COMPARING A TUTOR-LED AND SOFTWARE-ASSISTED CONSTANT TIME DELAY METHOD FOR TEACHING SIGHT WORDS TO THIRD-GRADE STUDENTS WITH DYSLEXIA

by

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Early reading skills are a strong predictor of later reading achievement and overall academic performance. Children, who are identified as poor readers in third grade tend to continue to struggle with reading throughout their academic journey. Dyslexia is the most prevalent reading difficulty, characterized by problems with accurate and/or fluent word recognition, as well as poor decoding skills. Reading researchers indicate that sight-word training can have a positive impact on the word reading accuracy of primary school students with dyslexia. This study employed an alternating treatment research design to compare the effectiveness and efficiency of a tutor-led and a software-assisted constant time delay method for teaching three third grade students with dyslexia to read Greek irregular sight words. Both instructional conditions employed operant conditioning approaches in order to enhance the learner's motivation towards reading. Results indicated that while both methods were effective, the software-assisted method was marginally more efficient in terms of trials to criterion. The utilization of PowerPoint software yielded favorable results in improving participants' reading accuracy and elevating reading motivation. Advancements in technology are expanding the potential for creating a more customized, stimulating, and interactive learning environment for students with dyslexia.

Keywords: Constant Time Delay, Developmental Dyslexia, Operant Conditioning, Sight Word Reading, Technology- aided instruction

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I. LITERATURE REVIEW

Introduction

The academic achievement of students is typically based on their reading competence, given that many courses in the school curriculum rely on reading skills (Howard-Gosse et al., 2023). Consequently, there is a notable level of interest and research dedicated to identifying the most efficient interventions and instructional approaches to improve reading difficulties during the early years of education (Moats, 2020). Children with dyslexia have been a subject of particular interest in this highly extensive field of research, as dyslexia is the most prevalent reading disability, affecting approximately 80% of individuals identified as having learning disabilities (Elliott et al., 2014; Zhou, 2022). One of the primary reading challenges encountered by children with dyslexia is the difficulty to decode words using conventional phonetic rules (Connor et al., 2009; Dehaene, 2009). In particular, children with dyslexia struggle with reading unfamiliar words due to challenges in mapping phonemes (sounds) to graphemes (letters) (Ehri, 2014). In consequence, students with dyslexia experience difficulties in reading fluency (Burani, 2010´Wyse & Goswami, 2008). Fluency, which comprises accuracy, automaticity, and prosody in oral reading, is a determinant that can either impede or facilitate comprehension during both silent and oral reading (Kuhn et al., 2010). To achieve reading fluency, elementary students must have developed the capacity to read a multitude of words with speed and accuracy by the end of third grade (Lesnick et al., 2010). Multiple exposures to these words are required to develop this skill (Pfost et al., 2010). This process is referred to as sight word reading (Parkin & Robins 2022). Third-grade children with dyslexia demonstrate a deceleration in the process of acquiring sight word vocabulary in comparison to their typically developing reading peers (Gentilini & Greer, 2020). As a result, the act of reading can be laborious and time-intensive task, eventually resulting in minimal gratification and eliciting negative emotions (Alexander-Passe, 2006; Mugnaini et al., 2009; Yanhong et al., 2020).

Reading Ability

Reading ability, defined as adequate language comprehension and accurate and fluent word decoding (Kamhi & Catts 2014; Vellutino et al., 2004), has a significant impact on academic achievement and on the outcomes for life in general (Carnine, L., & Carnine, D., 2004; Irwin et al., 2007). Early reading ability is a strong predictor of later reading achievement and overall academic performance (Sparks et al., 2014).

There exist two developmental theories that underlie the differential reading progress observed in children with reading disabilities compared to their peers without those disabilities. These theories are the developmental lag model and the developmental deficit model (Quinn et al., 2020). According to the developmental lag model, children with reading disabilities initially exhibit inferior reading abilities compared to their peers. Nevertheless, as time progresses, these children gradually reduce the disparity and ultimately achieve a comparable level of reading competence, provided that appropriate instructional techniques and interventions are used (Pfost et al., 2014). The developmental deficit hypothesis proposes that children who have reading disabilities struggle with reading due to an inadequately developed skill (Francis et al., 1996). Their reading difficulties might potentially pertain to their proficiency in word reading, such as phonological awareness or decoding abilities

(Snowling et al., 2020), or their competence in language understanding, such as vocabulary knowledge or background knowledge (Gersten et al., 2001; Spencer & Wagner, 2018; Spencer et al., 2019). According to the developmental deficit theory, students who experience these issues will consistently struggle to acquire reading skills, resulting in a widening gap throughout their schooling (Pennington, 2006; Scarborough, 2002). Several recent studies (Morgan et al., 2008; Ferrer et al., 2015) have provided evidence supporting the validity of the lag model. Morgan et al. (2008) and Ferrer et al. (2015) suggest that early detection of dyslexia is critical in order to enable children to fully develop their reading skills and eventually attain a reading proficiency level comparable to that of their peers. In either case, a considerable proportion of elementary school students who are identified as poor readers in the third grade will continue to face reading difficulties throughout their high school education if interventions and instructional strategies that improve their reading readiness are not implemented effectively.

The Significance of Third-Grade Reading Ability

Researchers emphasize the significance of acquiring proficient reading abilities throughout the early stages of school, since a student's reading proficiency in third grade serves as a crucial indicator of their future academic success (Lesnick et al., 2010; Pfost et al., 2010). Research has demonstrated a gap of 1,300 word families between students with reading difficulties and their on-grade level peers by third grade (Duff & Brydon 2020). This gap persists throughout the students' academic journey (Gentilini & Greer, 2020). Research has shown a clear link between reading performance in the third and eighth grades. Students who are reading at or above grade-level by third grade are more inclined to continue their education in high school following middle school (8th grade marks the end of middle school in the US and

UK) and to effectively enroll in and graduate from college. In contrast, students who are reading below the third-grade level are more likely to drop out of high school compared to their peers (Daniel et al., 2006; Hernandez, 2011; Lesnick et al., 2010). Children who read at or above grade-level by third grade are more likely to enroll in and graduate from college, while students reading below grade-level are more likely to drop out of high school compared to their peers (Daniel et al., 2006). Studies have specifically shown that third-grade students who do not have a strong level of reading ability are four times more likely to drop out of high school (Hernandez, 2011). In addition, those with lower reading proficiency are more prone to encountering emotional, behavioral, and social difficulties in the early stages of adolescence (Hwang & Duke, 2020; Irwin et al., 2007; Miles & Stipek, 2006; Morgan et al., 2008; Perry et al., 2008). Furthermore, as reported by Nelson and Manset-Williamson (2006) during the 3rd grade of primary school, a considerable number of students who are at risk of experiencing difficulties with reading undergo a decrease in their motivation to read.

A study examining the viewpoints of educators regarding the pivotal nature of third grade offer insight into why this grade has significant importance in the process of acquiring proficiency in reading (Blazar & Kraft, 2017). Teachers believe that during this school year, students move from learning to read to reading to learn, as they are anticipated to comprehend informational texts that include factual information, requiring them to comprehend the content rather than just deciphering words using the alphabet. Based on data from the Education Commission of the States (Atchison & Diffey, 2018; Workman, 2014), it has been seen that the more skilled readers in the class acquire knowledge and expand their vocabulary through contextual understanding, but struggling readers, due to their frustration, start to actively avoid reading. An inescapable circle ensues: Contemporary school tasks are progressively demanding students to possess prior knowledge and a deep understanding of academic vocabulary and specialized terminology (including literary, abstract, and technical terms). These skills are developed via the act of reading (Atchison & Diffey, 2018). Meanwhile, courses such as physics, social studies, and mathematics heavily depend on textual interpretation, causing struggling readers to lag behind in these areas as well (Workman, 2014). Consequently, they steadily fall behind their peers in their educational endeavors, leading to a considerably higher rate of student attrition (Atchison & Diffey, 2018).

In addition, children who do not achieve the expected reading level by the end of third grade are usually aware that they are not meeting the standards set by their school or their family (Kempe et al., 2011). As a result, they may feel impotent and inferior, which can make it challenging for them to develop a positive self-perception (Alexander-Passe, 2006). The absence of confidence, mostly triggered by the stigmatization experienced in the elementary school setting, might lead to social seclusion (Huang et al., 2020) or potentially aggressive behavior (Sako, 2016).

Given the enduring presence of reading difficulties and the significant impact of reading on multiple domains of development, such as academic, behavioral, emotional, and social aspects, many studies have explored the complex relationship between cognitive and motivational factors that forecast reading achievement outcomes during early and middle childhood (Fluss et al., 2009; Hwang & Duke, 2020; Lepola et al., 2000; Park, 2011; Taboada et al., 2009; Tarchi, 2017). These studies have been grounded in two theoretical frameworks: The cognitive learning theory and the operant conditioning theory.

The Cognitive and Operant Conditioning Approach to Reading

In his theory of cognitive development, Piaget (1936) proposed that humans progress through four developmental stages: sensorimotor stage, preoperational stage, concrete operational stage, and formal operational stage (Feldman, 2004). During the sensorimotor stage (0–2 years old), infants progressively construct knowledge through the fundamental senses of seeing, hearing, touching, and tasting. In the preoperational stage (2–7 years old), children begin to think symbolically and learn to use words and pictures to represent objects. During the concrete operational stage (7–11 years old), thinking becomes more logical and organized, but still very concrete. The final stage of Piaget's theory, the formal operational stage (11 years old through adulthood), involves an increase in logic, the ability to use deductive reasoning, and an understanding of abstract ideas. Piaget's theory of the age-related development of academic and pre-academic behaviors served as the foundation for a comprehensive perspective on the development of reading ability (McLeod, 2018). Today's research on reading ability development places emphasis on three distinct areas: language development, which involves the capacity to understand and comprehend spoken language, cognitive abilities associated with auditory, phonological, visual, and semantic processing, and literacy skills encompassing vocabulary, spelling, and reading comprehension (Christopher et al., 2012; Horowitz-Kraus et al., 2017; Sheldrick & Perrin, 2013). The developmental trajectory of reading acquisition within the language domain starts with babbling during the initial year of life, progresses to the generation of isolated words in the second year, and subsequently broadens the vocabulary to achieve fluent speech by the age of eight. The cognitive development of reading acquisition starts in early infancy with the exploration and manipulation of objects. As children mature, they learn to identify and correlate colors and forms, ultimately leading to the comprehension of complex instructions by the age of eight. Literacy skills develop gradually, beginning with early interactions with books that involve manipulation and verbal exploration and progressing to later stages where toddlers visually recognize and point to images, manipulate pages, and participate in pretend reading by the age of four. By the age of five, children frequently develop a link between letter sounds and their matching symbols, a milestone that paves the way to reading (Horowitz-Kraus et al., 2017). The milestones in reading acquisition during ages zero to eight years in the three different domains that underlie reading (language, cognitive ability, and literacy abilities) are summarized in Figure 1.

Piagetian theorists can predict what human beings will do at certain ages. By their nature these theories provide generic knowledge pertaining to individuals with average characteristics (Alberto & Troutman, 2022, p. 15). However, Skinner asserts that formulating a broad prediction regarding the conduct of an average person lacks practicality in addressing the needs of a specific individual (Skinner, 1953, p. 19). Skinner's operant conditioning theory not only predicts human behavior, but also provides explanations for it and offers potential avenues for behavior modification. Skinner's theory of operant conditioning largely focuses on the examination of behavior consequences and the construction of functional relationships between behavior and its outcomes. In operant conditioning learning, academic behaviors are acquired and modified through their association with consequences. Operant conditioning reading instructional methods employ three common components within a learning trial. First, the learner is presented with a word (i.e., antecedent or stimulus). Second, the learner has an opportunity to respond to the stimulus. Third, once a response is emitted, the learner receives feedback. This learning trial applies the use of the three-term contingency model - also referred to as the ABCs of behavior (antecedent-behavior-consequence), (Skinner, 1945).

The main component of Skinner's operant conditioning theory is reinforcement (Schieltz,2019). Skinner proposed that behavior that receives reinforcement is more likely to be repeated and enhanced, whereas behavior that is not get reinforced is more likely to diminish or weaken. Reinforcement works in two distinct modes: "positive" and "negative" (Skinner, 1958). While different strategies can be used depending on the situation, experts believe that positive reinforcement, rather than negative reinforcement or punishment, should be used more frequently (Schieltz, 2019). Positive reinforcement increases the probability of a desired response by the addition of a stimulus. Anything that reinforces a particular response, such as verbal praise, is a positive reinforcer (Mills, 1978). Contrarily, negative reinforcement enhances the probability of a response by means of the removal or reduction of an undesired stimulus, like studying for an exam to avoid getting poor grades. Both forms of reinforcement serve to enhance behavior, hence augmenting the probability of its recurrence (Sundberg, 2013). Figure 2 illustrates the three-term contingency or A-B-C (Antecedents-Behavior-Consequences) model of operant conditioning theory, showcasing examples of word reading practice.

Numerous studies have utilized the principles of operant conditioning, specifically the three-term contingency model, along with the techniques of prompting, fading, and differential reinforcement, as a theoretical framework to investigate reading acquisition in students with reading difficulties (Buttigieg, 2015; Greer et al., 2011; Greer & Ross, 2008; Longano & Greer, 2014; Singer-Dudek et al., 2010; Tsai & Greer, 2006). The consensus among researchers is that a strong interest in reading plays a crucial role in achieving reading proficiency, particularly for children who encounter challenges in reading, such as those with dyslexia. The occurrence of reinforcement through operant conditioning methods leads to an increase in students' intrinsic interest in reading (Gentilini & Greer, 2020). The researchers emphasized the necessity for further research to explore optimal and successful strategies for cultivating diverse reading abilities among elementary-level students who struggle with reading and lack conditioned reinforcement for reading material, which subsequently impacts their academic performance (Gentilini & Greer, 2020).

