SOS: a screening instrument to identify children with handwriting impairments

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Abstract

Poor handwriting has been shown to be associated with developmental disorders such as Developmental Coordination Disorder, Attention Deficit Hyperactivity Disorder, autism and learning disorders. Handwriting difficulties could lead to academic underachievement and poor self-esteem. Therapeutic intervention has been shown to be effective in treating children with poor handwriting, making early identification critical. The SOS test (Systematic Screening for Handwriting Difficulties) has been developed for this purpose. A child copies a sample of writing within 5 minutes. Handwriting quality is evaluated using six criteria and writing speed is measured. The Dutch SOS test was administered to 860 Flemish children (7-12 years). Inter- and intra-rater reliability was excellent. Test-retest reliability was moderate. A correlation coefficient of 0.70 between SOS and 'Concise Assessment Methods of Children Handwriting' test (Dutch version) confirmed convergent validity. The SOS allowed discrimination between typically developing children and children in special education, males and females and different age groups.

Keywords: handwriting difficulties; dysgraphia; reliability; validity;

Children with handwriting problems frequently experience distress and frustration when asked to complete their homework, record diary entries or write an essay. Forming letters requires more effort for these children and the child may forget what he wanted to write. Illegible writing, poor handwriting speed and labored writing are the core handwriting problems experienced by elementary school children (Rosenblum, Weish & Parush, 2003). Children with developmental disorders in particular demonstrate handwriting difficulties.

Developmental Coordination Disorder (DCD) is a prevalent yet under-recognized developmental problem, that significantly affects every day functioning (APA, 2000). Poor handwriting is the most frequent symptom in children with DCD (Geuze, Jongmans, Schoemaker & Smits-Engelsman, 2001; Rosenblum & Livneh-Zirinski, 2008). DCD has also been reported more frequently in children with Attention Deficit Hyperactivity Disorder (ADHD) (Flapper, Houwen, & Schoemaker, 2006) and autism (Fuentes, Mostofsky & Bastian, 2009). Kirby, Sugden, Beveridge & Edwards (2008) described the interaction between reading disorder or spelling disorders and handwriting difficulties. In the Netherlands, 25-50% of all interventions carried out by private practice physiotherapists involves handwriting remediation (Bosga-Stork et al., 2009).

Handwriting difficulties or dysgraphia was defined by Hamstra-Bletz and Blote (1993) as a disorder related to the motor output of writing in the absence of intellectual or known neurological deficits. Children with handwriting difficulties typically experience challenges keeping up with the volume of written work required, which may impede academic progress (Feder & Majnemer, 2007). Severe handwriting difficulties lead to academic underachievement unless compensations are made to complete school work. Moreover, secondary problems such as lower self-esteem or lack of confidence often accompany handwriting difficulties (Laszlo & Bairstow, 1984). Despite the widespread use of computers, legible handwriting remains an important everyday life skill that deserves greater attention

from educators and health practitioners (Feder & Majnemer, 2007). Importantly, teachers and parents frequently ascribe the problems to laziness or lack of motivation, which causes frustration and disappointment for the child (Smits-Engelsman, Schoemaker, Van Galen & Michels, 1996). Repeated failures will likely lower the child's motivation resulting in a vicious cycle.

Evidence suggests that occupational therapy or physical therapy can have a positive effect on handwriting skill (Jongmans, Linthorst-Bakker, Westenberg, & Smits-Engelsman, 2003; Ratzon, Efraim, & Bar, 2007). Thus, timely identification and assessment of handwriting difficulties is important to initiating intervention. Teachers are best positioned to identify children with handwriting difficulties. Before referring a child to a diagnostic centre, it can be helpful if the teacher can confirm any suspected problems in handwriting performance with a quick, sensitive, reliable and valid screening instrument. This is especially important in light of the long waiting lists at diagnostic centres. If a teacher can identify writing difficulties early, focused remediation strategies can begin. A child who is not developing handwriting skills as expected in the school system could first be offered supplementary handwriting practice or training. If insufficient progress is made after 3 months of supplemental training, Overvelde and colleagues (2011) suggest that implementing a motor-based intervention can be an option to consider. Since poor writing co-occurs with various developmental disorders, such as DCD, Attention Deficit Hyperactivity Disorder, autism and dyslexia, screening for children at risk for handwriting difficulties is even more important than in typically developing children.

