

# Validation of the Norwegian International Reading Speed Texts (IReST) in adult readers with normal vision

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## Abstract

There is a lack of standardised reading tests in Norwegian suitable for adults and persons with visual impairment (VI). The International Reading Speed Texts (IReST) measure reading performance of longer paragraphs. The aim of this project was to translate and validate the IReST in Norwegian.

Each of the German, English and Swedish IReST were translated into Norwegian. The translations were matched for length, linguistic difficulty, and structure, and piloted in five adults. Reading speed was assessed in 25 readers (41 years,  $SD = 10$ ) with normal vision and the readings were recorded. Reading speeds were analysed for variability between texts and participants.

There were no statistically significant differences between the ten texts (135 words, 765 characters [ $SD = 18$ ], word variation index 91.8% [ $SD = 0.9\%$ ]). Reading speed in adult readers was 204 ( $SD = 31$ ) words/min. There was no difference across texts for any of the participants ( $p > 0.05$ ). Reading speed variance was 77.4% between subjects and 22.6% between texts.

The Norwegian IReST is standardised and comparable to the international IReST tests. Reading speed falls within normative values in adult readers. The Norwegian IReST will be a valuable tool in assessing reading in clinical health care, rehabilitation and educational practice of adult and visually impaired readers and in reading research.

**Keywords:** paragraph reading, reading speed, sentences, text reading, reading test, reading performance

## Introduction

Reading is one of the most fundamental skills of daily life today, almost regardless of geographical and social standing. Good reading skills are required to be able to actively participate in society. In many ways, you have a greater disability as a poor reader today than in the past, and this is especially critical among people who are visually impaired (Kaltenegger et al., 2019; Lamoureux et al., 2007). Reading is a complex process, involving optical, neurological, cognitive and oculomotor factors. Reading requires both a clear image, precise eye movements, good field of view and a high degree of comprehension (Brussee et al., 2014; Mitzner & Rogers, 2006). In addition, reading can be challenging due to a range of visual perceptual issues (Chung et al., 2019; Mitzner & Rogers, 2006). The art of reading is about decoding signs perceived through sight and then systematising these into larger meaningful units, from letters, via words to sentences. In clinical practice, visual acuity is the most common measure used to assess central visual function (Kaiser, 2009). However, visual acuity measures the spatial resolution of the fixating retinal area, but is not adequate when measuring reading, or other aspects of functional vision in daily life.

Reading problems are very often the main reason why people seek help when they have vision problems and improvement of reading is a main goal in visual rehabilitation (Elliott et al., 1997; Hazel et al., 2000; Radner, 2017; Rubin, 2013).

To measure reading skills effectively, a selection of objective and standardised tests for reading function are needed (Legge, 2006; Rubin, 2013). Some tests measure reading speed, while others measure reading comprehension, or are intended for groups of people with special problems, such as decoding difficulties, visual impairments, or cognitive difficulties (Legge et al., 1992; Legge, 2006; Radner, 2017; Rolle et al., 2019). There is a lack of standardised reading tests in Norwegian for visually impaired readers that measure functional reading over longer paragraphs. Standardised tests are important both in regard to measuring visual function, and in regard to measures of reading function, in order to help people with impaired vision in daily life (Lovie-Kitchin, 2011; Rolle et al., 2019).

Reading speed is used as a reliable measure in research on reading, because it is easy to measure objectively, sensitive to changes in both vision and text type and makes sense for readers (Carver, 1992; Legge, 2016). The International Reading Speed Texts (IReST) were created in German to measure reading ability and reading fluency. They were later translated into English and the test is currently available in 19 languages (Gleni et al., 2019; Precision Vision, 2021; Trauzettel-Klosinski & Dietz, 2012). The IReST texts are mainly taken from factual literature for children aged 9–11 years and text material for 6<sup>th</sup> grade. The texts are intended to be neutral and easily read and understood (Hahn et al., 2006). One advantage is that IReST consist of ten texts, where each text is standardised in terms of content, length, degree of difficulty and linguistic structure. This makes IReST suitable for comparing reading speed between languages. Furthermore, IReST have the advantage of containing longer paragraphs, which are more similar to reading ordinary texts and they have been shown to give less variability in reading speed compared to more traditional tests using shorter texts (Altpeter et al., 2015; Rubin, 2013). IReST has been used to measure reading in normal ageing persons and in people with impaired vision and reading disabilities (Morrice et al., 2021; Trauzettel-Klosinski & Dietz, 2012). There is a lack of standardised reading tests in Norwegian suitable for adult readers and persons with visual impairment, and the aim of this project was therefore to translate and validate the IReST in Norwegian.

