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# Eye movements in reading[1]

## Implications for reading subtitles

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ABSTRACT: In this chapter, we review research on eye movements during reading. The characteristics of eye movements during reading have important implications for understanding eye movements when viewers read subtitles. Research findings on the following issues are discussed: (1) the size of the perceptual span, (2) what determines when and where to move the eyes while reading, and (3) cross–linguistic differences. Implications for reading subtitles are also discussed.

### 1. Introduction

Although research on eye movements during reading has been conducted for over a century, the past three decades or so has seen a flourish of research on this topic (Rayner, 1998, 2009). With the use of increasingly advanced state–of–the–art eye trackers we are able to measure eye movements and exert sufficient experimental control in experiments to rather precisely infer what is happening in the mind as we read. Clearly, the study of *how* one reads is relevant to any discussion about reading subtitles. That is in order for subtitles to be understood they must first be read. However, there are two additional tasks for a subtitle reader. First, they need to read at a pace imposed by the movie, or subtitle transcriber, whereas, under normal conditions, *where* and *when* to move the eyes is determined by the reader (but can also be influenced by the properties of the text itself). Second, when reading subtitles, people also shift their gaze back and forth

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between the subtitle and the movie / TV program. Other chapters in the present volume deal with this dynamic switching between film and subtitle and with subtitle reading per se; our goal is to provide some background information regarding eye movements during reading. We believe that is important to know what readers are doing under normal reading circumstances, in order to be better able to investigate and discuss how they read subtitles (for a good overview of eye movements during subtitle reading per se, see d'Ydewalle, & De Bruycker, 2007).

In the present chapter we review basic terminology, measures, and findings concerning eye movements during reading. We will consider topics such as the perceptual span, determinants of eye movements, and linguistic influences on reading. In the final section we will review some commonalities and differences of reading in different languages, as we believe this would be of particular interest to researchers studying the reading of subtitles.

## 2. Basic characteristics of eye movements

We obtain visual information with our eyes when light hits the retina and is transformed into electric signals, which get relayed to the brain to be interpreted. Importantly, not all parts of the retina have the same acuity, or resolution. The region of highest acuity—called the *fovea*—is located in the center of the retina and extends 2 degrees of visual angle in diameter. Outside the fovea, acuity drops off rapidly, in regions called the parafovea (1–5 degrees of visual angle from fixation) and the periphery (everything beyond the parafovea). For this reason, in order to process information most effectively we must move our eyes so that the fovea fixates the location of that which we intend to process. These eye movements are called *saccades* and last approximately 25–60 ms (milliseconds—depending on the size of the actual movement). Between the saccades, our eyes are relatively stable (in *fixations*), which last approximately 200–250 ms. It is during fixations that information is obtained from the visual stimulus since during saccades vision is suppressed[2] and we are essentially 'blind'. We may have the intuition that we are able to process all the information in a visual display in a single fixation, but it is simply not possible without moving our eyes so that our foveas may fixate a location to process the information therein (Rayner, 1978, 1998, 2009).

For the most part, overt attention (where the eyes are fixating) is tightly linked to covert attention (where the mind is attending). Although the most thorough and effective processing is reserved for that done in the fovea, some processing can also be accomplished for information in the parafovea and peripheral vision (see Schotter, Angele & Rayner, 2012 for a comprehensive review). In simple laboratory tasks, eye location and attention may be separated or dissociated (Posner, 1980). However, even in these simple laboratory tasks, it takes much conscious effort to keep the eyes fixated while attending to another location. Furthermore, in more complex tasks like reading, such dissociations, when they occur, are generally the consequence of programming an eye movement. It is well established that, in many tasks, a shift of attention to the saccade target precedes the actual eye movement (Deubel, & Schneider, 1996; Hoffman, & Subramaniam, 1995; Kowler, Anderson, Dosher, & Blaser, 1995; Rayner, McConkie, & Ehrlich, 1978). Since eye movements are motor programs, they take some time to plan and execute (approximately 175 ms) under circumstances in which no other cognitive processing is required and one's task is merely to move one's eyes to the location of a fixation target (Becker, & Jürgens, 1979; McPeek, Skavenski, & Nakayama, 2000; Rayner, Slowiaczek, Clifton, & Bertera, 1983). Additionally, they are largely ballistic, meaning it is difficult (though possible) to change the trajectory of a saccade once it is initiated.