Several handwriting tests are available worldwide but vary in terms of what they aim to measure. Some tests evaluate (1) handwriting speed and/or (2) legibility or readability judged globally and/or (3) specific features that characterize readability (e.g. letter formation, spacing between letters and words, the degree of line slant). Feder and Majnemer (2003)

offered an excellent review of the five handwriting assessments most commonly discussed in the literature. However, none of these tests could be used for screening Dutch children. Firstly, none of these tests is available in Dutch. Cultural differences in language, alphabet and education system require tests to have cultural adapted norms. One method of validating a handwriting evaluation tool would be to translate an existing instrument and standardize it to a particular population. But to be useful as a screening tool, the test administration time should be brief. The *Minnesota Handwriting Assessment* is a commonly used test with good psychometric properties and takes only a few minutes to administer (Reisman, 1993). However in several educational systems, words are written as continuous cursive script. The words in the *Minnesota Handwriting Assessment* are written in print and as such, the test is not valid for children learning a cursive font. Another short screening tool, available in English and evaluating cursive font is *the Children's Handwriting Evaluation Scale-Manuscript (CHES-M),* developed by Phelps and Stempel (1987). However, to the best of our knowledge, there is no information available on test-retest reliability, or on validity of this test. Moreover, according to Reisman (1991), a disadvantage of the CHES-M is that the scoring system is not well defined.

In the Dutch speaking part of Belgium and in the Netherlands, the most commonly used handwriting evaluation tool used by therapists is the *'Beknopte Beoordelingsmethode voor Kinder Handschriften* (BHK) (Concise Assessment Methods of Children Handwriting; Hamstra-Bletz, de Bie & De Brinker, 1987). The BHK is designed to measure handwriting quality on the basis of a completed piece of cursive writing by children in elementary school. Internal consistency between all 13 items was reported to be 0.52 suggesting that different aspects of writing performance are measured. Furthermore, the BHK has been shown to be sensitive enough to be used as an evaluation tool (Smits-Engelsman et al., 1996; Jongmans et al., 2003).

The writing task consists of copying a standard text in five minutes or at least five lines if the child is a very slow writer. The text is copied on unruled paper. The BHK evaluates both quality and speed of writing. In addition, it offers 13 criteria to evaluate the quality of the handwriting product. Unfortunately, the BHK is not suitable for screening. The scoring of the test needs extensive training and takes about 15 -20 minutes if the tester is experienced. Moreover only preliminary cut-off scores to classify children as good, poor and dysgraphic writers are available, based on the evaluation of writings of 10 children by 28 raters (Hamstra-Bletz et al., 1987).

The SOS test ('Systematische Opsporing van Schrijfmotorische problemen' or 'Systematic Screening of Handwriting Difficulties') (Smits-Engelsman, Stevens,Vrenken, & van Hagen, 2005) was developed to fulfill the need for a short, effective handwriting screening tool. The SOS is based on the BHK but can be scored in a shorter timeframe. This offers the opportunity to use the written text of a child first for screening and if necessary to score the complete BHK if more detailed information for developing an intervention plan is necessary. In a pilot study (n=128), the six most discriminating items explained 65% of the variance, and were thus selected from the 13 BHK criteria. They were reformulated and the scoring was simplified to develop the SOS test.

The aim of the present study was to evaluate intra-, inter-rater and test-retest reliability of the SOS. The convergent validity of the test was evaluated by comparing the test results of the SOS to those on the BHK using the same piece of writing. Discriminant validity was evaluated by comparing the SOS results from typically developing children with the results of children with a learning disability. Gender and age variations were also examined. The hypotheses related to this study were that (a) children with learning disabilities would have more writing problems, (b) females were expected to write better and faster than males (Berninger & Fuller, 1992; Berninger, Nielsen, Abbott, Wijsman & Raskind, 2008; Ziviani &

Watson-Will, 1998) and (c) writing quality and writing speed was expected to improve from 7 through 12 years of age.

Method

Participants

Children, ages 7 to 12 years, were recruited from mainstream schools and from special education schools. Special schools enroll children with an IQ of at least 70 but with developmental challenges. Parents signed informed consent forms allowing their child to participate and each child was asked for verbal assent. A total of 629 children attending 9 mainstream schools, in areas with different degrees of urbanization in Flanders (Belgium) were recruited. Children with a sensory, physical or intellectual disability known to the teachers were excluded from the sample in the mainstream schools. The parents of 26 children did not give permission to participate in the study. The final sample thus consisted of 603 children attending mainstream schools. In five special education schools, 268 children were recruited. Nine parents refused permission for their children to participate in the study. Therefore, the final sample consisted of 259 children from special education settings.

