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EXTENDED REPORT

New standardised texts for assessing reading performance in four European languages

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Aims: To develop standardised texts for assessing reading speed during repeated measurements and across languages for normal subjects and low vision patients.

Methods: 10 texts were designed by linguistic experts in English, Finnish, French, and German. The texts were at the level of a sixth grade reading material (reading ages 10–12 years) and were matched for length (830 (plus or minus 2) characters) and syntactic complexity, according to the syntactic prediction locality theory of Gibson. 100 normally sighted native speaking volunteers aged 18–35 years (25 per language) read each text aloud in randomised order. The newly designed text battery was then applied to test the reading performance of 100 normally sighted native speaking volunteers aged 60–85 years (25 per language).

Results: Reading speed was not significantly different with at least seven texts in all four languages. The maximum reading speed difference between texts, in the same language was 6.8% (Finnish). Average reading speeds (SD) in characters per minute are, for the young observer group: English 1234 (147), Finnish 1263 (142), French 1214 (152), German 1126 (105). The group of older readers showed statistically significant lower average reading speeds: English 951 (97), Finnish 1014 (179), French 1131 (160), German 934 (117).

Conclusion: The authors have developed a set of standardised, homogeneous, and comparable texts in four European languages (English, Finnish, French, German). These texts will be a valuable tool for measuring reading speed in international studies in the field of reading and low vision research.

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Reading problems are the main complaint of patients with visual field defects involving the visual field centre, the main pathology being age related macular degeneration (AMD). Efficient reading requires not only sufficient visual acuity to resolve the letters, but also a sufficient extent of visual field to process words and plan eye movements.^{1–6} Patients with AMD must learn to use parafoveal retinal areas instead of non-functional foveal vision, and the text must be magnified to compensate for lower resolution outside the fovea.

Most low vision examinations of patients with AMD involve an assessment of reading performance. Reading speed is a critical component of that evaluation, along with comprehension and endurance. It has been shown by many investigators that letter acuity is not a good predictor of magnifier aided reading speed (see, for example, Ahn and Legge^{1–7}). They showed that a standardised clinical reading test can give a valid prediction of the reading speed a low vision patient is likely to achieve with a magnifier. Many different reading tests have been designed for use in low vision examinations based on random words, sentences, and continuous text. However, most of these tests are not standardised for content and are not available in a variety of languages. In the United States, the Minnesota Reading Test (MNREAD) was devised as a standardised psychophysical test of reading. The test consists of single, simple sentences with equal numbers of characters, with the vocabulary selected from words appearing with high frequency in second and third grade reading material.^{8–10} MNREAD can be used to measure reading acuity, maximum reading speed, and critical print size (the smallest letter size for maximum reading speed). Translations into other languages are under way. Radner and his group created a

similar test set in German. The sentences consist of the same number of words, syllables, and characters taken from third grade reading material. All have a similar syntactic structure (for example, all contain relative clauses).¹¹

Both of these test sets consist of single and relatively short sentences. But in order to gain a more accurate measurement of reading speed and information about a patient's reading fluency, it is desirable to assess the patient's reading performance on a longer text passage. The aim of the study was to develop standardised texts for longer paragraph reading as a new tool for reading, rehabilitation, and low vision research.

METHODS

Texts

Text sets of 10 passages each were created in British English, Finnish, French, and German. The following criteria were used to ensure that the texts were comparable within and across languages.

Content

The texts were inspired by excerpts from an encyclopedia recommended for children aged 9–11 years and from reading material for sixth grade reading (age 10–12 years). All of the texts were self contained passages of general interest. To ensure that the main factor responsible for difficulties in reading is vision rather than intellectual abilities, the texts were not too demanding in terms of content and prose style.

