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Using Eye-Tracking in L2 English Teaching and Learning Research: A Review for its Implementation in Costa Rica

Rastreo ocular para la investigación en enseñanza y aprendizaje del idioma inglés: una revisión para su implementación en Costa Rica

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ABSTRACT

Research using eye-tracking technology has wildly increased in the last decade (Keating, 2013). Hence, studies on L2 teaching and learning have started to use that technology to improve research in that area. However, L2 eye-tracking research has not been explored in the Costa Rican context. This article aims to describe what eye-tracking is, what eye-tracking paradigms are, studies using eye-tracking in L2 teaching and learning, and research ideas for its implementation in Costa Rica. The methodology employed was an integrative review approach (Cooper, 1988) to review eye-tracking research and to discuss its application in Costa Rica. It was found that there are no studies regarding L2 teaching and learning in Costa Rica with the use of eye-tracking. Thus, research ideas to conduct eye-tracking research in L2 teaching and learning are discussed. It is concluded that the use of eye-tracking brings an opportunity to conduct multidisciplinary research to further advance the knowledge of L2 teaching and learning processes in Costa Rica.

KEYWORDS: Eye-Tracking, L2 Teaching and Learning, Eye-Tracking Paradigms, L2 Research.

RESUMEN

En la última década la investigación utilizando movimientos oculares ha crecido significativamente (Keating, 2013). Por lo tanto, estudios sobre la enseñanza y el aprendizaje de inglés como idioma extranjero/segundo idioma (L2) han comenzado a utilizar el rastreo ocular para mejorar la investigación en dicho campo. Sin embargo, la investigación en inglés L2 utilizando el rastreo ocular no ha sido explorada en el contexto costarricense. Este artículo tiene como objetivo discutir qué es el rastreo ocular, paradigmas de rastreo ocular, estudios que utilizan rastreo ocular en la enseñanza y el aprendizaje L2 e ideas de investigación para su implementación en Costa Rica. La metodología utilizada en un enfoque de revisión integradora (Cooper, 1988) para revisar investigación utilizando el rastreo ocular y discutir su aplicación en Costa Rica. Se encontró que no existen estudios sobre la enseñanza y aprendizaje L2 en Costa Rica con el uso de rastreo ocular. Por lo tanto, se discuten ideas para realizar investigaciones en la enseñanza y aprendizaje de inglés L2 utilizando el rastreo ocular. Se concluye que el uso del rastreo ocular brinda la oportunidad de realizar investigación multidisciplinaria para avanzar en el conocimiento de los procesos de enseñanza y aprendizaje de inglés L2 en Costa Rica.

PALABRAS CLAVE: Rastreo ocular, Enseñanza y aprendizaje de idioma extranjero, Paradigmas de rastreo ocular, Investigación en lengua extranjera.

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1. INTRODUCTION

Research into foreign/second (L2) English teaching is a growing field worldwide and Costa Rica is not the exception. Traditionally, offline methods, such as pen and paper materials and tests, have been employed to teach and test L2 learners. For instance, offline measures (e.g. pen-and-paper post-tests, think-aloud protocols, multiple-choice pre, and post-tests) are common in vocabulary learning (García-Castro, 2015, 2022; Pellicer-Sánchez & Schmitt, 2010), reading comprehension (Ghavamnia et al., 2013; Pretorius et al., 2022), speaking skills studies (el Majidi et al., 2021), amongst many others. However, with the advance of technology, newer online teaching and research methodologies such as self-paced reading (Keating & Jegerski, 2015), functional near-infrared spectroscopy (fNIRS) (Lloyd-Fox et al., 2010), electroencephalography (EGG) (Schneegass et al., 2019) have been developed to provide a deeper understanding of L2 teaching and learning processes and eye-tracking is one such technique.

Eye tracking, in simple terms, records eye movements while processing written and/or auditory stimuli. Therefore, teachers and researchers could have the opportunity to potentially explore cognitive difficulties and the online behavior of L2 learners while conducting a task through the analysis of their eye -movements. The use of eye-tracking then opens up a tremendous opportunity for multidisciplinary research to explore L2 language processing and L2 teaching and learning at a deeper level than with the use of offline measures. It is important to conduct research using the most recent techniques, to advance the knowledge of L2 teaching and learning processes in Costa Rica and worldwide.

In the field of education, eye-tracking has been used not only to research L2 teaching and learning but also to answer critical questions related to teachers' gaze (McIntyre et al., 2017, 2020), pre-service teachers' attention processes (Stürmer et al., 2017), teachers' sensitivity to students (Dessus et al., 2016), teachers' professional vision (Wyss et al., 2021), amongst others. Those studies will not be reviewed as their focus is not related to current issues in L2 teaching and learning; however, it is worth illustrating how eye-tracking can be employed in various topics in the field of education.

This short review describes the methodology employed (section 2) and it covers what eye-tracking is, eye-tracking paradigms, and studies using eye-tracking in L2 teaching and learning (section 3). Section 4 suggests eye-tracking research ideas in the field of L2 teaching and learning in Costa Rica. Section 5 concludes the review.