'Systematische Opsporing Schrijfproblemen' or SOS test

The child received a sheet with a printed story composed of sentences with increasing complexity, printed in decreasing height, and was provided with a blank sheet to copy the text. A standard pencil or pen is used to write and erasers are not allowed. All other materials were removed from the table. The child had 5 minutes to copy a part of the story with the instruction to write as quickly and as neatly as they usually do. If the child had not copied the first five lines after 5 minutes, the tester notes how much the child has written and allowed the child to continue until the first five lines were complete.

Writing speed was measured by counting the number of letters produced in exactly five minutes.

To evaluate the quality of the handwriting, the first five lines were used to evaluate 6 well- described criteria: (1) fluency in letter formation: abrupt directional changes in the writing trace, (2) fluency in connections between letters, (3) letter height, (4) regularity of letter height (5) space between words and (6) straightness or regularity of the sentence. Examples of the criteria are presented in Figure 1 and 2. For each criterion the manual provides several examples. The items evaluating letter height, regularity of letter height and straightness of the sentence were measured using a transparent sheet provided with the manual. A criterion is scored as zero when it does not appear in more than one of the five lines. A score of 1 is provided when the handwriting difficulty appears in two or three lines and a score of 2 is given when it appears in more than three lines. There is one exception to this scoring principle. The score 0, 1 or 2 is determined by the mean letter size for the criterion for letter height. The total score range is between 0 and 12, with a high score corresponding to poor handwriting quality.

Figure 1. Example of handwriting with abrupt directional changes in letter formation.

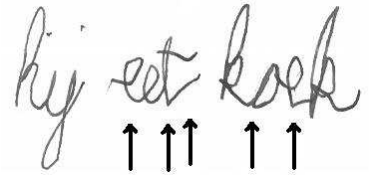


Figure 2. Example of handwriting with abrupt directional changes in letter connections (not fluent).

BHK test

The test procedure is identical to the SOS test, except for the scoring system. Handwriting is evaluated by assessing the following 13 characteristics: (1) the writing is too large; (2) widening of left-hand margin; (3) poor letter or word alignment; (4) insufficient word spacing, (5) acute turns in connecting joins to letters, (6) irregularities in joins and/or absence of joins; (7) collisions of letters; (8) inconsistent letter size; (9) incorrect relative height of the various kinds of letters; (10) letter distortion; (11) ambiguous letter forms; (12) correction of letter forms and; (13) unsteady writing trace. The items are measured on an ordinal scale with six categories resulting in a score from 0 to 5. Each child's total score on all 13 items is then used to determine if the child is (a) not dysgraphic (score 0–21), (b) ambiguous (score 22–28), (c) dysgraphic (score 29 or higher). The inter-rater agreement between pairs of raters has been reported to vary between r=0.71 and 0.89.

Procedure

Approval for this study was obtained from the Ethical Committee at the University Hospital Ghent, Belgium. The data was collected during the course of 3 separate research projects involving 6 final year physical therapy students. The students underwent training with regards to proper administration and scoring of the SOS. They received an instruction session of 3 hours, followed by a training session in which 5 copies were scored and discussed. In the revised version of the SOS manual the training copies will be included. The SOS was administered in Dutch, to children in a group setting.

Within the several research projects, the students were successful in recruiting different groups of children to participate. As a result, the number of subjects for test-retest, inter- and intra-rater reliability is different. Six testers scored 289 copies twice leaving at least two weeks between both evaluations to investigate intra-rater reliability. Four pairs of testers scored 267 copies twice, blind to each other's results, to investigate inter-rater reliability. One hundred ninety-nine children were asked, two weeks after their first test, to copy the text a second time to investigate test-retest reliability. Six testers also scored the BHK on the written text used to score the SOS for 73 children to investigate convergent validity between both tests.

Data analysis

Intraclass Correlation Coefficients (*ICC*) for single measures in a two-way mixed effects model was calculated to evaluate the intra-rater, inter-rater and test-retest reliability of the total SOS score and writing speed. ICC data range from 0 (no reliability) to 1 (perfect reliability) and were interpreted using the following criteria: 0.00 – 0.49 poor; 0.50 – 0.74 moderate and 0.75 – 1.00 excellent (Mc Graw, & Wong, 1996). For each ICC obtained, the 95% confidence interval (CI) was calculated to provide a range of values that is likely to cover the true population value.

