This is the author's accepted manuscript of the following article: Szarkowska, A., Silva, B. B., & Orrego-Carmona, D. (2021). Effects of subtitle speed on proportional reading time: Re-analysing subtitle reading data with mixed effects models. Translation, Cognition & Behavior, 4(2). https://doi.org/10.1075/tcb.00057.sza

Effects of subtitle speed on proportional reading time: Re-analysing subtitle reading data with mixed effects models

Agnieszka Szarkowska
Institute of Applied Linguistics, University of Warsaw

Breno Silva
Institute of English Studies, University of Warsaw

David Orrego-Carmona
Department of English, Languages and Applied Linguistics, Aston University
Department of Linguistics and Language Practice, University of the Free State

Abstract

How much time do viewers spend reading subtitles and does it depend on the subtitle speed? By posing these questions, in this paper we re-analyse previous data to address this issue while promoting two methodological advancements in eye-tracking audiovisual research: (1) the use of proportional reading time (PRT) as a metric of time spent on subtitle reading and (2) the analysis of data via linear mixed effects models (LMMs). We tested 19 Polish L1 viewers with advanced English proficiency watching two clips with English soundtrack with Polish subtitles. First, we compared PRT at two different subtitle speeds: 12 characters per second (cps) and 20 cps. Then, we used actual subtitle speed rates to better understand the speed-PRT relationship. The results showed a significantly higher PRT for 20 cps compared to 12 cps, with the models predicting a PRT of 45.24% at 20 cps. We have also found strong evidence of the advantage of LMMs over more commonly used statistical techniques.

Keywords

Subtitling, subtitle speed, eye tracking, proportional reading time, linear mixed effects models

1. Introduction

Unlike when reading a printed book, when watching subtitled videos, people are busy processing the sequences of images, sounds and text, and at the same time trying to understand the actions that construe the narrative. One of the factors that determine how much time viewers spend reading the subtitles, as opposed to watching the images, is the speed at which subtitles are displayed. Over the last decade, subtitle speeds have gone up considerably, sparking controversy among subtitling professionals and researchers (Díaz-Cintas & Remael 2021). The rise in subtitle speeds is particularly discernible on global streaming platforms, such as Netflix, whose policy on subtitle speed substantially departed from traditional norms (Netflix 2016, Pedersen 2018). The pervasiveness of subtitling, coupled with these dynamic changes, offers a timely opportunity to examine the effects of speed on the way viewers process subtitled videos and propose more suitable and comprehensive methods for future research.

As a response to the increasingly rising subtitle speeds, researchers have grown interested in assessing how these speeds affect the film viewing process (Koolstra, Van Der Voort, & d'Ydewalle 1999, Liao et al 2020, Szarkowska & Gerber-Morón 2018b). It is generally believed that higher subtitle speeds make viewers spend more time in the subtitle area to the detriment of watching the images (Romero-Fresco 2009, 2015a). But how much time exactly do viewers spend reading the subtitles while they are displayed on screen? Here, accounts differ considerably, from about 20% to 80% (see the discussion below). What is more, various researchers used different methods to calculate subtitle speed (Fresno & Sepielak 2020). To add to the confusion, the discussion on subtitle speed is blurred by conflating results from studies on different types of subtitling (live, pre-recorded), viewers of different hearing status (hearing, hard of hearing, deaf) and different ages (children, adults). All this makes the studies on subtitle speed difficult to compare and calls for more standards of analysis.

This paper addresses these research gaps and has two main goals: first, to better understand the impact of subtitle speed on the time spent by viewers in the subtitle area and, second, to promote a standardised metric to measure this: proportional reading time (PRT). Admittedly, the concepts of absolute reading time (ART) and proportional reading time are not new: they go back to the 1990s (Koolstra, Van Der Voort, & d'Ydewalle, 1999). Yet, PRT is not widely used by researchers studying subtitle reading. While ART tells us how much time a viewer gazed at the subtitles in absolute terms (seconds or milliseconds), PRT is based on a percentage of time spent in the subtitle area relative to subtitle duration. PRT is therefore a standardised measure, while ART is not (see Section 1.2).

In this paper, we examine the impact of subtitle speed on the time that hearing viewers spend reading interlingual L1 subtitles, i.e., containing a translation from one language into another. Our research questions seek to investigate the proportion of time viewers spend on subtitles relative to the total duration of the subtitles, and how this proportion is affected by subtitle speeds. To answer these questions, we use linear mixed models (LMMs) to re-analyse a subset of data from Szarkowska and Gerber-Morón (2018b), instead of the ANOVA analyses used by the researchers in the original study. On the one hand, this allows us to take advantage of an existing dataset to set the foundations for further studies on PRT. On the other, we contribute to the adoption of reanalysis as a way to propose new methods to provide more concrete demonstrations for long-standing hypotheses. Ultimately, our aim is to provide an overview of the research into how subtitle viewing is affected by the speed at which subtitles are displayed and propose a consolidated approach to promote standardisation, open science and rigour in audiovisual translation research.

1.1. Subtitle speed

Subtitle speed, also referred to as *reading speed* or *presentation rate,* is one of the most controversial subtitling parameters (Romero-Fresco 2009, Szarkowska & Gerber-Morón 2018b). The speed at which subtitles are displayed can be measured in either *characters per second* (cps) or *words per minute* (wpm). In the audiovisual translation industry, the cps measure is used more often because it is considered more accurate across languages given the differences in word length between languages (Martí 2013). The wpm measure is more common in English-speaking countries, and in subtitling for the deaf and the hard of hearing (SDH), also known as *closed captions* (Zarate 2021).

In the industry, particularly in countries with long-standing subtitling traditions, the traditional subtitle speeds have ranged from around 10 to 12 cps (Ivarsson & Carroll 1998, Tveit 2005, Pedersen 2011, Szarkowska 2016). This roughly corresponds to what is known as the 'six-second rule' (Díaz Cintas & Remael 2007; Szarkowska & Bogucka 2019). Established in the 1980s, the six-second rule stipulated that a two-line subtitle consisting of a maximum of 64 characters (32 characters per line, which was the maximum allowed at that time in television subtitling) should be displayed for six seconds to give viewers enough time to read the subtitles and to follow the on-screen action. Shorter subtitles, consisting of fewer characters, should be displayed proportionally for less time. Along the same lines, an eight-second rule would mean that the 64-character two-line subtitle is displayed for eight seconds, whereas a four-second rule would mean four seconds in display (see the discussion in the next section). To recalculate the six-second rule into cps, we divide 64 characters by 6 seconds, which gives: 64/6=10.5 cps. However, recent changes in technology have resulted in an increase of the maximum characters per line allowed on screen. Departing from the standard of maximum 32 characters per line in the 1980s, scholars have continued discussing the six-second rule as a guide while they also proposed more characters per line. For instance, Karamitroglou (1998) talked of 35 characters per line, which translates into 11.6 cps (70/6); Díaz Cintas & Remael (2007) considered 37 characters per line, which in turn gives 12.3 cps; and Ivarsson & Carroll (1998), which is 13.3 cps (see detailed discussion on the six-second rule in Szarkowska & Bogucka 2019). The traditional subtitling conventions, including the six-second rule, started to be challenged with the arrival of global streaming services, such as Netflix, which defied the pre-existing standards and spearheaded a rise in speeds, allowing 17–20 cps (Netflix 2016, TED 2017, Díaz Cintas & Remael 2021).