Abbreviations: AMD, related macular degeneration; MNREAD, Minnesota Reading Test

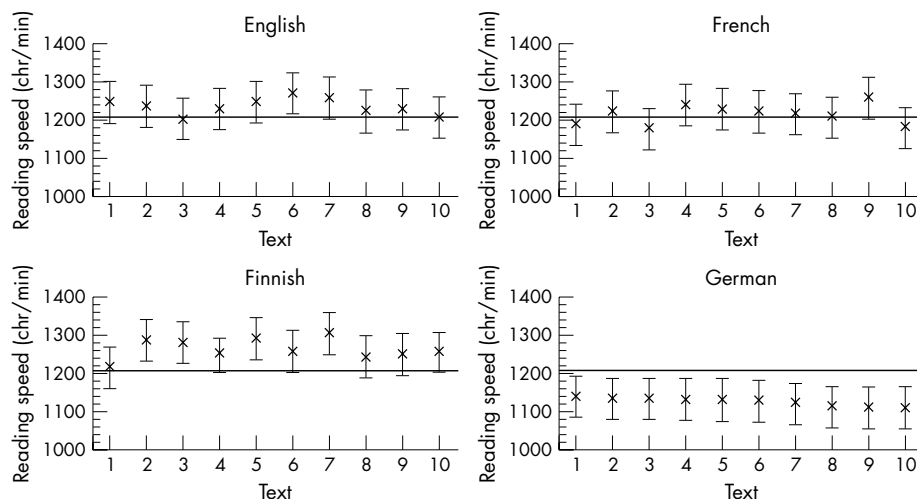


Figure 1 Reading speeds (mean and 95% confidence interval) listed for all 10 texts read by young observers in English, Finnish, French and German. (The solid line indicates the mean reading speed of all four languages.)

Length

All of the texts were of equal length (830 (plus or minus 2) characters). The number of characters is used as the measure for text length rather than number of words, since words vary considerably in length across languages.

Word frequency

Several experiments have demonstrated that word frequency affects reading speed. To account for the effect of lexical frequency in the texts, only words with a lexical frequency of 0.0001% or higher were used.¹²

Syntactic complexity

The time needed to read and comprehend a sentence is also affected by its syntactic structure. Each word read needs to be integrated with text previously read. Considering an example case will help to illustrate this point:

(1) "The cotton clothing is made of grows in Mississippi."

When reading the sentence in (1), the reader typically stops when he reads the word "grows" and restarts the reading process at the beginning of the sentence. This is because "grows" does not fit into what the reader has understood the sentence to mean so far. Taking the phrase "the cotton clothing" to be the subject of the sentence, one expects a noun phrase specifying the material after "is made of." Instead, the reader is confronted with the verb "grows." This conflict is resolved if instead of grouping "clothing" together with "cotton," one realises that "clothing is made of" is actually a relative clause modifying the noun "cotton." The sentence in (1) is a reduced version of (2).

(2) "The cotton which clothing is made of grows in Mississippi."

This example is extreme with respect to the time needed to integrate a particular word and the proportion of the sentence that has to undergo restructuring in order to do so. But similar processes are at work all the time in sentence comprehension.

The use of transformations in generating a sentence increases its syntactic complexity. The syntactic prediction locality theory of Gibson (1998, 2000) provides a metric of structural complexity.^{13 14} It associates the integration of a new word with a certain number of "energy units."

Since the goal of the project was to develop routine texts, we could not simply use sentences that have all the same syntactic make-up. We had to allow for sentences to vary in syntactic structure. Using Gibson's syntactic prediction locality theory, we were able to control for syntactic

Table 1 Statistical levels from Tukey HSD

Level	Text	Letter				
English						
1	6	A				
2	7	A	B			
3	1	A	B	C		
4	5	A	B	C	D	
5	3	A	B	C	D	
6	4	A	B	C	D	
7	9	A	B	C	D	
8	8		B	C	D	
9	10			C	D	
10	2				D	
Finnish						
1	7	A				
2	5	A	B			
3	3	A	B			
4	2	A	B			
5	6	A	B	C		
6	4	A	B	C		
7	10	A	B	C		
8	9		B	C		
9	8		B	C		
10	1			C		
French						
1	9	A				
2	4	A	B			
3	5	A	B	C		
4	6	A	B	C	D	
5	3	A	B	C	D	
6	7	A	B	C	D	
7	8		B	C	D	
8	1			C	D	
9	10				D	
10	2				D	
German						
1	1	A				
2	2	A				
3	3	A				
4	4	A				
5	5	A				
6	6	A				
7	7	A				
8	8	A				
9	9	A				
10	10	A				

