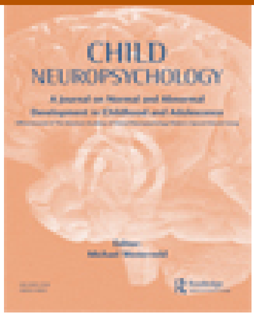

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Factor structure of the Behavior Rating Inventory of Executive Functions (BRIEF-P) at age three years

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The preschool period is an important developmental period for the emergence of cognitive self-regulatory skills or executive functions (EF). To date, evidence regarding the structure of EF in preschool children has supported both unitary and multicomponent models. The aim of the present study was to test the factor structure of early EF as measured by the Behavior Rating Inventory of Executive Function-Preschool version (BRIEF-P). BRIEF-P consists of five subscales and three broader indexes, hypothesized to tap into different subcomponents of EF. Parent ratings of EF from a nonreferred sample of children recruited from the Norwegian Mother and Child Cohort Study ($N = 1134$; age range 37–47 months) were subjected to confirmatory factor analyses (CFA). Three theoretically derived models were assessed; the second-order three-factor model originally proposed by the BRIEF-P authors, a "true" first-order one-factor model and a second-order one-factor model. CFA fit statistics supported the original three-factor solution. However, the difference in fit was marginal between this model and the second-order one-factor model. A follow-up exploratory factor analysis (EFA) supported the existence of several factors underlying EF in early preschool years, with a considerable overlap with the five BRIEF-P subscales. Our results suggest that some differentiation in EF has taken place at age 3 years, which is reflected in behavior ratings. The

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internal consistency of the BRIEF-P five clinical subscales is supported. Subscale interrelations may, however, differ at this age from those observed in the preschool group as a whole.

Keywords: Executive function; BRIEF-P; Preschool; Factor analysis; Development.

Complex cognitive functions that are integral to the self-regulation of behavior and development of social and cognitive competence develop during early childhood. Collectively referred to as executive function (EF), they are considered distinct from modular cognitive functions (visuospatial abilities, language skills, memory), encompassing higher order functions such as working memory, inhibitory control, planning and organization, mental flexibility, decision making, initiation of activity, and monitoring of ongoing behavior (Anderson, 2002; Miyake et al., 2000). EF is thought to be implicated in cognitive processes, emotional responses and behavioral actions (Anderson, 2002; Espy, Sheffield, Wiebe, Clark, & Moehr, 2011). In an influential integrative model of EF, Miyake and colleagues propose that EF may best be described as a unitary concept with partially dissociable constructs (Miyake et al., 2000).

The preschool years (ages 3–6 years) constitute a particularly active period in the development of EF. Developmental spurts are demonstrated in performance on several EF tasks during these years (Best & Miller, 2010; Carlson, 2005; Carlson & Moses, 2001), and prefrontal neural systems implicated in EF show a gradual differentiation into separate functional systems (Posner, Rothbart, Sheese, & Voelker, 2012; Rubia, 2013; Tsujimoto, 2008). Based on the literature on normative EF development, a developmental sequence has been proposed, with basic inhibitory and working memory abilities (inhibition of a prepotent response, information retention) emerging during the first year of life, followed by more complex forms of the two core EF components (solving response conflict, manipulation of information kept active in memory) around age 3 (Carlson, 2005; Garon, Bryson, & Smith, 2008). The ability to shift is thought to depend on basic inhibitory and working memory skills. At age 3, most children will be able to shift attention in response to situational demands and to shift between simple response sets following clear verbal instructions (Espy, Kaufmann, McDiarmid, & Glisky, 1999; Zelazo et al., 2003). Rudimentary planning and organizational skills have been demonstrated in studies of 3- to 4-year-old children (Espy, Kaufmann, & Glisky, 2001; Welsh, Pennington, & Groisser, 1991). These complex skills involve several other, more basic EF processes and show a more protracted developmental trajectory. The regulation of emotional responses is thought to develop in concert with other EF processes, steadily improving throughout childhood (e.g., Hill, Degnan, Calkins, & Keane, 2006; Lamm & Lewis, 2010; Posner et al., 2012). In early childhood, when fundamental executive skills first become operational, the structure of EF is likely to be different from what has been described in older children and adolescents (Lee, Bull, & Ho, 2013). Both unitary (Wiebe et al., 2011; Willoughby, Blair, Wirth, & Greenberg, 2010) and multifactorial models of early EF (Anderson, 2002; Isquith, Gioia, & Espy, 2004; Miller, Giesbrecht, Müller, McInerney, & Kerns, 2012) have been proposed, but methodological differences have complicated the comparison of competing theoretical models of EF in this age group (van der Ven, Kroesbergen, Boom, & Leseman, 2013; Wasserman & Wasserman, 2013).

The Behavior Rating Inventory of Executive Function- Preschool version (BRIEF-P; Gioia, Espy, & Isquith, 2003) was developed in order to provide information about specific subcomponents in EF through observable, behavioral manifestations of these processes in children aged 2 through 5 years. The preschool version is an adaptation of the original inventory, BRIEF (Gioia, Isquith, Guy, & Kenworthy, 2000), in which specific EF domains were defined on the basis of theory, clinical practice, and extant research literature (Gioia et al., 2000). The inventory represents a multicomponent view of EF. In the instrumentation of the preschool version, irrelevant items reflecting more mature levels of EF behavior were deleted, some were edited in order to reflect behavior in preschool contexts, and a new set of items were included to capture preschool-specific behavior (Isquith et al., 2004). The BRIEF-P consists of five subscales, assessing EF within five domains labeled *Inhibit, Shift, Emotional Control, Working Memory, and Plan/Organize*. Exploratory factor analyses (EFAs) performed in the normative sample and in a mixed clinical sample (ages 2–5) yielded three latent factors that proved stable across raters and the presence of neurodevelopmental disorder: The Inhibit and Emotional Control subscales constituted the broader construct of *Inhibitory Self-Control.* Combined with the Shift subscale, Emotional Control also loaded onto a second factor, which was labeled *Flexibility*. The third factor, *Emergent Metacognition* comprised the Working Memory and Plan/Organize subscales, referring to the developing metacognitive aspects of EF (Isquith et al., 2004). This three-part model of EF has clear similarities with models proposed in factor analytic studies of older children and adults, which seem to converge on inhibition, mental flexibility (shifting), and working memory or updating as the three main components in EF (Huizinga, Dolan, & van der Molen, 2006; Lehto, Juujaervi, Kooistra, & Pulkkinen, 2003; Miyake et al., 2000).

