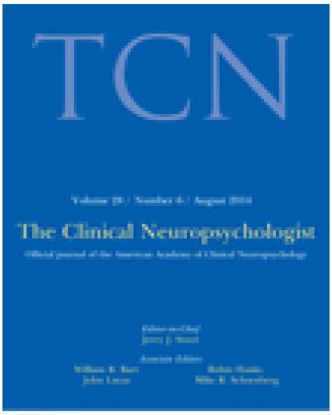

The Clinical Neuropsychologist
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/ntcn20

Organizational Strategy Use in Children Aged 5-7: Standardization and Validity of the Rey Complex Figure Organizational Strategy Score (RCF-OSS)

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Published online: 28 Jul 2014.

The Clinical Neuropsychologist, 2014
Vol. 28, No. 6, 954–973, http://dx.doi.org/10.1080/13854046.2014.939228

Organizational Strategy Use in Children Aged 5–7: Standardization and Validity of the Rey Complex Figure Organizational Strategy Score (RCF-OSS)

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This study investigated psychometric properties (standardization and validity) of the Rey Complex Figure Organizational Strategy Score (RCF-OSS) in a sample of 217 healthy children aged 5–7 years. Our results showed that RCF-OSS performance changes significantly between 5 and 7 years of age. While most 5-year-olds used a local approach when copying the Rey-Osterrieth Complex Figure (ROCF), 7-year-olds increasingly adopted a global approach. RCF-OSS performance correlated significantly, but moderately with measures of ROCF accuracy, executive functioning (fluency, working memory, reasoning), and non-executive functioning (visual-motor integration, visual attention, processing speed, numeracy). These findings seem to indicate that RCF-OSS performance reflects a range of cognitive skills at 5 to 7 years of age, including aspects of executive and non-executive functioning.

Keywords: Rey-Osterrieth Complex Figure; Strategy use; Children; Developmental trajectories; Executive functions.

INTRODUCTION

The sparse empirical literature on Rey-Osterrieth Complex Figure (ROCF) test performance at an early age contrasts with extensive reports on older children and adults. In the present study the psychometric properties of the ROCF were studied in a sample of 217 healthy 5- to 7-year-old children. The ROCF is a complex geometrical figure that consists of one large rectangle with vertical and horizontal centerlines, two diagonals, internal sections (e.g., a circle with three dots), and external attachments (e.g., a cross attached to the large rectangle; see Figure 1).

Copying the ROCF is assumed to impose demands on visuospatial abilities (e.g., perceptual, constructional, and graphomotor abilities) as well as executive, supervisory functions (e.g., self-initiation, organization, and planning) in adults and older children (Anderson, Anderson, & Garth, 2001; Lezak, Howieson, Bigler, & Tranel, 2012; McConley et al., 2008; Mitrushina, Boone, & D'Elia, 1999; Osterrieth, 1944; Rey, 1941). Diminished ROCF test performance has been associated with a variety of clinical conditions in older children (e.g., ADHD and autism spectrum disorders; Seidman et al., 1995; Tsatsanis et al., 2011) and adults (e.g., Alzheimer's disease and traumatic

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(*Received 8 July 2013; accepted 23 June 2014*)

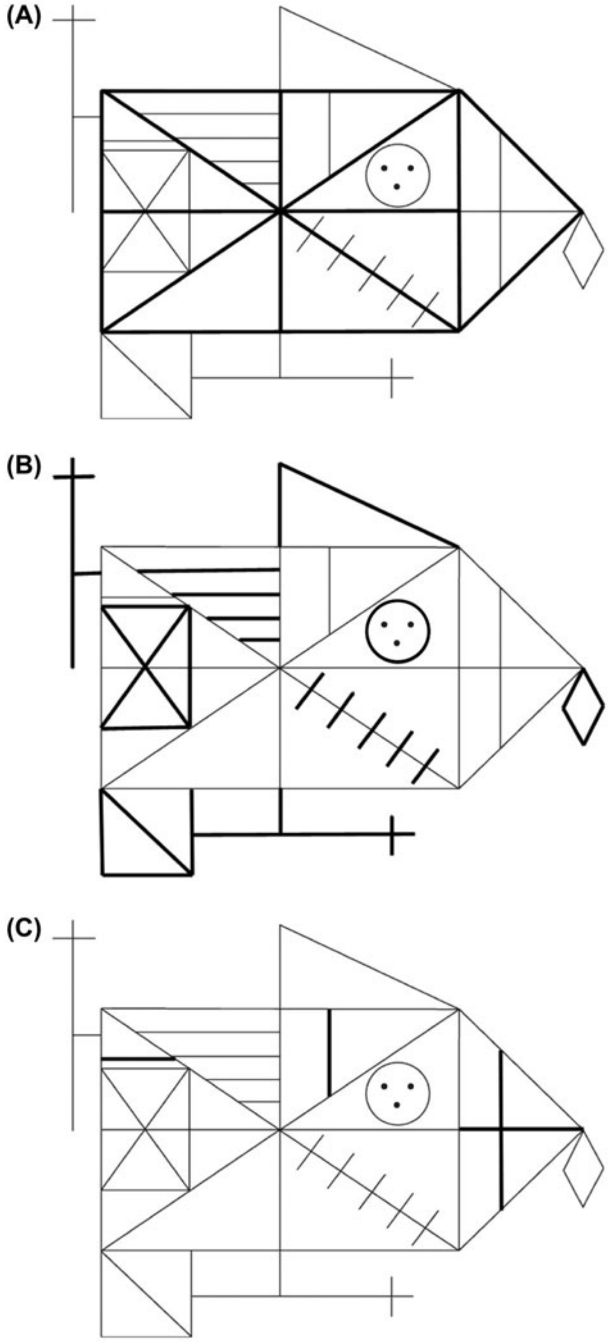

Figure 1. Assessment of Rey-Osterrieth Complex Figure Accuracy on the basis of three hierarchical levels. ROCF = Rey-Osterrieth Complex Figure (Osterrieth, 1944; Rey, 1941); A = Global score, B = Elements score, C = Lines score.

brain injury; Ashton, Donders, & Hoffman, 2005; Kasai, Ishizaki, & Meguro, 2007). So far, most studies have quantified ROCF task performance in terms of "accurate reproduction", which is judged on the basis of resemblance between an individual's reproduction of the ROCF and the original figure. The most commonly used method to assess reproduction accuracy was devised by Rey (1941) and standardized by Osterrieth (1944). It distinguishes 18 unique ROCF elements and rates them on the basis of their presence, completeness, and correct placement. However, scoring methods of accuracy alone may not fully capture all aspects that determine a participant's performance, given that the ROCF is a multifactorial task (as discussed above).

