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Ratings of Everyday Executive Functioning (REEF): A parent-report measure of preschoolers' executive functioning skills

Abstract

Executive functioning (EF) facilitates the development of academic, cognitive, and social-emotional skills and deficits in EF are implicated in a broad range of child psychopathologies. Although EF has clear implications for early development, the few questionnaires that assess EF in preschoolers tend to ask parents for global judgements of executive *dys*function and thus do not cover the full range of EF within the preschool age group. Here we present a new measure of preschoolers' EF - the Ratings of Everyday Executive Functioning (REEF) - that capitalizes on parents' observations of their preschoolers' (i.e., 3- to 5-year-olds) behaviour in specific, everyday contexts. Over four studies, items comprising the REEF were refined and the measure's reliability and validity were evaluated. Factor analysis of the REEF yielded one factor, with items showing strong internal reliability. Importantly, children's scores on the REEF related to both laboratory measures of EF and another parent-report EF questionnaire. Moreover, reflecting divergent validity, the REEF was more strongly related to measures of EF as opposed to measures of affective styles. The REEF also captured differences in children's executive skills across the preschool years, and norms at 6-month intervals are reported. In sum, the REEF is a new parent-report measure that provides researchers with an efficient, valid, and reliable means of assessing preschoolers' executive functioning.

Keywords: executive functioning, preschoolers, parent-report, cognitive development, assessment

Ratings of Everyday Executive Functioning: A parent-report measure of preschoolers' executive functioning skills

Executive functioning (EF) refers to higher order processes that aid in the monitoring and control of thought and action and thus facilitate goal-directed behaviour (Burgess, 1997). Executive functions can involve both "hot" affective aspects as well as "cool" cognitive aspects of self-regulation (Zelazo & Müller, 2011). Though different conceptualizations of EF exist (e.g., Jurado & Rosselli, 2007), core EF skills include inhibitory control (i.e., deliberately supressing dominant yet inappropriate responses), working memory (i.e., actively maintaining important information in mind), and shifting (i.e., considering simultaneous representations of an object or event and/or flexibly alternating between tasks), which are separable yet inter-related and show differential associations with more complex forms of EF, for example, planning (i.e., looking ahead to the attainment of a goal and planning one's actions accordingly) (Miyake et al., 2000). This conceptualization, based on findings from studies with adults (e.g., Miyake et al., 2000), has been replicated in developmental studies of children 6 years and older (Huizinga, Dolan & van der Molen, 2006; McAuley & White, 2011). In contrast, comparable work with younger children has shown that EF is more elusive earlier in development – with studies suggesting that EF constitutes an undifferentiated resource (Brocki & Bohlin, 2004; Hughes et al., 2010; Wiebe, Espy & Charak, 2008; Wiebe et al., 2011), or consists of two broad components reflecting working memory and inhibition (Müller & Kerns, 2015), or consists of multiple components that undergo a period of integration during the preschool years before they become separable once again later in development (Howard, Okely & Ellis, 2015).

Although executive functions have a protracted course of development and are not fully mature until adolescence or even young adulthood (Best, Miller, & Jones, 2009), they emerge in the first few years of life (e.g., behaviours indicative of working memory, inhibitory control, and

task shifting are shown prior to the age of two; Espy, Kaufman, McDiarmid, & Glisky, 1999; Kochanska, Coy & Murray, 2001; Reznick, Morrow, Goldman & Snyder, 2004). As noted by Garon, Bryson and Smith (2008), the period spanning 3 to 5 years of age is characterized by considerable growth in core executive skills: preschool-aged children are able to retain more information for longer periods of time, are becoming increasingly adept at manipulating information that is being held in mind, are developing the ability to withhold inappropriate responses and to generate alternative, less prepotent actions, are increasingly able to shift their attention from one aspect of a stimulus to another, and are becoming more practiced at integrating these core EF skills to engage in more complex forms of behaviour.

Indeed, the preschool years may be one of the most important periods in EF development. In addition to undergoing particularly dramatic improvements during this time, individual differences in preschoolers' EF underlie many areas of normative development, including school readiness, academic skills, language, and social competence (Bull, Espy, & Wiebe, 2008; Blair & Razza, 2007; Hughes, 1998; Hughes & Ensor, 2007; 2011; Sasser, Bierman, & Heinrichs, 2015; Thorell, Bohlin, & Rydell, 2004). Moreover, deficits in EF have been implicated in a host of negative developmental trajectories, including aggression, attention deficit / hyperactivity disorder (ADHD), autism spectrum disorder (ASD), learning problems, and anxiety and mood disorders (Johnson, Humphrey, Mellard, Woods, & Swanson, 2010; Raaijmakers et al., 2008; Sanders, Johnson, Garavan, Gill, & Gallagher, 2008; Snyder, Kaiser, Warren, & Heller, 2015; Wagner, Muller, Helmreich, Huss, & Tadic, 2015; Willcut, Doyle, Nigg, Faraone, & Pennington, 2005). Given the centrality of EF to many facets of development, the availability of a psychometrically sound tool that measures the full spectrum of EF is of critical importance – particularly during the preschool period.

Measurement of Executive Functioning in Preschoolers

Given the surge of interest in the role that EF plays in normative and atypical development, the assessment of EF in preschoolers has become increasingly relevant. One approach to the assessment of children's EF entails the use of laboratory-based measures which are typically administered within a controlled setting (e.g., lab or office). The advantage of this approach is that such tests are designed to capture components of EF and therefore can provide process-specific information; however, this approach comes with certain disadvantages. First, the context in which children's EF skills are assessed is somewhat artificial in that there are few distractors, they receive clear instructions with well-defined goals, their performance is closely monitored, and they often receive continuous feedback. Second, such tests attempt to separate integrated functions into component parts and as such do not represent the multidimensional and priority-based decision making that real-world situations demand (Burgess, 1997). Relatedly, there is a lack of agreement amongst researchers as to what specific component of EF particular tasks assess, and, in reality, no task is a pure measure of any EF component (Miyake et al., 2000). Whilst latent variable analysis provides a solution to some of these problems, it is time-consuming and resource intensive to administer a comprehensive battery of tasks that adequately assesses EF components. In addition, this approach poses a particular challenge when working with preschool-aged children who may have limited attention spans and be more susceptible to boredom and fatigue. Lastly, when using individual tasks to measure EF skills, there are very few measures that have been validated and standardized for use with preschool-aged children (one notable exception is the NEPSY; Korkman, Kirk, Kemp, 1998), which limits their clinical utility and the ability to compare findings across studies (Isquith, Gioia, & Espy, 2004). Further, the psychometric properties of many EF tasks are undocumented and for others they can be varied depending on the particulars of the sample (see, for example, Willoughby, Blair, Wirth & Greenberg, 2010). Addressing this limitation in the field, recent efforts are being made to

promote the use of tools with established psychometric properties (e.g., National Institutes of Health Toolbox; Zelazo & Bauer, 2013).

An alternative approach to capturing children's EF is to ask observers to report on children's behaviours using questionnaires. The advantage of assessing EF in this manner is that it may permit the integration of information from a child's everyday environment (home, school, daycare, etc.), thereby allowing for global aspects of behaviour to be determined. Observer ratings also allow for information to be gathered efficiently from multiple sources over different contexts and extended periods of time, which increases the ecological validity of the measure (Mahone & Hoffman, 2007). Questionnaires are easy to administer and, as such, can provide an efficient and useful way for screening EF in children who present with developmental concerns or who may be at risk for developing psychiatric disorders.