Three recent studies of nonreferred preschool children have investigated interrelations between the subscales and/or latent second-order factors in BRIEF-P. Based on an EFA of BRIEF-P ratings from parents and teachers, Bonillo, Jimenez, Ballabriga, Capdevila, and Riera (2012) concluded that the observed relations between the five clinical subscales in their sample of children aged 3–6 years corresponded well with the originally proposed three-factor structure. In a confirmatory factor analysis (CFA) of the complete BRIEF-P structure (63 items, five subscales, three indexes), Ezpeleta, Granero, De La Osa, Penelo, and Domènech (2012) found that the three-part model performed well in reconstructing interrelations in teacher ratings of a sample of 3-year olds after the removal of four items. An even more fractionated structure in EF was recently suggested in a study demonstrating that two of the BRIEF-P subscales (Inhibition and Shift) were likely to reflect more than one underlying construct (Duku & Vaillancourt, 2013).

In contrast to the above findings, the majority of research on EF in preschool children proposes that less fractionated models will be better able to capture the structure of early EF (Lee et al., 2013). Support for a single-factor model has come from several methodological traditions including neuropsychological tests (Hughes, Ensor, Wilson, & Graham, 2010; Wiebe et al., 2011; Willoughby et al., 2010), behavioral ratings (Espy et al., 2011), and studies of prefrontal networks implicated in self-regulation (Tsujimoto, 2008). The moderate-to-high correlations between latent factors in CFAs have also been argued to indicate a unitary EF construct (Espy et al., 2011). It should be noted,however, that previous conclusions in favor of a unitary EF construct have not always been based on a comparison of a unidimensional EF model with multidimensional alternatives. As pointed out by Miller et al. (2012), some of those investigating more fragmented models report similar or equal fit indices for two- and three-factor structures relative to the preferred unitary EF construct (Wiebe et al., 2011; Willoughby et al., 2010).

According to research on normative EF development, a gradual differentiation of EF components takes place during the preschool period, towards the multifactorial structure typically described in older children and adolescents (Huizinga et al., 2006; Lehto et al., 2003; Miyake et al., 2000). It is relevant to ask, whether multifactorial models of EF—here represented by the BRIEF-P—are the most adequate description of EF structure as measured through behavioral observations also for the youngest preschool children. Research to date does not offer a satisfactory answer to this question. The two previous studies investigating a one-factor structure of EF as measured by the BRIEF-P in a CFA were based on pooled data from children aged 3–6 years (Bonillo et al., 2012; Duku & Vaillancourt, 2013). During these three years, the preschool child undergoes fundamental changes in all aspects of cognition, and it is likely that the structural organization of EF changes significantly during this period. Possible age-specific interrelations in EF may thus have been obscured (Pauli-Pott & Becker, 2011). Factor analyses reported in the Bonillo et al. study (2012) were based exclusively on the inventory's five clinical subscales not on the individual items. This is also potentially problematic, given the questions raised about the unidimensionality of the clinical subscales (Duku & Vaillancourt, 2013). The third study, investigating EF structure as measured by the BRIEF-P in a large sample of 3-year olds (teacher ratings), assessed two multifactorial, first-order factorial solutions (63 items, five first-order factors;and 63 items, three first-order factors). No information is provided, however, regarding these models' fit to data, other than that they "yielded unsatisfactory solutions" (Ezpeleta et al., 2012, p.9).

Assessment of EF in the youngest preschool children needs to be based on an understanding of its structural organization. The BRIEF has gained support as an ecologically valid measure of EF, which captures important aspects of children's self-regulation in an everyday context. Both in school-aged and preschool samples, the inventory has been shown to capture profiles of EF characteristic of developmental and acquired disorders, such as attention deficit/hyperactivity disorder (ADHD), autism spectrum disorder, traumatic brain injury, and Tourette's syndrome (Donders, DenBraber, & Vos, 2010; Gioia, Isquith, Kenworthy, & Barton, 2002; Hovik et al., 2014; Mahone & Hoffman, 2007; Nadebaum, Anderson, & Catroppa, 2007; Teunisse et al., 2012). Little is known, however, about how its basic assumptions with regard to EF structure will map onto emerging EF processes in the earliest preschool years. The overall aim of the present study was to test whether a differentiation of EF into subfunctions is reflected in the BRIEF-P already at age 3. We compared the second-order three-factor model of EF proposed in the BRIEF-P with a first-order one-factor model and a second-order one-factor model using CFA. Given that the differentiation of EF processes still is in its earliest phase at age 3 years, a one-factor model (first- or second-order) was hypothesized to fit the observed structural relationships in our sample better than a more fractionated, three-factor model of EF.

METHOD

Participants

The present study used data from a longitudinal prospective study of ADHD that recruited its participants from The Norwegian Mother and Child Cohort Study (MoBa), a population-based birth cohort study including prospective data from more than 107,000 pregnancies, managed by the Norwegian Institute of Public Health (Magnus et al., 2006). The MoBa sample has been discussed elsewhere (Magnus et al., 2006; Nilsen et al., 2009). Participants in the MoBa completed questionnaires at several time points during pregnancy and after child birth. The questionnaire at 36 months covers child development and behavior including six questions on hyperactivity, impulsivity, and attention problems from the Child Behaviour Checklist (CBCL; Achenbach & Ruffle, 2000) and five questions reflecting *DSM-IV-TR*) criteria for ADHD (American Psychiatric Association, 2000). Children were invited to take part in the prospective study if the sum score of these 11 questions was above the 90th percentile in the population, or if their parents reported hyperactivity as a health problem. In addition, a comparison group was randomly selected among children in the full MoBa cohort and was invited to the same clinical assessment. A total of 2,798 children scoring high on the screening questions or parent report of hyperactivity as a health problem were invited, and 1,048 (37.5%) participated in the clinical assessments. For the comparison group, 654 were invited, and 147 (22.5%) participated.