Rephrased, this "classical" method of scoring accuracy may obscure the unique contributions of cognitive subsystems underlying ROCF test performance. Therefore, researchers have developed alternative scoring methods to quantify ROCF performance. Some of these methods have been developed or adapted for children, such as the Developmental Scoring System (DSS; Bernstein & Waber, 1996), the Boston Qualitative Scoring System (BQSS; Stern, Singer, Duke, & Singer, 1994), and the Rey Complex Figure Organizational Strategy Score (RCF-OSS; Anderson et al., 2001). According to Anderson et al. (2001), measures such as the DSS and BQSS use post-hoc rating systems that focus on the organization of the end product. For example, the DSS quantifies the organization of a drawing on the basis of the number of correct alignments and intersections of the elements in the end product. The present study, however, chose to focus on the RCF-OSS, since it incorporates both the quality of the end product and the initial drawing order in its definition of the concept "organization". More specifically, it focuses on the order in which an individual constructs a ROCF reproduction (i.e., organizational strategy use).

Higher levels of organization require the drawing of specific elements of the ROCF before others. For one, to meet the requirements of the highest level of organization of the RCF-OSS, the rectangle and centerlines of the ROCF have to be completed first. Furthermore, the RCF-OSS was selected because of its satisfactory psychometric properties and sensitivity to developmental variations in childhood, at least in older children (Anderson et al., 2001).

Researchers have suggested that the RCF-OSS is a valid method for measuring the above-mentioned supervisory, executive functions more purely, at least in older children (Anderson et al., 2001; Davies, Field, Andersen, & Pestell, 2011). The RCF-OSS rates performance on a 7-point scale that reflects the level of organization and takes the sequence in which structural elements of the ROCF are drawn into account. Thereby, irrespective of the resemblance between the end results of reproductions, this method can discern between participants who use a more detail-oriented approach and participants who organize their reproduction on a more global level (i.e., who start with core features such as the rectangle and centerlines). Discerning children who are detail-oriented from children who are more global-oriented is of particular importance, since using a well-organized strategy (i.e., starting at a global level) during the encoding of complex visual information benefits accuracy of recall, particularly if the strategy is self-generated (Newman & Krikorian, 2001). According to Anderson et al. (2001), the RCF-OSS can provide valuable insights in the development of children's organizational strategy use. The authors found that correlations between the RCF-OSS and traditional neuropsychological measures of planning, verbal fluency, processing speed, cognitive flexibility, verbal learning, and problem solving fall in the small to medium range (i.e., *r* = .27 to .35), while correlations with measures of memory performance are small (i.e., *r* = .16 to .23).

Given these findings, the question remains whether the RCF-OSS is indeed primarily a measure of organizational strategy use as Anderson et al. (2001) suggested or whether the RCF-OSS taps into a broader range of functions (including e.g., visuospatial abilities). The findings described by Anderson et al. (2001) actually seem to suggest the latter, given the height of the correlations and the specific measures under study. However, this needs to be investigated further, also in younger children. Thus far, the RCF-OSS has only been studied in a sample of 7- to 13-year-old children. The current study aimed to provide data on the psychometric properties (i.e., standardization and validity) of the RCF-OSS as a scoring method for younger children, aged 5 to 7 years.

Although the ROCF (and the RCF-OSS for that matter) is often only described as an appropriate test for the measurement of developmental trends in participants aged 6 years or older (Akshoomoff & Stiles, 1995; Lezak et al., 2012), multiple studies have shown that between 4 and 6 years of age important changes already take place in children's graphic strategies when copying complex figures other than the ROCF (i.e., complex composite figures with varying orientations and/or groupings, such as rectangles grouped in an increasing or decreasing sequence of lengths and presented upright or upside down). Whereas 4- and 5-year-olds adopt a more local approach to copy these complex figures (i.e., focusing on elements of the drawing), 6-year-olds are already capable of planning the construction of their drawing on a more global level (Minary & Vinter, 1996; Vinter, 1994; Vinter & Marot, 2007; Vinter, Picard, & Fernandes, 2008; Vinter, Puspitawati, & Witt, 2010). These studies seem to indicate that major changes take place in young children's graphic copying strategies. Therefore, even in children younger than 6 years the RCF-OSS is likely to be a suitable test for measuring organizational strategy use.

In sum, the present study aimed (a) to collect a sample of 5- to 7-year-old children for RCF-OSS standardization, and (b) to map the validity of RCF-OSS as a measure of organizational strategy use for this age range. The RCF-OSS was validated on the basis of three approaches. First, we mapped the developmental changes in organizational strategy use between 5 to 7 years of age. Anderson et al. (2001)'s research has already illustrated that the RCF-OSS can detect important changes in performance between 7 to 13 years of age. The present study aimed to extend these findings by examining if the RCF-OSS could also differentiate organizational strategies at an even younger age (i.e., 5 to 7 years). Second, the present study related RCF-OSS performance to reproduction accuracy. Waber and Holmes (1985) have criticized the original Rey-Osterrieth scoring system of accuracy for treating all units of the ROCF equally. Therefore, the present study extended this original accuracy measure in line with Stern et al. (1994): three accuracy sub-scores were added (i.e., a Global index, an Elements index, and a Lines index; see the Method section for more information). A significant association between reproduction accuracy and the RCF-OSS was expected, given the strong correlation that was already reported in an older population (*r* = .51; Anderson et al., 2001). Third, the present study assessed the relationship between RCF-OSS performance and performance on a range of measures of executive functioning (i.e., fluency, working memory, reasoning) and non-executive functioning (visual-motor integration, visual attention, processing speed, numeracy). Although a major value of the RCF-OSS in neuropsychological assessment is reported to lie in its measurement of organizational strategy use (Anderson et al., 2001), we expected RCF-OSS performance to be related to above-mentioned aspects of executive functioning as well as other abilities, such visual-motor integration, attention, and processing speed. This is in line with e.g., Anderson et al. (2001), Lezak et al. (2012), Shin, Kim, Cho, and Kim (2003), and Weber, Riccio, and Cohen (2013), who have indicated that (older) children's ROCF organizational performance requires the integration of a wide range of skills that include attention, visual perception, motor coordination, and processing speed as well as executive skills, such as fluency, working memory, reasoning, and organization. The present study's measures of executive and non-executive functioning were selected on the basis of their common use in (young) children's neuropsychological assessment (Lezak et al., 2012), and their hypothesized importance for ROCF performance (accuracy and organizational strategy use) as described in past developmental research (e.g., Anderson et al., 2001; Ogino et al., 2009; Watanabe et al., 2005; Weber et al., 2013). In addition, numeracy was included to study the relationship between a measure of scholastic performance and the RCF-OSS, which has not been studied thus far.

