How many words do we read per minute?

A review and meta-analysis of reading rate

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Abstract

Based on the analysis of 190 studies (18,573 participants), we estimate that the average silent reading rate for adults in English is 238 words per minute (wpm) for non-fiction and 260 wpm for fiction. The difference can be predicted by taking into account the length of the words, with longer words in non-fiction than in fiction. The estimates are lower than the numbers often cited in scientific and popular writings. The reasons for the overestimates are reviewed. The average oral reading rate (based on 77 studies and 5,965 participants) is 183 wpm. Reading rates are lower for children, old adults, and readers with English as second language. The reading rates are in line with maximum listening speed and do not require the assumption of reading-specific language processing. Within each group/task there are reliable individual differences, which are not yet fully understood. For silent reading of English non-fiction most adults fall in the range of 175 to 300 wpm; for fiction the range is 200 to 320 wpm. Reading rates in other languages can be predicted reasonably well by taking into account the number of words these languages require to convey the same message as in English.

Highlights

- Reading speed has been overestimated.
- For English silent reading it is 238 words per minute.
- For reading aloud it is 183 words per minute.
- There is no evidence for reading gears except for reading versus text scanning.

In a review paper on speed reading, Rayner, Schotter, Masson, Potter, and Treiman (2016) meticulously explained why reading rates of more than 1,000 words per minute (wpm) are impossible without severe loss of text understanding. Basically, when we read, we make a sequence of fixations (brief time periods during which the eyes stand still) and saccades (eye movements to new parts of the text). The text information we can extract during a fixation is limited and we need time to move our eyes. Both factors constrain the information that can be extracted from a text in a given time period. Rayner et al. (2016) were not the first to rebut popular and commercial claims that people can be taught to read much faster than they usually do without loss of information (e.g., Just & Carpenter, 1987; Spache, 1962; E.A. Taylor, 1957; S.E. Taylor, 1965) and they were not the last (e.g., Seidenberg, 2017).

A question related to the issue of speed reading is how fast we normally read silently. According to Rayner et al. (2016), for college-educated adults this is “about 200 to 400 wpm” (p. 1). To illustrate the argument, they presented a table of 10 skilled readers who had an average reading speed of 308 wpm. The table originally appeared in Rayner (1978) in a review paper on eye movements in reading.

The normal or typical reading rate of 300 wpm is widely mentioned (e.g., Aaron, 2012; Andrews, 2010; Smith & Pourchot, 1998; Whimbey & Lochhead, 1999; Yaworski, 2005). As it happens, it is one of the few numbers experimental psychological research has given to society. So, the number is used to calculate the typical time needed to read online newspaper articles, books, contracts, or legal cases. It is the speed computer programmers use to present information in rapid successive visual displays (e.g., on small screens) and it is the number used to determine whether someone is a slow reader (and could benefit from a remediation program).

In the present article, we discuss how the number came about and how well it is supported by the available data.

The origins of 300 words per minute

The first studies of reading rate in silent reading

To the best of our knowledge, the first author to write about reading rate in a scientific journal was Quantz (1898). He made a distinction between very slow and very rapid readers. The former had a reading rate of 3.9 words per second (234 wpm), the latter a rate of 7.3 words per second (438 wpm). Unfortunately, no information was given about how reading rate had been established. This encouraged Huey (1901) to reassess the issue. He selected 11 pages from an interesting novel, each containing 405 words, which presented no peculiar difficulties to the reader. Twenty university students were asked to read one page at a time while Huey measured the time with a stopwatch. There were 10 conditions. One was normal silent reading ("the way you like to read"). This rate was assessed twice. Another condition was to read silently as fast as possible, while still being able to follow the story line. Two other conditions of interest were reading aloud at a normal pace and at a maximal pace.[1] Huey reported reading rates of 5.35 and 5.91 words per second for silent normal reading (321 and 355 wpm), 8.21 words per second for silent maximal reading (493 wpm), 3.55 words per second for normal reading aloud (213 wpm), and 4.58 words per second for maximal reading aloud (275 wpm). The experiment was included in Huey's hugely influential book *The psychology and pedagogy of reading* (Huey, 1908), together with the data of Quantz (1898). As such, the very first estimates of normal silent reading were set between 300 and 350 wpm.

Tinker

An experimental psychologist very active in reading research in the first half of the 20th century was Tinker. He published a series of over 20 papers addressing various variables that may affect reading speed, such as letter font and various lay-out options. In most of these studies he used the Chapman-Cook Speed of Reading test. It had two forms, each containing 30 paragraphs of 30 words. Toward the end of the paragraph there was an awkward word spoiling the paragraph. Participants had to tick off the word and finish as many paragraphs as possible in 1.75 minutes. An example of a paragraph was: "Yesterday I went downtown to buy some shoes and rubbers, but when I got home, I found I had forgotten to go to the flower-store to get them."

University undergraduates typically finished some 18 paragraphs (540 words) in 1.75 minutes, making a reading speed of 309 wpm. In one of the rare studies taking longer than 1.75 minutes per condition, Tinker (1955) asked his participants to do the task for 30 minutes. They finished on average 317 paragraphs, given a reading rate of 317 wpm (30 words per paragraph and 30 minutes cancelling each other out). Unfortunately, the task was less than optimal, because the

[1] The remaining conditions involved several ways of silently voicing the text, both at normal and maximal pace.

incorrect word was not always the last word of the paragraph (making the text shorter to read) and participants had to tick off the errors (taking away some time from the reading). Tinker used easy texts (grade 6 primary school level), because these were all responded to correctly, so that there was no speed/accuracy issue (Tinker, 1939). Because of his procedure, Tinker rarely mentioned words per minute as dependent variable in his publications, but he was clear that "even with easy material, 500 wpm is very fast reading" (Tinker, 1958, p. 219).

Eye movement research

In the 1900s it also became feasible to track eye movements in large samples. This motivated a number of researchers to examine eye movements in normal silent reading and to establish reading norms. Buswell (1922) published a monograph on eye movements in children and young adults (university students). The participants had to read a short paragraph of text while their eye movements were registered. Buswell did not mention reading rate in terms of words per minute, because he found this too crude a measure (p. 102). Instead, he presented detailed information about the number of fixations per line of text, the duration of the fixations, and the number of regressive movements per line. However, he started the monograph with the following sentence: "In the silent reading of an easy paragraph, Barbara, a first-year pupil, read at a rate of 39.6 words per minute, while Miss. W, a college Senior, read at a rate of 369 words per minute" (Buswell, 1922, p. 1).

Clearly, for Buswell 300 wpm was a minimum for adult readers. Indeed, in a review paper in 1959 he summarized the results of research as follows: "The usual rate of reading non-technical material at the end of the elementary school is about 250 words per minute, while for college students the average is about 300 words" (Buswell, 1959, p. 113). He went on by saying that the smallness of the increase beyond the rate of elementary school was a cause of concern, in view of the selective character of the college population. Buswell believed in the possibility of teaching students to read faster without loss of comprehension. In his own words:

> "There have been extreme claims for gains in rate of reading that go quite beyond the credibility of serious researchers, but there is well substantiated evidence from research on rate of reading that leaves little room for doubt that a sizable increase in rate without loss in comprehension could be achieved if schools were to attempt it seriously. There is no support in research for the popular notion that the slow reader is superior in

> comprehension. … studies now available indicate that, at the college level, rate of reading may be forced from 100 to 300 words per minute above the reader's present rate without a break in level of tested comprehension" (Buswell, 1959, pp. 113-114).

Another eye movement researcher, who compared reading performance in children and adults was S.E. Taylor (1965). Like Buswell, he used eye-movement photography done by special cameras in which light was reflected from the readers' eyes and photographed on a moving strip of film. In total, Taylor tested 12,143 readers from first grade through college with at least 1,000 readers per grade. The average reading rate of the college students was 280 wpm (see below for the rates of the younger readers). Taylor (1965) did not mention the length of the texts, but given the equipment he used, these cannot have been longer than one paragraph. In Spichtig, Hiebert, Vorstius, Pascoe, Pearson, and Radach (2016), the materials were described as five paragraphs of 100 words each.

As indicated above, the number of 300 wpm was also mentioned by Rayner (1978) in his first review paper on eye movements in reading. It was repeated in the highly cited review paper of Rayner (1998) and two much used textbooks Rayner co-authored (Rayner & Pollatsek, 1989; Rayner, Pollatsek, Ashby, & Clifton, 2012). Finally, it figured in the Rayner et al. (2016) paper on speed reading.

Carver

A final author influential in promoting the 300 wpm norm was Carver. In a series of publications he developed a theory of reading inspired by the analogy of a gearbox in a non-automatic car or bicycle. Just like most cars have five gears with different optimal speeds, Carver ventured that readers used five reading speeds depending on their reading goal (Caver, 1977, 1982, 1992, 1997). The first reading gear was memorizing, a situation in which the reader learns a text for free recall. Average reading speed for this gear was 138 wpm (Carver, 1992). The second reading gear was learning, used when one wanted to pass a multiple-choice recognition test. Its speed was 200 wpm. The third gear was the one used in normal silent reading, to understand the text without aiming to answer questions afterwards. Carver called this gear "rauding" (for reasons explained later) and put it at 300 wpm. The fourth gear was skimming and used to pick up ideas from a text. Carver put its speed at 450 wpm. Finally, there was a fifth gear, scanning, which was used to find words in a text. Carver estimated it at 650 wpm.

Carver's estimate of 300 wpm for normal silent reading was influenced by Buswell and S. E. Taylor, which he both cited in his 1977 paper, but was also established independently. Before writing his theory of reading Carver had been involved in the understanding of compressed speech. Gradually, he came to the conclusion that there was a threshold around 300 wpm, above which the speech suddenly became much less intelligible.

Information take-up according to Carver involved two opposing forces: the speed with which information enters the system and the degree to which the information can be picked up by the system. This trade-off could be investigated by presenting information at different speeds and measuring how accurate the information take-up was. This was done most prominently in Carver (1982). Passages of 100 words were presented auditorily or visually at presentation rates going from roughly 80 wpm to 500 wpm.[2] After the passage, the participants were given cues and had to indicate whether these were related to the text. They were also asked to estimate the percentage of the passage they had understood. Efficiency of passage comprehension was then defined as the number of passage thoughts comprehended per unit of presentation time. As expected, understanding dropped the faster the information was presented. This was very similar for heard information as for seen information. When the information presented per time unit was added, information uptake was maximal at 300 wpm, both for listening and for reading. This number then became Carver's estimate of the ideal reading rate when reading for simple information uptake.

Hypotheses of why reading is faster than listening

If reading happens at a rate of 300 wpm, the obvious next question is why reading is so much faster than spoken language understanding. For instance, audiobooks are spoken at a rate of 140-180 wpm. Other estimates of speech rate are of similar magnitude (Rodero, 2012, 2016; Tauroza & Allison, 1990; Yuan, Liberman, & Cieri, 2006).

Carver gave one explanation for the faster reading rate: Speech remains understandable if it is compressed as long as the compression remains below twice the normal speed. He coined the word "auding" for this process, defined as listening to words and determining their meaning.

[2] Carver had a system of converting word and sentence lengths to standardized measures, which does not concern us here.

Auding does not involve the actual production of speech and, therefore, can be faster. In the same way, Carver called looking at words and defining their meaning "rauding" (reading + auding). Reading could not be faster than auding for Carver, because the translation of the visual code to the auditory code was necessary for language understanding. On the basis of existing information, Carver (1992, p. 89) hypothesized that: "… talking to oneself while operating the rauding process helps individuals to remember the beginning words of a sentence as the ending words are reached so that the complete thought can be comprehended". Already in 1908, Huey argued that inner speech formed a central part of silent reading.

A related hypothesis was put forward by Fulford (2001). She ventured that while we are listening to a person speaking, we simultaneously have an internal conversation preparing to make a response. Similarly, as a speaker we need an internal conversation because we want to monitor what we are saying and we may be thinking about making a point stronger. As a result, the total capacity of the language system is twice the speech rate (300 wpm instead of 150 wpm). The total capacity becomes available when no response is needed, such as when we are reading a text or listening to an audio tape. This is why silent reading and auding are fine for speeds up to 300 wpm.

Other researchers hypothesized that reading rate does not depend on speech-related processes, but is limited by visual and oculomotor factors. As we saw at the beginning of the article, two aspects are involved: how much written information can be extracted from the visual field during a fixation, and how long it takes to move the eyes to a new position. Seidenberg (2017) gave the following rough estimates:

- About 7 to 8 letters are read clearly on each fixation.
- Fixation durations average around 200 to 250 milliseconds (4 to 5 per second).
- Words in most texts are about five letters long on average.
- Four fixations per second = 240 fixations per minute.
- 240 fixations × 7 letters per fixation = 1,680 letters per minute
- 1,680 letters/6 (five letters per word plus a space) = 280 words per minute

A factor often invoked in discussions of the difference between reading and spoken language understanding is the serial and uncontrollable nature of the speech signal. When we listen to someone, a sequence of sounds is presented to us one after the other. These are combined into a meaningful message. We have very little control over the speed of the sounds and we cannot go back to a segment we misunderstood. This is different from the control we have as reader, both to set the pace of our reading and the ease with which we can regress to previous parts. In addition, the written text in most languages is neatly split in words, which makes parallel processing possible. It has been argued that the letters of visual words up to a certain length can be processed in parallel, unlike the sequential unfolding of sounds in spoken language (Adelman, Marquis, & Sabatos-DeVito, 2010; Radeau, Morais, Mousty, Saerens, & Bertelson, 1992). There are also indications that more than one word can be processed simultaneously in reading (Snell & Grainger, 2019), and it has been argued that reading enables better prediction of upcoming words (Huettig & Pickering, 2019). All these factors help to understand why reading can be faster than listening.

Some problems with the estimate of 300 wpm

In the previous sections, we saw why authors proposed a normal reading rate of 300 wpm. In general, they had to defend this number against claims that a little practice was enough to increase the speed to over 500 wpm. For instance, Fry (1963) claimed that good readers should easily achieve a speed of 350 words per minute, while fair readers reached 250 words, and slow readers 150 words per minute. The criticism not only came from commercial companies, trying to sell their training programs, but also from academics arguing that schools and universities should invest in optimizing the reading speed of their students (e.g., Bellows & Rush, 1952; Buswell, 1959; Deal, 1934; Henry & Lauer, 1939; Jensen, Mills, & Hershkowitz, 1972; King, Dellande, & Walter, 1969; Maxwell & Mueller, 1965; Poulton, 1961; Stoll, 1974; Thames & Rosster, 1972; Wooster, 1954).

However, at the same time there were "annoying" findings of normal reading rates well below 300 wpm. A prominent case was the Nelson-Denny Reading Test (Brown, Fishco, & Hanna, 1993; Nelson & Denny, 1929). In the comprehension subtest, participants are given short text passages of some 200-600 words (drawn from high school and college textbooks) and they have to respond to multiple-choice questions about the contents of the passages. Students are instructed to read at their normal rate, neither faster nor slower than usual. Before starting the first passage, they are told that a signal will be given after one minute and that they have to indicate on the page which word they are reading at that moment. This is used to calculate the reading rate. There are several versions of the Nelson-Denny test with their own norms. However, the mean reading rate is typically some 250 wpm and not 300 wpm (Benevides & Peterson, 2010; Brown et al., 1993; Masterson & Hayes, 2014; Nelson & Denny, 1929).

Another annoying finding came from the type of test used by Tinker. We saw that the Chapman-Cook Speed of Reading test used by Tinker typically resulted in reading rates around 300 wpm. However, there were other tests of the same format that gave much lower estimates. The Michigan Speed of Reading test, for instance, included 100 paragraphs of 30 words and was administered for 10 minutes. The test takers again had to indicate the awkward words at the end of the passages. The mean number of paragraphs finished by freshmen for this test was 70.6, equivalent to 212 wpm (Greene, 1934). Another test of the same construction was the Minnesota Speed of Reading test, which contained 38 paragraphs of on average 52 words with an awkward word towards the end that had to be ticked off. Students had to complete as many paragraphs as possible in 6 minutes. Eurich & Kraetsch (1982) mentioned an average reading speed of 17.8 paragraphs (154 wpm) for students tested in 1928 against 15 paragraphs (130 wpm) for students tested in 1978. Importantly, all these numbers are well below 300 wpm. Tinker (1939) argued against the use of these tests because they gave rise to a speed/accuracy trade-off, suggesting that the awkward words were too difficult to notice in normal reading. The Michigan and Minnesota tests indeed contained more difficult text paragraphs (college level), but also took longer than one minute to complete, a characteristic we will return to in the next section.