## Methods

### Linguistic development of the Norwegian IReST

The ten IReST texts were translated from the original German version into Norwegian by a linguist (DN), a fluent speaker of both Norwegian and German. The difficulty and complexity of the texts were set at the reading level of 10–12-year-old children (Hahn et al., 2006). To help ensure that all the Norwegian texts had the same readability and were easy to read, the texts were analysed using LIX, a calculation tool of Scandinavian origin designed to evaluate the linguistic complexity of a text (Anderson, 1983). The LIX formula uses the number of words, the number of long words (six letters and more), and the number of sentences to calculate a readability score (LIX score) and three underlying scores indicating word variability and vocabulary richness (TTR, OVIX and OVR). The goal was to ensure that all texts were within the easy-to-read-category (a LIX score between 30 and 40) (Anderson, 1983; Björnsson, 1983; Nordtømme, 2023). According to this, the Norwegian translated texts should be

easy to read, with a LIX score of 35 and a high word variability ratio (see Table 1 for details). Data collection was undertaken as part of a master's thesis (DN) at University of South-Eastern Norway (Nachtnebel, 2023) and some results have been presented at the ARVO conference (Nachtnebel & Falkenberg, 2023).

Table 1: The LIX readability indexes of the ten Norwegian texts

Text	LIX*	Type Token Ratio TTR %	Word Variability Index OVIX %	Word Variability Ratio OVR %
1	35	67.4	63.4	92
2	35	69.9	68.9	92.6
3	35	65.9	60.2	91.5
4	35	71.1	73	93.1
5	35	66.7	61.8	91.7
6	35	60.7	50.7	90
7	35	70.4	70.9	92.8
8	35	65.2	58.7	91.3
9	35	66.7	61.8	91.7
10	35	65.9	60.2	91.5
Mean (SD)	35	67.0 (3)	62.9 (7)	91.8 (1)
95% CI		[65, 69]	[58, 68]	[91, 92]

Note: \*LIX score range from 0–100, where 35 is within the easy read category.

As for earlier IReST texts, Gibson's syntactic prediction locality theory (SPLT) was used in the analysis of the translations (Gibson, 1998; 2000). According to Gibson, information in the immediate context of a word is used to predict the syntactic structure of a sentence. Therefore, it was important that the Norwegian texts had equal cognitive processing load, while simultaneously incorporating syntactic diversity to prevent the reader from benefiting by recognising a pattern.

To adjust for fluency, the Norwegian texts were additionally translated from the English and Swedish texts independently by both authors, fluent in both languages. Details were discussed until consensus was reached on the final versions. The aim was to make the Norwegian version similar in difficulty, linguistic complexity, and word and sentence lengths to these versions. See Figure 1 for a comparison of texts in the different languages. This also ensured that the Norwegian texts were comparable across languages.

Table 2 shows the parameters for the ten Norwegian texts. All consist of 135 words, 20% long words (over six letters), and nine sentences. The number of characters (including spaces and line breaks) for each text is 741–800, with a mean of 765 ( $SD = 18$ ). The mean number of characters per word is 5.7 ( $SD = 0.1$ ), and the mean number of syllables per text is 227 ( $SD = 8$ ). Texts with mainly short words have fewer syllables and are easier to read, process, understand, and recognise, which is beneficial to all readers. All texts have 16 lines with a maximum line width of 8.5 cm. Like the other existing IReST languages, the Norwegian translation uses a Times New Roman font size of 10 (equivalent to visual acuity 0.4 logMAR at 40 cm viewing distance or 1M unit) and 12-point line spacing (Hahn et al., 2006), corresponding to most newspaper print sizes. The finished texts were printed in high contrast on white 120 g matt paper.