METHOD

Procedure and participants

The present study's data were derived from a large-scale study into "normal" cognitive development. All caregivers of children enrolled in K-2 (i.e., the second year of preschool) or grade 1 (i.e., year 1 of primary school) of 24 Dutch schools received an information package. This package contained a letter stating the purpose of the study and a request to participate. In addition, caregivers were asked to fill out a questionnaire, containing information about their child's development and medical history and the maternal level of education (LME; De Bie, 1987), ranging from primary school (1) to university degree (8). The overall response rate was 24.3% across the schools. Next, all children were screened on the bases of following exclusion criteria: not speaking Dutch fluently, the use of medication (e.g., antihistamines) and the presence of neurological conditions (e.g., absence epilepsy) that could influence cognitive performance. Only eight children (3.7% of the sample) had an official diagnosis of a neurodevelopmental disorder (e.g., dyslexia, attention deficit hyperactivity disorder). The presence of these diagnoses was not an exclusion criterion. Instead, children were considered to be developing at a normal pace when they attended a school for regular education and were in the appropriate grade for their age. The sample hereby reflected a typical Dutch classroom with children who display a broad range of learning abilities and cognitive functioning. In total, 217 children participated in the study (109 boys; mean age = 6.23, *SD* = 0.62). Demographic information is presented in Table 1.

If caregivers gave consent for their child's participation and the child was not excluded based on the above-mentioned criteria, a neuropsychological test battery was administered to the child in the springtime of that school year. The test battery consisted of measures of numerical and cognitive abilities (including the ROCF); see the Instruments section for further details. Testing took place individually in a stimulus-free room at the participating schools and took approximately 90 minutes. Well-trained research assistants tested all children. The Ethics Committee of the Faculty of Psychology and Neuroscience of Maastricht University approved the research protocol.

Table 1. Demographic characteristics of the participants per age group (*N* = 217)

Demographic characteristics	Age groups 5.0–5.5 (*N* = 35)	5.5–6.0 (*N* = 45)	6.0–6.5 (*N* = 56)	6.5–7.0 (*N* = 53)	7.0–7.5 (*N* = 28)	*Statistic* F / χ^2
Age at measurement *M* (*SD*)	5.33 (0.02)	5.73 (0.02)	6.27 (0.02)	6.73 (0.02)	7.17 (0.03)	1075.74**[a]
LME *M* (*SD*)	5.34 (0.30)	5.00 (0.24)	5.18 (0.24)	4.68 (0.21)	4.70 (0.27)	2.27[b]
Sex (*N*) (%)						
Boys	21 (60.0%)	25 (55.6%)	23 (41.1%)	25 (47.2%)	15 (53.6%)	4.05[c]
Girls	14 (40.0%)	20 (44.4%)	33 (58.9%)	28 (52.8%)	13 (46.4%)	
Handedness (*N*) (%)						
Right	28 (80.0%)	37 (82.2%)	53 (94.6%)	42 (79.2%)	24 (85.7%)	8.96[d]
Left	7 (20.0%)	8 (17.8%)	3 (5.4%)	10 (18.9%)	4 (14.3%)	
Ambidextrous	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (1.9%)	0 (0.0%)	
Raven's CPM (*N*) (%)						
< 25th percentile	2 (5.7%)	3 (6.7%)	3 (5.4%)	4 (7.5%)	0 (0.0%)	4.41[d]
25th–75th percentile	14 (40.0%)	17 (37.8%)	18 (32.1%)	18 (34.0%)	7 (25.9%)	
>75th percentile	19 (54.3%)	25 (55.6%)	35 (62.5%)	31 (58.5%)	20 (74.1%)	

LME = Maternal level of education, ranging from primary school (1) to university degree (8; De Bie, 1987). Raven's CPM (Raven, 1962) = an estimate of fluid intelligence.
[a]One-way analysis of variance (df1 = 4, df2 = 212).
[b]One-way analysis of variance (df1 = 4, df2 = 210).
[c]Pearson Chi-square test (df = 4).
[d]Pearson Chi-square test (df = 8).
**p < .001.

Instruments

Rey-Osterrieth Complex Figure (ROCF). The original ROCF (Osterrieth, 1944; Rey, 1941; see Figure 1) requires the child to copy a complex figure (copy condition) and draw it from memory (recall condition). The ROCF is presented as a two-dimensional line drawing with a horizontal orientation that points to the right on an A4-size paper. The child is instructed to copy the ROCF as precisely a possible on a similar-sized paper, using a pencil without eraser. There is no time limit. In the present study only the ROCF Copy condition was administered, given that we were primarily interested in how children copy complex information (and not so much how they recall this information). Moreover, previous studies have shown that the strategic approach that is applied when copying the ROCF is predictive of later recall performance (Anderson et al., 2001; Lezak, 2012). Both accuracy of drawing and organizational strategy use were assessed in the present study.

Accuracy. To measure accuracy of copy performance, the present study used the original scoring method that was developed by Osterrieth (1944) and adapted by Taylor (1959). This method discerns 18 elements that are judged on the basis of accuracy and placement. Each element can be awarded 0, 0.5, or 1 point for accuracy and 0 or 1 point for placement. Placement and accuracy are added up to form the total score, with a maximum score of 36 points. In the present study, three subscales were added to assess different aspects of accuracy, in line with Stern et al. (1994). For these subscales, all elements were appointed to one of three hierarchical levels: Global, Elements, and Lines. The Global score is made up of units that are essential to the basic structure of the ROCF. The maximum Global score is 10. The Elements score represents smaller salient elements that can be awarded a maximum of 18 points. The Lines score is made up of the remaining non-salient elements. Its maximum score is 8 points. Figure 1 depicts the elements that constitute the present study's Global, Elements and Lines scores.