It has generally been assumed that there is near perfect binocular coordination during reading and that the two eyes start moving at the same time and land on the same letter. However, recent research (see Kirkby, Webster, Blythe, & Liversedge, 2008 for a comprehensive review) has demonstrated that up to 40–50% of the time the eyes are on different letters (sometimes as a result of the two eyes being

2. Although vision is suppressed, for most cognitive tasks, mental processing continues during the saccade (see Irwin, 2004, for a review of when cognition is also suppressed during saccades).

crossed—left eye fixating further to the right than the right eye—and other times when they are uncrossed—the left eye is much further to the left than the right eye; Liversedge, Rayner, White, Findlay, & McSorley, 2006; Liversedge, White, Findlay, & Rayner, 2006). Interestingly, the amount of disparity tends to be greater in beginning readers than skilled readers (Blythe, Liversedge, Joseph, White, Findlay, & Rayner, 2006). More importantly, perhaps, word frequency and case alternation affect fixation duration in reading (as we will discuss more in detail below), but not fixation disparity (Juhasz, Liversedge, White, & Rayner, 2006).

At one time, researchers doubted that eye movements reflected much of cognitive processing and believed that the eyes and mind were not tightly linked during information processing tasks, such as reading. They came to this conclusion based on the observation that saccade latencies in simple oculomotor tasks are relatively long (compared to, for example, the average fixation duration in reading). These relatively long latencies (and high variability in the latencies) led them to argue that there wasn't sufficient time for eye fixations to be influenced by cognitive processes. However, these conclusions were based on the assumption that programming saccades and cognitive processes occur in a serial fashion. But, more recent research has established that the eyes and mind are very tightly linked, that saccades can be programmed in parallel (Becker, & Jürgens, 1979), and that information processing can proceed concurrently with saccade programming (Rayner, 1998, 2009). Furthermore, information is obtained from words in the parafovea (see discussion below) and this parafoveal processing can facilitate foveal processing, leading to shorter fixation times than would be expected otherwise.

## 2.1. *Eye movements during reading*

Now that a basic overview has been provided, we turn to a discussion of what is known about eye movements during reading from research over the past 30 years. The majority of work on reading has been conducted in English, and the general findings we report in this section will be on reading English. Because the topic of this book is subtitles, we realize that our audience might be interested in characteristics of reading in other languages, as well. Therefore, at the end of this chapter there is a section illustrating the characteristics of reading in languages other than English. That being said, while the physical characteristics/anatomy of the eyes and eye movements reported above are not language specific, when measures in the immediately following section are reported, they refer to reading English.

During reading, the average saccade extends 7–9 letter spaces. Letter spaces are the appropriate metric to use, rather than visual angle, because letter spaces are more deterministic of saccade length than visual angle in reading. That is, if font size is held constant and the text is read either at a close reading distance (so that fewer characters comprise one degree of visual angle) or a far reading distance (so that more letters comprise one degree of visual angle) eye movements tend to extend the same number of characters (not the same degree of visual angle) across reading distances (Morrison, & Rayner, 1981).

Not all saccades move forward (to the right) with the direction of the text. Regressions, which comprise 10–15% of the eye movements during reading, actually move backward to previously read or skipped text. The percent of regressions depends on the difficulty of the text; more difficult texts lead to more regressive saccades. Similarly, more difficult texts lead to longer fixation durations and shorter saccades. Fixation duration, saccade length, and percent regressions — all of which are considered global measures of reading difficulty — are all clearly influenced by text difficulty. Additionally, the type of reading material and the reader's goal during reading influence these measures (Rayner, & Pollatsek, 1989).