Kappa statistics for multiple ratings per subject were used to evaluate the intra-rater, inter-rater and test-retest agreement of the item scores varying between 0, 1 and 2. This statistical method to measure agreement between different measurements takes into account chance agreement. The range for kappa is -1 to +1 with the following categories: -1 - perfect disagreement, 0 - chance agreement, 0-0.2 - poor agreement, 0.21-0.4 - fair agreement, 0.41-0.60 - moderate agreement, 0.61-0.80 - good agreement and 0.81-1 - very good agreement (Altman, 1991).

Pearson correlation coefficients were used to evaluate congruent validity between the

SOS score and the BHK. The SOS scores and writing speed were analyzed using a multivariate general linear model (GLM) to evaluate the effect of type of education, gender and age group. Because the variance of the SOS score was not equal between the different age groups, a weighted least squares estimation was used to control for this in the GLM. Pearson correlation coefficients were computed between age and SOS score and writing speed.

Results

Description of the sample

A total of 862 subjects between 7 and 12 years of age took part in this study. They were classified by age but the 11 and 12 year old children were combined into one group. The subjects attending regular mainstream schools were 65 7-year olds, 185 8-year olds, 122 9-year olds, 110 10- year olds and 121 11-12-year old children; 302 of them were males and 301 females. The subjects attending special education schools were 17 7-year olds, 54 8-year olds, 88 9-year olds, 55 11-year olds and 45 11-12-year old children; 153 of them were males and 106 females. Results of the SOS, corresponding to age, gender and type of education are reported in Table 1.

Table 1. Mean (standard deviation) of S0S score and writing speed for the different groups of children.

Age	**SOS score***						**Writing Speed**					
	Regular Schools			Special education			Regular Schools			Special education		
		Boys	Girls		Boys	Girls		Boys	Girls		Boys	Girls
7 y	3.4 (2.0)	3.7 (2.0)	3.1 (1.9)	6.1 (2.6)	6.5 (2.1)	5.6 (3.3)	136 (35.8)	134 (31.4)	138 (40.0)	80 (24.5)	75 (17.6)	88 (31.9)
8 y	3.1 (1.8)	3.4 (1.8)	2.8 (1.8)	4.2 (2.2)	4.9 (2.2)	3.3(1.8)	158 (41.4)	152 (45.6)	163 (36.7)	117 (35.2)	106 (32.0)	133 (33.8)
9 y	2.8 (2.0)	3.1 (2.1)	2.3 (1.7)	3.2 (1.8)	3.7 (1.8)	2.3 (1.4)	176 (46.1)	165 (44.4)	191(44.6)	146 (46.9)	137 (42.3)	159 (51.0)
10 y	2.3 (1.6)	2.6 (1.8)	1.9 (1.3)	2.8 (1.4)	2.9 (1.4)	2.6 (1.4)	224 (56.3)	225 (56.7)	222 (56.3)	167 (46.9)	160 (40.9)	178 (54.0)
11-12 y	2.1 (1.5)	2.5 (1.7)	1.8 (1.2)	2.6 (1.4)	2.7 (1.6)	2.4 (1.1)	260 (51.0)	251 (39.6)	266 (58.0)	199 (50.0)	205 (47.3)	192 (53.9)
Total	2.7 (1.8)	3.0 (1.9)	2.4 (1.7)	3.4 (2.0)	3.8 (2.0)	2.8 (1.8)	192 (63.4)	185 (61.7)	198 (64.5)	149 (54.4)	143 (53.6)	159 (54.6)

* A high score corresponds to a poor handwriting

Intra-rater reliability

Two hundred sixty-seven children, 178 from mainstream schools and 81 from special education settings, from the different age groups were randomly selected. The written text from each of these children was scored a second time by the same rater at least two weeks later. Results are reported in Table 2. SOS score and writing speed (ICC coefficients) showed excellent intra-rater reliability. Item scores (Kappa coefficients) showed good to very good intra-rater reliability.