Levels are ordered by mean reading speeds, with level 1 read fastest. Levels not connected by the same letter are significantly different.

complexity in our texts by, for example, avoiding split verbs and extraposition of relative clauses in the German texts. We decided to limit the maximal integration cost for each word to four energy units.

Layout

The readability of any text is influenced by parameters such as font, and spacing.^{10–15} We chose a Times New Roman font, and inter-line and letter spacing were kept as close as possible to newspaper standard.

The texts were translated by linguistic professionals. Basically, “translation” was conducted by using the content to create a text in the new language that would meet the criteria for text length, word frequency, and syntactic complexity.

Subjects

Normally sighted volunteers aged 18–35 years were recruited for the initial testing of the texts. In a subsequent study normally sighted volunteers aged 60 up to 85 were tested with the text battery. A total of 200 native speaking subjects (25 per language and age group) with minimum visual acuity of 0.6 (0.2 logMAR) and no history of ocular pathology were tested. All subjects gave their informed consent, and the examinations were conducted in accordance with the tenets of the Declaration of Helsinki. Ethics committee approval was secured for the study by the Institute for Ethics and History in Medicine, Tübingen, Germany.

Procedure

The 10 texts were printed in high contrast (98%) with a standard laser jet printer and laminated with matt surface. They were presented in random order. One text was uncovered at a time, and the subjects were instructed to read it aloud as fast as they could without making mistakes and without correcting mistakes. Oral reading times were measured.

Statistical analysis

An analysis of covariance was used to describe the differences between the 10 texts in the four languages. A one way

analysis of variance with subsequent Tukey HSD test for the comparison of all pairs of groups was performed to compare reading speed of the young and old volunteers (see table 1).

RESULTS

Comparison among texts

The maximal reading speed difference between texts was 5.4% in English, 6.8% in Finnish, 6.5% in French, and 2.6% in German (fig 1 and table 2). Table 2 lists the means of the reading speeds measured for each text. Capital letters connect the levels with no statistically significant difference ($\alpha = 0.05$). For future use, sets with at least seven texts connected with the same letter (10 in German, eight in Finnish, and seven in French, and seven in English) can be used interchangeably within one language to measure reading speed.

Comparison among languages

Mean values (SD) in characters per minute are: English 1234 (147), Finnish 1263 (142), French 1214 (152), and German 1126 (105) for young readers. There is a statistically significant difference among the reading speeds measured in the languages ($\alpha = 0.05$) with a maximum difference of the mean reading speeds of 10.8% (between Finnish and German).

Comparison between young and elderly readers

The comparison of young and elderly readers shows significantly ($\alpha = 0.05$) lower reading speeds in the older population. Differences between young and elderly readers were 19% in English, 25% in Finnish, 7% in French, and 19% in German (fig 2, table 2).

DISCUSSION

Continuous text is a much better predictor of real world reading performance than visual acuity. However, standardised texts are required to achieve reliable and valid measurements of reading speed. Mansfield *et al* standardised the MNREAD reading test according to the criteria of constant character count and controlled word frequency.

