The Braille Reading Skills of German speaking Students and young Adults with Visual Impairments

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Abstract

This study aims to investigate the literacy skills of braille readers in the areas of reading fluency, reading and listening comprehension, and spelling. A total of 119 German-speaking, braille readers aged between 11.0 and 22.11 years were tested for this purpose. Data collection was carried out using a questionnaire, psychometric tests and self-constructed assessments. Wherever possible, the results were compared with the standards of sighted peers. Regarding reading fluency, braille readers performed significantly slower than print readers. In terms of spelling, the braille users performed within an average range of sighted peers. Furthermore, a positive correlation was obtained between braille reading fluency and spelling, whereas the use of auditory aids (e.g. speech output) showed a negative correlation with braille reading fluency and spelling. In addition, a comparison between listening and reading within the study sample revealed that reading braille proved to be better for comprehension, although listening was significantly faster. In conclusion, the findings provide evidence that braille reading skills are important for the development of literacy skills in general. Nevertheless, listening skills are important and need to be systematically promoted.

Keywords: *Braille, literacy competencies, reading, reading fluency, reading speed, spelling*

Introduction

Visual impairments are relatively rare in industrialised countries and occur much more frequently in advanced age than in childhood and adolescence (Garber & Huebner, 2017). Summarised for Germany, Austria and Switzerland, about 300.000 people with blindness and severe visual impairment (according to ICD-10) can be assumed (cf. Lang & Thiele, 2020), although people with multiple disabilities are generally insufficiently taken into account in such figures. In Germany, 9.385 students received official support specifically for students with visual impairments in 2018 (Kultusministerkonferenz [KMK], 2020). Of these students, 4.590 (48.9%) attended special schools and 4.795 (51.1%) attended mainstream schools. The parallel availability of special schools and inclusive school forms also exists in

Austria and Switzerland. Students in inclusive schools are supported and advised by teachers of students with visual impairments (TSVIs).

Four different braille systems are currently used in German-speaking countries (see Table 1):

- Computer braille is an 8-dot uncontracted braille system with 256 possible dot combinations that was developed in the 1980s for computer coding on electronic devices. In computer braille, every sign is explicit with a clear 1:1 correspondence to print. Thus, no indicator signs were used (e.g. capital letter signs or numeric signs). Today, computer braille is also used for educational purposes. In some special schools and often in inclusive settings, it is the first braille system learned. To teach computer braille on paper, special 8-dot braillers are used.
- German basic braille (6-dots, uncontracted) is the easiest braille system to learn, as it has no contractions and only lowercase letters.
- German standard braille (6-dots, with a few contractions) is based on basic braille, except that it uses eight group signs for frequently used letter combinations (e.g. st, au, eu, ei, ch, sch, äu, and ie).
- German contracted braille (6-dots, fully contracted) further extends standard braille. It is the most comprehensive German braille code and includes approximately 300 contractions (e.g. group signs and word signs). Usually, the capitalization of text is omitted.

Table 1

Variants of the German braille code

Print	Computer braille ⣿	Basic braille ⠿	Standard braille ⠿	Contracted braille ⠿
1 2 3	⠡ ⠣ ⠩	⠼⠁ ⠼⠃ ⠼⠉	⠼⠁ ⠼⠃ ⠼⠉	⠼⠁ ⠼⠃ ⠼⠉
a b c	⠁ ⠃ ⠉	⠁ ⠃ ⠉	⠁ ⠃ ⠉	⠁ ⠃ ⠉
A B C	⡁ ⡃ ⡉	⠁ ⠃ ⠉	⠨⠁ ⠨⠃ ⠨⠉	⠁ ⠃ ⠉
der	⠙⠑⠗	⠙⠑⠗	⠙⠑⠗	⠗
die Maus	⠙⠊⠑ ⡍⠁⠥⠎	⠙⠊⠑ ⠍⠁⠥⠎	⠙⠬ ⠨⠍⠡⠎	⠬ ⠍⠡⠎
auf	⠁⠥⠋	⠁⠥⠋	⠡⠋	⠡