To assess the readability of the first Norwegian texts, the ten texts were piloted on five subjects with normal vision and reading skills. Words or sentences where the subjects hesitated or made mistakes were substituted. This did not influence the number of words, characters, and letters in the final texts.

Beveren er en fremragende svømmer. I vann kan den oppnå en hastighet på opptil ti kilometer i timen. For å beskytte seg mot kulde har beveren et tykt fettlag og en pels med tusenvis av hår. Ved hjelp av sine store lunger kan den uten problemer være under vann i inntil tjue minutter. Beveren er ikke bare dyktig til å felle trær, men den er også flink til å bygge demninger.

Der Biber ist ein vorzüglicher Schwimmer. Er kann im Wasser eine Geschwindigkeit von bis zu zehn Kilometern in der Stunde erreichen. Sein Schutz gegen die Kälte besteht aus einem Pelz mit Tausenden von Haaren und einer dicken Fettschicht. Mit seiner großen Lunge kann er leicht zwanzig Minuten unter Wasser bleiben. Der Biber kann nicht nur geschickt Bäume fällen, sondern er ist auch ein erfahrener Handwerker

The beaver is an excellent swimmer. It can achieve a speed of up to seven miles per hour in water. Its protection against the cold consists of a skin with thousands of single hairs and a thick layer of fat. With its big lungs it can easily stay under water for more than twenty minutes. The beaver is not only skilful in felling trees, but also an experienced craftsman in building dams. When the beaver fells a tree, it gnaws

Bävärn är en mycket skicklig simmare. I vattnet når den hastigheter av mer än elva kilometer i timmen. För att skydda sig mot kylan har bävern's hud tusentals små hårstrån och ett tjockt lager med fett. Med hjälp av sina stora lungor kan den stanna under vattenytan mer än tjugo minuter utan problem. Bävärn är inte bara duktig på att fälla träd, den är också en skicklig dammbyggare. När bävern faller

Figure 1: Extracts from the Norwegian, German, English and Swedish versions of IReST text 2 showing only the first eight lines.

Table 2: Parameters and values for the Norwegian IReST texts

Text	No. words	No. syllables	No. characters	Syllables per word	Characters per word
1	135	220	753	1.6	5.6
2	135	217	741	1.6	5.5
3	135	216	761	1.6	5.6
4	135	236	800	1.7	5.9
5	135	223	768	1.7	5.7
6	135	227	765	1.7	5.7
7	135	227	748	1.7	5.5
8	135	240	786	1.8	5.8
9	135	233	756	1.7	5.6
10	135	229	773	1.7	5.7
Mean (SD)	135 (0)	227 (8)	765 (18)	1.7 (0.1)	5.7 (0.1)
95% CI		[221, 233]	[752, 778]	[1.6, 1.7]	[5.6, 5.8]

## Participants

Twenty-five adults (18 females) aged 18 to 60 years of age ( $M = 41$ ,  $SD = 10$ ) with normal vision and reading abilities were recruited from the University of South-Eastern Norway and Statped. Inclusion criteria were: adults over 18 years, fluent in Norwegian, no diagnosed reading/attention disabilities, and normal or corrected to normal vision (near visual acuity [VA]  $\leq \log\text{MAR} 0.0$  [decimal VA  $\geq 1.0$ ], contrast sensitivity  $\leq 1.68$  logCS). The participants' mean near VA, mean distance VA, and Mars contrast sensitivity were  $-0.07$  logMAR ( $SD = 0.07$ ),  $-0.15$  logMAR ( $SD = 0.22$ ) and  $1.81$  logCS ( $SD = 0.05$ ), respectively. The sample size of 25 was matched to the original IReST-study (Hahn et al., 2006). This also satisfies an a priori power analysis calculated with G\*Power 3.1 (Kang, 2021). Testing the difference from a constant and a two-tailed test, a sample size of 23 was required to achieve power of 0.95 with a large effect size ( $d = 0.8$ ), and an  $\alpha$  of 0.05 (Faul et al., 2007).