All children participating in the prospective study's clinical assessments (N = 1,195) were eligible for the present study. Inclusion required a BRIEF-P parent form with overall number of missing responses less than 12 and less than two missing responses within any single subscale. In line with scoring instructions, missing scores were replaced with item score 1 (n = 110) (Gioia, Espy, & Isquith, 2002). Finally, 23 children were excluded due to IQ score below 70 (n = 5) or missing data on this variable (n = 18). Our data set thus consisted of BRIEF-P parent ratings of 1,134 children (544 girls and 590 boys with mean age = 41.8 months, range 37–47 and mean IQ of 101.8, range 70–130). Average number of ADHD symptoms were 4.0 (range 0–18), and average length of maternal education was 15.3 years (range 9–18). Missing analyses revealed no significant difference between children included in the data set, and those excluded were due to an incomplete BRIEF-P form (n = 38) with regard to any of these variables.

The present sample was recruited in order to investigate early symptoms of ADHD; thus, children meeting the diagnostic criteria for ADHD (American Psychiatric Association, 2000) were overrepresented (14.2%) compared to the general population, where prevalence estimates vary between 2 and 6% (Egger & Angold, 2006; Wichstrom et al., 2012).

None of the children in the sample were or had been receiving psychopharmacological treatment at the time of the assessment. Parents of the participating children gave informed consent to the research and to publication of the results. The study was approved by the Norwegian Regional Committee of Ethics in Medical Research and The Norwegian Data Inspectorate.

Procedure and Measures

Upon accepting the invitation to participate in the ADHD prospective study, parents were requested to fill out the BRIEF-P and return it by the time of the clinical assessment. This was done approximately 4 weeks prior to the 1-day assessment at the ADHD study location at Oslo University Hospital. As part of the clinical assessment, a semi-structured, clinical interview (described below) was conducted with one of the parents.

The BRIEF-P consists of 63 items or behavioral descriptors, that is, "Forgets what he/she is doing in the middle of an activity" or "Overreacts to small problems" within five theoretically and clinically derived domains (described earlier). Parents respond how often a specific behavior has been a problem during the past 6 months choosing Never (1), Sometimes (2), or Often (3). Thus, higher scores are associated with poorer executive functioning. The data collection in the prospective study commenced in 2007, using the existing Norwegian translation developed for research purposes (Nicholas & Solbakk, 2006). A new BRIEF-P translation with a closer resemblance to the original version (Gioia et al., 2003) became available for research purposes in 2009 and was implemented in the second half of the data collection (from 2009 to 2011). To ascertain that the different wordings in some of the inventory's items did not lead to differences in factor structure, we compared four different EFA solutions that allow same and/or different factor means and factor loadings for the two BRIEF translations. We found the best solution to be the one assuming same loadings and different means (Results listed in Appendix A). In sum, this analysis suggests a unitary factor structure for the two BRIEF translations, allowing us to combine their data for all further analyses.

Psychiatric symptoms were assessed using an adapted Norwegian version of the Preschool Age Psychiatric Assessment interview (PAPA; Egger & Angold, 2004). The interview provides information about the scale and frequency of symptoms according to diagnostic criteria in *DSM-IV-TR*. Interrater reliability (intraclass consistency) of the total number of *DSM-IV-TR* ADHD symptoms assessed by PAPA in the present study was .98.

Statistical Analyses

Three a priori models of BRIEF-P factor structure were subjected to CFA, assessing their ability to reproduce the pattern of item interrelations in our sample. CFA is a theory-driven, analytical approach that allows for the verification of the number of underlying dimensions (factors or latent variables) and the pattern of item-factor relationships in a prespecified structural model. It also allows for statistical testing of differences in model fit. The following models were assessed: firstly, a "true" unidimensional model, where all 63 items were expected to load directly onto a single, first-order EF factor; secondly, an alternative one-factor model where the 63 items were expected to load onto a single, unitary EF (second-order) factor through the five BRIEF-P subscales; and, thirdly, the complete three-factor model of EF (Isquith et al., 2004), consisting of the 63 items, the five clinical subscales (first-order factors), and the three broader indexes (second-order factors).

Due to the BRIEF-P three-category response format and a large proportion of positively skewed variables in our data set, weighted least squares means and variance (WLSMV) was used. Analyses were conducted on the factor variance-covariance matrix. Latent factors were expected to correlate—this was allowed in the model—while all measurement error was presumed to be uncorrelated. Due to a negative residual variance related to one of the first-order factors (Inhibit), variance for this variable was set to 0 in the estimation of the three-factor model. Model fit was evaluated and compared using a range-of-fit statistics: the Tucker-Lewis index (TLI), Comparative fit index (CFI), and the root-mean-square of approximation (RMSEA). According to recommended cut-off values, a TLI and CFI less than .90 indicate lack of fit, between .90 and .95 indicate reasonable fit, and between .95 and 1.00 indicate good fit. RMSEA values at .05 or lower are considered to indicate good fit, whereas values between .05 and .08 indicate reasonable fit (Marsh, Hau, & Wen, 2004; Tabachnick & Fidell, 2007). Bartlett's theory of Sphericity was highly significant ($p < .001$) and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy value of .96 indicated that the sample was suitable for factor analysis. The two second-order models were nested, allowing for statistical testing of differences in model fit in Mplus.