Although global measures are important indications of processing, more often in reading research local effects related to fixation time on a specific word in a sentence are reported, rather than the average duration on all words in the text. These measures include first fixation duration (the duration of the first fixation on a word), single fixation duration (duration of the fixation on a word in cases where the word was only fixated once, not including regressive fixations), and gaze duration (the sum of all fixations on a word before moving to another word). These measures are important because global measures would only be useful if readers fixated every word and each word only once, which is clearly not the case. Many words are fixated more than once and approximately a third of the words in the text are skipped (not fixated directly) during reading. Often times these skipped words are short, very common words (such as *the, of, in, and*), although longer words that are highly predictable from prior text are also frequently skipped (Ehrlich, & Rayner, 1981; Rayner, & Well, 1996). When words are skipped, there is good reason to believe that they were processed while eyes were fixating the previous word. Conversely, the words that are refixated (fixated more than once before the eyes move to the next word) are more likely longer and less common, taking more time and more fixations to fully process the word for meaning. The above mentioned local measures are useful to estimate how long it takes to process a word (Rayner, 1998).

### 2.2. *The perceptual span across languages*

As mentioned above, foveal vision represents the area with highest acuity; as we also noted, the reason we move our eyes during reading is to place the fovea over the words we wish to process. However, there is still some processing that can be done outside the fovea and much research has been done to investigate the size of the perceptual span—also called the region of effective vision or the functional field of view—during a fixation in reading. We may have the intuition that when we read we are able to see an entire line of text (or even the entire text) quite clearly, but this intuition is wrong. Experiments using the gaze–contingent moving window paradigm (see Figure 1) introduced by McConkie and Rayner (1975; see also Rayner, & Bertera, 1979) have clearly demonstrated that readers have little or no access to information about the characters outside a relatively small window around the character which they are fixating.

In these experiments, the eyes are monitored and the text around the point of fixation is revealed (i.e. accurate information is provided within the window area), with the text outside that window replaced by other letters (typically with x's or random letters). Eye Movements are recorded as people read with windows of various sizes to determine the window size that yields reading that is equivalent to when there is no window (i.e. with all letters revealed/available). When reading is like normal with a moving window, no information would have been obtained from the letters that are masked, and the window size would thus provide a valid estimate of the perceptual span. Research using this paradigm has revealed that readers of English typically have a perceptual span comprising a region from 3–4 characters to the left of fixation and 14–15 characters to the right of fixation. If the presently fixated word and the following word are normal and the rest of the letters are replaced with other letters, readers are typically unaware that anything is strange about the text and reading is only about 10% slower than without a window. If two words to the right of the fixated word are revealed/available, reading is generally equivalent to normal. Furthermore, readers obtain no information from lines above and below the line currently being read (Pollatsek, Raney, La Gasse, & Rayner, 1993). Finally, moving mask experiments (see Figure 1) — where the fixated and immediately surrounding letters are masked and letters outside the moving mask are revealed — have demonstrated that it is very difficult (nearly impossible) to read when the fovea cannot be used to obtain information and one must rely solely on parafoveal and peripheral vision (Rayner, & Bertera, 1979; Rayner, Inhoff, Morrison, Slowiaczek, & Bertera, 1981).

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Normal line
How large is the perceptual span in reading?

Moving window paradigm (13 character window)
xxxxxxxxxxxs the perceptxxxxxxxxxxxxxxxxxxx?
                 *
xxxxxxxxxxxxxxxxxxxxceptual span xxxxxxxxxx?
                          *

Moving mask paradigm (7 character mask)
How large is the pexxxxxxxl span in reading?
                      *
How large is the perceptuaxxxxxxxin reading?
                             *
Boundary paradigm
How large is the perceptual hand in reading?
                       *
How large is the perceptual span in reading?
                             *
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**Figure 1.** Examples of a moving window (with a thirteen character window), a moving mask (with a 7 character mask), and the boundary paradigm. When the reader's eye movement crosses an invisible boundary location (the letter *l* at the end of *perceptual*), the preview word *hand* changes to the target word *span*. The asterisk represents the location of the eyes in each example.