Subtitle speed is inextricably linked with the notion of text condensation (Ivarsson & Carroll 1998, Pedersen 2011). Low speeds require dialogue to be more condensed than with higher speeds: a subtitle displayed at 12 cps can contain fewer characters than a subtitle displayed at 20 cps. Fast subtitle speed may lead to more literal translations, as it does not require subtitlers to condense the text, which is a key skill in subtitling. Therefore, the current debate on subtitle speed in the AVT industry is not solely about the technical issue of speed, but lies at the core of the fundamental principles of subtitling. According to some professionals, the rise in subtitle speeds may lead to "an unwelcome relaxation of the requirement to condense the text", resulting in "less creativity, a higher degree of literalness in the target text and, overall, lower quality of the subtitles" (Szarkowska, Díaz Cintas, & Gerber-Morón 2020). A direct consequence of the interdependence of speed and text condensation is that the two notions tend to be conflated in research: it is difficult to study subtitle speed without text condensation in an ecologically valid setting. As a result, text condensation often becomes a confounding factor in research on subtitle speed (Romero-Fresco 2015b, Szarkowska & Gerber-Morón 2018b). An alternative approach, which would enable researchers to disentangle the impact of speed from that of text condensation, requires a departure from ecological validity towards an experimental or semi-experimental setting where subtitle speed can be manipulated while keeping the text constant (Liao et al 2020). The downside of this solution, however, is that most of the time it will not be possible to synchronise subtitles with the dialogues, which is why it may be necessary to show viewers subtitled videos with no sound, as was done by Liao et al (2020).

Another problem with previous research on subtitle speeds is the fact that researchers have conflated the data from deaf and hard of hearing people reading SDH with the data from hearing viewers watching standard, interlingual subtitles (Romero-Fresco 2015b, Szarkowska et al 2011). As deafness can be an important indicator of poor reading skills (Trezek & Mayer 2019), we argue that eye-tracking studies on subtitling should take this factor into consideration, and therefore, these different populations should not be mixed, unless required by a research question. In this paper, we are only interested in how subtitle speed modulates visual attention in hearing viewers. We acknowledge that viewers who are deaf or hard of hearing may show different reading patterns.

Previous research on the impact of speed in interlingual subtitling on hearing viewers has shown mixed results. On the one hand, slow subtitles are assumed to allow viewers to read comfortably and to follow the on-screen action. However, as mentioned above, slowing down subtitles usually requires the text to be condensed, particularly with fast speech rates. This may result in the text becoming less cohesive (Moran 2009), thus lowering the film comprehension and increasing incongruities between the spoken dialogues and the text in the subtitles, particularly with fast speech rates and viewers who can—at least to some extent—understand the original language of the film (Szarkowska & Bogucka 2019). On the other hand, fast subtitles make viewers spend more time on the subtitles and less on the images (Koolstra, Van Der Voort, & d'Ydewalle 1999), but they contain a fuller and more "accurate" version of the dialogues (Szarkowska, Díaz Cintas, & Gerber-Morón 2020). Some studies found that viewers can cope well with speeds up to 20 cps with no detriment to processing (Szarkowska & Gerber-Morón 2018b). However, as shown by a recent study by Liao et al (2020), there is likely to be a threshold above which viewers might not be able to keep up with the subtitles: Liao et al (2020) found that, unlike in the case of 12 or 20 cps, a speed of 28 cps may result in more skimming. At 28 cps, viewers spent less time fixating on individual words, skipped more words and focused on longer words to obtain the gist of the text. As a result, their comprehension score dropped significantly.

1.2. Measuring the reading time of subtitles

Back in 1984, when reporting results from one of his early eye-tracking experiments on subtitling, d'Ydewalle (1984, 202) stated that "the eyes are on the subtitles at least for one third of the subtitled time". Indeed, as shown by numerous subsequent studies which followed, this early finding has largely held true. However, there are important caveats to be considered, particularly related to how the time spent in the subtitle area is measured. First of all, when d'Ydewalle (1984) mentions "one third of the subtitled time", he means that when studying the time spent by viewers on gazing at subtitles, only the gaze patterns during which the subtitles were actually presented on screen are taken into consideration. This does not include the total duration of the video, which often contains some unsubtitled fragments. Second, as mentioned in the Introduction, the time spent by viewers on reading subtitles can be measured in absolute or proportional terms, relative to subtitle duration. Absolute reading time (ART) denotes the actual time spent in the subtitle area and is measured in (milli)seconds, whereas proportional reading time (PRT) is a metric relative to the subtitle duration and as such is calculated as a percentage of time viewers spent in the subtitle as a function of the total duration of all subtitles in a video (which is taken as 100%)[1]. This is what d'Ydewalle (1984) calls 'percentage time in subtitles' in his studies.

Why is this important? If we say that a viewer gazed at a subtitle for 2 seconds (using the ART measure), we still do not know whether they spent the entire time that this subtitle was on screen or just a fraction of its display time. While 2 seconds is a lot when the subtitle duration is 2.5 seconds, it is not that much when a subtitle lasts for 5 or 6 seconds. Therefore, unlike ART, PRT allows us to make comparisons between different subtitle speeds, relative to their duration. PRT also enables researchers to compare how various groups of viewers interact with subtitled content displayed at different speeds. Importantly, PRT allows us to analyse only the reading of those subtitles that were actually looked at and as such, it cannot be used to analyse subtitle skipping.

Finally, d'Ydewalle (1984) stated that viewers in his study gazed at the subtitle for about one third of its display time, showing he was using proportional reading time. The question now is whether the subtitle viewing patterns have changed since the 1980s, when his study was conducted, given the enormous changes in the subtitling industry and the increased prominence of subtitling as a type of audiovisual translation. Below, we present an overview of eye-tracking studies on interlingual subtitling with hearing viewers reporting how much time viewers actually spent in the subtitle area and how this time changed depending on subtitle speed (Table 1). We need to acknowledge that some of the studies listed here had different research questions and objectives, and were not solely focused on the same question as ours, so it is sometimes difficult to draw direct comparisons.

Table 1
Proportional reading time in eye-tracking studies on subtitling

Study and subtitle speed as reported by the Author(s)	Proportional time spent in the subtitle, in %		
	One-line subtitles (if reported)	Two-line subtitles (if reported)	Total PRT per subtitle
Muylaert et al (1983)			
Subtitles "shorter than 6-sec. rule"			68
6-second rule			55
Subtitles "longer than 6-sec. rule"			57
d'Ydewalle, Muylle, & Rensbergen (1985)			
4-second rule			28
6-second rule			23
8-second rule			21
d'Ydewalle, Rensbergen, & Pollet (1987)[a]			
2-second rule	ca. 40	ca. 55	ca. 48
4-second rule	ca. 30	ca. 40	ca. 35
6-second rule	ca. 23	ca. 30	ca. 27
d'Ydewalle et al (1991)[b]			
6-second rule	16.09	24.39	22.14
Koolstra, Van Der Voort, & d'Ydewalle (1999)			
6-second rule	36	46	41
8-second rule	30	38	33
10-second rule	28	38	33

[1] It is worth noting that some authors have used the total duration of the clip as 100%, rather than the total time in which subtitles were displayed.

d'Ydewalle & De Bruycker (2007)[c]			
6-second rule	31	37	
Szarkowska et al (2011)[d]			
7 cps			47
10 cps			52
13 cps			57
Caffrey (2012)[e]			
N/A	41.99	56.02	
Szarkowska & Gerber-Morón (2018b)[f]			
12 cps			39
20 cps			46
Szarkowska & Bogucka (2019)			
12 cps			36

Note. [a]As the original data was only reported visually in a figure, we provide rough estimates based on the figure for the interlingual subtitles watched by Dutch participants with the sound on. [b]Data only for Dutch subjects watching interlingual subtitles with the sound on. [c]Data only for adults watching standard interlingual subtitles. [d]Data for hearing participants only. [e]Data only for subtitles without glosses present. [f]Data only for Polish hearing participants watching an English video with Polish subtitles.