Reading and Dyslexia

Difficulties in acquiring reading skills are experienced predominantly by children with dyslexia (Elliott et al., 2014). The National Dyslexia Measurements Across Europe Report (2022) indicates that the prevalence rates of dyslexia in Europe range from 5% to 7%. Similarly, a study conducted by the National Institutes of Health (2021), shows the prevalence of dyslexia in the United States to be estimated between 5% to 10%.

According to the definition provided by the American Psychological Association (APA, 2015) dictionary, dyslexia is a learning disability that is characterized by significant challenges in the areas of reading, spelling, and writing. Dyslexia may be classified as either acquired, known as alexia, or developmental, referred to as developmental dyslexia. Children with developmental dyslexia (hereafter dyslexia) face challenges in the domains of reading and spelling, irrespective of their cognitive abilities (Lyon et al., 2003). Evidence for this comes from research findings indicating that a notable proportion of students diagnosed with dyslexia, who encounter challenges in reading, exhibit remarkable proficiencies in the domain of mathematical problem-solving (Fletcher, 2009; Snowling et al., 2020).

Dyslexia is mainly characterized by problems with accurate and/or fluent word recognition, as well as poor decoding skills. Children diagnosed with dyslexia face considerable challenges in acquiring the ability to connect spoken language with written language (Ehri, 2005; Norton et al., 2015; Snowling et al., 2020; Stein, 2018). Some reading researchers define dyslexia as a basic phonological deficit, since they claim that the primary cause of dyslexia is in the inability to appropriately process speech sounds (Adamson et al., 2008, Dehaene, 2009; Serena et al., 2019; Vellutino et al., 2004). However, the phonological deficit hypothesis has been challenged by the recognized heterogeneity among individuals with dyslexia and the existence of several reports of people with dyslexia with no apparent phonological deficit (Catts et al., 2017; McArthur, 2015; Ramus, 2008; Caccappolo-van Vliet, 2004).

The Phonological Deficit Hypothesis

Identifying the causes of dyslexia has been a primary focus for reading researchers. The initial claim posited that dyslexia may be rooted in a visual or visual memory impairment (Hinshelwood, 1900, 1917; Orton, 1925). Nevertheless, starting from the late 1970s, the prevailing theory indicates dyslexia is not primarily a visual impairment, but rather a language impairment, specifically related to phonological deficit (Anthony & Francis, 2005; Adamson et al., 2008, Boets et al., 2007; Connor et al., 2009; Dehaene, 2009; Wyse & Goswami, 2008).

In his book "Reading in the Brain," Dehaene asserts that the majority of children with dyslexia have “a problem with single-word decoding, which itself is due to an impairment in grapheme-phoneme conversion” (Dehaene, 2009, p. 239).

However, numerous reading researchers contend that this hypothesis presupposes the presence of a single, dominant form of dyslexia caused by the phonological deficit. They contend that this premise is flawed since the complexities of dyslexia limit the identification of a single cause (Castles & Friedmann, 2014; Catts et al., 2017; McArthur, 2015; Ramus, 2003; Caccappolo-van Vliet, 2004).

Numerous researchers in the field of reading concur that the copious documentation of developmental surface dyslexia is a particularly persuasive piece of evidence that challenges the phonological deficit theory (Ahissar, 2007; Goswami, 2003; Peterson & Pennington, 2012; Ramus & Szenkovits, 2008; Share, 2021; Stein, 2018; Tree & Kay, 2006). Children with this particular type of dyslexia do not encounter challenges in converting graphemes to phonemes, as they possess the ability to phonetically decode words with regular spellings. However, they face significant difficulties in decoding irregular print-to-sound words as they pronounce them in accordance with grapheme-phoneme rules. In essence, children with surface dyslexia exhibit a rigid adherence to the grapheme-phoneme norms, which results in their misreading of words that deviate from the standard rules. For instance, they articulate the "a" in the terms "early" and "earth" or the "l" in the words "half" and "talk"(Castles & Friedmann, 2014; Ramus & Szenkovits, 2008; Stein, 2018).

While holding divergent opinions regarding the absolute nature of the phonological deficit theory, the majority of the aforementioned reading researchers openly recognize the heterogeneous nature of dyslexia and the varying degrees to which it manifests in different languages. Research indicates that children with dyslexia exhibit different reading performance according to the language they are learning to read (Carioti et al., 2021; Provazza et al., 2022). In fact, research has demonstrated that an inconsistent spelling system can exacerbate certain symptoms associated with dyslexia (Miles, 2000; Moore et al., 2023). The determinant of spelling consistency is commonly referred to as orthographic depth.

The Impact of Orthographic Depth

The notion of orthographic depth refers to the complexity, consistency, or transparency of the connections between graphemes and phonemes in a written alphabetic language, and significantly influences the accuracy of word reading (Schmalz et al., 2015). Multi-letter graphemes and context-dependent rules result in a many-to-many mapping of graphemes to phonemes in deep or opaque orthographies such as presented by the English language (Borleffs et al., 2017). Shallow or transparent orthographies, such as Finnish, are distinguished by constant one-to-one mapping of graphemes to phonemes (Seymour et al., 2003). The general finding is that children with dyslexia learning to read in a transparent orthography outperform children learning to read in an opaque orthography in terms of word reading accuracy (Diamanti et al. et al., 2011; Serrano & Defior, 2008; Sprenger-Charolles et al., 2011).

The Greek language, which is of particular relevance to this discussion as the present study has been conducted in Greece with Greek speaking learners, is characterized by a notable degree of transparency (Protopapas & Vlahou 2009). However, the reading and spelling accuracy of Greek words is primarily determined by their morphology and etymology, which are frequently dependent on the word's origins and can be rather complicated (Mouzaki et al., 2021). Multiple correspondence, i.e., where one phoneme corresponds to more than one graph; simultaneous correspondence of two or more phonemes in the same graph; and, to a lesser extent, mismatch, i.e., where graphs without a corresponding phoneme are used, characterize the Greek orthographic system (Porpodas, 2001; Georgiou, 2008).

Because of the several morphological categories and the historical evolution of words, Greek orthography is complicated [illegible] peculiarities, notably in the use of vowels (Mouzaki et al., 2021). As an illu[illegible]s worth noting that the letter "i" in Greek may be represented by six distinct forms, namely: "ι, η, υ, ει, οι, υι" (Protopapas & Vlahou 2009). According to research, the complex structure of the Greek language is connected to the various types of errors produced by Greek students with dyslexia, with the majority of their errors being morphological and spelling errors rather than phonological errors (Andreou & Baseki, 2012; Protopapas et al., 2013). As a result, word reading accuracy is dependent not only on the reader's phonemic awareness, but also on his visual-spelling lexicon and morphological knowledge (Mouzaki et al., 2021; Papadopoulos, 2001). According to this "dual-route theory," as it is commonly referred, words are read either by converting graphemes to phonemes (phonological route) or by directly associating orthographic features with the lexical entry (visual route) (Coltheart, 2008). However, multiple recent studies on word reading have indicated that the interconnection of these two routes is crucial for achieving higher levels of word reading accuracy (Critten et al., 2019; Franceschini et al., 2021; Macchi et al., 2019; Soares et al., 2022). This holds true for both languages with opaque orthographies, such as French (Macchi et al., 2019), and languages with transparent orthographies, such as Brazilian Portuguese (Soares et al., 2022).

Orthographic Mapping and Orthographic Facilitation

Ehri (2005, 2014, 2022) states that the optimal storage of words occurs when there are established visual-phonological linkages between the spelling and pronunciation of words. By converting the written form of a word into its spoken form, orthographic information is retained, and grapheme-phoneme connections may be acquired without explicit instruction during reading (Ehri, 2005; Levlin & Mentzer

2020). This method is known as orthographic mapping (Ehri, 2014). The process of orthographic mapping is crucial for achieving word reading accuracy, especially for students with dyslexia (Ehri, 2014). Other studies indicate that incorporating written representations in spoken word learning can enhance word reading accuracy in children with dyslexia (Baron, 2018; Lavidor, 2006; Ziegler, 2007). This approach, referred to as orthographic facilitation, asserts that integrating written forms of words into the process of acquiring spoken vocabulary, improves both the understanding of the connections between spoken sounds (phonemes) and letters (graphs), as well as the learning and retention of spoken words (Baron, 2018).

According to the aforementioned studies, the process of word reading can manifest in various ways. Nevertheless, there exists evidence suggesting that children diagnosed with dyslexia can derive advantages from sight word reading (Anthony & Francis, 2005; Armstrong & Squires, 2015; Boets et al., 2010). This approach involves the automatic reading of high-frequency words with irregular spellings, which are typically impervious to decoding (Parkin & Robins 2022). Numerous reading researchers suggest that sight word reading can be a successful approach in supporting elementary students with dyslexia to address their phonological deficit (Adamson et al., 2008; Ehri, 2005; Boets et al., 2010; Snowling et al., 2020). In addition, multiple studies have shown that sight word reading can be beneficial for children with dyslexia, helping them to overcome the perception of reading as a difficult task (Anthony & Francis, 2005; Armstrong & Squires, 2015; Bjorklund, 2011), thus enhancing their motivation to engage in reading (Hwang & Duke, 2020; Joachim & Carroll, 2018; Lepola et al., 2000; Morgan et al., 2008; Park, 2011).

The Benefits of Teaching Total Word Structure to Children with Dyslexia

Historically, there have been two primary methodologies to teaching words: the "sight-word/whole-word method" and the "phonics" method (Parker, 2018). Phonics-based instruction focuses on teaching the correspondence between phonemes, the smallest units of sound in language, and the graphemes, or letters, which represent them. The whole-word method focuses on teaching children to read by emphasizing the recognition of words as complete units of language (Levlin & Mentzer, 2020; McArthur et al., 2015). Multiple studies have investigated the effectiveness of these two teaching methods. A wealth of studies supports the role of decoding (phonics) as a key foundation for reading (Anthony & Francis, 2005; Adamson et al., 2008, Boets et al., 2007; Connor et al., 2009; Wyse & Goswami, 2008). Furthermore, many reading researchers agree that phonics reading plays an important role in the acquisition of sight word reading (Ehri, 2005; Levlin & Mentzer 2020; McArthur et al., 2015; Snowling et al., 2019).

Ehri's (1992, 2005, 2014, 2022) connectionist theory posits that the whole-word method helps in retaining the connections between spelling and sound in memory and affects the processing of phonological components and phonological memory for words. Perfetti and Hart’s (2002) theory as well as recent studies on reading words in isolation (Ehri, 2022; Levlin & Mentzer 2020) suggest that when students with dyslexia are repeatedly exposed to unfamiliar words, they gradually gain implicit knowledge of the relationship between graphemes and phonemes and improve their accuracy in word reading. Furthermore, several studies have concluded that sight word training would lead to statistically significant gains in reading accuracy (Levlin & Mentzer, 2020; Vellutino et al., 2004) or speed (Ehri, 2014; Torgesen et al., 2001) for children with dyslexia.

The Relevance of the Order of Sight Word and Phonics Training

Previous research has revealed that different orders of sight word training and phonics training have different effects on the reading skills of children with reading difficulty, namely phonics training followed by sight word training, sight word training followed by phonics training, or phonics training and sight word training being implemented simultaneously (McArthur et al., 2015; Rose, 2006). Rose (2006), in her study on children, who exhibited reading difficulties, in kindergarten and first grade, found that engaging in phonics reading prior to sight word reading enhanced children's ability to fully interpret or decode regular words that were unknown to them, as well as partially decode irregular words that were unfamiliar to them. The aforementioned study resulted in the deduction that repeatedly decoding a word - either fully or partially - creates full or partial representations of the whole word.

In another study, conducted by McArthur (2015), it was determined that there was no statistically significant difference in the outcomes observed among children with dyslexia aged 7 to 12 years, who received different training sequences, especially phonics prior to sight words, sight words prior to phonics, and simultaneous instruction of phonics and sight words. However, sight word training before phonics training had a significant influence on trained irregular word reading accuracy, whereas phonics before sight word training had a significant impact on untrained irregular word reading accuracy. The mixed technique (teaching phonics and sight words at the same time) revealed no overall advantage or disadvantage on trained and untrained irregular word reading accuracy.

Both of the aforementioned studies (McArthur et al., 2015; Rose, 2006) also discussed the impact of age on phonics instruction, finding that phonics training tends to have a more pronounced effect on younger children (up to 8 years old) compared to older children overall. The idea presented is supported by Suggate's (2010) meta-analysis, along with additional studies that affirm the importance of systematic phonics instruction in learning to read in the first grade (Brunsdon et al., 2002; Ehri et al., 2001; Schaars, et al.,2017). Conversely, whole word instruction has been found to have notable impacts on the reading accuracy of irregular words in children with dyslexia, who are 8 years old and above (Brunsdon et al., 2002; Rowse & Wilshire, 2007).

Optimizing Sight Word Reading: Flashcards & Operant Conditioning Approaches

A common method used to teach sight words in children with dyslexia is the use of flashcards (Kaufman et al., 2011). When instructors employ flashcards utilizing operant conditioning approaches, there are three common components within a learning trial. First, the learner is presented with a word written on a flashcard (i.e., antecedent). Second, the learner has an opportunity to respond to the stimulus. Third, once a response is emitted, the learner receives feedback. This learning trial represents a three-term contingency (i.e., antecedent-behavior-consequence) (Kim et al., 2023). Researchers examining the use of flashcards to teach reading through applied behavior analytic practices commonly manipulate antecedent or consequent events (Zhi et al., 2023).

In the realm of antecedent manipulation, research has examined the impact of flashcards with or without visual aids as pictures, arrows, colored letters (e.g., Helda, 2019; Kaufman, 2011; Sartika, 2020). According to a recent broad review encompassing 40 studies, the majority of researchers reached a consensus that the incorporation of both visual images and printed words on flashcards had a positive impact on response accuracy (Zhi et al., 2023).