Based on an evaluation of the CFA results, we supplemented the examination of the theoretically derived models with two EFAs. In contrast to CFA, EFA is a data-driven procedure that does not require a highly constrained prespecified model of structural relations between items and factors. The method is considered appropriate when links between measured (indicators) and latent variables (factors) are unknown or uncertain (Byrne, 2005). EFA yields information that indicate a number of interpretable constructs that maximally account for covariances among the observed variables (Tabachnick & Fidell, 2007). The extraction of factors is usually guided by the inspection of factor eigenvalues and the scree plot. As these criteria may be affected differently by sample size and the number of variables, they often provide different solutions. Parallel analysis is recommended as a supplementary method (Field, 2009). An important, final criterion is that a factor must be substantially meaningful in a theoretical and/or a clinical perspective. In the present analyses, the solution was subjected to an oblimin rotation, which allows latent factors to be correlated. A second EFA, where the number of factors were restricted to three, was conducted in order to investigate how items from the five first-order factors combined into three proposed second-order factors in our sample.

Descriptive statistics, together with the EFAs, were calculated using PASW Statistics 21.0, and follow-up parallel analysis using Watkins' (2002) Monte Carlo Parallel analysis program. The confirmatory factor analyses (CFAs) were conducted in Mplus 7.11.

RESULTS

Internal consistency was adequate for all five subscales and the four indexes, with Cronbach's alpha values ranging from .76 to .95. Subscale intercorrelations were significant, ranging from .41 to .78 (Table 1).

CFA Results

The first-order model with the 63 BRIEF-P items loading directly on a single EF factor (the "true" one-factor model) represented a poor fit to data in our sample. The second-order unidimensional model yielded acceptable fit according to recommended cut-off values in two out of our three fit indices. Obtaining marginally different values, the three-factor solution yielded overall acceptable fit (Table 2). The five first-order factors in the second-order one-factor model were all significantly correlated and related to a proposed, single EF factor with the following factor loadings: .89 (Inhibit); .68 (Shift); .71 (Emotional Control); .93 (Working Memory), and .91 (Plan/Organize). The three second-order factors in the three-factor model showed moderate-to-strong

Table 1 Cronbach alphas and intercorrelations for BRIEF-P scales and indexes (N = 1,134).

			Scale- and index intercorrelations							
Scale		α	1	2	3	4	5	6	7	8
1	Inhibit	.90								
2	Shift	.76	.45							
3	Emotional Control	.85	.58	.52						
4	Working Memory	.89	.75	.47	.49					
5	Plan/ Organize	.79	.67	.41	.51	.78				
Index										
6	Inhibitory Self-Control	.92	.93	.53	.84	.73.	.68			
7	Flexibility	.87	.60	.83	.91	.55	.54	.81		
8	Emergent Metacognition	.92	.76	.47	.53	.97	.92	.75	.58	
9	GEC	.95	.89	.65	.75	.89	.83	.93	.81	.92

Notes. All scale and index intercorrelations were significant ($p < .001$). GEC = Global Executive Composite score.

Table 2 Summary of Fit Indices for Three BRIEF-P Models.

Model	RMSEA (90% C.I.)	TLI	CFI	X^2_{diff}
1-factor (first-order)	.06 (.060–.062)	.83	.84	
1-factor (second-order)	.05 (.047–.049)	.90	.89	
3-factor (second-order)	.05 (.044–.046)	.91	.91	9.92*

Note. C.I. = 90% confidence interval. The X^2_{diff} value indicates a significant difference in fit between the two second-order models in favor of the three-factor solution.
*p = .002 90%

intercorrelations (r = .59 to .84). As variance of the first-order factor Inhibit was fixed to 0 in the specification of this model, its loading onto the second-order factor Inhibitory Self Control was not estimated. The other factor expected to load onto the same second-order factor, Emotional Control, showed a moderate loading (.44) onto the second-order factor. First-order factor loadings onto the second-order factor Flexibility were .99 (Shift) and .40 (Emotional Control): For the second-order factor Emergent Metacognition, first order loadings were .98 (Working Memory) and .93 (Plan/Organize). Investigating the difference in fit between the two second-order models, we found a small but statistically significant difference in favor of the three-factor model (see Table 2).

Inspection of the modification indices singled out items 20 ("*Takes a long time to feel comfortable in new places or situations*") and 50 ("*Act overwhelmed or overstimulated in crowded, busy situations*") as particular sources of ill fit in both second-order models. In the prespecified three-factor model, these items were proposed to load onto the Flexibility factor through the Shift subscale. Item 20 proved unrelated to a large proportion of items from the other component of this second-order factor (Emotional Control), and item 50 was closely related to several items from subscales constituting the two other second-order factors.

EFA Results

The exploratory analysis indicated the presence of several latent factors (Table 3). EFA yielded 12 factors with eigenvalues exceeding 1. In the screeplot, there was a break between Factors 1 and 2, and a smaller one after the fourth factor. Results from the parallel analysis indicated that six factors exceeded the criterion value. A seventh factor was included on the basis of its interpretability and relatively high factor loadings (see Appendices B and C for complete pattern and structure matrices).

The seven rotated factors accounted for 45.4% of the variance in BRIEF-P ratings and were moderately correlated (rs ranging from .12 to .46). The first factor, accounting for 25.9% of the variance, comprised five items from the Working Memory subscale, two items from the Inhibit scale and one from the Plan/Organize scale. All eight behavioral descriptions were related to sustained attention (e.g., "Has trouble concentrating on games, puzzles, or play activities"; "Has trouble finishing tasks"; "Gets easily sidetracked during activities"; "Does not complete tasks even after given directions"). Seven items, all from the Emotional Control scale constituted a second factor, reflecting emotional reactivity and intensity in emotional reactions (e.g., "Has outbursts for little reason"; "Overreacts to small problems"; "Angry or tearful outbursts are intense but end suddenly"). The third factor comprised four items from the Shift scale; all four describing the ability to adjust to new people or situations (e.g., "Takes a long time to feel comfortable in

Table 3 Pattern and Structure Matrices with Oblimin Rotation of Seven Factor EFA Solution of BRIEF-P Items (N = 1,134).