Carver’s (1982) finding of an optimal auding rate at 300 wpm was not universally accepted either. After a major review of the literature, Foulke and Sticht (1969, p. 60) concluded that: “When these studies are considered collectively, the relationship that emerges is one in which listening comprehension declines at a slow rate as word rate is increased, until a rate of approximately 275 wpm is reached, and at a faster rate thereafter” (see also Beatty, Behnke, & Goodyear, 1979). As a matter of fact, Carver set up his 1982 study to “properly” test the idea of processing thresholds after two findings had been published that went against his theory of rauding. Jester and Travers (1966) reported different optimal presentation rates for auditory and visual prose material. Whereas it was 300 wpm for silent reading, it was 200 wpm for listening. Also Carver himself initially found that nearly every speeding up of auditory information came at a processing cost (Carver, 1973). Not all articles after Carver (1982) have pushed for an optimal auding rate of 300 wpm either. Rodero (2016), for instance, concluded that the ideal speech rate for radio news is 170 wpm for high density messages and 190 wpm for low density messages (also see Rodero, 2012). King and Behnke (1989) reported that comprehension of a formal lecture decreased as soon as the original signal was compressed. In contrast, short-term memory questions about series of numbers and letters could be answered well up to 45% compression (i.e., nearly twice the normal rate). In a third condition, participants had to listen to segments of dialogue and answer questions regarding the meaning or intentions of the individuals engaged in the dialogue. Here, performance also remained relatively good up to 45% compression. Unfortunately, no information was given about the speech rate of the original materials. On the positive side, Conrad (1989) reported that native speakers can repeat simple sentences speeded up to 320 wpm.

Finally, Rayner (1978) seems to have been selective in the choice of his illustrative table as well. The 10 readers from his table correspond remarkably well to the 10 participants tested in Rayner (1975). In this study participants read 225 short paragraphs of three to four sentences. They were asked to read the paragraphs silently while their eye movements were registered. After the readers had read a block of 15 paragraphs, they were shown a set of 12 sentences and asked to identify which of the sentences came from the passages just read. Importantly, the 10 participants of Rayner (1975) were described as 10 undergraduate students from Massachusetts Institute of Technology, a university with high entrance criteria. This may be important because in the same time period Rayner was co-author of two other papers on text reading (McConkie & Rayner, 1974; McConkie, Rayner, & Wilson, 1973) with much larger sample sizes and with much lower reading rates (ranging from 190 wpm to 265 wpm). Two reasons probably convinced Rayner (1998) that the 300 wpm group was more representative. First, it was the only study with eye movements (the topic of Rayner, 1998). Second, McConkie et al. (1973) and McConkie and Rayner (1974) showed that participants could be induced to read faster by giving them rewards, without much loss of text comprehension. So, Rayner probably felt right to conclude that although many of the participants he tested read below 300 wpm, they were easily capable of doing so. Of course, it is also possible that scientific psychologists are not immune to the social values and general beliefs in the world around them and are more likely to present data in line with them (Brysbaert & Rastle, 2013, Chapter 13; Ward, 2002).

To have a more widely supported estimate of reading rate, we decided to run meta-analyses of silent and oral reading rates, including all the studies we could find, spanning a time period from 1901 to 2019. This ensured that our estimates are based on the largest possible database. Because the meta-analyses were unable to address a critical prediction of Carver's theory, we also ran a small-scale empirical study on reading rates for popular fiction books, which will be discussed later on.

A meta-analysis of reading rates in silent reading

Two questions

So far we have seen where the idea of 300 wpm as average reading speed came from and why users of the Nelson-Denny test (widely adopted by schools and universities to detect reading problems) felt uneasy about the number, given that the Nelson-Denny norms gave a mean value of 250 wpm. Indeed, another summary measure often reported for normal reading rate is 250-300 wpm (e.g., Galitz, 2007; Huettig & Pickering, 2019; Jonassen, 2004). Because of the discrepancy, a systematic review of the literature is indicated.

There is another reason for a systematic review. Looking at the way reading rate has been assessed, it is worrying that many tests ask participants to read for one or two minutes only. If we take Carver's idea of reading gears seriously, short tests may call for a speed that can be sustained briefly but is not the long term reading rate. An analogy can be made with the way we move. Arguably, we have two movement gears: walking and running. In walking there is at least one foot on the ground; in running both feet are off the ground with each step. Walking does not consume much more energy than resting, can be done for hours a day, and does not put strain on the body (Carrier, 1984). In contrast, running does consume extra energy and puts strain on the body. As a result, it tends to be limited to rather short bursts and requires recuperation afterwards. It is what we do when we are in a hurry or in danger (and what a small segment of the population likes to do as a workout on a regular basis). Because of the existence of two types of locomotion we would be puzzled if someone asked us to move forward for 200 meter or for one minute "in the way we usually move". Do they mean we should walk or run? Chances are much lower we would be confused if we were asked to move for ten hours in our usual way, as not many of us are able to run for that long. Applied to reading, could it be that current tests of reading speed assess the equivalent of reading as running (meaning that we can do it for a short time after which we are exhausted and require recuperation) rather than the equivalent of reading as walking (which we can maintain for most of the day)? If so, we should find faster reading rates for short tests than for long tests.

In summary, we have two questions that can be addressed with a meta-analysis: (1) what is the average rate of silent reading, and (2) is it faster for short tests than for long tests?

Selection of the studies

We used two methods to find relevant studies. The first was a systematic search based on the Web of Science, using the selection criteria: ("words per minute" and reading) or "reading rate" or "reading speed" in Topic. At the last time of testing (February, 2019), this resulted in 2,026 hits. The abstracts were read and selected if they looked relevant. The criteria were:

- Participants included a group of healthy adults between 17 and 60 years (see below for younger and older people).
- The task involved reading for comprehension or fun.

The criteria resulted in 127 candidates, which were carefully read and pruned. Extra criteria used at this stage were:

- The stimulus materials were normal text. This excluded studies where participants responded to individual words or to random sequences of words without grammatical connections.
- Reading happened silently (see below for oral reading).
- The materials involved a language written in Latin alphabet (see below for other languages).
- At least 10 participants were tested. This excluded psychophysical studies with two or three participants.
- The test was administered to an unselected group of healthy participants. This excluded some studies in which slow readers were given the opportunity to take part in a reading training program. For a clinical study to be included, it had to comprise a control condition with healthy participants.
- Participants were native speakers (see below for non-native speakers).
- The task was reading for comprehension or fun. This excluded studies with proofreading or the type of task Tinker used. It also excluded studies that tested studying for fact retrieval.

- The full text was visible while the participants were reading. This excluded studies in which participants had to press a button to see the next word (self-paced reading) or studies with various forms of dynamic presentation (e.g., moving text).
- The article contained enough information to calculate reading rate in words per minute.

The extra pruning left us with 45 relevant articles. These were carefully checked for cross-references, which pointed us to another 124 articles not covered by the initial search. The studies embrace an era of more than a century (going from 1901 to 2019) and a large range of topics, including:

- Reading rates for various groups.
- The effects of adverse conditions on reading.
- The effects of various presentation forms on reading rate.
- Eye movement patterns for various types of information.
- Static versus dynamic forms of text presentation.

The vast majority of studies used English stimulus materials, but there were also a few in Dutch, Finnish, French, German, Italian, Norwegian, Slovenian, Spanish, and Swedish (language differences will be discussed in a separate section below). Most studies were short, involving a test of a few 100 words or a test of 1-2 minutes. Some were even shorter and involved unrelated sentences, presented one by one. Others were longer. The longest study involved five conditions per person with 80 minutes of reading per condition. It was published by Cushman (1986, Experiment 1) and compared reading on screens and printed pages. Participants were employees of East Kodak Company. They read articles of general interest, printed in 10-point Times Roman Medium type with approximately 55 characters per line and two columns per page. Each article was accompanied by several validated multiple-choice questions for measuring reading comprehension. In addition to reading rate, measurements of visual fatigue (ocular discomfort) were taken.

With respect to the short tests, it should be taken into account that often there were multiple conditions per experiment, meaning that participants in total read for a longer time. As such, they resemble Huey's (1901) experiment, in which participants read one page at a time, but did so 11 times. Similarly, in many eye movement studies, participants were asked to read sentences. However, they were typically given some 50-100 sentences per experiment.

Nearly all studies involved so-called WEIRD participants (Western, educated, and from industrialized, rich, and democratic countries; Henrich, Heine, & Norenzayan, 2010). Participants were predominantly university students (undergraduates). As such, the remit of the data is limited to this segment of the world population. Henry, Van Dyke, and Kuperman (2018) tested a non-university sample in addition to a university sample on the reading of short texts (see Table 1). Whereas the university students had an average reading rate of 248 wpm, the mean reading rate of the community sample was 218 wpm.[3]

For each article:

- We selected the most natural condition if there was a choice. This was, for instance, the condition in which the full text was visible, the condition in which the materials were presented on paper (as we did for Cushman, 1986)[4], or the condition with the longest text to read.
- If no condition stood out, we took the average of all conditions.
- Unless there were clear differences in reading rates for groups in a between-subjects variable, the data were added and the total number of participants calculated.

All in all, we found 190 studies in 169 articles, involving a total of 18,573 participants. They are summarized in Table 1 (see supplementary materials for a spreadsheet with more information).

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Insert Table 1 about here

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Results

There are several ways in which we can analyze the data of Table 1 (Hall & Rosenthal, 2018). First, we have to decide between a fixed effect model and a random effect model. The fixed model assumes that there is a single, true reading rate, which each study tries to measure. A random model assumes that there may be different reading rates (e.g., depending on text

[3] These data are not in the article, but were kindly provided by the authors upon request.

[4] Reading on paper results in slightly better comprehension than reading on a screen (Clinton, 2019; Delgado, Vargas, Ackerman, & Salmerón, 2018; Kong, Seo, & Zhai, 2018). Reading times are very similar, except in the first studies when the quality of the screens was low.

difficulty, length of the text, type of questions asked, and so on) and that we want to calculate the average of these reading rates. Unless a researcher has good evidence in favor of a fixed model, the default approach in current meta-analysis is to work with a random effects model.

The second decision to make is whether to use a weighted model or an unweighted model. In the former type, we assume that there are quality differences between the studies, so that they should get different weights. A variable that could be used here is the number of participants tested, with big studies getting a heavier weight than small studies. Another variable, which is used more often, is the variance present in a study. A study with a small variance in the estimates is assumed to measure the dependent variable more precisely than a study with a large variance and, hence, deserves a higher weight. In contrast, unweighted models start from the assumption that each study measures the underlying concept in an equally non-optimal way and that we want to generalize the findings to studies with other designs, populations, or features than available in the dataset. One reason for preferring this model could be that each study makes use a particular test/text, which should be considered a random variable as well (we want to generalize beyond the specific texts/tests used). On this criterion, a study testing 300 participants on test A with small variability does not measure reading rate more precisely than a study testing 20 participants on test B that has a larger variability.

A meta-analysis with unweighted, random effects is very simple to run. All one has to do, is to calculate the mean and the standard deviation of the values observed in the different studies. If we do this for the data in Table 1, we get an average reading rate of 238 wpm (SD = 51.2; 95% confidence interval = 230 – 246). The median is 235, indicating that the distribution is largely symmetric. If we weight the studies for the number of participants they included, the mean increases to 242 wpm. Remember that this number assumes that studies with large numbers of participants have more reliable measures.

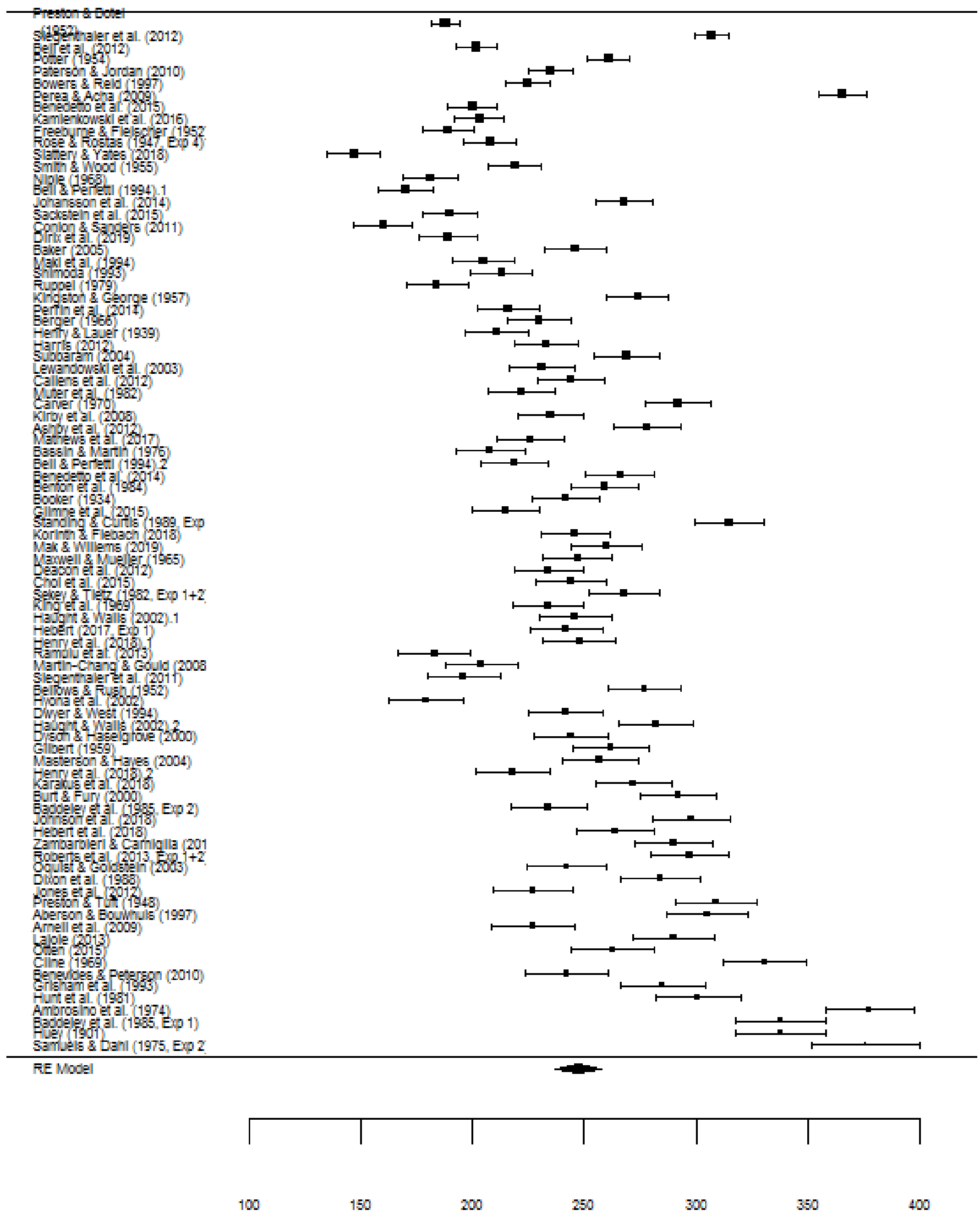
There are many dedicated software packages for weighted random models. Most of them use the precision of a study as the weighting variable. For this analysis we need information about the standard deviations (SD) of the reading rates in addition to the means. Unfortunately, such information was available for 87 of the 190 studies only. The fact that information is missing for more than half of the studies was due to two factors. First, some authors did not mention a measure of variability. Second, quite some studies reported reading times rather than reading rates. Because reading times form an unknown positively skewed distribution, it is not possible to translate their SD into a trustworthy SD for reading rates.

The subset of 87 studies with SD included 10,201 participants and had an average reading rate of 247.5 wpm (SD = 47.4, .95CI = 237.4 – 257.7). Surprisingly, for this subset the mean weighted by the number of participants per study was lower and amounted to 239 wpm. The reason for the discrepancy was a large sample outlier. Preston and Botel (1952) reported the reading rate of 2,048 students on the Iowa Silent Reading Test (M = 188 wpm; SD = 10.1) and related it to academic achievement.

The software we used for a weighted random effects meta-analysis was the function metamean() from the R package 'meta' (Schwartzer, 2019), which can run a random effects model on untransformed means with the inverse variance method.[5] The resulting mean was 247.1 wpm, with a 95% confidence interval of 237.4-256.7. The model further indicated that there was a strong degree of heterogeneity in the estimates [$Q(86) = 11669$; $I^2 = 99.3\%$]. This is illustrated in Figure 1, which shows the forest plot of the studies ordered as a function of SD. Part of the heterogeneity was due to the study of Preston and Botel (1952). When this study was removed, I^2 decreased to 98.3%, still a high value.

[5] The author thanks Martin Vasilev for pointing him to the package and checking the analyses.

