Executive Functioning Scale (EFS) Manual

Authors: Thomas W. Frazier, PhD & Mirko Uljarević, MD, PhD

Table of Contents

1.0 Brief Overview

The Executive Functioning Scale (EFS) is a brief (52-item) informant-report measure specifically developed to comprehensively capture key aspects of executive functioning abilities in children and adolescents with autism spectrum disorder and a wide variety of other neurodevelopmental and neuropsychiatric disorders. Executive functioning skills are crucial to evaluate in children with neurodevelopmental and neuropsychiatric disorders, as research suggests significant executive functioning deficits in these populations (Corbett et al., 2009; Fong & Iarocci, 2020; Frazier et al., 2004; Wade et al., 2020). Importantly, deficits in executive functioning skills can influence the occurrence and maintenance of challenging behaviors and decrease child and family quality of life (Frazier et al., 2022). The EFS was specifically designed to be applicable and sensitive across the full range of cognitive functioning and across all stages of development. Crucially, EFS captures both "cold" (e.g., processes related to the regulation of cognitive processes without an affective component, such as set-shifting and working memory) and "hot" (processes related to regulation of emotions such as emotion regulation and risk avoidance) aspects of executive functioning. The scale's development was informed by a systematic search of the literature on executive functioning and the broader self-regulation literature; review of existing instruments; and consultation with clinical and research experts, parents, and families. It was developed and validated through an iterative and comprehensive process, following gold standard guidelines for measurement development and validation (Boateng et al., 2018). Findings from a large, independent, nationally representative cohort provide evidence that the EFS is a psychometrically-sound instrument with good measurement reliability across a continuous range of scores and preliminary evidence of predictive validity. The measure may thus be an efficient, open-source instrument that can significantly improve screening and characterization of EFS and enable monitoring of intervention progress across both clinical and research settings.

2.0 Innovative Features

The EFS has several innovative features that distinguish it from the most commonly used measures in the field, including a balance between brevity and exhaustive domain representation and coverage, in particular with regards to "hot" and "cold" EFS processes; robust factor structure and measurement invariance across key parameters including age, sex race, and ethnicity; state-of-the-art regression-based norms; an online system for easy administration and automatic scoring; and a comprehensive set of interpretive statements and clinical recommendations. A more detailed overview of the innovative features is provided below. Comparison against the most widely used instruments is summarized in Table 1.

- Comprehensive domain representation and coverage of distinct subdomains of executive functioning, including working memory and sequencing, response inhibition, set-shifting, processing speed, emotion regulation, and risk

avoidance. Even though the Behavior Rating of Inventory of Executive Function (BRIEF) (Gioia et al., 2000) covers the majority of the constructs that EFS does, the BRIEF is more than twice as long when compared to the EFS. Further, the EFS provides a more detailed capture of "hot" aspects of executive functioning, capturing both emotion regulation and risk avoidance. In addition, the emotion regulation subscale was developed based on the latest models of emotion regulation. Specifically, in addition to down-regulation of negative emotions, it also includes items capturing the up-regulation of positive emotions, given that this skill has been shown to be important for long-term positive well-being. Crucially, unlike the BRIEF and other scales, including the Behavior Assessment System for Children, third edition (BASC-3) and Infant–Toddler Social and Emotional Assessment (ITSEA) that capture symptoms and impairments, the EFS was specifically designed to capture abilities in specific executive functioning domains. Thus, it is more suitable for the detailed characterization of areas of strength and where support is needed.

- The EFS includes broader age coverage and applicability across the cognitive functioning range than is the case with other measures.
- Careful attention to question wording and responses to ensure that measures can be completed for unique populations - non-speaking children, children with severe cognitive or intellectual impairments, and children with motor deficits.
- Clear and replicable factor structure derived using state-of-the-art factor analytic approaches, including demonstration of measurement invariance across age, sex, race, and ethnicity – a key consideration for measure use in the broader US population.
- Null/very weak associations with race/ethnicity.
- Use of Item Response Theory (IRT) to demonstrate good reliability (better measurement precision) across key score ranges.
- Regression-based norms accounting for linear and quadratic age effects and sex effects on score distributions.
- Standard scores based on a large neurotypical normative population and comparison to clinical populations where relevant.
- An online system for ease of administration, scoring and reporting as well as longitudinal profiling for intervention monitoring.
- Careful attention to convergent and discriminant validity and inclusion of validity indicators to inform interpretation.
- Clear reports with clinical recommendations for diagnostic and intervention monitoring contexts. For example, the inclusion of EFS scores in the broader cross-sectional symptom and skill pattern clinical profiles as well as the identification of longitudinal score patterns relative to the neurotypical score range.

Table 1. Comparison between EFS and other commonly used Executive Functioning instruments.

