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Hibaészlelés angol nyelven történő olvasás során: Egy szemmozgás követéses vizsgálat

Error detection in reading in English: An eye-tracking investigation

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CERTIFICATE OF RESEARCH

By my signature below, I certify that my ELTE MA thesis, entitled *Error detection in reading in English: An eye-tracking investigation* is entirely the result of my own work, and that no degree has previously been conferred upon me for this work. In my thesis, I have cited all the sources (printed, electronic, or oral) I have used faithfully and have always indicated their origin. The electronic version of my thesis (in PDF Format) is a true representation (identical copy) of this printed version. If this pledge is found to be false, I realise that I will be subject to penalties up to and including the forfeiture of the degree earned by my thesis.

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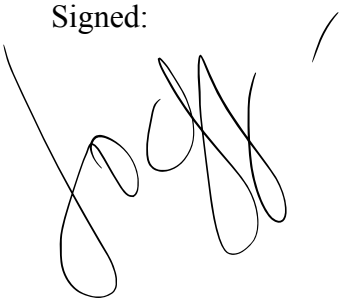

Abstract

This paper presents a quantitative analysis of reading processes in L2 with the help of an eye-tracker, and error detection in reading as methodological tools of research. It aimed at uncovering features of reading in L2 in terms of reading time, duration of fixations, and the total number of fixations. At the beginning of the work, I underlined the importance of several theories of reading as well as reading comprehension in L2. The paper also presented the theoretical background of eye tracking and error detection in reading. The participants of the study were 20 international university students studying in Hungary with a proficiency in English ranging between B2 and C2. The readers were presented with three texts to measure their reading performance, the standard text, a text with spelling mistakes, and a text with transpositions. Findings indicated that the content of the texts did not have a significant influence on participants' reading performance, nor did the order of the texts. However, there were significant changes in total reading time, total duration of fixations, and the total number of fixations after the mistakes were introduced in the texts.

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Introduction

Reading is one of the four language skills that plays a major role in language use and language literacy. It is critical for the process of L2 learning as it provides essential input to the L2 acquisition. Reading is also an important tool for language teaching and may be investigated for educational purposes. By shedding light on the reading problems, it becomes possible to avoid methodological mistakes in the process of teaching. Therefore, it seems highly appealing to observe texts and reading phenomena through psycholinguistic methodological tools such as Eye-Tracking (ET) to gain useful insights into the L2 reading process.

Based on several theories of reading (Goodman, 1967; Rumelhart, 1977; Smith, 1971), this study builds up the theoretical background establishing a profound connection between psychological processes involved in reading comprehension and reading performance. The research considers top-down (Goodman, 1967; Smith, 1971) and bottom-up (Gough, 1972) approaches, a mixture of those theories provided by Rumelhart (1977) who proposed an interactive model of reading, schema theory (Rummelhart, 1980) as well as cognitive theory (Forrest-Presley and Waller, 1984).

It is also crucial to highlight the theoretical background of the ET methodology since it is widely utilised for research in applied linguistics, and psycholinguistics in particular (Bisson, Van Heuven, Conklin & Tunney, 2014; Dussias, 2010; Foucart and Frenck-Mestre, 2012; Godfroid, 2019; Kaushanskaya and Marian, 2007; Roberts and Siyanova-Chanturia, 2013; Winke, Gass & Sydorenko, 2013). It allows researchers to record eye movement to track the attention span through fixation time (eye-resting position), saccades and regressions (forward or backward moves) simultaneously with the language use while providing insights into language learners' cognitive processes. ET is efficient in various fields of investigation from failure to notice word transposition in reading (Huang and Staub, 2021), predicting

phonology in language comprehension (Li, Li & Qu, 2022) to translation studies (Schaeffer, Nitzke, Tardel, Oster, Gutermuth & Hansen-Schirra, 2019).

This study will also look at different experiments revolving around text comprehension and failure to notice mistakes in texts. Gough and Wren (1999) investigated readers' ability to detect and process spelling mistakes in a text via SPR, reporting a slower reading pace for incorrect sentences. A more recent study conducted by Mirault, Snell, and Grainger (2018) reported students' tendency to judge ungrammatical sentences as grammatical when two short words were transpositioned. An investigation by Huang and Staub (2021) brought another dimension to the picture as they successfully used the ET method to support the idea that the process of word recognition had a serial character. Subsequently, it is possible to indicate a gap between the investigation of the reading speed of correct/incorrect sentences and the subconscious ability to notice those mistakes measured by the eye-tracker.

This research aims to apply a multidimensional analysis of reading and get a more in-depth understanding of L2 reading processes. By utilising a psycholinguistic tool of research and complementary visual data, it will be possible to uncover the peculiarities of reading comprehension and cognitive processes involved in reading and analysing the text in English. It is also the aim of the study to explore whether the introduction of various types of mistakes influences the reading performance of the participants in terms of several indicators, namely the total reading time, duration of fixations, and the total number of fixations on the text.

To fulfil the aim of the study, this paper presents several parts. The review of the literature provides an overview of reading theories, theories of eye-tracking in research, cognitive processes in reading and error detection. In the Method section, the chosen design, its justification, experimental procedures are clearly outlined to aid the reader in full

understanding of the tools and approaches used in the current investigation. The Results and Discussion section presents the results of the data analysis and consideration of the findings. Finally, in the Conclusion, the paper summarises the main discoveries in answer to the research questions and discusses the limitations and possible directions of future research in the field of psycholinguistics.

Review of Literature

Reading and reading comprehension models

Reading

As it was stated earlier, this paper is concentrated on the notion of reading and reading comprehension. In order to broaden the theoretical base of both, it was decided to consider some of the approaches towards the definition of reading. Bloome (1985) refers to the process of reading as a social phenomenon and suggests that "reading involves social relationships among people" (p. 134) including authors and readers themselves. The author also describes reading as a cultural activity and a socio-cognitive process. In this social paradigm, reading may play a crucial role and be one of the main tools of socialisation. This definition correlates with the current research in a way reading influences the cognitive and psychological aspects of life.

In the same year, 1985, Anderson et al. proposed another direction of defining reading as "the process of constructing meaning from written texts" (p. 7) shifting the social paradigm suggested by Bloome (1985) towards a more self-directed, personal nature. Now, reading is not something that is shared and used as a tool of socialisation, it is a personal and self-directed experience as the readers infer the message from the text themselves and build a cognitive model based on their perspective. By implying the textual, or textural, aspect of reading, Anderson suggests a structuralist approach towards reading and underlines the

importance of the text that implies the meaning. In the frame of this investigation, such a notion correlates with a certain type of reading comprehension, namely the bottom-up approach that will be reviewed later in the work.

However, just before the debate between social and personal, Walcut (1967) provides three definitions of reading. One of the definitions is “decoding the printed visual symbol into a spoken sound, which it designates” or as he further states “turning writing into language” (p. 363-364). He also suggests that reading has a functional property by pointing out that readers can actually read yet miss the meaning of the text. Finally, according to Walcut, reading is a source of intellectual enrichment and personal development. Walcut’s paradigm of defining reading three ways is a good example of how diverse the notion may be; however, his approach seems to mirror some of the ideas proposed later in the development of psycholinguistic research in the field of reading and bottom-up reading comprehension proposed by Gough (1972).

In a more recent paradigm, Grabe (2014) suggests that reading should be defined by the ability of the reader to use such skills as vocabulary recognition and other cognitive abilities. Such a definition proposes the idea of a great influence of the level of cognitive abilities on the reader, that, in the realm of this research, may be measured by such a psycholinguistic tool as eye-tracking.

Reading comprehension

Following the definition of reading, reading comprehension is another important aspect that must be reviewed in the paper. Top-down and bottom-up theories contradict each other and yet cannot exist independently. Interactive and metacognitive models of reading comprehension have also been established in the course of theoretical development. Schema theory has introduced another approach towards reading yet a very similar to the top-down approach. Those theories will be thoroughly explored in the current chapter.

Top-Down model. Starting with the Top-Down theory introduced by Goodman (1967) and Smith (1971), we can analyse the approach towards reading and the role that the text plays in reading comprehension. According to their theory, the reader brings meaning to the text by exploiting their experience and background as "if there is no category to which we can relate an object to which we are exposed, we can make no decision at all" (Smith, 2004, p. 18). The role of experience and prior knowledge of the reader becomes obvious when one understands the importance of a cognitive representation affecting the understanding of the visual, and textual domain. In other words, it would not be possible to understand the text without any mental representations of notions depicted in it. For the current work, it is essential to build the connection between the text and the reader's background to check whether it has any influence on noticing the mistakes in the text. Does the reader notice the mistake in the text when they bring their knowledge to understand it and do they not rely on the textual realm?

