Journal of Motor Learning and Development, **(Ahead of Print)**
https://doi.org/10.1123/jmld.2023-0029

First Published Online: Jan. 30, 2024

Human Kinetics
ORIGINAL RESEARCH

The Handwriting Legibility Scale: A Language and Age Extension for Students With and Without Specific Learning Difficulties

Nichola Stuart,[1] Stefania Zoia,[2] Marina Biancotto,[3] and Anna L. Barnett[1]

[1]Center for Psychological Research, Oxford Brookes University, Oxford, United Kingdom; [2]Struttura Complessa Salute della Donna, Età Evolutiva e della Famiglia, ASUGI Area Giuliana, Trieste, Italy; [3]Struttura Complessa Disturbi del Neurosviluppo e Psicopatologia dell'Età Evolutiva, ASUGI Area Isontina, Monfalcone, Italy

Handwriting is a useful skill through education, yet handwriting difficulties are common in students with Specific Learning Difficulties (SpLD), including Developmental Coordination Disorder. There are few practical tools to assess legibility, among these the Handwriting Legibility Scale (HLS) shows good reliability and validity for 9- to 14-year-olds in the United Kingdom. The aims of the current study were to investigate applicability of the HLS in students with and without SpLD in (a) another language and (b) older age groups. First, the HLS was translated and applied to writing scripts of 193 9- to 14-year-olds in Italy. Findings support previous work on reliability and validity. A principal component analysis confirmed a single component for the HLS at this age and there was differentiation between scripts from students with and without SpLD. Second, the HLS was applied to writing scripts of 80 15- to 16-year-olds and 120 17- to 25-year-olds in the United Kingdom. Results showed good reliability and differentiation between scripts from students with and without SpLD. A principal component analysis revealed two components for the HLS in the older age groups. Language and age differences in the use of the HLS are discussed, alongside other considerations when applying the tool to help identify handwriting difficulties in students.

Keywords: DASH, assessment, motor skills development, developmental coordination disorder, dyslexia

Despite the increased use of technology (i.e., personal computers, laptops, tablets) in schools and colleges, handwriting continues to be an essential skill (Santangelo & Graham, 2016). The development of functional handwriting is important for progressing through the education system, as students need to

Zoia https://orcid.org/0000-0002-4596-1396
Barnett https://orcid.org/0000-0003-3800-9468
Stuart (nstuart@brookes.ac.uk) is corresponding author, https://orcid.org/0000-0002-2438-9669

produce legible writing, at a reasonable speed, and in the case of written tests and examinations, to do so under time pressure.

Students with handwriting difficulties are at a disadvantage. They may struggle to keep up with classroom demands and may underachieve in written assessments. When handwriting is effortful, greater cognitive resources are devoted to these lower level transcription elements, leaving less cognitive capacity for higher level aspects of text generation. For example, handwriting speed (letter production) has been found to constrain overall writing performance in school and university students (Connelly et al., 2005; Limpo & Alves, 2013; Limpo et al., 2017). Poorly formed handwriting that is difficult to read may also lead to lower self-esteem (Feder & Majnemer, 2007). It can also have an impact on achievement, as handwriting legibility has been found to affect how college student essays were evaluated, with more legible writing being evaluated more positively than less legible material (Greifeneder et al., 2010).

Typical and Atypical Handwriting Development

Two elements of handwriting performance have been mentioned above: speed and legibility. Speed refers to how quickly students can write and is usually measured as the number of letters or words produced in a specific time period (for one, 5 or 10 min). Legibility is more difficult to define but is generally linked to the "readability" of the writing as a whole, and to the ease with which the individual letters and/or words are recognized (Rosenblum et al., 2003; van Drempt et al., 2011).

Studies investigating the development of handwriting suggest that handwriting legibility and speed do not follow a parallel course in development (Gosse et al., 2021). Graham et al. (1998) in their study of children in Grades 1–9 (aged 6/7 to 14/15 years) in the United States, found that the development of handwriting speed is relatively steady, with a brief slowdown in the intermediate grades before reaching a plateau in Grade 9 as children start to reach the speeds typically obtained by adults. Similar results for handwriting speed have been found in Australia (Wallen et al., 1996) and in Ireland (Killeen et al., 2006). However, in the United Kingdom, Barnett et al. (2011) studying 17- to 25-year-olds, found improvements in handwriting speed performance in copying tasks continued but leveled off after the age of 18, while handwriting speed in production of the alphabet and on a free writing task continued to develop linearly up to 25 years of age. Sex differences in handwriting speed are also commonly reported, with females writing faster than males (Barnett et al., 2009, 2011).

In contrast, the development of handwriting legibility appears to level off much earlier than writing speed (Gosse et al., 2021; Loizzo et al., 2023). For example, in Graham et al.'s (1998) study, improvements in handwriting legibility were found primarily in the intermediate grades and were then maintained in Grades 7–9. Girls were also found to produce more legible handwriting than boys. There is less research on handwriting legibility in adults (van Drempt et al., 2011). It has been reported that younger adults write more legibly than adults over the age of 40 and that women write more legibly than men (Berwick & Winickoff, 1996; Schneider et al., 2006).

Most people, with appropriate teaching, develop effective handwriting skills allowing them to cope with writing demands through their education and into the workplace. However, handwriting involves the integration of cognitive, language,

perceptual, and motor skills and it is; therefore, not surprising that those with difficulties in these areas will struggle to develop efficient handwriting. There has been research to examine handwriting difficulties in various groups, perhaps most commonly in the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, Text Revision (American Psychiatric Association, 2022) diagnostic categories of Developmental Coordination Disorder (DCD) and in Specific Learning Disorder (which includes dyslexia and difficulties with reading comprehension, spelling, written expression, mastering number sense, and mathematical reasoning). In the United Kingdom, DCD and Specific Learning Disorder (including dyslexia) are included under the term "Specific Learning Difficulty" (SpLD). SpLD is a more commonly used term in education and with specialist teacher assessors (Woodcock & Moore, 2021). In 2021–2022, students with SpLDs accounted for 6.15% of the higher education (HE) student population in the United Kingdom and for 33% of the student population with a known disability (Higher Education Statistics Authority, 2023). Handwriting difficulties are commonly reported in SpLD, including DCD and dyslexia, from the early school years and into young adulthood (Barnett & Prunty, 2020; Rose, 2009). Handwriting is often slow, with shorter texts produced compared with peers (Connelly et al., 2006; Kirby et al., 2010) and legibility poor, with scripts being untidy, and sometimes hard to read (Alamargot et al., 2020; Rosenblum & Livneh-Zirinski, 2008). Adults with DCD and those with dyslexia also report difficulties in producing handwriting that is neat and fast enough to keep up with tasks (Mortimore & Crozier, 2006; Tal-Saban et al., 2014).