Organizational strategy use. To assess organizational strategy use the RCF-OSS (Anderson et al., 2001) was implemented, a scoring method that rates a child's organizational approach by appointing it to one of seven levels on the basis of scoring criteria. Level 7 represents the highest organizational level (i.e., excellent organization), while level 1 represents a lack of organization (i.e., an unrecognizable or substituted drawing). The intermediate levels are conceptual organization (level 6), part-configural organization (level 5), piecemeal/fragmented organization (level 4), random organization (level 3), and poor organization (level 2). For more details about scoring criteria and information on psychometric properties of the RCF-OSS, see Anderson et al. (2001).

Assessment of construct validity

The following tests were used to map the construct validity (i.e., convergent and discriminant validity) of the RCF-OSS. Convergent validity was assessed by including measures of executive functioning: i.e., design fluency, working memory, and (spatial) reasoning. Measures of visual-motor integration, visual attention, processing speed, and numeracy were included for the assessment of discriminant validity.

Measures of executive functioning

Design fluency (NEPSY). This paper-and-pencil measure of non-verbal fluency (Korkman, Kirk, & Kemp, 1998) consists of two trials in which sheets of paper are presented that depict 70 squares, each containing five dots. These dots are arranged in either (1) a structured array or (2) a random array. The child has to generate as many different designs as possible within 1 minute by connecting two or more dots using straight lines. The total raw score consists of the number of unique, correct drawings summed across the two trials, with a maximum score of 70. Mean test–retest reliability for this measure is .59 (Korkman, Kemp, & Kirk, 2001).

Digit span forward and backward (Wechsler Intelligence Scales – Fourth Edition; WISC-IV). These estimates of working memory (Wechsler, 2003) require children to repeat a sequence of digits (ranging from 0 to 9) in the same order as the experimenter (Digit Span Forward) or the reverse order (Digit Span Backward). Both subtests consist of eight items composed of two trials of the same length, starting with two digits and increasing to eight digits (Digit Span Forward) or nine digits (Digit Span Backward). Item difficulty increases as trial length increases. The child receives 1 point per correct trial with a maximum raw score of 16 points per subtest. Administration is cut off if both trials of the same item are answered incorrectly. Mean internal consistency ranges between .80 and .89 (Strauss, Sherman, & Spreen, 2006).

Spatial memory (Kaufman Assessment Battery for Children; K-ABC). This measure of working memory (Kaufman, & Kaufman, 1983) assesses the child's ability to memorize the locations of pictures that are arranged randomly on a grid and to point to these locations on a similar, blank grid. The test consists of 21 items. Item difficulty increases as the number of pictures on the grid increases. Per correct answer 1 point is awarded, with a maximum raw score of 21 points. Administration is cut off when the child answers an indicated number of items incorrectly. This measure is part of the K-ABC battery, for which mean internal consistency ranges between .62 and .92 (Spreen & Strauss, 1998).

Block counting (Kaufman Assessment Battery for Children Second Edition; K-ABC-II). This measure (Kaufman, Lichtenberger, Fletcher-Janzen, & Kaufman, 2005) provides information on spatial reasoning. It consists of two-dimensional drawings of three-dimensional stacks of blocks. The child must determine the number of blocks in each pile, meanwhile taking into account that some blocks cannot be seen. Items increase in difficulty and the child is awarded 1 or 2 points per item dependent on item difficulty, with a maximum raw score of 44. Administration is cut of after four consecutive incorrect answers. Mean internal consistency is .90 (Kaufman et al., 2005).

Raven's CPM. This measure of fluid intelligence and reasoning (Raven, 1958) consists of 36 items. The child is shown a pattern with a missing piece and has to select the piece that completes the pattern from six possible options. Items gradually increase in difficulty. One point is awarded per correct answer, with a maximum total raw score of 36. According to Strauss et al. (2006), both mean test–retest and split-half reliability for this measure are higher than .80.

Measures of non-executive functioning

The Developmental Test of Visual-Motor Integration (VMI). This measure of the integration of visual perception and motor coordination (Beery & Beery, 2004) requires the child to copy geometrical forms of increasing difficulty. The child is awarded 1 point per correctly copied figure, with a maximum raw score of 24. Administration is cut off after three consecutive incorrectly drawn figures. Mean internal consistency is .96 and mean test–retest reliability is .89 (Beery & Beery, 2004).

Visual attention (NEPSY). This measure of focused and divided visual attention (Korkman et al., 1998) consists of two trials in which the child has to search and cross out drawings on a sheet of paper as fast as possible. In the present study only the second, more-challenging trial was administered: searching for two specific types of faces amidst distracting faces. If the child is still searching after 180 seconds, administration is cut off. The total raw score consisted of the number of correctly identified items minus the number of incorrect items, with a maximum score of 20. Mean test–retest reliability is .71 (Korkman et al., 2001).

Coding (Wechsler Preschool and Primary Scale of Intelligence-III-NL; WPPSI-III-NL). This measure of processing speed (Hendriksen & Hurks, 2009) requires the child to copy symbols that are paired with five basic geometric shapes. The shapes are presented in a random order on a sheet of paper and the child has to draw the symbols in the corresponding shapes as fast as possible. The child has 2 minutes to complete the test and is awarded a maximum of 59 points for completing all the symbols correctly as well as a time-dependent bonus if all symbols are completed in less than 2 minutes (i.e., extra 1–6 points). Mean split-half reliability is .73 and mean test–retest reliability is .57 (Hendriksen & Hurks, 2009).

Early Numeracy Test (ENT). This test (Van Luit, Van de Rijt, & Pennings, 1994) consists of eight sections measuring different aspects of early numeracy: Comparison, Classification, One-to-one correspondence, Seriation, Use of number words, Structured counting, Resultative Counting, and General understanding of numbers. Each section consists of 5 items (40 items in total). The child receives 1 point per correct answer, with a maximum raw score of 5 per section and maximum total raw score of 40. The test has two parallel versions (Form A and B), of which Form B was administered in the present study. Internal consistency for Form B is .94 (Van Luit et al., 1994). For more information about the ENT see, e.g., Aunio, Hautamaki, Heiskari, and Van Luit (2006) and Van de Rijt, Van Luit, and Pennings (1999).