There are widespread international fears about the loss of significance of braille, as the mostly inexpensive and quickly created auditory accesses to information appear to be faster, less strenuous and less practice-intensive than haptic reading (Carey, 2012; National Federation of the Blind [NFB], 2009; Tobin & Hill, 2015). Indications of an increased use of auditory access to information at the expense of haptic reading are available from France (Coudert, 2012). In other European countries and the USA, concerns are expressed about the future of braille, whose use appears to be declining (e.g. declining demand for printed braille books) (Bell, 2009; Danish Association of the Blind et al., 2018). In a study carried out in Germany and Switzerland among 819 braille readers (age: 6-89 years) almost all participants considered braille as vitally important (Hofer et al., 2016). There was no indication of a preference for auditory access to information over the conventional braille medium. Furthermore, the results showed that digital braille (e.g. on a refreshable braille display) and auditory aids (e.g. speech-output) are predominantly used together.

There are few recent studies on reading and writing skills of braille users. In the course of the Alphabetic Braille and Contracted (ABC) Braille Study carried out in 2002-2007 in fifteen states of the USA and one province of Canada, it became clear that students with visual impairments had difficulties in building up a reading vocabulary in comparison to sighted children (Emerson et al., 2009). Writing skills analyses showed that most writing errors were of a general nature and only about 13% could be described as "braille-specific" (e.g. missing dots, dot confusion) (Erin & Wright, 2011). With regard to braille reading, there is a broad consensus that, in analogy to visual reading, larger units of perception can be formed than individual letters, since in both writing systems alphabetic words are recognised faster than non-alphabetic words (Millar, 1997) and frequent used words are easier to read than rare ones (Carreiras & Alvarez, 1999; Hughes, 2011). Studies suggest the direct access to an internalized reference also for braille reading, although it is still largely unclear how this is done or which form of representation forms the basis of the internalized reference. It is possible that phonological processes could play a more important role here than in visual reading (Millar, 1997; Veispak et al., 2013). Recent data on the reading speed of braille readers of different ages (Laroche et al., 2012; Legge, 2007; Wright et al., 2009) confirm the previous findings that the reading speed in braille is about two to three times slower than that of print among people without visual impairment (Lang, 2017; Kamei-Hannan & Ricci, 2015). In a comprehensive study of the reading speed of German-speaking children without visual impairments, Klicpera and Gasteiger-Klicpera (1993) determined an average value of 80 wpm (words per minute; all words read were counted) for oral reading for the 2nd grade, 110 wpm for the 3rd grade and 130 wpm for the 4th grade. Adults without visual impairment read on average about 250-300 wpm in silent reading (Rosebrock et al., 2017), while oral reading is significantly slower with an average of about 160-170 wpm. According to Wright et al. (2009), in their study for braille reading students in the 2nd grade (*n*=28), the average value in oral reading was 45 wpm, in the 3rd grade (*n*=19) 51.2 wpm and in the 4th grade (*n*=9) 50.2 wpm. However, it should be noted that only correctly read words were counted in this study. In terms of reading speed, reading accuracy and reading comprehension, Kamei-Hannan and Ricci (2015) report that children with visual impairments are about two years behind the development of sighted children because of limited braille learning opportunities. Isolated research results indicate that haptic reading supports the development of spelling skills more than auditory text access. Papadopoulos et al. (2009) showed that subjects with visual impairments who used braille as their main medium achieved better spelling skills than those who used mainly auditory media. In a survey conducted in the USA, self-involved teenagers and young adults emphasised the importance of braille reading for correct spelling (D'Andrea, 2012), but at the same time rated working with speech output as faster and more efficient. A few years earlier, Erin et al. (2006) reported a similar finding. The research team compared the test-scores and required completion times in written and oral format between high school students with blindness, low vision and sight. According to their results, the nine braille users in the study achieved higher test scores (statistically not significant) when reading but completed the test faster when listening.

For the German-speaking countries, there are no current data on literacy skills. Several research questions appear to be of particular importance:

1. How fast is braille-reading in comparison to print-reading and what results are achieved in the reading fluency?
2. Are there differences in comprehension depending on whether a text is read or listened to?

3. How are reading comprehension and reading speed in braille related?
4. Are there differences in spelling skills between users of print and braille?
5. Does the extensive use of speech output influence reading and spelling skills?