Smith (2004) also proceeds to uncover the importance of the background knowledge appealing to long-term memory and underlining its role in text understanding by saying that "long-term memory is our permanent source of understanding the world" (p. 13). According to this concept, long-term memory or storage of our experience helps us understand the message the text puts across. Moreover, he suggests that the language itself is the background knowledge that is brought by the reader into the process of reading comprehension.

Goodman (1967) saw the process of reading as a very complicated process that "involves an interaction between thought and language" (p. 127) and approached the notion of reading comprehension as something requiring previous expertise and background knowledge. According to Goodman, the reader is going to select and understand the information in the text relying on the cognitive structure that matches the text. In other words, the reader sees only what they want or think they need to see. Goodman also suggests an

example using the focus point of the reader's eyes calling it an " "end of the nose" view" (p. 131) and pointing out that it would not be possible to maintain a high reading speed and receive the meaning simultaneously. Otherwise, it would be impossible to analyse every character and, consequently, every word to infer the meaning of the text. In terms of current research, it may indicate that bringing readers' cognitive structures into the reading process would distort their attention and they naturally would never notice any mistakes, however, it may quantitatively influence their reading performance.

Bottom-Up model. Another important theory contradicting the previously mentioned approach is called the Bottom-Up model proposed by Gough (1972). Gough and Hillinger (1980) describe the connection between the input in the form of the written word and the meaning the reader infers from this physical input. The information flow starts with phoneme recognition, then the morpheme, the word etc., and makes its way up to the higher cognitive processes leaving the meaning or association in the memory. Gough and Hillinger take a child learning to read as an example and underline the importance of the phonetic familiarity of the word. They confirmed that a child knows a sound form but is yet to know the written one. By learning to read, this child pairs the written input with a certain association and later while seeing the same item, they will extract the meaning from the memory. They also provide an argument that without knowing the letters, it is impossible to infer the meaning as there is nothing to decode.

Taking into consideration a beginner reader, Gough and Hillinger (1980) predict that the visual properties of a word make it easier for a child to understand and remember, i.e. if the font of the word is already familiar to the child, they remember it better. Their selectional hypothesis proposes that misreading words at the beginning of learning to read is normal. Gough and Hillinger suggest that it is normal for a child to make mistakes in one situation and read a word correctly in another. It supports the idea of the selectional hypothesis as the

reader matches some of the attributes of the word with the mental representation stored in their memory. They finally provided evidence in support of the theory by pointing out the diverse nature of cues chosen by a child for word recognition, i.e. that the child may choose the first letter or the last, or even the middle of the word to decode its meaning.

LaBerge and Samuels (1974) also propose the model of automaticity in reading that utilises the same principles as the Bottom-Up approach proposed by Gough (1972). In their theory, LaBerge and Samuels argue that the most important aspect of the theory is the physical visual stimulus that needs attention to be decoded. They connect the phonological system and the visual representation of the word in order to analyse the reading comprehension and the information flow of the reader. LaBerge and Samuels consider the word form to support the view that it is the word-to-meaning or text-to-meaning flow rather than background knowledge brought to the picture as it was in the Top-Bottom approach.

In the light of the current investigation, the bottom-up hypothesis may indicate that the error deliberately occurring in the word or a sentence might be noticed by the reader, however, it would not affect the general understanding of the text at all, as the meaning is traced back from the memory in any case.

Interactive model. Based on the previously mentioned theories that were relatively straightforward in terms of information flow, it is essential to note the model that blends them and proposes another direction in reading comprehension. Rumelhart (1977) criticises the bottom-up approach by saying that “results [of the previous theories] are very difficult to incorporate in a processing model that assumes that information flows strictly from lower to higher levels” (p. 723). First of all, he underlines the role the surrounding letters play in the distortion of reading comprehension. Secondly, Rumelhart draws his attention to the syntactic and semantic environment during reading comprehension. Finally, he suggests that the context, general and semantic, influences the interpretation of the meaning that we infer from

the text. Based on the evidence brought by Rumelhart against the bottom-up model, the researcher proposes his interactive model of reading comprehension.

Rumelhart (1977) suggests that “the reading process is the product of the simultaneous joint application of all the knowledge sources” (p. 732) and outlines the following information flow. The visual input is stored in the visual information store and is processed via an extraction device that takes into consideration various properties and characteristics of the written input. These features are analysed through the pattern synthesiser which includes nonsensory linguistic information such as semantics, lexical possibilities, context. This part of the information processing produces the most probable interpretation based on the strings it has produced earlier and the visual information it has stored. According to the interactive model of reading, the pattern synthesiser is the most important part of the whole information flow, and it holds the essence of the whole theory.

In agreement with the interactive model of reading, this approach is neither a top-bottom nor a bottom-up one as it combines the two theories and converts the information in the middle of the whole processing “machine” in an interactive manner. Moreover, this model makes the most of each theory and produces a new paradigm in the understanding of the reading process and, thus, contributes to the development of new directions in the field of reading comprehension.

In terms of the current research, such a model may indicate two things. On the one hand, if the reader fails to notice a mistake in the text, it may mean that the visual input was processed as if it was correct even though it was clearly incorrect. Consequently, the pattern synthesiser recognises a word or a phrase and allows the strings of possible meanings to occur in the reader’s mind. On the other hand, if the reader notices an error, the synthesiser does not reveal any strings of available interpretations, or has fewer interpretations, which slows down the comprehension of the text, and, therefore, the reader has to trace back to

make sure they understood the word or to wind up the synthesiser again to finally decode the meaning. This may also be indicated by the increase in reading time and other quantitative variables mentioned in the introduction to the present research.

Schema theory. After proposing his interactive model, Rumelhart (1980) puts forward another additional direction and introduces schema theory to the picture of reading comprehension. The essence of the approach lies in the definition of schema and its implications in the process of reading. Rumelhart (1980) defines schema as "a data structure for representing the genetic concepts stored in memory" (p. 34) that eventually plays a crucial role in decoding the message of the text. For example, Reynolds et al. (1982) proved that cultural schemata may greatly influence reading comprehension as different cultures interpret a text in a different manner when it comes to racial differences. This experiment illustrated the importance of cultural schemata in the reading process.

Brown (2001) underlined the importance of schemata by downplaying the role of visual stimuli such as text in reading comprehension. He suggested that a text does not have any meaning on its own, the message and the essence of a piece of text may only be uncovered by bringing the external reader's knowledge of the topic or the discourse structure. Brown describes content schemata as knowledge about the world while formal schemata as one helping us understand the discourse and its form and function.

As the current research proposes, failures to notice mistakes in the text may be supported by the vast number of schemata which help in grasping the message of the text without even paying attention to the words. It may also indicate a faster reading speed that allows the reader to skip some of the items in the text as they do not play a crucial role in the direct understanding of the text. Although the top-down approach and schema theory have some similarities, I decided to employ the theoretical basis of the latter and look at its application to reading comprehension. There are several reasons to do so. Firstly, the

resemblance of the top-bottom approach and the schema theory provides a wider angle helping to look deeper into the theoretical background. Secondly, it is important to cover the steps of theoretical development in the field of reading comprehension as it broadens the perspective used in the analytical investigation. Finally, schema theory was also considered as a part of the review of literature in the frame of the current investigation as a complementary base in support of the cognitive influence on reading comprehension. In addition, the schema theory is amongst the leading theories of reading comprehension that shall receive due attention.

Cognitive theory. According to Forrest-Pressley and Waller (1984) "reading is more than just decoding symbols" (p. 34). They believe that reading requires certain cognitive skills and efforts in order to establish an understanding of the text. They also underline that adult readers or skilled readers have "automatic" reading comprehension meaning that it takes less time to decode the information for a more experienced reader than for a poorer one. Forrest-Pressley and Waller also add that cognitive performance greatly changes when the context introduces the purpose of reading. Rothkopf and Billington (1975) conducted an experiment proving that a reader's performance changes according to the existence of the goal of reading, i.e. the reader is going to perform better when there is a clear goal for the reading. For instance, analysing a long text is easier and more effective when only looking for a certain piece of information.

Subsequently, Myers and Paris (1978) introduced evidence in support of metacognitive processes in reading by suggesting that senior readers know more about their reading behaviour and factors that affect their reading performance. In the frame of this research, it is possible that once a reader notices a mistake, they will always be looking for another in a forthcoming text. In addition, the level of English (L2) and academic track such as linguistics may also be reflected in the performance of the sample. Some of the

participants may be more attentive to details and be prepared to notice a mistake as they have more background and experience in the field of language.