There are a number of observer report measures that assess EFs in school-aged children (e.g., Behavior Rating Inventory of Executive Function [BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2000]); Childhood Executive Functioning Inventory [CHEXI; Thorell & Nyberg, 2008]; Comprehensive Executive Function Inventory [CEFI; Naglieri & Goldstein, 2013]; Barkley Deficits in Executive Functioning Scale - Children and Adolescents [BDEFS-CA; Barkely, 2012]; behavioural screener for estimating executive functions from the Behavior Assessment System for Children [Garcia-Barrera, Kamphaus, & Bandalos, 2011]); however, there are far fewer measures for preschool-aged children. One measure specifically designed to target this age group is the Behavior Rating Inventory of Executive Function – Preschool Version (BRIEF-P; Gioia, Espy, & Isquith, 2003). The BRIEF-P is a 63-item rating scale completed by parents or teachers for children 2 to 5 years of age. The items map onto five statistically driven scales reflecting the core EF skills of inhibitory control, working memory, and shifting as well as planning and emotional control. Although this measure has excellent internal consistency and

temporal stability (Gioia et al., 2003), it is not without limitation. First, similar to the school-age version of the BRIEF, items on the BRIEF-P tend to overlap with the diagnostic criteria for ADHD. It is problematic when the tool being used to predict future outcomes (e.g., ADHD diagnoses) is so similar to the outcome variable. Second, items on the BRIEF-P ask parents to make general evaluations of their children's behaviour as opposed to specific observations, which may provide more room for biases to play a role in reporting and thereby affect the validity of the results. For example, unlike performance-based measures of EF, the BRIEF-P shows little correlation with age (Mahone & Hoffman, 2007). Third, the BRIEF-P subscales tend not to correlate with performance-based measures of EF (e.g., Liebermann, Giesbrecht, & Müller, 2007; Mahone & Hoffman, 2007; Toplak et al., 2013) suggesting that it may be more a measure of children's behavioural disruption and impairment than deficits in EF per se (McAuley, Chen, Goos, Schachar, & Crosbie, 2010). Indeed, Toplak and colleagues argue that, in general, rating scales of EF capture different underlying mental constructs from performance-based measures (i.e., with the former capturing success in goal pursuit and the latter capturing efficiency of information processing; Toplak, West, & Stanovich, 2013).

Our aim was to develop a new parent rating scale – the Ratings of Everyday Executive Functioning (REEF) – that captures the executive functions of preschool children (3- to 5-year-olds) as demonstrated by their behaviours in a variety of everyday environments. In creating the REEF, we endeavoured to overcome some of the disadvantages that are associated with the use of observer report measures. For example, we sought to reduce ratings that are influenced by the general biases of observers or the unrealistic expectations that observers may hold of children's behaviour, as well as ratings that reflect observers' predictions of children's behaviour rather than children's actual behaviour, all of which may lead to overestimation in some areas and underestimation in others (Isquith et al., 2004). To circumvent these problems, we anchored

items on the REEF in well-delineated contexts (e.g., at home, in the community, etc.), required that parents provide specific ratings rather than global impressions, and had parents base their ratings on what they observed their children doing (i.e., function) as opposed to what they felt their children were not able to do (dysfunction). In doing so, we anticipated the REEF would improve upon the validity of existing informant rating scales of preschooler EF – as would be evident, for example, in a higher correspondence between parental ratings on our measure and children's performance on lab-based EF tasks than has been documented previously. We also sought to create a tool that would be efficient to administer and capable of capturing individual variation within typical development (i.e., rather than serving primarily as a screening tool for dysfunction).

Study 1

The primary aim of Study 1 was to administer the REEF to parents of preschoolers in order to gauge whether initial items were appropriate for this age range. A secondary aim was to determine whether children's performance on our newly developed measure corresponded to their performance on EF tasks. Given that past research has often not found a relationship between EF tasks and EF rating scales (Liebermann et al., 2007; McAuley et al., 2010; Toplak et al., 2013), it was important to assess at an early stage in the measure's development whether asking parents to report on specific, observable behaviours might lead to a stronger association with children's actual EF performance. To achieve these goals, parents completed the REEF and children participated in a battery of laboratory-based EF tasks.

Development of REEF items

The items for the REEF (see Appendix) were generated following a review of the EF literature regarding the types of everyday behaviours preschoolers display that demonstrate EF growth or success. The goal of item construction was to provide parents with common,

observable behaviours that would require some element of EF. Attention was given to identifying behaviours that captured different components of EF: inhibitory control (e.g., "Waits for you to finish on the phone before seeking your attention"), working memory (e.g., "Fetches all items requested by adult [e.g., Does not forget what he/she was asked to get]"), cognitive flexibility (e.g., "Rephrases language when another person doesn't understand what he/she is saying"), emotion regulation (e.g., "Recovers quickly from a disappointment or change in plans [e.g., the family is no longer going out for dinner]"), and planning (e.g., "Plans ahead when playing games [e.g., what he/she should do on the next turn]"). In order to provide a contextual frame for the responder to reference, items are separated into different themes. For example, one theme is "around the house" and items within this section refer to activities that children may do when at home. Other contextual themes include: playing games, playing games with others, interacting with others, in the community, in stores, story time. Drawing from observer rating tools of children's adaptive functioning (e.g., the Adaptive Behavior Assessment System-II; ABAS-II; Harrison & Oakland, 2003), parents make a forced-choice response of "is not able" (0), "never or almost never" (1), "sometimes" (2) or "always or almost always" (3). Parents are also asked to indicate if they "guessed" in their response for each item.

The language of administration for the REEF was English. This study, and all subsequent studies, were approved through the Office of Research Ethics at the University of [redacted].

Method

Participants

Forty-two children between the ages of 3- and 5-years-old (20 females, M = 51.7 months, SD = 11.1 months, range = 36.6 – 72 months) were recruited from local preschools and daycares via information letters that were sent home to parents. Mothers were primarily the respondents on the REEF (two fathers completed the REEF). Data from one participant was excluded from

analyses due to the number of missing items exceeding the inclusion criterion of less than 10% of items.

Procedure

Following the initial generation of REEF items, the measure was sent to three researchers whose primary field of study was the development of EF in children. Items were modified or removed if the researchers determined the item did not reflect EF. The first version of the REEF contained 171 items, which was completed by parents as part of the package that was sent home from the preschool/daycare. Children were tested individually by a researcher in a quiet location within their preschool or daycare over two 45-minute sessions.

Executive Functioning: The battery of EF tasks was derived from tasks that are commonly used with this age-range and capture skills in areas of working memory, inhibitory control, shifting, and planning/organizing (as well as two tasks of emotion regulation, not coded due to experimenter error). We attempted to assess performance in areas considered to be reflective of 'hot' EFs, which involve more emotional significance (e.g., delay tasks) as well as 'cold' EFs, which reflect more emotionally neutral, decontextualized tasks (e.g., span tasks). Tasks were administered in a standardized order over two sessions: Digit span, Bear/dragon, Gift delay, Self-ordered pointing, Tower of Hanoi, Count and Label, Flexible Item Selection Task, Truck Loading, Day/Night, and Whisper Task. Task descriptions and references are provided in Table 1.

[Insert Table 1 here]

Language: To assess children's receptive language skills, the Receptive Vocabulary Scale of the Wechsler Preschool and Primary Scale of Intelligence – III (WPPSI-III; Wechsler, 2002) was used. This test was administered according to standardized protocol.