In addition, empirical research has shown that the use of flashcards with one word printed on each card, accompanied by prompts requiring learners to identify the word or read it aloud (e.g., "what is the word" or "read the word,"), leads to significantly positive outcomes in terms of generating precise and correct replies (Ruwe et al., 2011; Crowley et al., 2013). Furthermore, research has indicated that the transition from easy to difficult irregular words throughout the experimental session yields more favorable outcomes in terms of accuracy (McArthur et al., 2015). McArthur et al. (2015), conducted a study to evaluate the accuracy of reading irregular words in two groups of children with dyslexia. In each training session, both groups were provided with a collection of 24 irregular words, exhibiting a range of difficulty levels. The first group, including 36 elementary students, started their training with irregular words that were comparatively less complex, particularly those containing fewer syllables. Following that, students received instruction on more complex irregular words, predominantly those with multiple syllables. The examination of the 24 irregular words in the second group including 32 elementary students, was undertaken in a randomized order, without considering the varying levels of difficulty. The first group of participants demonstrated comparatively superior outcomes in relation to reading accuracy. Several review articles on different methods of irregular words instruction indicate that sequencing tasks from easy to difficult is a key to improving the motivation of struggling elementary readers (Colenbrander et al., 2020; Margolis & McCabe, 2003).

Research on the three-term contingency model applied to children with reading difficulties has demonstrated that common consequences for sight word reading training include the use of positive reinforcement for accurate responses and error correction for wrong answers (Joachim & Carroll, 2018). Verbal praise and nonverbal communication, such as smiling, nodding, and giving a thumbs up, are the prevailing methods of positive reinforcement employed in flashcard lessons (Fitrianti et al., 2018). Tangible reinforcers, which entail the provision of edible rewards such as candies, snacks, or tangible rewards such as toys, money, tokens) have also been employed primarily in research with preschool and early school participants (Hardy & McLeod, 2020). Several studies have reported secondary outcomes indicating that the implementation of designated play periods, following the completion of a task, in which children are allowed to engage in enjoyable activities of their choosing, is particularly effective in promoting task completion (Crowley et al., 2013; Helda, 2019; Sage et al., 2016).

In relation to the instructional approach, research has shown that using direct flashcard instruction significantly improves the acquisition of sight words (Crowley & Kahn, 2013). Furthermore, studies indicate that employing response-prompting teaching techniques, such as time delay approaches, has proven to be efficacious in enhancing sight word reading proficiency among students with reading difficulties (Aldosiry, 2022). Two of these time delay methods are: a) progressive time delay, which involves gradually increasing the time before delivering a controlling prompt, and b) constant time delay, which involves delivering prompts at consistent intervals.

The Efficacy of Constant Time Delay Response-prompting

Response-prompting techniques are a form of systematic instruction based on the principles of applied behavior analysis (Collins, 2012). Researchers have identified six distinct response-prompting procedures: (a) graduated guidance (guidance as needed on a moment to-moment basis), (b) most-to-least prompting (decreasing assistance), (c) system of least prompts (increasing assistance), (d) progressive time delay (increase time before delivering controlling prompt), (e) constant time delay (delivering prompts at constant intervals), and (f) simultaneous prompting (delivering prompts with a 0-second delay interval), (Collins et al., 2018).

The prompting procedure that has been shown to be successful in enhancing sight word reading for children with reading disabilities is constant time delay (CTD) (Aldosiry, 2022; Appelman et al., 2014; Chazin & Ledford 2021; Coleman et al., 2012; Hughes & Fredrick, 2006; Hughes et al., 2002). The CTD procedure was developed as a method for transferring stimulus control from a prompt to the target stimulus by introducing a predetermined time delay between the presentation of the stimulus and the provision of a controlling prompt, thereby ensuring the student's accurate completion of the response initially but also ensuring independent responding as the time delay allows for independent responses to take place (Bradley & Noell, 2018). Additionally, the CTD approach allows for differential reinforcement. For example, the teacher can offer higher or lower quality reinforcement depending on the quality of the response. Initially, the teacher will provide lower quality reinforcers for prompted responses and for attempts to respond, slightly higher quality reinforcers for partially assisted responses and eventually high-quality reinforcers for independent responses (i.e., when the student beats the prompt)

(Chazin & Ledford 2021). As Skinner proposed, the use of a time-based schedule of reinforcement may effectively cultivate children's initial enthusiasm in reading and sustain their engagement even when they are confronted by a more difficult vocabulary (Evans, 1968, p. 73).

From Deficit Remediation to Capacity Building: The Strength-based Approach

The majority of the previously mentioned studies that utilized applied behavioral analysis techniques in the context of sight word reading argue that enhancing reading accuracy could potentially boost the reading motivation of children diagnosed with dyslexia (e.g. Aldosiry, 2022; Appelman et al., 2014; Bradley & Noell, 2018; Chazin & Ledford 2021; Coleman et al., 2012; Colenbrander et al., 2020; Hughes & Fredrick, 2006; Joachim & Carroll, 2018; Margolis & McCabe, 2003). This hypothesis is supported by a number of studies, which indicate that children with dyslexia experience frustration and subsequent avoidance of reading activities when they misread words (Morgan et al., 2008; Soriano-Ferrer et al., 2014; Zeinab et al., 2011). Insufficient motivation within the educational environment, in conjunction with traditional pedagogical methods that neglect the unique needs of children with dyslexia, undermines their drive to read (Morgan et al., 2008; Colenbrander et al., 2020).

Skinner's approach to learning, as outlined in his book “The Technology of Teaching” (1968), has had a considerable effect in education. Skinner contended that the basic purpose of education is to instill in children an excitement for learning in order to actively participate rather than passively receiving information (Skinner, 1961). He emphasized the importance of teachers customizing instruction to meet the unique needs of students and consistently providing positive reinforcement (Martens

& Witt, 2004). Skinner highlighted the significance of positive reinforcement in enabling individuals to fully realize their potential and nurture their talents (Gordan & Krishanan, 2014). The novel "Walden Two" by Skinner, published in 1948 (Skinner, 1976a), portrays the children as being characterized by their vigor, curiosity, and happiness (Skinner, 1976a, p. 110). In a cooperative society like the fictitious "Walden Two," positive reinforcement encourages exploration, variation, and creativity (Moxley, 2006). Additionally, the belief is that education should solely revolve around life itself (Skinner, 1976a, p. 115). Adams (2012) argues that Skinner's worldview in “Walden Two” is a precursor of positive psychology. The Positive Psychology movement, launched in 2000 by Seligman and Csikszentmihalyi, focuses on the scientific study of positive human functioning and flourishing across various aspects of life, including biological, personal, relational, institutional, cultural, and global aspects (Keyes et al., 2011).

There has been a change in the way the scientific and educational world views dyslexia. This change involves using creative teaching methods that focus on the unique abilities of children with dyslexia, rather than just focusing on their weaknesses (Sepulveda & Nicolson 2020; Tsang & Leung, 2006). Contrary to viewing dyslexia as a weakness (deficit model), researchers and educators have started recognizing some areas in which children with dyslexia have remarkable skills that exceed expectations (compensation model), (Kannangara et al., 2018). A number of studies offer empirical evidence for the efficacy of the strength-based approach, highlighting the existence of distinct strengths linked to dyslexia. These strengths include exceptional visual-spatial ability, the capacity to perceive the big picture, heightened creativity, and divergent thinking (Alexander-Passe, 2017; Attree et al., 2009; Everatt et al., 2008; Kannangara et al., 2018; Simmons & Singleton, 2009).

Visual-spatial ability is the ability to comprehend and conceptualize visual representations and spatial relationships and includes a set of skills in the areas of spatial relations, visualization, visual memory, closure speed, and spatial scanning (Mather & Wendling, 2005). Studies investigating the relationship between dyslexia and visual-spatial ability have produced inconsistent results. Visual-spatial abilities associated with dyslexia have been reported to be superior (Alexander-Passe, 2017; Attree et al., 2009; Duranovic et al., 2015; Everatt et al., 2008), inferior (Von Károlyi & Winner 2005; Tafti et al., 2009), or average (Lipowska et al., 2018). Nevertheless, even in studies that do not corroborate the presence of superior visual-spatial abilities associated with dyslexia, there were certain tests in which individuals with dyslexia outperformed non-dyslexic participants (Chong et al., 2018). The visual-spatial abilities of individuals with dyslexia appear to strongly influence their career choices in fields such as fine arts, graphic design, and architecture (Newman and Sternberg, 2012; Wolff & Lundberg, 2002).

Other areas of enhanced ability that are consistently reported as being typical of people with dyslexia include possessing the capacity to perceive the big picture, both figuratively and literally (e.g., West, 2005; Montgomery, 2013). This capacity entails an enhanced ability to reason in multiple dimensions (e.g., Eide and Eide, 2011; Gyarmathy, 2020). Further strengths associated with the capacity to perceive the big picture include the ability to discern and deduce information pertaining to complex systems, as well as to establish correlations between various perspectives and domains of knowledge through the recognition of patterns and analogies (Eide and Eide, 2011). The big picture capacity associated with dyslexia is a definite advantage in business (Alexander-Passe et al., 2017). While the prevalence of dyslexia is 5-10% in the United States (National Institutes of Health, 2021), 35% of entrepreneurs (Logan, 2009), and half of the most successful entrepreneurs experience dyslexia (Powers et al., 2021).

Numerous studies have documented empirical support for the hypothesis that individuals with dyslexia possess heightened creative capacity across various domains, including literary innovation and freeform drawing (Chakravarty, 2009; Tafti et al., 2009). Research on creative ability has also demonstrated an enhanced capacity for integrating and executing unusual combinations of ideas as well as heightened ability in tasks requiring novelty, insight, and more inventive modes of thinking (Cancer et al., 2016). The proficiency in these skills, coupled with their acquaintance with technology, enables them to thrive in professions such as software designers and systems analysts (Taylor & Vestergaard, 2022).

Engineering students enrolled in postsecondary education have an especially high prevalence of dyslexia (Taylor & Vestergaard, 2022). Lemon and Shah (2014) reported in a study encompassing multiple institutions in the United Kingdom and four-degree disciplines (medicine, dentistry, engineering, and law) that the prevalence of self-identified dyslexia was 28% in engineering and 5% in law.

Studies have demonstrated that the school environment and instructional methods may either amplify or hinder the specific skills of children with dyslexia (Kapoula et al., 2016). A differentiated system of learning that adapts instruction to the specific abilities of students with dyslexia may increase both their reading motivation and achievement (Ngong, 2019).

The Role of Multisensory learning

Multisensory learning is an effective instructional approach that caters to the unique abilities of students with dyslexia and enhances both their reading motivation and achievement (Supriatna & Ediyanto, 2021). Multisensory learning refers to an instructional approach wherein the topic of instruction is delivered across many sensory modalities, such as visual, auditory, and tactile, as opposed to relying solely on a single modality (American Psychological Association, 2015).

A body of research indicates that students with dyslexia exhibit enhanced learning outcomes when information is presented across many sensory channels simultaneously (Boardman, 2020; Nijakowska, 2013; Schlesinger & Gray 2017; Supriatna & Ediyanto, 2021). The aforementioned studies suggest that students with dyslexia comprehend and synthesize information more effectively because they can use more than one sensory input to make connections between facts or understanding (Nijakowska, 2013; Schlesinger & Grey 2017; Supriatna & Ediyanto, 2021). In addition to facilitating the acquisition of knowledge, the implementation of multimodal teaching methods has been found to elicit increased levels of motivation among learners with dyslexia (Boardman, 2020; Schlesinger & Grey, 2017).

Luque (2022) conducted a survey in 27 primary schools in Barcelona to document the impact of multisensory learning on the accuracy and speed of word reading. The study was conducted in two phases and involved participants with dyslexia as well as students with typical reading abilities. In the initial stage, the conventional method of text reading was employed to instruct vocabulary. During the second phase, students received guidance on vocabulary learning using three sensory modalities: visual, auditory, and kinesthetic/tactile. These modalities were utilized via movies (visual), music (auditory), dance (kinesthetic), and computer games (visual, auditory, and kinesthetic/tactile). The initial stage's results were discouraging for children with dyslexia, as they exhibited below-average performance in terms of word reading speed and considerably below-average performance in reading accuracy. The outcomes of the second phase, subsequent to the implementation of multimodal learning approaches, were quite positive. Children with dyslexia demonstrated above-average word reading speed and average reading accuracy.

In a study conducted by Ngong (2019), the effectiveness of the Multisensory Learning Approach in teaching word reading to students with dyslexia in ordinary primary schools was investigated. The study sample consisted of 24 fifth-grade students with dyslexia, who were selected from two schools in Cameroon. The students were then divided into four groups, with each group consisting of six pupils. Two of the groups were experimental groups, while the other two were control groups. The experimental groups were taught using the multisensory learning approach utilized simultaneous engagement of at least two sensory modalities (visual, auditory, and kinesthetic/tactile), while the control groups were taught using the traditional teaching approach mastered in two directions: visual to auditory (reading). The study's findings revealed statistically significant differences between the control and experimental groups, with the experimental group demonstrating favorable outcomes. Furthermore, the findings indicated that the implementation of a multisensory learning approach significantly improved the word reading abilities of individuals with dyslexia, resulting in a notable enhancement of their overall reading performance.

Bastea (2016), conducted an evaluation on the outcomes of utilizing the multisensory instructional method to address the reading and writing difficulties experienced by primary school students diagnosed with dyslexia. The method was implemented over a duration of three months. The study sample consisted of 48 pupils diagnosed with dyslexia, who were selected from public schools in Athens. The experimental group received instruction through the multisensory learning approach, which involved engaging multiple sensory modalities simultaneously (visual, auditory, and kinesthetic/tactile). In contrast, the control group received instruction through the traditional teaching approach, which focused primarily on the visual to auditory pathway (reading and writing). The results of the experimental group demonstrated statistically significant enhancements in all evaluated parameters (word reading speed and accuracy, spelling, and writing) when compared to the control group and their own performance prior to and following the intervention.

In the past few decades, there has been an integration of technology-assisted instruction in interactive multisensory learning environments. This includes the use of digital educational games, augmented reality technology, which combines real and virtual worlds to facilitate real-time interaction and precise 3D alignment of virtual and real objects, as well as audience response systems that utilize wireless digital devices and presentation software to enhance interaction between a speaker and an audience (Daud & Abas, 2013; Lin & Tsai, 2016).