In DCD, these difficulties may largely stem from the motor control and coordination difficulties which are at the core of the condition, making it hard to manipulate the writing instrument and accurately control movement of the pen to form letters and move across the page. In dyslexia, difficulties with handwriting may stem directly from the reading and spelling difficulties at the core of this condition (Sumner et al., 2014; Kandel et al., 2017), with poor orthographic skills leading to dysfluency (pausing) between and within words. However, a suggested automatization deficit in dyslexia may also impact motor skills (Nicolson & Fawcett, 2011) and recent work has reported difficulties with the graphomotor elements of handwriting (Gosse & Van Reybroeck, 2020). Understanding the causes and mechanisms underlying the handwriting difficulties in DCD and dyslexia is complicated by the frequent cooccurrence of these two conditions and also cooccurrence with difficulties in attention and executive functions (Blank et al., 2019; Chaix et al., 2007).

While the causes of handwriting difficulties ("dysgraphia") continue to be investigated, it is clear that many students with SpLDs face particular challenges when it comes to having to write quickly and legibly. Indeed, it has been reported that up to 27% of school-aged children experience handwriting difficulties (Van Hartingsveldt et al., 2011). Laptops are often provided for access arrangements in class and examinations, but they are not always practical and can be distracting (Cramm & Egan, 2015). Furthermore, it has been found that writing by hand has some advantages in terms of the organization of thought (Aragón-Mendizábal et al., 2016). However, students with handwriting difficulties can struggle to produce written work to the required standard, which can lead to a reduction in both academic and, later, vocational achievement, and to a lowering of self-esteem (Dinehart, 2015; Dunford et al., 2005). This highlights the need to assess both speed and legibility of handwriting, to ensure that students with handwriting

difficulties are offered effective support to avoid academic underachievement and support their well-being.

Assessment of Handwriting

A variety of tools are available to assess different aspects of handwriting, which can help understand the range of difficulties in SpLD (see Rosenblum et al., 2003 for a review). Speed of production is relatively easy to measure, although the nature and demands of the writing task will impact the number of letters or words produced in a given time. Practical assessment tools to measure handwriting speed from the final written product are available for the classroom and clinic. For example, the Detailed Assessment of Speed of Handwriting (DASH; Barnett et al., 2007), with U.K. norms, measures speed of production across different writing tasks. This includes writing out the alphabet (for 1 min), copying a sentence (for 2 min in a "best" and "fast" condition), and a 10-min "free writing" text generation task (following a topic prompt). Letters/words per minute are recorded and a standard score can be computed for each task, as well as for an overall composite. Most other tests use short copying tasks only (e.g., Handwriting Speed Test, Wallen et al., 1996; Evaluation Tool of Children's Handwriting, Amundson, 1995; Minnesota Handwriting Assessment, Reisman, 1999). The Concise Evaluation Scale for Children's Handwriting (Beknopte Beoordelingsmethode Kinderhandschriften [BHK]; Hamstra-Bletz et al., 1987), first developed in the Netherlands, has been translated into several languages and is popular in other countries including France (Charles et al., 2003) and Italy (Di Brina & Rossini, 2012). A shorter version of the Beknopte Beoordelingsmethode Kinderhandschriften, the Systematic Detection of Writing problems has been developed (Systematische Opsporing Schrijfproblemen [SOS]; Van Waelvelde et al., 2012) and also translated into English (Smits-Engelsman et al., 2015).

In research settings, more detailed examination of the temporal and spatial features of the handwriting process have been examined using digitizing tablets. These can reveal inconsistency and dysfluency in letter production and pausing in the production of text. However, variation in the tasks and measures employed has led to mixed findings and there is some debate about the interpretation of temporal characteristics, such as pauses in handwritten text (Alamargot et al., 2020). Furthermore, this method has not yet been widely adapted for practical use in the classroom or clinic.

As noted above, aspects of "readability" or "legibility" of the written product are more difficult to define than "speed" and their assessment involves greater subjectivity. Some detailed tools have been devised to measure legibility. These include the Beknopte Beoordelingsmethode Kinderhandschriften and Systematische Opsporing Schrijfproblemen mentioned above, as well as the Spelling and Handwriting Legibility Test (Downing & Caravolas, 2023) for English. These tools are designed for quite restricted age ranges and for specific languages as they require writing to dictation or copying of specified sentences or paragraphs. They also tend to be time-consuming, require training, and the use of scoring templates. In contrast, the Handwriting Legibility Scale (HLS; Barnett et al., 2018) was developed to provide a quick and easy-to-use assessment of handwriting legibility that could be applied across different languages and scripts. The HLS is designed to

be applied to written content generated by the writer. It was originally based on the script produced from the 10-min "free writing" task of the DASH, described above. The assessor is required to rate five aspects of legibility, each on a 5-point scale (details are provided below), which are summed to produce a total score. Originally developed in the United Kingdom for children aged 9–14 years, the HLS is being used by practitioners in education and allied health to help identify those with handwriting difficulties and to plan how best to support students. Barnett et al. (2018) report good reliability and validity of the HLS in the 9–14 years age range. Significant differences were found between the writing from girls and boys and the HLS also clearly discriminated the handwriting of children with, and without, DCD.