As reported in d'Ydewalle, Muylle and Rensbergen (1985, 379), an early pilot study by Muylaert et al (1983) found that "the percentage of time spent reading as a function of the projection time of the subtitle is longer with shorter presentations and shorter with longer presentations" although they admit that "detailed analyses on the data were not possible due to technical limitations". In the study, Muylaert et al (1983, 206) used "shorter" and "longer presentations" than the six-second rule, but no data is given as to the actual speeds of the subtitles tested. The subsequent study by d'Ydewalle, Muylle, & Rensbergen (1985, 380) showed that "the proportion of time spent in the subtitled area as a function of the projection time of the subtitle decreases linearly as a function of the four- (28%), six- (23%) and eight-second (21%) rules". They also reported that viewers dwell longer on two-line subtitles (28%) compared to one-line subtitles (20%).

One of the most widely cited papers reporting the results of an eye-tracking study on subtitle speed is the one by d'Ydewalle, Rensbergen, & Pollet (1987). In fact, in the paper, the authors report the results of two experiments. The first one used the same video clip with identical subtitles as the study by d'Ydewalle, Muylle, & Rensbergen (1985). However, instead of eye tracking, the authors used self-reports, asking the participants to declare immediately, for each subtitle, whether they found the subtitle presentation time "too fast", "appropriate" or "too long". The authors were interested in whether viewers can distinguish between different speeds. Two main effects were reported: (1) the faster the subtitles, the more the viewers complained about their speed, and (2) "one line is experienced as faster than two lines" (1987, 314). The combination where viewers had the fewest complaints was the one with two-line subtitles displayed in accordance with the six-second rule, as opposed to the four- or eight-second rule. This finding has since been taken as a validation for the six-second rule used in the subtitling industry (Romero-Fresco 2009). The second experiment reported by d'Ydewalle, Rensbergen, & Pollet (1987) used three subtitling versions of a video clip, this time with the following three subtitle speeds: two-, four- and six-second rule. In all conditions, viewers spent proportionally more time gazing at two-line subtitles compared to one-liners (see Table 1).

A handful of studies have compared how subtitles are read by children and adults (d'Ydewalle & De Bruycker 2007, Koolstra, Van Der Voort, & d'Ydewalle 1999). The results showed that children, particularly younger ones, spend proportionally more time on reading the subtitles. Caffrey (2012) investigated the reading of subtitles which appear together with or without "pop-up glosses", i.e., extra-textual explanations typical of fansubbing in Japanese anime. He found that the presence of pop-up glosses reduces the time viewers can spend on reading standard subtitles. Studies by Szarkowska et al (2011) and Szarkowska & Gerber-Morón (2018b) showed a small but consistent increase in PRT relative to an increase in subtitle speed. Interestingly, the quote from d'Ydewalle (1984) from the beginning of this section and the results of studies presented in Table 1 stand in stark contrast with the conclusions reported by Romero-Fresco (2015a). In his discussion on "viewing speed", he stated that an increase in subtitle speeds from about 120 wpm to 200 wpm results in an increase in time spent by viewers in the subtitle area from about 40% to about 80%. The possibility that increasing subtitle speeds could lead to viewers looking at the subtitle area for up to 80% of the time may directly affect viewer's engagement with subtitled content. With the increasing subtitle speeds currently used by some popular platforms, finding out how subtitle speed affects the reading of subtitles becomes more pressing. PRT can provide us with a comparable measure that allows us to complement our understanding of subtitle reading behaviours.

1.3. Overview of the current study

To answer our research questions, we reanalyse a subset of data from an eye-tracking study on reading subtitles by Szarkowska & Gerber-Morón (2018b), which is available in an open access data repository (Szarkowska & Gerber-Morón 2018a). While the original experiment also included Spanish and English viewers watching videos with different types of subtitles, our analyses here are based only on the data from Polish (L1) hearing participants watching English-language (L2) videos with Polish interlingual subtitles. In the current study, we use proportional reading time as the dependent variable in order to illustrate the usefulness of this metric for future research.

Eye-tracking studies in subtitle reading are resource-intensive and tend to be underexploited. In the field, as well as in the broader social sciences context, there is a clear pressing need to increase the rigour, credibility and validity of research (Christensen, Freese, & Miguel 2019). Through the re-analysis of readily available open data, we also intend to promote secondary analysis and the reuse of datasets. The exploration of available data provides an efficient testing ground for new methods and verification or proofs of concept that can contribute to the development of the field.

Given the above, another goal of this paper is to use linear mixed models to reanalyse the data by Szarkowska & Gerber-Morón (2018b), while in the process increasing the reliability of the results. This is because the amount and type of data collected in eye-tracking studies on subtitle reading require quantitative methods that are better suited than more commonly used techniques to yield more robust statistical analyses (Orero et al. 2018). As an example, when analysing data with methods more commonly used in the field, such as *t*-tests, regressions or ANOVAs, as was the case in the original study (Szarkowska & Gerber-Morón 2018b), scores are averaged so each participant occupies one row in the dataset. Consequently, these tests disregard the variation in scores for each individual test item (here, the subtitles) and participant. This random variability in scores for participants and items almost always exists and may well influence the results (Heck, Thomas, & Tabata 2014; Garson 2020). LMMs account for such variation in participant and item scores. These more advanced models compute the data for each individual score for each item (i.e., subtitle) so that any participant will have as many rows in the dataset as there are subtitles analysed. Using LMMs to analyse our dataset allows the model to account for otherwise unexplained variance (i.e., error) in the data, thus increasing accuracy and power (Meteyard & Davies 2020).

The current study asks two research questions:
RQ1. Is there a difference in proportional reading time between slow (12 cps) and fast (20 cps) subtitles?
RQ2. How does subtitle speed affect proportional reading time?

2. Methods

This section includes only the information relevant to our re-analysis. For a complete description of the methods used to collect the data, please refer to the original study (Szarkowska & Gerber-Morón 2018b).

2.1. Participants

In the experiment, 21 people were tested, but we removed data from two participants whose tracking ratio was below 80%. Therefore, our final data subset included data from 19 Polish participants (16 women; M_{age} = 24.84, *SD* = 5.88, range = 19-38). Five participants self-reported English proficiency at C1 level, and 14 of them at C2 level, indicating that all participants were highly proficient in the language of the original film soundtrack.

2.2. Apparatus

The eye tracker used in this study was an SMI RED 250 mobile. Participants' eye movements were recorded at the rate of 250 Hz. The velocity-based saccade detection algorithm was used with the minimum fixation duration set as 80 ms. SMI software package Experiment Centre was used to create and conduct the experiment and BeGaze 3.7.40 to draw individual areas of interest around each subtitle.

2.3. Materials

The material analysed here are two self-contained scenes from two shows: *Gilmore Girls* (henceforth GG) (2000, created by Amy Sherman-Palladino, 4 minutes 41 seconds) and *Grace and Frankie* (GF) (2015, created by Marta Kauffman and Howard J. Morris, 4 minutes 22 seconds). Both clips were dialogue-heavy and fast-paced, featuring two to four people engaged in a conversation. All clips had the original soundtrack in English and were presented with sound.