Results and Discussion

Item reduction on the REEF:

To refine the scale, items were removed if they, a) did not yield variable responses (i.e., only 2 response options were endorsed; 29 items), b) showed floor or ceiling effects (i.e., had means below 1.0 or above 2.7; 12 items), or c) engendered a relatively high proportion of guessing (i.e., >15% of parents indicated they had guessed; 12 items). Removal of these items resulted in a 119-item measure. These items were summed to provide a total score, which demonstrated excellent internal consistency ($\alpha = .97$). Missing data (when less than 10% of items were missing, representing .002% of responses) were replaced using single imputation with an expectation-maximization algorithm in SPSS.

Convergent Validity of the REEF and EF Tasks:

After reverse scoring gift delay, performance on the EF tasks was standardized and summed to create an EF task composite, which was internally consistent ($\alpha = .83$). As shown in Table 2, children's performance on the EF composite was positively related to their age and receptive vocabulary. Children's performance on the EF composite was also positively related to parents' ratings of children's EF skills on the REEF, which remained significant even when children's receptive vocabulary was controlled.

[Insert Table 2 here]

Using total scores from the reduced set of 119 items, we found that children who demonstrated more successful performance on the laboratory-based tasks of EF were rated by their parents as engaging in more EF behaviours within their daily environments. This finding contrasts with previous work that has found observer report measures of EF to be unrelated to children's EF performance (e.g., Liebermann et al., 2007; McAuley et al., 2010; Toplak et al., 2013). Since other EF measures tend to focus on global statements that are indicative of executive deficits, we speculate that asking parents to report on a wide range of observed

behaviours that are anchored within a concrete context (e.g., around the house) reduced reporting biases.

Study 2

The goals for Study 2 were twofold. First, we sought to further refine the REEF by removing items that did not meet the aforementioned criteria based on a larger sample. Second, we sought to further assess the convergent validity of the REEF by comparing parents' responses on the REEF with a measure of preschoolers' dysfunction, the BRIEF-P (Gioia et al., 2003).

Method

Participants

Parents of 3- to 5-year-old children were recruited through community centres, daycares and preschools. Packages with informed consent forms, questionnaires, and a $5 gift card were provided to 136 parents. One hundred forms were returned (87 mothers, 11 fathers, and 1 guardian; 1 respondent chose not to answer). The mean age of children being rated by caregivers was 49.79 months (*SD* = 9.06; range 36 months – 71.8months; 44 females). In total, there were 49 3-year-olds, 37 4-year-olds, and 14 5-year-olds. The general education of the respondents was high, with 72% reporting that they had received post-secondary education. Ninety-two percent of respondents indicated they primarily spoke English within their homes[1], though there were other languages spoken, such as languages from Asia (14%), South Asia (10%), and Europe (10%). If parents noted developmental concerns, data were removed from analyses (*n* = 2).

Procedure

Parents completed the 119-item REEF (i.e., the version of the REEF that was used in the analyses for Study 1), the BRIEF-P (Gioia et al., 2003), and a questionnaire related to parenting

[1] The pattern of data did not change when participants without English as their primary language were removed. Reported data includes all participants.

stress (not the focus of this study). The BRIEF-P consists of 63 items comprising 5 scales: Inhibit (16 items), which assesses shortfalls in the child's ability to inhibit or resist impulsive actions and stop behaviour at the appropriate time; Shift (10 items), which measures the child's difficulty transitioning from one situation or task to another or thinking about a problem in different ways; Emotional Control (10 items), which measures the degree to which the child struggles to modulate emotional responses; Working Memory (17 items), which assesses limitations in the child's capacity to hold information in mind for the purpose of completing a task or making a response; and Plan/Organize (10 items), which measures the child's difficulty with managing current and future oriented task demands. Parents responded to items with responses of "never", "sometimes", or "often" with higher scores reflecting worse EF. The BRIEF-P is reported to have high internal consistency and established validity (Gioia et al., 2003). Children's raw scores on the scales as well as on a Global Executive Composite (i.e., reflecting the total of all scales) were included in the analyses.

To control for children's general language/communication skills when comparing parent ratings on the REEF with the BRIEF-P, respondents also completed the Children's Communication Checklist – 2 US Edition (CCC-2; Bishop, 2003). The CCC-2 is a 70-item instrument that is used to assess children's communication skills. Items are grouped into 10 subscales that cover language structure and pragmatic skills that can be combined to produce a General Communication Composite. The CCC-2 has strong reliability and validity (Bishop, 2003).

Results and Discussion

Item reduction on the REEF:

The process used to inspect and remove items in Study 1 was applied to Study 2. Of the 119-items on the revised REEF, 5 were removed because they, a) showed insufficient variability

(3 items) or, b) had a high proportion of guessing amongst parents (2 items). Missing data (.003% of responses) were replaced using single imputation with an expectation-maximization algorithm in SPSS. The resultant 114 items were summed to create a composite, which showed good internal consistency ($\alpha = .97$).

Convergent Validity of the REEF and BRIEF-P:

As shown in Table 3, comparison of caregivers' responses on the REEF and BRIEF-P showed that the total REEF score was significantly correlated with all subscales of the BRIEF-P, even when controlling for the child's communication skills (all *p*s < .001). Results indicate that caregivers' observations of their children's everyday EF, as assessed per the REEF, were strongly related to their more global assessments of executive dysfunction, as measured per the BRIEF-P.

In conjunction with the findings of Study 1, these results suggest that the REEF is a tool that holds considerable promise as a measure of preschooler EF: it possess high internal consistency, shows strong convergent validity, and is easily administered to parents. However, the sample sizes of Study 1 and 2 were relatively small (with a particularly low number of 5-year-olds in Study 2) and thus precluded evaluation of the factor structure of the REEF. Moreover, at a current length of 114 items, over 1000 respondents would be needed to ensure sufficient statistical power for factor analyses in the future. As such, we set out to further reduce the number of items on the REEF and recruiting a large sample in order to inspect the underlying factor structure of this measure.

[Insert Table 3]

Study 3

Prior to collecting data, items from the 114-item REEF were further refined in several ways. Specifically, an item was removed if, based on findings from Study 2, a) a high percentage (> 65%) of parents responded "Never" or "Always or Almost Always" to that item (reflecting a

stricter criterion for a 'floor/ceiling' effect than used in Study 1 and 2), b) the item only had two types of responses or a mean above 2.7, c) the item did not correlate strongly with the BRIEF-P GEC (i.e., $p > .25$) or, d) the item showed poorer functions (i.e., all removed items had an item-total correlation below .43). Items were also removed if, e) there was a significant negative correlation between it and the lab-based EF tasks from Study 1 (with the exception of Gift Delay where a negative relationship was expected). According to these criteria, 18 items were removed.

Next, we solicited the input of three experts (different to those contacted in Study 1) in the area of EF who each had an established research program within an academic setting that focused on the executive skills of children and had published papers in this area. Experts were asked to specify whether or not each of the items on the REEF was reflective of EF and, if so, to identify which component of EF the item assessed. Items were removed if, e) two or more raters indicated the item was not a measure of EF, did not know where the item belonged, ascribed the item to different EF components, or indicated that they did not know which EF component to ascribe the item (suggesting that the described behaviour might not be clear). According to these criteria, 20 items were removed. However, three items, which were previously removed following the stricter criteria applied to the data in Study 2 (e.g., ceiling effects), were re-added as they met other inclusion criteria and were thought to represent important behaviours that rely on EF. The resulting REEF had 79 items.