As the HLS starts to be used more widely, the psychometric properties need to be examined across different groups. The HLS has already been translated and applied to scripts written by 10- to 14-year-olds in Hebrew (Fogel & Rosenblum, 2022) and 8- to 11-year-olds in Czech (Čunek et al., 2023). In the current study, we first look at the translation of the HLS into Italian and compare this with data from the U.K. 9- to 14-year-olds. Second, although the focus on handwriting is often restricted to primary and younger secondary school-aged children, handwriting continues to be important through secondary school. Beyond the age of 14 years, classroom demands continue to increase and, in the United Kingdom, high stakes written examinations (General Certificate of Secondary Education) take place at the age of 15–16 years. For students aged 17 years plus, moving into further and HE, computers, laptops, and tablets are often used to take notes and to produce assignments, reducing the requirement for daily practice in handwriting. However, handwriting skills are still important at this stage, particularly in exam performance where many exams are still required to be handwritten. In this study we; therefore, also consider the use of the HLS with students aged 15–25 years. In looking at extending the use of the HLS in a different language and in older English students, we also examined whether it was still sensitive to difficulties reported in handwriting in students with SpLDs, including DCD, in Italian and English.

Aims

The current study focused on use of the HLS. Typically developing Italian and English students were compared with a group of students with DCD and another group with SpLD. There were two main aims:

a. To examine the application and psychometric properties of the HLS to scripts written in Italian by 9- to 14-year-old students with and without SpLD, including DCD.
b. To examine the application and psychometric properties of the HLS to scripts written in English by 15- to 16-year-old students and 17- to 25-year-old students with and without SpLD, including DCD.

Methods

Free writing scripts were obtained from three samples of TD students: a younger group in Italy (9- to 14-year-olds) and two older groups in the United Kingdom (15- to 16-year-olds and 17- to 25-year-olds). In addition, there were students from

each country with and without DCD: younger students aged 9–14 years from Italy and older students aged 15–16 from the United Kingdom; and with and without other SpLDs: younger students aged 9–14 years from Italy with Specific Learning Disorder and older students aged 17–25 from the United Kingdom with dyslexia. All groups are described below.

Participants

Typically Developing Students

Italian Sample. Scripts from 193 TD children (101 male) aged 9–14 years (mean = 11) were examined (see Table 1). The children were recruited from four different primary and five secondary public schools in Friuli Venezia Giulia in Italy. Their school achievement level was judged by their teacher to be average, and none had a diagnosis of a Specific Learning Disorder or neurodevelopmental disorder.

U.K. Sample. Scripts from 200 students (100 male) aged 15–25 years (mean = 20) were examined. Scripts from participants aged 15–16 years were drawn from the United Kingdom stratified sample of 546 described in the DASH manual (Barnett et al., 2007). Those from the 17- to 25-year-old sample were drawn from the United Kingdom stratified sample of 393 described in the DASH17+ manual (Barnett et al., 2010). Participants were selected from a range of schools, colleges, and universities across the United Kingdom, including England, Scotland, Wales, and Northern Ireland. The number of participants is shown in Table 2.

Students With SpLD

As noted above, different terms are used within and across countries to refer to students with a SpLD/Specific Learning Disorder. This includes a range of more specific diagnoses, although these very commonly cooccur. Three different SpLD groups included in the study are described below:

DCD. Students with DCD were included in both the Italian and U.K. sample. In each country, the students had undergone a formal diagnostic assessment, meeting all Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition criteria for DCD. This included a score below the 16th percentile on the Movement Assessment Battery

Table 1 Number of Males and Females in the Italian Sample

Age	Male	Female	Total
9 years	11	13	24
10 years	32	35	67
11 years	18	13	31
12 years	17	8	25
13 years	16	15	31
14 years	7	8	15
Total	101	92	193

Table 2 Number of Males and Females in the U.K. Sample

Age	Male	Female	Total
15 years	20	22	42
16 years	19	19	38
Total (15–16 years)	39	41	80
17–18 years	21	20	41
19–21 years	20	20	40
22–25 years	19	20	39
Total (17–25 years)	60	60	120

for Children-2 (Movement ABC-2; Henderson et al., 2007) Test, parental report, and questionnaires describing everyday life motor difficulties and an absence of an intellectual deficit. In the Italian sample, scripts were examined from nine children (eight male) aged 10–14 (mean = 11). In the U.K. sample, scripts were examined from 10 participants (five male) aged 15–16 years (mean = 15) with DCD.

Specific Learning Disorder. Students with Specific Learning Disorder were included in the Italian sample. In Italy, the term "Specific Learning Disorder" is equivalent to "SpLD" in the United Kingdom. This includes children with dyslexia, dyscalculia, or spelling difficulties, with cooccurrence being very common. Children in this group, originally identified by a class teacher, were recruited through a Maternal and Child Health Service in Trieste (county seat of Friuli Venezia Giulia, Italy), where they had undergone a wide-ranging, multidisciplinary diagnostic assessment. Scripts from 39 children (25 males) aged 9–14 (mean = 12) were examined. Twenty-five children had a primary diagnosis of dyslexia, five had dyscalculia, and the remaining nine children had a primary diagnosis of spelling disorder. However, the assessment results showed that 85% (33/39) of the children had difficulties in more than one domain.

Dyslexia. Students with dyslexia were included in the U.K. sample. These students were reported to have dyslexia by the students themselves and by their support tutors. Scripts from 28 participants (11 male) aged 17–25 years (mean = 19) with dyslexia were examined.

For each of the above groups, a TD comparison group, matched on age and sex, was selected.

Measures

The HLS was applied to "Free Writing" scripts from the DASH/DASH17+.

Detailed Assessment of Speed of Handwriting

The Detailed Assessment of Speed of Handwriting (DASH) was used with the participants aged 9–16 years and the DASH17+ with the participants aged 17–25 years. The DASH (Barnett et al., 2007) and DASH17+ (Barnett et al., 2010) include four tasks to measure the speed of handwriting production, but for the

purpose of the current study only the scripts for the 10-min "free writing" task were used. In this task, the participant is required to write on the topic of "My Life." They are given some time before writing to generate ideas and writing prompts (presented as a "spider diagram") are available during the writing period. Students were instructed to write using their "everyday" handwriting on a sheet of lined paper and to write continuously for 10 min, marking their scripts every 2 min. The 15- to 16-year-olds completed the DASH individually; the 17- to 25-year-olds completed the DASH17+ in groups of 6–25 students. For the Italian sample, the spider diagram for the free writing task was translated into Italian. Trained test administrators followed the instructions in the manual to present the task.