L2 reading comprehension

There are different theoretical directions regarding L2 reading performance and comprehension. Some researchers claimed that L1 reading comprehension is transferred to the L2 process and therefore is crucial in L2 reading comprehension (Coady, 1979; Hudson, 1982). Others advocate for a different approach that highlights the "threshold" that a reader has to overcome to be successful in L2 reading. For example, Cummins (1979) proposed the idea that bilinguals can only become successful cognitively and academically if "a child has attained a certain minimum or threshold level of competence in a second language" (p. 229). Lee and Schallert (1997) also suggested that there are restrictions that do not allow the reader to fully interact with the L2 text unless their L2 proficiency is of a sufficient level. This indicates the importance of the L2 proficiency level in L2 reading comprehension and supports the idea of proficiency threshold.

Carrel (1991) suggested that "first language reading ability and proficiency in the second language – may be significant in second language reading" (p. 168) and added that other environmental factors may influence L2 reading. Guo and Roehrig (2011) explored the connection between L2 knowledge and general knowledge and L2 reading comprehension. They used native Chinese participants learning English to uncover the influence of several types of knowledge on reading performance. They, subsequently, proved that L2 vocabulary and metacognitive awareness greatly affect the process of reading. They also concluded that "well-developed general knowledge of reading strategies cannot compensate for lack of L2 language proficiency" (p. 59). Moreover, they appealed to the "threshold theory" proposed by Alderson (1984), a theory that states that it is impossible to transfer general reading knowledge to the L2 reading comprehension if the L2 knowledge is below the threshold. It

means that regardless of the L1 reading abilities, the same reading comprehension is inaccessible to those below the threshold in English as L2. The current investigation is trying to take into consideration the theories proposed above and look at the problem of L2 reading comprehension in more detail as well as attempting to shed light on certain aspects of reading performance in L2.

Error detection in reading

The current research is also going to address the theoretical issues behind the error detection process in reading and underline the gap in the literature that will be fulfilled by this investigation. For instance, Winograd and Johnston (1982) simply defined the methodological tool of error detection in reading as tasks that "usually involve reading (or listening to) a passage in which an error was embedded" (p. 62). The same methodology is used in the present research in the form of spelling errors and word transpositions in text.

Winograd and Johnston (1982) hypothesised that less skilled readers would facilitate their reading comprehension performance if they were presented with the schema to understand the passage (even if the passage has errors in it). According to the researchers, the textual input and introduced schema shall work together creating integrity and helping produce a smooth reading comprehension. Introduced schema creates expectations that connect with the text while reading and "when the incoming information fails to conform to these expectations, the monitoring processes signal trouble" (p. 63). It means that schemata can help fill in the gaps created by errors and assist the process of reading comprehension.

Winograd and Johnston (1982) used an error detection task to analyse readers' performance and outlined several outcomes. They did not report seeing any improvement in reading comprehension amongst junior readers after introducing schemata for the erroneous text. Their investigation underlined that although more experienced readers performed better, only 18% of the junior ones noticed the mistakes.

Vosniadou, Pearson, and Rogers (1988) conducted two experiments in order to provide evidence in support of the connection between schemata and reading comprehension via error detection task. They presented three types of inconsistencies: falsehoods (a fact in the text contradicting the general truth), factual contradictions (conflicting items within one text while one of them is a known fact), and textual contradictions (conflicting items within one text while neither of them is a known fact). Consequently, they proved that there is a difference between comparing existing schemata with the text and knowledge stored in the short-term memory with the same text. They reported that falsehoods were not easier to identify compared to the factual contradictions, but it was so if the falsehoods were compared to the textual contradictions. That may indicate a higher possibility of easier falsehood detection due to the present reader's schemata.

Gough and Wren (1999) conducted several experiments using the self-paced reading tool of investigation to uncover that the reading time increases with the introduction of errors in the text. This tool helps researchers measure the reading time by letting the participants press a key after they start/finish reading and checking the reaction time. Gough and Wren found out that the construction of the meaning is hindered by the presence of mistakes even though those mistakes were not noticed at all. That may indicate the malfunction of the pattern synthesiser proposed by Rumelhart (1977) and its inability to produce strings of meaning with the same speed as if the text did not have any mistakes. I also underline the importance of word decoding in the reading comprehension process and see the phenomena as a collaboration of decoding and comprehension. This investigation is going to utilise another methodological tool and three different factors to look at the actual changes in figures in connection to the reading comprehension of texts with mistakes.

While Gough and Wren (1999) worked with spelling errors, Mirault, Snell and Grainger (2018) attempted to shed light on the problem of noticing and comprehending

transpositions in the text. According to the researchers, readers tend to judge a sentence as grammatical even though some of the words switched places. However, three years later, Huang and Staub (2021) continued investigating the issue and found out that the key detail in the outcome of the experiment was the fact that only the transposition of two short words could be left unnoticed by the reader. They also concluded that the subjects reported noticing the mistakes only when they judged the sentence to be ungrammatical, in other cases the mistakes were unnoticed and the sentences were perceived as grammatical even though it was not always true.

Eye-Tracking as a research tool

Along with such methodological tools as interviews, error detection tasks, and think-aloud protocols, researchers employ various instruments to collect and analyse data. Thanks to technological progress in the field of academia, scientists have access to such a tool as eye-tracking, helping them delve deeper into the cognitive processes of their subjects of investigation. This research utilises a top-notch device to pierce into the essence of reading comprehension.

As eye-tracking as a tool of investigation has become popular (Bisson, Van Heuven, Conklin & Tunney, 2014; Dussias, 2010; Foucart and Frenck-Mestre, 2012; Godfroid, 2019; Huang and Staub, 2021; Kaushanskaya and Marian, 2007; Li, Li & Qu, 2022; Roberts and Siyanova-Chanturia, 2013; Schaeffer, Nitzke, Tardel, Oster, Gutermuth & Hansen-Schirra, 2019; Winke, Gass & Sydorenko, 2013), the common general understanding of such an instrument is required to be able to conduct sufficient and correctly executed experiments.

Rayner (1978, 1998) gives a very detailed description of the processes involved in eye-tracking. Firstly, the eye movement that brings another area into vision is called a saccade. In silent reading a saccade usually takes 30 ms and covers 8 characters in length (6 characters in oral reading), meaning that the eye moves over 8 characters. In visual scenes

such as pictures and videos, the time taken by the eye to move to another area is longer, it is 40–50 ms. Fixations, in contrast, are the pauses or stops that the eye makes between saccades. In silent reading, it takes 225 ms on average while in oral reading it is 275 ms. When a subject is presented with a visual scene, the fixation may be increased to 330 ms. Another important characteristic of eye movement is regression. It is a backward motion of the eye which constitutes 10-15% of the whole reading time amongst skilled readers. The presence of regressions may indicate several things, comprehension problems may be one of them. Rayner also points out that sometimes saccades may cover from 2 to 18 or more characters and fixations may be 100-500 ms in length.

Pickering et al. (2004) listed two possible assumptions for the existence of fixations. First, the longer the fixation, the more cognitive effort is required to process the piece of information in question. Second, fixation means consideration, i.e. fixation depicts attention put into the decoding of an item. The paradigm allows me to analyse the attention and cognitive processes involved in reading comprehension and, consequently, in error detection.

Conklin and Pellicer-Sanchez (2016) underlined the advantages of using eye-tracking in psycholinguistic research saying “because eye movements are a natural part of reading and viewing, eye-tracking can be done without secondary tasks (e.g. a button press in self-paced reading) that are often subject to strategic effects.” (p. 3). This fact greatly contributes to the convenience and stealth while collecting data especially when the eye trackers become more and more compact. Conklin and Pellice-Sanchez also accentuate the richness of the data collected by the eye-tracker. Such machines may collect precise data that describes the eye movement in ms and with razor-blade precision. It allows scientists to analyse eye behaviour within the frame of just one word.

The data collected by the eye-tracker shall be analysed with the presence of the Region (Area) Of Interest (ROI/AOI). According to Conklin and Pellice-Sanchez (2016)

"number of fixations in a region of interest … are reported as counts, the duration of fixations that calculate the amount of time spent in an ROI, and the likelihood or probability of fixating an ROI" (p. 3). They also indicate that the data may be divided into "early" and "late" measures. By "early" measures the researchers understand the initial cognitive process of word recognition and first fixation duration, while "late" measures are represented by regressions, fixation count, and total reading time. Late measures indicate possible problems in reading comprehension. Rayner et al. (2006) also reported that short regressions may simply indicate a false shooting (accidentally missing a letter/word because of an unintentional shift in gaze direction) of a word and not additional comprehension problems that may be illustrated by the presence of much less frequent regressions.