The study presented below attempts to find answers to these questions.

Methods

Design and data collection

The study is part of a mixed-methods project on basic research in the field of literacy skills and Assistive Technology (AT). This section presents the results of the quantitative part using a questionnaire and several formal and informal assessments (e.g. on reading fluency, reading and listening comprehension, and spelling). The data were analyzed using descriptive and inferential statistics. The research was approved by a university ethics committee. Approvals from the participating countries were obtained for the implementation of the study.

The study was conducted over a period of 10 months (03/2017 to 12/2017) in Germany, Austria and Switzerland. All braille users aged 11.0 to 22.11 years were eligible to participate. The assessments were conducted with the personal AT either at school, at the place of training or study or in the home environment of the participants and carried out by trained team members from the research project. An average data-collection lasted 3 hours.

Materials

A questionnaire was developed to collect data on visual impairment, school and learning biography, use of Assistive Technology and reading and writing habits. Standardised procedures were chosen to measure literacy skills. For the areas of reading fluency and spelling, diagnostic instruments with standard values for test persons without visual impairment could be adapted. The review of existing test materials by the research team showed a lack of standardised methods for measuring reading comprehension and listening comprehension in Germany. For this purpose, an informal, self-constructed, diagnostic procedure have been developed by the research team, which differentiate according to grade levels in terms of text difficulty and text length. These self-developed test procedures were previously tested and evaluated in a pilot project with persons who are visually impaired and of different age groups. The participants answered a total of 16 questions on four text sections, which were offered as reading or listening texts. Answers were evaluated and awarded 0, 1 or 2 points. Criteria for the awarding of points were determined and made more precise by means of sample answers after the pilot phase. Using both methods (reading and listening comprehension), values for reading and listening speed were determined simultaneously. Table 2 gives an overview of the test procedures used.

Table 2

Test materials used

Competency	Assessments	Description	Unit
Reading fluency	SLRT-II [Salzburger Lese- und Rechtschreibtest], Moll & Landerl, 2014	reading test from the SLRT-II; standardised and normed procedure	wcpm[1] (word reading)
Reading comprehension and speed	LVG [Leseverstehen und Lesegeschwindigkeit]	informal, standardised test; designed by the project team	comprehension points (0-32); wpm[2] (text reading)
Listening comprehension and speed	HVG [Hörverstehen und Hörgeschwin-digkeit]	informal, standardised test; designed by the project team	comprehension points (0-32); wpm (text listening)
Spelling	HSP [Hamburger Schreibprobe], May et al., 2016	standardised and normed procedure	t-values[3]

[1] wcpm = words correct per minute
[2] wpm = words per minute
[3] *t*-values = standard value with a mean of 50 and a standard deviation of 10

Participants

The sample of 119 braille readers was selected from a total of 190 participants. For the purpose of this study, participants who used print and braille (dual-media) were excluded as well as participants with additional disabilities. Table 3 shows the main characteristics of the 119 braille readers. Possible deviations in the sample size in the presentation of results are explained by specifications in the standardization levels or by participants who have not completed individual test procedures.

Table 3

Sample characteristics

Variable	Braille readers number (%)
Sample size	119
Gender	
Male	57 (47.9)
Female	62 (52.1)
Visual impairment	
Severe visual impairment[1]	26 (21.8)
Blindness[2]	93 (78.2)
Place of school	
Inclusive school	24 (20.2)
Switching school	37 (31.1)
Special school	56 (47.0)
Different type of school	2 (1.7)
Age in years (M)	15.5
Lifetime braille use (M)	8.0
Starting age of formal braille instructions (M)	7.0
Learned braille systems	
Computer braille	112 (94.1)
Standard	119 (100)
Contracted	96 (80.7)

[1] *Visual acuity ≤ 1/20 to exclusively 1/50 (*Definition according to ICD-10-GM 2018)

[2] *Visual acuity ≤ 1/50 (*Definition according to ICD-10-GM 2018)

Results

Reading fluency

The competency of accurate, automated and error-free decoding of words with prosody is called reading fluency (Rasinski, 2004). It is an important prerequisite for higher reading performance and is regarded as a characteristic from which generalising conclusions can be drawn about other literacy competencies (Rosebrock et al., 2017). Fast and error-free word identification can significantly promote reading comprehension (Moll & Landerl, 2014).