Handwriting Legibility Scale

The HLS (Barnett et al., 2018) was applied to the writing produced in the first 6 min or at least 10 lines of handwriting. Handwriting was assessed using each of the five legibility criteria (*Global legibility, Effort required to read the script, Layout on the page, Letter formation*, and *Alterations to the writing*) using a 5-point Likert scale (from 1-*good* to 5-*poor*). The instructions for scoring emphasize the importance of gaining an "overall impression" of each of the criteria in deciding on scores for each component. Total scores range from 5 to 25, with higher scores reflecting poorer legibility. The establishment of a cut-off score for the HLS followed the procedure of using the representative sample group mean plus one *SD* (see Barnett et al., 2018). This is considered an appropriate method for establishing a cut-off for a screening tool (Cascio et al., 1988). This then allowed for the identification of whether a script fell into the high (indicating poor writing quality), medium (average), or low (good) category. Using Beaton et al.'s (2000) guidelines, the HLS was translated into Italian, followed by a back translation into the original language to verify the meaning of each criterion.

Training of Raters

The Italian and U.K. raters received training for scoring the legibility of the handwriting using the HLS. Sample scripts were calibrated and any discrepancies in the application of the criteria were discussed before the final scoring was done. In the U.K. sample, the first author independently scored 20 of the U.K. scripts. Total agreement between two raters for the total HLS score, following categorization of the scores into low, medium, and high, was 90% and interrater reliability using Cohen's kappa was good: $k = .77$ (95% confidence interval [.47, 1.07]) $p \leq .001$. For the Italian sample, total agreement between three raters who independently evaluated 34 of the scripts was 79% and Fleiss' kappa was good: $k = .67$ (95% confidence interval [.50, .84]) $p \leq .001$.

Ethics

Institutional research ethics approval was previously obtained for the DASH and DASH17+ data collection in the United Kingdom and institutional approval was obtained for the collection of the data in Italy. Informed consent was obtained from the participants and from the parent/guardian of children and adolescents aged 18 years and younger.

Data Analysis

The data from the Italian and U.K. samples were analyzed and reported in the same format as the HLS data for the U.K. 9- to 14-year-olds (Barnett et al., 2018). Following the presentation of summary statistics on the overall HLS scores, the data are presented in two sections. The first evaluates the reliability (internal consistency) of the HLS. The second evaluates the validity (construct and differential validity) of using the HLS and examines its use in differentiating sex and groups with DCD and other SpLDs compared with age- and sex-matched peers. The results from the Italian sample are reported first.

Analysis was conducted using SPSS (version 28, IBM Corp, 2021). In cases where variables were not normally distributed, nonparametric test results are reported. Effect sizes are reported following Cohen (1992) for independent group differences as small ($d = 0.2$), medium ($d = 0.5$), and large ($d = 0.8$). p values are reported following adjustment using the Holm–Bonferroni method to correct for multiple comparisons. The significance level for all statistical tests was taken as $p < .05$.

Results

The mean total HLS scores for each of the groups in the Italian and U.K. samples in this study, together with the mean score for the U.K. 9- to 14-year-old sample reported in Barnett et al. (2018) are shown in Table 3.

Italian Data: 9- to 14-Year-Olds

Reliability

Cronbach's (1951) coefficient alpha was used to establish internal consistency and whether the five criteria (*Global legibility*, *Effort required to read the script*, *Layout on the page, Letter formation*, and *Alterations to the writing*) were all measuring handwriting legibility. The Cronbach's alpha coefficient was .78 ($n = 193$) falling in the acceptable range. If *Layout* were removed Cronbach's alpha increased to .80.

Validity

Construct Validity. To examine the construct validity of the HLS, a principal component analysis (PCA) of the five component criteria was undertaken to establish whether using the HLS assessed one or more components of handwriting legibility. Examination of the scree plot and eigenvalues indicated a one factor solution was appropriate; this explained 53.34% of the variance. The item loadings on the factors are shown in Table 4.

Differential Validity: Sex. The HLS scores for 9- to 14-year-old Italian male and female students on each of the five criteria are shown in Table 5, with significantly higher scores found for males (indicating poorer legibility). The total HLS score was also significantly higher ($p < .001$) for the male group (mean = 10.50, $SD = 2.86$, range 6–20) than for the female group (mean = 8.36 $SD = 1.90$, range 5–13): $U = 6{,}727.00$, $p < .001$.

Table 3 Mean (*SD*) Total HLS Score for the TD and SpLD Groups in the U.K. and Italian Samples

	TD groups			SpLD groups								
				DCD			Dyslexia			Specific learning disorder		
	Total HLS score			Total HLS score			Total HLS score			Total HLS score		
Sample	*n*	Mean	*SD*	*n*	Mean	*SD*	*n*	Mean	*SD*	*n*	Mean	*SD*
U.K. samples												
9–14 years[a]	150	12.80	3.24	29	17.28	3.66	—	—	—	—	—	—
15–16 years	80	11.85	3.12	10	15.90	4.63	—	—	—	—	—	—
17–25 years	120	9.78	2.24	—	—	—	28	11.14	3.21	—	—	—
Italian sample												
9–14 years	193	9.48	2.67	9	14.89	2.03	—	—	—	39	12.36	3.96

Note. HLS = handwriting legibility scale; TD = typically developing; SpLD = specific learning difficulty; DCD = developmental coordination disorder.
[a]Reported in Barnett et al. (2018).

Table 4 Factor Loadings of the Five HLS Criteria in the PCA for the Italian 9- to 14-Year-Olds

	Factor loadings
Global legibility	0.88
Effort required to read	0.85
Letter formation	0.84
Alterations to the writing	0.52
Layout on the page	0.44

Note. PCA = principal component analysis; HLS = handwriting legibility scale.