As a conclusion of the review of the literature, it is essential to say that the current research aims to proceed with the investigation based on the theoretical background introduced in this chapter. In order to address issues in reading comprehension, it was crucial to introduce models of reading in English and explain the process of reading and its mechanics. Error detection was also outlined as a methodological tool to shed light on the research conducted within the field of reading and error detection. Finally, the eye-tracking paradigm of research received due attention as it has a complex nature as a psycholinguistic tool of investigation. All three parts of the theoretical framework build strong support for the present investigation.

Method

Design

This investigation utilises quantitative data collection and analysis as it is the most suitable direction of the analysis aiming at uncovering particular characteristics of the reader's subconscious behaviour and shedding light on the peculiarities of reading

performance such as reading time, total duration of fixations, and a total number of fixations. As Dörnyei (2007) points out that "in quantitative research, there are explicitly specified procedures both for data analysis and data collection that leave little need for methodological self-reflection" (p. 23), it is logical to appeal to the quantitative paradigm when conducting an experiment requiring an analysis of numerical data collected within a physical realm of text and the physiological realm of human eyes and gaze direction. Moreover, quantitative data analysis will help find the mean values for several participants in such aspects as reading time, fixation duration, and the total number of fixations and report generalisable findings.

The current investigation presents three research questions connected to the nature of reading as a process and some aspects of reading comprehension. The following questions were formulated:

1. Did the content significantly influence readers' performance when they encountered errors in the text?
2. Did the order of the presented texts have any significant influence on the reading performance?
3. Is there a significant change in total reading time, total duration of fixations, and total number of fixations with the introduction of mistakes in the text?

Participants

The participants of the current investigation were 20 university students from well-known universities in Hungary within the 19-27 age range. All students had an Upper-Intermediate level of English or higher (B2 – C2 according to the CEFR) either supported by self-report or by referring to their latest IELTS exam results, and they used their language skills in academic life. The participants had different educational and language backgrounds as the group included international and native Hungarian students (Arabic = 6;

Hungarian = 6; Russian = 5; Chechen = 1; Romanian = 1; Urdu = 1) undertaking a variety of academic courses (starting from BA to MA to Teacher Training).

Procedures involved in sample collection included convenience sampling, or as Dörnyei (2007) puts it “partially purposeful” (p. 99), and snowball sampling. Participants were selected based on their level of English, their student status and their availability to take part in an eye-tracking experiment. The participants were recruited through social media and personally, as well as situationally meaning that some of the participants were found in the course of the data collection process. All members were reminded that their participation was totally voluntary to comply with the ethical rules of the data collection. They were also informed that their names would not be disclosed.

Materials

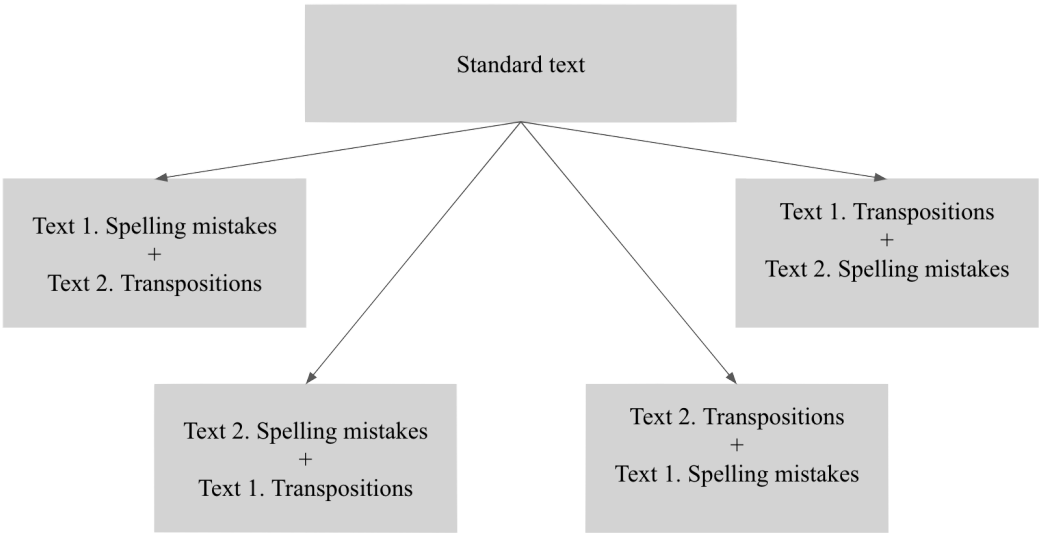
The current investigation utilised the materials presented by Goodman (1996) who modified a text that included 6 embedded mistakes called “The Boat in the Basement”. This text has been in use amongst different researchers for many years (Hung, 2019; Kim, Goodman, Xu, Gollasch, 2020; Stice, Bertrand & Manning, 2007; Xu, 2012). The current investigation used the text as a standard for reading time measurements, hence there are no errors in it.

In reference to the text proposed by Goodman (1996), this investigation came up with two additional texts with the same number of mistakes but different in their content. The first approach was a spelling approach, i.e., the text was modified in a way to have only spelling errors. The other text (its error paradigm) took inspiration from the study conducted by Mirault et al. (2018). This text had transpositioned words in it. Thus, each reader was presented with three texts: a standard text, a text with spelling mistakes, and a text with word transpositions.

Each participant was presented with three texts but in a different order meaning that each newly created text was modified twice to have spelling errors and transpositioned words. All participants read the standard text first, then two-quarters of the sample read a text with spelling errors (two different texts with the same error paradigm) and only after a text with transpositioned words (again, two different texts with the same error paradigm) while the other two-quarters read the same texts but in a reversed order. This helped create a homogeneous distribution of the input across the whole sample. A detailed explanation of the design is given in Figure 1 below.

Figure 1

Design of the experiment



In terms of text readability, each passage had the same range of 1-2 according to the Automated Readability Index developed by Senter and Smith (1967), meaning that kindergarten and first-grade pupils could fully understand them. Moreover, the texts had the same number of lines and were syntactically similar, i.e. had the same word order in each sentence. The standard text, texts 1 and 2 and their variations can be observed in Appendix A and B, respectively.

Data collection

Preparation for the experiment

Prior to the actual experiment, all texts and their variations were put into Tobii Pro AB (2014) software in the Design mode. There were four timelines hence four groups of participants in the forthcoming experiment. The names of the timelines were the following: 1S+2T, 2S+1T, 1T+2S, and 2T+1S where S stands for a text with spelling mistakes and T stands for a text with word transpositions; 1 stands for text 1 and 2 stands for text 2 that may be observed in Appendix A and B. For a clearer understanding of the presented text order, it was decided to assign numbers to the texts created on the basis of the standard one written by Goodman (1996).

Each timeline had 10 slides excluding the calibration procedure, three of them were slides with focus points helping to concentrate the gaze on the particular point to start calculating the visits of the Area of Interest and fixation duration and the number of visits of the AOI. There were also four slides with questions to check readers' comprehension and keep them engaged: What was the text about? What was this text about? What was the text about? Did you notice anything strange in the texts while reading?

Before the experiment started, each participant was assigned a timeline. Each timeline indicated what kind of text they would read content-wise, what type of mistakes they would see and in what order. The distribution of participants in numbers and percentages may be observed in Table 1 below.

Table 1

Distribution of the texts among participants

Name of the Timeline	n	%
1S+2T	6	30
2S+1T	5	25

Name of the Timeline	n	%
1T+2S	3	15
2T+1S	6	30

Note. The total number of participants is 20.

Experiment

All participants were invited to a classroom in an allocated timeslot of 30 minutes. They were asked to sit in front of a laptop with the eye-tracker attached to it and place themselves comfortably at a distance of not more than 60 cm from the screen so that they could stay in the frame of the eye-tracking sensors. They were also asked not to wave their hands in front of their faces to allow the sensors to fully capture their eye movements. It was important that the participants were in a relaxed environment and took a comfortable position to have an experience similar to a real reading exercise and leave with a good impression after the experiment.