Inter-rater reliability

Two hundred eighty-nine children, 186 from mainstream schools and 81 from special education, from the different age groups, were randomly selected. From these children the written text was scored a second time by another rater. Results are reported in Table 2. SOS score and writing speed (ICC coefficients) showed excellent inter-rater reliability, although the total SOS score extended into the moderate reliability range. Item scores (Kappa coefficients) showed fair to good inter-rater reliability.

Test-retest reliability

One hundred ninety-nine children, 131 from mainstream schools and 68 from special education, from the different age groups, were randomly selected. These children performed the test a second time two weeks later. Results are reported in Table 2. Test-retest reliability of SOS score and writing speed was moderate, with ICC's of 0.69 and 0.66, respectively. Test-retest reliability at item level was fair to moderate with Kappa coefficients between 0.26 and 0.41.

Table 2. Kappa Coefficients (for item 1 to 6) and Intra Class Correlation Coefficients (ICC) for total SOS score and writing speed with Confidence Intervals (CI of 95%), between the results of the SOS scored by two different testers (inter-rater reliability, N= 100); scored twice by the same tester (intra-rater reliability, N=100) and between the results of two SOS tests of the same child (test-retest reliability, N=68).

	Intra-rater reliability	Inter-rater reliability	Test-retest reliability
Item 1	0.70	0.51	0.41
Item 2	0.70	0.50	0.40
Item 3	0.84	0.77	0.60
Item 4	0.61	0.39	0.35
Item 5	0.78	0.64	0.30
Item 6	0.66	0.53	0.26
SOS score	0.88 (0.85-0.90)	0.77 (0.73 -0.82)	0.69 (0.61-0.76)
Writing speed	1.00 (1.00-1.00)	1.00 (0.99-1.00)	0.66 (0.57-0.73)

**all coefficients were significant, p <0.001*

Convergent validity between SOS and BHK

The written text of seventy-three children (29 males, 44 females) between 7 and 11years of age (mean age 9.7 years, SD=0.9) from two special schools was used to also score the BHK. The Pearson correlation coefficient between total BHK and SOS was 0.70 ($p<0.001$).

Discriminant validity

Significant differences in total SOS score (*handwriting quality*) were found between children from mainstream schools and children from special education schools ($F(1, 861) = 36.5$, $p<0.001$, $\eta^2 = 0.041$); between males and females ($F(1, 861) = 28.4$, $P<0.001$, $\eta^2 = 0.033$); and between children from the different age groups ($F(4, 858) = 22.5$, $p <0.001$, $\eta^2 = 0.096$). The interaction between type of education and gender was not significant ($F(1, 861) = 0.6$, $p=0.434$, $\eta^2 = 0.001$), nor was the interaction between gender and age group ($F(4, 858) = 0.8$, $p=0.530$, $\eta^2 = 0.004$). However, the interaction between age group and type of education was significant ($F(4, 858) = 3.9$, $p=0.004$, $\eta^2 = 0.018$). The box plot of the SOS scores by age group and type of education illustrates this finding (Figure 3). Children from special schools make *more* progress in handwriting *quality* between the ages of 7 and 12 years. Between age and SOS score, a correlation coefficient of 0.29 was calculated, with a coefficient of 0.27 for the typically developing children and 0.39 for the children from special schools (coefficients were significant at the 0.01 level).

Significant differences were found in *writing speed* between children from mainstream schools and children from special schools ($F(1, 861) = 152.6$, $p < 0.001$, $\eta^2 = 0.153$); between males and females ($F(1, 861) = 10.3$, $P = 0.001$, $\eta^2 = 0.012$); and between children from the different age groups ($F(4, 858) = 113.0$, $p <0.001$, $\eta^2 = 0.348$). The interaction between type of education and gender was not significant ($F(4, 861) = 0.2$, $p=0.698$, $\eta^2 < 0.001$), nor was the interaction between gender and age group ($F = (4, 858)\ 1.4$, $p=0.234$, $\eta^2 = 0.007$). Again, the interaction between age group and type of education did reach significance ($F(4, 858) = 3.2$, $p = 0.013$, $\eta^2 = 0.015$). The box plot of writing speed by age group and type of education illustrates this finding (Figure 4). Children from special schools make *less* progress in handwriting *speed* between the ages of 7 and 12 years. Between age and writing speed a correlation coefficient of 0.61 was calculated. For the typically developing children, a

coefficient of 0.67 was calculated between age and writing speed and for the children from special school, a coefficient of 0.59 (all coefficients were significant at the 0.01 level).

Figure 1. Box plots of the SOS score by age group.