Statistical analyses

All analyses were performed using SPSS 19.0 for Macintosh OS X. As a first step, extreme values and missing data were checked for. No extreme values were found; i.e., values minimally three times the interquartile distance above the 75th percentile or below the 25th percentile as defined by Huizingh (2002). The missing data were less than 5% of the total data and were therefore not replaced (Croy & Novins, 2005). One child refused to complete the ROCF, therefore this child's ROCF performance was excluded from all analyses. In addition, data on the validity measures were missing for three different children on the VMI ($n = 2$) and the Raven's CPM ($n = 1$).

As a second step, inter-rater reliability was calculated for the RCF-OSS. A qualified psychologist and a research assistant independently rated all copy drawings using the RCF-OSS. Agreement between the independent raters was .91 (calculated using Spearman's correlation coefficient), which indicates good inter-rater reliability. This in line with Anderson et al. (2001), who reported an inter-rater reliability of .85 to .92.

Further analyses aimed to establish developmental shifts in organizational strategy use by reporting the frequencies of the RCF-OSS levels (i.e., 1–7) per age group within our standardization sample. This approach is in line with Anderson et al. (2001). However, instead of studying age groups per year (i.e., 5-, 6-, and 7-year-olds), we opted for a more fine-grained approach in which age groups were formed per 6 months (i.e., 5.0–5.5 years, 5.5–6.0 years, etc.) The relationship between RCF-OSS performance and age was studied more in depth by performing a GLM Univariate analysis with age group (i.e., 5.0–5.5, 5.5–6.0, 6.0–6.5, 6.5–7.0, 7.0–7.5 years) as independent variable and RCF-OSS level of performance (i.e., level 1–7) as a dependent variable. It was expected that significant improvement takes place between 5 and 6 years of age in children's use of copying strategies, as measured by the RCF-OSS (in line with e.g., Vinter et al., 2010). Second, to assess the relationship between the RCF-OSS and accuracy measures of the ROCF (i.e., Global, Elements, Lines, and Total), partial correlations were calculated across the sample, controlling for age. In addition, these correlations were analyzed per age group to assess developmental changes in the connection between the RCF-OSS and accuracy measures. Finally, construct validity (i.e., convergent and discriminant validity) was assessed by studying the RCF-OSS in relation to performance on measures of executive and non-executive functioning. Spearman's correlations were calculated between the RCF-OSS and measures of executive and non-executive functioning. Furthermore, GLM Multivariate and Univariate analyses were performed with the RCF-OSS as an independent variable and raw data of all measures of executive and non-executive functioning as dependent variables. In these analyses, age was controlled for. The authors decided to conduct a GLM Multivariate analysis in addition to Univariate analyses, since a Multivariate analysis is capable of taking into account potential correlations among the dependent measures (Field, 2005). For all analyses significance levels were reported and the alpha-value was set at .05.

RESULTS

Distribution of RCF-OSS levels across age groups

Table 2 displays the distribution of levels of the RCF-OSS across age groups; i.e., represented in percentages. Since none of the children performed at level 6 or 7 of the RCF-OSS, these levels were omitted from Table 2. A closer look at this table revealed an important developmental shift across age groups in terms of the level of organization. We found that most younger children primarily performed at lower levels of organization (i.e., level 2 of the RCF-OSS), while the majority of the older children primarily functioned on more advanced organizational levels (i.e., level 4 of the RCF-OSS). More specifically, an important shift in organizational performance was observed between the age groups of 5.5–6.0 and 6.0–6.5 years. A GLM Univariate analysis with age group as independent variable and RCF-OSS performance level as dependent variable provided support for this observation by indicating significant differences between age groups in

Table 2. Changes in Rey Complex Figure Organizational Strategy Score with age

RCF-OSS	5.0–5.5 years (N = 35)	5.5–6.0 years (N = 44)	6.0–6.5 years (N = 56)	6.5–7.0 years (N = 53)	7.0–7.5 years (N = 28)
Level 1 (%)	8.6	6.8	0.0	0.0	0.0
Level 2 (%)	62.9	59.1	25.0	18.9	10.7
Level 3 (%)	11.4	11.4	35.7	26.4	14.3
Level 4 (%)	14.3	20.5	28.6	43.4	53.6
Level 5 (%)	2.9	2.3	10.7	11.3	21.4

RCF-OSS = Rey Complex Figure Organizational Strategy Score (Anderson et al., 2001). RCF-OSS levels 6 and 7 were left out, since none of the children performed at these levels.

the distribution of performance across RCF-OSS levels, $F(4, 211) = 15.79$, $p < .001$, $d = 0.23$. An additional analysis using a non-parametric test was performed, given the categorical nature of the independent and dependent variables. This analysis essentially provided the same result; i.e., $\chi^2(16) = 66.88$, $p < .001$. When zooming in further on RCF-OSS performance, post-hoc Bonferroni analyses revealed that age group differences were primarily explained by a performance shift between the age of 5.5–6.0 and 6.0–6.5 years. For one, while the groups aged 5.0–5.5 and 5.5–6.0 years did not differ significantly from each other, these age groups both differed significantly from the older age groups (i.e., 6.0–6.5, 6.5–7.0, and 7.0–7.5; all *p*-values < .01). Similarly, these older age groups did not differ significantly from each other. Yet they all differed significantly from the younger age groups (i.e., 5.0–5.5 and 5.5–6.0 years; all *p*-values < .01).

RCF-OSS in relation to accuracy of performance

All accuracy measures (i.e., Global, Elements, Lines, Total) correlated significantly (*r* varied between .37 and .87). Furthermore, as is shown in Table 3, the RCF-OSS correlated significantly with all measures of accuracy (*r* varied between .21 and .30). Yet correlations of the RCF-OSS with Global and Total accuracy scores were higher than those with scores of Elements and Lines. When studying these RCF-OSS correlations per age group, we found a fairly similar pattern, as can be observed in Figure 2. Across all age groups, the RCF-OSS correlations with accuracy scores of Global and Total were higher than those with Elements and Lines. In addition, a closer observation of this figure revealed that correlations between the RCF-OSS and measures of accuracy were highest between 5.5 to 6 years of age.