Written and oral information about the study was provided, and each participant gave written informed consent before taking part. The study was approved by the Norwegian Centre for

Research Data (ref: 56168) and was conducted in line with the Declaration of Helsinki (World Medical Association, 2013).

### Procedure

Texts were presented in random order on a table with a viewing distance of 40 cm. The mean illumination was 767 lux ( $SD=142$ ) avoiding glare. Participants were told to read each text once aloud and as quickly as possible, and not to correct mistakes along the way. The readings were recorded, and all audio recordings were reviewed in an editing program to measure the reading time(s). All errors were counted and noted. To uncover any error patterns across readers, incorrect words were marked with brackets and colour.

### Data and statistical analysis

For this dataset, reading speed means, medians and standard deviations for each text and each participant were calculated. In accordance with work by the IReST group, characters per minute were calculated by including spaces and line breaks and the relative standard deviation was calculated as  $SD/\text{mean reading speed in words/min} \times 100$  (Hahn et al., 2006; Messias et al., 2008). One-way analysis of variance (ANOVA) followed by Levene's post-hoc tests were used to compare reading speed. The null hypothesis was that there was no difference between the texts. The IReST group set a limit of 4  $SD$  for outliers (Trauzettel-Klosinski & Dietz, 2012). In the data set from the Norwegian pilot study there were no outliers, and all data were included in the analysis. Alpha was set to 0.05, and analyses were performed in IBM SPSS Statistics (Version 24, US).

### Results

The results showed that normally sighted adults read the ten texts with a mean reading time of  $40.5 \pm 5.8$  sec. This corresponds to a mean reading speed of 204 words/min ( $SD=6$ , 95% CI [200, 209]). Table 3 shows that Text 2 was the fastest read text (215.2 words/min) and Text 4 was the slowest (196.4 words/min). However, the differences in reading speed between the texts (ANOVA  $F[9,240] = 0.81$ ,  $p = 0.6$ ; Levene's test  $p = 0.82$ ) and within individual participants were not significant (all  $p > 0.05$ ) (See Table 3 and Figure 2).

Table 3: Mean (SD) reading speed and performance categories for each text

Text	Performance category	Words per min	Min/max	Syllables per min	Characters per min
2	A	215	155/303	337	1151
1	A B	210	160/273	335	1148
9	A B C	209	151/312	350	1137
5	A B C D	206	165/308	334	1152
7	A B C D	205	156/266	340	1121
6	B C D	204	149/308	334	1126
3	B C D	200	144/274	314	1105
10	B C D	200	143/260	331	1118
8	C D	199	153/246	349	1142
4	D	196	148/268	336	1139
Mean (SD)		204 (31)		336 (10)	1133 (16)
95% CI		[200, 209]		[329, 343]	[1123, 1145]

The total variation between all readings ( $n=250$ ) was distributed so that 77.4% lies between the individuals, while 22.6% of the mean variation was between the texts. Relative standard deviation varied between 2.6 and 8.4% among individuals ( $M=4.5\%$ ).

### Performance categories

The texts were divided into IReST performance categories based on mean reading speed per text (Hahn et al., 2006), as shown in Table 3. The ten Norwegian texts showed a total difference in reading speed of 18.8 words/min. For the total order of reading speed, see Table 3. The Norwegian texts were grouped into categories A to D, where each category represents a ten words/min range of reading speeds (Hahn et al., 2006). Performance category A starts from the fastest read text (Text 2 at 215 words/min). With a ten words/min range, category A has a range of reading speed from 215 to 205 words/min, and includes texts 2, 1, 9, 5 and 7 (Table 3). Category B was then calculated from the fastest read text outside category A (Text 6 at 204 words/min), and spans ten words/min upwards to 214 words/min ( $204 + 10$  words/min). Since there were no text read at 214 words/min, category B starts at the first read text within the calculated range which is Text 1 at 210 words/min. With ten words/min for each category, category B now covers reading speeds from 210 to 200 words/min (see Table 3). All texts belonging to the same category can be used in repeated measurements because they do not differ by more than ten words/min. It also means that most texts belong to more than one category and can be exchanged with all the other texts (for example, Text 5 and Text 7 which are included in all four categories [A–D]). This means that the Norwegian IReST is well suited for repeated measurements as there are at least five texts to choose from within the same category.