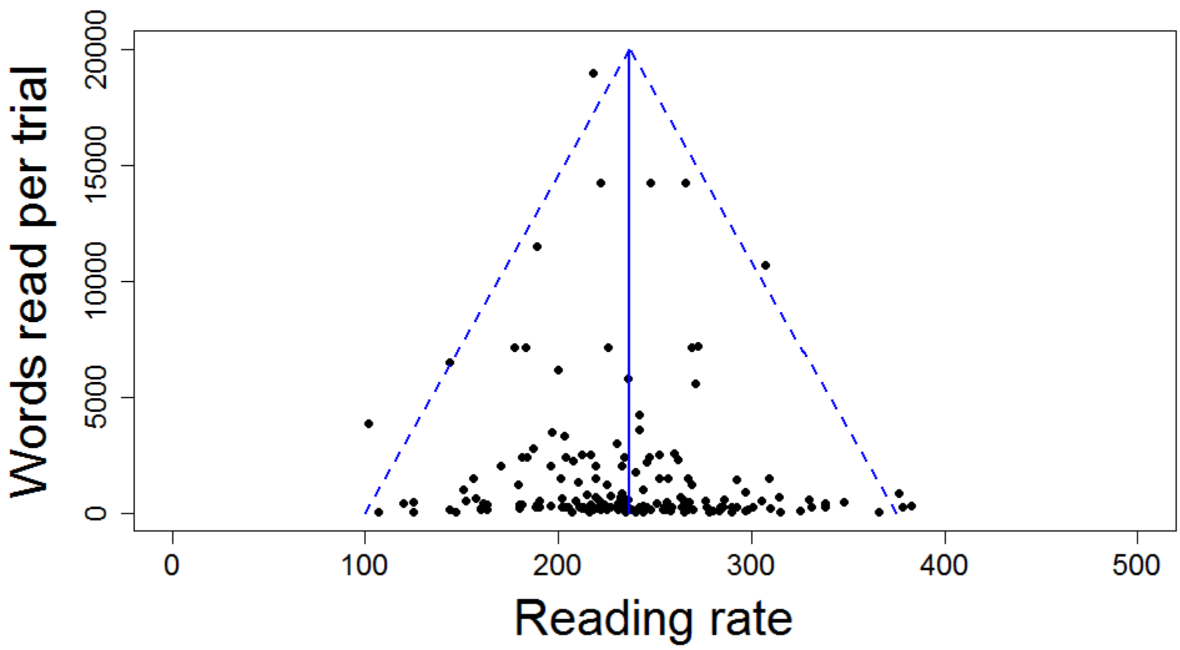
Figure 1: Forest plot (based on Hamilton, 2018) of the 87 studies included in the weighted meta-analysis based on the inverse variance method, ordered from smallest to largest SD. The plot shows the large heterogeneity in estimates and the positive correlation between mean reading rate and SD. The Preston and Botel (1952) study is the top one.



If 300 wpm is the typical reading rate, we can expect that SDs will become smaller when reading rate approaches this value. This is not what Figure 1 shows. In general, SDs are larger for higher reading rates (correlation between SD and mean reading rate across studies is $r = .56$, $N = 87$). According to Egger's regression test, the correlation is unlikely to be due to publication bias [$t(84) = 1.17$, $p = 0.24$; without the study of Preston & Botel (1952)]. A more likely reason for the positive correlation between reading rate and SD is the finding that mean and SD are often positively correlated for time-based variables, arguably as a result of the underlying processes. At the same time, the observation that the variability is particularly high for reading rates above 300 wpm confirms the conclusion that 300 wpm is not the 'average' reading rate.

Further analysis of Table 1 did not provide evidence for faster reading rates with short tests than with long tests, as we had hypothesized. What became evident, was that there was more variability in estimates based on short tests than on long tests, very similar to the funnel plot typically observed in meta-analyses when the effect size is plotted against study precision (Light & Pillemer, 1984). Figure 2 shows the association between the number of words per trial and the mean reading rate reported (all 190 studies included). It indicates that the reading rate did not become faster for short tests, as we assumed on the basis of the analogy with walking vs. running. Instead, what seems to happen is that short tests result in much more variability than long tests (even though each dot in Figure 2 is the outcome of a study involving at least 10 participants). This illustrates the concern we raised earlier that it is very difficult for participants to interpret the instruction "read for one or two minutes as you would normally do (but also as fast as you can)". Interestingly, the funnel was less clearly present when the total number of words read in the study was used instead of the number of words per trial. So, there is less variability in studies that asked participants to read one reasonably long text for five minutes than in studies that asked participants to read five short texts for one minute each. If the funnel can be relied on, quite stable estimates should be obtained if participants are asked to read for an hour or so (60*238 = 14,280 words).

Figure 2: Reading rates observed in studies as a function of the number of words read per trial, showing that studies in which participants read a text for one hour (about 14 thousand words) have less variance in the estimates than studies in which participants read for one minute or less (about 250 words). At the same time, there is no evidence for faster reading rates on short tests than on long tests. Each dot represents a study from Table 1.



A meta-analysis of oral reading rates

Another way to test reading rate is to look at the reading speed when participants are reading aloud. This has the advantage that the experimenter has more information (control) of what the participant is doing while reading. The disadvantage is that adults rarely read aloud for more than a few seconds, so that the usefulness of the measure is less clear.

Utility of oral reading rates

Reading aloud is the main way of understanding written text for starting readers, as they need access to the phonological information in order to understand the words they are reading (Sprenger-Charolles, Siegel, Béchennec, & Serniclaes, 2003). So, oral reading fluency is a good indicator of reading proficiency in the first years of primary school (Fuchs, Fuchs, Hosp, & Jenkins, 2001; Rasinski & Hoffman, 2003; Share, 2008).

Oral reading fluency is no longer thought to be of importance in higher education, as nearly everyone by then reads and studies in silence, except maybe in second language education (Gibson, 2008). Still, there are two research areas in which oral reading rates in adult native speakers are assessed. The first one has to do with vision problems and their impact on reading. The second one comes from dyslexia research, where students with dyslexia are compared to healthy controls on reading aloud a paragraph.

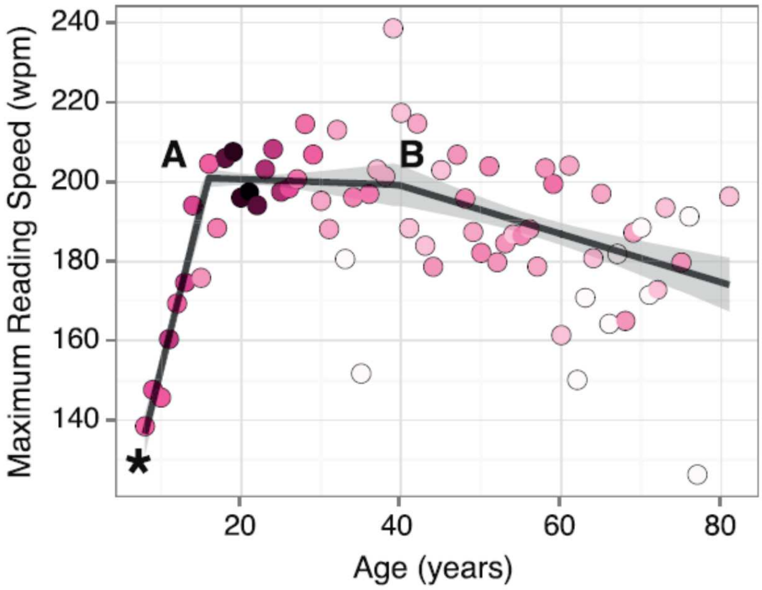
Reading charts in ophthalmology

In ophthalmology there is an interesting literature on the development of standardized and normed reading charts. Most interesting for our research questions are the reading charts consisting of short paragraphs of text. The most widely normed is the International Reading Speed Texts (IReST; Trauzettel-Klosinski & Dietz, 2012; see also Radner, Radner, & Diendorfer, 2016, for another set of paragraphs and their norms in German). The IReST consists of 10 equivalent paragraphs of some 150 words each, and is available for next to 20 languages (the texts in the different languages are translations of the original, German texts). The texts are simple (they must be readable by nearly everyone) and the words are short (e.g., 4.3 letters in the English version). The texts have been normed by presenting them to 25 healthy native speakers per language. Average reading speed is 228 wpm in English.

Other useful charts in ophthalmology present standardized sentences in various font sizes, to see at what point reading starts to deteriorate. One of these is the Minnesota Low-Vision Reading Test (MNread; Calabrèse et al., 2016). The test consists of a series of 60-character sentences (some 12-15 words) displayed on three lines. The patient has to read the sentence aloud as fluently as possible. Figure 3 shows the results as a function of age (the maximal speed refers to large font sizes, where reading speed is optimal). Notice the increase of reading speed below the age of 18 and the decrease in old age (see Hasbrouck & Tindal, 2006, and Ford, Missall, Hosp, & Kuhle, 2017, for more detailed information about reading aloud rates at young ages; also see Tortorelli, 2019, for lower reading rates when non-fiction, expository text is used).

Figure 3: Reading aloud rate as a function of age based on the MNread test (each dot is a different study; the darker the dot, the more participants were tested)

Source: Calabrèse et al. (2016)



An alternative to the MNread test is the Radner Reading Charts (Radner, Obermayer, Richter-Mueksch, Willinger, Velikay-Parel, & Eisenwort, 2002), also available for several languages. Each chart of this test has sentences of 14 words distributed over three lines. Brussee, van Nispen, and van Rens (2017) compared performance on IRest and the Radner Reading Charts in Dutch adults. They also looked at the effects of age and education. Mean reading rates in the various conditions ranged from 150 wpm to 220 wpm. They were higher for the Radner test, for younger participants, and for participants with more education. Particularly for the younger participants (18-36 years) there was a strong effect of education.

Morrice (2017) examined the importance of instruction. Using the English IReST stimuli, he observed reading rates of 203 wpm in Canadian students under normal instructions, which stress speed, compared to 181 wpm when the students were asked to read aloud normally (interestingly, both reading rates were below the English norms reported by Trauzettel-Klosinski & Dietz, 2012).

A final ophthalmologic study worth discussing at some length, was published by Mackensen and Stichler (1963). These authors were also interested in normal reading rates for the eye clinic. They tested 622 adult participants both on silent reading and on reading aloud. The texts were excerpts from a novella of Joseph von Eichendorff, completed in 1823. Time was measured with a stop watch. Education differed in four categories from academics to uneducated janitors. A further distinction was made between participants below and above 50 years. Mackensen and Stichler (1963) reported reading aloud times going from 2.8 seconds per 10 words (214 wpm) for the young academics to 3.85 seconds (156 wpm) for the old janitors. Silent reading rates varied from 353 wpm to 211 wpm.

The ophthalmological charts are interesting (certainly because they exist for several languages) but deviate from the texts used in silent reading, because they are considerably shorter and simpler. In addition, time registration is often manual because the charts are mostly hard copies, so that they can be presented in a uniform way. There are reasons to believe that the manual administration leads to an overestimate of the true reading rate by some 10%. This is because the participant can see the chart a few 100 ms before the timer is started (Calabrèse, To, He, Berkholtz, Rafian, & Legge, 2018). A final difference is that the texts are not followed by questions, as is customary in silent reading studies. These factors may increase the observed reading rates.

Norms for dyslexia tests

A second source of reading aloud rates comes from norming studies of dyslexia test batteries. Many of these batteries include an oral reading test, because students with dyslexia are known to perform worse on this test than controls. Callens, Tops, and Brysbaert (2012), for instance, tested 100 Dutch-speaking healthy undergraduates on silent reading of a text of 1,023 words and a reading aloud text of 582 words. Both readings were followed by comprehension questions. The authors observed a silent reading rate of 244 wpm and an oral reading rate of 136 wpm in the control participants. As is customary for this type of batteries,[6] the oral reading text was more difficult than the silent reading text (words of respectively 5.7 and 4.6 letters), meaning that the reading aloud rate based on this source is likely to be an underestimate.

[6] Re, Tressoldi, Cornoldi, and Lucangeli (2011), for instance, also used a reading aloud text with words of 5.7 letters in Italian.

The two reading rates of Callens et al. (2012) correlated r = .32 (N = 100, p < .01). One reason for this rather low correlation could be the difference in text difficulty, as just described. Other contributors may be the less than optimal reliability of the measures (which was not assessed, as only one measurement per modality was taken) and the fact that oral and silent reading are influenced by somewhat different factors. As Callens et al. (2012) investigated a range of variables, we can have a look at the latter possibility by examining the variables correlating with the reading speeds (Table 2).

Table 2: Significant correlations of silent and oral reading rates with other variables, based on the data of the 100 control participants of Callens et al. (2012), where more information about the variables can be found.

Variable	**Wpm_silent**	**Wpm_aloud**
Dutch word spelling	0.51	0.38
Dutch words read out loud correctly in 1 min	0.50	0.64
English words read out loud correcly in 1 min	0.47	0.36
Dutch nonwords read out loud correctly in 1 min	0.47	0.51
Mistakes in Dutch text spelling test	-0.42	-0.39
Vocabulary	0.36	0.10
Crystallized IQ (KAIT)	0.35	0.12
Arithmetic (4 operations)	0.33	0.26
English word spelling	0.31	0.32
LASSI preparation for test	0.22	0.00
Working memory (ordering random sequence of letters)	0.22	0.19
Conscientiousness	-0.22	-0.11
Fluid IQ (KAIT)	0.22	0.08
LASSI main idea selection	0.20	0.04
Spoken text comprehension (KAIT)	0.19	0.00
Delayed spoken text memory (KAIT)	0.18	0.21
Time needed to name digits	-0.03	-0.27

Silent word reading was influenced more than oral reading by spelling skills (the better the skills the higher the reading rate), vocabulary and crystalized intelligence (the higher, the higher the reading rate), and spoken text comprehension. In contrast, reading aloud correlated more with rapid naming of unrelated stimuli (random words, digits), as could be expected. Interestingly, silent reading rate also correlated with two non-cognitive factors. Conscientious students read more slowly and students who thought of themselves as well prepared for tests read more rapidly. The correlation of the two non-cognitive variables with silent reading but not reading aloud agrees with the hypothesis that students in a silent reading test feel uncertain about where to put emphasis: speed or accuracy on the test afterwards.

Lewandowski, Codding, Kleinmann, and Tucker (2003) examined 90 English-speaking students on silent reading rate (the Nelson-Denny Reading Test) and oral reading rate (reading aloud three 300 word passages from the Nelson-Denny Reading Test) as part of an assessment battery. Silent reading rate was 231 wpm, oral reading rate was 189 wpm. Both measures correlated .48 with each other. The reliability of the silent reading rate was not tested (as only one measurement was made), but from the norms we know it is unlikely to be higher than .7 (Brown et al., 1993). The three oral tests correlated .8 with each other. The average reading aloud rate correlated more with text comprehension than the silent reading rate, which could be due to the test's higher reliability.

Ciuffo et al. (2017) also reported a correlation of r = .48 between silent reading rate and oral reading rate in Italian speakers. Unfortunately, they did not assess the reliability of their measures.

Studies included in the meta-analysis

To have a more organized estimate of oral reading rate, we repeated the article search we did for silent reading. Twenty-two data points were found in the systematic search based on the Web of Science (see above). An additional 55 studies were located on the basis of references in and to these articles.

The 77 studies (5,965 participants) came from 55 articles with languages based on the Latin alphabet (see Table 3 and supplementary materials). One extra study was deemed to be an outlier. Kemper, Jackson, Cheung, and Anagnopoulos (1993) reported reading aloud rates of 295 wpm for college students and 248 wpm for older adults, which seem very unlikely given the other data.[7]

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[7] They would fit perfectly in the picture of silent reading, however.

Insert Table 3 about here

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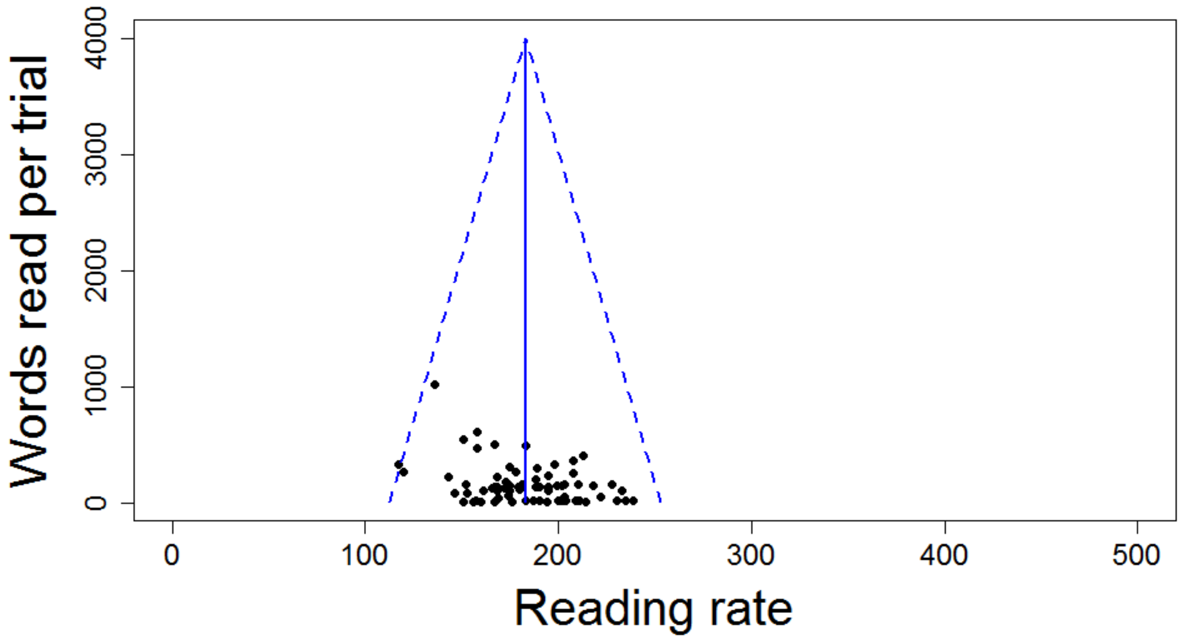
Results

Because a weighted meta-analysis results in fewer studies that can be included (due to missing SDs) and gives the same outcome as an unweighted analysis, only the latter is reported. Mean reading rate was 183 wpm when each study was given equal weight (SD = 25.9; 95% confidence interval = 177 – 189 wpm). The number was virtually the same when the studies were weighted according to the number of participants in them (180 wpm). Also the median was virtually the same (181 wpm), indicating that the distribution was symmetric. Figure 4 shows the findings in a figure with the same wpm scale as in Figure 2 (silent reading). This figure shows that the reading aloud studies in general had fewer words per trials, but that this was justified, because the range of observed reading rates across studies was considerably smaller. A 5 minute test (900 words) or 10 minute test (1,800 words) would seem to guarantee comparable results across studies (remember we had a combination of easy ophthalmological texts and difficult dyslexia texts).

