Assessment of Executive Functioning Using the Behavior Rating Inventory of Executive Function (BRIEF)

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Robert M. Roth, Peter K. Isquith, and Gerard A. Gioia

A Brief History of the BRIEF

The Behavior Rating Inventory of Executive Function (BRIEF) was one of the first attempts to measure executive function via self- and informant reports of everyday functioning in the real-world environment and was the first published measure of these self-regulatory capabilities in children and adolescents (Gioia, Isquith, Guy & Kenworthy, 2000a). The impetus for the BRIEF arose among the authors in 1994 while trying to reconcile the often discrepant parent and teacher reports of children's everyday functioning at home and in school with their performance on putative performance measures (i.e., "tests") of executive function. At that time, there were few such performance measures of executive function developed for children and adolescents, no rating scales or structured observational methods for evaluating executive functions, and very few published articles on executive function in children (Bernstein & Waber, 2007).

While deficits in executive functions are important features of many developmental and acquired neurological disorders, challenges in measurement have long been recognized (Denckla, 1994; Kaplan, 1988). Given the central importance of the executive functions to the direction and control of dynamic "real world" behavior, reliance on traditional performance measures potentially can yield a limited, incomplete assessment (Gioia & Isquith, 2004; Gioia, Kenworthy & Isquith, 2010; Silver, 2000). While performance tests attempt to tap executive functions in explicit and specific ways, multiple confounds can limit their ecological validity and generalizability. It has been argued that neuropsychological tests alone are inadequate for assessing executive function because they artificially and ambiguously fractionate an integrated system (Burgess, 1997). Performance-based measures tap individual components of the executive function system over a short time frame and not the integrated, multidimensional, relativistic, priority-based decision making that is often demanded in real-world situations (Goldberg & Podell, 2000).

Trained in a developmental 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 BRIEF authors recognized the potential efficacy of gathering structured observations of children's everyday self-regulatory functioning from parents and teachers. This behavioral assessment approach was intended as a complement to, rather than in lieu of, traditional performance measures and as

R.M. Roth (✉) • P.K. Isquith
Geisel School of Medicine at Dartmouth School, Lebanon, NH, USA
e-mail: Peter.Isquith@Dartmouth.edu

G.A. Gioia
Children's National Medical Center, George Washington University School of Medicine, Rockville, MD, USA

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an index of ecological validity for findings in the clinic or laboratory setting. The guiding framework for developing the BRIEF was based on a review of the literature on executive functions across the lifespan, with particular attention to developmental models. The resulting model defined executive functions as a collection of interrelated functions, or processes, responsible for goal-directed behavior and cognitive activity, or as the "conductor of the orchestra" that controls, organizes, and directs cognitive activity, behavior, and emotional responses (Gioia, Isquith & Guy, 2001). While authors vary in which functions are viewed within an executive function framework, most models include variants of *inhibition* of prepotent responses, competing actions, and interfering stimuli; flexible *shifting* of cognitive set or problem-solving strategies when necessary; *initiation* of goal-directed behavior; *planning* and *organization* of information and behavior; and *monitoring* one's own social and problem-solving behavior. In support of these behaviors, *working memory* capacity plays a fundamental role in holding information actively "on-line" in the service of problem-solving (Pennington & Ozonoff, 1996). Importantly, the executive functions are not exclusive to cognition, or so-called "cool" executive processes, but are reflected in behavior and emotional control ("hot") executive processes (Zelazo, Qu & Muller, 2004).

Following a traditional test development pathway, items for the BRIEF were extracted from clinical interviews with parents and teachers, generated within commonly agreed upon domains of executive function while minimizing overlap with commonly employed behavior rating scales (e.g., CBCL, BASC), reviewed for readability and fit within those domains by experts in the field, and the measure was developed, refined, studied, and validated over the following 6 years until first publication in 2000 (Gioia et al., 2000a). Since publication of the original BRIEF, the instrument family has expanded to include several versions covering the span from 2 to 90 years of age. Each of the versions has been accompanied by interpretive report software and, more recently, smartphone apps and electronic manuals and are now available for web-based administration.

A BRIEF Description

The BRIEF is a family of rating scale instruments that were developed to capture the behavioral manifestations of executive dysfunction across the lifespan from the age of 2–90 years. Four different versions are available: the BRIEF-Preschool Version (BRIEF-P) for ages 2–5 years with one report form for parents and teachers/caregivers (Gioia, Espy & Isquith, 2003), the original BRIEF (BRIEF) for ages 5–18 years with separate parent and teacher report forms (Gioia et al., 2000a), the BRIEF-Self Report Version (BRIEF-SR) for adolescents aged 11–18 years (Guy, Isquith & Gioia, 2004), and the BRIEF-Adult Version (BRIEF-A) for ages 18–90 years with separate self- and informant report forms (Roth, Isquith & Gioia, 2005).

The BRIEF contains problem-oriented rating scales that ask respondents to indicate if each specific behavior is *never*, *sometimes*, or *often* a problem. Although each version of the BRIEF varies in scale composition to some degree, the general domains assessed and scale names (in parentheses) include inhibitory control (Inhibit), cognitive and behavioral flexibility (Shift), emotional regulation (Emotional Control), self-monitoring in the social context (Self-Monitor), ability to initiate activity (Initiate), ability to sustain working memory (Working Memory), planning and organization of cognition and problem-solving (Plan/Organize), organization of materials and environment (Organization of Materials), and monitoring of problem-solving and task performance for accuracy (Task Monitor). Initiation was not included in the BRIEF-SR as it was not supported by the data, but a Task Completion scale emerged. While not considered an executive function per se, the Task Completion scale captures the end result of executive difficulties, for example, getting started on tasks and following them through to completion. There was also insufficient resolution of the Initiate, Plan/Organize, Organization of Materials, and Monitor scales on the BRIEF-P resulting in retention of the Inhibit, Shift, Emotional Control, and Working Memory scales but collapsing of the remaining scales into a

Plan/Organize scale. Finally, the original BRIEF and BRIEF-SR have a unitary Monitor scale that was subsequently subdivided into Self-Monitor and Task Monitor scales based on further factor analytic research. Scales and definitions are described as follows:

- *Inhibit* measures the individual's ability to stop one's own behavior at the appropriate time (i.e., the ability to inhibit, resist, or not act on an impulse).
- *Shift* measures the ability to move freely from one situation, activity, or aspect of a problem to another, as the circumstances demand. Key aspects of shifting include the ability to make transitions, problem-solve flexibly, switch or alternate attention, and change focus from one mindset or topic to another.
- *Emotional Control* addresses the manifestation of executive functions within the emotional realm and measures the ability to modulate emotional responses. Poor emotional control can be expressed as emotional lability or emotional explosiveness. Individuals with difficulties in this domain may have overblown emotional reactions to seemingly minor events.
- *Initiate*, included in the parent, teacher, and adult forms, contains items relating to independently beginning a task or activity and generate ideas, responses, or problem-solving strategies. Poor initiation typically does not reflect noncompliance or disinterest in a specific task. Individuals with initiation problems typically want to succeed at a task, but they cannot get started. Individuals frequently report difficulties with getting started on tasks or chores, along with a need for extensive prompts or cues in order to begin a task or activity.
- *Working Memory* captures the capacity to actively hold information in mind for the purpose of completing a task or generating a response. Working memory is essential for a variety of everyday cognitive activities including carrying out multistep activities, implementing a sequence of actions, or following complex instructions. Individuals with weak working memory may have trouble remembering things (e.g., directions) even for a few minutes, lose track of what they are doing as they work, or forget what they are supposed to retrieve when instructed.
- *Plan/Organize* measures the ability to manage current and future-oriented task demands within the situational context. The *Plan* component of this scale relates to the ability to anticipate future events, implement instructions or goals, and develop appropriate steps ahead of time to carry out a task or activity. Planning often requires sequencing or stringing together a series of actions or responses. Planning is often described in terms of ability to start tasks in a timely fashion or to obtain, in advance, the correct tools or materials necessary to complete the activity. The *Organize* component of this scale relates to the ability to bring order to information, actions, or materials to achieve an objective. Individuals with organizational problems often approach tasks in a haphazard fashion or become easily overwhelmed by large amounts of information. They may have difficulty maintaining order in their environment or among their personal belongings.
- *Monitor* includes two functions, a self-monitoring and a task monitoring function. These are subsumed within one scale for the parent, teacher, and adolescent self-report forms but separated for the adult forms. Neither appears separately on the preschool forms. *Self-Monitor* measures a personal or social self-monitoring function or the extent to which one keeps track of his or her own behavior and its effect on others. Problems with monitoring are described in terms of failing to appreciate or have an awareness of one's own social behavior and the effect this might have on others. *Task Monitor* measures a problem-solving task-oriented, monitoring function. That is, the extent to which one keeps track of his or her own problem-solving success or failure. Problems with task-oriented monitoring are described in terms of failing to appreciate or have an awareness of one's own errors during such activities as problem-solving.
- *Organization of Materials* is included in all versions, except the Preschool Version, and measures one's ability to maintain organization

in his or her everyday environment, such as orderliness of work, play, living, or storage spaces such as desks, closets, and bedrooms. While this scale is not capture an executive function subdomain directly, the ability to keep ones environment organized is thought to reflect at least partly executive function abilities.

- *Task Completion* replaces the *Initiate* scale on the adolescent self-report version. It asks adolescents about their ability to complete work appropriately and in a timely manner. While this scale does not attempt to capture an executive function subdomain directly, the ability to complete tasks is an outcome of well-regulated problem-solving. And may reflect executive function difficulties.

