



Handwriting development in grade 2 and grade 3 primary school children with normal, at risk, or dysgraphic characteristics

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ABSTRACT

The wide variation in prevalence of dysgraphic handwriting (5–33%) is of clinical importance, because poor handwriting has been identified as one of the most common reasons for referring school-age children to occupational therapy or physiotherapy, and is included as a criterion for the diagnosis of Developmental Coordination Disorder. This study aimed to map the development and improvement in handwriting during the early grades to differentiate between temporary and consistent dysgraphic handwriting. In this longitudinal and cross-sectional study, children in grade 2 (age 7–8 years, $n = 169$) and grade 3 (8–9 years, $n = 70$) took handwriting (Concise Assessment Method for Children's Handwriting; acronym BHK) and visuomotor integration (BeeryVMI) screening tests twice within one school year. Dysgraphia decreased strongly from 37% to 17% in grade 2 and diminished further to a low and stable rate of 6% in grade 3. Stability in handwriting quality only occurred in the children whose scores were within the normal range. The *at risk* and *dysgraphic* children continued to show significant and substantial improvement during grades 2 and 3. BeeryVMI was inappropriate as a screening instrument for handwriting problems. It was concluded that handwriting must be consistently dysgraphic before making any decisions about a diagnosis of dysgraphia or referral for therapy.

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1. Introduction

Handwriting is an important skill, related to school performance and the child's self-esteem (Feder & Majnemer, 2007). In previous studies, the prevalence of handwriting problems among school-age children has been estimated to vary between 5 and 33% (Hamstra-Bletz & Blote, 1993; Karlsdottir & Stefansson, 2002; Rubin & Henderson, 1982; Smits-Engelsman, Niemeijer, & Van Galen, 2001). This wide variation in prevalence of clinical importance, because problems with handwriting have been identified as one of the most common reasons for referring school-age children to occupational or physiotherapy services (Bosga-Stork et al., 2009; Hammerschmidt & Sudsawad, 2004). Moreover, poor handwriting has been mentioned as one of the diagnostic criteria for Developmental Coordination Disorder (DCD; DSM-IV-TR, APA, 2000; ICD-10, WHO, 1992). Clinical practice has shown that some children were able to overcome their handwriting problems easily, whereas others had more persistent problems. Precisely in these age groups, in which handwriting is undergoing development and rapid improvements are being made (Karlsdottir & Stefansson, 2002), the timing of testing could have great impact on the identification of handwriting problems and might form a simple explanation for the wide variation in the prevalence of handwriting problems. To establish whether there is a genuine indication for therapy, it is necessary to differentiate between temporary and persistent dysgraphic handwriting and to gain insight into the development of handwriting quality and

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speed. In a combined longitudinal and cross-sectional study on children in grades 2 and 3, our aim was to provide a more detailed description of the development of *normal*, *at risk* and *dysgraphic* handwriting.

Handwriting is a complex activity in which lower-level perceptual-motor (motor planning and execution) processes and higher-level cognitive (psycholinguistic and executive) processes continuously interact (Abbott & Berninger, 1993; Graham & Weintraub, 1996; Van Galen, 1991). As soon as the low-level motor processes have become relatively automatic, the high-level processes (e.g. planning, language generation, reading and editing) can be activated concurrently as in adult writing. Children in grade 3 still seem to alternate between these high-level and low-level processes while composing text, because the low-level processes had not yet become automatic (Olive & Kellogg, 2002). In our study on handwriting disability or dysgraphia, we focused on the low-level processes.

In children who were showing *typical* development, handwriting was found to be characterized by rapid quality improvement during grade 1 (age 6–7 years) that reached a plateau by grade 2 (age 7–8 years). Further improvements were seen by grade 3 (age 8–9 years), when handwriting had become automatic, organized and available as a tool to facilitate the expression of ideas (for an overview of studies see Karlsdottir & Stefansson, 2002; review Feder & Majnemer, 2007). These authors described continuous and somewhat linear increases in writing speed over the grades. Thus, although the typical development of the total group has been described, clinical practice needs more specific details about the characteristics of children *at risk* for handwriting difficulties and children with dysgraphia.