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2. METHODOLOGY

This review employs an integrative review approach to eye-tracking and L2 English teaching and learning. Integrative reviews aim to review, criticize, and synthesize selected and representative literature on a topic (Torraco, 2016) and they may create new perspectives on it (Fan et al., 2022).

This article followed Cooper's (1988) taxonomy of literature reviews in a set of six stages (Figure 1).

Stage 1: literature's review focus

In the field of education, literature reviews may focus on "research outcomes, research methods, theories, and practices or applications" (Cooper, 1988, p.108). The focus of this review is on eye-tracking in L2 English teaching and learning for its application in Costa Rica.

FIGURE 1.

Cooper's (1988) literature review stages.

Source: Own elaboration based on Cooper (1988).

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Stage 2: literature review goal

The most common goals of literature reviews are to integrate and criticize past literature; however, literature reviews can also have the goal of identifying central issues in a topic (Cooper, 1988). This review has the goal of identifying key issues in eye-tracking and L2 English teaching and learning.

Stage 3: literature review perspective

The literature review's perspective considers how the point of view of the reviewer may influence the review itself. Cooper (1988) classifies the literature review's perspective into two categories: neutral representation and espousal of position. In neutral representation arguments against and in favor are discussed by, the reviewer whether in an espousal of position, the reviewer analyzes the literature review to show the relevance of a particular topic (Cooper, 1988). In this review, an espousal of position was undertaken to demonstrate the relevance of the topic.

Stage 4: literature's review coverage

Cooper (1988) classifies coverage into four categories: exhaustive, selected sample, representation, and central or pivotal. Exhaustive coverage intends to include most of the literature available on a topic whereas selected sample coverage only selects some of the literature. Both categories based their conclusion on the literature reviewed. Representation coverage includes works that exemplify the literature available on a field and central or pivotal coverage includes only those studies that are key for a topic. Pivotal studies that have advanced theoretical and methodological knowledge of a field can be included in the central or pivotal category (Cooper, 1988).

For the purposes of this work, the central or pivotal category was employed. Only key literature on the topic was considered to illustrate recent theoretical and methodological advances in the field of eye-tracking and L2 English teaching and learning.

Stage 5: literature's review organization

The organization of a literature review is fundamental. Cooper (1988) suggests that reviews can be organized historically, conceptually, or methodologically. This paper follows a conceptual organization as topics and works are discussed based on content similarity.

Stage 6: literature's review audience

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A literature review may be written for various types of audiences. For instance, it can be written for researchers, practitioners, or policy makers (Cooper, 1988). The audience of this literature review is researchers, practitioners, policy makers, university students, and university lecturers as they all may benefit from the content of this paper.

Having outlined the methodology followed for this work, the next section describes its theoretical background.

3. THEORICAL BACKGROUND

3.1 What is eye-tracking and what does it measure?

Eye-tracking is a non intrusive experimental research technique that records eye movements when performing a task and thus the natural interaction of the eyes with a stimulus (Keating, 2013; Negi & Mitra, 2022) The human eye reveals what people are paying attention to, the cognitive effort involved when processing linguistic input (Conklin et al., 2018a), and attention-related processes (Eysenck & Keane, 2015). Eye-tracking details the moment-by-moment of visual processing tapping into cognitive processing (Just & Carpenter, 1980) and language processing.

One of the primary aims of eye-tracking, in the field of language learning, is to research comprehension and processing of written text (Keating, 2013; van Gompel et al., 2007). However, a range of studies on L2 listening tests (Aryadoust & Foo, 2022; Kho et al., 2022), L2 listening processing with subtitles (Wang & Pellicer-Sánchez, 2022), L2 word processing (Fernández & Jegerski, 2022; García-Castro, 2018; Huang et al., 2022; Yi & DeKeyser, 2022), L2 vocabulary learning (Wang & Pellicer-Sánchez, 2022), amongst many others, have been conducted and have shed light on L2 teaching and learning. Unfortunately, studies have not yet explored L2 teaching and learning processes within the population in Costa Rica. For instance, Aryadoust and Foo (2022) found that the eye-movements of L2 university learners in Singapore correlated with their while-listening-performance. Similarly, Kho et al. (2022) showed that gaze behavior, in university students in Asia, is related to participants' performance in listening tests. Eye movements have also been found to predict vocabulary gains, of Chinese learners of English, when watching a documentary with subtitles (Wang & Pellicer-Sánchez, 2022). Eye-tracking has been used to research various L2 learning populations; however, to the best of the researcher's knowledge, it has not been widely explored within the Costa Rican population. Thus, it is much needed to employ the use of eye-tracking in Costa Rica to better understand how to improve L2 teaching and learning in the country.

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What does eye-tracking measure?

In simple terms eye-tracking measures eye movements in milliseconds. The tracker records different types of eye movements humans automatically (i.e.i.e., without conscious awareness) produce while reading a text, viewing a scene and/or viewing while listening. It measures processing efforts while conducting a task (Conklin et al., 2018a) opening up an extraordinary opportunity to research online processing behavior in L2 teaching and learning (García-Castro, 2018). For instance, research studies can potentially explore whether L2 learners have reading comprehension difficulties when reading words embedded in short stories or classroom textbooks. Additionally, it can be researched if L2 learners process auditory stimuli faster in certain conditions and if they are mediated by cognitive individual differences, amongst many others.