Method

Participants

Parents or guardians of children 3- to 5-years-old were recruited through an on-line crowdsourcing website, Mechanical Turk, via CrowdFlower. This study was completed by 944 participants; however, participants were removed from analyses if: they resided outside of North America ($n = 96$); completed the survey in less than the minimal amount of time required to

answer all of the questions (i.e., 20 minutes: *n* = 210), had more than 10% missing data on the REEF (i.e., 8 or more unanswered items: *n* = 17), or responded to all items on the REEF with the same response (i.e., no variance in responding: *n* = 5); indicated that they were the child's biological mother and were older than 50 years (*n* = 2); the child was less than 36 months old (*n* = 46) or older than 72 months (*n* = 40); or the child was diagnosed with or was suspected to have developmental concerns (*n* = 22). The remaining sample size was 506.

The mean age of children being rated by their parent or guardian was 50.52 months (*SD* = 9.85; range 36 months – 71.50 months). The mean age of respondents was 394.99 months (32.83 years; *SD* = 84.72; range 18.24 – 68.41 years). The sample was comprised of children identified as White/European (70.4%), Black (6.9%), Asian (4.2%), Latin American (3.2%), Other (i.e., different ethnicity or multi-ethnic; 14.3%), or whose ethnicity was not provided (1%). Respondents were biological mothers (62.5%), biological fathers (27.1%), adoptive mothers (1.4%), adoptive fathers (2.0%), guardian females (3.6%), guardian males (2.2%), and other, such as grandparent (1.2%).

Procedure

Parents completed the 79-item REEF, as well as a demographic questionnaire (and other measures intended to assess children's social and behavioural functioning, not included here). Respondents were provided $1.80 for their participation.

Results and Discussion

Item Reduction on the REEF

The items of the REEF were again inspected as per criteria outlined in Study 1 and 2. There were no items with a mean greater than 2.7 or less than 1, no items with only two types of responses or less, and no items that were guessed by more than 15% of responders. Items were inspected further by calculating the corrected-item total correlations. Items were removed if the

corrected item-total correlation was less than .43 (n = 3). The resulting 76-item REEF showed good internal consistency (α = .97).

Factor Analysis of the REEF

Two-hundred seventy six participants had complete data on the REEF. For the remaining participants, missing data were replaced using single imputation with an expectation-maximization algorithm in SPSS. This affected 1.3% of all responses. Due to inconsistent findings in the literature regarding the underlying structure of preschoolers' EF, exploratory factor analysis with maximum likelihood extraction and oblique (promax) rotation was used to examine the 76-item REEF. Oblique rotation was chosen to permit correlations amongst multiple components. Inspection of the scree plot, as well as the loadings of each item on the produced factors, suggested that a one-factor solution was in fact most appropriate[2]. Specifically, there were no items that loaded on another factor more than the first factor and all loadings on the first factor were equal to or greater than .40. To ensure that EF behaviours were not situationally bound, we created an average score of items within each of the 8 contexts represented in the REEF provided that no more than 20% of an individual's responses were missing across context-specific items. These average scores were then entered into another exploratory factor analysis

[2] CFA was subsequently used to compare the fit of a unitary EF model with that of a two-factor model consisting of "hot" and "cool" aspects of EF (i.e., inhibition and emotion regulation vs. working memory, cognitive flexibility, and planning/organization) and a five-factor model in which all five EF skills were specified as separable (i.e., inhibition, emotion regulation, working memory, cognitive flexibility, planning/organization). In each model error variances for items drawn from the same context were allowed to covary within a factor. The five-factor model did not generate a permissible solution. Fit indices of the one- and two-factor models were comparable (i.e., CFI = .82; RMSEA (90% CI) = .05 (.052 - .053)); however, given the high correlation between the two aspects of EF (r = .92), the unitary EF model appears to provide a more parsimonious fit to the data.

with oblique rotation, resulting in a one-factor solution that explained 70% of the variance. Taken together, these findings suggest that parent ratings of preschooler's behaviour on the 76-item REEF reflect a singular EF factor that does not vary with situational demands.

Study 4

To further confirm that the REEF is measuring what it is proposed to measure, our final study sought to examine the convergent and divergent validity of the 76-item REEF with other aspects of children's behaviour. In particular, we asked parents to complete measures of their children's executive dysfunction and symptoms of ADHD, which we anticipated would show strong negative correlations with the REEF. As well, given that previous studies show that EF facilitates appropriate social behaviour (Ciairano, Visu-Petra, & Settanni, 2007; Huyder & Nilsen, 2012), we examined the degree to which children's REEF scores related to social outcomes by having parents report on their children's social functioning. Finally, we asked parents to report on other behaviours that may be under less executive control, such as children's general affect. Specifically, we asked parents to report on their child's degree of fears and sadness as these behaviours tend to fall on separate factors than those related to effortful control, that is, the ability to choose a course of action, plan, and detect errors, which shares much similarity with the executive function system (Rothbart, 2007; Rothbart, Ahadi, Hershey, & Fisher, 2001). In addition, we asked parents to report on their child's degree of smiling/laughter given that smiling in contexts where emotion regulation is not specifically required tends not to relate to executive functioning (Simonds, Kieras, Rueda & Rothbart, 2007) and executive functioning tends not to be facilitated by positive affect (Mitchell & Phillips, 2007; although see Qu & Zelazo, 2007). While we anticipated that such affective variables may be significantly related to observer-reports on the REEF (given significant relations between executive

functioning and emotional well-being; Wagner et al., 2015), we anticipated that these relations would be weaker than with other EF-specific measures.

Method

Participants

North American parents or guardians of children 3- to 5-years-old were recruited through Mechanical Turk via Crowdflower. This study was completed by 622 participants who had not previously completed Study 3; however, participants were removed from analyses if they: completed the survey in less than the minimal amount of time required to answer all of the questions (i.e., 10 minutes: n = 12); had more than 10% missing data on the REEF (i.e., 8 or more unanswered items: n = 3); responded to all items on the REEF with the same response (i.e., no variance in responding: n = 2); indicated that they were the child's biological mother and were older than 50 years (n = 1); indicated the child was less than 36 months old (n = 21) or older than 72 months (n = 8) or had no identifiable birthdate (n = 5); or indicated the child was diagnosed with or suspected to have developmental concerns (n = 12). The remaining sample size was 558.

The mean age of children being rated by their parent or guardian was 50.82 months (SD = 8.64; range 36 months – 71.10 months) and the sample was comprised of 49.5% female, 49.5% male, and 1.0% declined to answer this question. The mean age of respondents was 389.07 months (32.42 years; SD = 81.81; range 18.65 – 61.92 years). The sample was comprised of children identified as White/European (70.4%), Black (7.2%), Asian (5.6%), Latin American (4.3%), Other (i.e., different ethnicity or multi-ethnic; 11.5%), or whose ethnicity was not provided (1.0%). Respondents were biological mothers (49.1%), biological fathers (42.5%), adoptive mothers (1.1%), adoptive father (2.0%), guardian female (2.9%), guardian male (2.2%), other, such as grandparent, (0.1%), and declined to answer (0.1%).

Procedure

Parents completed the 76-item REEF, as well as a demographic questionnaire and other measures intended to assess children's everyday social and behavioural functioning. Respondents were provided with $3.00 for their participation.