After preparing the physical setting, participants were given specific instructions. They had to read three texts and answer a simple comprehension question after each text. They also had to push the “space” button to open the next slide with the next text or a question. They were asked to answer comprehension questions with a sentence or two, orally. After giving a short answer, they could move to the next slide. The participants were also aware of the focus point prepared for them beforehand. Following the last question about whether they noticed anything strange in the texts while reading, the participants were instructed to answer fully and press the button to finish the recording of their eye movements.

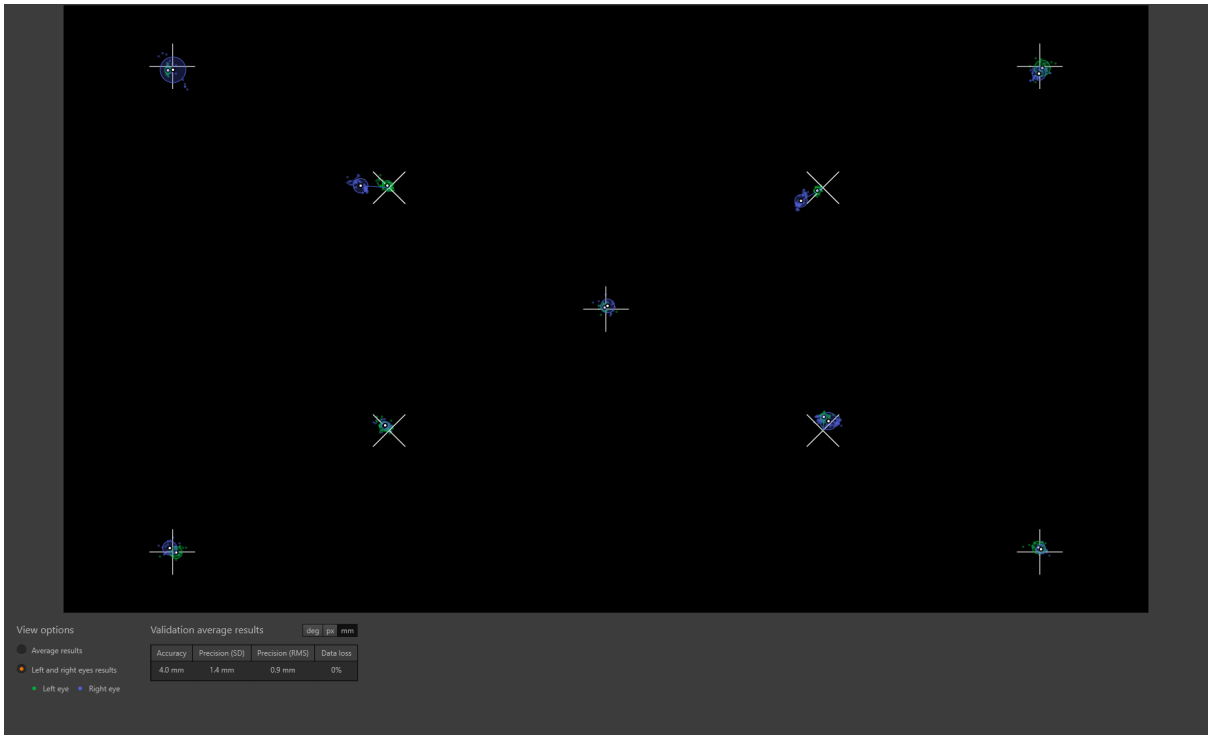
Interestingly, the participants were engaged in the actual experiment, so it was decided to show them their collected data. Each reader was shown their own recordings in order to make them aware of their own eye movements and let them read the texts one more time. Having seen the footage of the eye movements and their reading performance, participants were prone to self-reflect and shared their thoughts with me. In the scope of the

current research, it is, unfortunately, not possible to dive into the retrospective interviews and triangulate the data analysis with the help of interview data; thus, this shortcoming can be considered a limitation of this study.

It is also important to mention that the recording of each participant's eye movements started with a calibration process. It was important for my purposes that the data loss was minimal, hence the calibration went on if the data loss was more than 6%. The calibration results of one of the participants exported from Tobii Pro AB (2014) may be observed in Figure 2 below as an example of how the final calibration looked like.

Figure 2

Calibration results of one participant



Post-experimental procedures

In order to retrieve the data from the software, certain actions had to be taken. First of all, it was crucial to assign particular AOIs in the Tobii Pro AB (2014) software using the AOI tool. The AOIs were automatically detected by the program. Since there were four

different timelines and 20 participants, the data was very saturated and manual intervention in the data consolidation process was inevitable, i.e. four timelines yielded four different sets of data that were not compiled into one set, therefore, it was necessary to merge four sets of data into one array to be able to analyse it. After assigning all AOIs for each text in each timeline and participant, the researcher exported the data via the Metrics function in the Analyze folder.

Three types of metrics were exported. Firstly, the total duration of visits of the AOIs. This indicator demonstrates the actual reading time or simply how much time a participant looked directly at the text reading and rereading it. Secondly, the total duration of fixations on the AOIs was also exported, which helped measure a summative duration time of all fixations that happened in the AOIs. Thirdly, the total fixation count on the AOIs indicated the total number of fixations on the text with and without mistakes.

Data analysis

The data collected with the help of the Tobii Pro AB (2014) software was scattered over 20 recordings divided into four timelines and was put into the SPSS Version 29 for analysis. The first three variables were the total reading time for the standard text, the texts with spelling mistakes, and the texts with transpositions. In the case of the present research, the total reading time was equal to the total duration of visits of the AOIs. Moreover, there were a number of additional variables: the total fixation duration on the AOI and the total number of fixations on the AOI were also used for the texts with different types of mistakes in them.

Additionally, the order variable was added to the list of variables for me to be able to check whether it had any effect on reading comprehension. It was indicated which text, content-wise, the participants read first regardless of the type of mistakes they presented. For example, if a participant read text 1 with spelling mistakes and text 2 with transpositions,

then the variable called TextSpelling received number 1 and the variable named TextTranspositions received number 2 and so on to denote their order.

Several tests were run to analyse the data and draw conclusions about the research questions. Independent samples t-tests were run in order to check whether the texts with different content containing the same type of mistakes were comparable. The same kinds of tests helped establish whether order effects could be observed in the case of texts containing spelling mistakes or transpositions. Finally, repeated measures Analyses of Variance (ANOVA) were used to compare students' performance across the three different texts they read. These were complemented with post hoc Bonferroni analyses to determine differences between groups.

Furthermore, complementary visual data will be presented as a piece of supporting evidence. The visual data in the form of gaze plots will be presented to illustrate the actual eye movements of the participant during reading. The character of the eye movements observed in the visual gaze plots will help me illustrate the general complexity of the pattern in regard to the comprehension of texts with mistakes. It will also help gain deeper insights into the process of data collection and analysis procedures and provide an enhanced general understanding of the type of data collected by the eye tracker.

Results and Discussion

Main Results

The current chapter is going to highlight the most important findings and present descriptive as well as inferential statistical analysis and their discussion. First of all, the sample and the variables will be described to enhance an understanding of the data distribution. Then, with the help of several statistical tests mentioned earlier, it will become

possible to analyse the actual dataset and bring meaningful findings and discuss their possible interpretation.

The dataset contained several variables, namely Total Reading Time (in seconds), Total Fixations Duration (in seconds), and Total Number of Fixations as stated earlier. These variables were measured in the case of three texts: the standard text, a text with spelling mistakes, and one with word transpositions. The descriptive statistics for the different text types are presented in Table 2 below.

Table 2

Means and standard deviations for the AOIs in three main variables

Name of the variable	AOI	M	SD
Total Reading Time	Standard text	15.40	5.31
	Spelling mistakes	22.45	10.14
	Transpositions	20.60	10.09
Total Duration of Fixations	Standard text	12.73	4.15
	Spelling mistakes	18.78	8.14
	Transpositions	17.16	8.36
Total Number of Fixations	Standard text	62	19.57
	Spelling mistakes	88	38.28
	Transpositions	82	37.50

Note. The total number of participants is 20.

In order to answer the first research question about whether the content significantly influenced readers' performance when they encounter errors in the text, it was decided to run two independent-samples t-tests and compare mean values of total reading time, duration of fixations, and number of fixations for the two groups of students reading texts with different content across two error paradigms, namely spelling mistakes and transpositions. The results

of the t-test for the texts with different content both containing spelling mistakes are presented in Table 3 below.