	EFS	BRIEF	BASC-3	ITSEA	CBQ[1]
Completion time (minutes)	12-15	30-45	30-45	30-45	25-30
Cost	Free ($ online admin)	$$	$$$	Cost, but not listed	Free
Stable factor structure	Yes	Yes	Unclear	Yes	Unclear
EF Domain Coverage	Yes	Yes	Other[2]	No	Other[3]
Response Inhibition	Yes	Yes	Items only	Items only	Yes
Set-shifting	Yes	Yes	Items only	No	Items only
Working Memory	Yes	Yes	Items only	No	Items only
Processing Speed	Yes	Items only	No	No	No
Emotion Regulation	Yes	Yes	Yes	Items only	Items only
Risk Avoidance	Yes	No	No	No	Items only
Invariance (age, sex, race, ethnicity)	Yes	Partial	Not tested	Yes	Partial
Regression-based norms	Yes	No	No	No	No
Developmental scores (for monitoring longitudinal changes)	Yes	No	No	No	No
Automatically-generated guidelines	Yes	No	No	No	No
(treatment recommendations, identifying intervention targets, and monitoring progress)	Yes	No	No	No	No

Note. [1]The CBQ is based on the Rothbart's model of temperament, in addition to the CBQ (appropriate to ages 3-7) there are other age appropriate versions for younger and older age brackets that differ somewhat in terms of specific subscales and constructs that they capture; [2]Provides EF score that does not include "Hot" aspects of EF; [3]Provides effortful control scale that is conceptually similar but not entirely overlapping with the EF construct in terms of scope; BASC-3= Behavior Assessment System for Children, third edition; BRIEF= Behavior Rating of Inventory of Executive Function; CBQ= Child Behavior Questionnaire; EF= Executive Functioning; EFS= Executive Functioning Scale; ITSEA= Infant–Toddler Social and Emotional Assessment.

3.0 Development

The EFS was developed through a sequential process with iterative stakeholder feedback to produce the finalized measure for validation.

3.1. Conceptual model generation

The conceptual model of EFS was created based on the systematic review of the literature, current models of a) executive functioning, b) cognitive control, c) self-regulation, and d) emotion regulation across both normative and atypical development and a review of existing instruments. The following six key content areas were identified as crucial to capture: response inhibition, set-shifting, working memory, processing speed, emotion regulation, and risk avoidance. Although the existing executive functioning measures do not commonly capture risk avoidance, this domain is critical for adaptive responding to specific everyday challenges and reflects integration of skills across several different aspects of executive functioning, including evaluation of reward and punishment probability. Difficulties in this domain have been shown to be both common and highly impairing across a range of neurodevelopmental and neuropsychiatric conditions.
Described content areas were evaluated and rated on a scale of 0=not relevant to 100=highly relevant by ten neurodevelopmental disability clinician-scientist experts and ten neurodevelopmental disability caregiver/patient informants. All five content areas received a rating of >70 from both clinician-scientist experts and caregiver/patient informants. A concept elicitation process was conducted to explore whether any additional content areas would be identified. This process did not suggest any other aspects of executive functioning to include. Thus, all six executive functioning content areas were retained for the final conceptual model that served as the basis for item generation.

3.2. Item writing

The research team reviewed existing scales relevant to each domain and content area. Scales reviewed included (i) dedicated questionnaire measures of executive functioning such as the Behavior Rating Inventory of Executive Function (BRIEF), (ii) dedicated experimental measures of distinct executive functioning domains such as the Dimensional Card Sorting Task, Stroop Task, etc. (iii) general psychopathology and development instruments including the Behavior Assessment System for Children (BASC) and Infant–Toddler Social and Emotional Assessment (ITSEA), (iv) temperament and personality measures including the Infant Behavior Questionnaire, Child Behavior Questionnaire, and (v) measures of emotion regulation and self-regulation such as the Emotion Regulation Checklists, Emotion Regulation Questionnaire, and Difficulties in Emotion Regulation Scale. A set of items was written to capture each of the six key executive functioning content areas.

Specific guidelines described below were followed in the process of item generation and writing:

- Items should be as brief as possible to capture the content area,
- At least three items were written to ensure that the content area is adequately assessed and that future analyses on these items could identify any sub-factors within each domain,
- Ensure as much as possible that items do not probe more than one construct or that endorsement of an item is not a consequence of distinct processes,
- Use plain language (where possible),
- Provide examples for less obvious content but avoid excessive wording,
- Provide qualifiers where necessary,
- Ensure adequate coverage with attention to brevity.

Where possible, phrase content obtained in the concept elicitation process was also used to inform item writing – with the understanding that specific phrase content needed to be translated to more general items that could capture multiple exemplars.

3.3. Item Evaluation and Refinement

Fifty-two items were written to evaluate each of the above executive functioning types. The preliminary item bank was evaluated by ten neurodevelopmental disability clinician-scientist experts and ten neurodevelopmental disability caregiver/patient informants with regards to whether each item (i) effectively evaluated the specific executive functioning subdomain (experts and informants), (ii) was relevant to patients (experts) or child (informants), (iii) was relevant to the full age and functional range of patients (experts), and (iv) was easy/difficult to understand (experts and informants). More specifically:

Each expert rated preliminary items on the following questions:

- How well each item evaluated the domain (scale used - not at all, slightly, moderately, very, and extremely),
- How relevant each item was to the patient group the expert represented (scale used - not at all, slightly, moderately, very, extremely),
- How well each item evaluated the full range of patients (scale used - not at all, slightly, moderately, very, extremely),
- How easy it was for informants to read and understand the items (scale used - very difficult, somewhat difficult, neither difficult nor easy, somewhat easy, very easy).

Each caregiver/ informant / patient rated preliminary items on the following questions:

- How well the item evaluated the domain (scale used - not at all, slightly, moderately, very, extremely),
- How easy the item was to read and understand (scale used - very difficult, somewhat difficult, neither difficult nor easy, somewhat easy, very easy).

4.0 Validation

As a result of the above-described development process, the EFS questionnaire included 52 questions. Large-scale validation data was collected to evaluate factor structure, measurement invariance, classical test theory and item response theory-derived reliability, and convergent and discriminant validity.