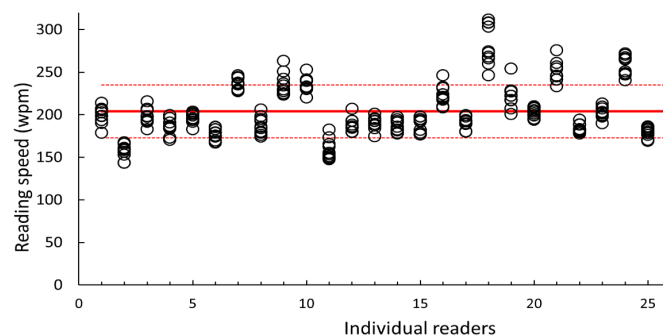


Figure 2: IReST reading speeds of all ten texts for individual adults. Solid and dashed lines show the mean and standard deviation for reading speed across the texts and all individuals.

### Discussion

The aim of this project was to validate the IReST reading test in Norwegian for adult readers. The text analysis showed that all ten texts had overlapping language parameters (number of words, sentences, sentence lengths, word lengths and readability index), with low variation between the texts.

The values are in line with IReST tests in other languages (Gleni et al., 2019; Hahn et al., 2006; Messias et al., 2008; Morrice et al., 2020; Trauzettel-Klosinski & Dietz, 2012). The Norwegian texts all have the same number of lines. This is in line with the Swedish translation, but in contrast to e.g., the English and German texts. The advantage of keeping the line number constant is that this influences the reading performance variables, as line breaks can be demanding for visually impaired or poor readers. Future research should consider the use of eye tracking to further elucidate the effect of line breaks when reading in both normal and visually impaired readers (Wang et al., 2023).

The reading speed was not significantly different in the ten standardised texts, with reading speeds similar to the German, English and Swedish texts they were translated from. The total variation between the ten texts was within the spread in the other languages (Gleni et al., 2019; Trauzettel-Klosinski & Dietz,



2012). The results show that the Norwegian translation meets the requirements for IReST, corresponds to the standardisation of already existing tests (Gleni et al., 2019; Hahn et al., 2006; Messias et al., 2008; Trauzettel-Klosinski & Dietz, 2012), and can be used as a test to assess reading performance. In comparison with the mean reading speed in the other languages, the Norwegian results are in the upper level, placed fourth, after English, Spanish and Greek, and before Dutch, Swedish and French. Different languages have different word lengths, and it is worth noting that short words lead to higher reading speeds when comparing words per minute across languages.

Another strength of this study is that a standardised and validated Norwegian paragraph reading test has now been established, which will be clinically important and where the results can be compared to international findings (Gleni et al., 2019; Hahn et al., 2006; Messias et al., 2008; Morrice et al., 2020). The study also shows that, although there are individual variations for each person, the variation between texts is low even with a small sample of individuals. This means that reading speed can be assessed and compared across texts in individual readers, but that one should be careful to compare across readers. The Norwegian IReST will be valuable in assessing reading in both research and clinical practice.

A limitation of this study was the design of this validation study, which makes it impossible to establish normal population values. Although our results compare to international reading performance, future studies, in larger samples, are needed to establish Norwegian normal values across age groups, reading disabilities, or in low vision.

Future research and development should also consider a digital test alternative to utilise new technology for assessing and monitoring functional reading in visual rehabilitation in adults, in the clinic and at home.

Overall, this study shows that the Norwegian texts are validated and comparable with other IReST texts.