Each clip was subtitled at two speeds: 12 and 20 cps, resulting in four subtitled videos. Clip presentation was counterbalanced based on a Latin square design, so that each participant saw two clips: one from GF and one from GG. At the same time, each participant saw one clip subtitled at 12 cps and one clip at 20 cps (see the recommendations by Conklin, Pellicer-Sánchez, & Carrol (2018, 42-43). The order of presentation of clips (GF and GG) was randomised for each participant, using the SMI Experiment Centre randomisation functionality.

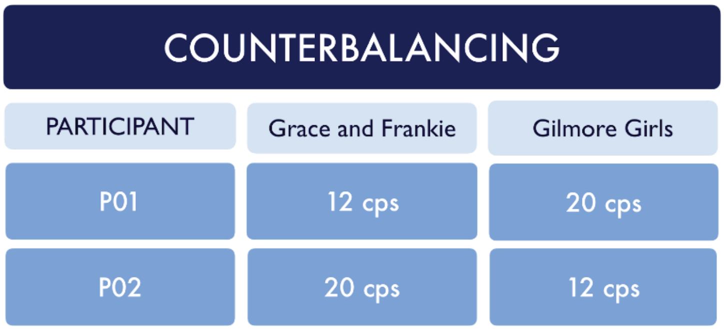

Figure 1. Presentation of experimental conditions

The resulting four subtitle files were controlled for readability using Jasnopis, a readability index for Polish (Broda et al 2015). The indices showed that the subtitle texts did not differ in complexity, ranking 1 (GF12, GF20, GG12) or 2 (GG20) on the 7-point scale in Jasnopis, which means they were very easy to read. We decided to control for readability owing to different degrees of text condensation in 12 and 20 cps conditions. Whereas it was possible to keep the same text of the subtitles between 12 and 20 cps in some subtitles (see the Results section), in the majority of cases—for ecological validity—12 cps subtitles contained a more condensed version of the dialogues than those in 20 cps. As shown by Jasnopis tests, the condensation did not impact readability.

Table 2. Characteristics of the Polish subtitles used in the study

	Grace and Frankie		*Gilmore Girls*	
	12 cps	20 cps	12 cps	20 cps
Number of subtitles	73	89	85	107
Total number of words in the subtitles	393	434	457	644
Mean number of words per subtitle	5.38	4.87	5.37	6.01
Mean number of characters per subtitle	32	29	34	39

2.4. Data processing and analysis

2.4.1. Subtitle selection

In the original study, the minimum subtitle duration was 20 frames (800 ms) and maximum 6 seconds. However, in the case of short subtitles (i.e., containing very little text, such as one or two words), the subtitle reading speed had to be overridden by the requirement of minimum subtitle duration. This resulted in short, one- or two-word subtitles having a very low reading speed (below 10 cps). Therefore, at the processing stage for this study, we removed subtitles lasting between 800 ms and 999 ms so in our dataset we only analysed subtitles with a minimum duration of 1 second.

Because we were interested in the proportional time viewers spend in the subtitle area depending on subtitle speed, in this exploratory study we only investigated subtitles that were actually looked at. We acknowledge that this subset of data does not provide us with a full picture of viewers' engagement with the subtitled videos in general. Our main aim in this study was to find out about viewers' engagement with specific subtitles as influenced by speeds. Studying a more general picture of viewers' engagement is possible using measures other than PRT, such as subtitle skipping, which is undoubtedly interesting, but answers a different research question than the one we posed here. In view of the above, we removed all cases where dwell time on the subtitle area of interest (AOI) was zero, meaning all the subtitles that were not gazed at. We also removed cases where PRT was higher than 100% and where dwell time was higher than visible time (due to a fixation lasting longer than the subtitle but being counted towards the AOI subtitle). Cases where mean fixation duration was below 80 ms or above 500 ms were also deleted (see Conklin, Pellicer-Sánchez, & Carrol (2018, 191).

Table 3. The breakout of subtitle data points analysed in the study per speed, clip and number of lines

		Speed		
Clip	Number of lines	12 cps	20 cps	Total number of subtitle data points per clip and number of lines
Grace and Frankie	1 line	254	225	479
	2 lines	297	241	538
Gilmore Girls	1 line	202	135	337
	2 lines	443	599	1042
Total number of subtitle data points per number of lines	1 line	456	360	816
	2 lines	740	840	1580
Total number of subtitle data points		1196	1200	2396

2.4.2. Variables and data analysis

The outcome variable PRT was used to answer both research questions. PRT was calculated as the percentage of dwell time—i.e., the sum of all fixations and saccades, starting with the first fixation on the AOI—a participant spent in the AOI relative to the subtitle display time. For instance, if a subtitle lasted for 4000 ms and the participant spent 2000 ms in that subtitle, PRT was 50%. PRT failed the assumptions of normality (z scores > 1.96) and homogeneity of variance (as measured by the Levene test). Still, we decided not to transform the variable so we could obtain more meaningful estimates in the final models. To improve the distribution of the variable, PRT data points with residuals above or below 3 SD were removed from the final models, leading to the exclusion of 13 data points and a final dataset of 2396 data points (see Table 3). The resulting, normed, PRT outcome variable approached normality and homoscedasticity. Finally, to further improve the reliability of the results, 1000-sample bias-corrected accelerated (BCa) bootstrap analyses were performed on the final models. BCa bootstrapping corrects for skewness and bias in the data (Field 2018, Kim, Kim, & Schmidt 2007), which ensures that the minor deviations from normality and homoscedasticity do not distort the results.

We ran linear mixed models to answer both research questions. Following recommendations by Meteyard & Davies (2020), see also Cunnings & Finlayson (2015), because the study is exploratory in nature, the models followed a minimal-to-maximal-that-improves-fit process and used Akaike's information criterion (AIC) to assess fit. The model-building process started with random effects: first intercepts, then slopes, then both intercepts and slopes, and finally, their correlation. Random effect estimates that were redundant or worsened model fit were discarded in later models. The variables entered as random effects were Participants and Subtitles.

Once the random effects had been defined, fixed effects were entered in the models. RQ1 asked whether subtitles presented at 12 cps or 20 cps differ in terms of PRT. To answer this question, the 2-level within-subject categorical variables entered as fixed effects were Speed (12 cps and 20 cps), Clips (GF and GG), Line (subtitles with one or two lines), and the Speed*Clips and Speed*Line interactions. Clip and Line (and their interactions with Speed) are not needed to answer RQ1; nevertheless, they were entered in the model to control for variation between clips and number of lines. To answer RQ2, which sought to investigate the relationship between subtitle speed and PRT, the categorical variable Line and the continuous variable Actual Speed (i.e., the real speed in characters per second for each subtitle) were entered as fixed effects. Unlike Speed (a categorical variable) used to answer RQ1, Actual Speed is a continuous variable, as it consists of the actual speed, calculated by dividing the number of characters in a subtitle per its display time. Some examples of real speeds are 13.3 cps and 11.03 cps, from the variable Speed (level 12 cps), or 21.43 cps and 19.06 cps, from the level 20 cps. Actual Speed was centred; therefore, the intercept of the second model reflects the grand mean. Only the two final models (one for each RQ) are reported here. All data were analysed using SPSS version 27, and the alpha level was set at .05. The dataset used in our study can be found at the online repository (Silva, Szarkowska, & Orrego-Carmona 2021).

3. Results

3.1. Comparing PRT at 12 cps and 20 cps

By posing the first research question, we wanted to know if PRT differed between the slow and fast subtitle speeds: 12 and 20 cps, respectively. The descriptive statistics for PRT are presented in Table 4 while the relevant LMM is shown in Table 5.