Items	Pattern (P) and Structure (S) coefficients														
	Factors														
No	1		2		3		4		5		6		7		
	P	S	P	S	P	S	P	S	P	S	P	S	P	S	Communalities
12 WM	.782	.787													.639
42 WM	.728	.767													.605
7 WM	.497	.635													.489
32 WM	.482	.622													.497
58 I	.471	.652													.509
56 I	.438	.571													.435
61 WM	.385	.622													.539
49 P/O	.351	.607													.567
16 EC			.668	.701											.626
1 EC			.645	.701											.523
6 EC			.628	.700											.549
21 EC			.609	.695											.538
26 EC			.598	.665											.537
11 EC			.525	.630											.495
31 EC			.519	.605											.451
20 SH					.867	.801									.668
10 SH					.695	.671									.459
40 SH					.578	.612									.402
5 SH					.452	.593									.443
52 I							.550	.739							.642
48 I							.546	.671							.525
60 I							.505	.640							.483
54 I							.413	.638							.539
62 I							.388	.549							.381
23 I							.328	.553							.457

(*Continued*)

Table 3 (Continued).

Items	Pattern (P) and Structure (S) coefficients														
	Factors														
No	1		2		3		4		5		6		7		
	P	S	P	S	P	S	P	S	P	S	P	S	P	S	Communalities
19 P/O									.825	.780					.618
44 P/O									.741	.744					.560
14 P/O									.320	.471					.348
43 I											.601	.735			.643
13 I											.513	.611			.450
18 I											.438	.596			.512
36 EC											.370	.558			.520
57 WM													.456	.528	.305
63 WM													.423	.550	.366
59 WM													.387	.520	.353
39 P/0													.359	.495	.348
47 WM													.358	.467	.283
55 WM													.350	.483	.294
53 WM													.333	.504	.435
Eigenvalues	16.33		3.31		2.59		2.00		1.58		1.49		1.28		
% of variance	25.92		5.26		4.12		3.16		2.51		2.36		2.03		

Notes. Only loadings above .32 are listed. I = Inhibit; EC = Emotional Control; WM = Working Memory; SH = Shift; P/O = Plan/Organize.

new places or situations"; "Has trouble joining in at unfamiliar social events"). A fourth factor, reflecting primarily the ability to control one's own behavior, comprised six items from the Inhibit scale (e.g., "Acts too wild or out of control"; "Talks or plays too loudly"). Three items, all from the Plan/Organize scale, constituted a fifth factor, related to the child's ability to find an item (i.e., toys, clothes) by following instructions. Another set of items from the Inhibit scale, similar in content to items in the fourth factor (out of control behavior), constituted a Factor 6. A closer inspection of the items in these two factors revealed that both reflect wild, uncontrolled behavior; the "new" factor differed from the other, however, by the inclusion of a comparison with other children (e.g., "Gets out of control more than playmates"; "Has to be more closely supervised than similar playmates"). Possibly, this refers to difficulties observed primarily in social interaction and play settings. The last factor comprised six items from the Working Memory subscale together with one item from the Plan/Organize subscale; all related to the monitoring of one's own task-oriented behavior (e.g., "Is unaware when he/she performs a task right or wrong"; "Cannot stay on the same topic when talking"). An inspection of the pattern and structure matrices indicated good discrimination between factors, with only one cross-loading (Item 18: "Acts wilder or sillier than others in groups") in Factor 6 showed a secondary loading on the fourth factor. When the number of factors were restricted to three in a second EFA, items from the Working Memory, Plan/Organize, and Inhibit subscales combined into a first factor, items from the Emotional Control and Inhibit subscales combined into a second factor, and a third factor comprised four items from the Shift subscale without any contribution from the other four subscales. Together, these three factors explained 35.3% of the total variance.

DISCUSSION

In the present study, we investigated the factor structure of EF in 3-year old children as measured by the BRIEF-P. Prior research was replicated and extended through a combination of CFA and EFA in a large, nonreferred sample of 3-year-old children. The second-order, three-factor model of EF proposed by the BRIEF-P authors proved a better fit to data than the two alternative, one-factor solutions. However, the difference in fit between this retained model and the second-order one-factor model was marginal. The exploratory analysis supported the presence of several underlying factors in our sample. EFA yielded seven interpretable factors, showing considerable overlap with the originally proposed five first-order factors in the BRIEF-P. Taken together, our results suggest that some differentiation in EF has taken place at age 3 years, which is reflected in parent ratings of behavior.

The empirically based BRIEF-P subscales showed acceptable levels of internal consistencies, with alpha values very close to those previously reported, both in the normative sample (Isquith et al., 2004) and in two other studies that included children aged 2–6 years (Bonillo et al., 2012; Duku & Vaillancourt, 2013).

Contrary to our expectations, confirmatory factor analyses yielded support for the proposed second-order three-factor structure of EF in our sample. As such, our results are in line with a multifactorial view of early EF as measured by the BRIEF-P in early preschool years and with previous preschool studies based on BRIEF-P ratings from both parents and teachers (Bonillo et al., 2012; Ezpeleta, Granero, Penelo, De La Osa, & Domenech, 2013; Isquith et al., 2004). The marginal difference in fit between our two second-order models (three-factor versus one-factor) suggests, however, that patterns of item interrelations in the present sample may not be very different from those described in previous factorial studies suggesting a unidimensional model of early EF (Wiebe et al., 2011; Willoughby et al., 2010). Moderate-to-strong factor intercorrelations on the second-order level indicate that the EF components, as they are defined in the BRIEF-P, are closely related in our sample and are possibly less differentiated than in the entire preschool-age span (Isquith et al., 2004).