Figure 4: Reading aloud rates as a function of text length. Each dot is a study from Table 3.



An average oral reading rate of 183 wpm agrees well what can be expected from speaking rates. At the same time, it is an unrealistic rate for day-to-day use (i.e., someone reading aloud for several hours per day). On the basis of a study with 10 male adults, Fredericks, Kumar, Oda, and Butt (2015) considered a mean oral speed of 120 wpm acceptable for an 8-hour day with 40 dB background noise. A similar rate was recommended by Zagoruiko and Tambovtsev (1982) for experienced operators; for new operators the recommended rate was lower.

Fiction reading as a critical test of Carver's theory

In the meta-analysis of silent reading rates we saw that the average reading rate was 238 wpm. This is 20% lower than the recommended rate of 300 wpm. It is also 5% less than the other recommended reading rate of 250 wpm. However, it could still be explained within Carver's (1992) theory by assuming that there are two groups of readers. One group (about 60%) misinterpreted the task as a learning task and read at a speed of 200 wpm; the other group (40%)

rauded as asked. Indeed, nearly all studies on silent reading asked the participants to answer (easy) questions to guarantee a minimum of comprehension and the 18 that did not do so, had a slightly higher reading rate of 265 wpm (see Table 1).

The only way to be sure that people are rauding as meant by Carver is to observe them while they are reading a fiction book for enjoyment. Surprisingly, no such study could be found. The five studies in Table 1 that come closest are the ones by Dwyer and West (1994), Tyrrell et al. (2001), Zambarbieri and Carniglia (2012), Benedetto et al. (2014), and Mak and Willems (2018).

Dwyer and West (1994) investigated the effect of sustained silent reading on the reading rate of college students. A group of 76 students (education majors or students otherwise interested in teaching) were asked to read novels for 25 slots of 15 minutes each. They were asked to estimate the number of words read (by counting the words on a few pages and multiplying them with the number of pages read) as part of a class project in which the effects of sustained reading were investigated. The average reading rate of the first five blocks (the first week) was 242 wpm. By the last week, the rate had increased to 278 wpm.

Tyrrell et al. (2001) examined reading performance for three types of display. Eighteen undergraduates were asked to read the novel Dracula for three sessions of one hour each: two on LCD displays and one on a high quality hard copy. There were no differences in reading rates between the conditions and the average reading speed was 248 wpm.

Zambarbieri and Carniglia (2012) asked 38 participants to read chapters of some 2,000-3,500 words from a novel in Italian on different devices, while the eye movements were tracked. Reading on average was 290 wpm, with no big differences between the devices.[8]

Benedetto et al. (2014) asked 48 participants (not further detailed, mean age = 27 years) to read a novel of Maupassant for an hour. The eye movements were registered but this could be done while the participants were sitting in a comfortable chair. Between-participant manipulations were the screen luminance and the ambient illumination. Ambient illumination did not have an effect, but screen luminance did. The two groups with a high screen luminance (the best condition) had reading rates of 256 wpm and 275 wpm.

[8] These data are not in the publication but were kindly provided by the authors upon request. Only data of 38 from the 43 participants could be retrieved without too much hassle.

Mak and Willems (2018) asked 109 participants to read three short stories (between two thousand and three thousand words), while their eye movements were tracked. Reading rate was 304 wpm for the first story, 253 wpm for the second, and 222 wpm for the third.[9] After each story the participants were asked three general questions to make sure they had read the stories.

Because reading fiction for pleasure is a critical test of Carver's theory of reading gears, we decided to collect extra data.

A new fiction book reading study

Participants

To collect more data on fiction reading, a study was set up in which regular readers were asked to register the time they needed to read the next book on their list. Because external validity was more important than internal validity, participants were recruited via emails to friends and colleagues and via social media.[10] They were simply asked for their next book to note down the time whenever they started and stopped reading. After the book was finished, the intervals were added to get the total reading time. The title of the book was noted together with the total reading time. All in all, 48 participants provided data for one book each. They were between 18 and 60 years and belonged to the WEIRD group as defined by Henrich et al. (2010). Indeed, 14 of the 48 had a PhD degree. All others had taken university studies or were taking them.

Books

Several languages were involved: 23 books were read in Dutch, 17 in English, 4 in French, 2 in German, 1 in Italian, and 1 in Hebrew. Sixteen of the non-English books were translations of English books. The number of words in the books was estimated via a website based on information from Amazon (http://wordcounters.com/, consulted in March, 2019) and/or by taking samples from the books and extrapolating to the complete book. Thirty-two of the books were detective, mystery or fantasy novels. The 16 other were more highbrow literature.

Results and discussion

[9] These data are not in the publication but were kindly provided by the authors upon request.

[10] The author thanks Heleen Vander Beken and the organization for reading promotion "Iedereen leest" (everybody reads) for their help with data collection.

Mean number of pages per book was 385 (SD = 166), mean number of words was 107,000 (SD = 65,800). Reading times ranged from slightly below one hour to over 17 hours. Mean reading rate was 260 wpm (SD = 87; 95% CI = 235-285). Figure 5 shows the distribution.

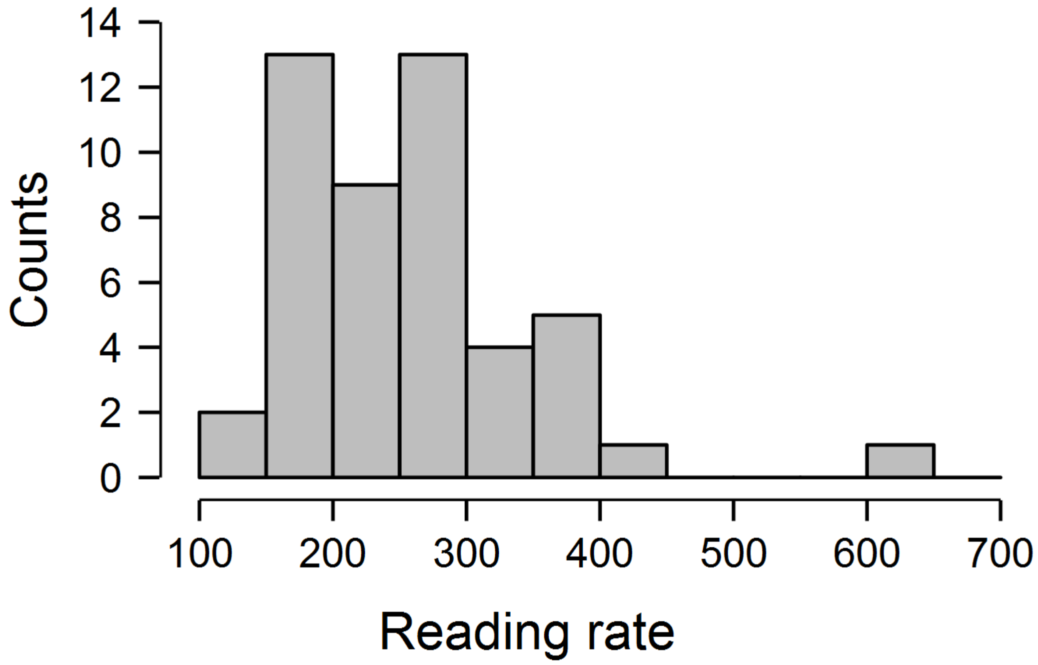


Figure 5: Distribution of reading rates for fiction books

A one sample Bayesian t-test with a Cauchy prior (scale .707) indicated that the average reading rate of the book reading study was in line with the silent reading rate of 238 wpm obtained in the meta-analysis, although the sample was too small and the results too diverse to give more than anecdotal evidence for the null-hypothesis (BF_{10} = .63; Wagenmakers et al., 2018; Bayes Factors between 1/3 and 3 are in line with both the null hypothesis and the alternative hypothesis). In contrast, there was strong evidence that the obtained reading rate is different from 300 wpm, even in a non-directional test (BF_{10} = 13.42).

To see whether a mixture of two Gaussian distributions (arguably with means around 200 wpm and 300 wpm) gives a better fit than a single Gaussian distribution (with mean around 260 wpm), the densityMclust() function of the R package mclust (Scrucca, Fop, Murphy, & Raftery, 2016) was run. It showed that a model with one Gaussian component is better than a model with 2 components (BIC = -571.4521 vs. -572.7989). The difference in BIC value of 1.35 indicates that the model with one component is about 3.8 times more likely than the model with two components (Kass & Wasserman, 1995), which is moderate evidence for the single component model.

All in all, the fiction book study fails to find any evidence for the hypothesis that the average silent reading rate of 238 wpm in the meta-analysis was a combination of two reading gears: One with a speed of 200 wpm and one with a speed of 300 wpm, depending on the reading goal. There is no evidence for a bimodal distribution. Furthermore, both the meta-analysis and the book-reading study question the assumption of an average reading rate of 300 wpm. In the book reading study, only 11/48 participants (23%) had reading rates above 300 wpm, even though the participant pool was an educated sample of very regular readers[11] and many books were so-called page-turners.

Reading rates in the wild

In the previous sections we saw that the typical reading rate is 240-260 wpm, also when people are reading fiction books for pleasure. Although the new study tried to make the conditions as non-evaluative as possible, the fact that the participants were measuring their reading times arguably had the effect that they kept focused on the task.

In principle, reading rates can be studied without pressure to remain on the task. Such observations are possible in e-readers, digital devices that allow people to read books for pleasure and that keep track of the reading times (mostly unknown to the reader). Unfortunately, these data are rarely made available to the public because they infringe on the readers' privacy.

An exception occurred in 2012 when an e-reader company communicated that the then popular last book of the Hunger Games trilogy, Mockingjay, was finished by the average reader in seven hours (Alter, 2012). Given that the book has 101,000 words, this estimates the average reading speed for another page-turner to 241 wpm.

[11] To a large extent the selective nature of the sample is unavoidable, as you can only observe book reading times in people who read books, just like you can only register marathon times for people who run marathons.

The only other study we could find, happened in Russia (Braslavski, Petras, Likhosherstov, & Gäde, 2016). The authors analyzed 10 months of data from a commercial ebook mobile app. It involved some three million reading sessions of 8,000 users. The users' speed showed a normal distribution with a mean of 150 wpm. Reading speed was fastest for books on cooking and food (161 wpm) and slowest for poetry (143 wpm). Overall, however, the differences between genres were small and substantially lower than the 238 wpm based on the meta-analysis.

A first factor involved in the low estimate is that Russian needs some 20% fewer words to express a message than English (see below). So, reading rate expressed as wpm is likely to be lower in Russian than in English. If we assume a 4:5 ratio, the equivalent English word rate would be 150/4 * 5 = 187 wpm.

A second factor is that people in everyday life are less task-focused than when they take part in a study. At least two elements are involved. First, there is good evidence that people tend to mind wander when they are reading. Feng, D'Mello, and Graesser (2013) asked participants to read the Nelson-Denny texts sentence by sentence. Occasionally, after a sentence the participants were asked whether they had experienced thoughts unrelated to the task during the previous sentence. Participants indicated this was the case in 42% of the sentences for difficult texts and 36% for easy texts (see also Jackson & Balota, 2012). Reading times increased by 958 ms when participants were mind wandering compared to when they were on task, and participants were 1.5 times less likely to respond correctly to a comprehension question related to the sentence.

A second reason why readers may not be reading equally fast when they do not feel monitored is that their reading may be part of multitasking. Bowman, Levine, Waite, and Gendron (2010) examined the effects of answering instant messages on reading. Unsurprisingly, they found that participants who received messages took longer to read an expository text than those who did not. More importantly, a difference remained when the time needed to read and respond to the messages was subtracted from the total reading time.

Daniel and Woody (2013) compared the time undergraduates need to read a chapter of an introductory psychology textbook (unfortunately, no length of the chapter in number of words was given). Participants were 298 undergraduate students. Goal of the study was to compare printed text to e-books. Orthogonally, there was a second manipulation. Half of the group read in the laboratory while being observed. The other half read at home. Students in the latter group were asked to register their reading time. Students in the lab finished the text in 34 minutes; students reading at home needed 1 hour and 9 minutes. There were no differences in comprehension as assessed by a 30-question performance quiz. Unfortunately, the two conditions were not completely equal because the group in the laboratory got the quiz immediately after reading the text, whereas the group reading at home got it later when they were back in class. Still, Daniel and Woody's (2013) study is a good reminder that reading rates observed under controlled conditions are likely to be faster than reading rates observed under more relaxed circumstances, because unobserved readers rarely remain fully focused on the task.

Reading rate and text difficulty

So far, we have discussed average reading rates across text types. However, it seems self-evident that reading is faster for easy texts than for difficult texts. Easiness depends on the demands to understand the text relative to the knowledge and skills of the reader. The demands can be at the word level, the sentence level, or the text level. Britton, Westbrook, and Holdredge (1978), for instance, asked participants to read easy and difficult texts. The first two sentences of an easy text were: "A nobleman and a merchant met in a tavern. For their lunch they ordered soup." The first two sentences of a difficult text were: "Sometimes great history is made suddenly and dramatically. Sometimes it enters our lives on tiptoe, almost warily." Britton et al. (1978) observed reading rates of 262 wpm for the easy texts, against 182 wpm for the difficult texts. Comparable findings were reported by Letson (1959), Oliver, Healy, and Mross (2005), and Conlon and Sanders (2011).

So, ideally a measure of normal reading rate takes into account text difficulty. Miller and Coleman (1971) noticed that text difficulty correlates very well with word length. If instead of words per minute, they used letters per second as dependent variable, the effect of text difficulty on silent reading rate disappeared (see also Carver, 1976, 1983; Coke, 1974).

Because fiction is easier to read than non-fiction, we can investigate whether this coincides with a difference in word length and what impact this would predict for reading rate. Average word length is indeed shorter in English fiction than in non-fiction (4.2 letters vs. 4.6 letters, based on the billion word corpora of Johns & Dye, 2019).[12] If we assume that the 238 wpm silent reading rate estimate from the meta-analysis mainly comes from non-fiction (expository texts), we can use the equation 238 * 4.6/4.2 to see what average reading rate would be predicted for fiction. The equation returns an estimate of 261 wpm, surprisingly close to the value of 260 wpm we obtained in the book reading study (although the close correspondence is likely to be due to a fair bit of sampling luck, given the large confidence interval of the reading rate in the book study). We can also apply the equation to Britton et al.'s (1978) study. The average word length of the two easy text passages was 4.2 letters; that of two most difficult passages was 5.4 letters. This translates to expected reading rates of 238 * 4.6/4.2 = 261 wpm for the easy texts (262 wpm obtained) and 238 * 4.6/5.4 = 203 wpm for the difficult texts (182 wpm obstained). So, it looks like we can use the equation 238 times 4.6 divided by mean word length of the text as a way to improve the predicted reading speed for a particular text.

To check whether the differences in reading rate between the three stories of Mak and Willems (2018) mentioned above, also correlated with differences in mean word length, we calculated the word lengths for the three stories. They were respectively 4.4 letters, 4.5 letters, and 5.1 letters (remember that the reading rates were 304, 253, and 222 wpm). This is the expected negative correlation. However, the wpm values do not agree very well with what would be predicted on the basis of the formula used for English texts. This suggests that the formula is language specific and depends on the distribution of word lengths in a language. Dutch on average has longer word lengths than English (Marian, Bartolotti, Chabal, & Shook, 2012). So, in all likelihood each language will require its own equation for word length correction.

Because reading rate differs as a function of word length, several authors have argued that reading rates based on letters, syllables, phonemes, or standard word length are better measures than words per minute (e.g., Carver, 1976, 1983; Coke, 1974; Miller & Coleman, 1971). However, these measures have never caught on beyond the small research communities involved, as they are more difficult to grasp intuitively. This is why we use wpm in the present paper and propose a formula to "correct" the estimate for average word length.

[12] The author thanks Brendan Johns for calculating the average words lengths and kindly making them available.

Life span differences in reading rate

Reading rates vary not only as a function of text difficulty, but also as a function of participant characteristics. In Figure 3 we saw the impact of age on the speed of reading aloud. The same pattern is found in silent reading.

Silent reading rates in primary school and secondary school children

There are two large-scale studies looking at how silent reading rates develop during school years. The first one was published by S.E. Taylor (1965), who tracked eye movements while participants were reading short texts.

S.E. Taylor (1965) tested a minimum of 1,000 readers from grade 1 (first year of primary school) to grade 12 (last year of secondary school), in addition to college students. Each group got stimulus materials adapted for their level and had to answer at least 70% of the true/false comprehension questions correctly to be included. Table 4 shows the results. They illustrate the increasing reading speed as children become older and more practiced in reading. As with many developmental studies, the college sample is selected more than the other samples, which may explain the considerable difference between grade-12 students and college students.