Table 5 Mean (*SD*) Scores for Italian 9- to 14-Year-Old Males and Females

	Male ($n = 101$)	Female ($n = 92$)	*U*	*p*
Global legibility	2.05 (0.88)	1.61 (0.65)	5,934.00	<.001
Effort required to read	2.15 (0.89)	1.55 (0.62)	6,421.50	<.001
Layout on the page	1.43 (0.55)	1.13 (0.37)	5,962.00	<.001
Letter formation	2.88 (0.82)	2.40 (0.74)	6,065.00	<.001
Alterations to the writing	1.99 (0.69)	1.66 (0.61)	5,839.00	<.001

Differential Validity: DCD and Specific Learning Disorder in 9- to 14-Year-Olds. The total HLS scores for both the DCD group and Specific Learning Disorder group were significantly higher than their age- and sex-matched peers. For the children with DCD, their mean total HLS score was 14.89 ($SD = 2.03$, range 11–17) and for the age- and sex-matched group it was 9.33 ($SD = 2.87$, range 6–14), indicating significantly poorer legibility: $U = 5.000$, $p = .001$. The total HLS score for the group with Specific Learning Disorder (mean = 12.36, $SD = 3.96$, range 6–21) was also significantly higher than the age- and sex-matched group (mean = 9.79 $SD = 3.25$, range 6–20) indicating poorer legibility: $U = 465$, $p = .003$. Performance on the individual HLS criteria for the individuals in the DCD and Specific Learning Disorder groups and their age- and sex-matched group are shown in Table 6. Performance across all the criteria was higher for the students with DCD and Specific Learning Disorder (indicating poorer legibility), with statistically significant differences after correction for multiple comparisons in both groups for *Layout on the page* and *Alterations to the writing*.

U.K. Data: 15- to 25-Year-Olds

Summary data (means and *SD*s) for the total HLS scores obtained from the administration of the HLS for the different age groups in the United Kingdom are shown in Table 7.

Table 6 Mean (*SD*) Scores on the Five HLS Criteria for Italian 9- to 14-Year-Olds With DCD, Specific Learning Disorder and Age- and Sex-Matched Groups

	DCD				Specific learning disorder			
	DCD ($n = 9$)	Age and sex match ($n = 9$)	*U*	*p*	Specific learning disorder ($n = 39$)	Age and sex match ($n = 39$)	*U*	*p*
Global legibility	2.33 (0.87)	1.78 (0.83)	26.00	1.000	2.54 (1.07)	1.95 (0.99)	515.50	.053
Effort required to read	2.78 (0.83)	1.78 (0.67)	15.50	.122	2.49 (1.17)	2.10 (1.03)	611.50	.598
Layout on the page	2.89 (0.78)	1.56 (0.53)	7.50	.009	1.71 (0.68)	1.23 (0.43)	465.00	<.001
Letter formation	3.56 (0.53)	2.44 (0.88)	13.00	.071	3.28 (0.97)	2.69 (0.89)	512.00	.046
Alterations to the writing	3.33 (0.71)	1.78 (0.67)	5.50	.004	2.33 (0.74)	1.82 (0.72)	499.00	.019

Note. HLS = handwriting legibility scale; DCD = developmental coordination disorder.

Table 7 Total HLS Mean (*SD*) Score for the Different U.K. Age Groups

Age groups and total	Number (*n*)	Mean	*SD*
15 years	42	12.12	2.96
16 years	38	11.55	3.32
Total (15–16 years)	80	11.85	3.12
17–18 years	41	10.12	2.16
19–21 years	40	9.80	2.42
22–25 years	39	9.41	2.11
Total (17–25 years)	120	9.78	2.24

Note. HLS = handwriting legibility scale.

Although the total HLS mean score declines (reflecting better legibility) as age increases, these differences between the age groups were not statistically significant, 15- to 16-years-olds: $t(78) = .807$, $p = .422$; 17- to 25-year-olds: $F(2, 117) = 1.015$, $p = .365$.

Reliability

The Cronbach's alpha coefficient was .78 ($n = 80$) for the 15- to 16-year-old sample and .73 ($n = 120$) for the 17- to 25-year-old sample, both alpha coefficients falling in the acceptable range. If *Alterations to the writing* were removed, Cronbach's alpha increased to .85 for the 15- to 16-year-olds and to .78 for the 17- to 25-year-old sample.

Validity

Construct Validity. To examine the construct validity of the HLS, a PCA of the five criteria was undertaken for each sample to establish whether using the HLS with the two older age samples assessed one or more components of legibility.

The PCA for both groups revealed two components that had eigenvalues greater than one. For the 15- to 16-year-old sample, the two component solution explained 56.48%, and 20.02% of the total variance and for the 17- to 25-year-old sample 49.74%, and 21.75% of the total variance. For both samples, the varimax orthogonal rotation had *Global legibility*, *Letter formation* and *Effort required to read the script* in the first component and *Alterations to the writing* and *Layout on the page* in the second component (see Table 8).

Differential Validity: Sex. The total HLS score in the 15- to 16-year-old sample was significantly higher ($p < .001$) for males (mean = 13.08, $SD = 2.99$) than for females (mean = 10.68, $SD = 2.81$): $t(78) = 3.69$, $p < .001$ with a large effect size (Cohen's $d = 0.82$). The scores for males and females on the five criteria of the HLS are shown in Table 9. No significant difference was found on *Layout on the page* and *Alterations to the writing;* however, the differences on the other criteria remained significant after correction for multiple comparisons.