The reading fluency was measured using the one-minute reading fluency test from the SLRT-II. The procedure is standardised and normed. There are norms for grades 1-6, and those attending higher grades are recorded in the norming level for young adults (> grade 6). Using word lists of increasing difficulty, the test measures oral word reading performance in the unit words-correct-per-minute (wcpm). The participants in this subsample all read version A in braille on paper (optionally in standard, computer or contracted braille).

Figure 1 and Table 4 show the average performance of the reading fluency in the grade levels examined. The comparison with the norming sample shows that the results of the study sample are far below those of children and adolescents without visual impairment (factor 2.4 to 3.1), whereby the greatest difference is found among the oldest participants.

With the exception of grade 5, all results of the study sample are below the value achieved by 1% of the slowest readers of the norming sample. Furthermore, multiple one-sample *t-tests* showed that the mean differences between the norms and the study sample were statistically significant for every grade level (p values always $< .05$).

Figure 1

Reading fluency of the norming sample and the study sample

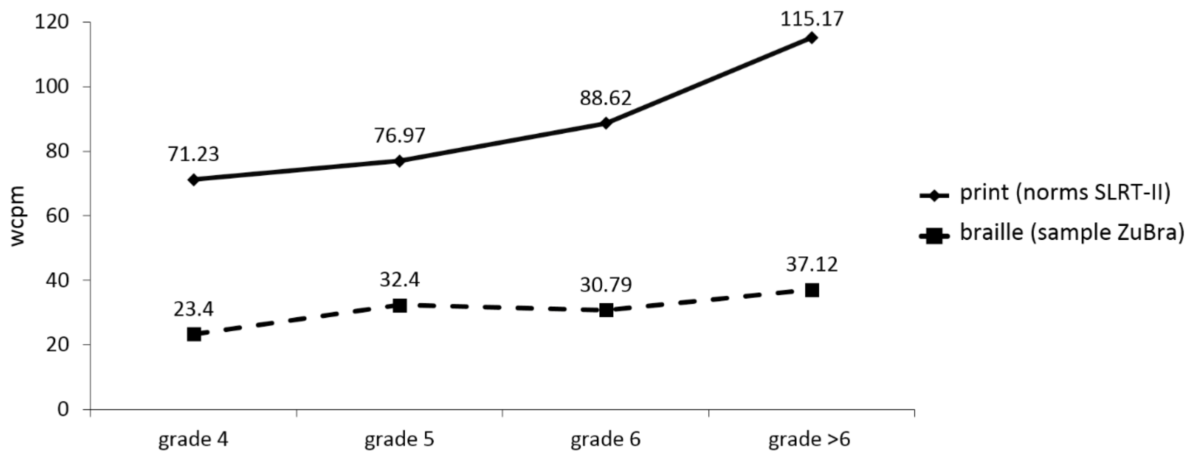


Table 4

Reading fluency of the norming sample and the study sample

Grade	Norming sample[1]	*M*	*SD*	Braille readers	*M*	*SD*	Where the study *M* fits
Grade 4	212	71.23	19.28	5	23.4	2.41	<1%
Grade 5	144	76.97	19.27	18	32.4	12.36	1-2%
Grade 6	136	88.62	17.55	14	30.79	13.05	<1%
Grade >6	121	115.17	19.50	82	37.12	12.18	<1%

[1] cf. Moll & Landerl (2014)

Effects of early and prolonged use of braille on reading fluency

Is there an influence on reading fluency depending on when the acquisition of braille began and how long the use of braille lasts? A multiple regression was run to predict the reading fluency from the two variables '*lifetime braille use*' and '*starting age of formal braille instruction*'. Both were measured in years and the reading fluency in the unit of words correct per minute (wcpm). A significant regression model was found (F(2.116) = 23.899, p < .001) with an R^2 of .279, which means that 28% of the variance can be explained by the two variables. The reading fluency increases by an average of 1.178 words per minute per year of braille use and decreases by -1.586 words per minute with increasing starting age of formal braille instructions. Both variables, '*lifetime braille use*' (p < .001) and '*starting age of* *formal braille instructions*' ($p < .001$), are significant predictors of reading fluency (see Table 5). The variable '*lifetime braille use*' contributed the most to the prediction. This leads to the conclusion that the earlier the braille instructions start and the longer the use of braille lasts, the better values can be expected in the reading fluency.