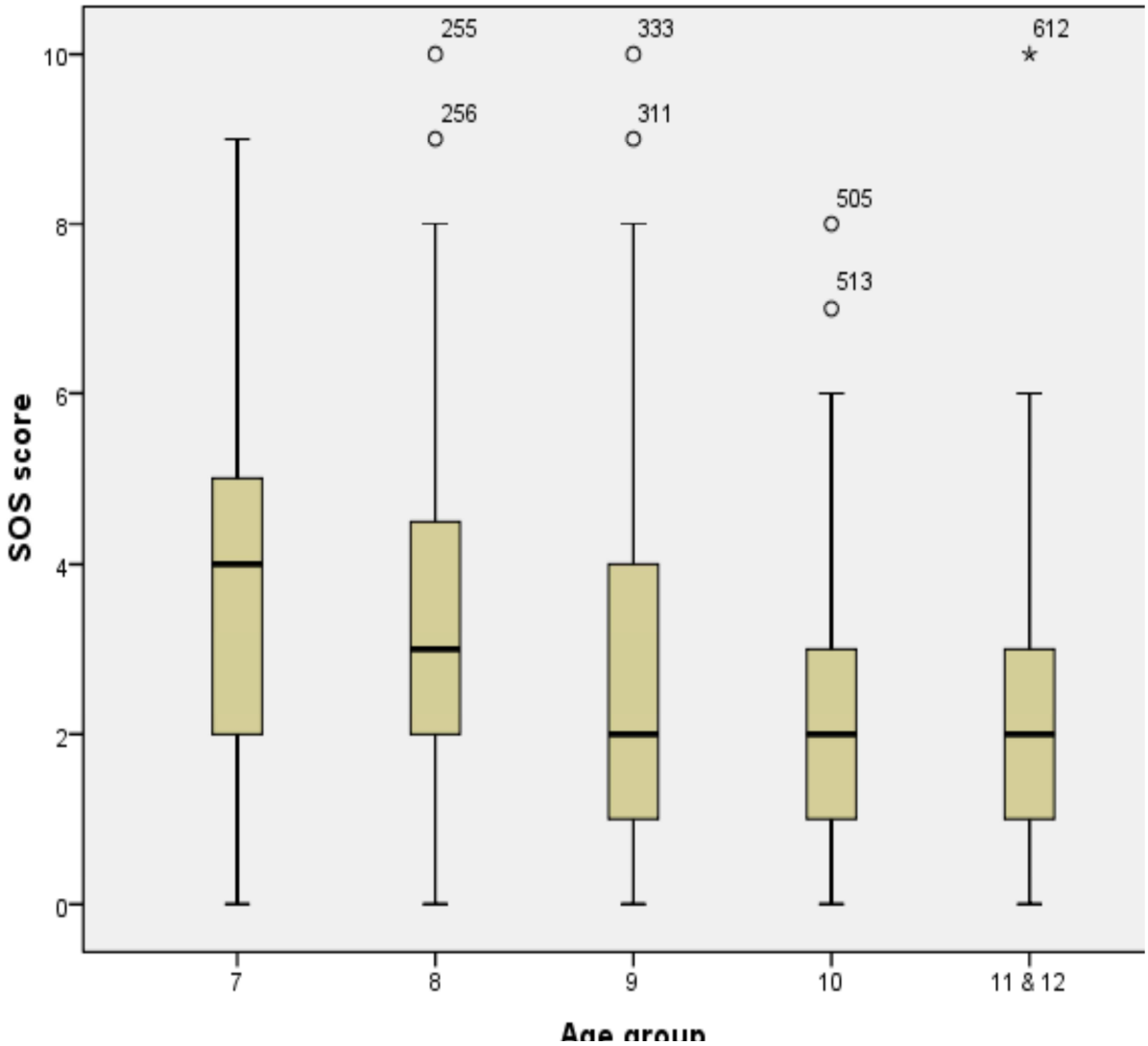
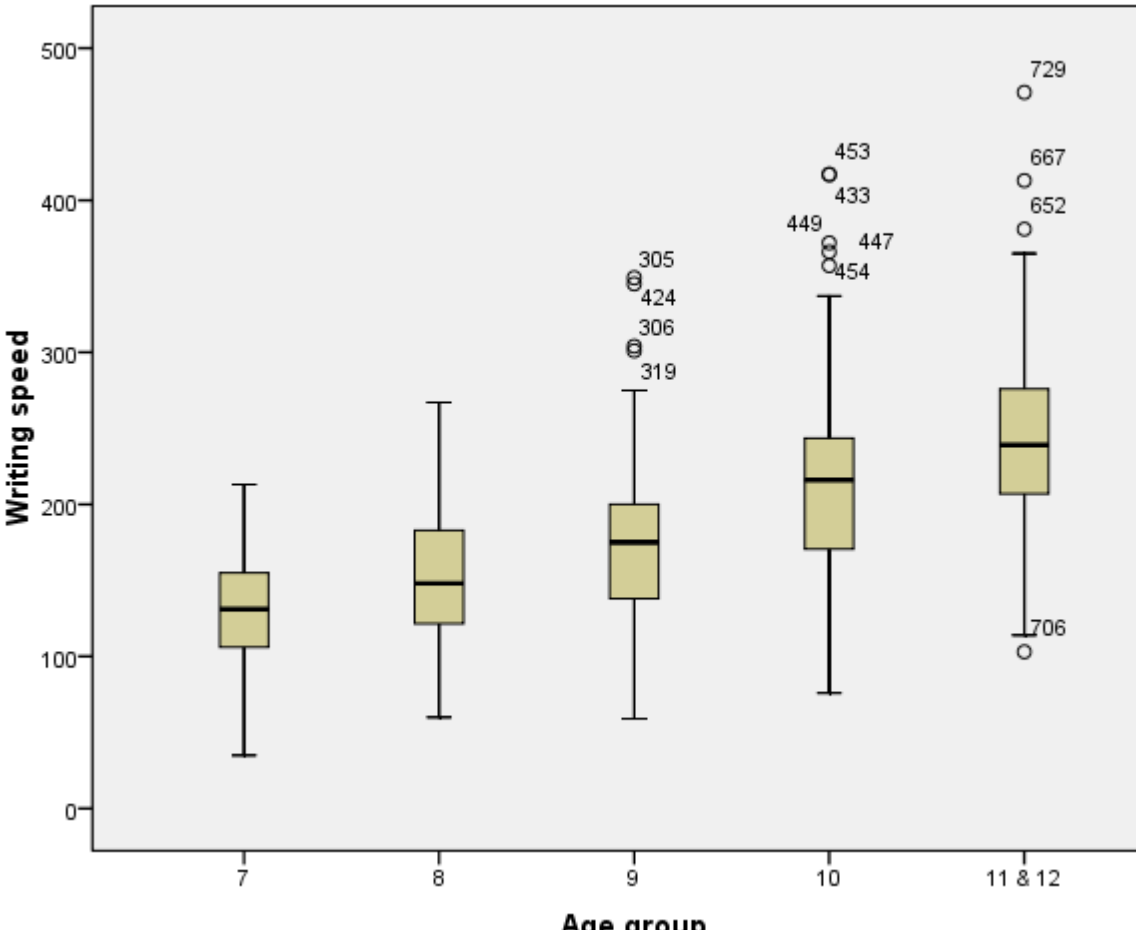


