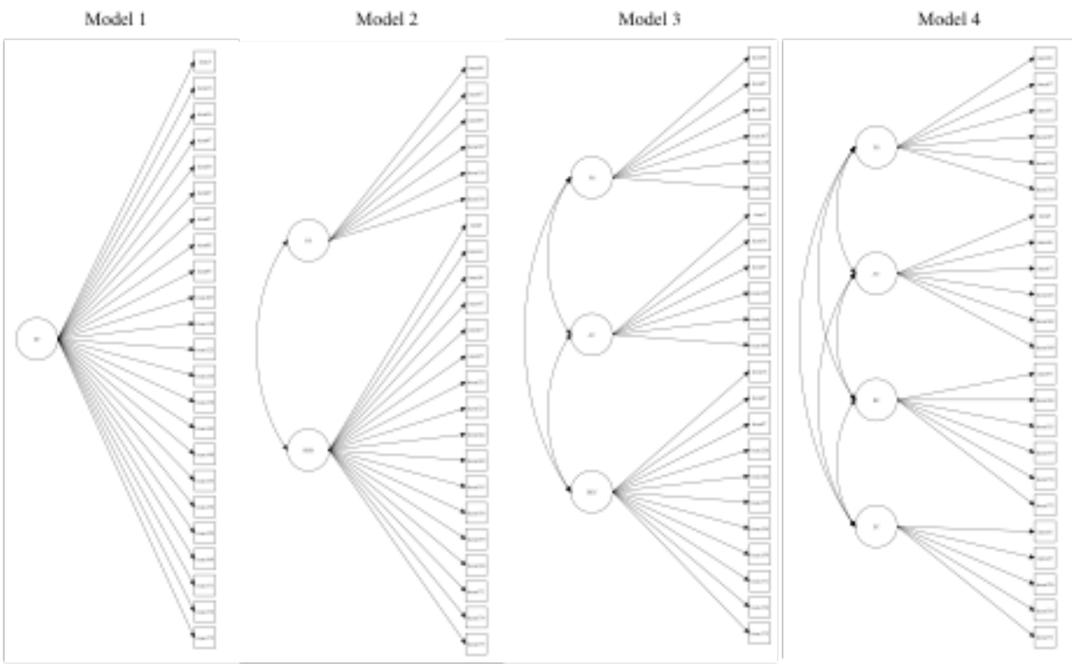
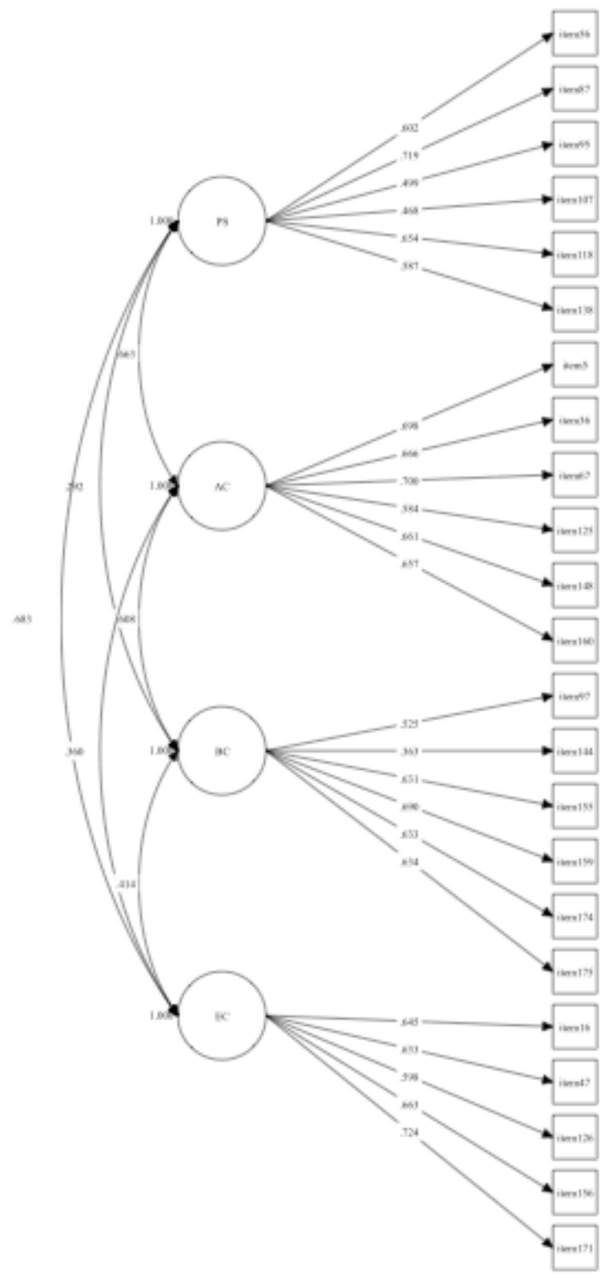


Figure 2.1. *Construct validity analyses of the BASC-2-SRP-COL executive functions screener: Unidimensional and multidimensional models tested*