In addition to the clinical scales, all versions of the BRIEF provide validity scales. The Negativity scale assesses the extent to which certain BRIEF items are answered in an unusually negative manner. A high Negativity score raises the possibility that the respondent had an unusually negative response style that skewed the results, though it is also possible that results represent the accurate perception of an individual with severe executive dysfunction. The Inconsistency scale indicates the extent to which the respondent answered a set of item pairs of similar content in an inconsistent manner. The BRIEF-A, but not the other versions, also includes an Infrequency scale measuring the extent to which adults endorse items in an atypical fashion. The scale includes items that are likely to be endorsed only in one direction by most people. For example, marking *often* to "I forget my name" is highly unusual, even for adults with severe cognitive impairment. An elevated Infrequency score raises the possibility of haphazard responding and/or the possibility that the respondent may have been biased toward endorsing items in an extreme manner. An elevated Infrequency scale score may raise the possibility of a purposeful attempt to portray the rated individual in a more positive or negative light than may actually be the case.

Structure of the BRIEF

Each version of the BRIEF summarizes individual scales within indexes based on theoretical considerations and the factor structure of the measures, as well as providing an overall executive function score across scales labeled the Global Executive Composite (GEC). Exploratory factor analyses suggested two factors for the BRIEF, BRIEF-SR, and BRIEF-A. The Behavior Regulation Index (BRI) summarizes the Inhibit, Shift, and Emotional Control scales for the parent/teacher forms; includes the Self-Monitor scale on BRIEF-A; and includes the Monitor scale on the BRIEF-SR. The BRI is interpreted as reflecting an individual's general ability to regulate or control his or her behavior and emotional responses, including appropriate inhibition of thoughts and actions, flexibility in shifting problem-solving set and adjusting to change, regulation of emotional responses, and, for adults and adolescents, monitoring of their own behavioral output.

The Metacognition Index (MI) summarizes the Initiate (Task Completion for BRIEF-SR), Working Memory, Plan/Organize, Organization of Materials, and Monitor scales for the parent/teacher forms. On the BRIEF-A this index also includes a Task Monitor scale. The MI can be interpreted as reflecting one's ability to get started on activity, to hold information in active working memory, to plan and organize problem-solving approaches, to complete tasks (adolescent self-report), and to maintain organization in the environment.

The BRIEF-P has three factor-based indexes: the Inhibit and Emotional Control scales forming an Inhibitory Self-Control Index, the Shift and Emotional Control scales forming a Flexibility Index, and the Working Memory and Plan/Organize scales forming an Emergent Metacognition Index.

More recently, confirmatory factor analyses have suggested that a three-factor model may more accurately reflect the underlying structure of the BRIEF. Please see the section on "Empirical Support for Test Structure" below for details.

Table 18.1 Translations of the Behavior Rating Inventory of Executive Function (BRIEF)

BRIEF-P	BRIEF	BRIEF-SR	BRIEF-A
Arabic	Afrikaans	Brazilian Portuguese	Afrikaans
Castellano	Bahasa	Chinese (simplified and traditional)	Chinese (simplified and traditional)
Catalan	Bemba (in-process)	Danish	Danish
Chichewa (in-process)	Castellano	Dutch	Dutch
Chinese (simplified)	Chichewa (in-process)	French	Dutch for Belgium
Danish	Chinese (simplified and traditional)	French for Canada	English for Australia
Dutch	Czech	German (in-process)	English for Canada
Finnish	Danish	Hebrew	English for South Africa
French	Dutch	Kannada	English for the United Kingdom
French for Canada	Finnish	Korean	Filipino
German	French	Norwegian	Finnish
Hebrew	French for Canada	Polish	French
Hungarian	German	Portuguese	French for Belgium
Italian (in-process)	Hebrew	Swedish	French for Canada
Japadhola	Icelandic		German
Kannada	Italian		German for Austria
Korean	Japadhola		German for Belgium
Latvian	Japanese		German for Switzerland
Luganda	Korean (in-process)		Hebrew
Lusoga	Luganda		Icelandic
Norwegian	Norwegian		Italian
Polish	Nyanja (in-process)		Japanese
Portuguese	Polish		Korean
Portuguese for Brazil	Portuguese (in-process)		Norwegian
Russian	Portuguese for Brazil		Portuguese
	Romanian		Portuguese for Brazil
Spanish	Russian		Romanian
Swahili	Sesotho (in-process)		Russian
Swedish	Shona (in-process)		Slovene
Teso	Slovakian (in-process)		Spanish for the USA
Thai	Slovene		Spanish for Spain
Turkish	Spanish		Spanish for Argentina
	Spanish for Puerto Rico		Spanish for Mexico
	Swedish		Spanish for Puerto Rico
	Teso		Swedish
	Thai (in-process)		
	Turkish		
	Xhosa		

Translations

At the time of publication of this book, translations of the BRIEF approved by the publisher were available in numerous languages and dialects on six continents, with additional translations in development (Table 18.1). For example, it recently was included in a multinational study of children's development in sub-Saharan Africa and has been used in national and international

pharmaceutical studies. The majority of translations were undertaken to facilitate research and were created through a process of translation and back translation with author review and input to ensure that the meaning of test items was retained. Normative data developed using the translated version is available for some of the translations and several are published as standardized instruments.

Administration and Scoring

Administration

All versions of the BRIEF typically take between 10 and 15 min to complete and have very similar instructions for administration and for respondents. Standardized instructions for administration of the BRIEF are available in the published Professional Manuals. Each of the BRIEF versions also has instructions for respondents printed directly on the rating form. Additionally, it is helpful to ensure that respondents understand the time frame for which they are rating behaviors (e.g., within the past month) and to encourage them to complete all of the items. Items are rated on a 3-point scale (1 = "never," 2 = "sometimes," 3 = "often"). A minimum fourth to fifth grade reading level is recommended for respondents.

Scoring

The BRIEF may be scored by hand or through the use of published scoring software. Both methods yield raw scores, *T*-scores, percentiles, and 90 % confidence intervals for each of the indexes and scales, as well as validity scale scores. The BRIEF should not be scored if more than a set number of responses are missing (e.g., 12 items for the preschool version). If responses are missing for more than two items on a given scale (or one item on the BRIEF-A Self- and Task Monitor scales), then the raw score should not be calculated for that scale. Missing responses for one or two items on a given scale can be assigned a score of 1 to permit calculation of raw and standardized scores for that scale.

Hand scoring is done by users first tearing off a perforated strip and peeling away the BRIEF report form to reveal a carbonless scoring sheet behind it on which the demographic information and responses are reproduced. The scoring sheet facilitates calculation of raw scores for each of the clinical scales and the three validity scales. Raw scores are transferred to a Scoring Summary sheet that includes detailed instructions for obtaining standardized scores (using the published Professional Manual) and gauging validity. The reserve side of the Scoring Summary sheet has a graph on which one may plot *T*-scores for scales and index scores.

Scoring software is available separately for the BRIEF-A and for the other versions combined (BRIEF, BRIEF-SR, and BRIEF-P). Examiners first enter the client's demographic details and information about the respondent (e.g., relationship to client) as appropriate. Next, item-level responses are entered by clicking with a mouse on the corresponding score circled on the report form (i.e., N, S, O) or by entering 1 for N, 2 for S, 3 for O, and 4 or ? for a missing response. Both software packages can then generate several types of reports. These vary in the level of detail from presenting scores (raw and standardized), item-level responses, and a plot of *T*-scores to presenting scores along with an extensive report explaining the measure, discussing validity and each clinical scale as well as providing a number of intervention recommendations tied to scale elevations. The reports for children and adolescents also offer language appropriate for IEP and 504 plan documentation. The software can also produce a "protocol summary" report that shows scores from up to four respondents (e.g., parent and one or more teachers) in a table and figure, thus facilitating comparison of ratings and providing a ready visual presentation of findings to clients, parents, or teachers. Demographic information and scores, both at the item level and all scores, from one or more clients can be exported from the software as delimited text files to facilitate importing into database, spreadsheet, and statistical software packages.

In addition to scoring software, the publisher of the BRIEF family of measures has made available online applications (Apps) that convert

BRIEF (all versions) raw scores into *T*-scores and percentiles and graph the standardized scores of the rated individual. Online administration and scoring of the BRIEF is now available via the publisher's web site.

Standardization, Norms, and Psychometrics

Characteristics of the Standardization Sample

Tables 18.2, 18.3, 18.4, and 18.5 present the characteristics of the standardization samples for the BRIEF versions. The standardization samples were collected with the goal of approximating the population of the United States according to key demographic variables. These included age, gender, ethnicity, and geographical population density. Socioeconomic status (SES) and parental education were also considered for some of the scales. The samples were weighted as needed to reflect estimated proportions for ethnicity and gender in the US population. Of note, while the standardization sample for the original BRIEF (Gioia, Isquith, Guy & Kenworthy, 2000b) was largely drawn from the State of Maryland, studies including typically developing children from around the world over the past decade have yielded scores consistent with the normative sample.