The Implementation of Multisensory Learning in Technology-Assisted Instruction

In the academic literature, the term "technology-aided instruction" (TAI) has been used interchangeably with "computer-aided," "computer-assisted," and "computer-based" instruction. Technology-aided instruction is defined as the utilization of computer technology to provide instruction on academic skills and evaluate knowledge (Anohina, 2005).

Multiple review studies utilized a comprehensive collection of 225 articles covering the most recent research period (2010-2023) to document the variety of TAI tools accessible to students with reading disabilities aiming to address their unique educational needs (Alqahtani, 2020; Chambers et al., 2011; Chambers et al., 2008; Dean et al., 2021; Degirmenci et al., 2020; Dogan and Delialioglu, 2020; Jamshidifarsani et al., 2019; Lerga et al., 2021; Smith & Hattingh, 2020). Among the research encompassed in the aforementioned reviews, a total of 48 studies were focused on comparing the effectiveness of multisensory technology-based instructions (experimental group), in contrast to conventional teacher-led instructional practices (control group), for primary school students with dyslexia. These studies employed digital educational games, artificial intelligence (AI), hardware, and software to enhance reading skills, particularly in phoneme skills (24 programs that provide phoneme activities such as letter-sound correspondence), fluency (18 programs that enhance reading speed and accuracy), and comprehension skills (6 programs that enhance reading comprehension). Among the 48 comparative studies for primary students with dyslexia, 37 revealed that the experimental group outperformed the control group in the reading measures that were examined (e.g., in phonics: Kyle et al., 2013; Li et al., 2020; Rosas et al., 2017; Saine et al., 2011), (e.g., in fluency: Barber et al., 2018; Bennett et al., 2017; Council et al., 2019; Gibson et al., 2014), (e.g., in comprehension: Horne, 2017; White & Robertson 2015). Only 2 studies demonstrated that the control group had superior performance compared to the experimental group (Larabee et al., 2014; Paige, 2011), while in 9 studies no statistically significant difference was observed between computer-assisted group and teacher-led group (e.g. Horne, 2017; Kim et al., 2017; Auphan et al., 2018).

According to research, integrating technology into instructional intervention can yield numerous additional advantages, beyond merely enhancing the literacy abilities of students with dyslexia (Cheung & Slavin, 2013). To commence, learning in a dynamic and entertaining digital environment has the potential to bolster motivation, thereby fostering improved engagement, concentration, acceptance, and perseverance in the completion of reading tasks (e.g. Bittencourt et al., 2016; Papastergiou, 2009). An additional advantage that technology-based instructions may offer is the potential to decrease cognitive load and enhance reading material retention (Mayer & Moreno, 2003). Furthermore, technology-based instruction has the capability to deliver individualized and flexible instruction with minimal or no instructor participation, which is particularly advantageous in situations where human resources are scarce (Andreev et al., 2009; Athanaselis et al., 2014; Gallardo et al., 2015). Finally, by enabling users to train at their own pace, it is possible for them to attain mastery levels without being restricted by the time limitations imposed by an instructor (Corbett, 2001; Yang, 2018).

The Impact of Technology-Aided Instruction on Sight Word Reading

In the realm of sight word reading, studies provide positive outcomes associated with the use of TAI (Cullen et al., 2013; Lee & Vail, 2005; Musti-Rao et al., 2015). The researchers' primary aim in the aforementioned studies was to investigate the effectiveness of mobile games, applications, or specialized software programs in promoting sight word reading among children with developmental disabilities.

The study conducted by Lee and Vail (2005) utilized the multimedia program “Word Wizard,” which integrated constant time delay (CTD), to instruct students with developmental disabilities on sight words and their definitions. Four 6- to 7-year-old boys were involved in the research. A total of five distinct categories of responses were documented: accurate responses without any prompts within a 5-second timeframe, incorrect responses preceding a prompt when a student selected an incorrect word or failed to select any word within the same timeframe, correct responses following the provision of a prompt, incorrect responses following the provision of a prompt, and no response within 5 seconds of a prompt. The outcomes demonstrated that the multimedia programmed incorporating CTD procedures was beneficial for the students. An issue that emerged was the participants' lack of interactive involvement, resulting in situations during which students struggled to maintain their concentration and instead stared at the screen without purpose (Cheung & Slavin, 2013).

Musti-Rao et al. (2015) conducted two experiments to determine the effect of "The Kids Learn" iPad® software on word reading accuracy in six first graders who were identified as having reading difficulties. In the first instructor-led iPad® experiment, which involved three students, the instructor prompted each student to perform the following steps: repeat the word, listen to the recorded word, say the word, write the word, and then record the word. Each session focused on a different word. This method was repeated for each word for ten minutes. The cycle was performed three times for each of the five words. Each student worked on the same set of words for three educational sessions spread out over a week. The next week, a new set of words was presented. The teacher-directed iPad® condition was applied for 13 weeks. In the second experiment, the same instructional cycle as the teacher-directed iPad® instruction was used. Unlike the teacher-directed iPad® condition, in which students were provided with the same five words for a week, students in self-mediated iPad® instruction were presented with five different words each session. The teacher sat closely with each student during the first session to verify that each instructive step was accomplished correctly. Following the initial session, students performed the method without the instructor's assistance. The self-mediated iPad® condition was used for 12 weeks. An improvement in sight word reading accuracy was observed in both experimental groups, as measured by correct words per minute (CWPM), in comparison to the baseline phase in which "The Kids Learn" iPad® app was not utilized.

In their study, Cullen et al. (2013), investigated the impact of the Kurzweil 3000 text-to-speech computer program on improving sight word acquisition in four African American fourth graders with minor impairments, including learning problems, mild intellectual disabilities, and ADHD. The program provided verbal and visual representation of words for students to practice reading. Subsequently, the students engaged in activities such as spelling, highlighting, recording, and dragging-and-dropping sight words to complete phrases. Measuring the percentage of target words that were correctly read by students indicated that their sight word fluency had improved. Three of the subjects sustained this learning even after a period of four weeks following the intervention.

Several other studies have examined the benefits of using PowerPoint software for sight word reading (Blackwell & Laman, 2013; Richardson et al., 2017). PowerPoint has been identified by researchers as a flexible tool that provides a multitude of opportunities to enhance sight word learning (Baker et al., 2018). Nevertheless, educators have yet to completely exploit the interactive functionalities provided by PowerPoint in order to enliven the reading of sight words (Baker et al., 2018). The applicability of PowerPoint in instructing sight words to children with developmental disabilities has been assessed in a number of studies (Coleman et al., 2012; Parette et al., 2009; Yaw et al., 2011).

Based on the research conducted by Parette et al. (2009), PowerPoint increases the likelihood that a student will be able to apply sight word reading skills in various environments, including their personal residences, provided they have access to a computer equipped with PowerPoint software. Hilton-Prillhart et al. (2011), employed individual computer-based sight word reading intervention with three students with reading difficulties in which each sight word was displayed on a PowerPoint presentation slide on the computer. The students were prompted to read the word before they could hear a recording of the word, listen to the word, and repeat the word before a new word was displayed. All three students accomplished or exceeded the target of 85% word reading accuracy. The researchers claimed that repeating the word after hearing it enhanced correct responses in students with reading difficulties.

A number of studies have been conducted to compare the effectiveness of PowerPoint-assisted instruction and teacher-directed instruction in facilitating the acquisition of sight words among children with developmental disabilities (Coleman et al., 2012; Parette et al., 2009; Yaw et al., 2011). Two of these studies (Coleman et al., 2012; Yaw et al., 2011) combined PowerPoint with constant time delay for sight word instruction. Yaw et al. (2011), used PowerPoint software with a 2-second delay to teach high frequency sight words to a sixth grader diagnosed with autism spectrum disorder. The words were selected from the Dolch Sight Words list, which is commonly used by teachers to teach children to read and contains high-frequency English vocabulary (Farrell et al., 2013). The student was prompted to read a sight word before the 2-second delay expired. This intervention was effective in increasing word recognition at a rapid rate. Coleman's study (2012), examined the efficacy of teacher-directed vs computer-assisted constant time delay procedures for teaching three students with moderate intellectual impairment to read functional sight words. The results showed that both methods were equally successful.

Given the numerous benefits of computer-based instruction for children with dyslexia (Dawson et al., 2021) and given that many children with dyslexia struggle with sight word reading, particularly when it comes to irregular sight words (Brunsdon et al., 2005), it is surprising that only a few studies have tested technology-aided sight word instruction in children with dyslexia (Ansari et al., 2020; Borhan et al., 2018). These studies examined intervention programs, including a mobile app for sight word reading (Borhan et al., 2018), and an android game designed to teach sight words (Ansari et al., 2020). In their study, Borhan et al. (2018), collected data from sight word recognition tests administered to a sample of 28 children with dyslexia aged 7 to 12 before and after utilizing a mobile phone application. After employing the mobile phone application, 19 of the 28 participants improved their scores on the sight word recognition test by more than 30%. The study conducted by Ansari et al. (2020), showed significant improvements in the average accuracy of sight word reading among elementary students with dyslexia when comparing the results of a pre-test conducted before to the use of an android game, and a post-test conducted after the implementation of the android game. It is important to acknowledge that the digital sight word learning tools utilized in the aforementioned research were applied with a limited sample size in a restricted geographic region. The mobile app for sight word reading used by Borhan et al. (2018), was tested on a small sample of children at the Learning and Resource Dyslexia Association Centre of Sarawak in Malaysia and the android game used by Ansari et al. (2020), was used in two schools in Kharagpur, India.

Exacerbating Factors for Students with Dyslexia in the Greek Educational System

Based on the results of the Program for International Student Assessment (PISA, 2020), which can be accessed on the official website of the Organization for Economic Cooperation and Development (https://www.oecd.org/pisa/data/), Greece consistently has a higher proportion of students with reading skills below the average when compared to other European Union countries. Poor results are significantly influenced by the socio-economic status, as well as the concentration of the Greek school system in urban areas owing to insufficient budget and decreasing birth rates, which led to the closure of smaller schools in rural areas (Giavrimis, 2019; Kounetas et al., 2023).

Studies indicate that the inflexibility and homogeneity in the Greek educational system hinder the provision of specialized support for students with reading challenges, particularly those with dyslexia (Papadogiannis et al., 2021; Kounetas et al., 2023). Despite the Greek legislation (Law 3699/2008) mandating special educational provisions for all children with learning difficulties at all levels of education, the lack of comprehensive training for teachers in addressing learning issues makes it impractical to implement universal planning, (Strogilos et al., 2016).With regard to co-teaching, a collaborative service delivery approach for addressing the educational needs of students with disabilities in inclusive classes, the Greek approach, known as "parallel support," was implemented in Greek schools starting in the 2003-04 school year. Usually, Greek special education teachers in the parallel support program are relatively young (under 30 years old), new to the profession (with around 2 years of experience), and have limited training in co-teaching (Mavropalias & Anastasiou, 2016; Strogilos et al., 2016).

Studies conducted in the Greek environment have likewise found a deficiency in comprehensive knowledge regarding dyslexia. Balasaki's (2015) study, which surveyed 181 teachers, revealed that nearly half of the participants possessed just rudimentary understanding of dyslexia. The participants of the study were primary school teachers in mainstream public and private schools of Greece as well as independent private tutors. Additionally, the legislation proposes that students with less severe learning difficulties, such as dyslexia, might participate in an "integration class" either in a small group or in a one-to-one setting for a maximum of 15 hours per week. Research has shown that children with dyslexia receive just three to five hours per week in an "integration class" (Anastasiou & Polychronopoulou, 2009). Students with dyslexia in Greece face additional obstacles as a result of the country's overall lack of psychological services within educational institutions, as well as the limited accessibility of specialized educational materials tailored to the needs of children with reading difficulties (Riga, 2012).

The Greek educational system's exam-centered and teacher-centered structure often leads to feelings of frustration and lack of interest in reading among children with dyslexia since it fails to inspire them and restricts their creativity (Kougias & Efstathopoulos, 2020). This strain leads to subpar grades and an increased propensity for experiencing negative emotions (Xystrou, 2004). In addition, primary grade students with dyslexia continue to study Greek vocabulary by traditional techniques such as word-by-word memorization, acquiring new terms through explicit instructor direction and reading from word lists (Kougias & Efstathopoulos, 2020; Mouzaki & Sideridis, 2007). Furthermore, most teachers in Greek schools continue to use traditional strategies to teach vocabulary, such as providing word lists with synonyms, analyzing sentence writing with target vocabulary, and vocabulary repetition (Papadogiannis et al., 2022; Sideridis et al., 2019).

Despite the inflexible and outdated methods of the Greek educational system, there has been a notable shift over the past decade among Greek researchers, who seek to motivate the teaching community to embrace novel strategies for enhancing reading skills among students with learning difficulties (Demetriadis et al., 2003; Vouglanis & Driga, 2023). Within this framework, novel pedagogical approaches were devised in accordance with the tenets of multisensory learning, and the feasibility of integrating technology-assisted instructional tools into the learning process were examined. According to a recent review study, the computer's visual and auditory features, along with its organized text display, diverse software for error correction, grammar guidance, grammar exercises, and word processing, greatly benefit children with dyslexia (Taxiarchis, 2023).

Several desktop and mobile applications, such as “Phonological Awareness Educational Software (PHAES),” “EasyLexia,” and “Eglotton,” have been assessed with Greek students diagnosed with dyslexia. The Phonological Awareness Educational Software (PHAES) is a hypermedia application designed to assist students with dyslexia by providing phonological awareness training specifically for the Greek language. Learning exercises introduce graphemes and their related phonemes at both the word and sentence levels. The application requires just fundamental computer proficiency, as it is created with uncomplicated visuals and navigation. Consequently, it is well-suited for elementary school pupils, who may utilize it alone or with minimal supervision. The tool can serve as a helpful instrument for both education and speech therapy treatment, employing a multisensory approach.

Furthermore, it is comprised of four distinct phases and assignments are allocated based on their level of complexity. The initial phase focuses on the acquisition of letter-sound associations, followed by the integration of letters into words during the subsequent phase. The third phase introduces the construction of sentences, and the final phase requires students to generate commonly used terms. The program has demonstrated its efficacy in facilitating early literacy development. Additionally, participants reported high levels of motivation and considered the software user-friendly (Kazakou, et al., 2011).