Table 5

Multiple linear regression analyses for the prediction of reading fluency in braille

Groups and variables	*B*	Std. Error	Beta	*t*	*p*
Braille readers only (*n*= 119)					
- *Lifetime braille use*	1.178	0.306	0.331	3.848	< .001
- *Starting age of formal braille instructions*	-1.586	0.439	-0.311	-3.614	< .001

Influence of auditory aids on the reading fluency

The questionnaire of the study also asked about usage habits in different reading and writing situations (e.g. What do you choose when you want to read a text as quickly as possible? What do you choose if you want to understand a text as well as possible? etc.). In this respect, the participants should indicate the braille system, the reading medium (paper or digital text), but also the use of speech output or input. Subsequently, the frequency with which study participants use auditory aids in reading or writing situations was counted. This frequency varies from no use to a maximum use of 14 responses, which is equivalent to using speech input or output in almost all reading and writing situations.

Using Spearman's rank-order correlation it was examined whether the increased use was accompanied by a decrease in reading fluency. A weak, negative, significant correlation was found ($r_s(119) = -.232$, $p = .011$).

This means that in many cases, the increased use of auditory aids correlates with lower levels of reading fluency. Consequently, an extraordinary use of auditory aids can have a negative influence on the reading fluency.

Reading speed and listening speed

The reading speed was measured using short, age-appropriate texts from the self-constructed reading comprehension test [Leseverständnis und -geschwindigkeit, LVG]. The texts could be read optionally in standard, contracted, or computer braille on a refreshable braille display as well as on paper. The measured speeds are average values of silent text reading measured in words per minute (wpm).

Table 6

Results of reading speed and listening speed

Grade	Participants	Reading speed		Participants	Listening speed	
	LVG	*M*	*SD*	HVG	M	SD
Grade 4-5[1]	5	39.00	14.10	5	160.20	29.50
Grade 5-6	32	50.50	25.26	31	151.26	16.54
Grade 7-8	27	63.37	20.83	27	166.70	27.64
Grade 9-10	19	63.84	30.86	19	156.26	30.11
Grade >10	35	65.06	26.82	36	151.00	21.69

[1] In many places in Germany the primary school comprises 5 school years and the secondary school usually begins with grade 5 or 6.

Analogous to the reading speed, the listening speed was measured with the parallel form, the auditory comprehension test [Hörverständnis und -geschwindigkeit, HVG]. The scope and difficulty of the listening and reading texts were identical. A reading app (Voice Dream Reader) was used to listen to the texts. The participants could individually select the reading speed using a test text.

Table 6 shows the average reading and listening speeds differentiated by grade level, showing the clear speed advantage of listening in all grade levels. Figure 2 illustrates these differences. Despite the fact that the gap between listening and reading speed decreases somewhat with age, listening remains about 2.5 times faster than reading in grades 9-10 and about 2.3 times faster above grade 10.