Table 3. Correlations between Rey Complex Figure Organizational Strategy Score and measures of Rey-Osterrieth Complex Figure Accuracy and convergent and discriminant validity

	Measure	RCF-OSS
ROCF Accuracy	Total	.30**
	Global	.29**
	Elements	.21*
	Lines	.23**
Convergent validity	Design Fluency	.31*
	Spatial Memory	.37*
	Digit Span Forward	.23*
	Digit Span Backward	.28*
	Raven CPM	.31*
	Block Counting	.20*
Discriminant validity	VMI	.43*
	Visual Attention	.38*
	Coding	.33*
	ENT	.47*

ROCF = Rey-Osterrieth Complex Figure (Osterrieth, 1944; Rey, 1941); RCF-OSS = Rey Complex Figure Organizational Strategy Score (Anderson et al., 2001); VMI = The Developmental Test of Visual-Motor Integration (Beery & Beery, 2004); ENT = Early Numeracy Test (Van Luit et al., 1994).
*$p < .01$. **$p \leq .001$.

Construct validity of the RCF-OSS

All correlations between the RCF-OSS and measures of executive and non-executive functioning were significant at $p = .01$ level (see Table 3). In terms of convergent validity, correlations varied between .20 and .43. In terms of discriminant validity, correlations varied between .23 and .47. As a next step, a GLM Multivariate analysis and Univariate analyses were performed with RCF-OSS performance level (i.e., range: 1–7) as an independent variable and raw data of all measures of executive and non-executive functioning as dependent variables (see earlier for a description of these measures). A significant overall effect of RCF-OSS performance level on outcomes of executive and non-executive functioning measures was found; Pillai's Trace: $F(40, 804) = 2.19$, $p < .001$, $d = 0.01$. In terms of convergent validity, Univariate analyses revealed significant effects for Design Fluency, $F(4, 207) = 3.11$, $p < .05$, $d = 0.06$, Spatial Memory, $F(4, 207) = 5.19$, $p = .001$, $d = 0.09$, Digit Span Backward, $F(4, 207) = 2.46$, $p < .05$, $d = 0.05$, and Block Counting, $F(4, 207) = 3.96$, $p < .01$, $d = 0.07$. In terms of discriminant validity, significant effects were found for the VMI, $F(4, 207) = 6.19$, $p < .001$, $d = 0.10$, Visual Attention, $F(4, 207) = 5.62$, $p < .001$, $d = 0.10$, Coding, $F(4, 207) = 6.36$, $p < .001$, $d = 0.11$, and ENT, $F(4, 207) = 7.92$, $p < .001$, $d = 0.13$. Post-hoc Bonferroni analyses revealed that differences in VMI performance between RCF-OSS levels could be explained by differences between children performing at levels 1 and 2 compared to levels 3, 4, and 5. For one, while level 1 and 2 did not differ significantly from each other, these levels both differed significantly from the organizational levels 3, 4, and 5 (respectively: p-values $< .01$ and p-values $< .05$). Levels 3, 4, and 5 did not differ significantly from each other. Yet they all differed significantly from levels 1 (all p-values $< .01$) and 2 (all p-values $< .05$). Thus, the mean raw VMI scores were significantly lower for children performing at levels 1 and 2 compared to levels 3 to 5. A similar pattern was found for the ENT and the Visual Attention Test. For the other measures

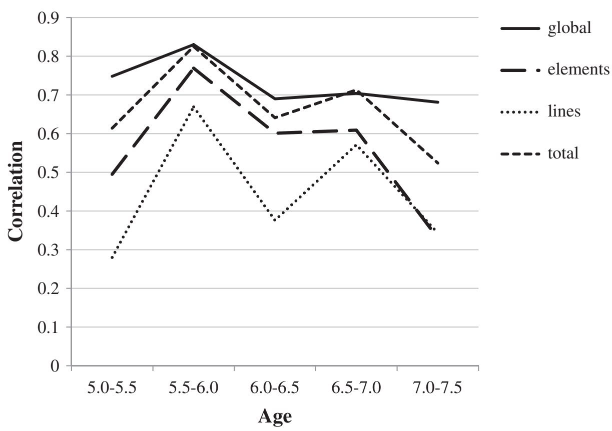

Figure 2. Correlations between Rey Complex Figure Organizational Strategy Score and Rey-Osterrieth Complex Figure Accuracy. ROCF = Rey-Osterrieth Complex Figure (Osterrieth, 1944; Rey, 1941); RCF-OSS = Rey Complex Figure Organizational Strategy Score (Anderson et al., 2001); Global = measure of accuracy of global units. Elements = measure of accuracy of elements units. Lines = measure of accuracy of lines units. Total = total accuracy.

Table 4. Mean test scores per level of the Rey Complex Figure Organizational Strategy Score

	Design Fluency	Spatial Memory	Digit Span Backward	Block Counting	VMI	Visual Attention	Coding	ENT
Level 1 (n = 6)	12.67	7.00	2.50	8.17	7.33	3.67	17.67	20.33
Level 2 (n = 75)	13.92	9.41	4.23	8.40	10.00	8.53	30.99	25.89
Level 3 (n = 47)	18.24	10.50	4.72	13.80	11.72	13.26	43.61	31.24
Level 4 (n = 68)	16.91	10.44	4.77	10.20	11.85	12.65	39.27	30.62
Level 5 (n = 20)	18.88	11.53	5.53	14.65	12.71	13.65	39.29	34.00
Statistic F	3.11[*a]	5.19[***a]	2.46[*a]	3.96[**a]	6.19[***a]	5.62[***a]	6.36[***a]	7.92[***a]

RCF-OSS = Rey Complex Figure Organizational Strategy Score (Anderson et al., 2001). RCF-OSS levels 6 and 7 were left out, since none of the children performed at these levels; VMI = The Developmental Test of Visual-Motor Integration (Beery & Beery, 2004); ENT = Early Numeracy Test (Van Luit et al., 1994). Statistic F = Significant outcomes of a GLM multivariate analysis (levels of RCF-OSS as independent variable and Design Fluency, Spatial Memory, Digit span Forward and Backward, Block Counting, Raven's CPM, VMI, Visual Attention, Coding, and ENT as dependent variables).
[a]GLM Multivariate analysis (df1 = 4, df2 = 207).
*p = .05. **p = .01. **$p \leq .001$.

differences between levels in terms of cognitive performance were also found, although the pattern was less unequivocal. Table 4 illustrates these findings by showing the mean raw test scores of the cognitive measures per level of RCF-OSS.