3.2. Types of eye-movements

There are different types of eye movements measured by the eye-tracker in milliseconds (Figure 2):

- Fixations: during a fixation the eyes are not moving, they are stationary (Gilchrist, 2011). It is during fixations that "the cognitive system processes the input and plans where and for how long to move the eyes next" (Conklin et al., 2018b, p. 1). It is assumed then that longer and more fixations in a particular section of a text, sentence, word, or visual image signals greater cognitive effort (Conklin et al., 2018a; Pellicer-Sánchez & Siyanova-Chanturia, 2018). Thus, "longer and more fixations indicate greater processing effort, and shorter fixations and/or more skipping indicate less processing effort" (Conklin et al., 2018b, p. 7).
- Saccades: a saccade is a very fast movement of the eye "that can be produced up to four times per second" (Land, 2007, p.3). They are followed by fixations (i.e., when the eyes are not moving but fixed) (Gilchrist, 2011).
- Regressions: a regression occurs when the eye moves back (i.e. regresses) to a previous place (e.g. a previous part in a text or a visual scene) (Conklin et al., 2018b). It may signal cognitive effort in reading tasks as the eye has to move to another section of the text to re-process it.

Figure 2 illustrates different types of eye movements while reading. First pass reading times take into account all fixations on a word before the eye exits it for the first time (Conklin et al., 2018a), and total reading times include all the fixations made on a word (Conklin et al., 2018a). The area of

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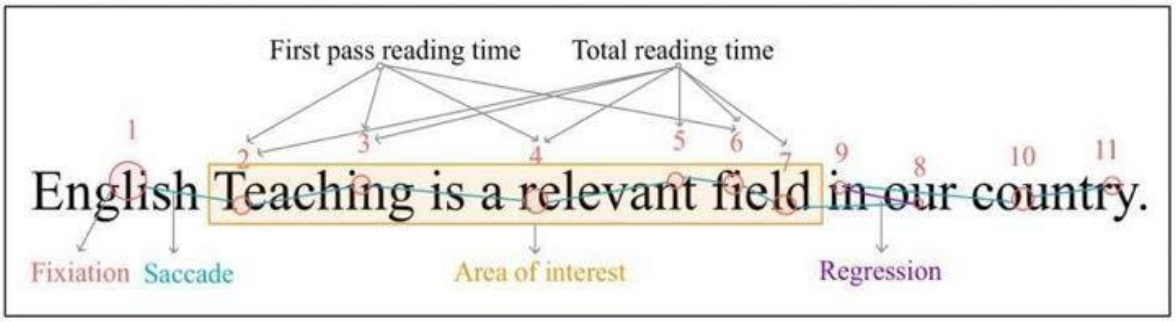
interest refers to the area researchers are interested in analyzing and it can be a single word, multi-word units, a noun phrase or adjectival phrases.

FIGURE 2.

Example of eye-movementseye movements while reading.



Source: Adapted from Eckstein et al. (2019).

The area of interest refers to the area researchers are interested in analyzing, and it can be a single word, multi-word units, a noun phrase, an adjectival phrase, amongst others. How do researchers know what areas of a sentence are they interested in analyzing? Choosing the area of interest should be in accordance with theoretical accounts and the purpose and objectives of the research project. To illustrate, if researchers want to explore how L2 students process the grammatical form of irregular verbs recently learned, they may design an eye-tracking study with sentences containing recently learned regular and irregular verbs. Then, they can compare and contrast reading times on both the irregular and regular verbs of sentences.

Having briefly introduced the different types of eye movements, the question to be asked now is how can we use them in L2 research? So far, there are two main types of experimental eye-tracking paradigms that can be employed to conduct eye-tracking research in the field of L2 teaching and learning: visual-world eye-tracking and eye-tracking while reading.

3.3. Eye-tracking Paradigms

3.3.1 Visual-world eye trackingeye-tracking paradigm

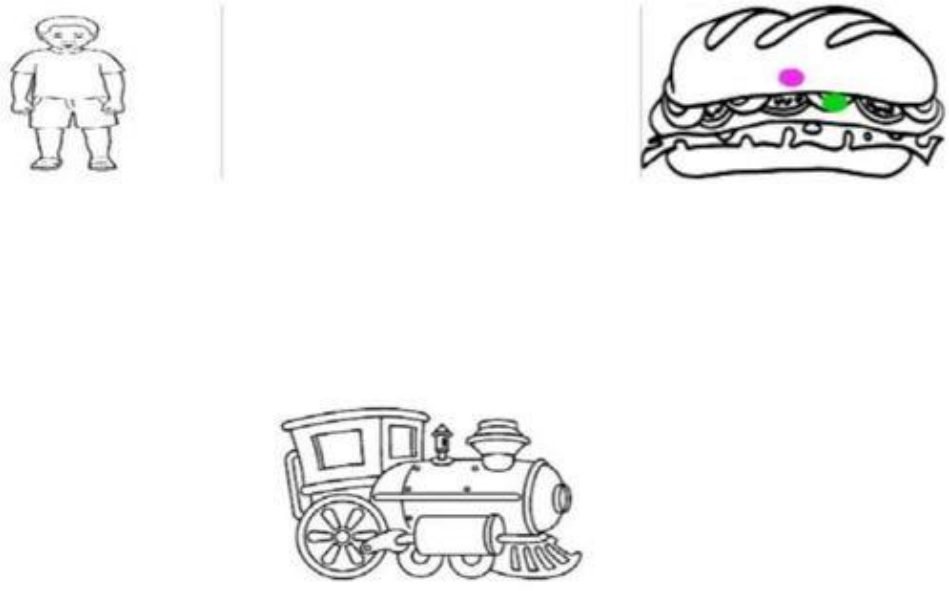
The visual-world eye tracking paradigm uses images and pictures together with auditory stimuli providing an extraordinary opportunity to research spoken language comprehension by analyzing the mapping of "acoustic signal onto linguistics representations as speech unfolds" (Dahan et al., 2007, p.473). Listening skills differ between L2 learners, thus, the visual world eye-tracking