Other research investigating how much information is obtained to the right of fixation involves another gaze–contingent display change paradigm (see Figure 1) called the boundary change paradigm (Rayner, 1975). This research has indicated that a valid preview of the upcoming word before the eyes fixate it leads to shorter fixations (by about 30–50 ms) on the word once it is looked at compared to a condition in which the preview of the word is invalid (i.e. another word, a nonword, or a random letter string in the location of the target word). This speeded processing with a valid preview compared to an invalid preview is termed *preview benefit*. This research has revealed that readers generally do not represent word information in a literal visual representation, but rather in an abstract form (McConkie, & Zola, 1979; Rayner, McConkie, & Zola, 1980). Preview benefit seems to be largely due to orthographic and phonological information (Rayner, 1998, 2009).

The perceptual span varies depending on reading skill; beginning readers (Häikiö, Bertram, Hyönä, & Niemi, 2009; Rayner, 1986) and dyslexic readers (Rayner, Murphy, Henderson, & Pollatsek, 1989) have smaller perceptual spans than more skilled readers. The smaller span is attributed to the fact that more cognitive effort is allocated to the fixated word and fewer attentional resources can be used to identify other words. The perceptual span also seems to change slightly as we age; older readers have smaller (Laubrock, Kliegl, & Engbert, 2006; Rayner, Reichle, Stroud, Williams, & Pollatsek, 2006) and less asymmetrical perceptual spans than that of younger readers (Rayner, Castelhano, & Yang, 2009).

### 2.3. *Linguistic influences on reading behavior*

Research on eye movements during reading has shown that how long the eyes remain on a word reflects the ease or difficulty with which that word is processed. The amount of time one spends fixating a word while reading is variable and can depend on many linguistic/lexical factors, such as the frequency of that word (Inhoff, & Rayner, 1986; Rayner, & Duffy, 1986), how predictable that word is (Ehrlich, & Rayner, 1981; Rayner, & Well, 1996), how many meanings that word has (Duffy, Morris, & Rayner, 1988; Sereno, O'Donnell, & Rayner, 2006), the age at which the meaning of the word was acquired (Juhasz,

& Rayner, 2003, 2006), semantic relations between the word and prior words in the sentence (Carroll, & Slowiaczek, 1986; Morris, 1994), how familiar the word is (Williams, & Morris, 2004), and so on (see Rayner, 1998, 2009 for reviews). In addition to these largely lexical variables, higher level discourse and syntactic variables also influence readers' eye fixations. For example, when readers read garden–path sentences, fixations are typically quite long (and there are also many regressions) when they encounter disambiguating information (Frazier, & Rayner, 1982; Rayner, Carlson, & Frazier, 1983; see Clifton, Staub, & Rayner, 2007; Staub, & Rayner, 2007 for extended reviews regarding discourse and syntactic influences on eye movements).

The strongest evidence in support of the claim that linguistic/lexical processing strongly influences how long readers look at words comes from what are called "disappearing text" studies. In such studies, a word either disappears or is masked shortly after (50–60 ms) it is fixated (Ishida, & Ikeda, 1989; Liversedge, Rayner, White, Vergilino–Perez, Findlay, & Kentridge, 2004; Rayner et al., 1981; Rayner, Liversedge, White, & Vergilino–Perez, 2003; Rayner, Liversedge, & White, 2006). Results from these studies show that even if the word is only present for a short amount of time (60 ms) people can read quite normally (i.e. they fixate that location for the same amount of time they would if the word had not disappeared). Furthermore, how long the eyes remain on a word once it has disappeared is highly determined by the frequency of that word, indicating quite strongly that the determining force on when to move the eyes forward during reading is the cognitive processing associated with the fixated word. Interestingly, if the following word also disappears or is masked at the same time as the fixated word it causes quite a disruption to processing (Rayner et al., 2006), indicating that the word to the right of fixation receives some processing before it is fixated and that this preprocessing is very important to normal reading.