To our knowledge, only two longitudinal studies described the development of handwriting in terms of profiles. Recently, Karlsdottir and Stefansson (2002) have given an overview of the number of children with handwriting problems and the distributions during grades 1–5. They presented average developmental profiles of children with 'functional' and 'dysfunctional' handwriting in grade 1 to grade 5, obtained by annual testing at the end of each school year. Children with *functional* handwriting reached their final quality level at the end of grade 1, whereas the children with *dysfunctional* handwriting improved significantly from grade 1 to grade 5. The definition of *functional* handwriting was based on the legibility of the written content and just five characteristics to judge the individualized letter forms (letter formation, slant, size, spacing and alignment). In an earlier study, Hamstra-Bletz and Blote (1993) described the longitudinal development of children with dysgraphia from grade 2 to grade 7. Normal handwriting and the product of dysgraphic children were described in more detail (13 characteristics). However, their dysgraphic group was determined by using a cut-off score of 10% of the total study population and consisted of only 12 children.

In clinical as well as in experimental research, good instruments must be used to rate handwriting and define groups. The Concise Assessment Method for Children's Handwriting (acronym BHK; Hamstra-Bletz, De Bie, & Den Brinker, 1987), developed from the dysgraphia scale of De Ajuriaguerra et al. (1964, 1979) (as cited in Hamstra-Bletz, 1993), has frequently been used for this purpose (e.g. Flapper, Houwen, & Schoemaker, 2006; Kaiser, Albaret, & Doudin, 2009; Smits-Engelsman et al., 2001). We consider that the 13-characteristic BHK is suitable to assess the rapid developments in handwriting during the early grades and to provide more detailed profiles of handwriting that is *at risk* or *dysgraphic*. The BHK covers more global characteristics ('organization of written work') and contains several items to score 'letter formation'. Checks should also be made of the quality of the letter trace ('fine motor ability') (Hamstra-Bletz et al., 1987; see Table 2). BHK-norm-references on the quality of handwriting have only been published for grades 2 and 3, but speed norm-references are available for all ages.

Until now, very little research has addressed global longitudinal profiles of *dysfunctional* or *dysgraphic* handwriting. Such characteristic developmental profiles are of great therapeutic importance in view of the high prevalence of handwriting problems and, correlatively, given that handwriting is the main focus of therapy in paediatric physiotherapy and occupational therapy. By using a simple and frequently-used test, such as the BHK, it should be possible to transfer the results to therapeutic practice. This study focused on the development of handwriting in subgroups of children (with *normal*, *at risk*, or *dysgraphic* handwriting) in the second grade (age 7–8 years) and third grade (age 8–9 years) of primary school. Testing a large group of children within a short period of half a year enabled us to map handwriting characteristics in specific subgroups. We analysed improvements in handwriting quality, the (clusters of) items of the BHK, correlations with the visual-motor-integration score and increases in handwriting speed.

2. Method

2.1. Participants

Data were obtained in two sessions (T1 and T2) from 239 children in grade 2 (age 7–8 years, $n = 169$) and grade 3 (age 8–9 years, $n = 70$) at four mainstream primary schools, located in the eastern part of the Netherlands. Mean age differed significantly between the children in grade 2 (7.7 years \pm 0.6 months at T1) and grade 3 (8.7 years \pm 0.5 months at T1) ($p < .001$). Duration of handwriting lessons also differed significantly (grade 2: 14.63 \pm 4.3 months; grade 3: 22.86 \pm 2.8 months; $p < .001$). Within the two grades, no significant differences were found between gender distribution or mean age. The percentages of left handed children were within the normal variation of handedness (13% and 11% in grade 2 and grade 3, respectively).

In the Netherlands, children with minor learning disabilities, motor dysfunction, or behavioural problems attend mainstream primary schools, where they have the opportunity to receive adaptive education. The following information was obtained from the teacher: in grade 2, nine children were receiving therapeutic assistance in handwriting (5.3%) and seven children had been diagnosed with spelling difficulties (4.1%). In grade 3, two children were registered as having minor behavioural problems. None of these problems (spelling, motor, or behavioural) were having severe effects on the children's

handwriting. The study was approved by the local institutional review board. All the parents of the participants gave informed consent.

2.2. Measures

2.2.1. Concise Assessment Scale for Children's Handwriting (BHK)

Handwriting was tested with the Concise Assessment Scale for Children's Handwriting (BHK; Hamstra-Bletz et al., 1987). This standardized norm-referenced test was designed to screen handwriting samples from second and third grade primary school children. It is normally used in the individual clinical setting and classical scholar setting.