Table 3

Independent samples t-test for measuring differences between readers' performance content-wise across texts with spelling mistakes

Main variable	Error type	Text (N)	M(SD)	Mean difference	t(18)	p
Total Reading Time	Spelling	1(12)	24.50(11.07)	3.71	.806	.431
		2(8)	20.79(9.52)			
Total Duration of Fixations	Spelling	1(12)	20.82(9.06)	3.71	1.013	.324
		2(8)	17.11(7.32)			
Total Number of Fixations	Spelling	1(12)	95.78(41.47)	13.23	.760	.457
		2(8)	82.55(36.36)			

As seen from Table 3 above, there was no significant difference between the performance of the groups when they read different texts, content-wise, with the same spelling error-paradigm in them. The total reading time of text 1 (M = 24.50, SD = 11.07) and text 2 (M = 20.79, SD = 9.52) did not have statistically significant differences $t(18) = .806$, $p = .431$. Similarly, there was no significant difference in the total duration of fixations between text 1 (M = 20.82, SD = 9.06) and text 2 (M = 17.11, SD = 7.32) as the mean difference of 3.66 between the totals was not significant: t (18) = 1.013, p = .324. Finally, such a variable as the total number of fixations on the AOI showed no significant difference between text 1 (M = 95.78, SD = 41.47) and text 2 (M = 82.55, SD = 36.36) with spelling mistakes since the mean difference is of no consequence (mean difference = 13.23) and t (18) = .760, p = .457.

According to the same logic presented above, independent samples t-tests were conducted to measure the difference between the two texts with different content both containing transpositions. The outcome of the test may be seen below in Table 4.

Table 4

Independent samples t-test for measuring differences between readers' performance content-wise across texts with transpositions

Main variable	Error type	Text (N)	M(SD)	Mean difference	t(18)	p
Total Reading Time	Trans-positions	1(8)	19.89(9.17)	-1.57	-.337	.740
		2(12)	21.46(11.64)			
Total Duration of Fixations	Trans-positions	1(8)	16.35(7.32)	-1.80	-.468	.645
		2(12)	18.15(9.86)			
Total Number of Fixations	Trans-positions	1(8)	79.64(35.55)	-5.36	-.310	.760
		2(12)	85.00(41.76)			

It may be observed that there were no significant differences between text 1 (M = 19.89, SD =9.17) and text 2 (M = 21.46, SD = 11.64) in terms of total reading time since the mean difference is very small as it can be seen in Table 4 and $t(18) = -.337$, $p = .740$. The total duration of fixations did not have any significant difference either as text 1 (M = 16.35, SD = 7.32) and text 2 (M = 18.15, SD = 9.86) did not have a large gap between mean values (mean difference = -1.80) and t (18) = -.468, p = .645. Eventually, the situation was similar in the total number of fixations: text 1 (M = 79.64, SD = 35.55) and text 2 (M = 85.00, SD = 41.76), mean difference = 17.28, t (18) = -.310, p = .760.

In the second step of the data analysis, I wanted to uncover whether the order of the presented texts had any significant influence on the reading performance of the participants and answer the second research question. The variable of order received two numbers: 1 for

the first text a participant read containing any type of mistake and 2 for the second text irrespective of the type of mistake. It should be mentioned that the first text all participants read was the standard one, however, when talking about error paradigms it was decided to consider the second text out of three as the first for the analysis and the third text as the second. It was done so in order to bring the texts with mistakes into the analytical domain and skip the standard text as it was unnecessary for answering the question above.

Independent-samples t-test was again run for the three variables (total reading time, total duration of fixations, and the total number of fixations) separately for the texts with spelling mistakes and with transpositions. The results indicated that there was no significant difference between the texts with spelling mistakes and the same results were found in terms of the texts with transpositions. I aimed at uncovering whether the order of the presented texts had any significant influence on the readers' performance outlined by the three main variables of the dataset. The results of the independent-samples t-tests may be observed in Tables 5 and 6.

Table 5

Independent samples t-test for measuring differences between readers' performance order-wise across texts with spelling mistakes

Main variable	Error type	Order (N)	M(SD)	Mean difference	t(18)	p
Total Reading Time	Spelling	1(11)	23.04(10.56)	1.30	.277	.785
		2(9)	21.74(10.19)			
Total Duration of Fixations	Spelling	1(11)	19.35(8.50)	1.27	.339	.739
		2(9)	18.08(8.14)			
Total Number of Fixations	Spelling	1(11)	90.64(40.45)	4.75	.269	.791
		2(9)	85.89(37.71)			

Table 6

Independent samples t-test for measuring differences between readers' performance order-wise across texts with transpositions

Main variable	Error type	Order (N)	M(SD)	Mean difference	t(18)	p
Total Reading Time	Trans-positions	1(9)	20.96(10.44)	.79	.170	.867
		2(11)	20.17(10.26)			
Total Duration of Fixations	Trans-positions	1(9)	17.42(8.75)	.58	.151	.882
		2(11)	16.84(8.39)			
Total Number of Fixations	Trans-positions	1(9)	83.09(37.44)	2.31	.134	.895
		2(11)	80.78(39.82)			

The figures from Tables 5 and 6 above prove that there was no significant difference between the readers' reading behaviour based on the order in which the participants encountered the texts, and this is true for both error paradigms. The total reading time of the text with spelling mistakes did not change significantly if the text with spelling mistakes was seen first (M = 23.04, SD = 10.56) or second (M = 21.74, SD = 10.19) as t (18) = .277, p = .785. No significant difference could be observed across the total reading time of texts with transpositions. It did not matter whether the initial text for a reader was with transpositions (M = 20.96, SD = 10.44) or it was the last text a participant read (M = 20.17, SD = 10.26), as again t (18) = .170, p = .867. Moreover, it is seen from Tables 5 and 6 that the same insignificant results were found in terms of the total duration of fixations of the text with spelling mistakes (t (18) = .339, p = .739) and transpositions (t (18) = .151, p = .882) and the total number of fixations on the AOI with spelling errors (t (18) = .269, p = .791) and transpositions (t (18) = .134, p = .895). Overall, the results illustrated an insignificant influence of the order on the participants' reading performance.

In order to answer the final research question concerning whether there was a significant change in total reading time, total duration of fixations, and the total number of fixations with the introduction of mistakes in the text, it was decided to run a repeated measures ANOVA tests to compare participants' performance across the three text types. The data analysed via ANOVA is presented in Table 7 below.

Table 7

Repeated measures ANOVA and post hoc analyses

Main Variable	Standard text (1)		Spelling mistakes (2)		Transpositions (3)		p	Wilk's Lambda	post hoc
	M	SD	M	SD	M	SD			
Total Reading Time	15.40	5.31	22.45	10.14	20.60	10.09	.004	.535	1<2.3
Total Duration of Fixations	12.73	4.15	18.78	8.14	17.16	8.36	.002	.514	1<2.3
Total Number of Fixations	62	19.57	88	38.28	82	37.50	.004	.544	1<2.3

Post-hoc Bonferroni tests indicated the task effect and revealed whether there was a significant statistical difference between the 20 readers' performance in accordance with the type of errors in the text on the variables measured. The first ANOVA test was significant as Wilk's Lambda = .535, F (2, 18) = 7.821, p = .004. It was found that there was a significant difference between the standard text (M = 15.40, SD = 5.31**)** and the texts with spelling mistakes (M = 22.45, SD = 10.14) as p = .002, and standard text and the texts with transpositions (M = 20.60, SD = 10.09) as p = .026, in total reading time. However, the

statistical difference between mean values of the total reading time of the texts with spelling mistakes and the texts with word transpositions was not significant as $p = .648$.

Accordingly, there were two more ANOVAs for the total duration of fixations and the total number of fixations. The first ANOVA was significant as Wilk's Lambda = .514, F (2, 18) = 8.517, $p = .002$. This test illustrated a significant statistical difference between the total fixations duration of the standard text ($M = 12.73$, $SD = 4.15$) and the text with spelling mistakes ($M = 18.78$, $SD = 8.14$) as well as between the standard text and the text with transpositions ($M = 17.16$, $SD = 8.36$), as for the first pair $p = .001$ and for the second pair $p = .029$. Similarly to the results of the total fixation duration, the final ANOVA indicated a significant effect on the total number of fixations as Wilk's Lambda = .544, F (2, 18) = 7.532, $p = .004$. This test showed a significant statistical difference between the total number of fixations of the standard text ($M = 62$, $SD = 19.57$) and the texts with spelling errors ($M = 88$, $SD = 38.28$), $p = .002$, and the standard text and the texts with transpositions ($M = 82$, $SD = 37.50$), $p = .023$. Finally, the statistically insignificant difference between the mean values of the texts with spelling errors and the texts with transpositions was proven in the course of the test as $p = .734$.