Table 18.2 Characteristics of the BRIEF standardization sample

	Parent report	Teacher report
Sample	25 private and public schools in urban, suburban, and rural areas of Maryland and 18 adolescents from a study in Cleveland, Ohio	Same as parent report
Exclusion criteria	History of special education or psychotropic medication use; maximum 10 % missing items on BRIEF	Same as parent report
N	1,419	720
Parental education (years)	Mean = 14.2 (SD = 2.57)	Not specified
Age groupings (years)	5–6, 7–8, 9–13, 14–18	Same as parent report
Gender (%)		
Boys	43	44
Girls	57	56
Race/ethnicity (%, actual/weighted)		
White	80.5/71.7	72.1/71.7
African-American	11.9/12.2	13.5/12.2
Hispanic	3.1/11.6	4.2/11.6
Asian/Pacific Islander	3.8/3.8	6.1/3.8
Native American/Inuit	.5/.7	.4/.7
Socioeconomic status (%)		
Upper	3.0	7.4
Upper middle	21.8	20.0
Middle middle	36.1	28.0
Lower middle	31.8	21.0
Lower	6.2	2.5
Unassigned	1.2	21.0

Table 18.3 Characteristics of the BRIEF-P standardization sample

	Parent report	Teacher report
Sample	20 preschool programs including private and public schools, as well as pediatric well-child visits, in urban, suburban, and rural areas of Maryland, Illinois, Vermont, New Hampshire, Florida, and Texas	Same as parent report
Exclusion criteria	History of special education, attention problems, developmental or cognitive difficulties, or psychotropic medication use; maximum 10 % missing items on BRIEF-P	Same as parent report
N	460	302
Parental education (years)	Mean = 15.7 (SD = 2.84)	Not specified
Age groupings (years)	2–3, 4–5	Same as parent report
Gender (%)		
Boys	53.5	54.3
Girls	46.5	45.7
Race/ethnicity (% actual)		
White	73.0	71.9
African-American	13.9	12.3
Hispanic	4.8	4.6
Asian/Pacific Islander	3.0	2.0
Native American/Inuit	.7	.7
Not Specified	4.6	8.6
Socioeconomic status (%)		
Upper	18.9	23.5
Upper middle	28.9	29.1
Middle middle	26.3	24.2
Lower middle	15.7	12.3
Lower	10.0	6.6
Unassigned	.2	4.3

Table 18.4 Characteristics of the BRIEF-SR standardization sample

	Parent report
Sample	Private and public schools, in urban, suburban, and rural areas of Maryland, Ohio, Vermont, New Hampshire, Florida, and Washington state
Exclusion criteria	History of special education or psychotropic medication use; maximum 10 % missing items on BRIEF-P
N	1,000
Parental education (years)	
Mothers	Mean = 13.55 (SD = 3.31)
Fathers	Mean = 13.88 (SD = 3.50)
Age groupings (years)	11–14, 15–18
Gender (%)	
Boys	44.8
Girls	55.2
Race/ethnicity (% actual)	
White	67.3
African-American	14.7
Hispanic	12.5
Other (Asian/Pacific Islander, Native American/Inuit)	5.5

Table 18.5 Characteristics of the BRIEF-A standardization sample

	Self-report	Informant report
Sample	Internet sampling throughout the USA	Same as self-report
Exclusion criteria	History of diagnosis or treatment of psychiatric illness, learning disorder, neurological disorder, serious medical illness (e.g., cancer), history of psychotropic medication use; all items had to be completed	Same as self-report
N	1,050	1,200
Education years (%)		
≤11	15.0	11.2
12	30.9	37.7
13–15	28.3	25.4
≥16	25.8	25.8
Age groupings (years)	18–29, 30–39, 40–49, 50–59, 60–69, 70–79, 80–90	Same as self-report
Gender (%)		
Male	50	45.2
Female	50	54.8
Race/ethnicity (% actual)		
White	72.6	71.8
African-American	9.3	13.0
Hispanic	12.0	8.5
Other (Asian/Pacific Islander, Native American/Inuit)	6.1	6.8
Geographic region (%)		
Northeast	20.0	19.4
Midwest	22.0	26.7
South	35.4	34.9
West	22.6	19.0

Reliability of the Scales

Internal Consistency

Internal consistency, the degree to which items on a single scale are measuring the same construct, has been reported using Cronbach's alpha (Cronbach, 1951). Alpha coefficients in the normative samples for both the BRIEF-P (range = .80–.97) and the BRIEF (range = .80–.98) parent and teacher reports are high. This was also seen in clinical samples for the BRIEF parent ($n = 852$) and teacher ($n = 475$) reports. Internal consistency was also reported to be high for the scales (.78–.90) and index scores (.93–.96) in a sample of 847 typically developing children using a Dutch translation of the BRIEF (Huizinga & Smidts, 2011). Alphas for the BRIEF-SR normative sample are moderate to high, ranging from .72 for scales with fewer items to .87 for scales with a larger number of items. Similarly, moderate to high alphas were obtained for both the BRIEF-A normative and mixed clinical samples. Coefficients tended to be higher for the informant than the self-report form, ranging for clinical scales from .80 to .93 in the normative samples and from .85 to .95 in mixed clinical samples. All but one index score across the versions were above .90 (BRIEF-P parent report Flexibility Index alpha = .89), with most at .93 or higher. These findings indicate that all BRIEF versions have strong internal consistency.

Table 18.6 Test-retest reliability and mean *T*-score difference for the BRIEF

	n	Test-retest interval (mean weeks)	Reliability coefficient mean (range)	*T*-score difference mean (range)
BRIEF-P				
Parent normative	52	4.5	.86 (.78–.90)	1.2 (.34–2.93)
Teacher normative	67	4.2	.83 (.65–.94)	1.6 (.04–3.03)
BRIEF				
Parent clinical	40	3	.79 (.72–.84)	3.1 (1.8–7.5)
Parent normative	54	2	.81 (.76–.88)	.8 (.0–3.0)
Teacher normative	41	3.5	.87 (.83–.92)	1.2 (.0–3.1)
BRIEF-SR				
Self-report	59	4.91	.78 (.59–.89)	4.5 (.37–6.19)
BRIEF-A				
Self	50	4.22	.89 (.82–.94)	2.5 (1.88–3.26)
Informant	44	4.21	.94 (.91–.96)	1.78 (1.32–2.18)

Test-Retest Reliability

Table 18.6 presents the test-retest reliability coefficients and the mean *T*-scores difference in the test-retest samples for all versions of the BRIEF. Between 41 and 67 participants were retested, with a mean retest interval ranging from 2 weeks to close to 5 weeks. Stability was observed to be adequate to high across nearly all scales, index scores, and versions ($r = .59–.96$), with the most coefficients being above .80. Furthermore, stability coefficients in the normative samples were similar across raters for the BRIEF-P, BRIEF, and BRIEF-A. Slightly higher average stability was seen for the teacher (mean $r = .87$) relative to the parent (mean $r = .81$) report on the BRIEF, as well as for the informant report (mean $r = .94$) relative to the self-report (mean $r = .89$) in adults. Furthermore, a recent study using the Dutch translation of the BRIEF observed high (.73–.94) test-retest reliability over a 2-week interval (Huizinga & Smidts, 2011).

Knowledge of the degree of expected change in *T*-scores over repeated administrations in normative samples, where little change should be seen over modest time frames, is important. This is particularly relevant for clinical purposes such as monitoring recovery (e.g., traumatic brain injury (TBI), stroke) and evaluating treatment effects (e.g., medication, behavioral, surgery). In the test-retest samples, the change in *T*-scores across versions was generally less than 2–3 points for scale and index scores. Perhaps not surprisingly, the largest discrepancies were observed for the BRIEF clinical sample and the adolescent self-reports.

Together, these findings indicate little variability in scores due to the instrument itself. This supports repeated administration and provides a basis for interpreting changes over time.

Inter-Rater Reliability

The test manuals report on the inter-rater reliability for the different versions of the BRIEF. Table 18.7 provides a summary of the correlations (mean and range) between scores for different raters. In preschool children, correlations between parent and teacher ratings are modest (mean = .19). Greater inter-rater agreement was reported for the Inhibit, Shift, and Emotional Control scales than the Working Memory and Plan/Organize scales. The BRIEF manual also reports data on the correspondence between the ratings of parents and teachers, noting a modest overall correlation of .32. The lowest correlations were observed for the Initiate ($r = .18$) and Organization of Materials ($r = .15$) subscales. Parents tended to rate their children, both boys and girls, as having more problems on the BRIEF-P and BRIEF as compared to teachers, which is consistent with other literature on

Table 18.7 BRIEF inter-rater reliability

	n	Sample	Raters	Reliability coefficient mean (range)
BRIEF-P	302	Normative	Parent–teacher	.19 (.06–.28)
BRIEF	296	Normative	Parent–teacher	.32 (.15–.50)
BRIEF-SR	243	Mixed control and clinical	Self–parent	.47 (.36–.57)
BRIEF-SR	148	Mixed control and clinical	Self–teacher	.28 (.20–.41)
BRIEF-A	180	Mixed control and clinical	Self–informant	.57 (.44–.68)

parent-teacher discrepancies (Offord et al., 1996). Jarratt et al. reported an average correlation of .58 (range = .46–.72) in a sample of 40 children (Jarratt, Riccio & Siekierski, 2005). Discrepancies between parent and teacher ratings, and differences in the inter-rater reliability of specific scales, may partly reflect the consistency with which behavioral and emotional difficulties are expressed in disparate environments. For example, problems with disinhibition may be more readily observed across settings than some other aspects of executive dysfunction. Differences with respect to degrees of environmental structure and demand in home and school settings may also contribute to inconsistencies between raters.