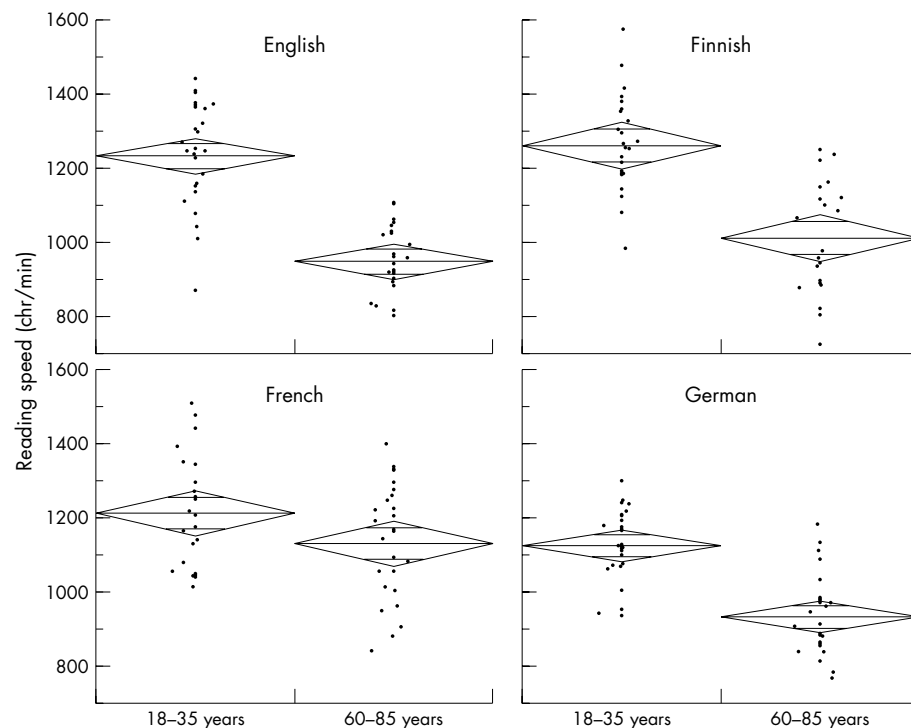


Figure 2 Young and old subjects' reading speed (chr/min) in all four languages. Points are the individual values (jittered), the horizontal lines indicate the means and the vertical extremities represent the 95% confidence intervals.

Table 2 List of average reading speeds (SD) and range (characters/minute) for young (A) and old (B) readers for each text in the four tested languages

(A) 18–35 years				
Text	English		Finnish	
	mean (SD)	min–max	mean (SD)	min–max
1	1247 (161)	884–1538	1216 (112)	948–1425
2	1201 (137)	849–1397	1281 (148)	975–1675
3	1236 (126)	923–1403	1286 (138)	1009–1568
4	1228 (133)	905–1416	1252 (121)	981–1568
5	1246 (153)	874–154	1291 (157)	990–1669
6	1270 (147)	904–1499	1255 (129)	1018–1518
7	1257 (155)	785–1516	1304 (166)	1009–1764
8	1223 (158)	799–1447	1241 (136)	988–1595
9	1227 (159)	862–1451	1250 (152)	935–1622
10	1207 (152)	900–1440	1254 (150)	995–1561
General	1234 (147)	785–1540	1263 (142)	935–1764
Text	French		German	
	mean (SD)	min–max	mean (SD)	min–max
1	1188 (132)	989–1478	1139 (96)	946–1290
2	1177 (153)	927–1486	1135 (112)	952–1406
3	1222 (161)	957–1603	1135 (135)	826–1362
4	1240 (141)	1024–1568	1132 (107)	947–1368
5	1228 (143)	949–1519	1131 (110)	896–1368
6	1222 (162)	988–1567	1128 (107)	935–1294
7	1216 (167)	936–1528	1122 (98)	899–1261
8	1207 (158)	990–1499	1114 (109)	877–1258
9	1258 (157)	1038–1584	1111 (95)	931–1256
10	1180 (155)	951–1458	1110 (81)	943–1243
General	1214 (152)	927–1603	1126 (105)	826–1406
(B) 60–85 years				
Text	English		Finnish	
	mean (SD)	min–max	mean (SD)	min–max
1	967 (118)	781–1230	987 (182)	626–1388
2	941 (87)	783–1099	1023 (184)	611–1355
3	952 (91)	780–1135	1032 (174)	693–1328
4	950 (97)	808–1132	1010 (188)	633–1352
5	971 (91)	812–1095	1026 (183)	663–1349
6	975 (90)	790–1111	1018 (173)	671–1305
7	969 (113)	809–1173	1030 (183)	668–1369
8	915 (89)	774–1067	995 (181)	614–1317
9	946 (87)	779–1117	998 (189)	608–1369
10	918 (94)	751–1184	1017 (182)	610–1353
General	951 (97)	751–1230	1014 (179)	608–1388
Text	French		German	
	mean (SD)	min–max	mean (SD)	min–max
1	1124 (162)	789–1413	956 (113)	802–1200
2	1084 (148)	810–1382	923 (109)	761–1188
3	1119 (151)	857–1417	931 (107)	772–1209
4	1169 (163)	884–1480	953 (125)	727–1248
5	1143 (171)	771–1409	925 (124)	745–1229
6	1148 (171)	838–1446	940 (124)	782–1216
7	1139 (169)	859–1378	950 (127)	764–1213
8	1107 (152)	814–1375	903 (111)	733–1141
9	1155 (156)	893–1416	935 (127)	763–1216
10	1119 (165)	785–1367	926 (114)	750–1182
General	1131 (160)	771–1480	934 (117)	727–1248