For the 17- to 25-year-old sample, there was also a significant difference between the mean total HLS score for males (mean = 10.53, $SD = 2.12$) and females

Table 8 Factor Loading of the Five HLS Criteria in the PCA for U.K. 15- to 16-Year-Old and 17- to 25-Year-Old Age Groups

	15- to 16-year-olds ($n = 80$)		17- to 25-year-olds ($n = 120$)	
	Rotated component coefficients		Rotated component coefficients	
	Component 1	Component 2	Component 1	Component 2
Global legibility	0.91	0.13	0.85	0.09
Letter formation	0.90	0.05	0.82	0.07
Effort required to read	0.90	0.16	0.88	0.18
Alterations to the writing	–0.01	0.93	–0.05	0.89
Layout on the page	0.46	0.50	0.37	0.66

Note. HLS = handwriting legibility scale; PCA = principal component analysis.

(mean = 9.03, $SD = 2.11$): $t(118) = 3.89$, $p < .001$ with a medium effect size (Cohen's $d = 0.71$). The scores for males and females on the five criteria of the HLS are shown in Table 9. However, only *Global legibility*, *Letter formation*, and *Alterations to the writing* were significant after correction for multiple comparisons.

Differential Validity: DCD in 15- to 16-Year-Olds. The total HLS score (mean = 15.90, $SD = 4.63$, range 8–23) for the group with DCD was significantly different to the age- and sex-matched group (mean = 10.90, $SD = 1.79$, range 8–13) indicating poorer legibility ($U = 14.00$, $p = .005$). Performance on the individual criteria for the individuals with DCD and their age- and sex-matched group are shown in Table 10. Performance across all the criteria was higher for the students with DCD, compared with the age- and sex-matched group, but these differences were not statistically significant after correction for multiple comparisons.

Differential Validity: Dyslexia in 17- to 25-Year-Olds. The total HLS scores (mean = 11.14, $SD = 3.21$) for the group with dyslexia was significantly different from the age- and sex-matched group (mean = 9.60, $SD = 2.33$) indicating poorer legibility, $t(54) = 2.050$, $p = .05$, with a medium effect size (Cohen's $d = 0.55$). Performance on the individual criteria for the individuals with dyslexia and their age- and sex-matched group are shown in Table 11. Performance across all the criteria was higher for the students with dyslexia except for *Alterations to the writing*; however, these differences between the groups were not statistically significant after correction for multiple comparisons.

Discussion

The HLS was first developed in the United Kingdom for children aged 9–14 years of age, to provide a quick and practical way of assessing handwriting legibility

Table 9 Mean (*SD*) Scores on the Five HLS Criteria for U.K. 15- to 16- and 17- to 25-Year-Old Males and Females

	15- to 16-year-old sample				17- to 25-year-old sample			
	Male ($n = 39$)	Female ($n = 41$)	*U*	*p*	Male ($n = 60$)	Female ($n = 60$)	*U*	*p*
Global legibility	2.41 (0.91)	1.71 (0.78)	465.00	<.001	1.88 (0.59)	1.60 (0.69)	1,349.50	.044
Effort required to read	2.92 (0.90)	2.34 (0.94)	525.50	.029	2.25 (0.73)	1.95 (0.65)	1,392.00	.081
Layout on the page	2.62 (0.71)	2.49 (0.87)	737.00	1.000	2.10 (0.68)	1.85 (0.61)	1,461.50	.213
Letter formation	3.08 (0.81)	2.41 (0.67)	450.00	<.001	2.58 (0.62)	2.23 (0.62)	1,269.00	.009
Alterations to the writing	2.05 (0.89)	1.73 (0.63)	652.50	.611	1.72 (0.56)	1.40 (0.53)	1,275.50	.009

Note. HLS = handwriting legibility scale.

Table 10 Mean (*SD*) Scores on the Five HLS Criteria for U.K. 15- to 16-Year-Olds With DCD and Their Age- and Sex-Matched Group

	DCD group ($n = 10$)	Age and sex match group ($n = 10$)	*U*	*p*
Global legibility	3.00 (1.33)	2.00 (0.67)	27.00	.446
Effort required to read	3.50 (1.35)	2.40 (0.70)	24.00	.262
Layout on the page	3.30 (0.95)	2.20 (0.63)	18.00	.073
Letter formation	3.60 (0.84)	2.60 (0.52)	17.00	.057
Alterations to the writing	2.50 (0.85)	1.70 (0.48)	14.00	.177

Note. HLS = handwriting legibility scale; DCD = developmental coordination disorder.

Table 11 Mean (*SD*) Scores on the Five HLS Criteria for U.K. 17- to 25-Year-Olds With Dyslexia and Their Age- and Sex-Matched Group

	Dyslexia group ($n = 28$)	Age and sex match group ($n = 28$)	*U*	*P*
Global legibility	1.96 (0.96)	1.61 (0.63)	319.00	.983
Effort required to read	2.29 (1.05)	1.89 (0.66)	298.50	.479
Layout on the page	2.39 (0.66)	2.00 (0.77)	283.00	.228
Letter formation	2.89 (0.79)	2.39 (0.63)	259.50	.091
Alterations to the writing	1.61 (0.74)	1.71 (0.54)	444.50	1.000

Note. HLS = handwriting legibility scale.

alongside an existing test of handwriting speed, the DASH (Barnett et al., 2018). In the original work, the HLS was found to discriminate between writing scripts from children with and without DCD, and to provide a useful tool for practitioners to identify poor handwriting, and describe the nature of the difficulties. The aim of the current study was to consider two extensions to the application of the HLS in students with and without SpLD. First, extension to a different language was studied by examining scripts written in Italian by 9- to 14-year-old TD students and two groups of students with SpLD, one in which students were diagnosed with DCD specifically, and the other in which they had been diagnosed with Specific Learning Disorder. Second, extension to older age groups was studied by examining scripts written in English by 15- to 16-year-old students and those aged 17–25 years, and a group of 15- to 16-year-olds with DCD, and a group of 17-

to 25-year-olds with dyslexia. Aspects of reliability and validity were examined to contribute to information on the psychometric properties of the tool.