In summary, the amount of information obtained on a given fixation during reading is limited (approximately 3–4 characters to the left and 14–15 characters to the right of fixation). Furthermore, the amount of information available for word identification is even smaller (approximately 7–8 characters to the right). The word following the fixated word is important to normal reading, as that word is processed to some extent before it is fixated (as evidenced by the preview benefit and disappearing text studies). In situations in which the following word is fully identified, that word is skipped, and the word following it is fixated. Finally, the strongest influencing factor on how long a word needs to be fixated is the ease or difficulty with which it is processed.

### 2.4. *Models of eye movements during reading*

Based on all the research that has been conducted on eye movements during reading over the past 40 years, a number of models of eye movement control in reading have been proposed, the most influential of which being the E–Z Reader model (Pollatsek, Reichle, & Rayner, 2006; Rayner, Ashby, Pollatsek, & Reichle, 2004; Rayner, Reichle, & Pollatsek, 1998; Reichle, Pollatsek, Fisher, & Rayner, 1998; Reichle, Pollatsek, & Rayner, 2006; Reichle, Rayner, & Pollatsek, 2003). For brevity, the other models will not be discussed in this chapter, but a comprehensive review can be found in a special issue of *Cognitive Systems Research* (2006, vol. 7). The E–Z Reader model is a robust model that can account for all of the previously stated data, predict fixation durations during reading, which words will be skipped, and which words will be refixated. It can accommodate both global and local measures of processing, as can most of the competing models. The currently accepted models are very similar in many ways, but differ on specific issues about how they explain certain effects. E–Z Reader happens to be very transparent and can therefore make clear predictions; when it cannot account for data it is clear *why* it can't (making necessary adjustments to the model apparent in the model itself). The model has also been able to account for data that otherwise might have proved to be enigmatic. However, it must be noted that the model does have some limitations: until recently the model did not accommodate higher order processes due to sentence parsing or discourse variables. A more recent version of the model attempts to deal with some aspects of higher order processing (see Reichle, Warren, & McConnell, 2009), but there remain aspects of higher order processing that are not dealt with. Furthermore, the assumption that lexical processing drives the eyes forward during reading is just that—an assumption. However, it is quite consistent with the results from the disappearing text studies we reviewed above. Even if it is an assumption, it is not an unreasonable one due to the fact that higher order processes generally only intervene when the processing system goes awry (see Rayner, Warren, Juhasz, & Liversedge, 2004). In summary, recent research on eye movements and reading has led to the implementation of computational models, which can closely simulate actual behavioral data of eye movements during reading.

## 2.5. *The influence of language and orthography*

Because subtitles are used to translate information (i.e. the words from a movie or TV program) from one language to another, we think it is important to consider the comparisons between different languages and orthographies with respect to reading. As mentioned previously, the majority of reading research with respect to eye movements has been conducted on English text. However, there has been much important work done on other languages, as well, and some important similarities and differences between languages arise. One must bear in mind, when comparing reading in different languages that one can often find similarities and differences between languages when considering the same measure or topic, depending on the grain of analysis. This will be discussed in detail below with respect to each topic, but the important thing to remember is that languages vary greatly on many facets, most importantly for our purposes in terms of orthography, and one must be careful with the terminology or grain of analysis one uses to compare them. A list of various eye movement metrics and comparisons across languages can be seen in Table 1.