Measures

The Childhood Executive Functioning Inventory (CHEXI) is a 24-item measure of children's EF that consists of two subscales: Inhibition (11 items), which assesses a child's difficulties in stopping inappropriate actions and maintaining on-task behaviour, and Working Memory (13 items), which assesses a child's difficulties holding information in mind or planning/organizing activities (Thorell & Nyberg, 2008). Parents rate their child on items using a 5-point scale with the choices being "Definitely not true", "Not true", "Partially true", "True", and "Definitely true." This measure is reported to have good test-retest reliability and established validity (Thorell & Nyberg, 2008). While this measure is aimed at children older than our targeted population (i.e., 4-years-old to 12-years-old), items were deemed general enough to apply to a younger population as well.

The Strengths and Weaknesses of Attention-Deficit/Hyperactivity Disorder Symptoms and Normal Behavior Scale (SWAN) is an 18-item measure that assesses children's manifestations of ADHD symptoms and consists of two subscales: Inattention and Hyperactivity/Impulsivity (Lakes, Swanson, & Riggs, 2012). Parents rate their child on these items using a 7-point scale to indicate a child's manifestation in comparison to other children of the same age with the choices ranging from "Far above" to "Far below". Higher scores are reflective of fewer difficulties with Inattention or Hyperactivity. This measure is reported to have good reliability and validity for preschool age children (Lakes et al. 2012).

The Strengths and Difficulties Questionnaire (SDQ) is a 25-item screening instrument to evaluate behavioural and emotional concerns that can be separated into 5 scales (Goodman &

Scott, 1999). Of interest to our study were the Peer Problems scale (5 items) and Prosocial Behaviour scale (5 items), which reflect a child's social skills. Parents were administered these 10 items and rated their child on each using a 3-point scale with the choices being "Not true", "Somewhat true", and "Certainly true." The SDQ has been used in the past as a measure of social competence or behavioural adjustment and has been shown to have good test-retest reliability and concurrent validity (Goodman, 2001).

The Children's Behavior Questionnaire-Short Form (CBQ-SF) is a parent-report measure intended to assess various dimensions of children's (3- to 7-year-old's) temperament (Putman & Rothbart, 2006). Of the 15 possible dimensions on this measure, we selected three subscales reflecting children's affect (i.e., Fear, Sadness, and Smiling). Parents were administered 25 items that were rated on a 7-point scale from "extremely untrue of your child" to "extremely true of your child." This measure is reported to have good reliability and validity (Putnam & Rothbart, 2006).

Results and Discussion

Age-related Change in the REEF

Five-hundred and eight participants had complete data on the REEF. For the remaining participants, missing data were replaced using single imputation with an expectation-maximization algorithm in SPSS. This affected 0.2% of all responses. Replicating our findings from Study 3, factor analysis of the 76-item REEF supported a one-factor solution that did not vary across situational contexts (69% of variance explained)[3]. These 76 items showed good internal consistency ($\alpha = .96$). After removing one univariate outlier, the mean for the total REEF

[3] Using CFA, comparison of fit indices of the one factor model with alternative two- and five-factor models yielded results that were almost identical to Study 3 and lent further support to a unitary EF model.

score was 160.66 (*SD* = 29.93). The REEF score was comparable across genders ($t(554) = 1.29$, $p = .20$) and so gender was not included in further analyses. As was expected, however, the REEF score was significantly correlated with children's age ($r = .28$, $p < .001$). Age-related differences in the REEF score were further examined by dividing participants in Study 3 and Study 4 into 6 six-month age intervals (36-41, 42-47, 48-53, 54-59, 60-65, and 66-71 months). Age groups means are presented in Table 4, excluding 12 participants who were identified as bivariate outliers on the association of age and the REEF score based on inspection of residuals. An analysis of variance (ANOVA) with the REEF score as the dependent measure and age group as a predictor revealed a significant main effect of age in both Study 3, $F(5, 484) = 6.92$, $p < .001$, and Study 4, $F(5, 551) = 11.02$, $p < .001$ (and combined, $F(5, 1041) = 16.67$, $p < .001$). In order to inspect which of the six age groups differed significantly on their observer report of EF behaviour, Tukey's post hoc tests were performed using the combined data from Study 3 and 4. The results of marginally significant differences are displayed in Table 5 and are summarized as follows: children between 36 to 41 months tended to have lower EF ratings than children between 42 to 47 months; both groups of younger children were generally rated as lower in their EF behaviour than the older age groups; children at an intermediate age of 48 to 53 months tended to have lower EF ratings than the oldest children between 60 to 65 months and 66 to 71 months; EF ratings were statistically comparable in children aged 54 months and onward.

[Insert Tables 4 and 5 here]

Convergent and discriminant validity of the REEF.

In order to assess the convergent and discriminant validity of the 76-item REEF, correlations between the REEF total score and other measures of children's everyday social and behavioural functioning were examined (Table 6).

The REEF total score was significantly correlated with EF as assessed by the CHEXI, including the Inhibition subscale, r = -.53, p < .001, and the Working Memory subscale, r = -.61, p < .001. It was also significantly correlated with behavioural traits associated with EF (e.g., fewer ADHD traits; Willcutt et al., 2005; Nigg, Quamma, Greenberg, & Kusche, 1999), such as the SWAN subscales reflecting Inattention, r = .49, p < .001, and Hyperactivity/Impulsivity, r = .46, p < .001. Replicating previous findings using laboratory tasks of executive functioning (e.g., Ciairano et al., 2007; Huyder & Nilsen, 2012), we found that children who received higher scores on the REEF demonstrated more prosocial behaviour, r =.49, p < .001, and fewer peer problems, r = -.28, p < .001 on the SDQ.

Reflecting divergent validity, the REEF total score was significantly more strongly correlated with the two CHEXI executive function subscales, than it was correlated to measures of affective functioning, i.e., the Fear (r = -.11), Sadness (r = -.09), and Smiling (r = .24) subscales of the CBQ, zs = -7.33 to -15.40, ps < .001. This was also the case when comparing the correlation coefficients for the REEF and traits of ADHD relative to affective functioning, zs = 4.95 to 10.05, ps < .001.

Re-analysis of the 76-item REEF and children's performance on EF tasks. To further assess the convergent validity of the final REEF, the data from Study 1 were re-examined using a total REEF score based on the 76 items (as opposed to the 119 initial items). There was a significant relation between children's performance on the lab-based measures of EF and the parent-reported REEF (r = .37, p = .04), even when children's language skills were controlled (r = .38, p = .04). Thus, our final version of the REEF was shown to positively relate to lab-based measures of EF (Table 2).

[Insert Table 6 here]

General Discussion

Given the rapid development of EF during the preschool period (e.g., Garon et al., 2008), the centrality of early executive skills to other areas of development (e.g., Best et al., 2009), and the robust association of EF with various developmental disorders (e.g., Johnson et al., 2010 Sanders et al., 2008; Snyder et al., 2015; Wagner et al., 2015; Willcut et al., 2005), the availability of a psychometrically sound and well-validated measure of preschool EF is theoretically important and clinically relevant. Although some EF rating scales have been developed for use with this population (e.g., BRIEF-P, Gioia et al., 2003), they tend to place a narrow focus on executive dysfunction rather than the full continuum of executive functioning, consist of general statements that are not tied to clearly observable behaviours, overlap with diagnostic criteria for developmental disorders such as ADHD, and do not correlate with children's performance on lab-based measures of EF – calling into question what constructs they are measuring. To address these limitations, and thus fill a critical gap in our corpus of tools that may be used to assess EF in preschool aged-children, we present the Rating of Everyday Executive Functioning (REEF) – a brief, easily administered, and psychometrically sound parent-report questionnaire that can be used to capture the everyday, observable behaviours of preschool-aged children that are reflective of their executive functioning.