Table 4: Taylor's (1965) data on school-age differences in reading rate

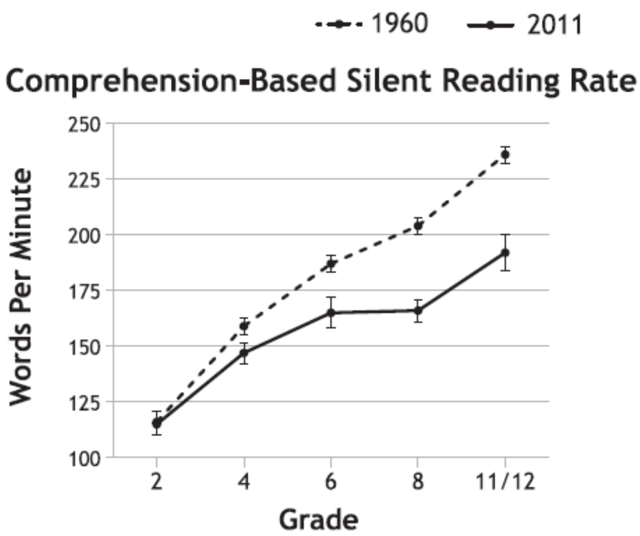
	Grade Level*												
	1	2	3	4	5	6	7	8	9	10	11	12	Col.
Rate with comprehension (words per minute)	80	115	138	158	173	185	195	204	214	224	237	250	280

S.E. Taylor's (1965) study was replicated by Spichtig et al. (2016), who tested 2,203 children from grades 2 – 12 (even grades only). They tried to stay as close as possible to Tayler's (1965) study (including the same materials and questions), so that a comparison across 50 years was possible.

Figure 6 shows the results. As can be seen, Taylor’s (1965) finding of an increase in reading rate in primary and secondary education was confirmed. However, reading rates were substantially lower in Spichtig et al. (2016) for all but grade 2. In addition, the participants did not have 70% correct on the yes/no questions in almost one third of the recordings. Spichtig et al. (2016) interpreted these findings as evidence for a strong decline in word recognition automaticity in the USA between 1960 and 2010. A comparison with Figure 2 puts this conclusion somewhat in perspective. Large differences are found in reading rates based on short texts, and Taylor’s (1965) reading rate for college students was well above the average of the meta-analysis.

Figure 6: A comparison of Taylor’s (1965) data collected in 1960 and Spichtig et al.’s (2016) data collected in 2011, both showing the increase in reading rate during primary and secondary school.

Source: Spichtig et al. (2016)



Slower reading in children is characterized by more and longer fixations, shorter forward saccades, and more regressions to earlier parts of the text, as already noticed by Buswell (1922). Rayner (1986) showed that during fixations children extract information from a smaller part of the visual field than adults, although he did not think this was the cause of the slower reading rates. Rather, the higher demands of information processing made it harder for children to pick up information beyond the currently fixated word. Hence the need for shorter forward saccades. Using a mathematical model, Reichle, Liversedge, Drieghe, Blythe, Joseph, White, and Rayner (2013) argued that the typical eye movement pattern seen in children is mostly due to slower word processing. Indeed, word processing goes faster the more often one has encountered the words (Brysbaert, Mandera, & Keuleers, 2018; Elgort, Elgort, Brysbaert, Stevens, & Van Assche, 2018).

Increase in reading rate during college years

The Nelson-Denny norms show an increase of 16 wpm from the first year of college to the fourth year (Brown et al., 1993). Along the same lines, Masterson and Hayes (2004) reported a difference of 10 wpm between the first and the third year of undergraduate studies in the United Kingdom. It is not clear to what extent these increases (also reported by Bear and Imus, 1938) are due to the high reading load at university or to the continuation of increasing reading rates with age in youngsters.

Decrease of reading rate in old age

The first study to investigate silent reading in old age, was Aberson and Bouwhuis (1997). They asked four groups of five persons from different age categories to silently read 12 easy, entertaining short stories of 534 words on average. The four age groups were: 36-45 years, 56-65 years, 66-75 years, and above 75 years. All participants were regular readers with good visual acuity and above average intelligence. They had graduated from higher education. After each story, participants were asked a question to ensure comprehension. No significant effect of age was found, in line with the small groups per age category and the fact that all participants were high performers. At the same time, the oldest group did not include really good performers (with reading rates above 300 wpm).

Subsequent research has documented processing costs in old age, as could be expected on the basis of physiological changes as people grow older. Changes in visual abilities occur frequently with old age (Owsley, 2011). This includes a loss of sensitivity to visual detail and increased suffering from visual crowding, characterized by reduced ability to recognize visual objects in clutter. Even for old individuals with good vision, there is evidence that the eye movement pattern is different from young adults (Kliegl, Grabner, Rolfs, & Engbert, 2004; Rayner, Reichle, Stroud, Williams, & Pollatsek, 2009). Their fixations tend to be longer, which has been taken as evidence for slower word recognition, and they often tend to compensate for this by adopting a more risky reading strategy. They are more likely to infer the identities of upcoming words on the basis of prior context. As a result they are more likely than young adults to skip words and make longer forward saccades. Because the predicted word recognition is not always correct, older people also show an increase in regressions to previously skipped words (but see Choi, Lowder, Ferreira, Swaab, & Henderson, 2017, who failed to find evidence for this pattern). As a result, contrary to what Aberson and Bouwhuis (1997) concluded on the basis of their small groups of fluent readers, several authors have reported lower silent reading rates in old adults than in young adults (Jackson & Balota, 2012; Kliegl et al., 2004; Rayner et al., 2009; Zang et al., 2016). This drop, however, is not expected to occur before the age of 60-65 in healthy participants (see also Lott, Schneck, Haegerström-Portnoy, Brabyn, Gildengorin, & West, 2001). For that reason we included participants up to 60 years in the meta-analysis. Figure 3 suggests that the decline may start somewhat earlier in reading aloud.

Interestingly, old individuals are also handicapped at understanding compressed speech (Gordon-Salant, Zion, & Espy-Wilson, 2014), suggesting another parallel between auditory and visual language processing. Finally, it is well-documented that working memory capacity shows an improvement up to the age of 30 and starts to decrease particularly after the age of 60-70 (Alloway & Alloway, 2013) and there is evidence that good performance in old age depends on the use of compensation strategies to counter the decrease in speed of processing (Reuter-Lorenz & Cappell, 2008; Salthouse, 1993; Stine-Morrow, Miller, & Hertzog, 2006). So, the developmental patterns of reading, listening, and working memory are quite comparable.

Individual differences in reading rate

Age is not the only participant variable influencing reading rate. Studies report stable individual differences in reading rate in all age groups, as evidenced by the high test-retest or parallel test reliability of reading rates. Reliability of the Nelson-Denny test is .7 (Brown et al., 1993; Kemper & Summer, 2001). It is even higher for longer tests. Ramulu, Swenor, Jefferys and Rubin (2013) reported a parallel test reliability of r = .95 for two texts with 7,300 words each. Mak and Willems (2018) found an average correlation of .86 between the reading rates for the three stories they asked their participants to read.

There is little evidence that the differences in reading rate lead to better or worse text comprehension (Carlson, 1949; Thalberg, 1967). If anything, fast readers tend to be slightly better than slow readers (e.g., Blommers & Lindquist, 1944; Hebert, 2016, Experiment 1). Arguably, there are at least three elements involved in the correlation between reading rate and comprehension. First, every reader is likely to have an optimal language input rate above which comprehension declines, but under which comprehension also falls because the information comes in too slowly to be integrated into meaningful chunks (Breznitz & Berman, 2003; Kintsch & van Dijk, 1978). Second, if a slower processing rate is used to better structure and organize the information via regressions and rereading, this should lead to richer memories for what was presented (Meyer, Talbot, & Florencio, 1999). Such memories, however, are only needed in high stake situations, such as studying a syllabus for a demanding exam (or a detailed memory test devised by a reading researcher), and the extra study time arguably has rapidly diminishing returns. Finally, people with reading or language difficulties, are likely to have slow reading rates and low accuracy scores. The first factor predicts a null-correlation between reading rate and comprehension (because the function is curvilinear); the second factor predicts a negative correlation (more time on the text predicts a better comprehension score); and the third factor predicts a positive correlation (the faster the reader the better the comprehension). Because of the three factors involved, researchers can find very different correlations between reading rate and text comprehension, depending on the difficulty and the length of the text, the test, and the range of readers investigated.

For the participants of the fiction reading study in Figure 5, we can assume that there is little difference in comprehension between the fast and the slow readers (or at least none that the readers care about). Furthermore, in this study we can assume that the individual differences in reading rate are quite stable, given the length of the texts and the data of Ramulu et al. (2013), although some 20-40 wpm of the differences could be due to the difficulty of the books read (as discussed in the section on the influence of word length).

An interesting question then is what factors correlate with individual differences in normal reading rate and, if they correlate, whether they are a cause or consequence of the reading rate.[13]

[13] There is a related literature on factors correlating with dyslexia (e.g., Huettig, Lachmann, Reis, & Petersson, 2018), which is not covered here unless it can be assumed that the variables also correlate with individual differences in normal reading rate.

A seminal series of studies on the topic was run by Jackson and McClelland and published in a number of papers (Jackson, 1980; Jackson & McClelland, 1975, 1979). They asked university students to read a short text of 4,286 words and to answer 10 comprehension questions. On the basis of this test, Jackson and McClelland (1975) selected a group of six average readers (200-300 wpm) and six fast readers (more than 450 wpm) with equal comprehension. The participants then took part in a series of studies to determine the differences between them.[14] The tasks involved brief (tachistoscopic) presentation of the following stimuli, which the participants had to report:

- Five-word sentences of the type "Dan fixed the flat tire".
- Letter and letter-pair identification
- Identification of a series of 8 unrelated consonants
- Discriminating between two very similar words

The fast group outperformed the average group on all tasks, except for the letter and the letter-pair identification tasks, making Jackson and McClelland (1975) conclude that faster readers were capable of encoding more information for higher-level conceptual processes from each fixation.

Jackson and McClelland (1979) selected a group of 12 slow readers and a group of 12 fast readers and presented them again with a series of tasks. They measured performance by correcting reading rate for the percentage questions answered correctly. Three tasks accounted for nearly all systematic variance between the groups: Listening comprehension, letter name matching (a and A have the same letter name) and a homophone decision task (doe and dough sound the same). At the same time, the authors observed that the fast readers made more errors in the experimental tasks, suggesting that they had a lower accuracy criterion. Visual discrimination did not make a difference between the groups.

Jackson (1980) extended the finding that fast readers are better at matching meaningful stimuli. He showed that fast readers more rapidly decided whether two pictures belonged to the same category (e.g., a picture of a dog and a chicken). He also taught them names for meaningless novel characters and found that fast readers were better at deciding if two characters had the

[14] Notice the low power of the study.

same name or not. At the same time, fast readers were not faster at indicating whether two meaningless, novel characters were physically the same or not.

Palmer, MacLeod, Hunt, and Davidson (1985) also examined which aspects of information processing correlate with normal adult reading. They replicated the high correlation between reading comprehension and listening comprehension, but on the basis of their findings concluded that reading rate was a distinct ability, only moderately correlated with reading comprehension. Reading speed correlated with visual word processing skills, as measured with a word search task (deciding whether a target word was in a set or not) and a word matching task (deciding that sink SINK are the same word but wink SINK not). Interestingly, the same tasks with letters had much lower correlations with reading speed.

Nearly all articles after Palmer et al. (1985) have focused on the reading comprehension part, meaning that the reading rate topic has remained largely untouched. The following is a list of variables that were examined by other researchers, and references to supporting evidence:

- Speed of visual word decoding (Garcia & Cain, 2014)
- Vocabulary knowledge (Dixon, LeFevre, & Twilley, 1988)
- Rapid naming of letters or numbers (Arnell, Joanisse, Klein, Busseri, & Tannock, 2009; Kasperski, Shany, & Katzir, 2016; Kirby, Georgiou, Martinussen, & Parrila, 2010; Savage, & Frederickson, 2005)
- Letter, name, and word matching (Stroud, 1945)
- Short-term memory span (Naveh-Benjamin & Ayres, 1986)
- Working memory span (Baddeley, Logie, Nimmo-Smith, & Brereton,1985; Perfetti, 1985)
- Metacognitive knowledge (knowing when your text understanding is good enough for your reading goal; Jones, Conradi, & Amendum, 2016; Mokhtari & Reichard, 2002)
- Number of book authors known (Choi, Lowder, Ferreira, & Henderson, 2015; Martin-Chang & Gould, 2008)
- Amount of reading relative to peers (Choi et al., 2015)
- Auditory word recognition (Breznitz & Berman, 2003)
- Speech rate (Bosshardt & Fransen, 1996)
- Spoken text comprehension (Hirai, 1999)
- Visual acuity (Aberson and Bouwhuis, 1997)

- Word spelling accuracy (Veldre & Andrews, 2014; Zutell & Rasinski, 1989)
- Intelligence (Hage & Stroud, 1959)
- Speed of finding word associations (Traxler, 1934)
- Processing speed (Choi et al., 2015)

Maximum reading rates

In addition to looking at the average, “normal” reading rate, we can also look at the maximum reading rates, the equivalents of record speeds in sports. Above, we compared reading to running, which is an interesting analogy here as well. Thus far, we have mainly talked about the equivalents of long distance disciplines, involving at least one minute of action.[15] We can, however, also look at the equivalents of the short disciplines, such as 100 m (9.58 sec = 37.5 km/hr), 200 m (19.19 sec = 37.5 km/hr), or 400 m (43.03 sec = 33.4 km/hr).

Perrin, Paillé, and Baccino (2015) generated short, easy sentences (in French) of the type “all dogs are animals”. Participants had to repeat the sentence aloud. Sentence presentation time was decreased until the participants could no longer do the task. A group of 45 young adults with good vision took part. The fastest participant needed the sentences to be shown for merely 15 ms, the slowest for 115 ms. This translates to reading speeds of 16,000 wpm and 2,100 wpm respectively. In all likelihood, these speeds are only possible in situations when all information can be entered from iconic memory to short-term memory at once; that is, for sentences containing some 3-4 critical pieces of information (Cowan, 2001; Sperling, 1960).

Rubin and Turano (1992, Experiment 2) used a similar approach to test maximum reading speeds for longer materials. They used short paragraphs (95 to 125 words in length) and also reduced the presentation time as long as the participants (middle-aged adults) understood the text. Comprehension was tested by asking four questions about the text, at least three of which had to be answered correctly. Rubin and Turano reported a median reading rate of 790 wpm. The fastest participant went up to the maximum possible speed of 1,652 wpm. This speed was also obtained by six of the nine participants when the words were presented after each other on the same place

[15] The record speeds for long-distance running range from 28.5 km/hr for 800 meters (world record = 1 min 41 sec), over 23.7 km/hr for 5 km (world record = 12 min 38 sec), 20.7 km/hr for the marathon (42.2 km, world record = 2 hr 2 min), to 16.2 km/hr for the 100 km ultra-marathon (6 hr 10 min).

(rapid serial visual presentation), so that the participants did not have to move their eyes, making the authors conclude that eye movements put a limit to the maximum reading speed in normal reading (see also Primativo, Spinelli, Zoccolotti, De Luca, & Martelli, 2016)..

It is important to keep in mind that these reading speeds are only possible for very brief time intervals when maximal use can be made of iconic and short-term memory. In addition, they require a recuperation period afterwards (just like running 100 meters at maximum speed does). Benedetto et al. (2015) asked participants to read the first chapter from a novel of Orwell for more than 20 minutes with rapid serial visual presentation. Participants could press on a pause button when the text was going too fast. Under these circumstance, participants read at a pace of 200 wpm (very similar to reading a hard copy text of the same chapter) and performed worse on a comprehension test than participants who were allowed to read from a book. Similar results were published by Ricciardi and Di Nocera (2017).

The maximum reading rates we discussed are also limited to situations in which participants intended to read and understand the full text. This is different from situations in which participants skim text for useful information. For instance, an analysis of newspapers in the Netherlands indicates that each edition contains some 40 thousand words (more in the weekend; Nederlandse Nieuwsmonitor, 2014). So, someone reading the newspaper for 1 hour a day, “reads” at a speed of 667 wpm. Someone only devoting half an hour per day, “reads” at a speed of 1,333 wpm. As Rayner et al. (2016) remarked, the upper speed limit for this type of reading depends more on the skills for turning pages than on those for reading.

Ultrafast “reading” also occurs in the scientific world, when researchers read abstracts instead of articles. For most purposes, everything worth remembering from this article (35 thousand words references included) is written in the abstract (196 words). So, everyone reading the abstract at 238 wpm (which takes about 50 seconds) “reads” the equivalent of an amazing 42 thousand words per minute!

Reading rate for text recall

Carver (1992) argued that reading rate is lower for memorizing texts than for reading, because of the additional need for rehearsal. He hypothesized that reading rate would drop to 140 wpm if participants expect recall questions. He referred to a study in which participants after reading had to write down everything they could remember and in which reading rate dropped below 130 wpm.

A finding that fits very well with Carver's prediction was published by Kemper and Summer (2001). They used the Nelson-Denny test, but told the participants that they would have to answer text comprehension questions without being able to consult the text. This arguably changed the test from text comprehension to text memory. Under these instructions, Kemper and Summer observed reading rates of 93 wpm both in young and older adults.