Figure 2. Box plots of writing speed by age group.



Discussion

Overall, the results of this study indicate that the SOS score is a reliable score. Intra-rater reliability is excellent. Inter-rater variability was also excellent, although the lower end of confidence interval extended into the moderate reliability range. Moderate test-retest variability can reflect the variance in the performance of a child on different occasions. Writing speed can be measured in a very reliable way within and between raters. However, test-retest reliability of the writing speed was also only moderate, indicating that there was considerable variance in writing speed between the two test time periods. We can conclude that the SOS is a tool that will reliably measure handwriting performance in children. The reason for the good reliability is likely related to the objective criteria used for scoring, to

include a simple and well laid out scoring system and the provision of scoring examples in the training manual.

The SOS aims to be a screening test to identify handwriting problems. A total score serves this aim and individual item scores should be interpreted with caution. At item level, inter- and intra-rater reliability varies between moderate to good but test-retest reliability of the items is only fair to moderate.

The BHK evaluates 13 items and takes 15 to 20 minutes to score a sample. Although the SOS evaluates just 6 items and takes only 5 minutes to score, the test results can be compared to the BHK results. A correlation of 0.70 between both tests is a confirmation of congruent validity and this is consistent with the reported coefficient of 0.78 between the BHK and the Dysgraphia Scale (Ajuriaguerra et al., 1979) (Hamstra-Bletz & Blöte, 1993).