In children and adolescents, examination of the relationship between self-ratings and other's ratings (e.g., parent) is subject to a number of methodological and developmental considerations (Surber, 1984). In particular, adolescence is commonly a period of growing self-awareness (Lyons & Zelazo, 2011) that in part parallels maturation of gray and white matter in frontal and other brain regions (Khundrakpam et al., 2012; Peters et al., 2012). Another important consideration in adolescents, as well as in other age groups, is that self-awareness may be compromised in a variety of clinical conditions such as acquired brain injuries (Beardmore, Tate & Liddle, 1999; Ciurli et al., 2010; Flashman, 2002). A study of 98 adolescents with TBI and 98 healthy teens found moderate agreement between the BRIEF-SR and BRIEF parent index scores in both the clinical ($r = .43–.54$) and control samples ($r = .40–.42$). While adolescents in both groups generally reported having fewer problems with executive function than observed by their parents, the difference was greater in the patient than healthy group for the Metacognitive Index but not the Behavioral Regulation Index (Wilson, Donders & Nguyen, 2011). In the BRIEF-SR manual, adolescent self-ratings were moderately to highly correlated with parents ratings (mean $r = .47$), while a significant but lower association was observed in relation to teacher ratings (mean $r = .28$). The lower correlation with teacher as opposed to parent ratings may reflect differences in demand characteristics of the school vs. home setting. It also possible that the greater percentage of subjects from clinical populations relative to typically developing adolescents in the self-teacher than the self-parent samples contributed to the discrepancy.

Inter-rater agreement for the BRIEF-A was examined in a mixed clinical and healthy adult sample. Correlations across the scales and indices were moderate ($r = .44–.68$), with the lowest correlation being seen for the Shift scale. Importantly, approximately 50–70 % of the *T*-scores for self- and informant reports were within a standard deviation. Thus, while there is often good agreement between adult raters, there is a nontrivial subset of cases in which disagreement is present. There are several possible explanations for discrepancies between self- and informant ratings such as awareness deficits in the person being rated, rater bias (e.g., the informant having overly positive or negative view of the individual being rated), and a variety of contextual factors (e.g., whether the rated individual is observed in more or less structured environments).

Use of the Rating Scale

Interpretation Methods: Case Example

Matthew was a 16-year-old tenth-grade student with a history of declining school performance since middle school and increasing attention, behavior, and mood difficulties in the context of loss of his closest friend; two unmanaged concussions in close proximity; onset of seizures that are well controlled with medication; and mononucleosis within the past year. Early history was unremarkable. In middle school, Matthew began having difficulty getting started on tasks and putting forth effort toward schoolwork unless tasks were inherently motivating, such that he earned As in classes he enjoys but failing grades in other areas such that he was at risk for not graduating. He was referred for neuropsychological consultation to assist in developing a more comprehensive understanding of his strengths and needs.

The evaluation protocol documented very superior verbal knowledge and reasoning along with superior nonverbal problem-solving, learning, memory, and motor function. Academic skills were high average. He was pleasant, social, straightforward, and aware of his own difficulties and strengths. On a variety of performance-based measures of executive function, Matthew performed well, suggesting intact fundamental "cold" executive functions when engaged in novel, short-term problem-solving. On the Tasks of Executive Control (TEC), a lengthy measure of the ability to sustain attention and vigilance when confronted with increasing working memory load and inhibitory demand, he demonstrated good performance in all respects. He was appropriately focused and vigilant for both novel and frequent information, was not impulsive, and demonstrated rapid and consistent response speed. There were no meaningful changes in his performance as the task became more demanding, suggesting good ability to hold complex information in working memory despite increasing challenges. His performance on a range of standard executive function measures (including Tower of London, Trail Making, and Stroop tasks) was similarly average to high average.

Matthew's mother and two teachers (English, Social Studies) completed the appropriate forms of the BRIEF and Matthew completed the BRIEF-SR. The protocols were scored using the BRIEF Software Portfolio to facilitate speed and accuracy of scoring, allow for comparison of profiles between raters, and generate suggestions for feedback appropriate for Matthew and his parents and teachers as well as recommendations for areas of difficulty, along with language appropriate for an IEP or 504 plan. Figure 18.1 shows *T*-scores and percentiles. A review of the Validity scales (Negativity and Inconsistency) at the bottom of Fig. 18.1 shows that all protocols had acceptable validity indicators with the exception of rater 3, a teacher, who obtained an Inconsistency score that was "Questionable." The raw score of 8 reflects a difference of 8 points between ten pairs of similar items on the BRIEF protocol, such as marking *never* in response to "Gets out of control more than friends" but marking *often* in response to "Acts too wild or 'out of control.'" A raw score difference of 8 is at the 99th percentile relative to other teachers' consistency scores in the standardization sample. This does not invalidate Rater 3s profile per se, but the protocol should be viewed with caution. Of note, Rater 3s scores on the clinical scales are generally higher than that seen for the other raters.

Figure 18.2 shows each rater's scores graphically in the BRIEF Software Portfolio Profile Report view. *T*-scores between 60 and 65 are typically considered mildly elevated, while *T*-scores above 65, shown in the shaded area on the profile view, are considered clinically elevated. Reading from left to right, the scales comprising the BRI are presented first: Inhibit, Shift, and Emotional Control. Rater 3s scores were on these three scales were all clinically elevated, though the protocol was "Questionable" due to highly inconsistent ratings. By comparison, Matthew, his mother, and his Social Studies teacher's ratings were clinically elevated only for the Shift scale. In viewing the profile regardless of *T*-scores, all four raters had the greatest

BRIEF® Protocol Summary

R1 =Mother; R2 =Social Studies(Teacher); R3 =English (Teacher); R4 Self				
Index/Scale	**R1 03/17/2011 *T* (%ile) Parent**	**R2 04/27/2011 *T* (%ile) Teacher**	**R3 03/31/2011 *T* (%ile) Teacher**	**R4* 3/20/2011 *T* (%ile) Self**
Inhibit	60 (89)	56 (83)	83 (96)	57 (77)
Shift	65 (91)	79 (97)	88 (97)	70 (98)
Emotional Control	63 (89)	62 (88)	73 (93)	54 (69)
Behavioral Regulation Index (BRI)	64 (89)	66 (88)	84 (97)	60 (84)
Initiate	53 (63)	80 (97)	88 (≥ 99)	--
Working Memory	71 (97)	101 (≥ 99)	97 (≥ 99)	77 (≥ 99)
Plan/Organize	66 (93)	95 (≥ 99)	98 (≥ 99)	60 (86)
Organization of Materials	72 (≥ 99)	130 (≥99)	116 (≥ 99)	62 (88)
Monitor	65 (96)	71 (91)	93 (≥ 99)	52 (58)
Task Completion (BRIEF-SR Only)	--	--	--	73 (97)
Metacognition Index (MI)	68 (96)	97 (≥ 99)	104 (≥ 99)	70 (95)
Global Executive Composite (GEC)	68 (92)	89 (≥ 99)	102 (≥ 99)	67 (93)

Validity Scale	**R1 Raw Score (Protocol Classification)**	**R2 Raw Score (Protocol Classification)**	**R3 Raw Score (Protocol Classification)**	**R4 Raw Score (Protocol Classification)**
Negativity	0 (Acceptable)	2 (Acceptable)	2 (Acceptable)	2 (Acceptable)
Inconsistency	4 (Acceptable)	4 (Acceptable)	8 (Questionable)	5 (Acceptable)

Fig. 18.1 BRIEF software portfolio protocol summary report multi-rater score table. **Note*: BRIEF-SP does not currently print BRIEF-SR scores with Parent and Teacher Form scores in the same table. They are presented in the same table here for convenience

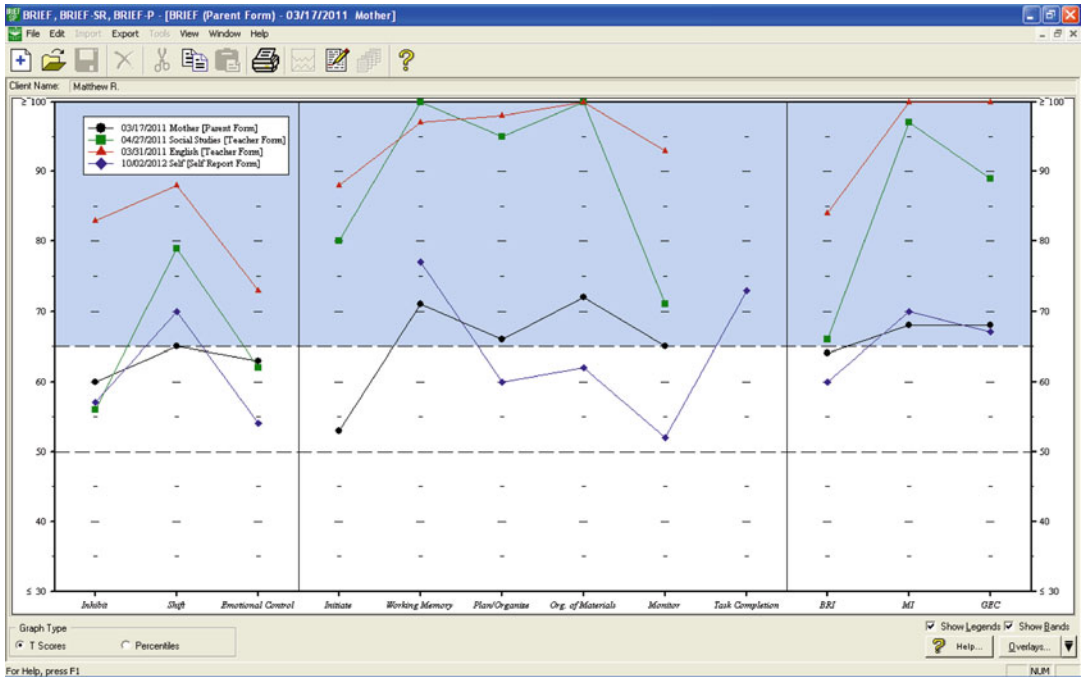

Fig. 18.2 BRIEF software portfolio parent, teacher, self-report profiles

concerns about Matthew's ability to adapt to change behaviorally and cognitively as reflected on the Shift scale. While there were some concerns with his emotional regulation (parent and teacher ratings above 60), these were of less concern. This pattern suggests that Matthew dislikes change and becomes upset when his plans or expectations are altered.