Although acceptable, neither of the two best-fitting factorial solutions proved a good fit to data in our young sample (Table 2). Frequently used in CFA studies, post hoc modifications may be valuable in improving a given theoretical model's ability to capture patterns of structural interrelations. For our purposes, however, complementary analyses with a data-driven approach was considered more useful, given the scarcity of previous research on the structure of EF as measured by the BRIEF-P at age 3 years. As the confirmatory and exploratory analyses were conducted in the same sample, information regarding item and factor interrelations from the EFAs was used to shed light on possible reasons for the modest fit between data and the two best-fitting models from the CFAs. Of the seven factors identified in EFA, four consisted of items from only one of the subscales, while three contained one or two items from a second subscale. As such, the identified factors did not depart substantially from factors constituting the first-order level of the BRIEF-P model of EF in our young sample. The EFA results identified, however, two additional factors. The discrepancy with regard to the original model (Isquith et al., 2004) seems primarily to be the partition of the Inhibit items into three subcomponents in our data: (a) sustained attention, (b) behavior control, and (c) behavior control in social settings. This partition bears a clear resemblance to the distinction between the monitoring of task performance and of one's behavior (self-monitoring) previously described in the school-age version (BRIEF; Gioia & Isquith, 2002; Gioia, Isquith, Retzlaff, & Espy, 2002), which has led to a change from two to three postulated second-order factors. A factor analytic study of the BRIEF in a mixed healthy and clinical school-aged sample confirmed this subdivision, noting that behavior regulation in a social context is likely to be more influenced by emotions than is task-oriented behavior (Egeland & Fallmyr, 2010). The concepts of "hot" and "cool" EF, separating regulative processes elicited in affect-laden situations from those implicated in emotional neutral settings, has gained growing research interest in recent years (Hongwanishkul, Happaney, Lee, & Zelazo, 2005). There is also a parallel between the described partition of the first-order Inhibit factor in the present sample and the reported multidimensionality in the Inhibit subscale (Duku & Vaillancourt, 2013).

The forced three-factor solution in the second EFA suggested a somewhat different pattern of factor interrelations in BRIEF-P ratings of the youngest preschool children, relative to findings from studies of the preschool group as a whole. The difference in content of the three second-order factors in this analysis versus the ones prespecified in the second-order three-factor model was related primarily to the combination of items from the Inhibit and Working Memory into a single, first factor, and to the splitting of the Emotional Control, and Shift subscales into two, separate factors in our sample. The factor related to emotional control was the one explaining the second largest proportion of the total variance, and one of the two most clearly differentiated factors in the exploratory analysis. This finding speaks for the significance of emotion regulation as a separate factor from early on in EF development, and for taking the emotional control dimension into consideration when describing and interpreting young children's executive behavior both in everyday situations and in clinical assessment. Previous theoretical conceptualizations of EF structure have to a large extent rely on performance-based measures (Hongwanishkul et al., 2005). Few of these have integrated, let alone investigated in factor analyses, emotional regulation as part of a general EF construct.

Recent research indicates that early EF development is characterized by both differentiation and integration of core executive processes (Lee et al., 2013). Results from the factor analyses in the present study do not support a unidimensional conceptualization of early EF as measured by the BRIEF-P. At the same time, we cannot rule out the possibility that a major proportion of variance in the BRIEF-P scores may be tracked down to a meaningful, single EF factor in the youngest preschool children. The seven factors in the EFA explained less than half of the total variance; with three factors, only about one third of the variance in BRIEF-P scores was accounted for. These low figures may be taken to mean that the reaction patterns inherent in the factors are not yet stable and consistent. It is likely that what we observe, comparing models differing in complexity at this early stage in EF development, can best be described as an initial stage of progress towards a more stable, multilevel executive system as it is outlined in Miyake's integrative model of EF (Miyake et al., 2000). This interpretation is supported by studies of neurological correlates to developing EF, showing progressive functional segregation and integration throughout childhood (Rubia, 2013). At this early stage in the differentiation process, EF components may operate more independently (Anderson, 2002). During the preschool period, these early regulatory capacities then develop further, into more complex, integrated processes, which become reliably identifiable first at a later stage in development.

Taken together, the present findings have several implications considered relevant for research on EF development, and for the clinical assessment of EF in young children. Our results suggest that early forms of EF processes as measured by parent ratings are differentiated and identifiable as early as age 3. Further, that EF subprocesses may be meaningfully assessed in young preschool children by the use of developmentally appropriate behavioral descriptions. A large proportion of unexplained variance in the exploratory analyses of the BRIEF-P inventory indicate, however, that emerging self-regulatory skills are still unstable and subject to considerable extraneous variation at this early point in development. Labels used to characterize specific EF subdomains should be interpreted with caution. This is illustrated by the differentiation in our results between possible subcomponents in the BRIEF-P Inhibit scale (i.e., attentional control or regulation of social- or task-oriented behaviors) and, on the other hand, the close relationship between items from the Plan/Organize subscale and items in the Working Memory subscale. Finally, our results indicate that the presence or absence of emotional cues may act as a salient, organizing factor from early on in the development of EF. The inclusion of "hot" EF tasks in assessments of children's self-regulatory capacities may thus add important information about early EF in both research and clinical settings.

Strengths and Limitations

The following strengths and limitations should be taken into consideration evaluating findings from the present study. Among its particular strengths is the large sample size, allowing for analyses of complex, multilevel factor structures. Circumventing methodological problems, such as divergent operationalization and measurement of EF, similarities and differences may more reliably be ascribed to structural aspects of the compared factorial solutions. The narrow age range in the present sample offers a unique opportunity to draw some conclusions regarding EF structure at age 3. At the same time, it limits the generalizability of the findings to the youngest preschool children.

Children were selected for participation in the present study through a two-step process; first into the MoBa study, and then from MoBa into the longitudinal ADHD study. Both screening procedures may have influenced our results. The relatively low participation rates in the MoBa cohort and in the longitudinal ADHD study (45% and 35%, respectively) are likely to have resulted in an underrepresentation of children from high-risk families (low-socioeconomic status, young mothers, single-parent families, smoking during pregnancy) and possibly of children with the most severe behavioral and cognitive problems (Nilsen et al., 2009; Overgaard, Aase, Torgersen, & Zeiner, 2012). Comparing mothers from the MoBa with mothers of children participating in our study, we found that the mothers of the children in the present study reported slightly higher educational levels (mean = 15.3 years versus mean = 14.9 years). Parental education has frequently been linked to both child IQ and behavioral difficulties; a similar trend is therefore likely, also with regard to other variables of interest in the second step of the sampling process. The oversampling of children with elevated levels of ADHD-related difficulties from the MoBa sample into the present substudy may have affected estimates of relationships between variables under study through restricted variance. Investigations of exposure-outcome relations in MoBa versus the population and in a similar Danish birth cohort suggest, however, that the effects that these two screening steps may have had on the present results are limited and not likely to represent a validity problem (Greene, Greenland, Olsen, & Nohr, 2011; Nilsen et al., 2013).