The SOS evaluates the ability of the child to copy text from a sheet of paper in a five minute period. The short administration time makes the SOS very useful as screening tool. However, this 5 minutes duration of writing time is also a limitation. The SOS does not evaluate the ability of the child to write legibly for longer periods. Therefore, it is unknown if perhaps legibility would decrease in some children if they were required to write for longer than 5 minutes. It is also known that writing speed is variable depending on context, the instruction given and whether the child is copying, taking dictation or free writing (Feder & Majnemer, 2007). However, it would be difficult to develop a valid, reliable handwriting screening tool that would cover every aspect of handwriting performance.

The SOS score allows for differentiation between typically developing children and children with special education needs, thus confirming discriminant validity. However, the effect size of the difference between typically developing children and those from special schools on the SOS score is small, although somewhat greater for writing speed. Children in

special school settings have a higher risk for reading disorders. Slow reading can possibly affect writing speed.

In accordance with the literature (Berninger & Fuller, 1992; Berninger et al., 2008; Ziviani & Watson-Will, 1998), males performed significantly worse than females at all ages, in the quality of their handwriting and writing speed. This suggests that separate normative data should be available for males and females. Boys may need more time for maturation and for the acquisition of fine motor skills (Richter & Janson, 2007; Lung, Chiang, Lin, Feng, Chen, & Shu, 2011), thus gender specific normative data can prevent over-diagnosis and treatment of dysgraphia in boys. Since handwriting produced by boys remains less readable and slower throughout their school career (Berninger & Fuller, 1992; Berninger et al., 2008; Ziviani & Watson-Will, 1998), it is recommended that handwriting requirements should be adapted for boys. Alternatively, boys should be given more training time during school hours to improve their handwriting skills. If their handwriting does not improve in the presence of these adaptations, then intervention should be considered.

The SOS score decreases between the ages of 7 and 11 years, indicating improved handwriting quality as children grow older. The variance of the writing abilities is not similar at all ages, as depicted in figure 3.Younger children show larger variances although some 7-year old children are already able to reach the maximum SOS score (a zero score). This validates existing literature on the longitudinal development of handwriting performance (Hamstra-Bletz & Blote, 1993; Karlsdottir & Stefansson, 2002, Overvelde & Hulstijn, 2011).

A significant interaction is shown between age group and type of education in the model comparing typically developing children with those in special school settings. This demonstrates that the course of handwriting development is different for the children with

learning challenges. Our study findings suggests that the special needs children in our sample were more delayed at younger ages (Figure 3).

Writing speed is more closely related to the age of the child within primary school as can be deduced from the higher correlation coefficients between age and writing speed, compared to the relationship between age and SOS score.

Limitations.

The SOS text to copy is in Dutch. A text in the native language of the child, with the appropriate level of difficulty, is necessary to make the test useful in other countries. The SOS has been translated in German and English, and normative data collection is currently ongoing. The same qualitative criteria can be used for other languages, if these languages use the Latin alphabet and a cursive fluent writing style. The SOS may be used as an alternative to the CHES-M for screening children quickly for handwriting problems. However, the brevity of the SOS limits more in depth screening of handwriting difficulties.

The reliability of the SOS was investigated by comparing the scoring results of trained physiotherapy students. Comparing the results of teachers evaluating copies of children with poor handwriting, could be a next step to support the inter-rater reliability of the SOS. The convergent validity could only be investigated with the BHK because no other Dutch handwriting tests were available. However, the SOS can be considered as an adapted short version of the BHK. The English translation of the SOS will allow further investigation of convergent validity. Specificity and sensitivity of the SOS to identify children with handwriting problems should also be investigated. Furthermore, we recommend that performance of children over extended periods is evaluated using longitudinal research methods.

Conclusions.

Although continuing research is necessary to investigate the reliability and validity of the SOS, the results of this study are promising. Inter- and intra-rater reliability was excellent and test-retest reliability was moderate. Convergent validity with the BHK was confirmed. The SOS test discriminated between typically developing children and children in special school settings, between males and females and between different age groups. The SOS can be used for early identification of handwriting difficulties. This tool may assist in achieving the goal of timely intervention for children and thus prevent secondary problems often associated with handwriting difficulties such as academic underachievement and low self-esteem.

Declaration of interest

The authors report no conflicts of interest.

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