## Conclusion

The results show that there are no significant differences between the ten Norwegian texts, and that they can be used for repeated measurements in adults with normal vision. The results also show that the Norwegian IReST values for reading speed are among the fastest, similar to English and Swedish. The Norwegian IReST reading test will be a valuable addition in clinical practice and for research as an important tool in the evaluation of reading function over time. With today's technology, it would also have been useful to be able to expand the testing apparatus with digital tools, which would increase the test availability and could lead to an even greater degree of standardisation.

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## Validering av den norske International Reading Speed Texts (IReST) lesetesten

### Sammendrag

Det er et behov for standardiserte lesetester på norsk, som også passer for voksne personer med synshemming. Den internasjonale lesetesten IReST (International Reading Speed Texts) måler lesefunksjon over lengre tekstavsnitt. Målet med dette prosjektet var å oversette og validere IReST til norsk.

De opprinnelige tyske, engelske og svenske IReST-tekstene ble oversatt til norsk. Oversettelsene ble analysert med hensyn til tekstlengde, språklig vanskelighetsgrad og struktur, og pilotert på fem voksne. Lesehastigheten ble deretter målt på 25 deltakere (41 år,  $SD = 10$ ) med normalt syn. Det ble gjort opp-tak og lesehastigheten ble analysert for variasjon mellom tekster og deltakere.

Det var ingen statistisk signifikante forskjeller mellom de ti tekstene (135 ord, 765 tegn ( $SD = 18$ ), ordvariasjonsindeks 91,8% ( $SD = 0,9\%$ )). Gjennomsnittlig lesehastighet hos voksne lesere var 204 ( $SD = 31$ ) ord/min. Det var ingen signifikant forskjell mellom tekstene for noen av deltakerne ( $p > 0,05$ ). Fordelingen av variansen i lesehastighet var 77,4% mellom deltakere og 22,6% mellom tekstene.

Den norske IReST-testen er standardisert og sammenlignbar med de internasjonale IReST-testene. Lesehastigheten faller innenfor normative verdier hos voksne lesere. En norsk utgave av IReST vil være et verdifullt verktøy for å vurdere lesing i klinisk helsevesen, rehabilitering og utdanningspraksis for voksne og synshemmede lesere, samt i leseforskning.

*Nøkkelord:* Avsnittslesing, lesehastighet, setninger, lesetest, leseprøve, leseferdighet

## Validazione della versione Norvegese dell'International Reading Speed Texts (IReST) in lettori adulti con visione normale

### Riassunto

Mancano test di lettura standardizzati in Norvegesi, adatti per adulti e persone con disabilità visive (DV). L'International Reading Speed Texts (IReST) misura le abilità di lettura in paragrafi lunghi. L'obiettivo di questo progetto è tradurre e validare IReST in Norvegese.

Le versioni in Tedesco, Inglese e Svedese di IReST sono state tradotte in Norvegese. Le traduzioni sono state adattate per lunghezza, difficoltà linguistica e struttura, e sottoposte a prova pilota su cinque adulti. La velocità di lettura è stata misurata in 25 lettori (41 anni,  $SD = 10$ ) con visione normale e le letture sono state registrate. Le velocità di lettura sono state analizzate per variabilità tra testi e partecipanti.

Non sono state trovate differenze statisticamente significative tra i dieci testi (135 parole, 765 caratteri [ $SD = 18$ ], indice di variazione delle parole 91,8% [ $SD = 0,9\%$ ]). La velocità di lettura in lettori adulti è stata di 204 ( $SD = 31$ ) parole/min. Non è stata riscontrata differenza tra testi per nessuno dei partecipanti ( $p > 0,05$ ). La varianza della velocità di lettura era 77,4% tra i soggetti e 22,6% tra i testi.

La versione in Norvegese dell'IReST è standardizzata e comparabile alle versioni internazionali. La velocità di lettura rientra nei valori normativi dei lettori adulti. La versione Norvegese dell'IReST rappresenta uno strumento prezioso nella valutazione della lettura nella pratica clinica, nella riabilitazione e nella pratica educativa di lettori adulti e con deficit visivi, nonché nella ricerca sulla lettura.

*Parole chiave:* Lettura di paragrafi, velocità di lettura, frasi, test di lettura, abilità di lettura