As only parent ratings were included here, findings may not apply to the use of the inventory by teachers. Evidence have so far been inconclusive with regard to possible differences in the structural organization of EF in normally developing children versus children with psychiatric symptoms (Delis, Jacobson, Bondi, Hamilton, & Salmon, 2003; Gioia, Isquith, Retzlaff, & Espy, 2002). Thus, the generalizability of the present findings may be limited with regard to normally developing preschool children. The findings are, however, considered to be highly relevant in clinical settings, addressing relations between EF ratings and psychiatric symptoms in a group of children with behavioral difficulties sufficient to raise concern in their parents.

CONCLUSIONS

In the present study, the second-order three-factor model of BRIEF-P proposed by the BRIEF-P authors was found to capture the structural organization of EF better than two competing, one-factor models in a large sample of nonreferred 3-year-olds. The presence of several EF subcomponents was confirmed in exploratory analyses. Our findings thus suggest that some differentiation in EF has taken place at age 3 years, which is reflected in parents' perceptions of behavior. Our findings support the internal consistency of the BRIEF-Ps five clinical subscales but indicate that subscale interrelations at age 3 years may differ from those observed in the preschool group as a whole. Labels used to characterize specific EF subdomains should be interpreted with caution when assessing EF in young preschool children.

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Appendix A: Summary of Fit indices for four EFA models assuming same and/or different factor means and factor loadings for the two BRIEF translations (n = 488 and n = 646)

Model	RMSEA	Chi square Mean value	TLI	CFI
Different loadings different means	.029	5000.830	.959	.964
Different loadings same means	.034	5623.796	.943	.951
Same loadings different means	.027	5130.569	.966	.968
Same loadings same means	.030	5547.117	.956	.959

Appendix B: Complete Pattern Matrix for EFA with Oblimin Rotation of a Seven factor Solution of BRIEF-P items (N = 1,134)

	Pattern coefficients						
	Factor						
Item	1	2	3	4	5	6	7
12 WM	**.782**	−.018	−.016	−.025	.015	.088	−.104
42 WM	**.728**	−.002	.017	−.004	−.009	.061	−.001
7 WM	**.497**	.034	−.020	−.047	.151	.058	−.003
32 WM	**.482**	.086	.103	.053	.025	.008	−.025
58 I	**.471**	.050	.007	.138	−.006	−.047	.137
56 I	**.438**	.016	.035	.208	−.041	.015	.221

(*Continued*)

Appendix B (Continued).

	Pattern coefficients						
	Factor						
Item	1	2	3	4	5	6	7
61 WM	**.385**	.042	.020	.201	−.031	.059	.159
49 P/O	**.351**	.081	−.012	.140	.142	−.095	.059
29 P/O	.269	.049	.042	−.096	.143	.047	.170
51 WM	.225	.007	.006	.076	.215	.028	.180
16 EC	.052	**.668**	−.062	.015	.079	.047	−.001
1 EC	.040	**.645**	−.007	−.067	.020	−.005	.018
6 EC	−.031	**.628**	.084	.054	−.007	.107	−.100
21 EC	.022	**.609**	.040	.016	.029	.010	.017
26 EC	−.003	**.598**	−.011	.045	.078	.010	.075
11 EC	.009	**.525**	.178	.013	.022	−.027	.010
31 EC	.042	**.519**	.023	.062	−.067	.049	−.015
20 S	.002	.006	**.867**	−.021	.005	−.074	−.011
10 S	−.040	.004	**.695**	−.018	−.024	−.033	−.030
40 S	.015	−.062	**.578**	.010	.042	.131	.015
5 S	−.019	.133	**.452**	−.010	−.003	−.002	.024
52 I	.074	.034	−.005	**.550**	.034	.204	−.140
48 I	.022	.076	−.023	**.546**	.074	−.048	−.014
60 I	.014	.035	.032	**.505**	.046	−.028	.162
54 I	.059	.008	−.005	**.413**	.064	.047	.001
62 I	.018	−.050	.034	**.388**	−.009	.135	.088
23 I	.202	.053	−.029	**.328**	−.026	.077	−.047
50 SH	.085	.003	.133	.265	.014	.144	.048
28 I	.116	.046	−.014	.245	−.082	.130	.047
22 WM	.150	.079	.020	.208	.146	−.079	.188
19 P/O	−.020	.009	−.002	.013	**.825**	.011	−.100
44 P/O	−.036	.010	.051	.007	**.741**	−.046	.002
14 P/O	.040	−.038	.010	−.074	**.320**	.068	.157
2 WM	.172	.042	.008	−.001	.174	−.018	.077
43 I	.030	.239	−.002	.128	.018	**.601**	.001
13 I	.163	−.048	.075	−.070	−.032	**.513**	.068
18 I	.011	−.055	−.061	**.333**	.123	**.438**	−.086
36 EC	.005	.297	.143	−.027	−.011	**.370**	.063
57 WM	.040	.022	.066	.011	−.001	.003	**.456**
63 WM	−.002	−.093	.042	.049	.025	.027	**.423**
59 WM	.032	−.006	.033	.009	.154	.081	**.387**
39 P/O	.035	.086	−.018	−.018	−.001	−.034	**.359**
47 WM	.026	.019	.010	.065	−.021	.029	**.358**
55 WM	.035	.007	.036	−.008	.086	.079	**.350**
53 WM	.315	.047	.082	.062	.150	.014	**.333**
27 WM	.220	.000	.021	−.048	.107	.103	.225
17 WM	.179	.045	.000	.010	.167	.076	.191
8 I	−.033	.036	.052	.125	.068	.076	.180
45 SH	−.003	−.012	.012	.025	−.028	−.050	.018
15 SH	.093	.051	.015	.026	−.009	.021	−.048
30 SH	−.017	−.050	.078	−.052	.052	.053	−.008
46 EC	−.051	.179	.016	−.017	.023	.075	.117
35 SH	−.061	.041	.004	.057	.064	.111	.111
25 SH	.091	.028	.132	.087	.042	−.048	−.007

(*Continued*)

Appendix B (Continued).