## 2.6. *Eye movement measures across languages*

As mentioned previously, saccade lengths when reading English, are approximately 7–9 characters in length. At first glance, one would think that saccade lengths in Chinese (2 characters; Shen, 1927; Wang, 1935; Stern, 1978) and Japanese (3.5 characters; Ikeda, & Saida, 1978) are comparatively much shorter. Importantly, though, "characters" mean very different things in English (an alphabetic language for which a character constitutes a letter) and languages such as Chinese (for which a character constitutes a morpheme) and Japanese, which is made up of two orthographic systems: Kanji (comprised of mor-

| Language | Eye movement measure | | Reference |
|---|---|---|---|
| | Saccade length (characters) | | |
| English | 7–9 | | Rayner, 1978, 1998 |
| Chinese | 2 | | Shen, 1927; Wang, 1935; Stern, 1978 |
| Japanese | 3.5 | | Ikeda and Saida, 1978 |
| Hebrew | 5.5 | | Pollatsek, Bolozky, Well and Rayner, 1981 |
| | Perceptual Span (characters) | | |
| | Left | Right | |
| English | 3–4 | 14–15 | McConkie and Rayner, 1975 |
| Japanese | Not specified | 6 | Ikeda and Saida, 1978 |
| Chinese | 1 | 2–3 | Chen and Tang, 1998; Inhoff and Liu, 1998 |

**Table 1.** Eye movement measures across languages with citation references.

phemic characters) and Kana (comprised of syllabic characters). Writing systems like that of Chinese and Japanese are comprised of words with fewer characters than alphabetic languages such as English and more information is contained within a character (e.g. one morpheme or syllable, compared to one letter). Therefore, while saccades of readers of English may subtend a longer distance (in letters/characters) than those of readers of Chinese or Japanese, when considered in terms of words the saccade lengths are comparable across languages. Readers of Hebrew exhibit saccades of approximately 5.5 characters (Pollatsek, Bolozky, Well and Rayner, 1981) and although Hebrew is also an alphabetic language, it is more densely packed than English. Hebrew is written without vowels—words are shorter than those in English—and function words are clitic, meaning that they attach like affixes to other words. Therefore, although saccade length is shorter than English in terms of number of characters, it is comparable to English and other languages in terms of words, or informational content. The aforementioned data are important to show that informational density of the text determines how far the eyes move during a saccade while reading. This conjecture is corroborated by studies of English in which the difficulty of the text—and consequently the information density—is manipulated. As informational density increases, saccade length decreases (Rayner, 1998).

Similar to saccade metrics, measures of reading rate across languages are superficially different (when measured in terms of letters/characters) but in reality are very similar (when measured in terms of amount of information obtained in a given time). For example, the reading rate in Hebrew (average number of words per minute) is equivalent to that of English when based on the number of words in the English translation of the Hebrew text (Pollatsek et al., 1981). Likewise, reading rate in Chinese and Japanese is fairly equivalent to English when based on words.

Another important difference between orthographies is the direction in which the text is read. In general, the direction in which the print is read does not affect reading. For comparative studies of readers of different orthographies, all observed differences in reading speed were due to the more familiar orthography being read more easily than the less familiar one (Shen, 1927; Sun et al., 1985). Experiments that manipulate the direction in which text is read have come to a similar conclusion. Tinker (1955) found that English readers reading English text printed vertically were initially 50% slower than when they read horizontally arranged text, but improved to be only 22% slower after four weeks of practice. Similarly, Kolers (1972) found similar improvement with practice in English readers trained to read from right to left. Furthermore, beginning readers can learn to read from left to right just as easily as from right to left (Clay, 1979). There might be a physiological reason why reading horizontally might be better than reading vertically (and indeed, the majority of the world's languages have horizontal orthographies); visual acuity falls off faster in the vertical direction than in the horizontal direction. Therefore, it might be easier to identify words in the parafovea to the left and right of fixation than above and below fixation.