Table 4. Proportional reading time by speed, clip and lines

		12 cps		20 cps	
		M	*SD*	*M*	*SD*
Grace and Frankie	1 line	33.24	15.33	45.75	19.22
	2 lines	38.60	19.07	48.63	20.72
Gilmore Girls	1 line	38.45	16.60	42.47	19.03
	2 lines	46.80	19.17	51.95	20.98
	Total	40.47	18.69	49.05	20.64

Table 5. Fixed and random effect estimates for PRT comparing 12 cps and 20 cps

Fixed effects[a]			
	Estimate (Std. error)	*95 % CI*	*p*
Intercept	32.04 (.87)	[30.35, 33.53]	< .001
Speed	11.13 (-1.45)	[8.16, 14.11]	< .001
Clip	7.11 (1.11)	[5.04, 9.27]	< .001

Line	7.11 (1.03)	[5.10, 9.25]	< .001
Speed*Clip	-5.81 (1.98)	[-9.73, -2.29]	< .001
Speed*Line	-.51 (1.64)	[-3.65, 3.02]	.750
Random effects[b]			
	Variance (Std. error)	*p*	*Intraclass correlation*
Residual	220.01 (6.80)	< .001	
Participants (Intercept)	56.72 (22.01)	.010	0.1432
Speed | Participants slope	37.19 (15.56)	.017	0.0939
Line | Participants slope	15.92 (8.35)	.057	0.0402
Subtitles intercept	66.16 (8.20)	< .001	0.1671

Note. Number of data points = 2396; participants = 19. Degrees of freedom estimation: Satterwaitte.
[a]The estimates reported for fixed effects are based on a 1000-sample BCa bootstrap. [b]Covariance structure: variance components.

As can be seen, the LMM shows significant differences in all variables apart from the Speed*Line interaction. This means that PRT 1) increased significantly between 12 cps and 20 cps (see Speed in Table 4), 2) between 1-line and 2-line subtitles (see Line), and 3) was higher for GG than for GF (see Clips). The Speed*Clips interaction suggests that the amount of increase in PRT in Speed differed between clips. The descriptive statistics in Table 4 show that the PRT increase between 12 cps and 20 cps was higher for GF than for GG. In fact, the effect of Speed when only analysing the data for GG becomes far less significant relative to the previous analysis, $\beta = 4.25$, SE = 2.02, $p = .028$, 95% CI [.06, 8.14] (see Appendix A for the full final model). As mentioned in the literature review, the reason for this interaction might be the different levels of text condensation in subtitling between clips and the resulting amount of text in the subtitles (see the Discussion). To investigate this, we re-analysed the data using only a subset containing 592 subtitles identical in terms of text, thus effectively removing the confounding effects of condensation and different amounts of text. Unsurprisingly, perhaps, the LMM found no difference in PRT for Clips, $\beta = .05$, SE = .05, $p = .319$, 95% CI [-.05, .15], and for the Clips*Speed interaction, $\beta = -.10$, SE = .08, $p = .168$, 95% CI [-.26, .05] (see Appendix B for the full final model).

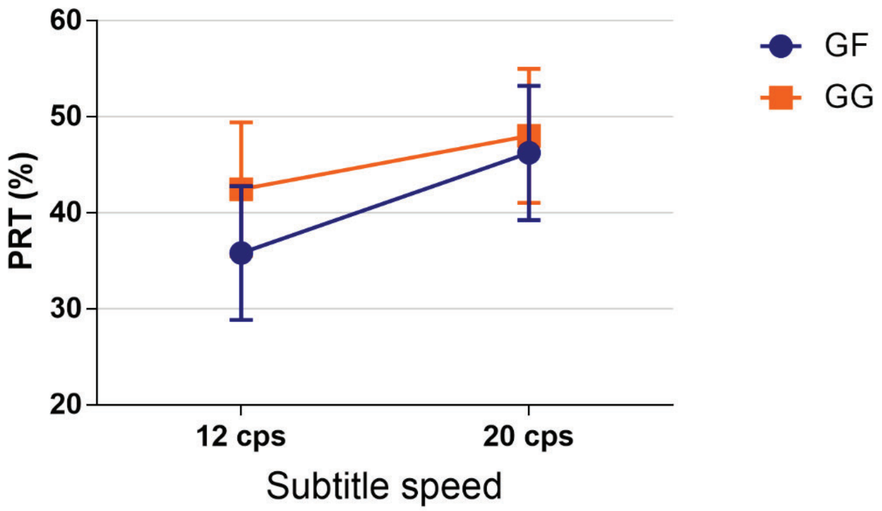

Figure 2. Proportional reading time by subtitle speed and clip. Error bars correspond to 95% CIs.

The intraclass correlation (ICC) in Table 5 describes the proportion of variance explained by the random effect (see Heck et al. 2014). For instance, the ICC for Subtitles is 0.1671, or 16.71%. Taken together, the random effects entered in the model explained 44.44% of the variance left unexplained by the fixed effects.

To answer RQ1, the LMM found significantly higher PRT for 20 cps than for 12 cps. The model shows that PRT may increase by up to 14.11 points (see upper end of 95% CI in Table 5) when subtitle speeds change from 12 cps to 20 cps. These results will be discussed in some detail in the next sections.

3.2. Finding the Relationship between Actual Speed and PRT

By posing the second research question, we sought to find how subtitle speed affects PRT. The LMM with Actual Speed as a fixed effect is presented in Table 6. The results show that Actual Speed significantly predicts PRT, with a positive relationship between the variables. The estimate of the intercept corresponds to the value of PRT at the grand mean of Actual Speed (i.e., 39.55 PRT at 16 cps). This means that at 20 cps, holding Line constant, the model predicts a PRT of 43.55 (an increase in PRT of 1.00 for each increase of one unit in cps). Considering the upper ends of the 95% CIs (Intercept: 40.48; Actual Speed: 1.19), the model predicts a PRT of 45.24 at 20 cps when controlling for the number of lines. These results stand in stark contrast with the results reported by Romero-Fresco (2015a) and will therefore be discussed in detail in the next section. Finally, the ICC values show that the random effects explained 45.61% of the variance in the data that would have been left unexplained had only fixed effects been included in the model. Again, more explained variance equals less error, thus more statistical power.

Table 6. Fixed and random effect estimates for PRT with Actual Speed

Fixed effects[a]			
	Estimate (Std. error)	*95 % CI*	*p*
Intercept	39.55 (.62)	[38.41, 40.48]	< .001
Actual Speed	1.00 (.11)	[.81, 1.19]	< .001
Line	7.15 (.76)	[5.39, 9.20]	<. 001
Random effects[b]			
	Variance (Std. error)	*p*	*Intraclass correlation*
Residual	219 .97 (6.79)	< .001	
Participants (Intercept)	60.33 (22.76)	.008	0.1492
Speed | Participants slope	42.68 (17.67)	.016	0.1055
Line | Participants slope	15.34 (8.10)	.058	0.0379
Subtitles intercept	66.10 (8.25)	< .001	0.1634

Note. Number of data points = 2396; participants = 19. Degrees of freedom estimation: Satterwaitte.
[a]The estimates reported for fixed effects are based on a 1000-sample BCa bootstrap. [b]Covariance structure: Variance components.