Our studies demonstrate that the REEF has excellent psychometric properties, including high internal consistency and validity. It is particularly noteworthy that our REEF aligns with other laboratory-based measures of EF, given that most studies have failed to find associations between informant-ratings of children's behaviour on EF questionnaires and children's EF task performance (Liebermann et al., 2007; McAuley et al., 2011; Toplak et al., 2013). Study 1 revealed a significant relationship between the initial 171-item REEF and children's performance on commonly used EF tasks, which remained significant when this association was re-evaluated using the final 76-item version of our questionnaire, even when controlling for language ability.

It has been argued that measures that ask individuals to report on specific behaviours yield higher reliability and validity scores than measures that ask individuals to render more global judgments (Sattler & Hoge, 2006). Accordingly, by asking parents to report on their preschoolers' specific, observable behaviours that are reflective of executive functioning, rather than general statements of executive dysfunction, we believe that the REEF provides a more detailed and accurate picture of a preschooler's executive skill set. This property of the REEF makes it particularly useful for researchers who often rely on laboratory-based measures of EF in their studies, which is both time consuming and resource intensive (indeed, our battery of tasks took two sessions that each spanned close to an hour). By utilizing a questionnaire that relates to actual EF task performance, researchers will be able to capture the domain they seek to measure (i.e., EF) efficiently. This being said, even though we found a correlation between the REEF and lab-based measures, we cannot rule out the possibility that they are measuring related, but different constructs (an assertion made by Toplak et al., 2013). For instance, even when correlations between lab-based measures and parent-report measures have been found in past research (albeit in an older age group than the present study), these different measures contributed to other constructs, such as academic achievement, in unique ways (e.g., the CHEXI, Thorell & Nyberg, 2009). Moreover, it was not the case that children's performance on all of the individual executive function tasks was significantly related to the REEF. It may be the case that certain lab-based measures are more predictive of children's everyday demonstration of EF behaviours than others.

The REEF also demonstrates convergent and divergent validity with other parent-report questionnaires of children's behaviour. Study 2 showed that parent ratings on the REEF were significantly associated with parent ratings on the BRIEF-P, such that parents who rated their preschoolers as demonstrating more advanced executive behaviours on our questionnaire were also rated as showing less evidence of executive dysfunction. This finding is important as it

suggests that the specific behaviours that we ask parents to comment on in the REEF are capturing an aspect of children's EF that is similar to the more global assessment that existing measures capture. Moreover, results from Study 4 highlight the divergent validity of the REEF. That is, the REEF showed a stronger relation with measures of executive functioning and ADHD traits than affective measures. Demonstrating this is important because it suggests that relations between the REEF and other constructs are not simply due to an overall positive (or negative) view parents hold of their children's behaviour. Rather, the REEF targets areas related to executive control.

In addition to developing a psychometrically sound tool that assesses EF in preschool-aged children, we wanted our tool to capture age-related differences in EF. Consistent with this goal, we found that children's scores on the REEF showed significant differences within the preschool-years, reflecting the sensitivity of our measure to the normative developmental changes in EF that are known to occur early in development (Garon et al., 2008). Specifically, we found that parents rated 3-year-olds as demonstrating behaviours indicative of advanced EF less frequently than 5-year-olds, with the most dramatic differences emerging between 3 year-olds and older children. Similar findings have been demonstrated in studies using performance-based tasks to assess EF in preschoolers (e.g., Carlson, 2005). Taken together, findings from studies using varied approaches to the assessment of EF converge on the view that the preschool period is one of noticeable improvement in EF development. However, it should be noted we did not find that scores significantly differed between the older preschool ages, which suggests that the REEF is more sensitive to age-related differences in EF behaviour within the early (rather than later) preschool years.

Finally, items selected for inclusion on the REEF converged on a unitary EF construct in our preschool-aged sample. This is consistent with findings from other studies that have

examined the factor structure of EF early in development using performance-based tasks (Hughes et al., 2010; Wiebe et al., 2008; Wiebe et al., 2011). However, it is in contrast to other work which has found that a two factor structure (i.e., working memory and inhibition) may more adequately capture the pattern of data for preschoolers' EF performance (Miller, Giesbrecht, Müller, McInerney, & Kerns, 2012; Usai, Viterbori, Traverso, & De Franchis, 2014). Findings also diverge from other studies using informant ratings of executive dysfunction in preschool-aged children, in which multiple factors have emerged in young children (i.e., BRIEF-P; Bonillo, Araujo Jiménez, Jané Ballabriga, Capdevila, & Riera, 2012; Duku & Vaillancourt, 2014; Isquith et al., 2004). The factor structure of preschoolers remains somewhat elusive, though there is converging evidence that EF is differentiated later in development, with separable, though inter-related, EF skills being discernable at least by the early elementary school-age years and remaining separable through young adulthood (Huizinga et al., 2006; McAuley & White, 2011).

Our series of studies provide promising data regarding the utility of the REEF for assessing EF in preschool-aged children; however, there are limitations with regards to the development of our scale that warrant mention. Because Studies 3 and 4 were conducted via an on-line questionnaire system, a tool that is becomingly increasingly established in the social sciences (Mason & Suri, 2012), we were less able to ensure that participant criteria for inclusion in our study were valid. For example, though we specified that all respondents were required to have a child between 3- to 5-years of age, we were not able to verify that participants met this requirement. Further, though we implemented quality control measures to exclude participants with unusual response patterns (e.g., very short completion times, suggesting that the questionnaire was completed in an overly expedited fashion), we cannot ensure that all participants paid careful attention to all items. Lastly, by virtue of these studies being conducted on-line, there were no opportunities for participants to seek experimenter input in the event that a

question was unclear. With these concerns in mind, we had relatively large samples to try to ensure that any problems – should they have arisen – would have affected only a small proportion of our data. If anything, we expect that the findings that we observed in our studies would be stronger if we conducted them in-person. Another limitation to note is the relatively limited ethnic diversity of our samples. Specifically, the majority of our participants in the last two studies identified as 'White/European'. It would be important for future work to include a more diverse sampling of participants, as well as to include information about respondents' family income and marital status, in order to increase the generalizability of the results. A final limitation is that we did not include a measure of IQ in our battery of tasks in order to determine whether the REEF uniquely relates to EF behaviours, independent of IQ. We did control for children's vocabulary, which has been found to relate to IQ (e.g., Childers, Durham, & Wilson, 1994); however, future work could more directly assess and control for children's general cognitive function abilities.

Future Directions

The studies presented here represent the foundational work in creating the REEF. There are a number of future steps that can be taken to further elucidate the psychometric properties and application of this measure. First, though the internal consistency of the REEF is high, test-retest reliability could be assessed to determine how consistent caregivers are in reporting observations of their children's behaviour at different time periods and, similarly, it would be useful to determine the consistency of responses across multiple informants (e.g., different parents, day care providers, etc.) as well as across settings (home, day care, etc.). Second, future work could also identify other internal indices, such as those indicative of positive/negative response bias and inconsistent responding, to further increase one's confidence in ratings that are provided by caregivers. Third, the REEF could be used to assess the concurrent relationship between

children's EF and other academic, cognitive, and social-emotional competencies, and to examine the predictive relationship between children's EF and their future development in each of these domains. Relatedly, the REEF could also be used to equate typical/atypical groups of children on EF when investigating other correlates of executive functioning (e.g., social communication). While the REEF was designed with research purposes in mind, there are some potentially interesting clinical applications as well. For example, given the importance of preschoolers' EF for other aspects of functioning, the REEF might be used to screen young preschoolers to determine who might benefit from early intervention. In addition, the REEF could be used to determine whether interventions aimed at bolstering EFs generalize to a preschooler's everyday behaviours. Whereas most intervention studies look for evidence of transfer using children's performance on lab-based tasks of EF, inclusion of the REEF in this line of research would enable researchers to determine whether there may also be concomitant improvements in children's abilities to use their executive skills in their everyday lives. Certainly, though, prior to using the REEF for such clinical applications, the predictive validity as well as sensitivity/selectivity of the REEF would need to be determined.