Continuing to interpret the profile from left to right, the next set of scales composes the Metacognition Index, reflecting an individual's ability to cognitively self-manage tasks. Matthew's teachers rated him as having substantial difficulty in all domains. He was described as having marked difficulty initiating, planning, organizing, and monitoring his problem-solving efforts while holding information and goals in working memory. His mother's ratings were clinically elevated for most scales with the exception of the Initiate scale. Follow-up interview revealed that Matthew initiated activities of his choosing at home, such as composing music and going out with friends, but avoided bringing any schoolwork home or letting his parents know what school-related tasks were due. Thus, his mother had little opportunity to observe the initiation difficulties noted by his teachers in the school setting.

While parent and teacher ratings on the BRIEF can provide useful information about a student's everyday self-regulatory functioning, adolescent self-reports add to the complete assessment picture by capturing the individual's own experiences and perspectives. Adolescent self-reports present a special case because adolescents are actively developing executive self-awareness. While adolescent self-reports on the BRIEF-SR correlate well with parent ratings (approximately .50 overall) and reasonably well with teacher ratings (approximately .25 overall) on the BRIEF, this does not mean that they have the same scores but instead means that the ratings tend to be parallel; that is, raters tend to describe similar peaks and valleys in their ratings though *T*-scores may be higher or lower. Indeed, some 56 % of adolescents' ratings on the BRIEF-SR were within 10 *T*-score points above or below their parents' ratings, another 38 % were up to 20 *T*-score points *below* their parents' ratings. Only 5 % of adolescents rated themselves as having over 10 *T*-score points *greater* difficulty than described by their parents. A similar pattern is seen for adolescent ratings in comparison to teacher ratings. Thus, parent, teacher, and adolescent ratings tend to show similar profiles, and adolescents' ratings are often within one standard deviation of parent and teacher ratings, many are more than one standard deviation *lower*, and it is unusual for an adolescent to report substantially *greater* difficulty than their parent or teacher.

In this example, Matthew's self-report was indeed parallel to his mother's and teachers' ratings, and within 10 *T*-score points of his mother's ratings with the exception of the Monitor scale where his ratings were much lower. This suggested good agreement between raters as to the primary areas of concern, including ability to adjust to change, to hold information in working memory, and to plan, organize, and monitor his problem-solving approaches. While Matthew's ratings on these latter scales were not "clinically elevated," his ratings on the Task Completion scale were high. This scale assesses the adolescent's ability to complete tasks appropriately and/or in a timely manner. While the scale does not attempt to capture a primary executive function, the ability to complete tasks is an outcome of well-regulated problem-solving. Problems in this area are often closely linked to other executive difficulties such as poor working memory, planning, and organization.

In essence, the evaluation profile as a whole highlights a history, observations, and formal test performance reflecting difficulty with initiating and sustaining cognitive and behavioral activity absent strong external incentive in an academically and cognitively capable adolescent boy with several risk factors upon entry to high school. In the context of superior to very superior overall current cognitive functioning, above-average learning and memory, and strong academic skills, Matthew demonstrated a pattern of difficulty initiating and sustaining cognitive activity and behavioral output that is consistent with his history of increasing problems with focusing in class and getting started on his work. While demonstrating appropriate executive function on

a range of performance-based measures, ratings of Matthew's executive functioning in the real-world context indicated problems with initiating attention and behavior, sustaining working memory, and planning, organizing, and monitoring his own output, accompanied by resistance to change. This is consistent with his historical pattern of good early academic performance, but decline beginning in middle school, and teacher observations of a "drifty" inattentive style and trouble getting started on tasks in school. His difficulty initiating activity was context dependent, as he brought minimal schoolwork home thus did not exhibit initiation difficulties in that setting. Students with similar profiles tend to exhibit a pattern of good performance on tasks or activities for which they feel highly motivated vs. problems doing the work on tasks that they find less interesting. The good agreement between all raters about Matthew's resistance to change may reflect his anxiety and distress regarding perceived inability to accomplish tasks. Matthew wants to do well, to graduate, and to attend college and study music composition and production but does not know how to correct his current path.

While these everyday executive difficulties were emerging during the middle school years, the pattern was complicated by a number of risk factors. As he was making the transition into adolescence and high school, he sustained a mild TBI with significant post-injury symptoms but returned to school without rest or management. He sustained a second injury several months later, notably followed by sudden onset of depression and longer-term post-concussion symptoms. More recently, he experienced the onset of seizures and began medication. Matthew's best friend also moved away, and he had a difficult time adjusting to the loss. While none of these risk factors fully explains Matthew's functional difficulties, they may be exacerbating factors and add complexity to the clinical presentation. Concussion or mild TBI effects typically resolve within a few weeks to months of the injury. This can be prolonged, however, in students with vulnerable neurological systems such as those with attention problems or seizures. Repeated concussion can have compounding effects as well. Adolescents who have or develop chronic illness (e.g., seizure disorders) often experience a difficult adolescent period, as the normal processes of developing competencies, self-confidence, and separating and becoming an independent individual are complicated by the illness and its effects and limitations.

Interventions Based on Test Results

The software packages for the BRIEF, BRIEF-SR, BRIEF-P, and BRIEF-A were designed to provide the user with the option of generating reports containing brief or detailed descriptions of the individual's profile and recommendations for each of the scales with an elevated *T*-score or, alternatively, recommendations whatever scales the user selects. The recommendations are organized according to the guiding model of executive function (e.g., Inhibit, Shift, Emotional Control, Initiate) and were compiled by the authors based on clinical experience and a review of literature on managing executive dysfunction in clinical populations (e.g., Cicerone et al., 2000; Mateer, 1999; Ylvisaker & Feeney, 1996, 1998; Ylvisaker, Szekeres & Feeney, 1998). These are similar to several recently described approaches to managing executive dysfunction (Cooper-Kahn & Dietzel, 2008; Dawson & Guare, 2010, 2012; McCloskey, Perkins & Divner, 2009).

The majority of recommendations are designed to serve as compensatory strategies that circumvent, rather than directly improve, deficits (e.g., learning cognitive strategies such as verbalization, development of an organized plan, goal setting, and strategies for aiding monitoring of behavior). Such strategies have demonstrated effectiveness in a number of patient populations (Dirette, 2002; Velligan et al., 2000; Wexler & Bell, 2005). Other recommendations emphasize the interaction of the individual and their environment, suggesting environmental modifications or accommodations (e.g., keeping work space clutter-free) that could facilitate executive functions (Ylvisaker, Hanks & Johnson-Greene, 2002; Ylvisaker, Jacobs & Feeney, 2003).

It is important to note that the offered recommendations are generic in nature and should be tailored on a case-by-case basis to conform to individual needs based on severity of deficit, preserved strengths, and environmental demands. Furthermore, the decision to use any given strategy to address executive dysfunction should be based on an appropriate assessment of the individual and tailored accordingly. The interpretive reports generated by the BRIEF software portfolio also include language appropriate for inclusion in writing an IEP or 504 plan.

Validity

Relationships to Other Similar Measures

Until very recently, the BRIEF was the only published rating scale for use with children. Thus, the majority of research on the convergence of the BRIEF with other rating scales has focused on behavioral measures with which it should theoretically correlate. For example, both the test manuals and several other studies have examined the relationship between BRIEF scores and parent ratings of attention-deficit/hyperactivity disorder (ADHD) symptoms. In the test manual, BRIEF-P scale and index scores were reported to show significant correlations with the Inattention ($r = .66–.90$) and Hyperactivity/Impulsivity ($r = .49–.87$) scales of the ADHD-IV-P. Similarly, BRIEF scale and index scores had moderate to high correlations with the Inattention ($r = .39–.67$) and Hyperactivity/Impulsivity ($r = .15–.73$) scales of the ADHD-IV. Significant correlations with the CBCL and BASC Attention Problem scales, the BASC Hyperactivity scale, and relevant scales on the Conner's Parent Rating Scale were also reported in the test manuals. Other investigators have also generally observed moderate to high correlations between the BRIEF and ADHD symptoms as measured using rating scales such as the ADHD Rating Scale (Mahone et al., 2002), BASC (Jarratt et al., 2005; McCandless & O' Laughlin, 2007), and Conner's Parent Rating Scale—Revised (Mahone & Hoffman, 2007).

In contrast to the pediatric literature, a number of other rating scales have been developed to assess executive functions in adults. The Dysexecutive Questionnaire (DEX) was designed to provide a single overall score reflecting executive functioning (Wilson, Alderman, Burgess, Emslie & Evans, 1996). All of the BRIEF-A scale and index scores correlated with the DEX in the expected direction. This was seen for both the self- and the informant ratings on the two instruments. The Frontal Systems Behavior Scale (FrSBe) was designed to assess three domains of frontal lobe deficits including Apathy, Disinhibition, and Executive Dysfunction (Grace & Malloy, 2002). Significant associations with FrSBe scores were reported in the BRIEF-A manual for both self- and informant ratings, the strongest correlations being observed with the Executive Dysfunction scale. Interestingly, the Shift and Emotional Control scales on the BRIEF-A showed some of the lowest correlations with the FrSBe scales, likely due to differences in the aspects of executive function tapped by the item content in the two measures. Nonetheless, the pattern of correlations with both the DEX and the FrSBe provides strong evidence for the convergent validity of the BRIEF.