4.1. Sample

Informants were recruited using the Prolific Academic online data collection service (https://prolific.co/). The final sample included 954 children (ages 2-17), with good variability and representativeness for parental education, US region, household income, child age, child sex, child race, child ethnicity, and co-occurring non-ASD diagnoses. For factor analyses, the above sample was included as the confirmatory sample and an earlier sample (N=2,004) that was also collected via Prolific Academic (see Open-Source Challenging Behavior Scale manual) was used as the exploratory sample. Detailed characteristics of this combined sample (full sample) are shown in Table 2.

Table 2. Demographic and clinical characteristics across autism spectrum disorder (ASD), developmental disability (DD), and neurotypical (NT) controls in the validation sample.

	NT *n (%)*	DD *n (%)*	ASD *n (%)*	X^2 / *F (p)*
N	1925	790	243	
Informant (n, %)				74.86 (<.001)
Biological mother	1119 (58.1%)	513 (64.9%)	167 (68.7%)	
Biological father	686 (35.6%)	184 (23.3%)	53 (21.8%)	
Other / not reported	120 (6.3%)	93 (11.8%)	23 (9.5%)	
Highest Parental Education (n, %)				26.8 (.003)
Less than HS	6 (0.6%)	2 (0.6%)	1 (1.0%)	
High school or GED	90 (8.9%)	38 (10.8%)	11 (10.6%)	
Some college	178 (17.6%)	94 (26.8%)	32 (30.8%)	
College graduate	427 (42.2%)	132 (37.6%)	40 (38.5%)	
Graduate degree or higher	295 (29.2%)	80 (22.8%)	18 (17.3%)	
Unknown	16 (1.6%)	5 (1.4%)	2 (1.9%)	
US Region				10.9 (.205)
Northeast	188 (18.6%)	51 (14.5%)	16 (15.4%)	
Midwest	215 (21.3%)	69 (19.7%)	23 (22.1%)	
South	402 (39.8%)	168 47.9%)	50 (48.1%)	
West	203 (20.1%)	62 (17.7%)	15 (14.4%)	
Other / chose not to respond	4 (0.4%)	1 (0.3%)	0 (0.0%)	
Household Income (n, %)				59.2 (<.001)
<$25,000	281 (9.5%)	92 (11.6%)	38 (15.6%)	
$25,000-$34,999	288 (9.7%)	87 (11.0%)	29 (11.9%)	
$35,000-$49,999	348 (11.8%)	96 (12.2%)	43 (17.7%)	
$50,000-$74,999	641 (21.7%)	176 (22.3%)	50 (20.6%)	
$75,000-$99,999	496 (16.8%)	140 (17.7%)	34 (14.0%)	
$100,000-$149,999	563 (19.0%)	129 (16.3%)	26 (10.7%)	
$150,000-$199,999	176 (5.9%)	36 (4.6%)	13 (5.3%)	
$200,000 and above	138 (4.7%)	28 (3.5%)	8 (3.3%)	
Unknown	27 (0.9%)	6 (0.8%)	2 (0.8%)	
Child Age (M, SD)	8.58 (4.70)	11.46 (4.50)	10.31 (4.74)	111.8 (<.001)
Child Biological Sex (n, % male)	915 (47.7%)	431 (54.6%)	181 (74.8%)	69.9 (<.001)
Race				
White / Caucasian (n, %)	1578 (82.0%)	658 (83.3%)	200 (82.3%)	0.67 (.716)
Black / AA (n, %)	182 (9.5%)	71 (9.0%)	29 (11.9%)	1.9 (.385)
Middle Eastern (n, %)	5 (0.3%)	4 (0.5%)	2 (0.8%)	2.4 (.305)
East Asian (n, %)	66 (3.4%)	11 (1.4%)	4 (1.6%)	9.9 (.007)
South Asian (n, %)	33 (1.1%)	2 (0.1%)	2 (0.1%)	10.1 (.006)
Pacific Islander (n, %)	10 (0.5%)	4 (0.5%)	1 (0.1%)	0.5 (.975)
Native American (n, %)	22 (1.1%)	20 (2.5%)	6 (2.5%)	7.9 (.019)
Multiracial (n, %)	151 (5.1%)	74 (2.5%)	27 (0.0%)	3.9 (.139)
Unknown race (n, %)	3 (0.2%)	2 (0.3%)	0 (0.0%)	0.7 (.683)
Chose not to respond (n, %)	15 (0.8%)	3 (0.4%)	1 (0.4%)	1.6 (.445)
Hispanic or Latino (n, %)	101 (11.4%)	43 (12.1%)	26 (22.4%)	12.4 (.015)
Non-ASD Diagnoses (n, %)				
ID/GDD	-	10 (2.8%)	6 (5.8%)	2.1 (.150)
Speech/language disorder	-	75 (21.4%)	16 (15.5%)	1.7 (.193)
ADHD	-	146 (41.6%)	29 (27.9%)	6.1 (.014)
ODD/CD	-	25 (7.1%)	5 (4.9%)	0.7 (.415)
Anxiety disorder	-	111 (31.6%)	19 (18.4%)	6.8 (.009)
Specific learning disorder	-	33 (9.4%)	3 (2.9%)	4.6 (.032)
Motor / coordination disorder	-	16 (4.6%)	2 (1.9%)	1.4 (.231)
Depressive disorder	-	50 (14.2%)	8 (1.8%)	3.0 (.083)
Bipolar disorder / mania	-	7 (2.0%)	1 (1.0%)	0.5 (.488)
Obsessive compulsive disorder	-	11 (3.1%)	5 (4.9%)	0.7 (.405)
Tic disorder	-	6 (1.7%)	1 (1.0%)	0.3 (.593)
Feeding / eating disorder	-	16 (4.6%)	0 (0.0%)	4.9 (.029)

Note: NT=neurotypical controls, DD=non-ASD developmental disability, ASD=autism spectrum disorder. ID/GDD=Intellectual disability/global developmental delay, ADHD=Attention-Deficit/Hyperactivity disorder; ODD/CD=oppositional defiant disorder/conduct disorder. Non-ASD diagnoses do not sum to 100% because children could be diagnosed with more than one condition. Cognitive level information was only completed for n=886.