An innovative interactive mobile application called EasyLexia has been developed to enhance the fundamental skills of Greek students with dyslexia. The application focuses on improving reading comprehension, orthographic coding, short-term memory, and mathematical problem-solving through the use of gamification techniques. The application has been developed to be compatible with both mobile phones and tablets. It has undergone testing among students at a "Speech Therapy Centre" in Syros, Greece. It is important to note that the application is designed in the English language. The initial assessment of this application, conducted with a group of five students with dyslexia aged 7-12, yielded encouraging findings. Specifically, the students demonstrated notable improvements in their performance within a relatively brief timeframe (Skiada et al., 2014).

In their study, Athanaselis et al. (2014), investigated the utilization of the automatic speech recognition software "Eglotton" to support the development of reading fluency in Greek students with dyslexia. The primary objective of this platform is to facilitate access to reading materials within an integrated learning system. Additionally, it strives to enhance the performance of speech recognition in order to gradually enhance the reading abilities of the user. Over time, the level of assistance provided will be reduced until the student with dyslexia is able to read at the same level as a typical reader. The preliminary analysis of the software pilot study indicated a notable enhancement in both reading speed and accuracy.

To summarize, recent studies have shown that the widespread integration of technology into children's daily lives (Haleem et al., 2022) and the ease with which children with dyslexia can utilize new technologies (Taylor & Vestergaard, 2022), lend credence to the idea that combining TAI with motivation-boosting instructional approaches can produce favorable results in improving the reading abilities of children with dyslexia (Andres et al., 2021).

Importance of the Study

The present study attempted to contribute to the existing literature by examining the effectiveness of two response-prompting (CTD) instructional methods to improve the acquisition of sight words among elementary students diagnosed with dyslexia. The two methods under evaluation were traditional tutor-led CTD instruction and a novel CTD approach that incorporated computer-assisted PowerPoint instruction. While the existing research on the use of technology-assisted methods for sight word learning in children with dyslexia is limited, it is reasonable to assert that the implementation of assistive technology for sight word reading provides evident advantages for both students and educators (McArthur et al., 2015). Assistive technology, such as PowerPoint software, can be beneficial for teachers in the context of differentiated instruction by offering alternative materials and tools to students with dyslexia, thereby reducing the teacher's need for additional effort (Mize et al., 2022). Additionally, PowerPoint offers a platform for interactive experiences, allowing students to actively participate in a multisensory instructional approach that integrates the use of several sensory modalities, such as auditory, visual, and kinesthetic (Baker et al., 2018). Furthermore, the use of technology resources in the field of education facilitates the customization and fulfilment of the requirement to tailor the instructional process and approaches to accommodate the specific demands of students with dyslexia (Sage et al., 2016). As previously indicated, the limited research conducted in this domain has hindered a definitive understanding of the extensive advantages that assistive technology for sight word learning may offer to both students with dyslexia and their instructors. However, the potential in this field appears to be highly promising.

Research aim

Drawing upon existing research that highlights the significance of third-grade students' reading proficiency as a reliable indicator of their future academic success, as well as the findings from multiple studies indicating that the acquisition of sight words facilitates the development of reading accuracy in elementary students with dyslexia, this study aimed to assess the efficacy of two instructional approaches in teaching sight words to third-grade students with dyslexia. The purpose of this study was to assess the effectiveness of a tutor-led and a software-assisted constant time delay method for teaching three third grade students with dyslexia to read Greek irregular sight words.

II. METHOD

Participants

Three elementary-aged children diagnosed with dyslexia, participated in this study. Of the three participants two are male and one is female. All participants attend a private primary school in Athens. Greek is their first language, thus the study was conducted in the Greek language.

The inclusion criteria for participating in the study were as follows: (a) being in 3rd grade. Choosing this age group (8 to 9 years old) enables a better evaluation of the intervention's impact due to a decline in reading motivation and persistent challenges with multiple elements of reading (accuracy, fluency, speed, comprehension), which becomes evident around this time age wise and school wise, as highlighted in the literature review; (b) being diagnosed with dyslexia by the official local agencies representing the ministry of Education in Greece (KEDASY); (c) receiving a consent from both parents; (d) having no prior experience learning through the use of a constant time delay procedure.

In order to uphold participant confidentiality and enhance the clarity and significance of the findings, pseudonyms have been assigned to the students participated in this research. The pseudonyms of the participants have been allocated in alignment with the sequence in which the results have been presented. First Participant: James; Second Participant: Robert; Third Participant: Patricia.

James was 8.5 years old at the time of the study. James received an official diagnosis of dyslexia from the Athens Medical Pedagogical Centre when he was 7.5

years old. The diagnosis was prompted by the schoolteachers' notice of his difficulties in reading and writing. At the time of the study, he received support from a special education teacher, who provided him with private tutoring sessions at his home twice a week.

Robert was 8 years and 8 months old at the time of the study's execution. At the age of 7 years and 8 months, Robert was formally diagnosed with dyslexia by a Greek public institution that specializes in developmental and behavioral pediatrics. Based on the results of the LAMDA test, that were voluntarily submitted by Robert's parents, it was found that Robert performed poorly (below the 25th percentile) in areas such as grammar, spelling, sentence completion, working memory, and visual word recognition. The LAMDA test is a software for screening learning skills and difficulties in the written and spoken language of school-age children (2nd grade of primary school to the 2nd class of secondary school) and it consists of activities presented as computer games (Protopapas & Skaloumbakas, 2007). At the time of the study, Robert attended a special study center three times per week, where he received help in subjects from the primary school curriculum. The center used dyslexia-friendly techniques, such as multisensory learning, to teach the classes.

Patricia's age at the time of the study's execution was 8 years and 5 months. At the age of 7 years and 7 months, Patricia was diagnosed with dyslexia and dysgraphia by a Greek public unit specializing in developmental and behavioral pediatrics. Based on the ATHENA test results, Patricia performed below average in the phonological test, reading speed and accuracy test, and comprehension detection test. The ATHENA test assesses intellectual ability, sequential memory, completion of patterns, and neuropsychological development. The test primarily evaluates reading fluency by examining the ability to read individual words. This is done through categorized lists of tasks, which measure reading speed, accuracy, and comprehension detection (Paraskevopoulos, I. & Paraskevopoulou, P., 2011). At the time of the study, Patricia was assisted by a special education instructor who conducted three private tutoring sessions per week at her residence.

Ethical considerations

The study adheres to the ethical guidelines and principles established by the American Psychological Association (APA), (https://www.apa.org/ethics/code/index.aspx). Provisions had been implemented to ensure confidentiality, anonymity, institutional permission, and parental agreement (see Appendices A, B). Parents also received notification that pseudonyms had been employed in order to safeguard the identity of their children. The commencement of the experiment was contingent upon obtaining approval from the Institutional Review Board of the American College of Greece.

Setting

Sessions were conducted individually with each participant. All phases of the study were conducted in the participants' residences. The experimenter administered all trial sessions in the participants' room. Working at home was anticipated to improve the overall comfort and decrease stress levels for the participants.

James' room had ample lighting and was compact in size. The desk in the room where the sessions were held was positioned across from the window and situated close to the bed. It had a clean, rectangular design and was of a modest size. Playmobil toys were neatly arranged on the shelves atop the desk. Textbooks were typically stored on the lower shelf of the desk, but in several sessions, they were placed directly on the desk. Two chairs were positioned in front of the desk - one being an anatomical black desk chair and the other a plain chair. The floor was adorned with a children's rug, scattered with an array of toys including remote-controlled cars and airplanes. During most sessions, the room was quite disorganized.

Robert's room was well-lit and generously sized. The child's desk where all sessions were held was white and rather spacious. The desk was adjacent to the window in the room, just across from the bed. In opposition to the desk were two chairs, one of which was an anatomical grey desk chair and the other of which was a standard chair. Next to the desk stood a big bookcase stocked with textbooks, school supplies, and an assortment of toys. An easel adorned the center of the room, accompanied by coloring sheets, while a table adjacent to it displayed an array of coloring crayons, catering to Robert's passion for painting. The room was tidy during each session, with just the child's pencil box, a pack of tissues, and a bottle of water on the desk.

Patricia's room was bright and spacious. The desk used for all the sessions was beige and generously sized. It was positioned adjacent to the window within the room. Next to the desk, there was a spacious bookshelf. The lower shelves housed the schoolbooks and a collection of crafts skillfully crafted by Patricia. On the upper shelves, an array of dolls and a prominent Barbie poster were displayed. Opposite the desk, there were two chairs, one being an anatomically designed pink office chair and the other a standard chair. A sizable dollhouse occupied the central position in the room. The area remained somewhat organized during each session, but on few occasions, drawings, crafts, and toys were cleared from the desk to facilitate the session.

Material

Informed Consent Comic Book

During the initial individual meetings with participants, a spiral-bound book size 14 x 20 cm in landscape format was used. This book served the purpose of clarifying the study procedures and obtaining informed consent from the participants, ensuring their voluntary participation in the study. The book outlined the steps of the study in a format that was accessible to children, employing a comic style, spanning a total of 21 pages. The study's method was effectively elucidated through a question-and-answer dialogue between a cartoon instructor and an emoji. The purpose of the comic book was to be utilized alongside ongoing dialogues concerning consent across various stages of the study (see Appendices C, D).

Pretraining materials

To ensure that the student fully understood the process, a tutorial video explaining the procedures in depth and providing support for successfully completing each phase was developed. It explained the baseline procedure as well as the tutor-led, software-assisted, and generalization procedures and particularly for software-assisted training, a simulated procedure had been included. Examples of the actual materials were presented, including word samples that had not been subjected to testing during the training sessions.

Baseline materials

Two sets of irregular words were assessed during the baseline. These sets had been obtained from two separate sources. The first set was derived from the history book used in the third grade of the public and private schools in Greece (see Appendix

E). The history book is named: “From Mythology to History" (Kalyvi, Maistrellis & Michael, 2008). The chosen vocabulary aimed to optimize the participants' accuracy in reading the Labors of Hercules (3rd grade History Textbook, chapter 1, section 2, pp. 26- 34). The second set was derived from the digital publication titled "Young Rigas and the secret symbols of Charta" authored by Leda Varvarousis and published by the Onassis Foundation (2021), (see Appendix F). This digital material may be accessed through the Onassis Foundation's website (https://www.onassis.org). The selected vocabulary was chosen to improve the accuracy with which participants read the words in the prescribed sections of the e-book about the great acts of the mythical hero Hercules (Varvarousis, L. " Young Rigas and the secret symbols of Charta", pp. 27-35).

In this study, irregular words were defined as those that contain at least one diphthong or digraph, as well as those that exhibit variations in orthographic representation for the same letter. It is important to acknowledge that the verbs, nouns, and adjectives employed in this study were instructed in the exact form as they appear in the chosen sections from the two books, as this research measured the reading accuracy of these words during reading. This included maintaining the same conjugation, tense, grammatical voice (active and mediopassive), number (singular and plural), gender (masculine, feminine, or neuter), and cases (nominative, genitive, accusative, vocative) of the selected words (see Appendices E & F). The baseline data collection encompassed all the irregular words that were present in both the nine pages of the history book and the nine pages of the eBook. It was imperative to ensure the inclusion of words that posed challenges in readability, in order to mitigate any potential difficulties for the children during the generalization phase.

The words in the two sets were different. In order to minimize the impact of a potential confounding variable, both sets of irregular words had been examined for equal difficulty. Specifically, each set had a total of 120 Greek words, 95 polysyllabic words and 25 disyllabic. Moreover, each set consisted of 33 words encompassing diphthongs (αι, ει, οι, ου), 13 words involving combinations of letters pronounced as a single sound (αυ, ευ), 9 words containing double consonants (λλ, μμ, νν, ππ, ρρ, σσ), 5 words featuring consonant diphthongs (μπ, ντ, γγ, γκ), and 60 words exhibiting orthographic variations for the same letter (e.g., the letter "i" represented by "η, υ", the letter “o” represented by “ω”), (see Appendices E & F).

The words assessed during the baseline were created using lower case, 72-point, Roboto black font and were printed on 76 mm x 127 mm (3" x 5") plain white text-only index cards. Each word was presented on the front of the card (See Appendix G). The tested word cards were placed in 4 separate index card plastic boxes. Set A's correctly read cards were placed in the red box labeled as Box 1. Set A's incorrectly read cards were placed in the blue box labeled as Box 2. Set B's correctly read cards were placed in the yellow box labeled as Box 3. Set B's incorrectly read cards were placed in the white box labeled as Box 4 (See Appendix H for more details).

Alternating Instructional Conditions materials

The two instructional conditions occurred in a randomized order across days to minimize any carryover effects. For this purpose, the online Number Generator (accessible at numbergenerator.org) was used. The tutor-led condition was assigned as the number 1 and the software-assisted condition was assigned the number 2. According to the random order derived from the online randomization tool (e.g., 2-1, 2-1, 1-2, 2-1, 1-2, 2-1, 2-1, 2-1, where 1 = tutor led and where 2 = software assisted instruction), the two conditions were presented in the following order: 1st day: software-assisted followed by tutor-led, 2nd day: software-assisted followed by tutor-led, 3rd day: tutor-led followed by software-assisted, etc.

For the purpose of collecting interobserver agreement all sessions were audio taped using a Sony digital voice recorder (ICD-PX Series). A second observer collected interobserver agreement data on 33% of sessions for each student. Data on the number of words mastered, the number of trials necessary for mastery, and the length of training sessions were gathered. Percent agreement for the number of words mastered and the number of trials necessary for mastery, was obtained by dividing the number of agreements by the sum of the agreements and disagreements and multiplying by 100. The training duration agreement was calculated by dividing the shorter duration by the longer duration and multiplying by 100.