## 2.7. *The perceptual span across languages*

Studies using the moving window technique in different languages have found the following comparisons (see Table 1). The writing system that is most different from English is Chinese. Typically, now, Chinese is read from left to right in mainland China, although that has not always been true, historically. A number of recent studies have investigated readers reading in the horizontal direction. These studies have found that the perceptual span in Chinese extends 1 character to the left and 2–3 characters to the right of fixation (Chen, & Tang, 1998; Inhoff, & Liu, 1998). The perceptual span of Japanese (a mixture of morphemic Kanji and syllabic Kana characters) extends approximately 6 characters to the right of fixation (Ikeda, & Saida, 1978). Hebrew is read from right to left, unlike English; Pollatsek et al. (1981) found that the perceptual span of Hebrew readers was asymmetrical, containing more letters to the left of fixation than to the right. But those same readers, when reading English, had the canonical asymmetry—more letters to the right of fixation than to the left.

From these data, one might expect that the size of the perceptual span across languages is quite variable. Indeed, in terms of character spaces it is. But, again, when one considers that the amount of information contained within a given character space also varies across languages it is apparent that the perceptual span is quite similar across languages in terms of information obtained. Hebrew contains fewer letters than that of English. As mentioned above, the words in Hebrew are typically shorter than those in English, and the perceptual spans for readers of the two languages contain approximately the same number of words. Likewise, the average word in Chinese is 2 characters long (but many are 1, and some are 3–4), so in terms of words the perceptual span is probably not that different from English. Furthermore, in Japanese, when only logographic (Kanji) characters are used, the perceptual span is shorter than when mostly syllabic (Kana) characters are used (Osaka, 1987), indicating that informational density of the text modulates perceptual span. In short, although the perceptual span for readers of different languages varies in size with respect to number of characters, they are similar in terms of number of words. Furthermore, Pollatsek et al.'s (1981) data on the direction of asymmetry indicates that the perceptual span is not "hard–wired", but depends on the direction of the text being read, as shown by bilingual readers' ability to switch the direction of the asymmetry, based on the language they are reading. In short, the perceptual span is larger *ahead* of fixation than behind it.

## 3. Summary and implications for subtitle research

In this chapter we have reviewed some basic information regarding eye movements during reading. First, we reviewed the anatomical characteristics of the eyes per se and noted that there are areas of high acuity (the fovea) and relatively lower acuity (parafovea and periphery) that strongly influence what our eyes do when we read. We also reviewed the two main characteristics of eye movements: saccades (the actual movements of the eyes) and fixations (the period of time when the eyes are relatively stable) and we discussed various measures of eye movements: global measures (such as saccade length and reading speed measured in words per minute) and local measures (such as first fixation duration, single fixation duration, and gaze duration). We also provided an overview of research on the size of the perceptual span—the area of the text from which useful information is obtained—and how it is measured (e.g. gaze contingent display change and disappearing text experiments). Then we discussed how linguistic factors of the text (for example, word length, frequency, polysemy, predictability, age of acquisition, familiarity, and semantic relations) influence eye movements during reading. We then briefly reviewed models of eye movements during reading, focusing on the E–Z Reader model. In the last section of the chapter we addressed similarities and differences between eye movements during reading languages of different orthographies. Particularly, eye movements seem to differ greatly depending on orthography, but when considering the information obtained on a given fixation or saccade size based on number of words, they are very similar.

It is obviously important, when talking about reading in any context — including reading subtitles — to understand how the eyes work and what the mind is doing as one reads. In this chapter we have provided some background information regarding eye movements in reading. But, it is also the case that more work is needed to fully understand how people shift their attention and eye location when reading subtitles (d'Ydewalle, & De Bruycker, 2007). Research on how people look at advertisements (Pieters, Wedel, & Liechty, 2008; Rayner, Miller, & Rotello, 2008; Rayner, Rotello, Stewart, Keir, & Duffy, 2001) is quite interesting in the context of examining how viewers alternate their attention between pictorial and written information. This research indicates that the strategy of the viewer and their goal very much influence where they look. Like research on eye movements when examining advertisements, research on eye movements when viewing a movie/TV program with subtitles would seem to provide useful information regarding how people integrate information across different channels and how parallel/serial processing comes into play as they deal with a complex stimulus array.

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