The handwriting task consists of copying a standard text for 5 min (or, for slow writers, at least the first five sentences) on an unlined sheet of A4 paper. Quality (norm-referenced for children in grades 2 and 3) and speed (norm-scores for children in grades 1–6) are measured. Handwriting quality is rated according to 13 features (see Table 2, also for the distribution within item clusters) with a minimum score of 0 and a maximum score of 65. Scores of 0–21 are considered to be normal, scores of 22–28 indicate 'at risk for handwriting problems' and scores of 29 and higher reflect dysgraphic handwriting. BHK quality (*BHK-quality*) is categorized according to legibility, based on the original standard scores of the dysgraphia scale developed by De Ajuriaguerra et al. (1979). Copying speed (*BHK-speed*) is determined by counting the number of letters (including corrected letters) written in 5 min. Copying speed can be translated into a decile score (composed by Hamstra-Bletz et al., 1987) scaled to the norm of the child's grade. Interrater reliability of the BHK has been reported to vary between $r = 0.71$ and $r = 0.89$; intrarater reliability was $r = .87$ to $r = .94$ for grade 2 and $r = .79$ to $r = .88$ for grade 3. Test-retest reliability was $.51$ – $.55$ (Hamstra-Bletz et al., 1987). In the present study, all the handwriting products were assessed by two evaluators, under the supervision of one of the authors (AO). Differences were discussed until consensus was reached.

2.2.2. Visual-motor integration

Visual-motor integration was tested using the Developmental Test of Visual Motor Integration (Beery VMI; 5th ed., Beery & Beery, 2004). In this test, a developmental sequence of geometric forms must be copied using paper and pencil within a time limit of 3 min. Graphic responses are scored using the criteria listed in the manual. Shapes that meet specified criteria are given a score of 1, whereas non-passed items receive 0 points. The maximum raw score is 30. Raw scores were converted into standardized scores (*VMI-SS*), based on the cumulative frequency distribution (Beery & Beery, 2004) and used to interpret the data. Reliability of the VMI was good (Beery & Beery, 2004; inter-scorer: $r = .92$; internal consistency: $.96$; test-retest: $.89$). The VMI was selected because of its assumed and frequently discussed relationship to handwriting.

2.3. Procedure

Data were collected in two separate sessions: early in the school year (T1 in November 2008) and later in the school year (T2 in May 2009). In each session, the two frequently-used screening tools were administered simultaneously to all the children in their classrooms. Handwriting products were assessed by two evaluators, under the supervision of one of the authors (AO). Differences were discussed. VMI scores were assigned by one of the authors (AO).

2.4. Statistical analysis

Differences between scores were analysed using *t*-tests and χ^2 tests.

Based on the BHK score at T1, the children were categorized as having *normal* writing (NW), *at risk* writing (RW) and *dysgraphic* writing (DW). Descriptive statistics (means, standard deviation and percentages) of *BHK-quality*, *BHK-speed* and *VMI-SS* were used to describe the differences between these three subgroups.

To examine the differences in handwriting development between the three subgroups, repeated measures ANOVA were conducted on these variables, with development (the difference between the two sessions T1 and T2) as the repeated variable. Interactions were calculated with Tukey post hoc tests. Effect sizes are given in partial eta squared (partial η^2).

Correlations between handwriting quality and visual-motor integration were tested with Pearson's correlations. The prevalence of dysgraphic handwriting in poor visual-motor integration were derived by coding the standard scores as poor (*VMI-SS* < 90), normal (≥ 90 *VMI-SS* ≤ 110) and good (*VMI-SS* > 110).

3. Results

3.1. Handwriting quality

The main results concern the development of handwriting quality in children during grades 2 and 3, with particular focus on the differences in development between *normal* writing, *at risk* and *dysgraphic* writing (see Table 1, Figs. 1 and 2). Results of the other test variables are presented as separate items below.

As expected, the overall quality of the handwriting was significantly better in grade 3 than in grade 2 ($F(1,237) = 48.56$, $p < .001$, partial $\eta^2 = .170$). The children in grade 3 seemed to have reached their final quality level at the first measurement (T1) and even showed slight deterioration at T2, whereas the performance of the children in grade 2 was significantly better

Table 1

Mean BHK quality scores, percentages of children in each quality range, division into normal writing (NW), at risk for handwriting difficulties (RW) or dysgraphic writing (DW) subgroups, mean BHK speed scores, VMI standard scores and correlations between BHK quality and VMI-standard scores.