Other evidence in line with Caver's prediction was published by Greene (1931). He asked students to study psychology texts of 2,500 words either as fast as possible or as carefully as possible while in addition taking notes. The former group proceeded at a speed of 212 wpm, the latter at a speed of 104 wpm. A group that read carefully without taking notes had a speed of 122 wpm. Accuracy on subsequent memory tests was higher in the two slower groups than in the fast group. No additional advantage was seen for taking notes, rather the reverse, making Greene conclude that taking notes was a distraction if the notes could not be used for studying.

Comparable figures have been published more recently, although there is a large variability in the study rates. Rothkopf and Billington (1983) observed that their participants read at a pace of 147 wpm, when instructed to read the passage carefully and try to remember as much about the passages as they could. Ackerman and Goldsmith (2011) reported that students needed about 10 minutes to study expository texts of 1,500 words (150 wpm). Chen and Catrambone (2015) observed that students required on average 18 minutes to study expository texts of 1,000 words in length (56 wpm), although in this study participants had to respond three times to metacognitive prompts. A similar number was found by Dirix, Vander Beken, De Bruyne, Brysbaert, and Duyck (2019): Participants studied at a rate of 54 wpm, whereas they read matched texts at a rate of 189 wpm. Persky and Hogg (2017) reported that their students on average needed 3.2 hours to study 7,500 word textbook chapters on physiology and pharmacokinetics (39 wpm), but studying happened at home (cf. Braslavski et al., 2016). Singer Trakhman, Alexander, and Silverman (2018) found that students on average needed 10.5 minutes to study 1,800 word passages from an introductory biology textbook (171 wpm).

Findings less in line with Carver's hypothesis of a reading pattern specific for memorizing have been obtained by authors who looked more in detail into what people are doing when studying texts. Goldman and Saul (1990) reported that the reading patterns could be divided into three strategies. The most frequent strategy (50%) was one in which participants often made regressions to previous text parts while reading. The two other strategies were equiprobable (25% each) and consisted either of reading the text just once, or reading the entire text followed by rereading (parts of) the text. Participants did not use one strategy consistently, but changed between them for the eight passages they were asked to study. None of these strategies seemed to match Carver's (1992) hypothesis of slow reading because of rehearsal. A peculiarity of Goldman and Saul's (1990) study was that the participants saw the text sentence by sentence and had to navigate forward and backward by pressing keys.

Hyona, Lorch, and Kaakinen (2002) measured eye movements while the participants were studying. They obtained evidence for three big clusters and one small. The biggest cluster (almost half of the participants) read the text linearly from beginning to end at a speed of 231 wpm. The second largest cluster (about one quarter) also read linearly but at a much slower speed of 133 wpm. The remaining participants made many regressions. For the third cluster, these were related to the structure of the text because the regressions went back to places were new topics had been introduced or summarized. For the smallest cluster the regressions were nonselective. Both groups with frequent regressions proceeded at a speed of about 130 wpm. After the study, participants were asked to write a summary of the text. Best performance (83% correct) was observed for the topic structure processors (the ones with regressions to the topic heads and summaries). The fast linear readers and the nonselective regressors performed equally well (77% and 80% correct). Worst performance was for the slow linear readers (66%). Contrary to Goldman and Saul (1990), the students of Hyona et al. (2002) largely fell in the same cluster for the two texts they read.

All in all, the more detailed data do not agree well with Carver's (1992) idea of a separate, slower reading gear for text memorization due to the need for text rehearsal. The only group that showed this pattern, the slow linear readers of Hyona et al. (2002), had the worst memory performance in addition to being rather uncommon. Instead, what seems to happen is that text memorizing involves text reading and (if needed) memory structuring. The lower processing rate is not due to longer fixations and shorter forward saccades, but to relating informative parts with each other via regressive saccades and rereading (see also Dirix et al., 2019; Strukelj & Niehorster, 2018; Weiss, Franziska Kretzschmar, Matthias Schlesewsky, Ina Bornkessel-Schlesewsky, & Staub, 2018). The absence of maintenance rehearsal is in line with recent doubts about the usefulness of such rehearsal for memory (Lewandowsky & Oberauer, 2015).

Reading rates in non-native speakers

Reading speed in second-language (L2) speakers is considerably slower than in first-language (L1) speakers. Indeed, reading rates below 100 wpm are not uncommon. Hirai (1999), for instance, studied English L2 reading rate in Japanese university students. All students had taken six years of formal English education in junior and senior high school. In addition, most of the participants had two 90-minute English lessons per week at the university and a subgroup majoring in English had about five to eight English courses per week. Text materials were easy prose passages, followed by a set of eight four-option multiple-choice questions. Reading rate was 139 wpm for participants who could answer more than 75% of the questions correctly and 61 wpm for the other participants. Interestingly, Hirai (1999) also tested the participants on English L2 listening and found that their estimated optimal listening rates corresponded well to the observed reading rates. Before, Conrad (1989) had already observed that understanding of compressed speech drops much faster in L2 users than in L1 users. This was the case even for highly proficient L2 speakers who had obtained an average score of 83/100 on the Michigan State University English Language Exam, which tested the subskills of listening comprehension, grammar, vocabulary, and writing in English.

Cop, Drieghe, and Duyck (2015) asked reasonably proficient Dutch-English bilinguals to read half a novel in L1 and the other half in L2. Reading rate was 17% slower in L2 than in L1.[16] In addition, the eye movement pattern of L2 readers very much resembled that of L1 children: They made more fixations per sentence, fixations times were longer, forward saccades were shorter, and fewer words were skipped. Only the number of regressions did not differ. Similar results were published by Whitford and Titone (2014) for sentence reading, although in their study regression rates were higher in L2 than in L1 as well. Dirix et al. (2019) observed 10% slower

[16] Unfortunately, the authors like many other eye movement researchers did not report the statistics needed to compute reading rate in a way that is comparable to studies without eye movements.

processing rates when participants read or studied texts in a second language (respectively 174 wpm and 50 wpm) than in the first language (189 and 54 wpm).

The similarity of L2 eye movements to children's eye movements agrees with the hypothesis that a lower exposure rate to L2 words is the main reason why it takes longer to recognize L2 words than L1 words, particularly for low-frequency words (Diependaele, Lemhöfer, & Brysbaert, 2013). Only when L2 readers have the same degree of exposure to L2 words as L1 speakers to L1 words, can we expect both groups to be equally efficient at reading the language.

Reading rates in different languages

So far, we have discussed reading rates in Western languages written in Latin alphabet, based on the assumption that differences between these languages are smaller than the differences between the studies in each language. At the same time, we have seen that reading rates expressed as wpm depend on the length of the words.

Differences in average word length and other aspects of the English language may imply that the wpm estimates discussed so far are to some extent English-specific, given that they are based predominantly on studies in English.

The following features of English are likely to have an impact on the average word length in the language.

- English makes extensive use of short function words. These words are limited in number (some 250) and consist of prepositions (at, between, in, of, …), pronouns (anybody, he, I, it, …), determiners (a, more, that, the, …), conjunctions (and, because, or, when, …), auxiliary verbs (be, do, get, go, …), and particles (as, no, not, …). Function words substantially reduce the average word length in English texts (mean word length of content words in English is 5.9 letters for fiction and 6.7 letters for non-fiction text; footnote 12). Languages without (some of the) function words need fewer words to express the same ideas and, therefore, may have lower reading rates expressed in wpm. For instance, languages like Chinese, Indonesian, Japanese, Hindi, and Russian do not have articles before nouns. Other languages use fewer prepositions, because they have case marking or a wider system of suffixes (e.g., Turkish) or use fewer pronouns (e.g., Arabic).

- English makes a distinction between 44 phonemes (sounds that signal word meanings) whereas Spanish only distinguishes between 25 phonemes. Cutler, Norris, and Sebastian-Galles (2004) argued that this difference results in longer spoken words in Spanish than in English. At the same time, the richness in phonemes in English must be represented with the same set of letters, so that written syllables in English contain more letters than written syllables in Spanish (Yap, Liow, Jalil, & Faizal, 2010).
- English is written in Latin alphabet and word length depends on how the sounds are represented by letters of the alphabet. So, words written in other alphabets or in other writing systems can have radically different lengths. For instance, words in Chinese are much shorter. The vast majority of words in Chinese texts consist of one or two characters (Chen & Liu, 2014). Indeed, a rule thumb in the language industry is that a Chinese word on average has 1.5 characters (likely to be more in non-fiction texts than in fiction texts).[17] The Chinese language further differs from English because there are no spaces between the words. Indeed, the concept of words in Chinese is much less prominent than the concept of character or morphemic unit.
- The English language frequently uses compound words, combinations of two or more words that function as single units of meaning. The best known are compound nouns (teaspoon, coffee spoon), but compounding can also involve other parts of speech (to spoon-feed, a spoon-fed student). Because compounds tend to become long, they are often written as separate or hyphenated words in English. This is different from other closely related languages such as Dutch or German, which require compound words to be written as single words. Noun compounding in English goes beyond what is possible in other languages. For instance, in most languages close to English the expression “the writer of the text in English” cannot be expressed as “the English text writer”. This drop of prepositions and articles tends to increase the average word length in English relative to the other languages. The same is true for the use of the Saxon genitive (“my sister’s daughter’s friend instead of “the friend of the daughter of my sister”).

Because languages express ideas with different numbers of words of different lengths, it has been proposed that it is better to look at the information transmitted in a text rather the number of

[17] Yan, Kliegl, Richter, Nuthmann, and Shu (2010), for instance, reported that the sentences they used from a Chinese newspaper contained on average 21 characters for 11.2 words, or 1.87 characters per word.

words used. Some evidence that reading times are equivalent when text messages are matched, was published by Liversedge, Drieghe, Li, Yan, Bai, and Hyönä (2016). They wrote eight short texts in English, Finnish, and Mandarin Chinese. They made sure that the translations were as close as possible. For these stories, the time needed per sentence to read the information did not differ significantly between the languages, despite the differences in word length (1.5 characters in Chinese vs. 5.6 letters in English) or the number of words in the corpus (1,301 in Finnish vs. 1,762 in English). A similar finding was reported by Kuperman, Siegelman, and Frost (2019). They compared reading times for non-fiction paragraphs (Wikipedia articles) in Hebrew and English. Again, the times per paragraph did not differ significantly between the languages, despite the differences in number of words and word lengths.

Still, given the present topic of reading rate, it is worthwhile to see which reading rates expressed as wpm are observed in different languages, in particular those languages without a Latin writing system. In total, we managed to find 77 studies from the following languages: Arabic, Chinese, Greek, Hebrew, Japanese, Korean, Malay, Russian, Turkish, and Urdu. The full dataset is available in the supplementary materials. Here we give a summary in alphabetic order of the languages for which we managed to find at least two silent reading studies and two reading aloud studies.

We found 15 studies on **Arabic**: 10 with silent reading and 5 with reading aloud. Mean silent reading rate was 181 wpm, mean reading aloud rate 142 wpm.

In **Chinese** we found 26 studies coming from 23 articles: 18 on silent reading and 8 on reading aloud. Mean reading rates were respectively 260 wpm and 152 wpm. With respect to these estimates, it is important to know that we often had to estimate the number of words from the number of characters given. When we had to do so, we used the conversion 1.5 characters for 1 word. For those texts in which the words on average were longer than 1.5 characters, our value is an overestimate. One more study (Yen, Tsai, Chen, Lin, & Chen, 2011) was excluded as an outlier, because according to the authors the participants read text passages of 2,000 characters in 100 seconds total reading time, giving an unrealistic speed of 800 wpm.

For **Hebrew** we found 10 studies: 7 for silent reading and 3 for reading aloud. Of the silent reading studies, two were considered outliers. Ben-Yehudah and Eshet-Alkalai (2019) examined the effect of text-highlighting in print and digital reading. They reported a reading rate of 58 wpm in the condition without highlighting (the rate was even lower in the condition with highlighting). This reading rate is more in line with what we saw for text studying rather than text reading. A more controversial case is a study reported by Hanauer (1998). He compared the reading rate for poetry to that for encyclopedic items. Even though the participants were told that they would be taking part in a reading experiment and that they should read the texts in their usual manner and in a way that they think is appropriate, their reading rate for the encyclopedic texts was 42 wpm only. Given the many tasks participants had to complete after reading based on the text, it is fair to conclude, we think, that this was perceived as study task rather than a reading task as well. Based on the remaining five studies, average reading rate is 224 wpm for silent reading and 147 wpm for reading aloud.

Finally, for **Korean**, we were able to locate 7 studies in five articles: 5 with silent reading and 2 with reading aloud. Silent reading rate was 226 wpm, reading aloud 133 wpm.

Table 5 summarizes the results, together with those for the languages based on Latin alphabet for which we had at least two independent studies on silent reading and reading aloud. These data allow us to examine whether there are meaningful, systematic differences between languages.

Table 5: Reading rates for languages for which there are at least two studies for silent reading and reading aloud. Also given is the expansion/contraction index. This indicates the number of words needed in other languages to translate a text of 1,000 words in English (based on the translation of typical texts with Google translate).

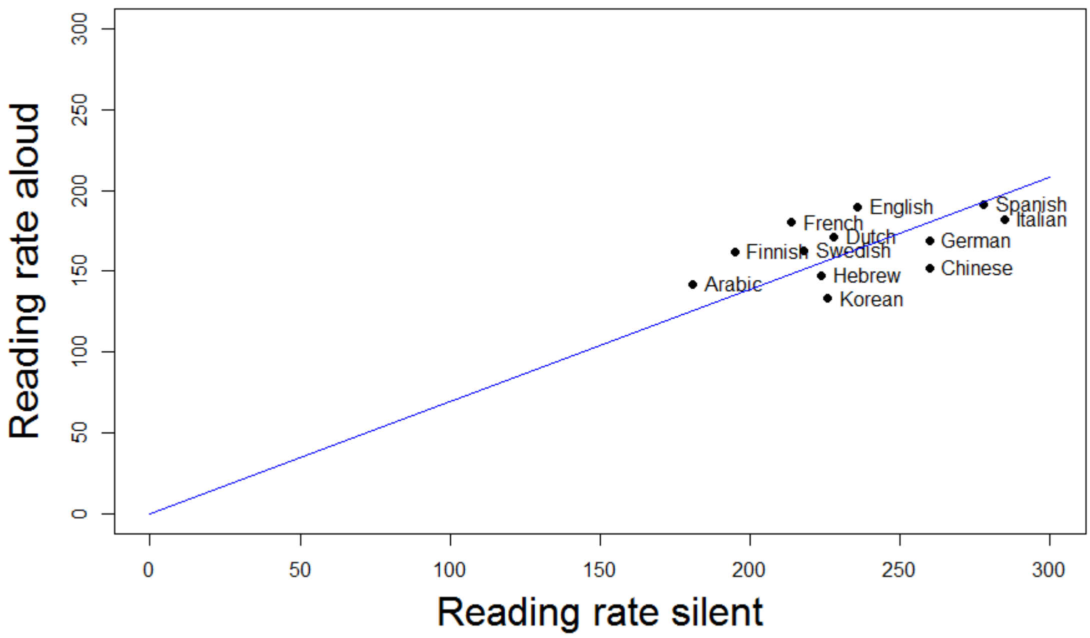
		Silent			Aloud		Expansion
Language	Nstudies	Nparts	Wpm	Nstudies	Nparts	Wpm	index
Arabic	10	673	181	5	281	142	822
Chinese	18	786	260	4	197	152	980
Dutch	7	403	228	3	161	171	1005
English	144	15409	236	27	3482	190	1000
Finnish	4	96	195	3	204	162	764
French	6	215	214	4	307	180	1062
German	13	853	260	16	2674	169	975
Hebrew	5	168	224	2	83	147	782
Italian	3	253	285	5	511	182	1006
Korean	5	186	226	2	90	133	692
Spanish	6	213	278	6	189	191	1025
Swedish	5	129	218	3	55	163	897

A first variable we can look at is the so-called text expansion/contraction index between languages, the degree to which texts expand or contract when you translate them from one language to another. This number is important for translation services and so there are calculators for this. [18] Unfortunately, they tend to contradict each other for certain language pairs. In the end we translated the 4 easiest and the 5 most difficult texts of the 36 given by Aquino (1969). These are exemplary for most of the texts used in reading rate studies. Table 5 includes the resulting estimates for the languages in our dataset. If we assume that the information transmitted is more important than the number of words used, then we can predict that reading rates expressed as wpm will increase in languages requiring more words than English to express a message, and will decrease in languages that need fewer words. This is what we find. There is a positive correlation between wpm and the expansion index for silent reading ($r = .55$, $N = 12$, $p < .05$, directional test) and for reading aloud ($r = .82$, $p < .001$, directional test). If the average of the two reading indexes is used, we get a correlation of .75.

[18] An example is https://www.tomedes.com/wordcountratio/helpmyself.

A second pattern worth checking is the relationship between silent and oral reading rate across languages. If reading is similar to processing compressed speech, we should not only find a correlation between both reading rates, but in addition the regression line should have a zero intercept. The data at hand are not strong enough to draw firm conclusions (the correlation between silent and oral reading rate is only r = .50), but the pattern looks promising, as can be seen in Figure 7.