The relationship between subjective ratings and scores on performance-based measures (e.g., Wisconsin Card Sorting Task, Trail Making) of executive function is another source of data pertaining to validity. A commonly raised concern is that rating scales of executive function do not always correlate in predictable ways with performance measures of the same or similar constructs. Indeed, there is inconsistency in the literature with respect to the presence of significant correlations between the BRIEF and performance-based tests. A recent review noted, however, that there are many measureable correlations between the BRIEF and such tests (McAuley, Chen, Goos, Schachar & Crosbie, 2010), though when such correlations are observed they tend to be small to moderate (e.g., Mahone, Cirino et al., 2002; Shimoni, Engel-Yeger & Tirosh, 2012; Toplak,

Bucciarelli, Jain & Tannock, 2009). For example, in a sample of children with TBI, a subset of BRIEF scores were reported to show correlations ($r = .24–.38$) with performance on the TEC, a computerized instrument emphasizing working memory and inhibitory control (Isquith, Roth & Gioia, 2010). Many authors have discussed explanations for the modest relationship between subjective ratings of cognitive functioning, including executive functions, and performance on tests in the clinic or laboratory setting (Gioia & Isquith, 2004; Isquith, Roth & Gioia 2013; McAuley et al., 2010; Sbordone, 1996).

Fairness, Sex, Race, and Ethnic Differences

The influence on demographic characteristics on BRIEF scores is reported in the test manuals. In addition, although the majority of respondents on the parent form were mothers (BRIEF, 83.2 %; BRIEF-P, 88.7 %), there was no significant difference between mother and father reports with respect to level of scale scores. Furthermore, for both the BRIEF-P and BRIEF, how well and for how long the teacher has known the rated child had little effect on scores, accounting for no more than 3 % of variance.

A significant effect of age was observed in the BRIEF standardization sample, for both parent and teacher report forms, with executive functions noted to improve with increasing age. This was reflected in both the index and scale scores. A small but significant effect of age was also seen in the BRIEF-P standardization sample, with younger children being reported by parents and teachers as having greater difficulty with some aspects of their executive functions. Similarly, on the BRIEF-SR younger adolescents reported themselves as having more difficulty with executive functions than older teens. Together, these findings are consistent with other evidence for developmental changes in executive functions from early childhood through adolescents (Anderson, Anderson, Jacobs & Smith, 2008; Best & Miller, 2010). Analysis of the BRIEF-A standardization sample revealed slightly greater difficulty with executive functions on several scales in younger (especially the 18–39-year-old group) than older adults for both self- and informant reports. Between 1 and 7 % of variance on the scales was accounted for by age in the adult samples.

Gender of the rated child has been found to affect scores. In the BRIEF-P standardization sample, parents tended to rate boys as having greater problems than girls on the Inhibit scale, while teachers rated boys as having more difficulty on the Inhibit, Working Memory, and Plan/Organize scales. Gender differences were also noted for the ISCI, EMI, and GEC scores. For most of these scales, however, no more than 3 % of variance was accounted for by gender. No interaction between age and gender was noted. On the BRIEF, both the parent and teacher forms show differences between boys and girls as well as there being an interaction between age and gender with boys showing dramatic improvements in executive function with increasing age. On the BRIEF-SR, boys tended to rate themselves on most scales as having slightly greater difficulty than girls, but girls reporting more problems on the Emotional Control scale. No interaction between gender and age was noted for the adolescent respondents. On the BRIEF-A, minimal gender differences were noted. Men reported more difficulty on the Initiate scale, while women reporting more problems with Emotional Control. The informant report was only found to show a gender difference for the Organization of Materials. Less than 2 % of variance was accounted for by gender on the BRIEF-A.

Significant but low correlations have been reported indicating that lower parental education is associated with report of greater problems with executive function on the BRIEF-P, BRIEF, and BRIEF-SR. These findings are consistent with that observed for parent behavioral ratings of their children's social-emotional functioning (Achenbach, McConaughy & Howell, 1987). Similarly, for both the self- and informant report forms of the BRIEF-A, several small but significant correlations were noted with years of education, indicating that lower education of the rater individual is associated with greater difficulty

with executive function as reflected by some of the scales. Importantly, across the scales no more than 5 % of variance was accounted for by education in the child and adolescent versions of the BRIEF (BRIEF-P, BRIEF, BRIEF-SR) and less than 2 % of variance for the BRIEF-A. Therefore, education makes relatively small contribution to scores and is not considered a major factor when interpreting the measures.

SES has a small but significant relationship to BRIEF scores. Children from lower household SES are likely to be rated as having greater problems with executive function on both the BRIEF-P and the BRIEF, though SES accounts for no more than 2 % of variance in the former and 5 % of variance in the latter measure.

Race/ethnic group membership of the rated child does not have a significant impact on BRIEF, BRIEF-P, or BRIEF-SR scores. The BRIEF-A self-report form showed only a single significant effect indicating that African-American respondents obtained slightly higher scores than Hispanic respondents on the Organization of Materials scale. Analysis of the informant report form indicated that the race/ethnic group of the rated individual was associated with slightly different scores on the Inhibit, Self-Monitor, and Task Monitor scales. These differences on the BRIEF-A accounted for only about 1 % of variance, thus indicating that they are of little clinical significance

Profiles of Abilities and Their Relationship to Diagnosis

There is considerable evidence for the value of the BRIEF in assessing executive functions. Literature referencing the BRIEF has grown to over 300 scholarly articles and book chapters, the BRIEF-P and BRIEF-SR to over 100 articles each, and the more recently published BRIEF-A to over 50 articles, and countless conference presentations and posters include the BRIEF. The instrument has been included in many treatment trials, both pharmacological and behavioral, as well as longitudinal, multicenter studies of development (Waber et al., 2007; Waber, Forbes, Almli & Blood, 2012). The BRIEF has been demonstrated to be sensitive to executive functioning in a wide range of clinical populations. Table 18.8 presents a selection of this literature. The two diagnostic groups in which the BRIEF has been most frequently studied are ADHD and TBI. Here, we provide a brief overview of the BRIEF in relation to these groups.

ADHD

Numerous studies have examined the diagnostic utility of the BRIEF in children with ADHD. The authors presented the first such data (Gioia et al., 2000b), showing that the Working Memory scale predicted ADHD-Inattentive type (ADHD-I) and ADHD-Combined type (ADHD-C) with approximately 80 % accuracy for the parent form (81 %) and teacher form (83 %), while the Inhibit scale did so to a lesser degree (78 %, 70 %, respectively). Consistent with the requirement of impulsivity for a diagnosis of ADHD-C, the Inhibit scale was useful in distinguishing between children diagnosed with ADHD-I and ADHD-C. Reddy, Hale and Brodzinsky (2011) found similar rates of correct classification (77–86 %) in a well-controlled study comparing children diagnosed with ADHD vs. controls, providing convergent evidence for the clinical utility of the BRIEF for identifying children with attention disorders. Other ADHD subtypes may potentially also be distinguished by the BRIEF. Children with the sluggish cognitive tempo (SCT) variant of ADHD were rated as having greater problems on the Initiate (Isquith, McQuade, Crawford & Roth, 2005) or Monitoring scales of the BRIEF than were groups of children with ADHD-C or ADHD-I without SCT (Capdevila-Brophy et al., 2012). In addition to distinct profiles on the BRIEF between children diagnosed with ADHD-I vs. ADHD-C, each of these conditions was distinguishable from children with reading disorders and those with autism spectrum disorders (ASDs; Gioia, Isquith, Kenworthy & Barton, 2002). Several other studies have shown independent support for the utility of the BRIEF in identifying individuals with ADHD and subtypes (Mahone, Cirino et al., 2002; Mares, McLuckie, Schwartz & Saini,