	Grade 2 n = 70			Grade 3 n = 169		
	T1 Nov (SD)	T2 May (SD)	F(1,166)	T1 Nov (SD)	T2 May (SD)	F(1,67)
BHK quality	25.26 (7.94)	20.91 (7.88)	68.813 ^{***}	16.26 (7.14)	16.33 (7.06)	4.452 [*]
Normal range (%)	33	54		80	79	
At risk range (%)	31	29		14	16	
Dysgraphic range (%)	37	17		6	6	
BHK speed	118.98 (27.41)	139.49 (41.67)	64.658 ^{***}	152.77 (41.94)	167.24 (46.07)	.058
VMI-SS	98.62 (12.11)	103.30 (10.14)	26.286 ^{***}	97.54 (10.88)	101.00 (8.72)	8.755 ^{**}
NW	101.11 (12.85)	105.60 (11.37)		98.95 (11.02)	101.93 (8.80)	
RW	98.96 (12.74)	104.46 (8.76)		93.30 (9.72)	95.60 (7.50)	
DW	96.08 (10.48)	100.23 (9.45)		88.50 (2.52)	101.50 (7.00)	
Correlation BHK quality – SS VMI	.229 ^{**}	.371 ^{**}		.308 ^{**}	.107	

^{*} p < .05.
^{**} p < .01.
^{***} p < .001.

at T2 (mean BHK difference: grade 2 = +4.35; $F(1,166) = 68.81, p < .001$, partial $\eta^2 = .239$; grade 3: $-0.7, F(1,67) = 4.452, p = .039$, partial $\eta^2 = .062$).

Based on the BHK quality score at T1, the children were rated as NW, RW, or DW. No significant differences were found between the subgroups with respect to age (grade 2: $p = .163$; grade 3: $p = .718$), duration of handwriting lessons (grade 2: $p = .082$; mean grade 3: $p = .472$), or minor learning or behavioural problems (grade 2: $p = .355$; grade 3: $p = .345$). Children with therapeutic assistance were over represented in the DW subgroup (8 out of the 9 children).

Improvements in the overall scores during grade 2 were significantly different between the NW, RW and DW subgroups. At T2, 41% of the children had progressed to a higher rated subgroup, while 50% (mainly NW) remained in the same subgroup. The mean score in the DW group improved the most, whereas the NW group showed only minor improvement

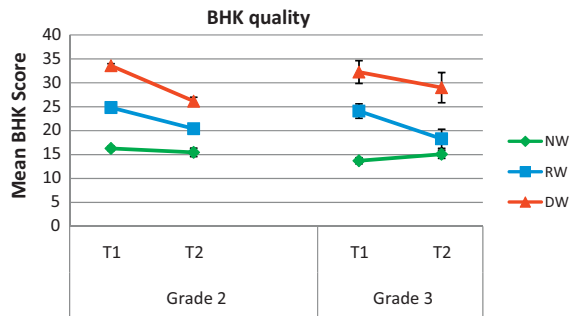


Fig. 1. Mean BHK quality scores in children with normal writing (NW), at risk writing (RW) and dysgraphic writing (DW) in grade 2 and grade 3 at T1 and T2.

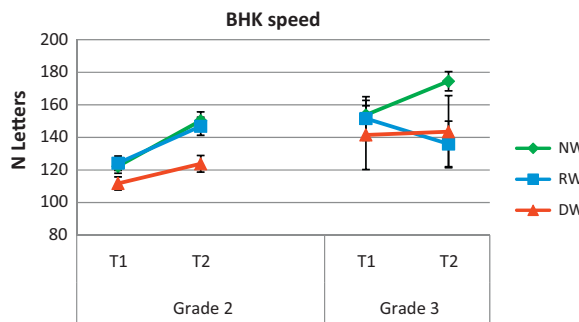


Fig. 2. Mean BHK speed scores in children with normal writing (NW), at risk writing (RW) and dysgraphic writing (DW) in grade 2 and grade 3 at T1 and T2.

(test session*grade: $F(2,166) = 14.60, p < .001$, partial $\eta^2 = .150$). Mean score in the DW group improved to within the range of 'at risk' (BHK score from 33.58 to 26.16), while the RW group reached the normal writing level at T2 (BHK score from 24.83 to 20.40). Children in the NW group only showed minor improvement (BHK score from 16.29 to 15.47). Correlations between the BHK quality scores at T1 and T2 were significant ($r = .596, p < .001$).