4.2. Measures

In addition to the 52-item version of the EFS, the following measures were collected in the validation sample:

- Demographic and health information: Informants provided information on the informant's and child's age, informant's and child's gender, child's race/ethnicity, informant's relationship status, household income, and estimates of autism symptom severity and cognitive level.
- Behavior Rating Inventory of Executive Function—Short Form (BRIEF-sf): A 24-item informant-report scale designed to capture different aspects of executive functioning (LeJeune et al., 2010). Total raw score was used.
- C-NET ADHD-ASSESS Scale (ADHD-A): An 18-item informant-report scale designed to capture ADHD symptoms in children ages 2 to 17, including inattention, hyperactivity, and impulsivity. [see C-NET ADHD-ASSESS manual].
- C-NET Comprehensive Anxiety Scale (CAS): A 35-item informant-report scale designed to capture anxiety symptoms in children ages 2 to 17. The instrument includes a total score and six subscale scores covering generalized anxiety, social anxiety, separation anxiety, panic/physiological anxiety symptoms, obsessive/compulsive symptoms, and specific fears [see C-NET Comprehensive Anxiety Scale manual].
- C-NET Daily Living Skills (DLS): A 53-item informant-report scale designed to capture daily living skills in children ages 2 to 17. The instrument includes a total score and three content subscale scores for enhanced interpretation across self-care, home-care, and community participation [see C-NET Daily Living Skills manual].

4.3. Findings

4.3.1. Factor Structure

In the exploratory (n=2004) and confirmatory (n=954) samples, Exploratory Structural Equation Models (ESEM) suggested improvements in fit up to the point of estimating 6 specific factors with a general bifactor. Increases in CFI and TLI and decreases in RMSEA beyond this solution tended to be modest (≤|.006|) and the ESEM with

7 specific factors and a general executive functioning bifactor had inconsistent and difficult to interpret loading patterns across the exploratory and confirmatory subsamples. Thus, the ESEM model with 6 specific and one general factor was considered the optimal model for additional consideration (Figure 1) (Exploratory sample fit indices: CFI= .967, TLI= .956, RMSEA= .054 [95% CI: .052, .055], SRMR= .021; Confirmatory sample fit indices: CFI= .966, TLI= .955, RMSEA= .055 [95% CI: .053, .056], SRMR= .022). Using this model, a final model was estimated in the total sample (N=2,958). Fit indices for this model were: CFI= .963, TLI= .950, RMSEA= .057 [95% CI: .056, .058], SRMR= .021. Given the observation of substantive cross-loadings from items with primary loadings on other factors, a CFA model based on the ESEM model was not estimated. Final scoring was based on the ESEM model with item-subscale choice based on the highest loading for each item, with the exception that two items (items 38 and 44) had substantial loadings on two factors and therefore were included on both of the respective scales and two items (items 13 and 35) did not have substantive loadings beyond the general factor and, therefore, were only included on the general executive functioning factor. Figure 1 below presents the ESEM factor structure of the EFS in the total sample.