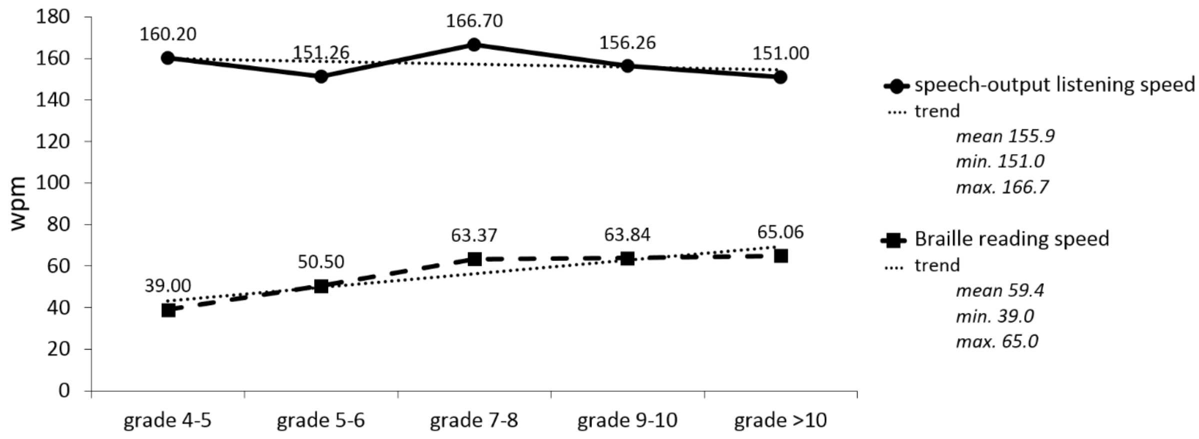


Figure 2
Comparison of reading speed and listening speed

The results show that the listening speeds, especially in the lower grades (e.g. grade 4-5: 160 wpm), were higher than the speeds of sighted people of the same age in print-reading (e.g. grade 4: 130 wpm according to Klicpera & Gasteiger-Klicpera 1993). However, the recorded braille reading speeds of an average of 39 wpm (grades 4-5) to 63.84 wpm (grades 9-10) are far below the values for children and adolescents without visual impairment. It should be noted that there are large individual differences in braille-reading speed (minimum: 12 wpm, maximum: 128 wpm). Values of more than 100 wpm were achieved by the fastest readers regardless of the chosen braille system (standard, contracted or computer braille).

Comparison of reading and listening comprehension

When reading or listening to texts, text comprehension is of central importance. This is influenced by very different variables such as intelligence, reading strategies or text difficulty (Legge, 2007). In the study, reading and listening comprehension were assessed together with reading and listening speed. Due to the fact that the comprehension and speed tests (HVG and LVG) were self-constructed, there are no comparative norms.

Table 7 shows the significantly higher average listening speeds of the sample compared to reading speeds. However, listening comprehension scores (21.49) were lower than reading scores (23.19). A paired sample t-test shows that listening speed is clearly and significantly higher than reading speed, with a very large effect size ($t(116) = -30.120$, $p < .001$, $d = 2.78$). The better performance in reading comprehension compared to listening comprehension also proves to be significant, however with low effect size ($t(116) = 3.824$, $p < .001$, $d = .35$).

Table 7

Comparison of reading and listening

	Participants	Speed (wpm)		Comprehension (points[1])	
		M	*SD*	*M*	*SD*
(1) Reading (LVG)	118	59.42	26.14	23.19	5.37
(2) Listening (HVG)	118	154.99	24.30	21.49	4.56