In grade 3, a different pattern of change in BHK scores was observed (test session*grade: $F(2,67) = 6.66, p = .002$, partial $\eta^2 = .166$). The 10 children in the RW group showed the most improvement (BHK score from 24.10 to 18.30), while all four children in the DW group had reached the boundary level of dysgraphia (BHK score from 32.25 to 29.00). Performance of the large group with normal writing ($n = 56$) was poorer at T2 (BHK from 13.71 to 15.07), but remained well within the range of normal. Thus, during grade 3, only small shifts occurred and 71% of the children (almost exclusively with normal writing) remained in the same subgroup. The correlation between BHK quality scores at T1 and T2 was significant ($r = .583, p < .001$).

In grades 2 and 3, as expected, the overall performance of the girls was better than that of the boys (grade 2 BHK scores at T1 in girls and boys are 22.32 and 27.97, respectively; at T2: 18.23 and 23.38, respectively; in grade 3 BHK scores at T1 in girls and boys are 13.33 and 18.86, respectively; at T2: 14.85 and 17.65, respectively). At T1 in grade 2, 49% of the girls (40 out of the 81) were categorized as NW, while 49% of the boys (43 out of the 88) had dysgraphic scores. In grade 3, 94% of the girls (31 out of the 33) had reached the normal writing level compared to 68% of the boys (25 out of the 37). The DW group comprised only (four) boys. Developments in handwriting quality were significant only in grade 2 ($p < .001$). No interactions in T1 and T2 scores were found between boys and girls.

3.2. Handwriting quality on an item level

Table 2 shows the differences in development between grade 2 and grade 3 on an item level. In grade 2, the improvement in handwriting quality was caused by improvements in three clusters of items. The effect size of improvements in letter size and height (items 8 and 9) was higher than the decline in incorrectly written letter forms (items 10 and 11). Fine motor ability aspects (items 5 and 13) improved, as well as the organization of written work.

In grade 3, improvements in two items (consistency of letter size and steadiness of writing trace) between T1 and T2 could be interpreted as progress in the consistency of the handwriting. Only one (low scoring) item, collision, had deteriorated between grades 2 and 3.

Comparisons between the two grades, however, showed a different picture: in grades 2 and 3, all the items in the clusters *Letter formation* and *Fine-motor ability* differentiated between the three handwriting subgroups, while four out of the five items in the cluster *Organization of written work* differentiated significantly between the subgroups in grade 2, but only one of the latter items was significant in grade 3.

3.3. Handwriting speed

Details of handwriting speed are shown in Table 1 and Fig. 2. As expected, the total number of written letters was higher in grade 3 than in grade 2 ($F(1,237) = 40.57, p < .001$).

Children in grade 2 showed a significant increase in the number of letters ($n = 20.51; F(1,166) = 64.66, p < .001$, partial $\eta^2 = .280$). The number of written letters in grade 2 differed significantly between the children with *normal*, *at risk* and

Table 2

The 13 BHK items in three clusters *Organization of written work*, *Letter formation* and *Fine-motor ability* (according to the classification of Hamstra-Bletz et al., 1987); all items with significant differences ($p < .05$, coded with an *) in combination with an effect size of (partial η^2) $\geq .06$ are shown in italics.

BHK quality		Grade 2 <i>n</i> = 169				Grade 3 <i>n</i> = 70			
Item descriptions	It	T1	T2	Partial η^2 T1–T2	Partial η^2 gr	T1	T2	Partial η^2 T1–T2	Partial η^2 gr
<i>Organization of written work</i>									
Overall letter size	It1	1.93	1.22	.171*	.263*	.70	1.00	.000	.135*
Left margin widening	It2	1.17	.78	.051*	.048*	.51	.44	.030	.016
Alignment	It3	3.57	2.62	.199*	.317*	1.54	2.04	.001	.058
Word spacing	It4	2.73	2.78	.001	.055*	2.71	2.47	.003	.049
Collision	It7	.08	.41	.165* ¹	.001	.20	1.03	.074* ¹	.012
<i>Letter formation</i>									
Inconsistent letter size	It8	4.15	2.62	.384*	.190*	2.63	1.26	.174*	.155*
Incorrect letter height	It9	1.72	1.23	.136*	.288*	.81	.66	.008	.209*
Letter distortion	It10	.40	.66	.048* ¹	.183*	.49	.93	.017	.115*
Ambiguous letter forms	It11	2.36	2.89	.097* ¹	.324*	1.90	2.50	.021	.352*
<i>Fine-motor ability</i>									
Acute turns	It5	2.44	1.86	.092*	.226*	1.27	1.00	.017	.212*
Irregularities	It6	2.48	2.20	.023	.360*	1.64	1.63	.019	.123*
Correction letter forms	It12	1.02	1.11	.005	.240*	.73	.94	.000	.095*
Unsteady writing trace	It13	1.22	.54	.130*	.170*	1.13	.43	.272*	.307*