paradigm may contribute to the understanding of how L2 learners process and develop listening skills by allowing “researchers to examine both comprehension and production using a single method” (Dussias et al., 2013, p. 120). Being able to study L2 learners' learning process in real timereal-time offers the opportunity to know what they are doing and what they are paying attention to as they process the input.

In the visual-world paradigm eye-movements are recorded while watching pictures prior to listening to the auditory lexical stimuli and while listening to it. In this way, learners are looking at scenes in the visual-world that may or may not be related to the auditory stimuli they will listen to; however, at least one image (i.e.i.e., a target) should be related to the auditory stimuli. When students process the auditory lexical stimuli, they are likely to make linguistic and conceptual inferences between the pictures they are watching, the target image, and the auditory input. When processing the visual images, their conceptual representation and lexical forms are activated; thus, when the auditory stimuli unfoldsunfold, learners may also process the phonological form of the conceptual representations onin the visual-world (Figure 3).

FIGURE 3.

Example of a visual-world, presented on a computer screen, in aan L2 teaching and learning research study.



Source: García-Castro (2018).

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Figure 3 exemplifies a visual-world from a linguistic experiment designed to teach L2 vocabulary (García-Castro, 2018). Participants looked at the images, on a computer screen, while listening to the sentence The boy will gwap (i.e., eat) the simple sandwich with the image of the boy acting as the agent, the image of the train as a distractor, and the image of the sandwich as the target image to be looked at. Eye movements were recorded (i.e., the pink circle signals participant's left eye and the green circle the right eye) while participants looked at the images and listened to the auditory stimuli.

If learners understand the meaning (i.e., semantic form) of the word eat they are likely to look at the image of the sandwich, instead of the train, soon after listening to will eat and prior to listening to the word sandwich. On the contrary, if students do not understand the meaning of the word eat, they are not likely to look at the image of the sandwich prior to listening to the word sandwich. In either case, the time taken to move the eyes from one image to another in relation to when the auditory stimuli unfolded is analyzed to determine students' lexical process and comprehension of the semantic and phonological representations of the words they recently learned.

One of the first studies in L2 language processing and learning using the visual-world eye-tracking paradigm was that of Spivey & Marian (1999). They explored if L2 and L1 words (i.e., lexical items) activated when given instructions in a monolingual scenario. They designed a visual-world eye-tracking experiment containing a distractor and a target object in which participants listened to instructions in the L2. The visual display included a distractor with a similar L1 phonological form of the L2 target, in the auditory stimuli, and the target object. If participants looked at the object with a similar L1 phonological form, even though they were listening to the input in the L2, activation of both the L1 and the L2 took place. Results showed that participants activated both languages when processing input in only one of them signaling parallel activation of the L1 and the L2 in the mental lexicon. This was a pioneering study demonstrating that the bilingual mental lexicon activates both L1 and L2 words when processing either language. The implications of this study for L2 teaching and learning are significant as learners activate both the L1 and L2 when processing either and this, undoubtedly, interferes in the L2 teaching and learning process. For instance, students who are learning in a classroom setting are likely to activate their L1 (e.g., Spanish) when solving a grammatical exercise or in a speaking task in the L2 (e.g., English) and this should be known by both L2 teachers and learners.

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An innovative English teaching experiment with the eye-tracking paradigm is that of Escudero et al. (2008). They trained L2 learners in novel L2 twenty English words. They divided participants into two groups: group one (N=25) learned the phonological aspects of novel words by matching them with pictured meanings, and the other group (N=25) also learned them via pictured matching and was exposed to the words' written form. In the testing phase, participants saw a visual display per each target word containing the target image, a phonological competitor image, and a distractor. Results showed that including the words' spelling generated more fixations towards the target image than when spelling is not included. Researchers concluded that establishing novel L2 phonological forms can benefit from the words' grapheme representation.

Employing the visual-world eye-tracking paradigm Canseco-Gonzalez et al. (2010) found out that age of acquisition (AoA) influences L2 language processing. They tested bilingual participants whose L2 AoA varied: participants who learned L2 Spanish after completing 6 years of age, participants who learned L2 English after being 6 years old, and participants who learned the L2 before turning 6 years of age. Participants had to identify the spoken form, of a given word, by clicking on its right image on a computer screen. The target was presented on a computer screen together with an image of a phonological competitor, and an image of an object which did not phonologically compete with the target. For instance, participants listened to the word beans and the visual-world paradigm presented the image of some beans, a beetle which phonologically overlaps with beans, and an image of a cone as an unrelated phonological object. Results showed that those who acquired the language at an earlier age proportionally had more looks to the target than those who learned at a later age. The use of the visual-world paradigm contributed to research whether AoA has an effect in spoken word recognition.