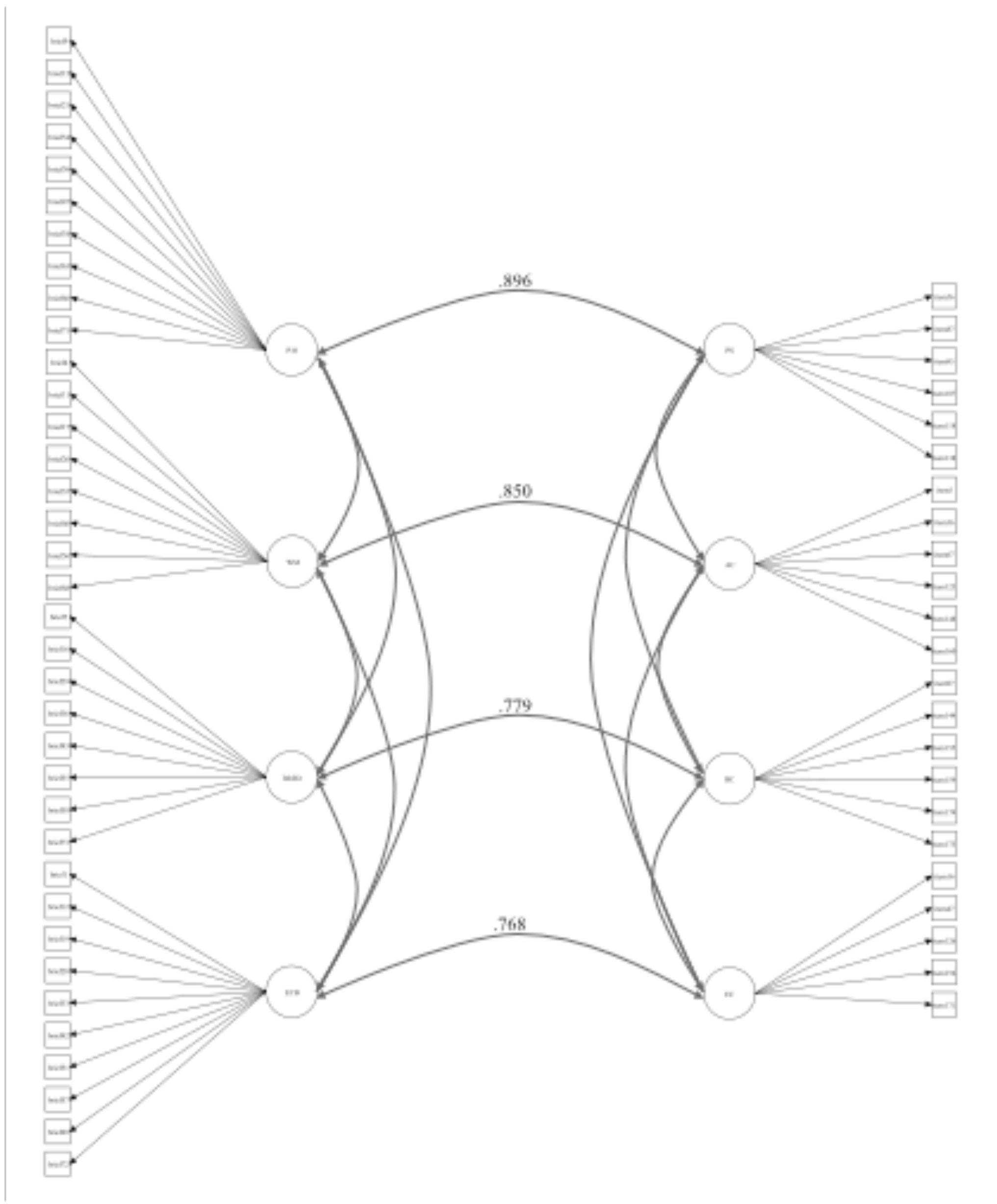
Note. EF = Executive Function; PS = Problem Solving; BSR = Behavioral Self-Regulation; AC = Attentional Control; BEC = Behavioral/Emotional Control; BC = Behavioral Control; EC = Emotional Control.

Figure 2.2. *Final confirmatory factor analysis model for the BASC-2-SRP-COL executive functions screener*



Note. BASC-2-SRP-COL = Behavior Assessment System for Children, 2nd edition, Self-Report of Personality, College version; PS = Problem Solving; AC = Attentional Control; BC = Behavioral Control; EC = Emotional Control.

Figure 2.3. *Comparison of the BASC-2-SRP-COL four-factor model to the selected corresponding target BRIEF-A scales*



Note. The values in this figure correspond with those reported in table 2.6. BASC-2-SRP-COL = Behavior Assessment System for Children, 2nd edition, Self-Report of Personality, College version; BRIEF-A = Behavior Rating Inventory of Executive Function, Adult version; P/O = Plan/Organize (BRIEF-A scale); WM = Working Memory (BRIEF-A scale); Inh = Inhibit (BRIEF-A scale); ECB = Emotional Control (BRIEF-A scale); PS = Problem Solving (BASC factor); AC = Attentional Control (BASC factor); BC = Behavioral Control (BASC factor); EC = Emotional Control (BASC factor).

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