4. Discussion

Drawing on a re-analysis of data, in this study we posed two research questions investigating the relationship between subtitle speed and subtitle reading. First, we sought to find out how much time viewers spend gazing at subtitles while watching videos with subtitles displayed at the average speed of 12 cps and 20 cps (RQ1); then, we investigated how this time is related to the actual speed of subtitles (RQ2). We answered these questions in an attempt to promote the use of proportional reading time as a dependent variable and of linear mixed models as a suitable statistical technique. We believe that PRT may be used as the standardised metric to measure the time spent by viewers in the subtitle area. Also, LMMs are typically more accurate and powerful than more commonly used statistical methods, see for example, Bates et al (2018), Meteyard & Davies (2020), and are therefore better able to find significant effects if they exist.

Using LMMs as opposed to the ANOVAs utilized in the previous study (Szarkowska & Gerber-Morón 2018b) has a number of advantages. Most importantly, in the current study, LMMs allowed to reduce statistical error in the analyses. This is because the inclusion of random effects in the model helped explain additional variance in the data, up to 45.61% the variance left unexplained by fixed effects (see Results). Notably, the intercepts for Participants and Subtitles explained the largest proportion of random-effect variance in both models (see Tables 5 and 6). This means that PRT varied significantly among participants (e.g., due to differences in reading skills or familiarity with subtitling) and among different subtitles (e.g., because of varied textual characteristics such as word length or frequency and speech rate). All this extra explained variance allowed the models to better single out variation in PRT that was due to the treatment (i.e., differences in speed) rather than other confounding factors.

In the first research question, we asked whether there is a difference in PRT between slow (12 cps) and fast (20 cps) subtitles. Our model showed that indeed the time spent by viewers reading fast subtitles is proportionally higher than when reading slow subtitles. However, the difference between the slow and high speeds is not as large as previously suggested (e.g., Romero-Fresco (2015a); see below). In our study, the mean PRT was 40% and 49% for the slow and fast subtitles, respectively. This is consistent with the results of the original study by Szarkowska & Gerber-Morón (2018b) and various studies conducted by d'Ydewalle and colleagues (see Table 1).

Our first model (see Table 5) also provided insights that extend beyond the first research question. First, the analysis showed that PRT is higher for two-line compared to one-line subtitles. This corroborates the results of previous studies (see Table 1). We attribute this result to the larger amount of text that two-line subtitles typically contain compared to one-liners as well as to the possible return sweeps between the lines and corrective saccades (Rayner 1998). Second, the two clips differed in terms of PRT (see Figure 2), even though every effort was made to ensure the comparability between the clips used in the study (i.e., we controlled for readability indices such as Jasnopis (Broda et al 2015), duration, the number of speakers). Nevertheless, the LMM showed a significant increase in PRT between 12 cps and 20 cps for GF, but not so much for GG. This effect of the clips on the viewers' behaviour, even when assessed for comparability and taken from the same audiovisual product, has been shown before in studies using linear mixed-effects models (e.g., Orrego-Carmona (2015). In our study, this finding may stem from the higher speech rate in GG compared to GF. Given that high speech rates necessitate a higher degree of text condensation in subtitling (Díaz-Cintas & Remael 2021), the resulting subtitles may become less congruous with the original dialogues and contain the gist of the utterance. This incongruity between the Polish subtitles and the original English dialogues, which our highly proficient viewers could easily follow, possibly made them focus more on comparing the two sources of information (i.e., soundtrack and subtitles) and noticing incongruities, thus increasing PRT. Indeed, previous research showed that a high speech rate and the resulting higher degree of condensation may have an impact on viewers' gaze and performance Szarkowska & Bogucka (2019). A recent study by Szarkowska, Díaz Cintas, & Gerber-Morón (2020) reported that some viewers who are proficient in English preferred to watch intralingual English SDH to interlingual subtitles because they find them more "accurate" (i.e., less incongruous). Naturally, the effects of incongruity resulting from text condensation can only be discernible with viewers who are familiar with the language of the film soundtrack. In the current study, the higher text condensation[2] in GG at 12 cps (44% condensation rate compared to 24% in GF12) may have resulted in higher PRT. At 20 cps, condensation rates were similarly equally low in both clips (21% in GG20 and 17% in GF20). The result is that while PRT increased due to an increase in speed (from 12 cps to 20 cps), it possibly increased less in GG than in GF because the confounding effects of condensation disappeared. In fact, Table 4 shows that, for 1-line subtitles, the PRT at 20 cps is higher for GF than for GG, effectively inverting the trend seen at 12 cps. This reinforces our assumption that the existing difference in PRT between GF and GG may have been due to the different levels of condensation between the clips, especially at 12 cps. Still, the lack of control of condensation rates may have inadvertently distorted our results, signalling a variable that should be controlled for in future studies.

In the second research question, we asked how actual subtitle speed affects PRT. Whereas some studies have shown that an increase in subtitle speed will result in an increase in PRT (see Table 1), it is unclear to what extent subtitle speeds may affect this measurement. The results of our study show that as subtitle speed rises, PRT increases. This increase depends on the characteristics of the subtitles and viewers—as shown by the random effects—as well as on the characteristics of the clip. The positive correlation between PRT and subtitle speed lends

[2] Condensation rate was calculated as the percentage of words omitted in the Polish subtitles relative to the original English dialogue

support to previous findings (see Table 1). However, we did not find any evidence in our data that supports Romero-Fresco's (2015a, 338) suggestion that an increase in speed from 120 wpm to 200 wpm would result in an increase in PRT from roughly 40% to 80%. According to our model (see Table 6), even when using the higher ends of the 95% CIs, PRT would reach 79.75% only at the speed of 49 cps, an extremely high speed never recommended in subtitling[3]. To put it in terms of wpm, since the average word length in our subtitles is 5.22 characters, in our analysis 49 cps equals 563.22 wpm, thus a far cry from the 200 wpm suggested by Romero-Fresco (2015a). This of course assumes that PRT increases linearly, which may not be the case. Of importance, Romero-Fresco (2015a) study was based on data from hearing, deaf and hard of hearing viewers while ours comprised hearing viewers only. Nevertheless, the discrepancy between our and Romero-Fresco (2015a) results should be investigated further.

We believe that there is probably a threshold in subtitle speed above which viewers are unable to read the subtitles and to follow the action; yet, pinpointing the exact number—just like formulating the "ideal" or "optimum" subtitle speed for all viewers in all types of video materials—might be impossible. This is because subtitle speed is only one of many relevant factors contributing to the viewing process. Other crucial aspects include the characteristics of the clip (e.g., film editing, genre), of the dialogue (e.g., speech rate, complexity, word length, and word frequency), or other characteristics of the subtitles apart from speed (e.g., condensation rate, number of lines, legibility, and cohesion). The importance of other factors than speed was demonstrated, for instance, by Moran (2009), who showed that viewers reading subtitles containing more high-frequency words had a shorter overall reading time than those subtitles with low-frequency words. Also, Perego, Del Missier, & Stragà (2018) reported that the complexity of the video materials impacted the cognitive processing of subtitled videos, with more complex videos resulting in more effortful processing and lower performance. In a study by Szarkowska & Bogucka (2019), a higher speech rate, which required more text condensation in subtitling, resulted in lower comprehension compared to slow speech rates. Naturally, subtitle reading also largely depends on the characteristics of particular viewers and their reading abilities, as we showed above when discussing the random effects.

5. Conclusions, limitations and future research avenues

This re-analysis is an initial exploration that takes the opportunity to use existing data to assess long-standing questions in subtitling. Eye-tracking studies are by definition resource-intensive, time-consuming and costly. In an effort to show the field can adopt more sustainable and efficient strategies, we have successfully re-analysed a dataset using a more advanced statistical approach to shed some light on new research questions. Our study is very narrow in scope: we selected a subset of subtitles according to clearly defined criteria to assess reading at the subtitle level and we do not claim this subset is representative of the entire viewing process of subtitled content.