Table 18.8 A sample of studies using the BRIEF in clinical populations

Population	Authors
ADHD	Biederman et al. (2011), Findling, Ginsberg, Jain and Gao (2009), Jarratt et al. (2005), Mahone, Cirino et al. (2002), Mahone and Hoffman (2007), Mares et al. (2007), McCandless and O' Laughlin (2007), Qian, Shuai, Cao, Chan and Wang (2010), Rotenberg-Shpigelman et al. (2008), Shimoni et al. (2012), Toplak et al. (2009), Yang et al. (2012)
Autism spectrum disorders	Chan et al. (2009), Christ et al. (2010), Semrud-Clikeman, Walkowiak, Wilkinson and Butcher (2010)
Bipolar disorder	Shear, DelBello, Lee Rosenberg and Strakowski (2002), Stange et al. (2011)
Brain tumor	Hocking et al. (2011)
Cancer survivors	Christ et al. (2010)
Cerebral palsy	Tervo, Symons, Stout and Novacheck (2006)
CHARGE syndrome	Hartshorne, Nicholas, Grialou and Russ (2007)
Cochlear implant	Holt, Beer, Kronenberger, Pisoni and Lalonde (2012)
Conduct disorder	Tobon, Puerta and Pineda (2008)
Down's syndrome	Edgin et al. (2010), Lee et al. (2011)
Epilepsy	Parrish et al. (2007), Sherman, Slick and Eyrl (2006), Slick et al. (2006)
Fetal alcohol syndrome	Chasnoff, Wells, Telford, Schmidt and Messer (2010), Wells, Chasnoff, Schmidt, Telford and Schwartz (2012)
Focal frontal lesions	Anderson et al. (2002), Lovstad et al. (2012)
Galactosemia	Antshel, Epstein and Waisbren (2004)
Hepatitis C	Rodrigue et al. (2011)
Hydrocephalus	Anderson et al. (2002), Mahone, Zabel, Levey, Verda and Kinsman (2002)
Hypersexuality	Reid, Karim, McCrory and Carpenter (2010)
Hypertension	Lande et al. (2009)
Juvenile myoclonic epilepsy	Gilotty et al. (2002), Pulsipher et al. (2009)
Lead exposure	Roy et al. (2009)
Leukemia	Campbell et al. (2009)
Liver transplant	Sorensen et al. (2011), Varni et al. (2011)
Mild cognitive impairment	Rabin et al. (2006)
Multiple sclerosis	Till et al. (2012)
Neurofibromatosis I	Payne, Hyman, Shores and North (2011)
Obstructive sleep apnea	Beebe et al. (2004)
Pathological gambling	Reid, McKittrick, Davtian and Fong (2012)
Phenylketonuria	Anderson et al. (2002), Waisbren and White (2010)
Prenatal phthalate exposure	Engel, Miodovnik, et al. (2010)
Psychosis prodrome	Niendam, Horwitz, Bearden and Cannon (2007)
Schizophrenia	Garlinghouse et al. (2010), Kumbhani, Roth, Kuck, Flashman and McAllister (2010), Power, Dragovic and Rock (2012)
Sickle cell anemia	Berg, Edwards and King (2012), Hollocks et al. (2012)
Sleep disordered breathing	Bourke et al. (2011)
Specific language impairment	Hughes, Turkstra and Wulfeck (2009)
Spina bifida	Burmeister et al. (2005), Kelly et al. (2012), Tarazi, Zabel and Mahone (2008), Zabel et al. (2011)
Subcortical band heterotopia	Jacobs, Anderson and Harvey (2001)
Substance abuse	Hadjiefthyvoulou, Fisk, Montgomery and Bridges (2012)
Tourette's	Cummings, Singer, Krieger, Miller and Mahone (2002), Mahone, Cirino et al. (2002)
Traumatic brain injury	Anderson et al. (2002), Anderson et al. (2005), Chapman et al. (2010), Conklin et al. (2008), Donders et al. (2010), Garcia-Molina et al. (2012), Maillard-Wermelinger et al. (2009), Mangeot et al. (2002), Matheson (2010), Toglia et al. (2010), Wilde et al. (2012), Wilson et al. (2011)

(continued)

Table 18.8 (continued)

Population	Authors
Turner syndrome	Lepage, Dunkin, Hong and Reiss (2013)
Type 1 diabetes	McNally, Rohan, Pendley, Delamater and Drotar (2010)
Velocardiofacial syndrome (22q11.2 deletion syndrome)	Antshel et al. (2006), Antshel, Conchelos, Lanzetta, Fremont and Kates (2005), Kiley-Brabeck and Sobin (2006)
Very low birth weight	Anderson et al. (2011), Verkerk et al. (2012)
Williams syndrome	John and Mervis (2010)

2007; Sullivan & Riccio, 2007). For example, McCandless and O'Laughlin reported that discriminant function analysis using the Inhibit scale and Metacognition Index correctly classified 77.8 % of children as having ADHD and 76 % as not having the disorder (McCandless & O' Laughlin, 2007). Jarratt et al., 2005 found that the BRIEF and BASC (Reynolds & Kamphaus, 1992) worked well complementarily in identifying children with ADHD subtypes, with the former measure providing a detailed picture of executive functions and the latter measure capturing a range of associated behavioral, social, and mood difficulties.

As with older children, preschoolers (Isquith, Gioia & Espy, 2004; Mahone & Hoffman, 2007) and adolescents (Toplak et al., 2009) with ADHD have also been found to have elevations on the BRIEF. Adults with ADHD show similar difficulties on the BRIEF-A to those seen in pediatric samples (Rotenberg-Shpigelman, Rapaport, Stern & Hartmen-Maeir, 2008), with deficits across a number of scales, most prominently Working Memory. Difficulty with monitoring on the BRIEF-A has also been reported (Chang, Davies & Gavin, 2009), consistent with other work demonstrating that individuals with ADHD have more difficulty monitoring their performance on tasks for accuracy (Herrmann et al., 2010)

The BRIEF has also been noted to be sensitive to interventions for ADHD. For example, children with the disorder show improvements in executive function with medication (Turgay et al., 2010), cognitive/behavioral intervention (Hahn-Markowitz, Manor & Maeir, 2011), and computerized working memory training (Beck, Hanson, Puffenberger, Benninger & Benninger, 2010). Interestingly, a recent study reported that treatment with a stimulant improved BRIEF-A scores in adults with ADHD, but a subgroup of patients continued to show residual executive dysfunction on the measure (Biederman et al., 2011).

Traumatic Brain Injury

Between publication of the BRIEF and 2010, 16 studies were published showing ratings for 1,248 children and adolescents with TBI (Gioia et al., 2010). In a review of ecologically valid assessment of cognition in TBI, the BRIEF was noted to stand out as the preferred caregiver rating measure in children and adolescents with acquired brain injury (Chevignard, Soo, Galvin, Catroppa & Eren, 2012). The BRIEF has also been included as a supplemental measure in the interagency Pediatric TBI Outcomes Workgroup (McCauley et al., 2012).

Studies of the BRIEF in TBI have been distributed over a wide range of time post-injury, from the first year (Maillard-Wermelinger et al., 2009; Sesma, Slomine, Ding, McCarthy & Children's Health After Trauma Study Group, 2008), through 1–5 years (Chapman et al., 2010) (Conklin, Salorio & Slomine, 2008; Donders, DenBraber & Vos, 2010; Vriezen & Pigott, 2002), and from 5 to 10 years post-injury (Kurowski et al., 2011; Mangeot, Armstrong, Colvin, Yeates & Taylor, 2002; Muscara, Catroppa & Anderson, 2008; Nadebaum, Anderson & Catroppa, 2007). All studies found deficits in at least one aspect of executive function as measured on the BRIEF. Ten studies documented global deficits on the GEC, seven found specific deficits on the Metacognition Index, seven on the BRI, and several reported elevations on specific scales, most notably Working Memory. While all studies reported elevated ratings relative

to control samples in parent or teacher reports on the BRIEF, only some studies also observed poorer scores on performance tests of executive function in the TBI group (Conklin et al., 2008; Muscara et al., 2008; Vriezen & Pigott, 2002), and ratings and performance measures correlated in only one study (Mangeot et al., 2002). As a whole, these studies suggest that executive function deficits in children with TBI may be captured on the BRIEF, even when not observed in test performance, and that injury severity is reflected in greater everyday executive dysfunction as reflected on the BRIEF.

A smaller number of studies have examined the BRIEF-A in adults with TBI. A study of 32 adults with moderate to severe TBI, evaluated on average 7 months after injury, reported clinical impairment ($T \geq 65$) in a subset of patients as rated by themselves and by a family member (Garcia-Molina, Tormos, Bernabeu, Junque & Roig-Rovira, 2012). Furthermore, greater executive dysfunction as rated on the BRIEF-A was associated with poorer ability to complete activities of daily living, interpersonal behavior, emotional behavior, and cognition on the Patient Competency Rating Scale. A study of 62 adults of mixed severity TBI observed that patients classified as having executive dysfunction based on performance-based tests were rated as having greater problems on the BRIEF-A informant but not self-report form (Matheson, 2010). A small study of four patients with TBI showed sensitivity of the BRIEF-A to the effects of cognitive strategy use training (Toglia, Johnston, Goverover & Dain, 2010).

Autism Spectrum Disorders

Executive function difficulties are commonly seen in children with ASDs (Pennington & Ozonoff, 1996). While not causally linked, executive functions contribute to symptom clusters, such as repetitive behaviors and restricted interests. In the first study of BRIEF profiles in children with ASDs, the profiles were unique in their spike on the Shift scale, differentiating them from children with ADHD-I, ADHD-C, and TBI (Gioia, Isquith, Kenworthy & Barton, 2002). In a second group study of children with ASDs, children showed similar elevations on the Shift scale but also the Plan/Organize scale, consistent with broader deficits in flexibility and organization of complex information in this population (Kenworthy et al., 2005). Kenworthy and colleagues explored these relationships in 89 high-functioning children with ASDs. They found that more ecologically oriented performance measures and parent ratings on the BRIEF (Kenworthy, Yerys, Anthony & Wallace, 2008), particularly the BRI scales, were significant predictors of autism symptoms (Kenworthy, Black, Harrison, della Rosa & Wallace, 2009). Executive functioning in children with ASDs was related to real-world adaptive functioning, particularly communication competence (Gilotty, Kenworthy, Sirian, Black & Wagner, 2002). Children with ASDs who also exhibited characteristics of ADHD showed greater deficits on the Emotional Control scale and the Working Memory scale of the BRIEF, suggesting that the presence of ADHD may moderate the expression of components of the ASD cognitive and behavioral phenotype, but the combination of ASD and ADHD may not represent an ideologically distinct phenotype (Yerys et al., 2009).

One study has investigated executive functions using the BRIEF-A in adults with autistic traits. In a large sample of undergraduate students ($n = 1{,}847$), those with high as opposed to low self-report autistic traits endorsed significantly greater problems with executive function on several BRIEF-A scales (Christ, Kanne & Reiersen, 2010). Consistent with studies of children with ASD, the largest effect size was observed for the Shift scale, with group accounting for 33.6 % of the variance even with statistical control for the presence of ADHD symptoms.