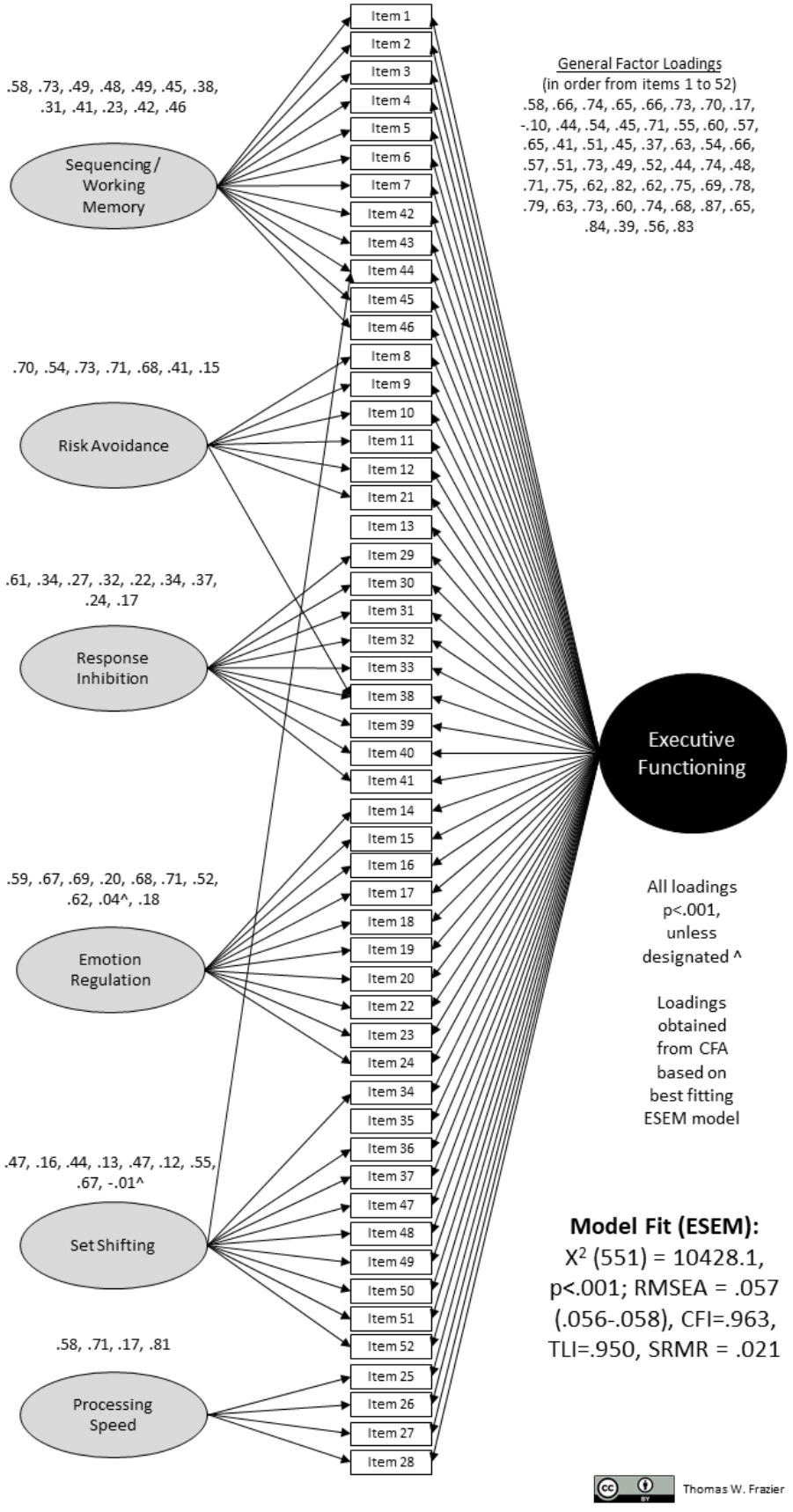

Figure 1. Factor Structure of the EFS.

4.3.2. *Measurement Invariance*

Estimating measurement invariance for ESEM bifactor models often results in convergence problems. Therefore, a simple CFA model without the EF bifactor was used to estimate measurement invariance. This permits examination of measurement equivalence for the subscales with the assumption that if these show scalar invariance, then invariance of the general EF factor is likely. Results indicated strong (scalar) invariance across age, sex, race, and ethnicity groups (Table 3).

Table 3. Measurement invariance analyses for the EF specific factor model across sex, age, race, and ethnicity.

Sex (M, F)

		Fit					*Difference Testing*					
Model	Par	X^2	DF	RMSEA	CFI	TLI	X^2	DF	p	ΔRMSEA	ΔCFI	ΔTLI
Configural	607	26721.6	2461	.082	.904	.896	-	-	-	-	-	-
Metric	511	9453.5	2557	.043	.973	.972	85.1	96	.779	-.039	.069	.076
Scalar	331	11630.5	2737	.047	.965	.966	1269.4	180	<.0001	.004	-.008	-.006

Age (2-4, 5-11, 12-17)

		Fit					*Difference Testing*					
Model	Par	X^2	DF	RMSEA	CFI	TLI	X^2	DF	p	ΔRMSEA	ΔCFI	ΔTLI
Configural	899	25120.7	3703	.077	.917	.911	-	-	-	-	-	-
Metric	707	15692.6	3895	.055	.954	.953	1219.8	192	<.0001	-.022	.037	.042
Scalar	347	18757.4	4255	.059	.944	.947	4100.1	360	<.0001	.004	-.010	-.006

Race (Caucasian, other races)

		Fit					*Difference Testing*					
Model	Par	X^2	DF	RMSEA	CFI	TLI	X^2	DF	p	ΔRMSEA	ΔCFI	ΔTLI
Configural	607	23891.5	2461	.077	.915	.908	-	-	-	-	-	-
Metric	511	9484.4	2557	.043	.973	.971	112.6	96	.118	-.034	.058	.063
Scalar	331	9453.0	2737	.041	.973	.974	279.3	180	<.0001	-.002	.000	.003

Ethnicity (Hispanic, non-Hispanic)

		Fit					*Difference Testing*					
Model	Par	X^2	DF	RMSEA	CFI	TLI	X^2	DF	p	ΔRMSEA	ΔCFI	ΔTLI
Configural	607	21860.2	2461	.073	.918	.911	-	-	-	-	-	-
Metric	511	8447.5	2557	.039	.975	.974	69.5	96	.981	-.034	.057	.063
Scalar	331	8422.9	2737	.037	.976	.977	217.1	180	.031	-.002	.001	.003

4.3.3. *Model and Scale Reliability*

Model reliability was excellent for the general factor (ω=.98) and specific factors (ω≥.89-.96). Using item scores, internal consistency reliability was excellent for the total scale (α=.97) and very good to excellent for all subscale scores (α≥.84-.94).

Table 4. Reliability statistics for EFS general (total scores) and specific factors (subscale scores).

	Internal consistency α	Model reliability ω
EF Total	.97	.98
Sequencing / Working Memory	.94	.96
Risk Avoidance	.82	.89
Response Inhibition	.89	.92
Emotion Regulation	.90	.93
Set Shifting	.91	.95
Processing Speed	.84	.90

Note: Model reliability is McDonald's omega coefficient derived from bifactor modeling.