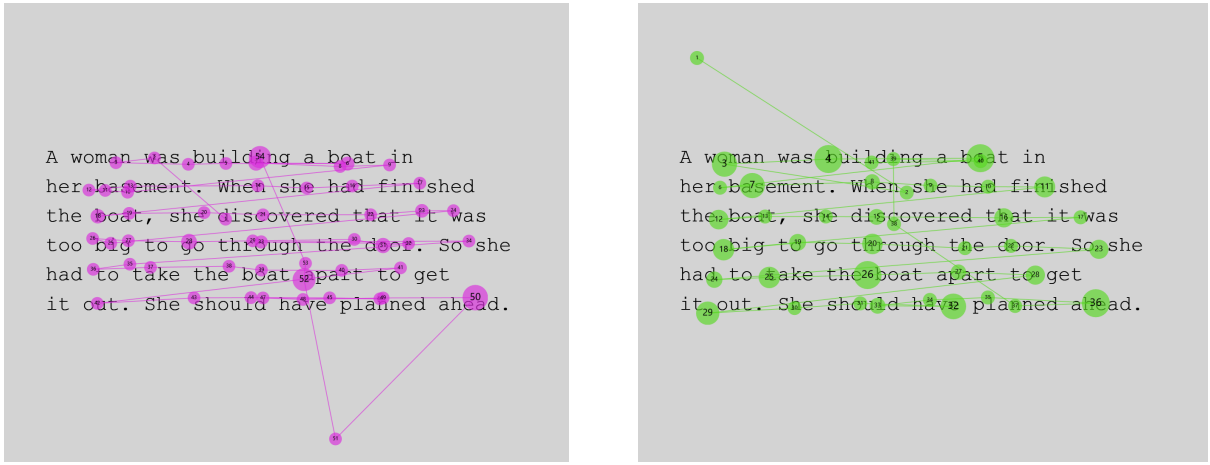
Complementary visual data findings

It was also decided to use complementary visual data in order to present certain findings in a more tangible format. Thanks to the software used in the current research, it was possible to obtain the gaze plots of the AOIs or texts. As it was already established, there were several texts: a standard text, and two pairs of texts that differed in content and the type of introduced errors. Below are presented the visualisations of two participants' eye movements where lines indicate saccades and regressions and circles indicate fixations. The duration of each fixation is also marked by the size of the circle. Moreover, the number of the circle showcases the sequence of fixations and, therefore, it is possible to distinguish between

the saccade and regression. Figure 3 below exhibits two common gaze plots of the readers for the standard text.

Figure 3

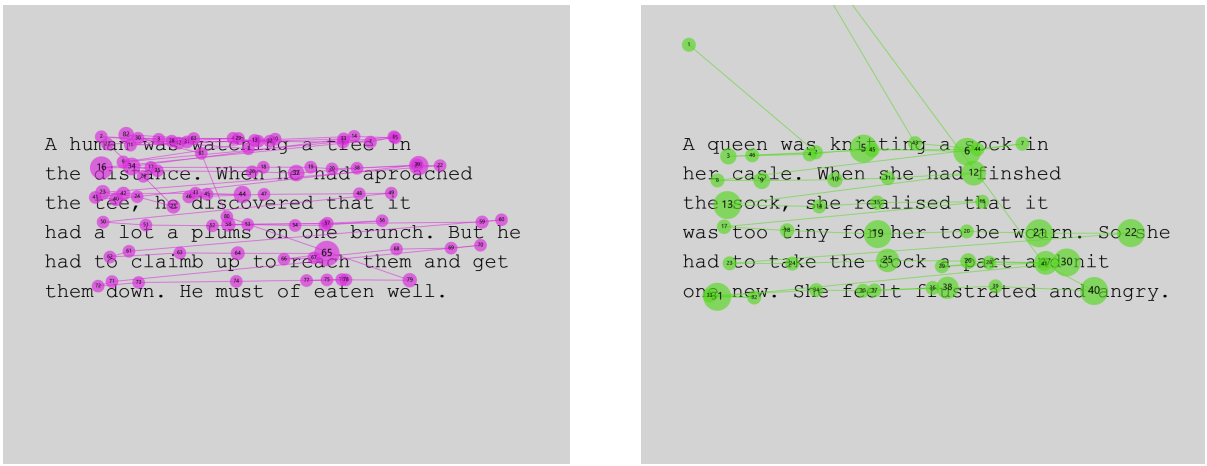
Gaze plots of two standard texts



As can be observed in the figure above, the gaze plots of both participants had a direct and straightforward nature. The gazes of participants followed the basic z-shape indicating a conventional reading technique found among most of the readers. The number of regressions is extremely small as seen from the sequencing numbers on fixation circles. The situation changes with the introduction of the mistakes in the texts. Figure 4 illustrates the gaze plots of the same participants when they encountered spelling mistakes in the texts.

Figure 4

Gaze plots of two texts with spelling mistakes

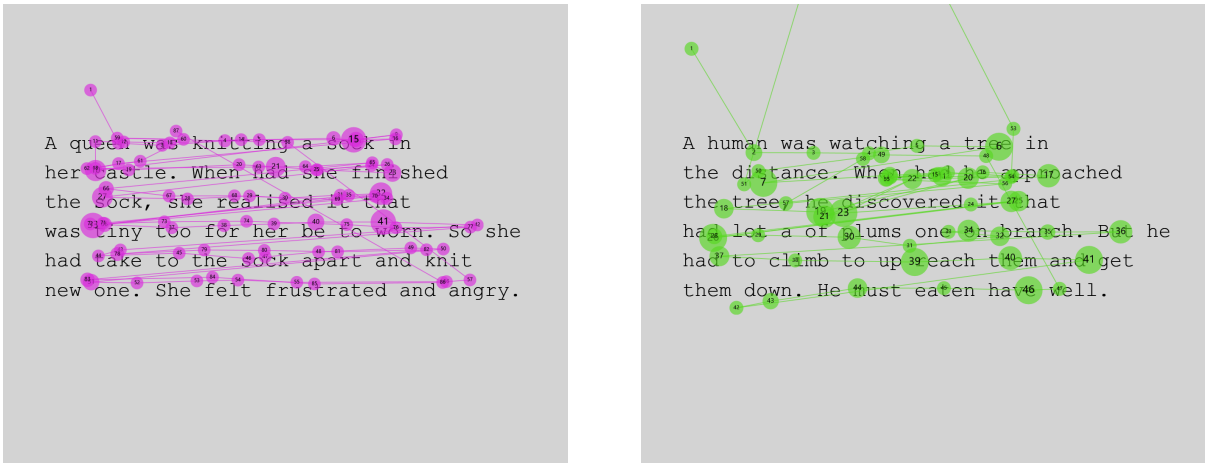


It is now evident that the z-shape of eye movements is completely distorted as the readers encounter spelling errors in the words. In the first scenario highlighted in pink, the reader tried to clarify the ambiguities by increasing the number of saccades and regressions to check whether they understood the word correctly while in the case of the green highlighting on the right, it was obvious that the reader utilised another approach and increased the duration of fixations to decode the meaning of words with errors.

Figure 5 below shows the gaze plots of the same participants when reading a text with transpositions. The gaze plots indicate an intricate manner of decoding the text by the two participants and highlight the changes in the reading method. It was easier for the first participant (on the left) to increase the number of saccades and regressions in order to check the presented information and decode the meaning of the text, whereas, for the second participant (on the right), text comprehension was rather more difficult as the gaze plot illustrates a tangled web of saccades and regressions not following a previously established line by line reading and potentially indicates another type of reading behaviour coping with errors in the text.

Figure 5

Word transpositions. gaze plots



However complex the gazes may be, the data presented during the main data analysis stage proved that neither the content of the texts nor their specific order of presentation had a significant influence on the way they were processed as reflected by the total reading time and the number and length of fixations. Moreover, although the introduction of errors seemed to disrupt normal processing, no significant differences between the texts with different types of mistakes could not be detected.

Discussion

The following part is going to address the research questions stated above on the basis of the data analysis and results described previously. It is organised according to the research questions stated previously in the course of the work.

1. Did the content significantly influence readers' performance when they encountered errors in the text?

It was proven statistically that there was no significant difference between the two texts with spelling mistakes, nor was there a difference between the texts with transpositions based on the content of the texts. In the frame of the data analysis reported above, the total reading time of the text with spelling mistakes and the text with word transpositions were not significantly different from each other. Moreover, the total fixation duration of texts with either type of mistake did not have any meaningful difference. Finally, the total number of fixations across the texts with spelling mistakes did not differ critically from the number of fixations in the texts with transpositions.