Ellert (2013) researched the extent of language proficiency in L2 ambiguity resolution. Thirty-two university students took part in the study, and they were asked to listen to sentences with pronoun ambiguities. The visual display contained three pictures: one picture referring to the correct pronoun, a picture with a related pronoun to the target, and a distractor. Participants' eye-movements were recorded while they looked at the pictures on a computer screen while listening to the auditory stimuli (i.e., sentences). Researchers predicted that participants' first fixations to the target would occur while listening to it. Results suggested that learners with lower proficiency behave differently than learners with higher proficiency. The former seems to focus less on the target pronoun than the latter. Ellert's (2013) study contributes to the understanding of how L2 learners resolve lexical

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ambiguities when encountered with them which may be used to develop targeted pronoun teaching strategies.

A more recent study employing the visual-world eye-tracking paradigm is that of Connell et al. (2018). Via an eye-tracking study, they researched L2 learners' ability to extract segmental and suprasegmental information from auditory stimuli. The visual display, on the computer screen, included the target word, a competitor, and two distractors. Participants had to listen to the auditory stimuli, containing segmental and suprasegmental cues, and had to click on the right word as soon as they heard it. One of the main findings is that suprasegmental information seems to affect L2 phonological lexical activation and competition in L2 learners. The result has relevant implications for the field of L2 teaching and learning as L2 learners need to understand and interpret segmental and suprasegmental cues to convey the meaning of what they are listening to. Additionally, L2 learners must decode and activate segmental and suprasegmental cues to understand words' stress and to be able to pronounce them correctly. Thus, the main findings of Connell et al. (2018) can potentially be used to design classroom materials to teach segmental and suprasegmental cues. The work of Connell et al. (2018) illustrates how the visual world paradigm can be employed to research topics that can contribute to the L2 teaching and learning process.

3.3.1.2. Equipment needed to use the visual eye-tracking paradigm

To conduct research using the visual-world eye-tracking paradigm an eye-tracker is needed. There are various eye trackers on the market based on the research purpose, where the camera is, and the precision of the lens, amongst others (Conklin et al., 2018a). An eye-tracker from eye-link is recommended due to the precision, speed, accuracy, and binocular recording of eye-movements. Eye trackers include a camera that tracks and records eye-movements based on the position of the eyes in relation to the camera. Eye trackers may have a head mount (Figure 4) or a head-free approach (Figure 5).

FIGURE 4.

Example of a head-mounted eye-tracker

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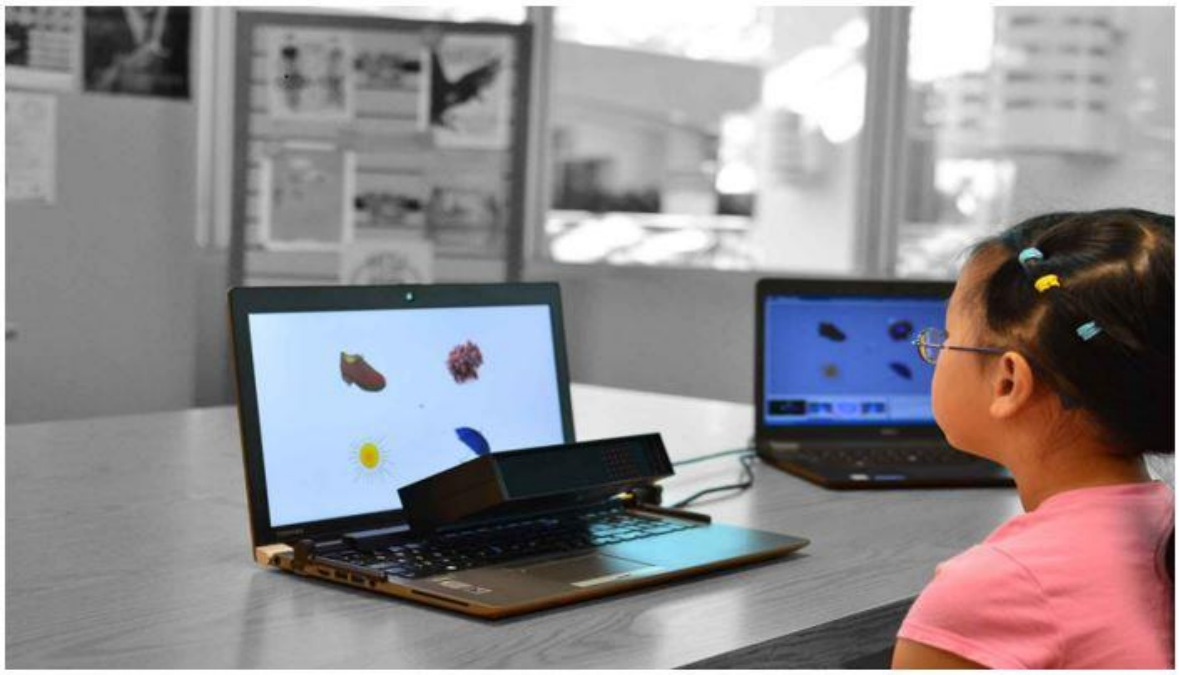
Source: Staffordshire University (2023).