Conclusion

The assessment of preschoolers' EF is important due to the role that EF plays in facilitating development in domains, such as academic skills, cognitive and social-emotional development, and healthy psychological functioning (Best et al., 2009). The REEF is a promising new measure of preschoolers' executive functioning – one that relies on caregivers' observations of preschoolers' behaviours that are indicative of their ability to apply executive skills in their daily lives. The REEF correlates with lab-based measures of EF, shows strong internal consistency, demonstrates convergent and divergent validity, and has scores that reflect variability in the preschool years. We hope that the REEF will be used by researchers as an

efficient way of measuring the EF of preschool-aged children and anticipate that our questionnaire will contribute to our understanding of the correlates and consequences of EF that occur early in development.

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Table 1

Description of EF Tasks used in Study 1

Construct	Task	References	Description
Working Memory	Digit Span	Davis & Pratt, 1996	Children repeated single digits in forward and backwards order with series size increasing after each successful trial until ceiling criteria were achieved. The total number of correct trials were recorded.
	Self-ordered Pointing	Luciana & Nelson, 2002	Children were shown a set of pictures that were arranged in a different spatial arrangement on each trial. Children were instructed to point to a picture they had not pointed to on a previous trial. The largest set of correctly recalled pictures was recorded.
	Count and Label	Gordon & Olson, 1998	Children were asked to first count, then label, then count and label a series of objects. Scores reflected the total number of correctly counted and labeled objects across trials.
Inhibitory Control	Bear/Dragon	Reed, Pien, & Rothbart, 1984	Children were instructed to perform actions given by a bear puppet but not a dragon puppet. Performance was coded as 0 (performed action), 1 (performed partial action), 2 (performed a different action), or 3 (no action). Children's scores were summed across dragon trials.
	Day/Night	Gerstadt, Hong, & Diamond,1994	Children were instructed to say 'day' when shown a moon picture and 'night' when shown a sun picture. The percentage of correct responses across trials was recorded.
	Gift Delay	Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996	Children were instructed not to look at a gift they would eventually receive. Peeking was recorded using a video camera and the number of peeks was tallied.

	Whisper	Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996	Children were instructed to refrain from shouting the names of familiar cartoon characters. Performance was scored as 0 (shouting), 1 (normal voice or mixed shouting and whispering), or 2 (whispering). Children's scores were summed across trials on which a response was given.
Shifting	Flexible Item Selection Task	Jacques & Zelazo, 2001	Children were presented with 3 cards depicting items that varied in shape, size, and color. Children were asked to first select two cards that matched on one dimension and then to select two cards that matched on a different dimension. The number of correct responses on the second match (when the first match was correct) was recorded across 15 trials.
Planning/ Organization	Tower of Hanoi	Adapted from Welsh, 1991	Children transferred disks on pegs from an initial start state to a goal end-state in the minimum number of moves. Children's total score reflected the number of points awarded based on the trials/levels the child was able to successfully attain.
	Truck Loading	Carlson, Moses, & Claxon, 2004	Children loaded and delivered invitations using a toy truck while adhering to 4 rules: (a) the street is one-way, (b) can drive around the block only once, (c) the color of the invitation must match the color of the house, and (d) invitations must be taken only off the top of the pile from the back of the truck. Children's score corresponded to the highest level they achieved out of a possible 4 levels for a total score of 0 to 4.

Table 2.

Correlations between REEF (119-item and final 76-item version), Executive Function Tasks, and Language in Study 1 with partial correlations controlling for receptive vocabulary in parentheses

	Age	Receptive Vocabulary	119 item REEF	76 item REEF
Receptive Vocabulary	.42**			.03
119 item REEF	.39*	.01		.99
EF Task composite	.77**	.60**	.35* (.40*)	.37*(.38*)
Digit Span	.76**	.44**		.29†(.23)
Self-ordered pointing	.39*	-.11		.26 (.41*)
Count and Label	.62**	.36*		.23 (.22)
Bear / Dragon	.55**	.54**		.05 (-.21)
Day / Night	.31*	.51**		.07 (-.05)
Gift Delay	-.33*	-.26		-.39* (-.46*)
Whisper	.07	.34*		.28† (.28)
Flexible Item Selection	.76**	.50**		.32† (.38*)
Tower of Hanoi	.52**	.33*		.33* (.25)
Truck Loading	.53**	.51**		.10 (.15)

Note. Gift delay was reverse coded for the EF Task composite measure as it was the only task whereby a higher score reflected worse functioning.
† $p < .10$ (two-tailed). * $p < .05$ (two-tailed). ** $p < .01$ (two-tailed).

Table 3.

Bivariate correlations between the REEF and BRIEF-P in Study 2 with partial correlations controlling for reported language skills (CCC-2) in parentheses

BRIEF-P Measures	REEF Composite
Inhibit	-0.53 *** (-.40***)
Shift	-0.46 *** (-.35***)
Emotional Control	-0.44 *** (-.38***)
Working Memory	-0.64 *** (-.47***)
Plan/Organize	-0.60*** (-.47***)
Inhibitory Self-Control Index	-0.55 *** (-.44***)
Flexibility Index	-0.51 *** (-.42***)
Emergent Metacognition Index	-0.66 *** (-.51***)
Global Executive Composite	-0.65 *** (-.53***)

*** $p < .001$ (two –tailed).

Table 4.

Performance on the REEF for each age group Study 3 and Study 4

Age Group	n	M (SD)	Range
36-41 months			
Study 3	105	152.40 (32.57)	65.48 - 217.40
Study 4	107	147.67 (30.53)	65.00 - 208.00
Combined	212	150.01 (31.57)	65.00 - 217.40
42-47 months			
Study 3	119	157.98 (31.55)	75.00 - 225.00
Study 4	92	156.91 (27.20)	71.00 - 211.00
Combined	211	157.51 (29.67)	71.00 - 225.00
48-53 months			
Study 3	105	162.40 (29.24)	68.00 - 221.00
Study 4	175	165.46 (28.38)	81.00 - 224.00
Combined	280	164.31 (28.69)	68.00 - 224.00
54-59 months			
Study 3	54	170.57 (26.97)	101.00 - 222.00
Study 4	77	162.23 (25.55)	97.00 - 211.00
Combined	131	165.67 (26.37)	97.00 - 222.00
60-65 months			
Study 3	58	173.58 (23.36)	116.20 - 217.40
Study 4	76	172.08 (20.73)	124.00 - 219.00
Combined	134	172.73 (21.84)	116.20 - 219.00
66-71 months			
Study 3	49	173.45 (24.56)	108.00 - 217.00
Study 4	30	176.01 (20.09)	137.00 - 220.00
Combined	79	174.42 (22.87)	108.00 - 220.00

Table 5.

Summary of Tukey's analyses between the different age groups' REEF total scores using data from Study 3 and 4 combined (N = 1047).