[1] range 0-32 points for comprehension

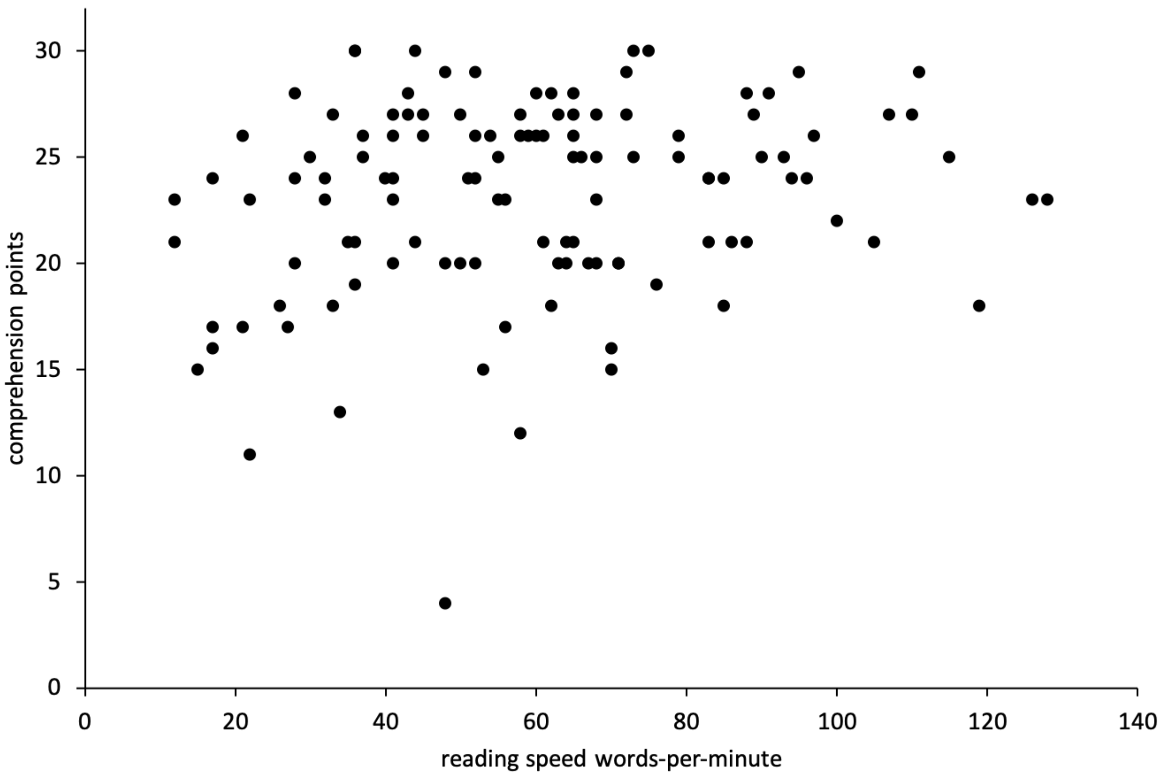
The relationship between reading speed and reading comprehension

In the specialist literature it is generally emphasised that sufficient reading speed is an important prerequisite for the comprehension of texts. Accordingly, a minimum value of 100 words per minute for print-reading is mentioned (Rosebrock et al., 2017; Vacca et al., 2015).

In the study, the correlation between reading speed and reading comprehension was determined using a Pearson product correlation. This showed a weakly positive, significant correlation ($r = .201$, $n = 118$, $p = .029$): Low values in reading speed are associated with low values in reading comprehension and high values in reading speed with high values in reading comprehension. Figure 3 illustrates that in the braille-reading sample relatively high levels of comprehension were achieved even at very slow reading speeds, in contrast to the above assumptions for print reading.

Figure 3

Correlation between reading speed and reading comprehension in the LVG



Spelling

The formal test named "Hamburger Schreibprobe (HSP)" (May et al., 2016) was used to assess the spelling skills. This standardised procedure, which is normed for sighted test persons, measures test results in *t*-values (mean value M = 50, standard deviation SD = 10). This means that test results with values from 40 to 60 are in the average range of the standard deviation. The test records different strategies of spelling, whereby in the following only the orthographic strategy, which refers to the correct application of spelling rules, is presented as an example. Due to high correlation values, it is possible to infer the overall spelling performance from the orthographic strategy (correlations of the subsample of the study (n=117) to the alphabetical strategy r = .645 , p < .001, to the morphematical strategy r = .719, p < .001 and to the supralexical strategy r = .634, p < .001). The results of the study sample (see Table 8) show that the scores achieved in all grades are in the average range of sighted peers (*t*-values from 40 to 60). A one-sample t-tests revealed that the overall mean value of the braille readers (n = 83, M = 48.27) is not significantly different from the norms (*M* = 50) ($t(82) = -1.362$, $p = .177$). In other words, the braille readers performed normally in terms of spelling.

Table 8

Orthographic Strategy Results

Grade	Participants	Spelling	
	HSP spelling test	*M*	*SD*
Grade 4-5	5	46.80	7.69
Grade 5-6	32	45.56	9.16
Grade 7-8	27	51.00	12.16
Grade 9-10	19	47.63	14.99
Total	83	48.27	11.60

The influence of auditory aids on spelling

A Spearman's rank-order correlation was performed to check whether the increased use of auditory aids is accompanied by a decrease in spelling competence. A weak, negative, significant correlation was determined ($r_S(83) = -.284$, $p = .009$). Consequently, especially an exceptionally high use of auditory aids is associated with lower spelling scores.