FIGURE 5.

Example of a head-free eye-tracker in a visual world eye-tracking paradigm



Source: SR Research website (2023a).

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Figure 5 shows a student undertaking a head-free visual-world eye-tracking study while the camera records her eye-movements.

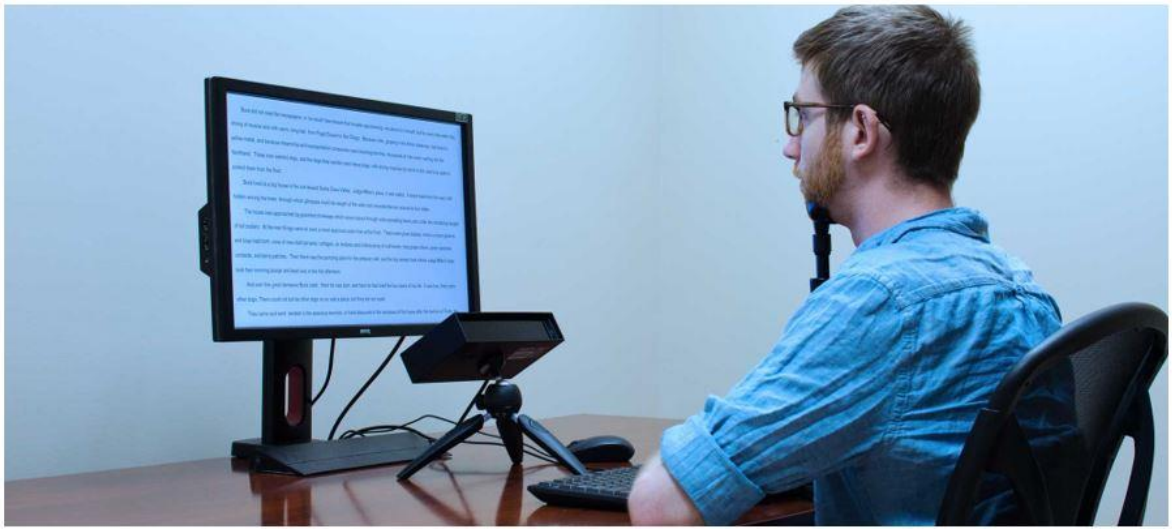
3.3.2 Eye-tracking while reading paradigm

The eye-tracking while reading paradigm employs written text as the main source of linguistic input and it aims to research written comprehension and processing (Keating, 2013; van Gompel et al., 2007) of either words or sentences. Eye-movements in reading research show if a word is easier to recognize and understand, for instance fixation times on a word are shorter if it is understood (Clifton et al., 2007). Thus, language researchers are interested in fixation times when conducting eye-tracking research as well as other measures such as total reading times, regressions, and total fixation times.

Usually, in research using eye-tracking while reading, learners sit in front of a computer and read text on a computer screen while their eyes are recorded (Figure 6). Learners may also solve reading comprehension tests after their reading exercise.

FIGURE 6.

Example of an eye-tracking while reading task.



Source: SR Research website (2023b).

Figure 6 exemplifies a chin-mount approach in which students rest their chin on the mount while the camera records their eye movements in an eye-tracking with text paradigm.

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One of the first research studies on eye movements during reading dates back to 1879 with the work of the German physiologist Ewald Hering. He created Hering's law of equal innervation highlighting that saccadic movements in animals are produced by the eye muscles and thus each eye movement is proportionally innervated (Bridgeman & Stark, 1977). However, the first studies using eye-tracking in language-related processing started in the mid-1970s and on L2 learners in 2008 with the work of Roberts et al. (2008) (Keating, 2013). Multiple L2 studies have employed eye-tracking with text to better understand L2 learners' reading comprehension processes. However, to the best of the researcher's knowledge, there are no studies researching L2 learners in Costa Rica.

Previous L2 studies had researched for instance how L2 learners comprehend and process pronouns (Roberts et al., 2008) in experimental manipulations. Roberts et al. (2008) conducted a study in which L2 learners had to read three different types of sentences: (1) sentences containing a plural NP or singular NPs in subject position, (2) an adverbial clause with a proper noun in subject position, and (3) a main clause with a subject pronoun. L2 learners had to read the sentences in a computer screen while their eye-movements were recorded by the eye-tracker. One of the main findings is that L2 learners are able to resolve ambiguities when processing L2 pronouns highlighting comprehension of L2 pronouns. They also found that learners' L1 may influence their L2 pronouns processing in written text. Given the relevance and applicability eye-tracking started to have in L2 learning and processing, Dussias (2010) published a short review on its implementation to explore L2 language processing. In regards to eye-tracking with text, the author emphasized that it can be employed to research L2 lexical access and how L2 learners solve lexical and grammatical ambiguities.