4.3.4. *Conditional Reliability Based on Item Response Theory Analyses*

Conditional reliability estimates indicated excellent reliability (≥.90) for the total EF scale from extremely low (θ ~ -4.2) to very high (θ ~ +2.6) scores. Adequate or better reliability (≥.70) was present for subscale scores in the range from very low (θ ~ -3.0) to high scores (θ ~ +1.8), with the exception of processing speed which showed a drop off in measurement precision beyond high average scores (θ ~ +0.8) (Figure 2).

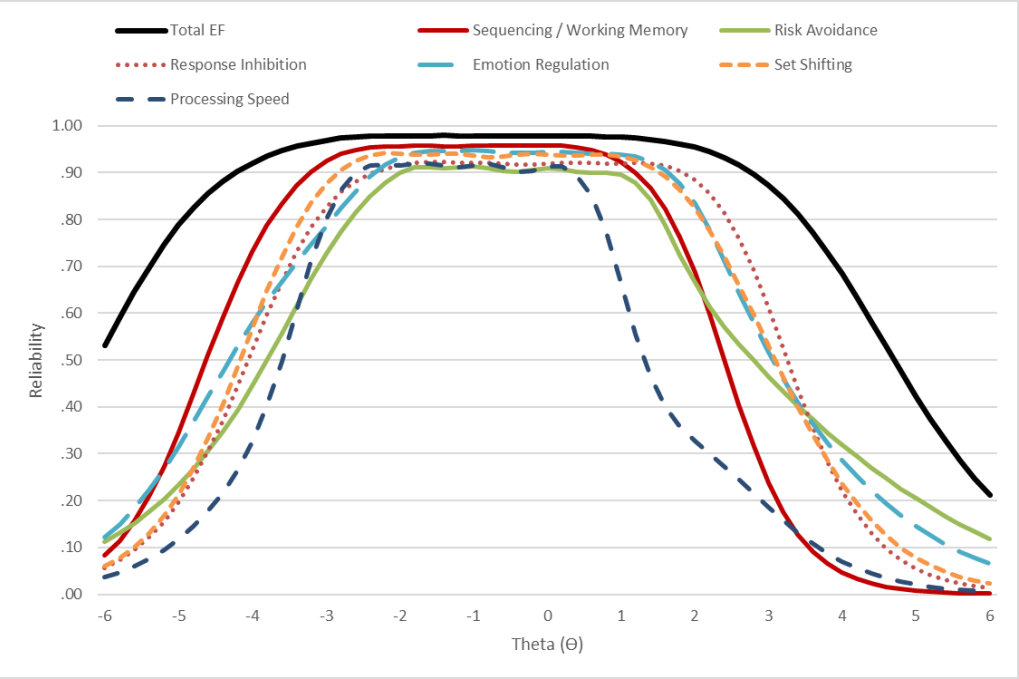

Figure 2. Conditional reliability for the EFS total scale and subscales.

4.3.5. Convergent and Discriminant Validity

The EFS showed strong convergent validity with the 24-item BRIEF-sf (r=+.85) and with the C-NET ADHD-ASSESS total score (r=-.76); the latter is relevant because ADHD symptoms include several aspects of cognitive functioning that overlap or are closely related to executive functions, particularly impulsivity (response inhibition). Evidence of discriminant validity (lower correlations expected with other neurobehavioral processes) with measures of other aspects of functioning and psychopathological symptoms was also good – C-NET Daily Living Skills (r=.59), C-NET Motor Skills (r=.54), and C-NET Comprehensive Anxiety Scale (r=-.49).

5.0 Administration

5.1. Response Scales

The full EFS instrument is presented below. A 5-point Likert scale (0=Never, 1 = Rarely 2 = Sometimes 3 = Often 4 = Very Often) was used. The reasoning for this choice is that 5-point Likert scales have been shown to yield good reliability and validity for psychopathology/personality items and that differentiation between never and rarely is important for these behaviors and their impact on functioning. Further, a frequency scale is often sufficient for most psychopathology symptom areas as frequency is the primary determinant of behaviors or skills that are either present or absent. Frequency scales make rating easier since the informant only needs to evaluate how often the behavior/symptom or skill is observed.

5.2. Rating Frames

A one-week rating frame was chosen. This timeframe was considered justified because most executive functioning skills have an opportunity to manifest every week. Importantly, executive functioning development is dynamic and non-linear during specific developmental stages, especially during the first five years of life; thus, changing to a longer timeframe would be less useful within clinical trials or for monitoring intervention progress.

EXECUTIVE FUNCTIONING

Instructions: For each item, please indicate how often over the last week the person has shown this behavior, skill, or ability using the response options below.

If you know that the person does not show this behavior, please select the following option:

0 = Never

If you know that the person does show this behavior, please rate how often using the response options provided below:

1 = Rarely
2 = Sometimes
3 = Often
4 = Very Often

		Never	Rarely	Sometimes	Often	Very Often
1	**Follows one-step directives**					
2	**Follows two-step directives**					
3	**Follows a complete sequence of steps or actions**					
4	**Can repeat actions they just learned to do**					
5	**Is good at remembering the exact order something happened**					
6	**Is good at following a simple set of instructions**					
7	**Is good at following a complex set of instructions with more than 8 steps** (Examples: baking. constructing objects, etc.)					
8	**Goes after something they want with reckless abandon**					
9	**Seems to crave excitement and new experiences**					
10	**Does not consider possible danger when doing something**					
11	**Seems to act without thinking first**					
12	**Takes risks that most people do not take**					
13	**Makes good decisions in dangerous situations**					