* $p < .05$; significant decline in item scores are coded with ¹.

dysgraphic writing ($F(2,166) = 6.307, p = .002, \text{partial } \eta^2 = .071$), and the interaction with group and test session was significant ($F(2,166) = 3.40, p = .036, \text{partial } \eta^2 = .039$). Post hoc analysis revealed that this interaction was due to a smaller increase in the number of letters in the *dysgraphic* children ($\Delta\text{Nletters} = 12.06$) than in the *at risk* ($\Delta\text{Nletters} = 22.7, p = .010$) and *normal* writing groups ($\Delta\text{Nletters} = 27.97, p = .006$).

In grade 3, no significant effects of test session (T1–T2) were found in handwriting speed ($F(1,67) = .058, p = .811$). Although there was a considerable increase (of 20.73) in the number of written letters in the large *normal* writing group (55 out of the 80 children) ($t(56) = 3.38, p = .001$), in contrast to a decrease (of 15.60) in the number of letters in the *at risk* subgroup and an equal number of letters in the four *dysgraphic* children, the interaction between test session and the handwriting subgroups was not significant (speed T1–T2*Grade: $F(2,67) = 2.48, p = .091$).

In grades 2 and 3, the correlations between T1 and T2 BHK speed scores were significant (grade 2: $r = .597, p < .001$; grade 3: $r = .359, p = .002$). With respect to gender, results of handwriting speed were comparable with the results of handwriting quality in grade 2. Overall, the girls outperformed the boys in speed of handwriting (grade 2: $F(1,167) = 12.08, p = .001, \text{partial } \eta^2 = .067$), but not in grade 3 ($p = .091$). No interaction between gender and test session was found.

3.4. Visual-motor integration

Mean VMI standard scores and correlations between BHK quality and VMI-SS are given in Table 1. All mean standard VMI scores were close to the average standard score (= 100) in grades 2 and 3 at T1 and T2. There was a small, but significant increase at T2 in grades 2 and 3 (grade 2: 4.68; $p < .001$; grade 3: 3.46; $p = .004$), due to a learning effect.

Significant differences between handwriting subgroups were only found in grade 2 ($F(2,165) = 4.80, p = .009$; grade 3: $F(2,67) = 2.847, p = .065$). Post hoc analysis showed that this difference (of 5.20 SS) was caused by the NW group versus the DW group ($p = .008$).

Significantly low correlations between the BHK quality scores and the standard VMI scores were found in grade 2 and at T1 in grade 3. Clustering on an item level (in conformity with the BHK) showed that in grade 2, the clusters *Letter Formation* and *Fine Motor Ability* had low correlations ($r = .136$ and $r = .133$, respectively). In grade 3, only the cluster *Organization of Written Work* had a low correlation ($r = .256$). There were no significant differences in the numbers of children with poor, normal, or good VMI-SS between the handwriting subgroups (grade 2: $X^2(4) = .283$; grade 3: $X^2(4) = .180$). Only 26% of the DW subgroup in grade 2 had poor VMI-SS, while only 11% of the NW group in grade 3 had good VMI-SS.

4. Discussion

This study tested the widely held belief that the proper time to assess the quality of children's handwriting is in the second half of grade 2. By that age, handwriting is assumed to have been mastered (i.e. during grade 1 and the first half of grade 2 and it is expected to remain stable from that time onwards). Contrary to this widely proposed hypothesis, the present study demonstrated considerable improvements in the quality of handwriting throughout grade 2 and even into the first half of grade 3, with stability being reached in the second half of grade 3. More importantly, the percentage of children who were classified as *dysgraphic* decreased strongly from 37% to 17% in grade 2 and diminished further to a low and stable rate of 6% in grade 3. It is also worth noting that stability in handwriting quality only occurred in the children with *normal* writing. The subgroups who were classified as *at risk* or *dysgraphic*, continued to show significant and substantial improvement during grades 2 and 3.