Dussia's (2010) article opened up the path for more research into L2 vocabulary learning and processing. For instance, Godfroid et al. (2013) researched L2 learners' attention in incidental word learning. They analyzed if more attention generates more vocabulary learning. Participants were twenty-eight L2 adult learners of English and they were asked to read 20 short paragraphs on a computer screen while their eyes were recorded. Researchers designed four experimental conditions: (1) sentences containing existing English words as targets, (2) sentences with pseudowords as targets, (3) sentences with a pseudoword followed by the existing English word as targets, and (4) sentences with the existing English word followed by the pseudoword as targets. After reading the paragraphs participants answered a surprise vocabulary post-test. Results showed that L2 learners spend more time reading the pseudowords in comparison to the existing English words. Due to the

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implementation of eye-tracking with text researchers were able to demonstrate that more noticing of the pseudowords led to more vocabulary learning gains.

Most studies, by 2015, using the eye-tracking with text paradigm had researched L2 issues with adult learners. However, over the years with the array of findings eye-tracking brought, researchers started to employ eye-tracking with text in younger populations. To illustrate, Tragant-Mestres & Pellicer-Sánchez (2019) carried out an innovative study to research young learners' L2 reading comprehension. Researchers created two experimental conditions, one in which learners read while listening (RWL) a text and another condition of reading only (RO). Participants were learners (N=30) of English as a foreign language and they were instructed to read a story containing images on a computer screen that recorded their eye-movements. Results highlighted that L2 learners tend to spend more time processing the text rather than the images on a story in both RWL and RO conditions. However, learners spend more time processing the images in the RWL condition. Additionally, both conditions seem to elicit similar reading comprehension results; thus, both are effective to enhance L2 young learners' reading comprehension processing. Overall, the results of this study highlight that young learners make use of images when reading and processing L2 texts.

In a more recent study employing eye-tracking with text on words, Huang et al. (2022) researched L2 learners' reading comprehension and its relation with working memory. L2 learners undertook a reading task, while their eyes were recorded, with two different conditions: (1) the text with 17 unfamiliar words as target items, and (2) the text including the L1 translation of the unfamiliar words. Learners also took a reading span task (RST) as a measure of their working memory and a reading comprehension test. Results highlighted that those L2 learners that spent more time reading the unfamiliar words obtained better results in the reading comprehension test. Additionally, learners with higher working memory seem to have an advantage when processing and understanding unfamiliar words.

Eye-tracking with text can also be researched in combination with audio stimuli. Negi and Mitra (2022) researched the use of subtitles in L2 content learning. Learners watched a 12-minute video, while their eyes were recorded, and they were allocated in three different groups: (1) group one watched the video with L2 subtitles, (2) group two watched the video with no subtitles, and (3) group three watched the video with L1 subtitles. Learners also undertook pre and post comprehension tests. The eye-tracking data showed that learners that read the L1 subtitles made more fixations on that area than learners in the other groups. Overall, results showed that having L1 subtitles was more beneficial than L2 subtitles and no subtitles at all in content learning.

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The studies mentioned above illustrate how eye-tracking with text can be employed for different research purposes and the array of L2 research possibilities eye-tracking brings. However, they also demonstrate that studies on eye-tracking with text have not researched neither the Costa Rican nor the Central American population. To the best of the researcher's knowledge, there are no studies in Costa Rica that have researched L2 teaching and learning with the use of eye-tracking. More research studies taking into account non-WEIRD (western, educated, industrialized, rich and democratic (Wen et al., 2022)) populations are required to gain a better understanding of L2 teaching and learning in different regions across the world.

3.3.1.2. Equipment needed to use the eye-tracking while reading paradigm

The same equipment mentioned in section 3.3.1.2 can be used to conduct research studies with the eye-tracking while reading paradigm.

4. DISCUSSION

This article has demonstrated that eye-tracking paradigms are an extraordinary tool to research L2 teaching and learning processes. For instance, employing the visual world eye-tracking paradigm can provide insights into learners' word phonological learning (Escudero at al., 2008), age of acquisition and its influence in L2 learning (Canseco-Gonzalez et al., 2010), the role of L2 proficiency in ambiguity resolution (Ellert, 2013), and processing L2 auditory stimuli (Connell et al., 2018). It has also been shown that eye-tracking with text contributes to explore L2 topics such as L2 pronoun resolution (Roberts et al., 2008), lexical access (Dussias, 2010), L2 vocabulary learning (Godfroid et al., 2013) reading comprehension with images (Tragant-Mestres & Pellicer-Sánchez, 2019), use of subtitles for L2 content learning (Negi & Mitra, 2022), and L2 learners' reading comprehension and working memory (Huang et al., 2022). However, the studies already stated have researched L2 populations from various cultural and socioeconomic backgrounds different from the Costa Rican context. Additionally, many other topics, besides the ones explored in the previous studies, can be researched with the use of eye-tracking attending to current issues in L2 teaching and learning in Costa Rica.

Overall, to start conducting research with eye-tracking it is fundamental to find a gap to be addressed. You may be aware of a didactic need you as an English teacher have or a situation your students are experiencing when completing language tests that should be further explored. You can also review research studies that have employed eye-tracking as they could be replicated in the Costa

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Rican context. Researchers may want to test a theoretical construct or explore an L2 language learning and teaching phenomena occurring in their contexts.