Others

In addition to studies of clinical populations, the BRIEF has been used in a variety of investigations as a predictor or outcome measure. With respect to academic performance, several studies have observed associations between BRIEF scores and reading (Locascio, Mahone, Eason & Cutting, 2010; McAuley et al., 2010) and math (Clark, Pritchard & Woodward, 2010) abilities. Clark et al. (2010)

reported that captured teacher ratings of 4-year-old preschool children's everyday executive functions on the BRIEF-P were predictive of math achievement at age six, over and above performance-based measures of executive function, particularly for working memory, planning, and inhibitory control. Waber, Gerber, Turcios, Wagner and Forbes (2006) found that teacher ratings on the BRIEF were the best predictor of performance on statewide academic testing.

Parent and teacher ratings on the BRIEF have also been studied in relation to certain genetic polymorphisms (Acevedo, Piper, Craytor, Benice & Raber, 2010) and sensitivity to relational aggression among adolescent girls (Baird, Silver & Veague, 2010). Scores on the BRIEF-A have been reported to be associated with alexithymia (Koven & Thomas, 2010), academic procrastination (Rabin, Fogel & Nutter-Upham, 2010), social functioning (Dawson, Shear & Strakowski, 2012), disordered eating (Salmon & Figueredo, 2009), family history of alcoholism (Schroeder & Kelley, 2008), and was recently reported to be a good predictor of alcohol-induced aggression (Giancola, Godlaski & Roth, 2012). Together, these investigations provide further support for the usefulness of the BRIEF for a wide range of clinical and experimental purposes.

Empirical Support for the Test Structure

The Professional Manuals for the BRIEF, BRIEF-SR, and BRIEF-A report exploratory factor analyses that support a two-factor solution in the normative samples and in mixed clinical samples. The factors correspond to the Behavioral Regulation Index and the Metacognitive Index described above. Exploratory factor analysis of the BRIEF-P, in contrast, yielded a three-factor solution, labeled as the Inhibitory Self-Control Index, Flexibility Index, and Emergent Metacognition Index.

Gioia and Isquith (Gioia, Isquith, Retzlaff & Espy, 2002) reexamined the BRIEF and found that the item content of the Monitor scale reflected two different types of monitoring. They therefore separated the scale into a Task Monitor scale reflecting the monitoring of task-related activities and a Self-Monitor scale reflecting monitoring of the effects of one's behavior on others. These two monitoring scales were only modestly correlated with one another ($r = .47$) in a sample of children (Gioia, Isquith, Retzlaff & Espy, 2002), a finding also noted in the normative sample for the BRIEF-A (self-report form, $r = .58$; informant report form, $r = .68$) (Roth, Isquith & Gioia, 2006), and they loaded on different factors (Self-Monitor on the Behavioral Regulation Index, Task Monitor on the Metacognition Index).

Gioia et al. subsequently conducted a confirmatory factor analysis using a nine-scale version of the BRIEF parent report, with separate Task Monitor and Self-Monitor scales, in a large mixed clinical sample (Gioia & Isquith, 2002). A three-factor solution was found to best fit the data. The Metacognition Index remained unchanged, retaining the same scales. The Behavioral Regulation Index, however, separated into a Behavioral Regulation factor, consisting of the Inhibit and Self-Monitor scales, and an Emotional Regulation factor composed of the Emotional Control and Shift scales. A recent confirmatory factor analyses of the BRIEF parent and teacher forms in a mixed healthy and clinical sample supported the nine-scale, three-factor model of the BRIEF including separate Behavioral Regulation and Emotional Regulation factors (Egeland & Fallmyr, 2010). An unpublished confirmatory factor analysis in a sample of adults was also consistent with this three-factor solution (Roth, Lance, Isquith & Giancola, 2013). Two other factor analyses of the BRIEF have been reported, one in children with epilepsy (Slick, Lautzenhiser, Sherman & Eyrl, 2006) and the other TBI (Donders et al., 2010). Although both of these reported that the best fit was for a two-factor solution, they both examined factor structure based on an eight rather than nine-scale model of the BRIEF (i.e., using only the unitary Monitor scale).

Together, factor analytic studies support the argument that executive function, at least as measured by the BRIEF, is not a unitary construct. Furthermore, while research using the

three-factor solution at present is limited, there is a wealth of evidence indicating that the Behavioral Regulation Index and the Metacognitive Index show differential associations with a variety of clinical populations and outcome measures (Giancola et al., 2012; Shimoni et al., 2012; Wilson et al., 2011). It should be noted, however, that at present the Professional Manuals for the BRIEF only provide normative data for the two-factor solution.

Other Evidence of Validity

Additional support for the validity of the BRIEF may be found in an extensive literature relating scores on the inventory with a variety of outcome measures. In particular, several studies have found associations between neural substrate and everyday executive function as measured by the BRIEF. In one of the first such studies, Anderson, Anderson, Northam, Jacobs and Mikiewicz (2002) found that BRIEF profiles of children with frontal focal lesions were substantially more elevated than those of children with early treated phenylketonuria (PKU) and early treated hydrocephalus who, in turn, were more elevated than controls. Children with prefrontal lesions had greater problems with inhibitory control, shifting set, and monitoring with highest BRIEF ratings for children with right prefrontal lesions (Anderson, Jacobs & Harvey, 2005). Several investigations have examined the relationship BRIEF scores and brain integrity as measured using magnetic resonance imaging (MRI) scans. Poorer working memory on the BRIEF has been reported to be associated with smaller volume of the frontal lobe on MRI in typically developing children (Mahone, Martin, Kates, Hay & Horska, 2009) and adults with schizophrenia (Garlinghouse, Roth, Isquith, Flashman & Saykin, 2010). BRIEF scores have also been found to be significantly correlated with cortical thickness (Merkley et al., 2008; Wilde et al., 2012) and white matter integrity (Wozniak et al., 2007) in children with TBI. A prospective study found that shorter corpus callosum length in infancy was found to be related to poorer executive functions on the BRIEF at age four (Ghassabian et al., 2013). Using functional MRI, a recent study observed that poorer self-report executive function was correlated with brain activation during a card sorting task in women with breast cancer who had not received chemotherapy (Kesler, Kent & O'Hara, 2011).

Summary and Conclusions

The BRIEF family of instruments began as a practical means for its authors to measure executive function in children at a time when the domain was little known outside of neuropsychology, it was rarely applied to children and adolescents, and there were no rating scale approaches to measuring everyday executive functions. As the first instrument of its kind, the BRIEF enjoyed a grassroots beginning and has enjoyed wide acceptance and use in the USA in clinical and research settings since first publication in 2000, with global presence increasing rapidly. The BRIEF has demonstrated its usefulness for capturing executive functions in the everyday lives of children, adolescents, and adults. It is sensitive to a plethora of behavioral, emotional, and social characteristics and clinical conditions across a variety of settings. The reliability data is strong, and there is a wealth of evidence supporting its validity for measuring executive function.

It is important to appreciate that, in general, behavioral assessment methods that rely on self- and/or informant reports present their own limitations. While providing a more global or molar view of behavior, they also provide less process-specific information. For example, while performance measures attempt to fractionate and measure specific subdomains of executive function such as working memory vs. planning or organization, specific components of the executive functions in the everyday context may be less separable. Indeed, much of everyday behavior may depend on the integration of executive function subdomains, such as the ability to inhibit distraction that protects working memory which, in turn, may enable planning and organization of

goal-directed behavior. As such, it may be more difficult to parse deficits in specific executive functions via self- and informant reports. Evaluators have more limited control over environmental factors that may affect ratings. An individual who struggles in a highly demanding, multitasking work environment may describe his or her executive functions as inadequate, while another individual in a simpler, more routine environment may report that his or her self-regulatory capacity is up to the challenge. Rater perspective or bias must also be considered when interpreting rating scales. An individual's emotional state or personality characteristics may influence his or her ratings or simply whether or not he or she like or dislike the rated individual. For example, one teacher may dislike a child or, as is sometimes the case, simply dislike completing rating scales, while another teacher may enjoy the same child and appreciate the opportunity to provide input into the evaluation process.

With respect to the BRIEF itself, there have been several reviews since its inception. The first published review (Baron, 2000) offered no criticisms. The second review (Goldstein, 2001) was complementary of the data provided about the new instrument but noted that some of the sample sizes were small. A review of the BRIEF-SR stated that is a "theoretically and psychometrically sound self-report measure of executive functioning for adolescents" (Walker & D'Amato, 2006). The most recent edition of *A Compendium of Neuropsychological Tests* (Strauss, Sherman & Spreen, 2006) provided a thorough review and noted that there were few limitations but offered important comments, primarily that the norms for the BRIEF parent and teacher forms were not fully aligned with the US Census data, some age and gender groups were small, and the standardization samples for all versions excluded cases with any developmental or acquired disorders. The review indicated that it would be helpful to have more information about how the BRIEF behaves in specific populations (e.g., individuals of Hispanic ethnicity) and how the BRIEF scales align with diagnoses or symptoms as found in the Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association, 2000). Otherwise, there have been very few criticisms of items, the format and layout of forms, or the use of the scoring software. Indeed, many comment that the BRIEF is easy to use, that the software is helpful in offering interventions, and that it captures aspects of an individual's functioning in the everyday environment that no other measures detect. Strauss et al. (2006) described the BRIEF as "a well-designed, psychometrically sound instrument that, despite its recent publication, already boasts a substantial body of literature on its application in clinical contexts" and noted that "the manual is well written and thorough, and it includes detailed examination of psychometric properties in clinical groups, a feature that is sometimes overlooked in other tests and questionnaires." Goldstein, 2001 concluded that the "reasonable cost relative to many of the measures we utilize during assessment, the theory-based format and the focus on executive function make this an attractive instrument."

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