Comparison Age Groups	Mean Difference
36-41 vs. 42-47 months	-7.50†
48-53 months	-14.30***
54-59 months	-15.66***
60-65 months	-22.72***
66-71 months	-24.41***
42-47 vs. 48-53 months	-6.80†
54-59 months	-8.16†
60-65 months	-15.22***
66-71 months	-16.91***
48-53 vs. 60-65 months	-8.42*
66-71 months	-10.11†

Note. Only the mean differences that are significant at the 0.10 level are displayed.

† $p < .10$ (2-tailed). ***$p < .001$ (2-tailed).

Table 6.

Correlations between REEF, CHEXI, SWAN, SDQ, and CBQ in Study 4

	REEF
CHEXI	
Inhibition	-.53***
Working Memory	-.61***
SWAN	
Inattention	.49***
Hyperactivity	.46***
SDQ	
Peer Problems	-.28***
Prosocial Behaviour	.49***
CBQ	
Fear	-.11**
Sadness	-.09*
Smiling/laughing	.24***

*$p < .05$ (2-tailed). **$p < .01$ (2-tailed). ***$p < .001$ (2-tailed).

Appendix: Ratings of Everyday Executive Functioning (76 Items)

PART A – HOW YOUR CHILD PLAYS GAMES

This section will ask you about your child's abilities related to playing games.

1	Plays "Hide and Go Seek" without cheating (e.g., does not peek when counting).
2	Follows and plays games with two step directions (e.g., in a memory game selects cards and checks if they match) without reminders.
3	Remembers lengthy instructions about how to play games (e.g., board games).
4	Remembers the rules of games (e.g., does not need to be reminded frequently).
5	Persists at games or puzzles even when he/she finds them frustrating.
6	When playing a game, he/she stops and thinks before acting.
7	Follows instructions to a game without needing repeated directions.
8	Learns from trial and error in mastering a new task (i.e., changes strategies when something doesn't work).
9	Follows verbal instructions to a new game without being shown how to play.
10	Gets all the materials he/she needs before starting an activity.

PART B – HOW YOUR CHILD PLAYS GAMES WITH OTHERS

This section will ask you about your child's abilities when playing with others.

1	Can play "I spy" without disclosing the thing he/she is thinking about before the other player guesses the object.
2	Waits his/her turn in games and other activities.
3	Controls his/her anger when another person breaks the rules in a game.
4	Plays games without having disputes with playmates.
5	In role playing games, he/she chooses to play different roles (e.g., does not always want to be "the mommy").
6	Waits his/her turn and works cooperatively with other players in board games.

PART C – HOW YOUR CHILD INTERACTS WITH OTHERS

This section will ask you about your child's abilities when interacting with other children and adults.

1	Is good at keeping secrets (i.e., doesn't blurt them out).
2	If a companion is being asked a question, your child can withhold giving his/her answer.
3	During conversations waits for his/her turn to speak.
4	Waits until someone has finished talking before leaving the conversation.
5	Waits until a question has been completed before answering it.
6	Is able to wait for a reasonable period of time when asked to do so by an adult (e.g., will not keep talking if you ask him/her to wait for a minute while you finish another conversation).
7	Refrains from hitting/pushing other children when he/she is angry.
8	Regulates his/her own facial expressions so they are socially appropriate
9	Apologizes, without reminders, when he/she has hurt the feelings of others.
10	Resolves small disputes with other children without adult intervention.
11	Appreciates other individuals' perspectives.
12	Rephrases language when another person doesn't understand what he/she is saying.
13	Let's you have a conversation with other people without interrupting needlessly.

PART D – AROUND THE HOUSE

This section will ask you about your child's behaviours at home.

1	Sits at dinner table for entire meal without fussing or getting up from table.
2	Sits still for extended periods of time (e.g., during movies, performances).
3	Will refrain from taking "goodies" that are left in an accessible location.
4	Completes chores that involve multiple steps (e.g., setting the table).
5	Concentrates on a task (e.g., doing a puzzle) even when there are distractions (e.g., a sibling is crying).
6	Remembers all steps involved in completing tasks (i.e., does not forget half way through activity).
7	When asked to do several things, remembers to do most or all of them (e.g., putting toys and books away).
8	Fetches all items requested by adult (e.g., does not forget what he/she was asked to get).
9	Keeps next step in mind while performing an activity (e.g., remembers to clean up toys after eating snack).

10	When asked to put away toys, does so in an organized manner.
11	Keeps his/her bedroom tidy.
12	Concentrates on a task even when the task is not very appealing to him/her.
13	Sorts multiple items (e.g., clothing, cutlery) easily (i.e., doesn't need to do only one item at a time).
14	Waits for you to finish on the phone before seeking your attention.

PART E – IN THE COMMUNITY

This section will ask you about your child's behaviours while out of the house.

1	Waits in line without complaint (e.g., for his/her turn to go on a ride).
2	When given a time frame, he/she is able to adjust actions accordingly (e.g., he/she does not start reading a new book if about to leave the library).
3	Stops fun activity, without complaint, when he/she is told time is up.
4	Recovers quickly from a disappointment or change in plans (e.g., the family is no longer going out for dinner).
5	Gets over minor disappointments easily (e.g., he/she is not permitted to watch TV because he/she was disobedient earlier).
6	Refrains from talking at inappropriate times (e.g., at the library during story time).
7	Waits for food at restaurants without complaining.

PART F – OUT SHOPPING

This section will ask you about your child's behaviours while you are out at the grocery store or at the mall.

1	Doesn't stay disappointed for long after being told he/she isn't going to receive a treat at a store.
2	Refrains from making inappropriate comments about other shoppers (e.g., "look at that fat man").
3	Waits to pay for items without complaint.
4	He/she would forego enjoying an immediate treat for receiving a larger treat later.
5	If asked, stops him/herself from touching objects that look fun to play with (e.g., fragile items in a store).
6	Refrains from touching things he/she is not supposed to approach (e.g., buttons on the elevator).
7	Will remind you about the next step in an activity (e.g., what item you need to pick up next in the grocery store) if you ask him/her.
8	Fetches requested items from grocery store (i.e., doesn't get distracted by other items).
9	When at the grocery store, only places items that are needed in the cart. (e.g., doesn't get distracted by other items).
10	Accepts when something happens that he/she doesn't like (e.g., doesn't whine when he/she does not get favourite cereal at the grocery store).

PART G –STORY TIME

This section will ask you about your child's abilities related to reading and telling stories to others.

1	Tells you a made-up story in an organized manner (e.g., starting at the beginning, finishing at the end).
2	Tells a story about something that has happened so that others can easily understand.
3	When telling a story, real or fictional, links events in a way that makes sense.
4	Repeats stories or jokes he/she has heard from others.
5	If interrupted, will continue from where he/she left off in telling you a story (i.e., doesn't need to start from the beginning again).
6	Is quiet when you read him/her a story (i.e., doesn't interrupt you).

PART H – GENERAL SKILLS AND BEHAVIOURS

This section will ask you about your child's general abilities.

1	Puts on his/her own clothing.
2	Is able to put the brakes on his/her actions when asked (e.g., can stop acting silly).
3	Can do simple calculations in his/her head (e.g., 2 plus 3).
4	Can do things that require mental effort (e.g., counting backwards).
5	Plans/talks about the next day's events.
6	Understands concepts of time (i.e., appreciates the difference between 5 minutes and half an hour).
7	Uses the same object for different or novel uses (e.g., using a pencil as chop sticks).
8	Can shift gears and easily adapt behaviours to a new task.
9	Adjusts behaviour to different situations (e.g., eating at a restaurant versus eating at home).
10	Uses suggestions from you when trying a new task (e.g., learning to tie his/her shoelaces).)