As a re-analysis, the results of this study should be understood within the constraints of the design of the original study and the decisions we made in selecting the subset. We have shown in the analysis that, even within these constraints, useful insights into subtitle-reading time and its relationship with speed can be gained from existing data. As a natural follow-up to our study, more targeted and robust studies will be needed to verify or challenge the extent of these findings. For instance, when investigating the relationship between subtitle speed and PRT, the variation in speed in our data comprised speeds around 12 cps or 20 cps. Future studies could look into more varied speeds to obtain a better representation of viewers' reactions to variations in speed. Additionally, further studies should control for the speed rate and the resulting text condensation in subtitling as a relevant factor influencing the viewers' processing of subtitled videos. Needless to say, as our study has only examined a small sample of young Polish viewers with high proficiency in English reading Polish subtitles, further research should include more diverse populations.

Our results also highlight the relevance of the material as a variable in the study of subtitle reading. More clips and different genres also need to be studied. The limitation in the field pertaining to the duration of the clips included in the studies should probably be revised considering the developments in hardware, software and

[3] Typically, the maximum speed in subtitling does not exceed 20 cps, with roughly 30% flexibility allowed (Netflix: https://partnerhelp.netflixstudios.com/hc/en-us/articles/115001352352-Is-there-flexibility-on-the-reading-speed-threshold-)

methods. When designing future studies, and considering that data can be re-used effectively, longer clips could be included to better assess factors such as exposure, fatigue and habituation. Short clips, as have been traditionally used, may not be sufficient to draw definitive conclusions as fatigue related to watching fast subtitle speeds may be discernible only with longer film fragments. The experiments using longer stimuli may be supported by more accurate eye trackers and more automated data-processing tools.

We hope the review of the PRT formula and its definition will ensure transparency, enable replication and facilitate comparisons between studies conducted in various countries, with different languages and viewer demographics. We believe that the use of PRT as a measure has a number of advantages, although - as any other metric - it does have certain limitations. First of all, PRT only provides information about the proportional time spent on the subtitle and how this time might be affected by speed. While PRT in itself is limited, it has the potential to increase comparability and to support studies on longer subtitled video content with variable speeds. Thus, PRT would be particularly convenient for the type of further studies suggested above. The promotion of PRT as a standardised measure in subtitle reading studies can also encourage methodological reflection on the part of AVT researchers, discouraging them for instance from taking the entire duration of the clip as the basis to calculate how much time viewers gaze at the subtitles (rather than the time when the subtitles were actually displayed). Another advantage of PRT is that, unlike absolute values such as ART, it allows comparisons between different subtitle characteristics and across various groups of viewers.

Finally, we acknowledge that to gain a more comprehensive picture of how viewers engage with subtitled content, it is necessary to use a combination of measures - both quantitative (such as fixation count, fixation duration) and qualitative (such as interviews). Only a comprehensive study can actually assess the engagement with subtitled content. PRT as a metric depends on the amount of text in the subtitles, which in turn has an impact on the required speed of subtitles. Therefore, careful considerations need to be followed to decide when to use it.

References

Bates, Douglas, Reinhold Kliegl, Shravan Vasishth, and R. Harald Baayen. 2018. Parsimonius Mixed Models.

Broda, Bartosz, Maciej Ogrodniczuk, Włodzimierz Gruszczyński, Bartłomiej Nitoń, Edyta Charzyńska, Łukasz Dębowski, and Milena Hadryan. 2015. Jasnopis czyli Mierzenie zrozumiałości polskich tekstów użytkowych. SWPS Uniwersytet Humanistycznospołeczny.

Caffrey, C. 2012. "Using an eye–tracking tool to measure the effects of experimental subtitling procedures on viewer perception of subtitled AV content." In *Eye tracking and audiovisual translation*, edited by E. Perego, 223-258. Rome: Aracne.

Christensen, Garret, Jeremy Freese, and Edward Miguel. 2019. *Transparent and reproducible social science research: How to do open science.* Oakland: University of California Press.

Conklin, Kathryn, Ana Pellicer-Sánchez, and Gareth Carrol. 2018. *Eye-tracking: a guide for applied linguistics research*. Cambridge: Cambridge University Press.

Cunnings, Ian, and Ian Finlayson. 2015. "Mixed effects modeling and longitudinal data analysis." In *Advancing Quantitative Methods in Second Language Research*, edited by Luke Plonsky, 159-181. New York: Routledge.

d'Ydewalle, Géry. 1984. "Processing TV information and eye movements research." Readings on Cognitive Ergonomics - Mind and Computers, Berlin, Heidelberg.

d'Ydewalle, Gery, and Wim De Bruycker. 2007. "Eye movements of children and adults while reading television subtitles." *European Psychologist* 12 (3):196-205. https://doi.org/10.1027/1016-9040.12.3.196.

d'Ydewalle, Gery, Patrick Muylle, and Johan van Rensbergen. 1985. "Attention shifts in partially redundant information situations." In *Eye Movements and Human Information Processing*, edited by R. Groner, G. W. McConkie and C. Menz, 375-384. Amsterdam: Elsevier.

d'Ydewalle, Gery, C. Praet, K. Verfaillie, and J. Van Rensbergen. 1991. "Watching subtitled television: automatic reading behavior." *Communication Research* 18 (5):650-666.

d'Ydewalle, Gery, Johan van Rensbergen, and Joris Pollet. 1987. "Reading a message when the same message is available auditorily in another language: the case of subtitling." In *Eye movements: from physiology to cognition*, edited by J. K. O'Regan and A. Levy-Schoen, 313-321. Amsterdam/New York: Elsevier.

Díaz-Cintas, Jorge, and Aline Remael. 2021. Subtitling. Concepts and Practices.

Díaz Cintas, Jorge, and Aline Remael. 2007. *Audiovisual translation: subtitling*. Manchester: St. Jerome.