DISCUSSION

Learning can be facilitated by the ability to organize information in a meaningful manner (e.g., Cornford, 2002; Garner, 2009). Consequently, assessment of children's organizational strategy use may provide useful information for the identification of children that are at risk for the development of learning difficulties (Frisk, Jakobson, Knight, & Robertson, 2005). Although ROCF copying performance can provide important insights into organizational strategy use, studies exploring ROCF performance at preschool and early primary school age are scarce—particularly in terms of the organizational strategies that children apply (e.g., Akshoomoff & Stiles, 1995; Ogino et al., 2009; Waber & Holmes, 1985; Watanabe et al., 2005). The present study focused on one measure in particular, the RCF-OSS, given that it is the only measure that incorporates initial drawing order in its assessment of organizational strategy use. The present study added to the current knowledge of young children's organizational strategy use by investigating the psychometric properties (i.e., standardization and validity) of the RCF-OSS in children aged 5 to 7 years in two manners: (1) by mapping developmental trajectories of RCF-OSS performance, and (2) by exploring the relationship between RCF-OSS performance and performance on both a validated ROCF accuracy measure and measures of executive and non-executive functioning.

Developmental changes in RCF-OSS between 5 and 7 years

Our findings indicate that a developmental shift (or growth spurt) in accuracy and organization of copying performance takes place between 5.5 and 6.5 years of age. This is in line with previous studies by e.g., Vinter (1994) and Vinter and Marot (2007) who describe that 6-year-old children are more inclined to adopt a global approach to copying figures—i.e., drawings other than the ROCF—than 5-year-old children, who prefer to construct their drawings on a more local level. In line with this, Poirel, Mellet, Houdé, and Pineau (2008) and Poirel et al. (2011) have described a transition from a local to a more adult-like global processing preference of visual information around 6 years of age that coincides with gray matter reductions in right occipital and parietal visuospatial regions in 6-year-olds, which are suggested to reflect anatomical and functional maturation processes. The present study adds important insights to these previous findings by taking a closer look at this transitional period through the construction of narrower age groups (per 6 months instead of 12 months).

Thereby we demonstrated that the shift in copying performance seems to occur during an even more narrow age interval than previously described; i.e., somewhere between the second half of children's fifth year and the first half of their sixth year. This age period marks children's transition from preschool to primary school, a time that is characterized by an increase in formal instruction at school. In terms of organizational development of 7-year-old children, there are also some differences between the present study and Anderson et al. (2001). In our study the majority of the 7-year-olds already performed at a level of fragmented organization, while in the study by Anderson et al. the majority still performed at a poor organizational level. Whether this is an issue of psychometrics, sample selection, or cultural differences cannot be determined on the basis of the available information and requires further investigation.

Our findings do, however, provide an interesting description of children's transition through organizational levels between the ages of 5 to 7, by showing a clear pattern of organizational development in ROCF copying performance during this period. Romine and Reynolds (2005) have described a similar developmental shift. They found that between 5 to 8 years of age a great development takes place in a number of important executive functions (i.e., inhibition, fluency, and rudimentary planning). Other research has also indicated that the majority of executive functions undergo critical development at preschool and early primary school age (e.g., Anderson, 2002; Cartwright, 2012; Davidson, Amso, Anderson, & Diamond, 2006; Zelazo & Carlson, 2012). Yet Lezak et al. (2012) have indicated that the ROCF can only be administered to children from age 6 onward. Our findings have shown that ROCF administration can already be meaningful at an earlier age, at least in terms of copying performance, given the developmental shift and the spread in scores that can already be observed at 5 to 6 years of age (see Table 3).

RCF-OSS performance in relation to accuracy

Our findings suggest that the ROCF performance measures of "accuracy" and "organization" are related in children aged 5 to 7. More specifically, the results revealed significant correlations between a measure of organization (i.e., the RCF-OSS) and all accuracy measures (i.e., Global, Element, Lines, and Total). The correlation of the

RCF-OSS with the accuracy measure Global was higher than those with Elements and Lines (namely, r = .29). This could be expected, since the ROCF units that constitute the accuracy measure Global play an important role in the classifications of the RCF-OSS (i.e., especially the horizontal and vertical centerlines). Our findings of strong positive correlations between the RCF-OSS and the total score for accuracy are in line with the significant correlations between RCF-OSS and accuracy of ROCF copy performance as reported by Anderson et al. (2001) for 7- to 13-year-old children. Yet our findings are also somewhat lower than those reported by Anderson et al. (2001). This could potentially be explained by less variability in strategy use at a younger age (i.e., none of the children applied the advanced conceptual strategies) in comparison with accuracy of performance, thereby decreasing chances of correlations with accuracy measures. With increasing age, children seem to become more variable in their strategy use, as visual inspections of our findings (see Table 3) and the findings reported by Anderson et al. (2001, p. 90) seem to reflect. As Anderson and colleagues have described, children's organizational strategy use is likely to begin in early childhood, gradually proceeding through different stages of skill development, implementation, modification, and refinement. Supplementary to Anderson et al. (2001), we demonstrated that young children's accuracy scores for more global ROCF units are more strongly related to RCF-OSS performance level than more local ROCF units. These findings indicate that even in young children the RCF-OSS can indeed (partly) capture core features of the ROCF. These correlations suggest that children who apply more global organizational strategies are also more likely to produce an accurate copy of the ROCF than children who use a more local approach.

Together these findings show that at a young age organizational strategy use, as measured by the RCF-OSS, is strongly related to accuracy of ROCF performance on a more traditional measure. Our findings also indicate that even as young as 5 to 7 years of age the RCF-OSS can capture aspects of ROCF performance beyond accuracy, as Anderson et al. (2001) did for children aged 7 to 13 years.