Language Extension

No major changes were needed for the translation of the instructions for administrating and scoring the HLS into Italian. Raters found it easy to apply the HLS to scripts produced in Italian by school children aged 9–14 years. The Italian sample of 193 children was drawn from just four primary schools and five secondary schools in a single northeast Italian region. Although larger in number than the original U.K. HLS sample (Barnett et al., 2018), it was not representative of the whole country in terms of geographic region or other demographic variables. Nevertheless, the psychometric properties examined demonstrated very similar levels of reliability and validity as reported for the original U.K. sample. Internal reliability of the HLS was acceptable in the Italian sample (Cronbach's alpha .78) and improved if the criterion for *Layout on the page* was removed. This reflects the good internal reliability reported in the original U.K. data (.92) from 150 children.

In terms of the construct validity of the HLS, a PCA revealed a one factor solution for the Italian data, which explained 53.34% of the variance. This was similar to the analyses from the original U.K. data, which also indicated a single factor solution in this age group. In the Italian data, the criteria for *Alterations to the writing* and *Layout on the page* had the lowest factor loadings (0.52 and 0.44, respectively), whereas in the U.K. data the only criterion with a factor loading below 0.60 was for *Alterations to the writing* (0.41). It may be relevant here to note that in Italian classrooms, the aspects considered in *Layout on the page* (e.g., positioning of the margin, placement of letters on the baseline and spaces within and between words) are specifically taught. This contrasts with other aspects, such as letter formation, which do not receive specific attention.

The similarities in the data analyses from the original U.K. and current Italian samples lend support for the strong psychometric properties of the HLS as a measurement tool and demonstrate its applicability across different languages. Although the HLS was originally developed for and applied to written English, it was designed to be relevant across languages and scripts and is able to accommodate differences in languages. For example, while Italian and English both use a Latin-based alphabet, Italian has a relatively shallow (or transparent) orthography with a consistent mapping between sounds and the letters used to represent those sounds. Italian also consists of predominantly open consonant vowel (CV) syllables which contain few initial or final consonant clusters. In contrast, English has a deep orthography with an inconsistent mapping of sounds to letters and has both open CV syllables and closed consonant–vowel–consonant syllables which can contain complex consonant clusters. The orthographic depth and syllabic structure of a language has been found to effect the acquisition of literacy skills, with children speaking languages, such as Italian, being more accurate and fluent in single real-word and nonword reading at the end of their first year of school than children learning languages like English (Seymour et al., 2003). The orthographic depth and syllabic complexity of a language may also impact the legibility of writing and may explain why *Alterations to the writing* had a lower factor loading in the Italian data as "alterations" to letters in Italian may have less impact on legibility. The

predominance of open syllables with fewer consonant clusters may also result in less effort being required to read scripts. Interestingly, in the Italian data, although performance across all the HLS criteria was higher for the students with learning difficulties, this was not statistically significant for the criterion *Effort required to read the script*. This finding might relate to the fact that words with poor letter formation are easier to decipher in Italian compared with English due to the more transparent nature of the Italian language and its less complex syllabic structure.

The HLS has been translated and used in other languages, including Hebrew (Fogel & Rosenblum, 2022) and Czech (Čunek et al., 2023). Although the studies in Hebrew and Czech used the HLS on different writing tasks, the findings further support the reliability and validity of the HLS in languages other than English. Significant differences were found for students aged 10–14 years with Executive Function difficulties compared with TD controls (Fogel & Rosenblum, 2022). Furthermore, Čunek et al. (2023) report for students aged 8–11 years, a one factor solution for the HLS, high internal consistency, and interrater reliability of the HLS. They also report significantly higher scores for males than females and significant differences in children with and without handwriting impairment. The strong psychometric findings now available across countries further support the recommendation by Čunek et al. (2023) of the HLS as a good choice for practitioners.

Age Extension

The HLS was originally developed for primary and early secondary aged children (Barnett et al., 2018) and its potential value for use with this age group is supported with the above language extension for Italian. Although there is evidence that some aspects of handwriting speed continue to develop beyond this age, it has been suggested that there may be less change in legibility of handwriting in the later school years. However, some secondary school-aged children do struggle with handwriting (Alves & Limpo, 2015; Christensen, 2005) and students with SpLDs (including DCD and dyslexia) have difficulties in this area that persist through school and into early adulthood. The second aim of the current study was, therefore, to examine the applicability of the HLS to two older age groups.

The U.K. 15- to 16-year-old sample was taken from the DASH standardization sample and the 17 to 25-year-old from the DASH17+ standardization. The Cronbach's alpha coefficient was similar for the younger and older sample (.78 and .73, respectively), both falling in the acceptable range. If *Alterations to the writing* were removed Cronbach's alpha increased to .85 for the younger and .78 for the older sample. This reflects the good internal reliability reported in the original U.K. data (.92) from younger children aged 9–14 years.

The construct validity of the HLS was tested to check that it was still measuring the construct that it was designed to measure. Barnett et al. (2018) found a single component model for the HLS explained 61% of the variance with lower component loadings for *Layout on the page* (0.68) and *Alterations to the writing* (0.41). However, in the current study, for both older age groups the PCA revealed two components, in both cases around 50% for one component and 20% for the other. For both samples, the first component included *Global legibility*, *Letter formation*, and *Effort required to read the script* and the second component included *Alterations to the writing* and *Layout on the page*.

These findings suggest that *Layout on the page* and *Alterations to the writing* may not be measuring the same things as *Effort required to read the script, Global legibility*, and *Letter formation.* The presentational features of the layout on the page and number of alterations appear to be not so critical for these older TD groups in determining legibility. The interpretation of the data was consistent with the effort required to read the writing, the overall impression of legibility, and the formation of the individual letters as being most important in establishing handwriting legibility in both the 15- to 16-year-olds and 17- to 25-year-olds.

Differential Validity—Sex

Further aspects of validity of the HLS were examined in the current study by looking at group differences, first with a focus on sex. Lower legibility for boys compared with girls has been a consistent finding in the literature on handwriting (Barnett et al., 2007 ; Graham et al., 1998) and has also been found in adults (van Drempt et al., 2011). The current study found a similar pattern in the Italian data on 9- to 14-year-olds, and the U.K. data on 15- to 16- and 17- to 25-year-old age groups. In each case, males exhibited significantly poorer performance for overall legibility than the female participants. This significant difference was also seen in some of the individual HLS criteria, although with a slightly different pattern across the age groups. These findings build on the original HLS study reporting sex differences in 9- to 14-year-olds in the United Kingdom (Barnett et al., 2018), extending them to a different language and across a wider age range.