Tutor-led instructional materials

For each tutor-led CTD teaching session, 25 words sourced from baseline blue Box 2, were printed in 96-point size Roboto font on 127 X 178 mm (5" x 7") text and picture flashcards. The selection of the typeface was not arbitrary. The majority of textbooks designed for third-grade students utilize this particular typeface, hence ensuring consistency in the font encountered by the participants throughout their educational materials. The words were presented in lower case as they are more frequently seen in textbooks and other reading materials. Each flashcard's front side featured a single word-picture pair, namely the target word and a representative picture of the word. For example, the word “vessels” (αγγεία), was accompanied by an image depicting two ancient Greek vessels (4 samples of flashcards are presented in Appendix I). The pictures that were utilized were sourced from Google images. The selection process involved the application of three filters: the license to reuse filter, the filter for picking color images, and the filter for determining the type of clip art. The inclusion of clip art photos was preferred since they tend to be more engaging for children (Ybarra et al., 2003). The correct, incorrect responses and the nonresponses per session were recorded using a pen on a special CTD data sheet obtained from slideplayer.com. The correct responses were recorded with check marks (✓), the incorrect responses with x's marks (X) and the nonresponses with "0". The header row included the fictitious name of the student and the name of the instructor. The first column contained the words. The remaining columns corresponded to each session. The first column represented the 0-second delay. The remaining columns were for the 5-second delay sessions. Each column was separated into two columns, on which the tutor marked the responses to the before and after prompts (see Appendix J).

Software-assisted instructional materials

For each software-assisted CTD teaching session, 25 words sourced from baseline white Box 4, were presented in a PowerPoint slideshow. A Hewlett-Packard laptop (HP 17 Laptop PC) was used. Each slide contained a single word-picture pair, namely the target word and a representative picture of the word (4 samples of slides are presented in Appendix K). The words were presented in the same font as the flashcards and the pictures were selected with the same criteria as in the tutor-led CTD condition. Multiple PowerPoint tutor-developed presentations were created during which word order was randomized, using the online randomization tool mentioned previously, to prevent students from learning the word order. Audio narrations that accompanied each slide were prerecorded on all PowerPoint slides using the tutor's voice. Active student participation was necessary for the PowerPoint presentation, as the process of differential positive reinforcement for prompted and independent responses, necessitated the activation of a PowerPoint action button. Table 1 displays an example of the PowerPoint presentation with the slides and their accompanying computer output narrations. The authentic colors and design are depicted in Appendix L. Correct and incorrect answers were audio recorded with the PowerPoint recording system and transcribed into the CTD data sheet (Appendix J) once each session had been completed.

Generalization Materials

During the generalization phase, two same literary sources used in baseline were employed, namely the History textbook and the eBook. While the student read the specific sentences that encompassed the vocabulary acquired from the two instructional conditions, the tutor recorded correct, incorrect words on a data sheet (see Appendix M). The correct responses were recorded with check marks (✓) and the incorrect responses were marked with (X). The data sheet was divided in three columns. The first column contained the taught words from both the history book and the eBook, preprinted by the tutor in a green color font for the history book words and in a blue color font for the eBook words. In the second column the tutor marked the correct or incorrect words read from the History book. Similarly, in the third column, the tutor recorded the correct and incorrect words read from the eBook.

Student Questionnaire for Social Validity Purposes

Following the generalization phase, social validity was measured using a 5-point Likert Scale brief questionnaire prepared by the tutor (see Appendix N). The form of the questionnaire was based on Smiley Face rating scale, a type of scale that uses emoji faces to measure satisfaction levels (Chyung et al., 2018). With the goal of evoking more nuanced responses and accurately representing participants' experiences, the Likert scale incorporated vibrant colors and cartoon-like emojis that were especially designed to captivate children's attention (Chyung et al., 2018). To prevent inflated data, the response options were presented in ascending order. This approach is supported by a body of research indicating that response scales arranged in descending order tend to elicit more positive replies (Hartley & Betts, 2013; Liu & Keusch, 2017; Maeda, 2015). The two-page questionnaire had seven questions in total. The first six questions, which were divided into three sets of two questions each, compared the two methods of teaching. The first pair of questions was intended to assess the students' overall experience for each teaching condition, the second set assessed the level of word difficulty for each condition, and the third set captured participants' opinions about the quality of the images in each condition. The final question was intended to elicit the participants' opinions about the teacher.

Given the small number of participants and the limited number of questions in the questionnaire, the data were analyzed using an Excel spreadsheet. For the three groups of the questions, the total number of replies corresponding to each sentiment level (ranging from 1 to 5) were calculated. Subsequently, the totals were summed and divided by the number of respondents. The Excel worksheet sample is provided in Appendix O. The final question was excluded from the scoring procedure due to its deviation from the 1 to 5 rating scale, as it pertained to the children's perception of the tutor.

Experimental Design

An alternating treatments design was employed in this study to compare two teaching methods in relation to their effectiveness and efficiency on the reading accuracy of Greek irregular sight words: tutor-led CTD and software-assisted CTD. The alternating-treatment design allows to directly compare more than one intervention on the dependent variable (Alberto & Troutman, 2022, pp. 151-154). In this experiment, the dependent variable was the number of correct sight words read, whereas the independent variables were the two teaching conditions. This study's experimental conditions included baseline, intervention consisting of comparison of tutor-led CTD and software-assisted CTD, replication of the preferred CTD condition and generalization during which students were asked to read selected pages from the two books (History textbook and eBook) that contain the words they had learned.

Procedure

Parental Agreement

Prior to the study, meetings were arranged with the parents of each participant to provide comprehensive information regarding the study's objectives, procedures, data protection and recording, voluntary participation, absence of risks, and the anticipated benefits for their children upon completion of the study. A prerequisite for proceeding with the execution of the study was obtaining agreement from both parents. After the informed meetings, both parents of each participant signed the parental consent form.

Informed Consent Meeting with Participants

Individual meetings with each participant had been scheduled prior to the study to provide thorough details on the study procedures, allowing them to give their informed consent for their participation in the study. Children above the age of seven, such as the participants in this study, should be addressed directly about their participation and offer their informed consent for their involvement in the study, according to the European Code of Conduct for Research Integrity (ALLEA, Revised Edition 2023). An informed consent comic book was utilized in this study to explain the study's method through a form of question-and-answer discussion between a cartoon tutor and an emoji. Grootens-Wiegers et al. (2015) investigated and assessed the comic book approach of obtaining informed consent from pediatric study participants. According to the findings of the Grootens-Wiegers et al. (2015) study, the children were more aware about scientific research after reading the comic book, and they could make an informed decision about whether or not to participate (informed consent). The informed consent comic book for this study was intended to be used in conjunction with continuous discourse to familiarize the student with the study environment and content, the technique for collecting baseline data, the two alternating teaching conditions, and the generalization phase. The comic book also provided opportunities for ongoing discussion regarding the participants' voluntary engagement in this study, the benefits of participation on word reading acquisition, and the importance of gaining their informed consent at all stages of the research process. Finally, the book provided a chance to explore each child's interests and preferred activity (p.17), which was incorporated by the tutor in the differentiating reinforcement strategy during the alternating conditions phase. Appendix C includes the themes covered on each page of the book, along with the objective of each topic. Appendix D provides the specific layout and structure of the comic book.

Pretraining

To aid in full knowledge of the procedure, the teacher presented a tutorial video to the student that provided support for successfully completing each phase. It explained the baseline procedure as well as the tutor-led, software-assisted, and generalization procedures. In particular, for software-assisted training, the student participated in a simulated procedure in which he or she was requested to practice four words that would not be examined during the training sessions. The tutor asked him/her to respond to these four words in the following formats: response 1: "I did not read the word"; response 2: "I read the word incorrectly"; response 3: "I read the word correctly after hearing it from the computer voice"; response 4: "I read the word correctly before hearing it from the computer voice". Students conducted a total of 16 trials in order to gain proficiency with the four action buttons. This simulation aimed to demonstrate that the student's active participation was necessary, since the process of differential positive reinforcement for prompted and independent responses required the student to click on the representative action button for each response style. Samples of the material were provided, utilizing words that were not subjected to testing during the training sessions.

Baseline

Following the informed consent and the pretraining, the baseline data were collected on consecutive days. For maximum benefit of the instructional intervention, unknown irregular words were required. The words tested during baseline were printed on 3" x 5" plain white text-only index cards (see Appendix G). The collection of baseline data did not involve the use of a software program or the use of flashcards with a picture of each word. Both sets of irregular words were assessed during baseline (see Appendices E & F). The baseline phase ended when each participant had a pool of 50 unknown words, with an equal distribution of 25 words from Set A and 25 words from Set B. These words were then assessed during the tutor-led and software-assisted conditions, respectively.

At the beginning of each baseline assessment session, the students were informed that it was acceptable if they were unfamiliar with many of the words, as the objective of the study was to start with a collection of unknown words. However, they were driven to give their best effort. The instructor and the participant were seated next to each other at the participant's desk. The tutor started the assessment by shuffling and arranging the word cards in a random order. The cards were then placed with their face down on the desk, positioned in a way that allowed the student to maintain eye contact. Subsequently, the instructor imparted the directive "read" to the student. The tutor silently counted 3 seconds (one one hundred, two one hundred, etc...) prior to delivering the next instruction. The student could say "skip" if he or she did not know the word. If the student did not respond within three seconds or read the word incorrectly, the tutor removed the card from view and told the student to try the next word. The tested word cards were placed in 4 separate index card plastic boxes (See Appendix H). Set A's correctly read cards were placed in the red box 1. Set A's unknown or incorrectly read word cards were placed in the blue box 2. Set B's correctly read cards were placed in the yellow box 3. Set B's unknown or incorrectly read word cards were placed in the white box 4 (Appendix H). The use of boxes allowed for the documentation of both correct and incorrect answers, hence obviating the necessity of recording information on a data sheet while running the baseline session. Data were transcribed to the data sheet later.

Students were examined four more times on the words from the blue and white boxes to confirm that the words were unknown to them. To be included in the study, a word had to have 0% accuracy. Twenty-five words from the blue box were taught during the teacher-led condition, and twenty-five words from the white box were taught during the software-assisted condition. During the baseline phase, students received occasional generic praise statements, such as "very good practice!" for exhibiting on-task behavior such as following directions and demonstrating effort. No planned consequences were delivered for correct or incorrect responses.

Intervention

Each participant engaged in two 30-minute sessions on a daily basis. During the intervention, the two instructional conditions, tutor-led (condition 1) and software-assisted (condition 2), were applied sequentially in each session. The two conditions were presented in a randomized order across sessions to minimize any carryover effects. According to the random order derived from the online randomization tool (e.g., 2-1, 2-1, 1-2, 2-1, 1-2, 2-1, 2-1, 2-1), the two conditions were presented in the following order: 1st day: software-assisted followed by tutor-led, 2nd day: software-assisted followed by tutor-led, 3rd day: tutor-led followed by software-assisted, etc.

The students participated in both instructional conditions until they achieved 90% or higher accuracy for three consecutive trials in one of the two conditions. To calculate the percentage of accuracy the number of irregular sight words read correctly was divided by the total number of words presented and then multiplied by 100. The instructional condition that resulted in the student reaching criterion in fewer trials was referred to as the preferred CTD condition.

For the purpose of collecting interobserver agreement (IOA), all sessions were audio taped using a Sony digital voice recorder (ICD-PX Series). During the tutor-led CTD condition, the correct and incorrect responses per session were recorded on a special CTD data sheet obtained from slideplayer.com (see Appendix J). Correct responses were marked with a “✓” sign, incorrect responses were marked with a “x” sign and no responses were marked with “0” (see Appendix J). The non-responses were recorded in order to facilitate a comparison between the two conditions with regards to the students' hesitance or unwillingness to participate or respond. Research among primary students with reading difficulties suggests that reading interventions or instructional methods that promote active participation, regardless of the accuracy of their responses, leads to more positive results (Marmuta, 2022; Peng 2020). During the software-assisted CTD condition, student responses were audio recorded with the PowerPoint recording system and transcribed into the CTD data sheet (Appendix J) once each session has been completed. The method of recording answers via the software recording system without the direct involvement of the tutor was related to the potential to gradually reduce the level of support provided during computer-assisted instruction, as highlighted in the literature review.

Both instructional conditions employed the three-term contingency, i.e., antecedent-behavior-consequence (ABC), which is one of the primary tools of operant learning. The participants were presented with a word (i.e., antecedent) either written on a flashcard during tutor-led instruction or on a PowerPoint slide during software-assisted instruction. Visual supports in the form of pictures were used on flashcards and PowerPoint slides. Prompts were delivered at constant intervals (CTD) in both conditions, either by the teacher in tutor-led condition or by the computer voice in software-assisted condition, to ensure the participants’ responses (i.e., behavior).

Contingent feedback was provided on student response either by the tutor in tutor-led condition or by the computer voice in software-assisted condition. Prompted, and independent responses were reinforced differentially. Independent replies (i.e., when the student beat the prompt) received greater verbal reinforcement, whereas prompted responses (when the student responded after the prompt) received lower verbal reinforcement. The various reinforcements are discussed in depth in the next sections (tutor-led and software-assisted conditioning process). Following the conclusion of each instructional session, a brief recess period of 5 minutes was allocated to allow the students to participate in their preferred activity, as identified during the informed consent discussion. James was engaged in listening to music, Robert was involved in painting, and Patricia was engrossed in watching music videos on her tablet.

Tutor-led CTD

For each tutor-led CTD teaching session, 25 words sourced from baseline blue Box 2, were printed on flashcards (127 X 178 mm or 5 x 7 inches) in Robot font (size 96-points), including both text and a picture. In other words, each flashcard featured a single word-picture pair, namely the target word and a representative picture of the word. For example, the word vessels (αγγεία), was accompanied by an image depicting two ancient Greek vessels (4 samples of flashcards are presented in Appendix I).