A negative effect of a specific braille system (computer, standard or contracted braille) on spelling could not be proven in the detailed analyses. Thus, learning spelling seems to be possible regardless of the preferred braille system.

Discussion

The present study investigated the reading fluency and reading speed of German-speaking braille readers in comparison to the print reading-norm. The results confirm the studies already available on reading fluency and reading speed (Laroche et al., 2012; Legge, 2007; Wright et al., 2009). In general, braille-reading is much slower than print-reading without visual impairment, regardless of age. This applies even to very competent braille readers. There are modality-specific limits to haptic reading, whereby there are great individual differences in reading speed. However, with regard to the reading fluency, the distances between the study sample and the norming sample that increase with age are remarkable. Similar effects have been documented for younger braille readers in the ABC Braille Study (Emerson et al., 2009). Nevertheless, the results of the study also show that an early start and longer periods of braille use can have a positive effect on reading fluency. The introduction of braille should always be as early and intensive as possible. Future research should address ways and methods to improve braille reading fluency.

The reading and listening speeds determined in the study reveal a particular relationship to comprehension performance: a marked difference in speed between haptic reading and listening had only a moderate effect on comprehension performance. Reading braille gave a slightly better result for comprehension, although listening was significantly faster. This finding is consistent with a previous study conducted by Erin et al. (2006).

Furthermore, the data imply that the relationship between reading speed and reading comprehension is different in braille. For print readers without visual impairments, it is widely accepted that a minimal reading speed of 100 wpm is an important prerequisite for comprehension (Rosebrock et al., 2017; Vacca et al., 2015). However, the braille readers in this study showed relatively good comprehension even at very slow speeds. The positive correlation between braille reading speed and comprehension was just weakly significant.

As in previous studies (Emerson et al., 2009), the results for spelling show that braille readers perform within the normal range. This implies that learning contractions and braille-specific rules, in addition to general orthographic rules, do not have a negative effect on the spelling skills of most students.

Finally, the data from two negative, statistically significant correlations suggest that the excessive use of auditory technologies seems to have an adverse impact on both spelling and reading fluency, a link that Papadopoulos et al. (2009) had already made. Moreover, the finding contributes to the theory that auditory learning does not develop the same literacy skills as reading and writing print or braille (Swenson, 2016). Nevertheless, auditory access is of compensatory importance for almost every braille reader. Both access modes, listening and reading, therefore have their modality-specific justification and cannot replace each other. Yet little is known about aural reading as a compensatory reading method.

Consequently, future studies will have to further investigate the role of listening for students with blindness and visual impairments.

Limitations

The chosen SLRT-II assessment does not record all variables of reading fluency as it is limited to reading words. Nevertheless, the fast and reliable word identification required here is considered a central aspect of reading fluency. In addition, the procedure allows a comparison of the study sample with the norming sample of readers without visual impairment. Precautions should be taken, particularly in inclusive school settings, to ensure that braille readers are given more time to read, for example, during exams. For this purpose, comparisons of reading speed between braille and print are helpful. In the study, it was not possible to record and compare comprehension and speed in reading and listening; in these areas, only an internal analysis of the results could be performed. Furthermore, it must be taken into account that it was not possible to compile comparable numbers of grade levels within the study sample.

Conclusions

Overall, the results clearly show that the special features of haptic reading require didactically comprehensive educational and support offers. To ensure that people with blindness have access to written information, a wide range of braille learning offers are indispensable for success and independence (Wormsley & D'Andrea 1997). It should be noted that braille is the only possibility of reading for people with blindness. To prevent these students from falling behind their sighted peers, there should be a focus on braille reading fluency throughout their schooling. In addition, reading fluency seems to have a positive overall effect on other literacy skills such as spelling. Moreover, the ability to recognise orthographic rules and the establishment of appropriate means of checking writing are important. The teaching of an appropriate use of speech output depending on the reading task can help to ensure that the use of auditory technologies does not have negative effects on spelling performance or the development of reading fluency.

In conclusion, the results of the study suggest that reading braille, listening and spelling skills need to be systematically and specifically promoted regardless of the school context (special or mainstream schools). For this purpose, sufficient time, financial and personnel resources are the basic prerequisite.

Declaration of conflicting interests

The authors declare no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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