Field, Andy P. 2018. *Discovering statistics using IBM SPSS statistics*. 5th ed. Los Angeles: SAGE.
Fresno, Nazaret, and Katarzyna Sepielak. 2020. "Subtitling speed in Media Accessibility research: some methodological considerations." *Perspectives*:1-17. https://doi.org/10.1080/0907676X.2020.1761841.
Garson, G. David. 2020. *Multilevel modelling: Applications in Stata, IBM SPSS, SAS, R, & HLM*. Los Angeles/London: Sage.
Heck, Ronald H., Scott Loring Thomas, and Lynn Naomi Tabata. 2014. *Multilevel and longitudinal modeling with IBM SPSS*. New York / London: Routledge.
Ivarsson, Jan, and Mary Carroll. 1998. *Subtitling*. Simrishamn: TransEdit HB.
Karamitroglou, Fotios. 1998. "A Proposed Set of Subtitling Standards in Europe." *Translation Journal* 2 (2).
Kim, Myungsup, Yangseon Kim, and Peter Schmidt. 2007. "On the accuracy of bootstrap confidence intervals for efficiency levels in stochastic frontier models with panel data." *Journal of Productivity Analysis* 28 (3):165-181. https://doi.org/10.1007/s11123-007-0058-2.
Koolstra, Cees M., Tom H. A. Van Der Voort, and Gery d'Ydewalle. 1999. "Lengthening the presentation time of subtitles on television: effects on children's reading time and recognition." *Communications* 24 (4):407-422. https://doi.org/10.1515/comm.1999.24.4.407.
Liao, Sixin, Lili Yu, Erik D. Reichle, and Jan-Louis Kruger. 2020. "Using Eye Movements to Study the Reading of Subtitles in Video." *Scientific Studies of Reading*:1-19. https://doi.org/10.1080/10888438.2020.1823986.
Martí Ferriol, José Luis. 2013. "Subtitle reading speeds in different languages: the case of Lethal Weapon." *Quaderns: Revista de traducció* (20):201-210.
Meteyard, Lotte, and Robert A. I. Davies. 2020. "Best practice guidance for linear mixed-effects models in psychological science." *Journal of Memory and Language* 112. https://doi.org/10.1016/j.jml.2020.104092.
Moran, Siobhan. 2009. "The effect of linguistic variation on subtitle reception." PhD, York University.
Muylaert, Willem, Johan Nootens, Daniel Poesmans, and A. K. Pugh. 1983. "Design and utilisation of subtitles on foreign language television programmes." In *Theorie, Methoden and Modelle der Kontaktlinguistik*, edited by P. H. Nelde, 201-214. Bonn: Dummler.
Netflix. 2016. Timed Text Style Guide: General Requirements.
Orero, Pilar, Stephen Doherty, Jan-Louis Kruger, Anna Matamala, Jan Pedersen, Elisa Perego, Pablo Romero-Fresco, Sara Rovira-Esteva, Olga Soler-Vilageliu, and Agnieszka Szarkowska. "Conducting experimental research in audiovisual translation (AVT): A position paper." *JosTrans: The Journal of Specialised Translation* 30 (2018): 105-126.
Orrego-Carmona, David. 2015. "The reception of (non)professional subtitling." PhD, Department of English and German Studies, Universitat Rovira i Virgili.
Pedersen, Jan. 2011. *Subtitling norms for television: an exploration focussing on extralinguistic cultural references*. Amsterdam: John Benjamins.
Pedersen, Jan. 2018. "From old tricks to Netflix: How local are interlingual subtitling norms for streamed television?" *Journal of Audiovisual Translation* 1 (1):81-100.
Perego, Elisa, Fabio Del Missier, and Marta Stragà. 2018. "Dubbing vs. subtitling. Complexity matters." *Target* 30 (1):137-157. https://doi.org/10.1075/target.16083.per.
Rayner, Keith. 1998. "Eye Movements in Reading and Information Processing: 20 Years of Research." *Psychological Bulletin* 124 (3):372-422. https://doi.org/10.1037/0033-2909.124.3.372.
Romero-Fresco, Pablo. 2009. "More haste less speed: Edited versus verbatim respoken subtitles." *Vigo International Journal of Applied Linguistics* 6:109-133.
Romero-Fresco, Pablo. 2015a. "Final thoughts: Viewing speed in subtitling." In *The Reception of Subtitles for the Deaf and Hard of Hearing in Europe*, edited by Pablo Romero-Fresco, 335-341. Bern: Peter Lang.
Romero-Fresco, Pablo. 2015b. *The Reception of Subtitles for the Deaf and Hard of Hearing in Europe: UK, Spain, Italy, Poland, Denmark, France and Germany*. Bern: Peter Lang.
Silva, Breno B, Agnieszka Szarkowska, and David Orrego-Carmona. 2021. "Dataset PRT paper". Figshare. Dataset. https://doi.org/10.6084/m9.figshare.16840240.v1
Szarkowska, Agnieszka. 2016. Report on the results of an online survey on subtitle presentation times and line breaks in interlingual subtitling. Part 1: Subtitlers. University College London.
Szarkowska, Agnieszka, and Lidia Bogucka. 2019. "Six-second rule revisited: An eye-tracking study on the impact of speech rate and language proficiency on subtitle reading." *Translation, Cognition & Behavior* 2 (1):101-124. https://doi.org/https://doi.org/10.1075/tcb.00022.sza.

Szarkowska, Agnieszka, Jorge Díaz Cintas, and Olivia Gerber-Morón. 2020. "Quality is in the eye of the stakeholders: what do professional subtitlers and viewers think about subtitling?" *Universal Access in the Information Society*. https://doi.org/10.1007/s10209-020-00739-2.

Szarkowska, Agnieszka, and Olivia Gerber-Morón. 2018a. SURE Project Dataset. RepOD.

Szarkowska, Agnieszka, and Olivia Gerber-Morón. 2018b. "Viewers can keep up with fast subtitles: Evidence from eye movements." *Plos One* 13 (6). https://doi.org/10.1371/journal.pone.0199331.

Szarkowska, Agnieszka, Izabela Krejtz, Z. Kłyszejko, and A. Wieczorek. 2011. "Verbatim, standard, or edited? Reading patterns of different captioning styles among deaf, hard of hearing, and hearing viewers." *American Annals of the Deaf* 156 (4):363-378. https://doi.org/10.1353/aad.2011.0039.

TED. 2017. "English Style Guide." http://translations.ted.org/wiki/English_Style_Guide.

Trezek, Beverly, and Connie Mayer. 2019. "Reading and Deafness: State of the Evidence and Implications for Research and Practice." *Education Sciences* 9 (3). https://doi.org/10.3390/educsci9030216.

Tveit, Jan Emil. 2005. *Translating for television: a handbook in screen translation*. Bergen: JK Publishing.

Zarate, Soledad. 2021. *Captioning and Subtitling for d/Deaf and Hard of Hearing Audiences*. London: UCL Press.

Appendix A - Fixed and random effect estimates for PRT comparing 12 cps and 20 cps with data from *Gilmore Girls* only.

Fixed effects[a]			
	Estimate (Std. error)	*95 % CI*	*p*
Intercept	38.14 (1.02)	[36.08, 40.08]	< .001
Speed	4.25 (2.02)	[.06, 8.14]	.028
Line	7.99 (1.59)	[4.65, 11.11]	< .001
Speed*Line	1.71 (1.40)	[-2.63, 6.61]	.434

Random effects[b]			
	Variance (Std. error)	*p*	*Intraclass correlation*
Residual	231.01 (9.46)	< .001	
Participants (Intercept)	73.78 (29.48)	.012	0.1843
Line | Participants slope	24.44 (14.45)	.091	0.0611
Subtitles intercept	71.06 (11.40)	< .001	0.1775

Note. Degrees of freedom estimation: Satterwaitte.
[a]The estimates reported for fixed effects are based on a 1000-sample BCa bootstrap. [b]Covariance structure: variance components.

Appendix B - Fixed and random effect estimates for PRT (log-transformed) comparing 12 cps and 20 cps with data from identical subtitles only.

Fixed effects[a]			
	Estimate (Std. error)	*95 % CI*	*p*
Intercept	3.40 (.036)	[3.33, 3.46]	< .001
Speed	.25 (.053)	[.14, .36]	< .001
Clips	.05 (.05)	[-.05, .15]	.319
Line	.24 (.06)	[.10, .43]	.002
Speed*Clips	-.10 (.08)	[-.26, .05]	.168
Speed*Line	-.09 (.07)	[-.21, .03]	.225

Random effects[b]			
	Variance (Std. error)	*p*	*Intraclass correlation*
Residual	.175 (.014)	< .001	
Participants (Intercept)	.04 (.01)	< .001	0.1404
Speed | Participants slope	.04 (.02)	.009	0.1404
Subtitles intercept	.03 (.01)	< .001	0.1053

Note. Degrees of freedom estimation: Satterwaitte.
[a]The estimates reported for fixed effects are based on a 1000-sample BCa bootstrap. [b]Covariance structure: variance components.