Each tutor-led session began with the tutor saying, "Let's learn new words" followed by a short reminder phrase: "Remember, if you do not know the word, wait and I’ll tell you." When first introducing the flashcard, a 0-sec delay was implemented in which the teacher presented the flashcard, ensured that the student was looking at the card, and said: "Read this word." The correct answer was given immediately, followed by the prompt "Read this word" to encourage student participation. In the event that the student accurately read the word, the tutor marked a "✓" symbol on the designated CTD data (Appendix J). Additionally, the teacher provided feedback to the student, by stating, "Yes, the word is ______." In the event that the student misread the word, the tutor annotated an "x" symbol on the CTD data sheet and provided the following feedback: "No, the word is ______” and repeated the instruction: “Read it." Subsequently, the student proceeded to accurately reproduce the word. In the event that the student failed to provide an answer, the tutor proceeded to indicate a "0" symbol and provided the following feedback: "The word is ________. Read it." The 0-second delay was maintained until each participant performed three consecutive trials of reading accurately to the prompt.

During the following sessions, the teacher began the session as stated above, but quietly counted to five seconds before giving the prompt: "Read this word." This delay between presenting the card and giving the prompt, allowed the child an opportunity to respond independently. If the student accurately read the word prior to the prompt, the instructor placed a "✓" sign in the 5sec delay before prompt column of the CTD data sheet (see Appendix J). In this scenario, the teacher praised the student verbally: "Awesome. The word is _____." If the student accurately read the word after the prompt, the instructor placed a "✓" sign in the CTD data sheet's column of 5sec delay after prompt. The teacher praised the student verbally: "Good trying,” "The word is _____." If the student read the word incorrectly before the prompt, the tutor marked with a "x" symbol in the corresponding column and provided feedback: "No, the word is ______. Read it" with the reminder: "Remember, you have more time to answer." The student then accurately repeated the word. In the event that the student wrongly read the word after the prompt, the tutor indicated this by marking the "x" symbol in the corresponding column. Additionally, the tutor provided feedback stating, "No, the word is ______. Read it." In the event that the student failed to provide a response following the prompt, the tutor proceeded to indicate a "0" symbol and provided the feedback, "The word is________. Read it.". Following the presentation of three consecutive words, the tutor consistently reminded students: "Remember, if you don't know the answer, wait and I'll tell you."

During this phase, commendation was also given for diligent effort and focused engagement. "Your level of effort and dedication is truly admirable today!" or "You did your task exceptionally well!" or "Congratulations on your focused attention today!" are examples of such commendations that were utilized on a regular basis.

Software-assisted CTD

During the software-assisted CTD, students followed the same procedure as the tutor-led condition, except that the computer provided the prompts and the contingent feedback. For each software-assisted CTD teaching session, 25 words sourced from baseline white Box 4, were presented in a Power Point slideshow. A Hewlett-Packard laptop (HP 17 Laptop PC) was used. Each slide contained a single word-picture pair, namely the target word and a representative picture of the word (4 samples of slides are presented in Appendix K). The words were presented in the same font as the flashcards and the pictures were selected with the same criteria as in the tutor-led CTD condition. Multiple PowerPoint tutor-developed presentations were created during which word order was randomized to prevent students learning the word order. Audio narrations that accompanied each slide were prerecorded on all PowerPoint slides using the tutor's voice. Slide one presented the statement, " Let's learn new words." The slide changed automatically following a two-second pause. On Slide 2, the line, " Remember, if you do not know the answer, wait and I'll tell you", was presented. The slide switched automatically following a three-second pause. This slide was displayed automatically after every three words. On slide 3, the voice of the computer read the word and instructed the student to "Read this word." This slide presented an irregular word together with its associated picture. Slide 4 provided the answer, namely the word displayed on slide 3 without the image. The computer-generated voice uttered: "The word is ______" (Table 1 and Appendix L).

During the first software-assisted session, a one-second pause followed the narration of slide 3 before switching to slide 4 with the answer. The 0-second delay was maintained until each participant performed three consecutive trials of reading accurately to the prompt. During following sessions, a five-second pause followed the narration of slide 4 before automatically changing to the answer slide. The provision of conditioned feedback on the students' replies by the computer necessitated the active engagement of the student in the process. Once the answer on slide 4 was displayed, slide 5 appeared, featuring four action buttons. The computer voice instructed the user to “click on the right button.” On the slide, there was a yellow button accompanied by a written caption that said: "I didn't read the word", a blue button that said: "I read the word incorrectly", an olive button that said: "I correctly read the word after hearing it from the computer " and a brown button that said: "I correctly read the word before hearing it from the computer." Each button was automatically linked to a corresponding slide. If the student pressed either the yellow or the blue button, the slide with the solution (the word with the instruction “Read it”) reappeared. Upon the student's activation of the olive button, a slide materialized, displaying the praise "Good trying!" accompanied by animated images, including a silver medal and a "well done" emoji. Upon clicking the brown button, the student was presented with a slide with the commendatory phrase of "Awesome!" accompanied by animated images of a golden medal, fireworks, and a jubilant emoji. The use of animated visuals aimed to equalize the two conditions. In tutor-led instruction, the teacher's vocal tone, facial expressions, and overall body language effectively conveyed the reward. However, in the computer-based instruction, capturing the same level of realism was not possible. The final slide of the presentation featured a verbal acknowledgment from the computer voice, recognizing and appreciating the student's active participation, equivalent to the tutor-led praises.

The utilization of the PowerPoint action button functions ensured that the two instructional conditions remain equivalent and can be effectively compared. Additionally, the action buttons provided opportunities for interactive experiences, allowing students to actively participate in a multisensory instructional approach that integrated the use of several sensory modalities, such as auditory, visual, and kinesthetic. Table 1 displays an example of the PowerPoint presentation. The authentic colors and design are depicted in Appendix L.

Preferred CTD Condition

The preferred condition was considered to be the one in which participants achieved the criterion with the minimum number of trials. Once the requirement of achieving 90% accuracy for three consecutive trials was met in a particular condition, the word list from the condition where this requirement was not met (referred to as the nonpreferred condition) was merged with the word list from the condition where the requirement was met (referred to as the preferred condition). This implies that under the preferred CTD condition, students were exposed to both words they have successfully acquired and words they were still in the process of acquiring. Instruction proceeded until students attained the criterion of 90% accuracy for three consecutive trials. The process of replicating the preferred condition aimed to detect the probability that the most effective treatment may lose its effectiveness when provided in isolation.

Generalization Phase

During the generalization phase, the teacher and the student engaged in a joint reading activity, where they read aloud the selected chapters from the two sources (History textbook and eBook) including the 50 words learnt in both conditions. The teacher read the sentences that did not contain the 50 words. The students read the sentences that included the 50 words. The teacher indicated to the student that it was his/her turn to read by saying "your turn". The tutor kept track and mark, both right and wrong words on a data sheet (see Appendix M). Corrections were made subsequent to the conclusion of the sentence. Researchers who examined the efficacy of reading error correction methods for children with dyslexia (Shaywitz, S. E., & Shaywitz, J., 2020) and educators who have recorded their own observations (Kalsoom et al., 2020) have both documented this process as the most effective. In order to mitigate feelings of frustration and lack of commitment, the misread words were constructively corrected. In this context, the instructor pointed out the incorrect word and asked, “Does that sound right?” or “Can you read this word again?” By employing this approach, the process of self-correction was enhanced. If the student accurately read the word, the teacher provided positive feedback by expressing, "Excellent. The word is ______." In the event that the student failed to correctly read the word on the second attempt, the instructor proceeded to read the entire sentence while specifically indicating the targeted word. Subsequently, the instructor requested the student to read the sentence by saying “Try reading that sentence again.” When a student accurately read the sentence, the instructor provided verbal reinforcement by stating: " Good try, the word is _____." Following the completion of each book's specified parts, students were given a 5-minute break to participate in their preferred activity.

Social Validity

Upon completion of the study, participants were asked to fill out a brief questionnaire using a 5-point Likert Scale. This questionnaire, prepared by the tutor, aimed to gather feedback on their experiences for each of the CTD conditions (see Appendix N). This survey provided a chance to have meaningful conversations with each participant and collect their viewpoints regarding each of the CTD conditions. The audio recording of the conversation between the instructor and the student was later shared with the parents.

III. RESULTS

In order to gather an overall total of 50 words with 0% accuracy (25 words from Set A and 25 words from Set B), three baseline sessions were required. This pattern held true for each of the three participants. All 50 of the words, that participants could not read correctly, were polysyllabic and exhibited spelling variations for the same letter or had at least one diphthong either vowel (αι, ει, οι, ου, αυ, ευ) or consonant (μπ, ντ, γγ, γκ). On the contrary, all three participants showed a high level of accuracy during the baseline sessions when reading words with two syllables and words with double consonants (λλ, μμ, νν, ππ, ρρ, σσ). These words were not included on the reading list.

In the tutor-led CTD condition, the average accuracy rate for correctly read words was 78% among participants, while under the software-assisted CTD condition, the average accuracy rate of correctly read words was 80%. Although the percentage of words read correctly was similar between the two conditions, the software-assisted method was marginally more efficient in terms of trials to criterion as the students reached criterion with a mean of 13 sessions under alternating instructional conditions. In the preferred CTD condition the average accuracy rate for correctly read words was 91%. Table 2 displays the mean percentages of correct responses from the participants in each condition. Figure 3 presents the average percentages of accurate and inaccurate responses for each condition.

In the tutor-led CTD condition, the average rate for independent correct replies (correct answers before the prompt) was 54% while under the software-assisted CTD condition, the average rate was 59%. In the tutor-led CTD condition, the average rate for correct answers after the prompt was 46% while under the software-assisted CTD condition, the average rate was 41%. In relation to the two types of incorrect answers (no answers and wrong answers), the participants in the tutor-led CTD condition had an average rate of 20% for no answers, whereas in the software-assisted CTD condition, the average rate was 18%. In the tutor-led CTD condition, the average rate of wrong answers was 80%, compared to 82% in the software-assisted CTD condition. Figure 4 illustrates the mean percentages for each participant and answer type in the two alternating instructional conditions. Over an average of 7 sessions, accurate replies before prompt exceeded the number of accurate responses after the prompt. This pattern stayed true for all participants. The profile of accurate student responses for each participant and answer type in the two alternating instructional conditions is depicted in Figure 5.

James: During baseline, when no software program or flashcards with word pictures were used, James did not correctly read any of the 50 words. During the tutor-led CTD condition, the average proportion of words read correctly improved to 75%. James's best reading accuracy rate for three consecutive trials under the teacher-directed CTD condition was 87%, hence he did not meet the criterion. During the software-assisted CTD condition, his mean percentage of words read correctly climbed to 77%. By the 14th software assisted session, James surpassed the required criterion (91%). Although the percentage of words read correctly was comparable, James's learned the targeted words faster under the software-assisted CTD condition. In the tutor-led CTD condition, James's average rate for correct answers before the prompt was 54% while under the software-assisted CTD condition, his average rate was 59%. In the tutor-led CTD condition, his average rate for correct answers after the prompt was 46% while under the software-assisted CTD condition, his average rate was 41% (Table 3). Regarding the two types of incorrect answers (no answers and wrong answers), James had an average rate of 21% for no answers in the tutor-led CTD condition, whereas in the software-assisted CTD condition, the average rate was 18%. In the tutor-led CTD condition, the average rate of wrong answers was 79%, compared to 82% in the software-assisted CTD condition (Table 3). The lower average percentage of non-replies under the software-assisted condition serves as a measure of the effectiveness of this condition. Since James met the criterion in the software-assisted CTD condition, the software-assisted CTD procedures were reimplemented during the preferred CTD condition phase to teach words from both lists. James's mean proportion of words read correctly under the preferred CTD condition was 91%. During the generalization phase, James correctly read phrases including the 50 words. Figure 6 illustrates James's results.

Robert: During the baseline, Robert did not accurately read any of the 50 words. Under the teacher-directed CTD condition, the mean percentage of accurately reading words increased to 80%. Under the software-assisted CTD condition, his average accuracy in reading words increased to 85%. By the 12th software assisted session, Robert surpassed the required criterion (92%). Robert 's best reading accuracy rate for three consecutive trials under the tutor-led CTD condition was 88%, hence he did not meet the criterion. Robert demonstrated greater efficiency in learning the targeted words while using software-assisted CTD, despite the similar number of properly read words. In the tutor-led CTD condition, Robert's average rate for correct answers before the prompt was 52% while under the software-assisted CTD condition, his average rate was 61%. In the tutor-led CTD condition, his average rate for correct answers after the prompt was 48% while under the software-assisted CTD condition, his average rate was 39% (Table 3). Regarding the two types of incorrect answers (no answers and wrong answers), Robert had an average rate of 17% for no answers in the tutor-led CTD condition, whereas in the software-assisted CTD condition, the average rate was 14%. In the tutor-led CTD condition, his average rate of wrong answers was 83%, compared to 86% in the software-assisted CTD condition (Table 3). The lower average percentage of non-replies under the software-assisted condition serves as a measure of the effectiveness of this condition. Since Robert met the criterion in the software-assisted CTD condition, the software-assisted CTD procedures were reimplemented to teach words from both lists during the preferred CTD condition phase. Robert's mean proportion of words read correctly was 93% under the preferred CTD condition. During the generalization phase, Robert correctly read phrases including the 50 words. Figure 7 illustrates Robert's results.

Patricia: During the baseline, Patricia did not accurately read any of the 50 words. Under the teacher-directed CTD condition, there was a notable increase in the average accuracy rate of properly read words, reaching 78%. As Patricia's highest reading accuracy rate was 88% in the teacher-directed CTD condition, she failed to satisfy the criterion. Under the software-assisted CTD condition, her average accuracy in reading words increased to 79%. By the 15th software assisted session, Patricia reached the required criterion (90%). Although the percentage of words read correctly was comparable, Patricia learned the targeted words more efficiently under the software-assisted CTD condition. In the tutor-led CTD condition, Patricia's average rate for correct answers before the prompt was 56% while under the software-assisted CTD condition, his average rate was 58%. In the tutor-led CTD condition, his average rate for correct answers after the prompt was 44% while under the software-assisted CTD condition, his average rate was 42% (Table 3). Regarding the two types of incorrect answers (no answers and wrong answers), Patricia had an average rate of 23% for no answers in the tutor-led CTD condition, whereas in the software-assisted CTD condition, her average rate was 22%. In the tutor-led CTD condition, her average rate of wrong answers was 77%, compared to 78% in the software-assisted CTD condition (Table 3). The comparable mean non-response rate observed in both the tutor-led and software-assisted conditions does not provide evidence of any difference in the effectiveness of either condition. As Patricia fulfilled the criterion in the software-assisted CTD condition, the software-assisted CTD processes were reimplemented during the preferred CTD condition phase to instruct words from both lists. Patricia's average percentage of words read correctly was 89%, under the preferred CTD condition. During the generalization phase, Patricia's accuracy percentage was 93% since she did not read all 50 words correctly. Figure 8 illustrates Patricia's results.