		Never	Rarely	Sometimes	Often	Very Often
14	Is easily upset					
15	Has trouble soothing themselves					
16	Gets frustrated quickly					
17	Calms down easily after something exciting					
18	If they are sad, they seem to have difficulty lifting their mood					
19	Remains upset or emotional longer than others					
20	Has difficulty not showing strong negative or positive emotions					
21	Is easily excitable					
22	Has trouble with managing their emotions					
23	Can distract themselves from upsetting events					
24	Can regain emotional control after being upset					
25	Seems to process information slowly					
26	Responds slowly, even when asked to do something they enjoy					
27	Works quickly and accurately on an activity					
28	Processes information slowly, even when interested					
29	Thinks before acting or saying something					
30	Refrains from certain actions when asked					
31	Stops what they are doing when told to stop					
32	Waits for more than 1 minute for a desirable item or activity					
33	Stops a preferred activity when they have to complete another task					
34	If interrupted during an activity, can resume what they were doing					
35	Comes up with new activities or things to do					
36	Can transition from one activity to another without problems					
37	Misses important information because they are engrossed in what they are doing					
38	Considers consequences before acting					
39	Can resist immediate desires because they are not good over the long-term					
40	Focuses on finishing important tasks without being distracted by more interesting activities					

		Never	Rarely	Sometimes	Often	Very Often
41	Is able to change their behavior based on the feedback from others					
42	Can repeat something they just saw someone else do					
43	Can hold several pieces of information in mind at once					
44	Has trouble with mentally juggling multiple things					
45	Is good at holding information in their mind and putting it in order					
46	Is good at remembering the exact way something happened					
47	Can shift from one activity to another with ease					
48	Has trouble stopping one thing and starting another					
49	Is able to easily go back and forth between two activities that need attention					
50	Insists on doing only one thing at a time					
51	Gets overwhelmed when two or more demands are required at the same time					
52	Is able to stop a preferred activity to do something they need to do					

6.0 Scoring

Several items are reverse scored (items 8-12, 14-16, 18-22, 25-26, 28, 37, 44, 48, 50-51) and, after recoding, higher scores indicate better executive functioning. Table 5 below provides a list of items that constitute EFS total and subscale scores.

Table 5. EFS subscale content

Scale	Items
EFS Total score	Sum of all items
Sequencing / Working Memory	1-7, 42-46
Risk Avoidance	8-12, 21, 38
Response Inhibition	29-33, 38-41
Emotion Regulation	14-20, 22-24
Set Shifting	34, 36-37, 44, 47-52
Processing Speed	25-28

7.0 EFS raw, norm-referenced, and developmental scores

The EFS produces three types of scores: raw scores, norm-referenced standard scores with percentiles and interpretive ranges, and developmental scores.
Raw scores are item averages for the total and subscale. These item averages range from 1-5 and assist with content interpretation relative to the 5-point Likert scale used by informants to respond to each item (1=Never, 2=Rarely, 3=Sometimes, 4=Often, 5=Very Often). For the EFS, content interpretation can be useful for understanding the frequency with which executive functioning skills are exhibited.

EFS norm-referenced standard scores provide adjustment for age, age-squared, and sex and permit interpretation relative to peer group. The associated percentiles provide an estimate of where the child's executive functioning skills fall relative to other children of the same age and sex. The interpretive ranges provide a general description of the child's executive functioning skills relative to others in their peer group.

EFS developmental scores are not adjusted by age or sex. These scores are scaled as z-scores and provide a relative sense of the child's executive functioning skill level compared to all other children in the normative sample. These scores are useful for tracking change over time. While norm-referenced scores are generally expected to remain stable over time, particularly in the absence of intervention, developmental scores should increase with age and intervention as the child gains better executive functioning skills.

8.0 Interpretation and clinical guidance

The EFS automatic scoring system provides a separate set of guidelines and recommendations for cross-sectional monitoring, general intervention approach, and treatment target selection. These recommendations are generated through the evidence-based scoring algorithms built into the online administration and scoring platform and are produced as a report. For each individual assessment, the interpretation process involves the following steps:

1. Checking the validity of the scores;
2. Examination and interpretation of the total score;
3. Examination and interpretation of subscale scores;
4. Examination and interpretation of the developmental scores; and
5. Identifying specific actions and/or recommendations.

Through each of the described steps, the clinician is guided by the specific recommendations outputted by the automatic scoring system. Abbreviated examples of the cross-sectional monitoring and general intervention approach interpretation and guidelines are provided below.

8.1. Interpretation for Cross-Sectional Monitoring

Below is an example scale output for a 5-year-old, female:

Scales	Item Average	Developmental Score	SS	90% CI (+/-)	Percentile (%)	Normative Description
Total Executive Functioning	1.0	-4.0	39	4.5	<0.1	Very Low
Sequencing / Working Memory	1.0	-3.7	45	6.2	<0.1	Very Low
Risk Avoidance	1.0	-3.2	53	10.5	0.1	Very Low
Response Inhibition	1.0	-3.0	55	8.3	0.1	Very Low
Emotion Regulation	1.0	-3.2	55	7.8	0.1	Very Low
Set Shifting	1.0	-3.3	50	7.5	<0.1	Very Low
Processing Speed	1.0	-3.7	43	9.8	<0.1	Very Low

- The Total Executive Functioning scale score indicates a Very Low skill level, falling at the <0.1 percentile in the neurotypical population.
- The sequencing/working memory subscale score indicates a Very Low skill level, falling at <0.1 percentile in the neurotypical population.
- The risk avoidance subscale score indicates a Very Low skill level, falling at the 0.1 percentile in the neurotypical population.