They allowed variable word length and syntactic structure across the sentences.¹⁶

Radner *et al* developed a set of sentences that were highly constrained to have similar lexical difficulty, word length, and semantic structure. Reading speeds for normally sighted observers were similar across all of the sentences. They reported that the reading speeds for the sentences were highly correlated with reading for text passages consisting of about 250 words ($r = 0.89$).^{11, 17}

Both the MNREAD and Radner tests use single sentences in a range of letter sizes. This is useful for measuring reading

acuity and critical print size, but the passages are rather short for making accurate measurements of reading speed. We have developed a set of longer text passages in four European languages (English, Finnish, French, and German) that can be used to accurately measure reading speed. The texts conformed to the criteria of equal length and comparable linguistic complexity. The homogeneity and comparability of the texts was verified in experimental testing in a group of 100 readers aged 18–35 years and 100 readers aged 60–85 years without vision disorders. We identified sets of texts that are statistically homogeneous. This resulted in a

minimum of seven passages in English and French, eight Finnish, and 10 texts in German that were comparable. For many purposes, the maximal difference of 7% in mean reading speed between texts can be tolerated; in these cases all texts can be used. If an even higher accuracy is needed, the normative data of table 2 can be used to calculate corrective factors. This is especially recommended for inter-language comparisons, since the reading speed differences among the languages are partially caused by the structural differences of the languages.

In testing we found a difference in reading speeds across subjects. However, within each subject the reading times for different texts are very homogeneous. This is a further indication that the texts require the same amount of processing capacity from a subject to read them.

Clinical studies evaluating the reading performance of low vision patients, in particular those with central scotoma and eccentric fixation, underline the need for a reading test to assess visual performance especially in the context of low vision rehabilitation.¹⁸ We recommend text reading as a tool for the evaluation of reading performance rather than single sentences.

Summary

The newly developed texts close a gap in reading diagnostics, whereas reading acuity tests, like MNREAD and the Radner test, in which single sentences are arranged in a decreasing order of size, are useful for quantifying reading acuity and magnification need. Paragraph reading texts, like the one developed here, are crucial to judge reading performance as a task of everyday life to lay the foundation of visual rehabilitation. Comparing reading speeds measured in a patient under different conditions requires several comparable text passages to assess the patient's visual performance. The reading texts we compiled are well suited to test the reading ability of patients in a realistic task. Texts in additional languages will be available soon.

These new texts are designed to be used in the field of reading and low vision research for a variety of purposes, for example:

- as a diagnostic tool in vision or reading disorders
- for follow up testing of reading performance
- for comparison of different magnifying aids
- for international comparative studies assessing reading performance.

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