In this study, data were gathered from two large samples of 169 children in grade 2 and 70 children in grade 3 who were attending regular mainstream primary schools. The demographic variables of these children, as well as the prevalences of minor learning, behavioural or motor problems and the number of children who were receiving therapeutic assistance, were all within the normal range, which suggests that these samples were representative of the general population at mainstream schools.

4.1. 'At risk' and dysgraphic writing

The percentages of children with *normal* writing increased from 33% (T1) to 54% (T2) in grade 2, reached 80% in the first half of grade 3 and then remained stable during the rest of that grade. For the Dutch operationalization of the qualitative criteria of Developmental Coordination Disorder (DCD; DSM-IV-TR, APA, 2000) with respect to poor handwriting, a cut-off point of BHK ≥ 21 has been recommended, which includes the ranges of *at risk* and *dysgraphic* writing (see the Dutch version of the Leeds Consensus Statement [LCS], 2006). According to this norm, as many as 46% of our children would have fulfilled this qualitative criterion for handwriting-DCD at the proposed time of testing, i.e. in the second half of grade 2. The large improvement in quality observed during grade 2 and the first half of grade 3 indicates that it is not justified to label or classify handwriting as *at risk* or *dysgraphic* until grade 3. By this age, poor and illegible handwriting was less common and quality itself remained more stable, which resulted in no more than 14–16% of the children being classified as *at risk* and 6% as *dysgraphic*, based on their BHK quality score.

None of the studies that used the BHK to assess handwriting focused on children in grades 2 and 3 and observed the rapid improvement in handwriting found in the current study. Mostly, children in the second half of grade 2 and in grade 3 were combined into one group, as occurred in the study by Smits-Engelsman et al. (2001) on 125 children. These authors had 72%

of their children in grade 2 and found that 6% of their participants fell within the *dysgraphic* range, while another 27% were *at risk*. In our study, if we combined the scores obtained in the second half of grade 2 (71%) with the scores of grade 3, then 14% of our children would have been classified as *dysgraphic* and 25% as *at risk*. Thus, compared to the study by Smits-Engelsman et al. (2001), we had more than twice as many *dysgraphic* children.

In a study on children who were about two years older, Van Hoorn, Maathuis, Peters, and Hadders-Algra (2010) found lower percentages of children with poor handwriting (2% with dysgraphia and 19% *at risk*). These percentages were similar to those found in studies that used other instruments. Rubin and Henderson (1982) obtained data from 82 grade-4 teachers (representing approximately 2500 children) and found a lower percentage of children with 'serious handwriting problems' (12.3%). Maeland (1992) reported that 9.6% of their 10-year-old children had 'handwriting problems', while Karlsdottir and Stefansson (2002) classified 13% of their grade-5 children as having *dysfunctional* handwriting. These findings indicate clearly that handwriting should not be assessed during grade 2, but postponed until grade 3 or later.

4.2. Development of handwriting

In agreement with the studies on handwriting development by Hamstra-Bletz and Blote (1993) and Karlsdottir and Stefansson (2002) we observed considerable improvement in the quality of handwriting during grades 2 and 3, but only in the children with *at risk* or *dysgraphic* writing. Hamstra-Bletz and Blote (1993) reported that the children who had dysgraphia in grade 2 (10% of the sample) still had writing problems in the subsequent grades. More informative results were presented in the study by Karlsdottir and Stefansson (2002) on the development of handwriting from grade 1 to grade 5. These authors reported that handwriting quality increased rapidly during grade 1 and remained stable from grade 2 to grade 5, which was largely confirmed by our observations. However, these results only applied to the children with normal writing. Their *dysfunctional* writers made more gradual and weaker improvement from grade 1 to grade 5.

4.3. Analysis on a BHK item level

In contrast to most handwriting evaluation scales, the Concise Assessment Scale for Children's Handwriting (BHK) enables detailed scoring on 13 items (characteristics) divided into 3 clusters (see Table 2). Our BHK results showed that poor handwriting was not confined to a specific set of these 13 items. In grade 2, all of the items except for one contributed to differentiating between the three subgroups (*normal*, *at risk* and *dysgraphic*). In grade 3, this applied to nine out of the 13 items, eight of which belong to the clusters *Letter formation* and *Fine-motor ability*. In addition, the improvements in handwriting in grade 2 involved almost all the characteristics.