	Pattern coefficients						
	Factor						
Item	1	2	3	4	5	6	7
9 P/O	.030	.071	−.005	.050	.135	.059	.063
33 I	.024	.023	.013	.028	.000	.038	−.044
38 I	−.049	−.007	.005	.056	.009	.016	.071
3 I	−.004	.139	.013	.000	−.016	−.011	−.011
34 P/O	.119	.055	.043	.052	.110	−.050	.014
4 P/O	.107	.033	−.013	.050	.152	−.093	.058
24 P/O	.029	.056	.030	.125	.024	.112	−.009
41 EC	−.003	.090	.062	.146	.063	.179	.084
37 WM	.083	−.021	−.011	.020	.148	.077	.213

Notes. Major loadings for each item are bolded. I = Inhibit; SH = Shift; EC = Emotional Control; WM = Working Memory; P/O = Plan/Organize.

Appendix C: Complete Structure Matrix for EFA with Oblimin Rotation of a Seven-Factor Solution of BRIEF-P items ($N = 1,134$)

	Structure coefficients						
	Factor						
Item	1	2	3	4	5	6	7
12 WM	.787	.191	.149	.331	.319	.296	.281
42 WM	.767	.204	.168	.333	.320	.276	.343
58 I	.652	.247	.182	.422	.342	.238	.432
7 WM	.635	.251	.147	.282	.433	.260	.339
61 WM	.622	.251	.187	.488	.336	.339	.447
32 WM	.622	.290	.243	.337	.345	.232	.303
49 P/O	.607	.321	.164	.426	.463	.197	.396
56 I	.571	.176	.171	.415	.256	.250	.429
51 WM	.484	.231	.192	.333	.477	.255	.451
29 P/O	.453	.248	.233	.194	.404	.233	.413
2 WM	.428	.226	.156	.281	.416	.210	.351
1 EC	.238	.701	.196	.201	.233	.211	.193
16 EC	.203	.701	.149	.247	.208	.267	.161
6 EC	.180	.700	.213	.271	.184	.286	.079
21 EC	.240	.695	.260	.279	.239	.274	.218
26 EC	.225	.665	.241	.235	.288	.241	.254
11 EC	.224	.630	.392	.237	.245	.238	.224
31 EC	.258	.605	.152	.289	.179	.241	.153
20 SH	.087	.149	.801	.010	.143	.044	.132
10 SH	.078	.158	.671	.055	.125	.099	.120
40 SH	.152	.138	.612	.121	.206	.243	.197
5 SH	.189	.340	.593	.166	.234	.230	.247
52 I	.387	.318	.154	.739	.269	.500	.192
48 I	.365	.319	.139	.671	.316	.285	.269
60 I	.353	.257	.180	.640	.299	.285	.379
54 I	.385	.304	.166	.638	.319	.364	.299

(*Continued*)

Appendix C (Continued).

	Structure coefficients						
	Factor						
Item	1	2	3	4	5	6	7
23 I	.463	.274	.107	.553	.263	.340	.245
62 I	.323	.163	.115	.549	.237	.353	.289
28 1	.407	.284	.129	.501	.241	.373	.295
50 SH	.347	.259	.323	.470	.276	.406	.317
19 P/O	.276	.175	.171	.184	.780	.189	.273
44 P/O	.273	.188	.224	.181	.744	.154	.339
14 P/O	.300	.110	.158	.155	.471	.232	.381
43 I	.299	.458	.210	.456	.263	.735	.253
13 I	.351	.191	.264	.268	.243	.611	.309
18 I	.302	.195	.096	.555	.304	.596	.201
36 EC	.265	.507	.386	.288	.272	.558	.304
41 EC	.203	.228	.225	.296	.225	.356	.258
63 WM	.305	.128	.218	.293	.323	.248	.550
57 WM	.283	.174	.230	.197	.281	.183	.528
59 WM	.322	.125	.177	.225	.396	.246	.520
53 WM	.485	.199	.221	.271	.397	.189	.504
39 P/O	.315	.276	.198	.227	.314	.196	.495
55 WM	.304	.161	.192	.219	.340	.257	.483
27 WM	.473	.231	.237	.257	.426	.312	.480
47 WM	.297	.184	.159	.277	.263	.232	.467
17 WM	.408	.230	.204	.279	.400	.295	.428
37 WM	.330	.130	.147	.245	.361	.259	.403
22 WM	.397	.245	.174	.384	.369	.178	.400
8 I	.165	.157	.163	.233	.219	.207	.280
45 SH	.146	.261	.296	.176	.169	.210	.220
15 SH	.195	.282	.305	.181	.167	.262	.182
46 EC	.095	.307	.198	.116	.166	.216	.216
35 SH	.153	.241	.204	.205	.247	.270	.265
30 SH	.098	.132	.240	.082	.168	.188	.149
25 SH	.171	.152	.276	.150	.156	.119	.153
9 P/O	.275	.228	.150	.228	.340	.224	.271
33 I	.330	.326	.213	.430	.279	.329	.265
38 I	.288	.297	.193	.435	.287	.302	.328
3 I	.318	.398	.195	.392	.279	.277	.269
34 P/O	.408	.300	.128	.337	.383	.180	.283
4 P/O	.372	.197	.030	.278	.370	.097	.273
24 P/O	.238	.239	.143	.309	.211	.290	.187

Note. I = Inhibit; SH = Shift; EC = Emotional Control; WM = Working Memory; P/O = Plan/Organize.