Multiple research topics can be conducted using the visual world and eye-tracking with text paradigms to contribute to the field of English teaching and learning in Costa Rica. Some examples are presented below; however, many other research possibilities are also available and should be explored.

Research options for high-school learners:

1. In Costa Rica, 74% of students who took the PISA (Programme for International Student Assessment) test in 2018 scored in the lowest reading comprehension levels. Are high-school students able to predict upcoming linguistic material in the L1 and in the L2 for the betterment of their reading comprehension skills? When predicting upcoming linguistic material, learners activate lexical information of the context they are encountering for its comprehension (Huettig et al., 2011). A project could employ an experimental design (García-Castro, 2023) to explore if high-school students are able to predict upcoming linguistic material in their L1 and L2 and how it may influence their L1 and L2 reading comprehension skills. The visual-world eye-tracking paradigm could include target images related to the upcoming stimuli. Fixation times and total reading times may shed light on students' predictive abilities.

2. High–school students in Costa Rica have deficiencies in reading comprehension in the L1 (Programa Estado de la Nación, 2021). Are those deficiencies transferred into their L2? A research project addressing L1 and L2 transfer in reading comprehension can be designed with the use of eye-tracking with text. Learners could read ambiguous and unambiguous sentences in the L1 and the L2 and complete reading strategies tests to determine if their reading comprehension skills behave similarly in the L1 and the L2 and if their reading comprehension strategies transfer from one language to another.

Research option for university learners:

1. Phonetic memory seems to contribute to L2 students' vocabulary learning in Costa Rica (García-Castro, 2015). Is phonetic memory mediated by other factors such as frequency of exposure with the target words? Do Costa Rican university learners learn more L2 words depending on the number of times they have encountered them? A research project could explore the effects of frequency and phonetic memory in a visual-world eye-tracking paradigm

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in which participants decode visual images of recently learned words while their eyes are being recorded. The visual world could present a target image and a distractor of the recently learned words controlled by frequency of exposure. Fixation times, total reading times to the target and the distractor can potentially show effects of frequency of exposure that can further be tested for correlations with phonetic memory.

2. University students learning L2 English in Costa Rica seem to suffer from foreign language anxiety (FLA) (García-Castro & O'Reilly, 2022). Do they experience FLA while undertaking reading comprehension tests? Does their FLA interfere in their L2 reading comprehension processes? To explore the topics mentioned above an eye-tracking study can be designed in which learners are tested for FLA while conducting a reading comprehension test in the eye-tracker. The number of fixations, total reading times, and regressions may shed light on reading comprehension difficulties correlated with learners' FLA.

The research options aforementioned are only instances of possible research projects. Hence, they could be modified and improved to suit various research objectives. There are many more multidisciplinary and transdisciplinary research options that can, and should, be proposed for the use of eye-tracking in L2 teaching and learning research in Costa Rica.

It is worth mentioning that the eye-tracking paradigms reviewed in this article offer the possibility to research topics in the field of education and not only in L2 teaching and learning.

5. CONCLUSION

This article sought to describe what eye-tracking is, eye-tracking paradigms, and research options for the use of eye-tracking in Costa Rica. It highlighted that, undoubtedly, the use of eye-tracking brings an opportunity to conduct multidisciplinary research in the field of L2 teaching and learning in Costa Rica to advance the knowledge of L2 teaching and learning processes.

The collection of studies presented demonstrated that there are L2 English teaching and learning issues that could be tackled using the eye-tracking paradigms such as word phonological learning (Escudero at al., 2008), age of acquisition and its influence in L2 learning (Canseco-Gonzalez et al., 2010), the role of L2 proficiency in ambiguity resolution (Ellert, 2013), L2 pronoun resolution (Roberts et al., 2008), lexical access (Dussias, 2010), L2 vocabulary learning (Godfroid et al., 2013) reading comprehension with images (Tragant-Mestres & Pellicer-Sánchez, 2019), use of subtitles for L2 content learning (Negi & Mitra, 2022), amongst others. Nevertheless, the studies also

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showed that there is a lack of research employing eye-tracking in the field of L2 teaching and learning in Costa Rica.

Due to the research gap found on the use of eye-tracking in Costa Rica, research ideas to address L2 issues were discussed. For instance, research suggestions, using eye-tracking, for L2 high-school and university learners were given that could contribute to advance the understanding of current issues in L2 learning in Costa Rica. The present study, undoubtedly, lays the groundwork for future research into multidisciplinary approaches employing eye-tracking paradigms with the Costa Rican population.

Taken together, the results of the studies reviewed and the research suggestions given across this article have made evident the relevance of employing eye-tracking to research current issues in L2 teaching and learning in Costa Rica. However, one of the limitations of this article is that it did not give recommendations to research L2 learning and teaching in primary school children and preschoolers. It is recommended to continue discussing the use of eye-tracking in Costa Rica and to open up the possibilities to conduct multidisciplinary research with that technology.

The Faculty of Education of the University of Costa Rica would greatly benefit from an eye-tracker to conduct multidisciplinary research on various topics in the educational field. One recommendation is then to open up the discussion on the advantages and disadvantages of acquiring an eye-tracker for research purposes.

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