Please note that the names given to the three clusters only specify the visible product of the handwriting and its legibility. Therefore, they cannot be used as indications of the underlying deficits. Rubin and Henderson (1982), Maeland (1992) and Karlsdottir and Stefansson (2002) stressed that weak letter formation was the cause of reduced legibility in poor handwriting. Smits-Engelsman and Van Galen (1997) and Smits-Engelsman et al. (2001) presented additional kinematic data on children with handwriting problems that suggested deficits in fine motor control as the basis for poor handwriting.

4.4. Handwriting speed

It is generally assumed that handwriting speed increases as the grades progress. Speed increased in all three subgroups in grade 2 in the current study, but only in the NW group in grade 3. The *dysgraphic* subgroup in grade 2 had a significantly lower writing speed that discriminated them from the other subgroups. This might have been because these children needed to pay extra attention to their handwriting in order to produce their best effort. In grade 3, handwriting speeds did not differ between the three subgroups, which was in line with the results reported by Blöte and Hamstra-Bletz (1991) and Karlsdottir and Stefansson (2002).

4.5. Beery VMI as a screening instrument for handwriting quality

Although Beery and Beery (2004), one of the designers of the Beery Developmental Test of Visuomotor Integration (VMI), pointed out that the VMI was not intended to evaluate handwriting abilities, this test is widely considered to measure an integral component of skilled handwriting and has often been used in handwriting assessment. Our data showed that the VMI was unsuitable to screen children for dysgraphia. Although we found significant differences in VMI standard scores between the handwriting subgroups, all the VMI standard scores fell within the normal range (mean SS from 96 to 101). Significant but low correlations were only found in grade 2 and at T1 in grade 3. Then a non-significant correlation of $r = 0.11$ was seen at T2, which was the best time to assess the children for handwriting problems.

In a study on mainstream school children (two years older than our participants) Van Hoorn et al. (2010) found comparable VMI scores and the same lack of correlation with *dysgraphic* handwriting. Equally low correlations between handwriting quality and VMI performance were also reported by Karlsdottir and Stefansson (2003), Maki, Voeten, Vauras, and Poskiparta (2001) and Goyen and Duff (2005). This leads to the conclusion that the VMI is inappropriate as a screening instrument for handwriting difficulties.

4.6. The quality of handwriting in the past 20 years

The first mean BHK scores were reported by Hamstra-Bletz and Blote (1993) from a study on 121 children in grade 2. Their mean BHK score was 15.0 (Hamstra-Bletz & Blote, 1993), which was much better than our mean BHK score of 20.9 in a comparable group of 169 children. Their mean score in the poorest 10% of the children was 29, whereas in the present study, about 20 years later, the poorest 10% had a mean score of 32. In the publication discussed above, Smits-Engelsman et al. (2001) found only half as many *dysgraphic* children compared to the present study in their 125 children in grade 2 and grade 3. These findings all suggest that the quality of handwriting in grade 2 has declined over the past two decades. Given that our findings on handwriting quality in grade 3 did not seem to be at odds with earlier research, it might be suggested that factors related to the amount of time spent on handwriting or the quality of the lessons in grade 2 have changed over the past 10–20 years.

5. Conclusions and implications

The best time to screen for dysgraphic handwriting seems to be of crucial importance. In this study, the children had not reached their final handwriting quality level until the first half of grade 3. Thus, a diagnosis of dysgraphia and decisions about referral to a physiotherapist or occupational therapist (for remedial treatment of dysgraphia) must not be made too quickly and definitely not in the second part of grade 2, which is now common practice. As handwriting quality is an important criterion for the diagnosis of Developmental Coordination Disorder (criterion A; DSM-IV-TR, APA, 2000; see Leeds Consensus Statement [LCS], 2006) the course of dysgraphia and writing development should be taken into account. Children with *normal* handwriting reached a stable level in grade 2, but the children with handwriting problems (those *at risk*, or with scores in the *dysgraphic* range) continued to develop strongly during grade 2 and the first half of grade 3.

Our results showed that the VMI was inappropriate as a supplemental screening instrument for handwriting problems in young children. In line with the task-specific approach taken in assessment and therapy, handwriting should be measured with a handwriting instrument.

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