- The response inhibition subscale score indicates a Very Low skill level, falling at the 0.1 percentile in the neurotypical population.
- The emotion regulation subscale score indicates a Low skill level, falling at the <0.1 percentile in the neurotypical population.
- The set-shifting subscale score indicates a Very Low skill level, falling at the <0.1 percentile in the neurotypical population.

8.2. Interpretation for General Intervention Recommendations

Based on the pattern of specific EFS scores, the following general recommendations are offered to inform future intervention planning:

- Parents, clinicians, and other interventionists should consider focusing on improving the ability to sequence information. The intervention plan may also provide accommodations for difficulties with remembering or following the steps or order of an activity or list. Use short phrases in speech and only provide simple directives (only 1 or 2-step directives). Use visuals to assist in following directives, learning new information, or following a sequencing of steps. Focus on procedural learning with frequent reinforcement for approximating each step of a chain when learning new skills or activities.
- Teach identifying risky situations and appropriate responses, including avoiding and/or limiting exposure to such situations. Seek additional family or caregiver supports to reduce the need for constant vigilance by one person. Identify possible safety plans and technology approaches to limit opportunity or reduce the likelihood of dangerous encounters. Consider referral to local resources to assist in acquiring appropriate safety technologies and human supports.
- Include impulse control targets on the intervention plan (e.g., waiting, not responding, turn taking, back and forth play and conversation). Provide caregiver and family training regarding impulse control difficulties and appropriate management responses to avoid unnecessary punishment or other negative consequences. Provide frequent reinforcement for appropriate responding, including waiting, showing patience, finishing activities before moving on to other things, turn-taking, etc.
- Provide instructions regarding emotion differentiation (if not yet achieved). Provide instructions, including visual supports, regarding differentiating between weaker/subtler emotions that do not need to be regulated or are easier to regulate and stronger/difficult to control emotions (e.g., anger thermometer) that require the application of emotion regulation skills. Consider teaching methods to manage strong emotions, including stop-think-act and physiological management strategies (e.g., deep breath). Provide feedback on strong emotional

expressions, their impact on others, and modifying strategies. Teach problem-solving and problem-sizing (big, medium, small problem) skills with appropriate responses to different types and sizes of problems. Provide accommodations for situations where strong emotions are difficult to manage, but without reinforcing a lack of control over emotions or escaping other demands. Provide intervention and parent, caregiver, or family training on the strategies to avoid reinforcing inappropriate emotional responses and shaping to be more appropriate.

- Teach how to manage multiple activities or demands. Accommodate difficulties with task switching by providing only one task or set of directives at a time or using a visual schedule to facilitate sequencing activities or demands. Teach how to transition from one activity to another. If necessary, provide warnings or visuals to assist transition. Start with easier transitions from less desirable to a more desirable or favored activity. Accommodate difficulties with processing speed by providing additional time for task completion and limiting the number of directives, tasks, demands, or other competing stimuli.
- Consider neuropsychological evaluation to characterize and generate appropriate intervention strategies for executive functioning weaknesses. Consider intervention and/or accommodations to manage executive functioning difficulties. Given the importance of executive functioning for other behaviors (e.g., social functioning, challenging behavior, academics), consider the impact of specific executive functioning deficits on the child's other skills, behaviors, and settings.

References

Boateng, G. O., Neilands, T. B., Frongillo, E. A., Melgar-Quinonez, H. R., & Young, S. L. (2018). Best Practices for Developing and Validating Scales for Health, Social, and Behavioral Research: A Primer. *Front Public Health*, *6*, 149. https://doi.org/10.3389/fpubh.2018.00149

Corbett, B. A., Constantine, L. J., Hendren, R., Rocke, D., & Ozonoff, S. (2009). Examining executive functioning in children with autism spectrum disorder, attention deficit hyperactivity disorder and typical development. *Psychiatry Research*, *166*(2-3), 210-222. https://doi.org/10.1016/j.psychres.2008.02.005

Fong, V. C., & Iarocci, G. (2020). The Role of Executive Functioning in Predicting Social Competence in Children with and without Autism Spectrum Disorder. *Autism Res*, *13*(11), 1856-1866. https://doi.org/10.1002/aur.2350

Frazier, T. W., Crowley, E., Shih, A., Vasudevan, V., Karpur, A., Uljarevic, M., & Cai, R. Y. (2022). Associations between executive functioning, challenging behavior, and quality of life in children and adolscents with and without neurodevelopmental conditions. *Frontiers in Psychology*. https://doi.org/10.3389/fpsyg.2022.1022700

Frazier, T. W., Demaree, H. A., & Youngstrom, E. A. (2004). A meta-analysis of intellectual and neuropsychological test performance in Attention-Deficit/Hyperactivity Disorder. *Neuropsychology*, *18*(3), 543-555.

Gioia, G., Isquith, P., Guy, S., & Kenworthy, L. (2000). *BRIEF: Behavior Rating Inventory of Executive Function: Professional Manual*. PAR, Inc.

LeJeune, B., Beebe, D., Noll, J., Kenealy, L., Isquith, P., & Gioia, G. (2010). Psychometric support for an abbreviated version of the Behavior Rating Inventory of Executive Function (BRIEF) Parent Form. *Child Neuropsychol*, *16*(2), 182-201. https://doi.org/10.1080/09297040903352556

Wade, M., Zeanah, C. H., Fox, N. A., & Nelson, C. A. (2020). Global deficits in executive functioning are transdiagnostic mediators between severe childhood neglect and psychopathology in adolescence. *Psychological Medicine*, *50*(10), 1687-1694. https://doi.org/10.1017/S0033291719001764