RCF-OSS performance in relation to measures of executive and non-executive functioning

To the best of our knowledge, the present study is the first to provide information on construct validity of the RCF-OSS in a healthy sample of children aged 5 to 7. In line with our expectations, our findings revealed that the RCF-OSS is not exclusively a measure of executive functioning at this age, but is also related to non-executive functioning. More specifically, RCF-OSS scores were linearly related to measures of executive functioning (i.e., design fluency, spatial and verbal working memory, and reasoning) as well as non-executive functioning (i.e., visual attention, visual-motor integration, processing speed, and numeracy). The hypothesized outcomes have been supported by the present study's findings: at this young age the RCF-OSS seems to capture a multitude of components that are known to play a role in ROCF performance. These findings might be related to the age of the participants, given the important changes that take place in a multitude of (executive) skills at this age (e.g., Romine & Reynolds, 2005). Therefore, the authors cannot rule out that the RCF-OSS may capture aspects of executive functioning more clearly with increasing age. Yet our findings are in line with studies that have included older children and adults (e.g., Lezak et al., 2012; Shin et al., 2003). For one, Anderson et al. (2001) also reported small to medium correlations of the RCF-OSS with a range of measures, including measures of (verbal) fluency, (working) memory, and processing speed in addition to measures of planning, cognitive flexibility, and verbal learning (in healthy children aged 7–13 years). Furthermore, the pattern across organizational levels found by Anderson et al. (2001) was similar to the pattern reported in the present study. Children who performed on higher organizational levels obtained higher scores on tasks measuring memory, planning, cognitive flexibility, verbal learning, and verbal fluency performance than children who adopted lower-level strategies.

Previous studies that explored similar relationships in school-aged children with neuropsychological difficulties have reported more varied findings. For instance, Watanabe et al. (2005) and Ogino et al. (2009) found no relationship between organizational performance, as measured by the BQSS, and multiple aspects of cognitive functioning in their original sample of 5- to 14-year-old children with neurological problems. In a larger, comparable sample the authors did find a relationship between organizational abilities and planning ability as well as cognitive flexibility. Conversely, Weber et al. (2013) reported correlations between ROCF copy performance and tests measuring intelligence, visual-motor integration, and visuospatial abilities in a clinically mixed sample of children aged 7 to 16 years. The authors did not find any relationship between ROCF performance and tasks measuring verbal fluency, planning, or cognitive flexibility.

Comparing findings of these previous studies and the present study remains difficult, primarily because the samples differ largely in age range and neurological functioning. In addition, different measures were used to quantify ROCF performance as well as executive and non-executive functioning. Yet, despite these differences, there are similarities in findings of significant correlations of ROCF performance with visuospatial abilities, visual-motor integration, (fluid) intelligence, and working memory. Findings of a relationship with (verbal) fluency have been more varied.

Although the present study provides interesting information about the relationship between the RCF-OSS and various measures of executive and non-executive functioning, the representativeness of our sample forms a potential limitation of our study. The majority of the participating children had a relatively high Raven's CPM score (> 75th percentile), which limits the generalizability of our findings. Also, the array of measures that was included to assess validity could have been composed differently or been extended. For one, our evaluation of the construct validity of the RCF-OSS could have been extended by including e.g., visuo-spatial construction tasks, such as the Block Design test of the Wechsler intelligence battery. This task is known to correlate positively with the accuracy scores of the ROCF Copy task and provide information on visual construction, another aspect of children's spatial abilities (Weber et al., 2013). Furthermore, our test battery could ideally have included more ecologically valid measures, such as a measure of reading ability and parent or teacher questionnaires of executive functioning. However, when assembling a new test battery, it is necessary to take the limitations of this particular age range into account. For one, the young age of the participants constrains the inclusion of additional tests, as was the case in the present study. As Anderson and Reidy (2012) have indicated, young children's performance on a test battery is particularly sensitive to fatigue, a decline in motivation and attention, and receptive and expressive communication challenges. In addition, the age range of the participants can complicate the selection of a suitable test battery in terms of valid and reliable tests with sufficient normative data (Anderson & Reidy, 2012). Consequently, restriction of range issues may occur and can potentially hinder the interpretation of test results.

Although the reported reliability of most measures of executive and non-executive functioning that were included in the present study is sufficient to good (Evers, Sijtsma, Lucassen, & Meijer, 2010), the test–retest reliability of two measures tended to be lower. At present, however, our findings do not suggest that these psychometric properties had an influence on our conclusions regarding the construct validity of the RCF-OSS. For one, the test–retest reliability of measures generally tends to be lower than e.g., the internal consistency (Evers et al., 2010). Furthermore, in the present study no remarkable differences were found among the range of tests that were used to assess convergent validity in comparison to discriminant validity. However, it remains important to consider the influence that the reliability of selected measures can potentially have, especially since our study was the first to study the use of the RCF-OSS in this age range. Also, although the present study's test battery was selected on the basis of findings from previous research, a stronger theoretical foundation would have strengthened the selection of tests. That, however, requires more extensive research into the relationship between the ROCF and measures of executive and non-executive functioning in young children. For future compositions of test batteries, that aim to establish the validity of the RCF-OSS, this should be a starting point. The present study's findings are therefore considered to be a first exploration of the validity of the RCF-OSS for assessing ROCF performance of 5- to 7-year-old children.

In sum, our study was the first to assess the psychometric properties of the RCF-OSS at age 5 to 7 years, by studying organization and accuracy of ROCF copying performance in relation to other measures of executive and non-executive performance. The present study showed that between 5 to 7 years of age children undergo important changes in organizational strategy use. Furthermore, our findings revealed that, even at this young age, the RCF-OSS is sensitive enough to detect individual differences in children's executive and non-executive functioning. Assessment of organizational strategy use by means of the RCF-OSS may thereby aid in the improvement of short interventions that aim to stimulate ROCF performance by implementing organizational scaffolding of information. For one, Frisk et al. (2005) have found that applying a step-by-step training approach in a typical population of 6-year-olds can improve their ROCF recall performance so that it resembles the performance of 8-year-olds. Given the sensitivity of the RCF-OSS in detecting individual differences, implementing this scoring method may help to assess whether individual differences influence training effectiveness. The RCF-OSS may also be a potentially valuable measure in clinical populations. Assessment of organizational strategy use may aid in the identification children with or at risk for learning difficulties, since children with learning difficulties are reported to display affected ROCF performance (e.g., Shin et al., 2003; Waber & Bernstein, 1995). The potential use of the RCF-OSS in the assessment of clinical populations or the effectiveness of interventions, however, requires further research.

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