Differential Validity—SpLD

Finally, differential validity was also examined by looking at the performance of three different SpLD groups: DCD, Specific Learning Disorder, and dyslexia. Two small groups with DCD were examined, and in both the Italian 9- to 14-year-olds and the U.K. 15- to 16-year-olds, the performance of the DCD group was significantly poorer than that of their age- and sex-matched peers in terms of their overall handwriting legibility scores. This extends the findings reported in the original HLS study in the United Kingdom (Barnett et al., 2018), where a group of 9- to 14-year-old children with DCD had significantly poorer total HLS scores compared with an age- and sex-matched comparison group. Regarding the individual HLS criteria in the DCD groups, differences are seen across language and age. While in the original U.K. study, significant group differences were reported across all HLS criteria, in the Italian DCD group in the current study, only the scores for *Layout on the page* and *Alterations to the writing* were significantly different to their age- and sex-matched peers. As noted above, these differences may be explained by language differences (as the same differences are seen for the Italian Specific Learning Disorder group). Alternatively, these aspects may relate to the difficulties in planning and organization typically found in DCD, emphasized by Rosenblum (2013). Statistically significant differences in the HLS criteria were not found in the older 15- to 16-year-old DCD group in the United Kingdom. This may be because as children with DCD get older, the difficulties change and may be more subtle. Further investigation is needed across different age groups

with DCD to determine any developmental trends in the HLS criteria and whether these match the differences in the PCA between younger and older TD groups.

While difficulties with handwriting performance are found in children with DCD (Ibana & Caçola, 2016), handwriting difficulties are also reported in other SpLDs. The current study found a similar pattern of performance on the HLS in the Italian group of children with Specific Learning Disorder and an older group of U.K. students with dyslexia, where both groups had a total HLS score significantly higher than their age- and sex-matched peers. In the Italian group of 9- to 14-year-olds with a diagnosis of Specific Learning Disorder, significant differences on the *Layout on the page* and *Alterations to the writing* criteria were also found.

In the United Kingdom, a group of 17- to 25-year-olds in further and HE with a diagnosis of dyslexia were also examined. There are now increasing numbers of students with developmental dyslexia entering HE, with many of these students also experiencing difficulties with handwriting speed and legibility. Not all of these students will have been assessed as children and it is important to develop sensitive measures so that these students' difficulties are identified and that they receive appropriate support. Assessment of phonological processing tasks, spelling, nonword reading, short-term memory, and writing speed have been found to reliably discriminate college students with dyslexia from nondyslexic students (Hatcher et al., 2002). In the current study, a small group with self-reported dyslexia was compared with a group of age- and sex-matched peers. The group with dyslexia had poorer performance on all criteria and performance on the total HLS score was significantly different to the age- and sex-matched group.

Taken together, these findings suggest that the HLS is sensitive enough to show differences in groups of children with various types of learning difficulties. Future work is needed to continue to examine aspects of reliability and validity of the HLS across different ages and in groups of individuals with different developmental disorders. For practitioners, the HLS offers a quick and easy checklist for investigating the legibility of written text compared with other available tools (e.g., BKH, Systematische Opsporing Schrijfproblemen) and can be used by a range of practitioners. It also allows the practitioner to establish first whether there is a difficulty with handwriting legibility. Second, if there is a difficulty, a referral for further clinical evaluation can be made and/or a more detailed assessment of handwriting difficulties can be undertaken. In either case, it is also important to consider broader aspects of performance and potential cooccurring difficulties. This will provide a more holistic understanding of the capabilities of the individual and presenting difficulties, allowing for appropriate support to be implemented.

Limitations

The current findings need to be considered in the light of a number of limitations. First, there are some limitations relating to the samples employed. The U.K. samples of 15- to 16- and 17- to 25-year-olds may be considered representative of the United Kingdom at the time of data collection, as they were part of the DASH and DASH17+ normative samples, carefully selected from schools, colleges, and universities across the United Kingdom. However, the Italian data collection was based on recently collected samples of Italian school children, although these could

not be described as representative as they came from only one region in Italy. Four groups of students with SpLD were described in the current study: the children in the DCD groups in Italy and in the United Kingdom had a formal diagnostic assessment and met all Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition criteria for DCD, the Italian Specific Learning Disorder group underwent a full diagnostic assessment, while the other U.K. group self-reported as having dyslexia.

Although we have suggested that the findings support the use of the HLS in its current form with older students, further work is needed to establish what is an appropriate cut-off point to denote "poor legibility." When first developed, categories were suggested for children aged 9–14 years to denote good, average, and poor performance based on the average range within this younger age group. Further validation is needed to support this and to establish appropriate categories for the older age groups.

Conclusions

The current study provides further support for the use of the HLS as a quick, practical tool to identify difficulties in handwriting legibility. The validity of the HLS for identifying handwriting difficulties was originally established in children with DCD. The current study, which included samples of children with DCD, and other SpLD groups, as well as older students in the United Kingdom, provides support for its use more widely in identifying handwriting difficulties in SpLDs. The frequent cooccurrence of different SpLDs means that a broad assessment is often needed to understand the range of difficulties. Speed and practicality are, therefore, important in assessment tools in order to optimize what can be achieved in a single assessment session. The current study also adds to the growing body of work demonstrating the use of the HLS in languages other than English and the importance of continuing to study the use of the HLS across languages. In addition, findings demonstrate that the HLS can be used in older secondary school-aged children and in young adults aged 17–25 in education. Examination of reliability and validity support, and extend, earlier findings (Barnett et al., 2018), demonstrating good psychometric properties of the HLS. The HLS can, therefore, be recommended as a useful tool to help identify poor handwriting legibility in children and young adults and across different languages.

Acknowledgment

We are grateful to Karen Gurney for HLS scoring of the scripts from the United Kingdom.

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