Figure 7: Relationship between silent reading rate (abscissa) and oral reading rate (ordinate) across languages. Each dot represents one language. As expected, there is a positive correlation. More importantly, the regression line could go through 0, as is needed if reading resembles listening to compressed speech.



General discussion

In this paper a quantitative review was made of reading rates. These rates are important for several reasons. They are needed to decide about deficient reading in various forms (dyslexia, vision deficiency, slow reading without a clear cause), to gauge the time required for various tasks (most prominently reading assignments), and to test the quality of new presentation devices and letter fonts. Reading rate is also important for psychological theories about the reading processes, individual differences in information processing, language differences, task effects, and metacognition. Finally, the average reading rate is a value of interest to the public at large, as they often want to compare their own performance to that of the population. As a result, reading rate is a variable found in many discussions. Surprisingly, no systematic review of the literature was done yet. Even worse, some of the views propagated by researchers appear to be based on thin empirical evidence and are not substantiated by the present analysis. Below we summarize the main conclusions.

Normal silent reading rate in English is 238 wpm for non-fiction and 260 wpm for fiction

The best estimates we have at the moment for silent reading in English are 238 words per minute (wpm) for non-fiction texts and 260 wpm for fiction texts. There are large and stable interindividual differences, so that a better summary is a range of 175-300 wpm for silent reading of non-fiction texts and 200-320 wpm for fiction texts. The difference between the two registers can reasonably well be captured by the fact that longer words are used in non-fiction texts than in fiction texts. To capture word length in a reading rate calculator for individual texts, the following equation can be used for English: Expected reading rate text = 238 * 4.6 / average word length text. This will decrease the predicted reading rate for texts with many long words and increase it for texts without these words. For instance, the average length of the words in the present article is 5.1 letters, meaning that the expected reading rate is 238 * 4.6/5.1 = 215 wpm (translating to roughly two hours of solid reading for the present article without the references).

The values observed are considerably below the number of 300 wpm, promoted by various eye movement researchers (see the introduction). Setting the target reading rate at 300 wpm is unrealistic for the majority of people and likely to result in disappointment of what can be achieved. On a more positive note, the reading rates are close to the reading norms of the Nelson-Denny test, suggesting that rehabilitation services have a better view of what is possible.

The values of 238 and 260 wpm are valid for adults between 18 and 60 years without reading problems. They are lower for younger children and older adults. In addition, they are only valid for native speakers. Second language readers have lower reading rates.

Reading rates for other languages can be approximated by looking at the expansion/contraction index vis-à-vis English (Table 5). Languages requiring more words to convey a message, have a higher reading rate expressed as wpm, whereas languages requiring fewer words have a lower reading rate. This is because the amount of information transferred seems to be more important than the number of words needed to do so.

It may also be good to keep in mind that these are reading rates for people who keep on task the whole time. Reading rates in less constrained situations are likely to be lower because of mind wandering and task interruptions.

There is no evidence for reading gears except for the distinction between reading and scanning

Carver (1992) proposed the idea of five reading gears: reading for recall (140 wpm), reading for recognition (200 wpm), reading out of interest (300 wpm), skimming (450 wpm), and scanning (650 wpm). Reading gears can be compared to gears on a bike or a motor, where the sizes of the cogs determine how much distance is covered per rotation. This is different from increasing the speed of the rotations (by pedaling faster or pressing the gas pedal). Reading gears can also be compared to the difference between walking and running, which involve different mechanisms (as opposed to faster or slower walking).

We failed to find evidence for a distinction between reading for recognition and reading out of interest. As it happens, when word length was taken into account, both reading rates were very comparable and in-between the two supposed gears. We found no evidence for a bimodal curve either, which could have saved the theory.

We further failed to find a different type of reading for recall than for recognition/interest. It is true that reading for recall takes more time (100 wpm seems to be a good estimate, although in several studies it was even lower), but this was not due to a different type of reading. What seems to happen is an increased structuring and organization of text information, as can be concluded from the many regressions and rereadings observed. A notion that springs to mind is that of elaborative rehearsal introduced by Craik and Lockhart (1972). Recalling a text requires it to be well structured in memory.

The best evidence for a difference in gear is between reading and scanning. In the latter condition one no longer tries to understand the text but to locate a word in the text. In such a situation, forward saccades are longer and fixations shorter. In addition, fixation durations are much less influenced by the frequencies of the words (Rayner & Fischer, 1996; Wang, Sui, & White, 2019). Reichle, Pollatsek, and Rayner (2012) argued that this pattern of eye movements can be understood by assuming that words are no longer processed for meaning but for form (based on a coarse familiarity check). Using classification algorithms applied to eye movement data, Simola, Salojärvi and Kojo (2008), and Biedert, Hees, Dengel and Buscher (2012) reported 60-85% accuracy in deciding whether in a study participants had read a text for meaning or tried to find particular information in the text.

Whether there is a further distinction between skimming and scanning, as supposed by Carver (1992), is less clear. Carver saw skimming as a gear to find ideas in a text (proceeding at a rate of 450 wpm), different from scanning, which was used to find words in a text (at a speed of 650 wpm). It is very well possible that skimming involves alternations between scanning / skipping (large) parts of text and bouts of normal reading (when the text looks interesting). In that case, one is likely to find the information if it falls in a part that is read, and to miss it when not. In addition, we would predict that the distributions of saccades and fixations are composed of two subdistributions: One for normal reading and one for scanning. This possibility remains to be tested.

There is no need for different language processes in reading and listening

In the introduction we saw that researchers proposed hypotheses why silent reading is twice as fast as auditory language processing. These involved qualitative differences between reading and listening. They were based on the assumption that silent reading happens at an average rate of 300 wpm.

However, for the reading rates we observed, there is no need to postulate a difference between auditory and visual text processing. Speech remains understandable to healthy, young participants when compressed to 260 wpm. Furthermore, participant groups unable to attain such a reading rate (children, old adults, second language speakers) also seem unable to process spoken language presented at 260 wpm. Finally, a comparison between languages reveals a correlation between oral reading speed and silent reading speed, in line with the idea that reading resembles the processing of compressed speech (Figure 7).

The correspondence between reading and listening can be interpreted in two ways. The first says that it is because reading depends on auditory word processing. The written text must be translated into a spoken form before it can be processed. There is indeed good evidence that silent reading involves the activation of phonology (Frost, 1998; Rastle & Brysbaert, 2006; Shankweiler & Fowler, 2019; Van Orden,, Johnston, & Hale, 1988), possibly because verbal short term memory relies on a phonological code (Baddeley, 2012). Alternatively, it could be that the maximum speed in reading and hearing coincides because both inputs must be translated into an abstract, amodal memory code for thought (Aydede, 2010). The bottleneck then would be the speed with which the abstract memory codes can be built and stored.

Recommendations

The meta-analysis also leads to three recommendations that researchers may want to take to heart. The first is the observation that many articles do not contain enough information to calculate reading rate. This was particularly true for eye movement papers (limiting themselves to fixations and saccades, very much like Buswell, 1922) and correlational studies (where it is surprising to see how often correlations are reported without descriptives). For every article included in the tables, there were at least two that could not be included because of insufficient data. In a few cases this could be corrected by contacting the authors, but most of the time the data were lost irrevocably. If every author in the future reports the number of words in their texts, the length of the words (in characters and syllables) and the mean reading rate (preferentially with SD), a rich database will build up rapidly at no extra cost. Having this information as part of an article is also very informative, because it allows readers to see how fast/slow the participants in the study were. This is important background information to interpret the more detailed findings. Information about reading rate is preferred to reading time, because the means of both variables are unlikely to agree entirely (as a result of non-symmetric distributions) and it is impossible to derive SD of one variable from that of the other.

The second recommendation is that a good assessment of reading rate requires more than a one-minute test. This is particularly true for silent reading. Although the average of short tests is representative, there is much more variability between studies for short tests than for long tests (Figures 2 and 4). On the basis of the present review, a minimum of 5 minutes seems required. Preferentially, this involves one long text rather than five short ones, as the latter seem more susceptible to demand characteristics. In addition, it would be wonderful if researchers more often included several text types in their studies, as this would help us to get a better view of how reading rate depends on the type of materials used.

Finally, it would be good practice if from now on researchers always reported the reliability of their variables. Correlations between variables depend on the reliability of the variables, as no variable can correlate more with another variable than with itself. Reliability can be assessed by looking at the internal consistency of the data (e.g., split-half correlation or intraclass correlation), test-retest correlation, or the correlation between parallel tests (e.g., Revelle & Condon, 2018).

Remaining issues

The meta-analyses reported in the present article have been able to settle a number of important issues. At the same time, the analyses make clear that there are still important gaps in our knowledge. In particular, it is not clear whether the patterns observed at the macro-level (between tasks, languages) are also valid at the meso-level (predicting reading rates for specific texts, tasks, participants) and at the micro-level (predicting processing times at the level of individual words). Below a few remaining issues are highlighted.

Is the relationship between silent and oral reading observed for individuals?

If silent reading resembles listening to compressed speech, then the relationship found in Figure 7 (including the zero intercept) should also be observed when individuals read texts silently or orally. Furthermore, we can expect the relationship to be present both when the intended speed is maximal or the individual's long-term average. The only factor that is expected to change is the slope of the regression line (indicating the degree of compression). Finally, we should see similar decreases in comprehension when speech and visual text are presented at rates higher than the individual's reading speed. Important for this research is that matched stimulus materials are used in visual and auditory modality, something not taken into account so far. It is also important that the reading speeds are measured with high reliability.

Are languages equally good at conveying information?

We saw two studies that compared languages and reported that languages seem to be equivalent at conveying information despite differences in word lengths and writing systems (Kuperman et al., 2019; Liversedge et al., 2016). This is important information, but we must take into account that both studies were severely underpowered to test realistic differences in a between-groups design. Liversedge et al. only had 20-25 participants per group and Kuperman et al. tested 56 participants per group. Such small designs cannot reliably pick up effect sizes of d = .4, which seems to be the mean effect size in psychology (Stanley, Carter, & Doucouliagos, 2018). For such an effect size we require at least 100 individuals per language.

The issue is all the more important because Shimron and Sivan (1994) reported slower reading times for Hebrew texts than for matched English texts, a trend that was also present in Kuperman et al. (2019). So, there are reasons to look at this issue in good detail.

How well can we predict individual differences in normal adult reading rates?

There are stable differences in reading rate between healthy adults. However, little research has examined how well these can be predicted and which variables are important. In the text we saw different variables assessed in different studies with different types of materials. What is lacking is a big study in which a decent number of participants read a variety of texts and provide us with information about potentially important variables, such as processing speed or working memory capacity (see the text for the complete list of variables that have been proposed). As suggested in Table 2, personality variables may be important in this respect. People may differ in how deeply they want to understand a text (so-called good-enough representations; Christianson, 2016; Ferreira, Bailey, & Ferraro, 2002), in which case variables such as conscientiousness and perfectionism may play a role. People may also differ in their susceptibility to mind wandering while they are reading (Vannucci & Chiorri, 2018).

Are there better measures to predict reading rates for texts?

Word length and the expansion / contraction index seem to work surprisingly well to account for differences in reading rate at the macro level (differences between fiction and non-fiction, between reading rates of languages). How well do they work to predict the reading rates for individual texts? Above we saw already that the equation connecting reading rate to word length is likely to be language specific, depending on the average length of words in the language.

In addition, word length is unlikely to be the main cause of differences in text difficulty. It should not be too difficult to make two texts that are matched on average word length but vary considerably on reading rate. Similarly, one would expect it is possible to make two texts differing in average word length but read equally fast (for variables involved in text and word difficulty, see Chen & Meurers, 2016; Crossley, Skalicky, Dascalu, McNamara, & Kyle, 2017; Hiebert, Scott, Castaneda, & Spichtig, 2019; Vajjala, & Meurers, 2014). Rather, what happens is that in spontaneous language use word length is correlated with a range of variables that also make texts easy or difficult. As such, average word length is only a proxy for text difficulty, easy to calculate and integrate in a reading rate calculator to improve predictions for texts, but without much theoretical value.

So, a remaining, important research question is how much the other variables (e.g., word frequency, concept difficulty, syntactic complexity, familiarity with the discourse schema, …) contribute to the prediction of reading rate. This has theoretical implications but could also improve the calculation of expected reading times for individual texts.

Availability

Most data discussed in the present review are available as supplementary materials on the website of the article. They are also available on the open science framework website https://osf.io/3wfas/.

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Table 1: Studies investigating silent reading in languages with Latin alphabet

Study	Language	Text type	Nwords/ trial	Ntrials	Time (mins)	Reading rate (wpm)	N parts	Questions asked?
Aberson & Bouwhuis (1997)	Dutch	fiction	534	12		305	40	Yes
Acklin & Papesh (2017)	English	nonfiction	500	12		221	41	Yes
Altaribba et al. (1996, Exp 1)	Spanish	unclear		1	2	348	32	Yes
Ambrosino et al. (1974)	English	nonfiction		1	1	378	268	Yes
Arnell et al. (2009)	English	nonfiction		1	1	227	64	Yes
Ashby et al. (2012)	English	unclear	11.2	80		278	24	Yes
Baddeley et al. (1985, Exp 1)	English	nonfiction		1	1	338	51	Yes
Baddeley et al. (1985, Exp 2)	English	nonfiction		1	1	234	107	Yes
Baker (2005)	English	fiction	2191	1		246	66	Yes
Ball & Hourcade (2011, Exp 1)	English	nonfiction	383	4		161	12	Yes
Ball & Hourcade (2011, Exp 2)	English	nonfiction	634	2.5		157	24	Yes
Bassin & Martin (1976)	English	nonfiction	2217	1		208	20	Yes
Bear & Imus (1938)	English	nonfiction		1	2	256	383	Yes
Bell & Perfetti (1994)	English	nonfiction	2000	6		170	10	Yes
Bell & Perfetti (1994)	English	fiction	2000	6		219	10	Yes
Bell et al. (2012)	English	nonfiction		1	1	202	161	Yes
Bellows & Rush (1952)	English	nonfiction		1	1	277	71	Yes
Benedetto et al. (2014)	French	fiction		1	60	266	24	Yes
Benedetto et al. (2015)	French	fiction	6160	1	30	200	30	Yes
Benevides & Peterson (2010)	English	nonfiction		1	1	242	227	Yes
Benton et al. (1984)	English	nonfiction		1	1	259	33	Yes
Berger (1966)	English	nonfiction	3000	1		230	222	Yes
Birkmire (1986)	English	nonfiction	?	3	?	230	90	Yes
Boije & Gustafsson (2012)	Swedish	unclear	3500	4		197	16	Yes
Booker (1934)	English	unclear	?	?	?	242	664	?
Bowers & Reid (1997)	English	nonfiction	150	9		225	10	Yes

Bowman et al. (2010)	English	nonfiction	3828	1		102	30	Yes
Bridgeman & Montegut (1993)	english	unclear	5600	1		271	20	?
Britton et al. (1978, Exp 1)	English	unclear	150	20		222	24	Yes
Burt & Fury (2000)	English	nonfiction		1	1	292	100	Yes
Callens et al. (2012)	Dutch	nonfiction	1023	1		244	100	Yes
Calvo et al. (1994, Study 1+2)	Spanish	nonfiction	650	3		314	36	Yes
Calvo et al. (1994, Study 3)	Spanish	nonfiction	410	3		231	36	Yes
Campbell et al. (1989, Exp 1+2)	English	nonfiction	592	1		236	152	Yes
Carver (1970)	English	nonfiction		1	6	292	60	Yes
Carver (1983)	English	nonfiction	100	24		325	102	No
Cavalli (2016)	French	fiction	2800	1		187	20	Yes
Choi et al. (2015)	English	nonfiction	52	80		244	70	Yes
Ciuffo et al. (2017)	Italian	nonfiction	556	1		330	158	No
Cline (1969)	English	nonfiction		1	1	331	192	Yes
Cohen & Waiss (1991)	English	unclear	?	6		233	60	Yes
Conlon & Sanders (2011)	English	nonfiction	200	10		160	19	Yes
Cronan (1987)	English	nonfiction		1	1	231	173	Yes
Cupples & Holmes (1992, Exp 1)	English	nonfiction	125	22		160	24	Yes
Cupples & Holmes (1992, Exp 2)	English	nonfiction	125	22		163	72	Yes
Cushman (1986)	English	unclear	35000	5		218	16	Yes
Deacon et al. (2012)	English	nonfiction		1	1	234	33	Yes
Deal (1934)	English	unclear	?		?	180	275	Yes
Dee-Lucas (1979)	English	nonfiction	415	3		120	20	Yes
Dee-Lucas (1979)	English	nonfiction	415	3		251	20	Yes
Dirix et al. (2019)	Dutch	nonfiction	340	4		189	80	Yes
Dixon et al. (1988)	English	nonfiction		1	1	284	95	Yes
Dumler (1958)	English	unclear	?		?	254	50	?
Dwyer & West (1994)	English	fiction		1	15	242	76	No
Dyson & Haselgrove (2000)	English	unclear	1000	6		244	24	Yes
Dyson & Haselgrove (2001)	English	nonfiction	1000	6		151	18	Yes
Dyson & Kipping (1997)	English	nonfiction	2000	3		196	18	Yes
Everatt & Underwood (1994)	English	unclear	30	18		188	36	Yes