In light of the present research, this lack of significant differences may be backed up by the bottom-up approach suggested by Gough (1972) as the participants did not heavily rely on their background knowledge. However, since the texts did not convey any information about the general knowledge of the world and were completely new to the participants, it is rather obvious that readers' knowledge was not used in the decoding of the

text. Following this point, it is also possible to add that, on the contrary, schemata concerning readers' linguistic knowledge might have helped them to decode the meaning of the text even if the texts had errors in them.

Overall, the results suggest that even when the content of the texts is different but the error paradigm is the same across those texts, it is equally difficult for the reader to comprehend the text, and there is no significant difference between the processing of the two texts for the person regardless of the content of the texts. According to Pickering et al. (2004), longer fixation time and, therefore, the increase in reading time, indicate an increased cognitive load on the reader. I tried to evenly distribute the texts across the sample and even created similar texts; thus, the texts had the same number of lines and the same number of mistakes in the same places. Therefore, in the case of texts which were similar in terms of readability and errors, the content of the text did not have an effect on readers' performance.

2. Did the order of the presented texts have any significant influence on the reading performance?

It was obvious from the data analysis that the order did not play any crucial role in the comprehension of the texts used. For the readers, it was equally difficult to read the second and the third text after the standard one regardless of whether they read the text with spelling mistakes first or last. The same tendency was observed for the word transpositions meaning that the reader had difficulties in reading regardless of seeing the text with transpositions before the one with spelling mistakes or after. Primarily, when the participants read the erroneous texts after the standard one that was linguistically correct, they still struggled, to a certain extent, with the reading of the texts that followed.

In terms of the theoretical background of the current research, it is possible to appeal to the cognitive theory proposed by Forrest-Pressley and Waller (1984). I believe that the readers realised that the third text would also have mistakes in it regardless of the type of

errors. Subconsciously, they could have been waiting for the next text to have mistakes in it too. However, as it was already proven, there was no effect of the order on the reading performance of the current sample.

3. Is there a significant change in total reading time, total duration of fixations, and the total number of fixations with the introduction of mistakes in the text?

The statistical analyses conducted earlier revealed that there is a significant difference between the standard text and the text with mistakes, either spelling or transpositions, across three main variables, namely the total reading time, total duration of fixations, and the total number of fixations. It was also noted that the texts with spelling mistakes had slightly higher mean values across the variables, yet it was not thoroughly investigated and, therefore, will be considered as a limitation to the study. Complementary visual data provided previously also revealed that the introduction of the mistakes in the text with similar linguistic properties hindered the reader's behaviour and made their gaze direction more complex and tangled. The gaze plots illustrated that the number of regressions increased if a person read a text with mistakes and the same tendency was seen in regard to the duration of fixations. Moreover, the normal linear gaze structure of reading under normal conditions was completely changed, which might indicate the struggle of the reader to decode the meaning of the text. As repeated measures ANOVAs showed significant differences in comprehension of the standard text and the texts with errors, it was also possible to illustrate the changes in reading behaviour via complementary data suggesting higher cognitive load and prolonged attention according to Pickering et al. (2004).

Overall, it is quite clear that the introduction of mistakes in the text added to the complexity of the reading process, since based on the bottom-up approach proposed by Gough (1972), it is the actual text that is being decoded, and changing the properties of it would definitely change its perception. However, the interactive approach suggested by

Rummelhart (1977) with its pattern synthesiser may also contribute to the interpretation of the findings. The pattern synthesiser combines the visual input and the stored memories to produce a string of meaning. In light of the present question, it may be inferred that playing with the language properties and adding errors in the texts hinders the work of pattern synthesiser as the visual input does not match with the linguistic knowledge stored in the reader's mind. Consequently, after an attempt to produce a string of meanings, the synthesiser fails to do so and restarts the process again, causing the reader's eyes to regress and check the input once more. Moreover, for some of the participants, it was enough to increase the duration of fixations to "restart" the pattern synthesiser, while for others it was the increase in the number of regressions that was necessary to make further input contribution to the process and then decode the meaning.

It is also important to mention that for all participants the language of the texts was foreign, they were written in their L2 (English). The participants had a rather high level of language proficiency and it is more likely that they overcame the threshold applied to the reading in L2 described earlier in the course of the review of the literature.

Conclusion

This paper aimed at investigating reading processes via eye tracking and posed three research questions. In the course of the work, the literature on the topic of reading and reading comprehension as well as reading in L2 was thoroughly reviewed. Moreover, such methodological tools as error detection and eye tracking and their background were taken into consideration. After revisiting the main theories, this investigation described methodological procedures including the experimental process and data collection and analysis. With the help of several statistical tests, it became possible to analyse the actual dataset and draw meaningful conclusions about the reading performance of the sample.

Consequently, the results and their interpretations were discussed in detail in the discussion part.

It was revealed that the content of the reading materials had no statistically significant effect on the readers' performance when they encountered errors in the texts. It was also established that the order of the presented texts with errors did not have any significant effect on the participants' reading behaviour. Finally, it was uncovered that there were significant changes in the total reading time, total duration of fixations and the total number of fixations when the texts had errors embedded in them, regardless of the type of mistake. However, I was able to detect a tendency towards longer reading and fixation times and a higher number of fixations in the case of texts with spelling mistakes when compared to transpositions although these differences were not statistically significant. Since the observation was not significant, it can be considered a limitation of the study.

There are a number of practical implications of the main findings of this investigation. First of all, it is essential to understand the nature of reading for pedagogical purposes. This study may help educators of all levels to gain deeper insights into the process of reading taking into consideration the difference in patterns of reading performance. Secondly, this paper is trying to contribute to the scientific area of reading and reading comprehension in L2 allowing others to gain deeper insight into this process as this research combines two error paradigms together which was not previously discussed in the field. Finally, the research may serve as a basis for future investigation in the area of psycholinguistics by posing questions on differences between the reading performance in changing conditions, e.g. correct text and texts with errors.

This study also has several limitations leading to suggestions for future research in the field. The size of the sample was quite limited in quantity, and this could have been a factor contributing to the failure to find significant differences between the texts with different error

types. Therefore, the questions posed at the beginning of the paper may be further analysed on a bigger sample to bring more generalisable findings and interpretations. Additionally, this paper did not utilise data deriving from qualitative techniques such as retrospective interviews. For limitations of time and space, it was decided to utilise the quantitative paradigm of data collection and analysis only and leave the possibility of complementing the findings with qualitative data as a next step to be taken. In the future, the qualitative analysis of the responses given by readers after reading the texts and their answer to the final question of the experiment may bring further meaningful results. It is also considered highly interesting to conduct the same experiment with a native sample and look at their reading performance as well as compare the findings of the two studies. It is possible that the level of automatisation of reading amongst native speakers shall be higher compared to the non-native speakers, therefore, they would probably skip most of the errors, though its possibility must be thoroughly explored via empirical means.

In addition, it should also be mentioned that the current research utilised a complex psycholinguistic methodological tool that produces manifold data. Thus, further research in the field may also attempt to extract other types of data, such as a number of regressions or the total duration of fixation across the texts, paying special attention to the individual words and completing a word-by-word comparison between texts.

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Appendices

Appendix A

Standard text by Goodman (1996)	Text 1	Text 2
A woman was building a boat in her basement. When she had finished the boat, she discovered that it was too big to go through the door. So she had to take the boat apart to get it out. She should have planned ahead.	A human was watching a tree in the distance. When he had approached the tree, he discovered that it had a lot of plums on one branch. But he had to climb up to reach them and get them down. He must have eaten well.	A queen was knitting a sock in her castle. When she had finished the sock, she realised that it was too tiny for her to be worn. So she had to take the sock apart and knit one new. She felt frustrated and angry.

Appendix B

Error paradigm	Text 1	Text 2
Spelling	A human was watching a tree in the distance. When he had aproached the tee, he discovered that it had a lot a plums on one brunch. But he had to claimb up to reach them and get them down. He must of eaten well.	A queen was knitting a sock in her casle. When she had finshed the sock, she realised that it was too tiny for her to be woarn. So she had to take the sock a part and nit one new. She feelt frustrated and angry.
Transpositions	A human was watching a tree in the distance. When had he approached the tree, he discovered it that had lot a of plums one on branch. But he had to climb to up reach them and get them down. He must eaten have well.	A queen was knitting a sock in her castle. When had she finished the sock, she realised it that was tiny too for her be to worn. So she had take to the sock apart and knit new one. She felt frustrated and angry.