Fisher (1975, Exp 1)	English	nonfiction	200	9		220	81	Yes
Franken et al. (2015)	Slovene	unclear	125	50		238	48	No
Freeburne & Fleischer (1952)	English	nonfiction	11,500	1		189	43	Yes
Gilbert (1959)	English	nonfiction	2300	2		262	64	?
Glimne et al. (2015)	Swedish	nonfiction	800	4		215	16	Yes
Glock (1949)	English	nonfiction	1500	1		156	135	Yes
Graf & Levy (1984, Exp 2 & 3)	English	unclear	350	6		180	64	Yes
Greene (1931)	English	nonfiction	2500	4		212	65	Yes
Grisham et al. (1993)	English	nonfiction			1	285	78	Yes
Gunraj & Klin (2012, Exp 1 & 3)	English	fiction	510	1		276	224	Yes
Gunraj et al. (2014, Exp 2 & 4)	English	fiction	327	1		217	140	Yes
Harris (2012)	English	nonfiction	821	3		233	58	Yes
Hartley (1993, Exp 2)	English	nonfiction	195.5	2		212	24	No
Hartley et al. (1994)	English	nonfiction	195.5	2		180	24	No
Haught & Walls (2002)	English	nonfiction		1	1	246	542	Yes
Haught & Walls (2002)	English	nonfiction		1	1	282	576	Yes
Hausfield (1981)	English	unclear	255	2		255	30	Yes
Hebert (2017, Exp 1)	English	nonfiction		1	1	242	230	Yes
Hebert et al. (2018)	English	nonfiction		1	1	264	124	Yes
Heij & van der Meij (2014)	Dutch	nonfiction	6475	1.33		144	16	Yes
Henry & Lauer (1939)	English	nonfiction		1	1	211	307	Yes
Henry et al. (2018)	English	nonfiction	145	5		248	85	Yes
Henry et al. (2018)	English	nonfiction	145	5		218	39	Yes
Hess & Tate (1992)	English	fiction	?		?	194	33	Yes
Huey (1901)	English	fiction	405	2		338	20	No
Hunt et al. (1981)	English	nonfiction		1	1	301	74	Yes
Hyona & Niemi (1990, Exp 1)	Finnish	nonfiction	371	1		224	11	Yes
Hyona & Niemi (1990, Exp 2)	Finnish	nonfiction	351	1		163	18	Yes
Hyona et al. (2002)	Finnish	nonfiction	1200	2		179	47	Yes
Jackson & Balota (2012, Exp 4)	English	fiction		1	30	177	29	Yes
Jackson et al. (1999)	English	unclear	50	25		315	12	Yes
Jensen et al. (1972)	English	unclear	?		?	328	276	Yes

Johansson et al. (2014)	Swedish	fiction	146	9		268	18	Yes
Johnson et al. (2018)	English	unclear	116	20		298	60	Yes
Jones et al. (2012)	Norwegian	unclear		1	3	227	92	No
Juola et al. (1982, Exp 4)	English	nonfiction	199	12		215	48	Yes
Just & Carpenter (1987)	English	nonfiction	1750	2		240	25	Yes
Kamienkowski et al. (2016)	Spanish	unclear	3312	10		203	36	Yes
Karakus et al. (2018)	English	fiction	7200	1	30	272	31	Yes
King et al. (1969)	English	nonfiction		1	10	234	115	Yes
Kingston & George (1957)	English	unclear	?		?	274	160	Yes
Kintsch & Monk (1972, Exp 1)	English	nonfiction	46	20		107	60	Yes
Kirby et al. (2008)	English	nonfiction		1	1	235	66	Yes
Korinth & Fiebach (2018)	German	nonfiction	182	90		246	25	Yes
Kruk & Muter (1984, Exp 1)	English	fiction			5	225	24	Yes
Kuperman et al. (2019)	English	nonfiction	90	10		273	54	Yes
Lajoie (2013)	English	nonfiction		1	1	290	88	Yes
Laubrock & Kliegel (2015)	German	unclear	8.5	144		244	31	Yes
Lee (2003)	English	nonfiction	452	4		125	16	Yes
Letson (1959)	English	unclear		2	5	268	601	Yes
Lewandowski et al. (2003)	English	nonfiction		1	1	231	90	Yes
Liversedge et al. (2016)	English	unclear	253	8		285	21	Yes
Liversedge et al. (2016)	Finnish	unclear	186	8		213	20	Yes
Lloyd & McKelvie (1992)	English	nonfiction	320	3		244	45	No
Mackensen & Stichler (1963)	German	unclear	10	?		353	69	?
Mackensen & Stichler (1963)	German	unclear	10	?		286	30	?
Mackensen & Stichler (1963)	German	unclear	10	?		300	98	?
Mackensen & Stichler (1963)	German	unclear	10	?		279	64	?
Mackensen & Stichler (1963)	German	unclear	10	?		261	107	?
Mackensen & Stichler (1963)	German	unclear	10	?		226	78	?
Mackensen & Stichler (1963)	German	unclear	10	?		231	97	?
Mackensen & Stichler (1963)	German	unclear	10	?		211	79	?
Mak & Willems (2019)	Dutch	fiction	2532	3		260	105	Yes

Maki et al. (1994)	English	nonfiction		1	1	205	75	Yes
Martin-Chang & Gould (2008)	English	nonfiction		1	1	204	171	Yes
Masson (1982, Exp. 1)	English	nonfiction	700	8		232	72	Yes
Masterson & Hayes (2004)	English	nonfiction		1	1	257	197	Yes
Mathews et al. (2017)	English	fiction		1	30	226	50	Yes
Maxwell & Mueller (1965)	English	nonfiction		1	10	247	132	Yes
Mayr et al. (2017, Exp 1)	German	unclear	580	12		235	155	Yes
McConkie & Meyer (1974)	English	nonfiction	325	7		181	14	Yes
McConkie & Rayner (1974)	English	nonfiction	500	7		152	10	Yes
McConkie & Rayner (1974)	English	nonfiction	500	7		190	10	Yes
McConkie et al. (1973, Exp 1)	English	nonfiction	500	6		265	140	Yes
McConkie et al. (1973, Exp 2)	English	nonfiction	500	6		209	45	Yes
Miller & Coleman (1971)	English	unclear	150	36		270	83	Yes
Monk (1984, Exp 1-3)	English	fiction	1500	1		252	120	No
Moys et al. (2019)	English	nonfiction	622	3		202	40	Yes
Muter et al. (1982)	English	fiction		2	60	222	14	Yes
Muter & Maurutto (1991, Exp 1+2)	English	fiction	2000	6		233	30	Yes
Niple (1968)	English	nonfiction		1	10	181	140	Yes
Noyes & Garland (2003)	English	unclear	295	1		383	50	No
Oliver et al. (2005)	English	nonfiction	186	8		226	32	Yes
Oquist & Goldstein (2003)	Swedish	fiction	4250	4		242	15	Yes
Otten (2015)	Dutch	nonfiction	650	1		263	22	Yes
Park (2016)	English	nonfiction	252	12		190	33	Yes
Pashler et al. (2013, Exp 1)	English	nonfiction	1500	3		201	109	Yes
Paterson & Jordan (2010)	English	unclear	10	80		235	16	Yes
Perea & Acha (2009)	Spanish	unclear	10	120		366	24	Yes
Perrin et al. (2014)	French	nonfiction	30	54		216	28	No
Potter (1954)	English	nonfiction	?		?	261	322	Yes
Poulton (1961)	English	unclear	700	2		219	564	Yes
Preston & Botel (1952)	English	nonfiction		1	1	188	2048	Yes
Preston & Tuft (1948)	English	nonfiction	1500	1		309	22	Yes
Ramulu et al. (2013)	English	fiction		2	30	183	49	Yes

Rayner (1986, Exp 1-4)	English	unclear	8	48		290	15	Yes
Rayner et al. (1998, Exp 1)	English	unclear	100	6		283	12	Yes
Rayner et al. (2010)	English	unclear	11.1	160		265	32	Yes
Rello & Baeza-Yates (2015)	Spanish	fiction	60	12		258	49	Yes
Ricciardi & Di Nocera (2017, Exp 1+2)	Italian	nonfiction	5804	1		236	57	Yes
Roberts et al. (2013, Exp 1+2)	English	unclear	910	1		297	42	No
Rose & Rostas (1947, Exp 4)	English	unclear	?		?	208	27	Yes
Ruppel (1979)	English	nonfiction		1	10	184	204	Yes
Sackstein et al. (2015)	English	nonfiction	?	2	?	190	68	Yes
Samuels & Dahl (1975, Exp 2)	English	nonfiction	820	4		376	84	Yes
Sekey & Tietz (1982, Exp 1+2)	English	unclear	470	6		268	56	Yes
Sheedy et al. (2003)	English	fiction	2500	12		252	20	Yes
Sheedy et al. (2008, Exp 5)	English	fiction	2500	5		217	30	Yes
Shimoda (1993)	English	nonfiction	225	4		213	24	Yes
Siegenthaler et al. (2011)	German	fiction	300	12		196	10	No
Siegenthaler et al. (2012)	German	fiction		8	45	307	10	No
Singer Trakhman et al. (2017)	English	nonfiction	550	2		286	86	Yes
Slattery & Rayner (2010, Exp 1)	English	unclear	150	30		254	18	Yes
Slattery & Yates (2018)	English	unclear	20	54		147	92	Yes
Smith & Wood (1955)	English	nonfiction	1500	1		219	27	Yes
Spragins et al. (1976)	English	unclear	110	4		256	12	Yes
Standing & Curtis (1989, Exp 1)	English	unclear	50	4		315	24	No
Stoll (1974)	French	unclear	1300	1		210	54	Yes
Strukelj & Niehorster (2018)	Swedish	fiction	146	1		144	64	Yes
Subbaram (2004)	English	fiction		1	30	269	30	Yes
Taylor (1965)	English	unclear	100	5		280	1000	Yes
Thalberg (1967)	English	nonfiction	1500	1		257	80	Yes
Thalberg (1967)	English	nonfiction	1500	1		267	96	Yes
Thames & Rosster (1972)	English	nonfiction		1	1	236	46	Yes
Tombauch et al. (1985)	English	nonfiction		1	1	285	90	Yes
Tyrrell et al. (2001)	English	fiction		1	60	248	18	No

Veldre & Andrews (2014, Exp 1+2)	English	unclear	20	64		240	96	Yes
Wagner & Sternberg (1987, Exp 1)	English	nonfiction	150	44		231	40	Yes
Whitford & Titone (2015)	English	unclear	10	75		207	36	Yes
Whitford & Titone (2015)	French	unclear	11	75		207	59	Yes
Wooster (1954)	English	nonfiction		1	10	183	60	Yes
Zambarbieri & Carniglia (2012)	Italian	fiction	2755	1		290	38	No
Zwaan (1991)	Dutch	unclear	216	6		193	40	Yes

Table 3: Studies investigating reading aloud in languages with Latin alphabet

Study	Language	Text type	Words/ trial	Ntrials	Time (mins)	Reading rate (wpm)	N parts	Questions asked?
Alio et al. (2008)	Spanish	unclear	14	18		239	30	No
Alio et al. (2008)	Spanish	unclear	14	18		204	30	No
Ashby et al. (2012)	English	unclear	11.2	80		209	24	Yes
Awadh et al. (2016)	French	nonfiction		1	3	158	39	No
Awadh et al. (2016)	Spanish	nonfiction		1	3	167	42	No
Brubaker (1972)	English	fiction	100	1		233	23	No
Brussee et al. (2017)	Dutch	fiction	141	10		175	36	No
Calabrese et al. (2016)	English	unclear	12	19		200	600	No
Calabrese et al. (2018)	English	unclear	12	14		183	165	No
Callens et al. (2012)	Dutch	nonfiction	1023	1		136	100	Yes
Calossi et al. (2014)	Italian	unclear	14	18		187	211	No
Cavalli et al. (2018)	French	unclear	265	1		178	164	No
Chamorro et al. (2017)	Spanish	unclear	263	1		120	32	Yes
Ciuffo et al. (2017)	Italian	nonfiction	248	1		208	158	No
Dysli et al. (2014)	German	fiction	138	16		168	16	No
Folkmann Pedersen et al. (2016)	Danish	unclear	223	1		143	16	Yes
Gunraj & Klin (2012, Exp 2)	English	fiction	358	1		208	60	Yes
Gunraj et al. (2014, Exp 1 & 3)	English	fiction	122	1		172	151	Yes
Huey (1901)	English	fiction	405	1		213	20	No
Jackson et al. (1999)	English	unclear	50	25		222	12	Yes
Karakus et al. (2018)	English	fiction	77	1		153	31	Yes
Korinth & Fiebach (2018)	German	nonfiction	220	1		168	25	No
Laasonen et al. (2001)	Finnish	unclear		1	1	152	16	?
Laubrock & Kliegel (2015)	German	sentences	8.5	144		151	32	Yes
Leinonen et al. (2001)	Finnish	unclear	173	2		173	100	?

Lewandowski et al. (2003)	English	nonfiction	300	3	189	90	No
Lijka et al. (2019)	English	unclear	14	18	157	24	No
Lindgren & Laine (2011)	Swedish	unclear	328	1	117	20	No
Lutz & Mallard (1986)	English	nonfiction	330	1	198	50	No
Mackensen & Stichler (1963)	German	unclear	10	?	214	69	?
Mackensen & Stichler (1963)	German	unclear	10	?	194	30	?
Mackensen & Stichler (1963)	German	unclear	10	?	194	98	?
Mackensen & Stichler (1963)	German	unclear	10	?	194	64	?
Mackensen & Stichler (1963)	German	unclear	10	?	176	107	?
Mackensen & Stichler (1963)	German	unclear	10	?	167	78	?
Mackensen & Stichler (1963)	German	unclear	10	?	160	97	?
Mackensen & Stichler (1963)	German	unclear	10	?	156	79	?
Marx (2015)	German	fiction	132	3	167	30	No
Mathews et al. (2017)	English	unclear	305	1	175	50	No
Mellard et al. (2012)	English	nonfiction	?	2	151	296	No
Miller-Guron & Lundberg (2000)	Swedish	unclear	59	1	174	10	No
Miranda et al. (2018)	Portuguese	fiction	134	8	167	20	No
Monteiro de Castro et al. (2005)	Portuguese	unclear	12	19	200	20	No
Morrice (2017, Exp 1&2)	English	fiction	153	10	203	100	No
Morrice (2017, Exp 3)	English	fiction	153	10	181	100	No
Munch et al. (2016)	Danish	unclear	105	2	195	50	No
Munch et al. (2016)	Danish	unclear	105	2	168	50	No
Nergard-Nilssen & Hulme (2014)	Nowegian	unclear	?	4	146	47	Yes
Ousler et al. (2015)	English	text	153	?	210	10	No
Radner & Diendorfer (2014)	English	unclear	14	34	202	50	No
Radner et al. (2002)	German	unclear	14	24	230	99	No
Radner et al. (2002)	German	unclear	14	24	190	99	No
Radner et al. (2016)	German	fiction	111	7	180	40	No
Re et al. (2011)	Italian	nonfiction	543	1	151	99	No
Rosa et al. (2016)	Portuguese	unclear	14	27	235	50	No
Sobel & Sobel (1972)	English	unclear	613	3	158	16	No
Sobel et al. (1982)	English	nonfiction	76	3	146	16	No

Standing & Curtis (1989)	English	unclear	50	4		203	24	No
Suarez-Coalla & Cuetos (2015)	Spanish	nonfiction	228	1		195	30	No
Subramanian & Pardhan (2006)	English	unclear	12	19		211	30	No
Trauzettel-Klosinski & Dietz (2012)	Dutch	fiction	141	10		202	25	No
Trauzettel-Klosinski & Dietz (2012)	English	fiction	153	10		228	25	No
Trauzettel-Klosinski & Dietz (2012)	Finnish	fiction	101	10		161	25	No
Trauzettel-Klosinski & Dietz (2012)	French	fiction	133	10		195	25	No
Trauzettel-Klosinski & Dietz (2012)	German	fiction	132	10		179	25	No
Trauzettel-Klosinski & Dietz (2012)	Italian	fiction	135	10		188	25	No
Trauzettel-Klosinski & Dietz (2012)	Polish	fiction	127	10		166	25	No
Trauzettel-Klosinski & Dietz (2012)	Portuguese	fiction	134	10		181	25	No
Trauzettel-Klosinski & Dietz (2012)	Slovenean	fiction	137	10		180	25	No
Trauzettel-Klosinski & Dietz (2012)	Spanish	fiction	143	10		218	25	No
Trauzettel-Klosinski & Dietz (2012)	Swedish	fiction	146	10		199	25	No
Vankatagiri et al. (1999)	English	nonfiction	200	1		188	16	No
Van Landingham et al. (2014)	English	unclear		?	0.25	169	1369	?
Viénot et al. (2009)	French	fiction	133	10		190	30	?
Warmington et al. (2013)	English	nonfiction	492	1		183	106	Yes
Wetzel & Knowlton (2000)	English	fiction	?	1		184	24	No
Zeri et al. (2018)	Italian	fiction	100	12		175	18	No