Social Validity

Participants engaged in individual surveys conducted by the researcher to assess the social validity and student approval of the CTD conditions. All three participants found the process of completing the cartoon Likert Scale questionnaire to be enjoyable. Each student concurred that they derived equal enjoyment from both conditions. They expressed their satisfaction with using the computer as a tool for reading practice. They acknowledged the positive impact it had on their reading performance and expressed an eagerness to continue using it for future reading practice. Robert displayed a high level of enthusiasm regarding the software-assisted condition. According to James and Patricia, the words in both conditions posed some difficulty, whereas Robert found them to be relatively easy. All participants expressed their admiration for the pictures on both flashcards and slides. In relation to the participants' opinions of the tutor, Patricia checked the box labelled "cool" on the Likert scale, while James and Robert checked the box labelled "fun."

Following the completion of the intervention, individual meetings were conducted with the parents of the participants. A discussion was held regarding the children's perspectives on the entire process, in addition to their outcomes under both instructional conditions. During these meetings, the tutor provided the parents with a detailed report of the children's progress in reading and their overall attitudes towards the procedure. Parents provided the teacher with feedback concerning their children's overall response to the process, as well as their preferences and impressions regarding the two instructional conditions. James' parents observed that he never voiced any discontent with the lessons, instead describing them as a form of “playtime”. He stated a slight preference for PowerPoint lessons over tutor-led procedure. Robert's parents reported that he occasionally voiced his discontent regarding the length of the sessions. Nevertheless, his disposition frequently shifted to an upbeat mood following the lesson. Robert also mentioned his preference for sessions that utilized software. Patricia's parents observed her strong enthusiasm for the process, as she frequently showcased the words she was acquiring. She indicated a preference for instruction led by the tutor, even though she met the criterion in the computer condition. All parents expressed contentment with the procedure, highlighting the efficient use of technology in education, which can reduce the high costs associated with personalized services and intensive instruction that children with reading difficulties require.

Interobserver Reliability

The sessions were recorded using a digital voice recorder to allow for interobserver reliability assessment. Data on interobserver reliability were collected for at least 33% of sessions for each student. Data was gathered on three variables: the number of words mastered, the number of trials necessary for mastery, and the length of training sessions were gathered. In order to calculate the interobserver reliability percentage, the total number of agreements was divided by the sum of agreements and disagreements. The interobserver reliability for all three variables measured was found to be 100%.

IV. Discussion

This study aimed to evaluate the efficacy and efficiency of teaching Greek irregular sight words to third-grade students with dyslexia. The comparison was made between tutor-led instruction and software-assisted constant time delay. Both conditions were effective in teaching sight word reading to all three students, according to the results. None of the three participants demonstrated clear fractionation between the two conditions. The findings are consistent with two prior comparative studies conducted by Kim et al., 2017 and Auphan et al., 2018. The effectiveness of technology-based and teacher-led instruction in enhancing reading skills in primary school children with reading difficulties was compared in these studies. The effectiveness of both methods was found to be comparable, as indicated by the positive results observed in reading for fourth (Kim et al., 2017) and fifth grade students (Auphan et al., 2018) using both teacher-assisted and computer-based methods.

When comparing the efficacy of the two methods, the software-assisted CTD condition resulted in more efficient word learning for all three students, as measured by trials to criterion. Under the software-assisted instruction, the participants achieved an average of 91% reading accuracy in a mean of 13 sessions. During the same time frame of tutor-led instruction, the participants attained an average reading accuracy of 87.5%, which was slightly lower than the criterion (≥ 90%). This finding aligns with two previous comparative studies conducted by Council et al., 2019 and Horne, 2017, which demonstrated the superior efficiency of computer-assisted instruction over teacher-assisted instruction on reading fluency of elementary students with learning disabilities. In the study conducted by Council et al. in 2019, the number of correct words per minute was 22% higher during computer-assisted sessions in comparison to teacher-assisted sessions. In the study conducted by Horne, 2017, it was found that 38 primary students (3rd to 5th grade) with learning disabilities reached the reading comprehension criterion (i.e., 10 correctly answered quiz questions) in 10 sessions of computer-led instruction compared to 13 sessions of teacher-led instruction. While the present study does not exhibit as pronounced differences as the two aforementioned studies, it does validate that computer-assisted instruction is more time-efficient when compared to tutor-led instruction.

The participants' familiarity with technology was apparent during each software-assisted session, especially when they were required to select the corresponding button on the computer to observe their performance for each of the tested words. This finding is consistent with a previous study conducted by Taylor and Vestergaard (2022), which demonstrated that children with dyslexia possess the ability to effectively manipulate commands within software programs or applications. It is worth mentioning that the tutor needed to intervene only once during Patricia's first software-assisted session when she became confused with the procedure and required assistance in selecting the appropriate button. The potential benefits of computer-based instruction with minimal or no instructor involvement are noteworthy, as it fosters self-directed learning among children diagnosed with dyslexia, who rely significantly on individualized instruction to enhance their reading abilities (Armstrong & Squires, 2015).

With regard to engagement and concentration throughout the sessions, Robert exhibited attentiveness under both conditions. James demonstrated greater engagement in the software-assisted condition, whereas Patricia exhibited higher commitment in the tutor-led condition. Nevertheless, she successfully met the criterion with software-assisted instruction. The implementation of the differential reinforcement strategy yielded favorable results in both conditions with respect to the number of accurate responses given without prompting and the degree of motivation exhibited by the participants. It is worth mentioning that in the software-assisted condition when the computer voice uttered "awesome" and the congratulatory emoji was displayed, participants exhibited slightly more ebullient facial expressions. The finding is consistent with previous research conducted by Bittencourt et al. (2016) and Papastergiou (2009). These studies have demonstrated that learning in an interactive and captivating digital environment may increase motivation and enhance children's enjoyment when engaged in reading activities.

The average rate of independent responses in the last tutoring session was 88.4%, whereas in the final computer session, the mean percentage of independent answers was 90.2%. Consistent with prior research on sight word reading, the results of this study demonstrate that children with reading difficulties achieve a substantial increase in the percentage of independent responses and word acquaintance in the CTD procedure (Aldosiry, 2022; Appelman et al., 2014; Chazin & Ledford 2021; Coleman et al., 2012; Hughes & Fredrick, 2006; Hughes et al., 2002). In addition, the relatively low rates of non-answers (20% in the tutor-led CTD and 18% in the software-assisted CTD) indicate that students were not hesitant to take risks in both conditions. This attitude is beneficial for instructional outcomes, as research suggests that “errors can be a successful tool for instruction for children with reading difficulties” (Peng, 2020). Active student engagement, even if the response is incorrect, is preferable to no response, since mistakes enhance learning and motivation (Marmuta, 2022). The slightly lower average percentage of non-replies, as opposed to wrong responses, under the software-assisted condition serves as an indicator of the effectiveness of this condition. This aligns with research indicating that instructional methods encouraging active participation, regardless of response accuracy, result in more effective instructional outcomes (Käfer et al., 2019).

An interesting finding was observed regarding the varieties of errors committed by the participants during the process of word reading. A significant proportion of errors was recorded in words comprising vowel diphthongs (αι, ει, οι, ου, αυ, ευ). Participants tended to read these diphthongs as separate units instead of as a single unit. For example, the word "κατάμαυρο" (katámavro) meaning "pitch black" was incorrectly pronounced as "καταμάυρο" (katamáyro). There were fewer errors observed in the words that displayed variations in their orthographic depiction, such as the word "αποτυπώθηκε" (apotypóthike), which was incorrectly pronounced as “αποτυπίθηκε” (apotypýthike). A small portion of the reading errors were phonological in nature, such as the word “θάλασσα” (thálassa), which was misspelt as "φάλασσα" (fálassa), which means "sea". This pattern held true for all the participants. These findings align with the research conducted by Andreou and Baseki (2012) and Protopapas et al. (2013), which indicate that Greek students with dyslexia primarily produce errors related to morphology and spelling. Morphological errors primarily pertain to mistakes in adjective endings related to gender and degrees of comparison (comparative-superlative), as well as verb errors regarding tense and voice. Spelling errors can encompass errors in intonation, the separation of diphthongs, the omission of diacritics, and more. In relation to the recurrence of reading errors, an apparent pattern was found wherein participants committed the same error on the most challenging words for over five trials.

In terms of time efficiency, tutor-led CTD sessions lasted an average of 2.1 minutes less than software-assisted CTD. This is attributable to the structure and pace of the PowerPoint presentations, as opposed to the tutor's ability to eliminate gaps upon correct student response or between the conclusion of one trial and the next in the tutor-led condition. Furthermore, the preparation of the PowerPoint presentations necessitated a larger time investment in comparison to the flashcards. However, once slides were created for a particular word in PowerPoint, it was effortless to duplicate and transfer them to new presentations. This has practical implications for teachers, as a PowerPoint presentation, once developed, may be utilized across several students or classrooms, resulting in a greater return on the initial time invested.

Emphasizing the primary findings of the study, while the data does not demonstrate a significant advantage for computer-led instruction, it is noteworthy that it is just as effective as tutor-led instruction for students with dyslexia. This is very important in the field of special education, considering the need for one to one individualized instruction and the limited financial resources available to provide such support. Technology has the potential to bridge this gap (Starks & Reich, 2023).

Furthermore, the rapid progress of technology, particularly in the field of artificial intelligence (AI), holds great promise for transforming reading practices among elementary students with learning disabilities (Alqahtani, 2020). Research has demonstrated promising outcomes in the enhancement of reading and writing skills for students with dyslexia through the utilization of AI and robotics (Dean et al., 2021). A recent review study conducted by Papakostas et al. (2021) examined the application of artificial intelligence (AI) in special education. The findings of the review show that in most studies, robots demonstrated significant effects in improving reading skills, boosting reading motivation, and enhancing self-esteem of students with reading difficulties. Research indicates that robots have the ability to enhance learning through motor interaction, provide adaptive empathic feedback and adapt content to cater to the specific needs and particular interests of children with reading difficulties (Johal, 2020).

Limitations

The findings of this study suggest that software assisted CTD can be a valuable tool for teaching Greek irregular words to third graders with dyslexia. However, it is important to acknowledge certain limitations. First, the current study utilized a small number of participants (specifically, three), which limits the generalizability of the findings (i.e., external validity). Second, the irregular words used in this study may have been too difficult for third graders with dyslexia, given their difficulties in accurately reading irregular words with uncommon letter combinations (Ehri, 2005; McArthur et al., 2015; Protopapas et al., 2013). The word sets utilized in this study comprised a range of irregular elements, such as diphthongs, odd vowels (ω,υ), and consonants, particularly the “labials” which are formed with the lips, (π [p], β [v], φ [f]) and/or dentals which are formed with the tongue and teeth, (τ[t], δ [d], θ [th]), all of which pose challenges for students with dyslexia (Andreou and Baseki, 2012).

During the baseline sessions, it was assured that the participants were unfamiliar with the words selected for intervention. Nevertheless, there might be a chance that the participants in this study were exposed to the target terms through regular classroom instruction. Yet, this likelihood was diminished since 70% of the intervention sessions took place around the holiday season, a time when participants were not attending classes. Relatedly, the increased levels of engagement and commitment observed throughout the sessions, along with the heightened motivation reported in both conditions (particularly in the software-assisted condition), could potentially be linked to the sessions taking place during the holiday period when children were not experiencing stress. The absence of tension and tiredness could also explain the children's accelerated familiarity with and successful execution of the complicated automated procedure, which required them to select the appropriate button from the four buttons presented on the differential response slide (slide 5 in Table 1). It is important to acknowledge the limitation of the holiday timing issue, as it has the potential to introduce bias into the findings of this study (Schaffner & Schiefele 2016).

One additional limitation of this study pertains to the categorization of inaccurate responses into two groups: non-responses and incorrect responses. Hence, in contrast to previous research that employed differential reinforcement approaches for computer-assisted reading instruction (Lee & Vail, 2005), the present study did not assess the number of incorrect responses prior to and subsequent to prompting. It is important to acknowledge that in Lee and Vail's study, the researchers regularly got involved in the computer instruction procedure to assist the participants. The purpose of this study was to compare the two conditions by imposing consistency between the two instructional conditions. Specifically, it was necessary to validate the effectiveness of the software-assisted condition as a self-paced instructional approach that does not necessitate the teacher's involvement. It was anticipated that the addition of two extra answer categories would burden the children throughout the automated procedure of selecting the matching to the response button (slide 5 in Table 1) would confuse the children and demand teacher involvement.

Finally, during the generalization phase, participants were exposed to sentences from the two books that contained both words they had learned during intervention and those they had not come across previously. This may potentially lead to feelings of frustration among students. Nevertheless, the likelihood of this event was diminished by two factors. Firstly, the sentences in both books were short, with an average of 15 words per sentence. Secondly, the students had already mastered the most difficult vocabulary within these sentences. The implementation of the whole-sentence repetition method as a corrective strategy proved to be successful in facilitating the children's ability to accurately identify and correct errors in new words.

V. Conclusion

Future Research

In light of the present findings and limitations of the current study, there are various potential directions for future research. Further research is needed to verify the results of this study and to examine a larger number of participants. Future research could also evaluate the effect of integrating digital resources as a means to enhance word reading accuracy in children with dyslexia. Furthermore, it is imperative for future studies to explore the impact of incorporating positive reinforcement strategies into digital resources in order to enhance reading motivation among children with dyslexia. Another area for further study is the correlation between the emotional experiences of children with dyslexia, such as embarrassment and anxiety, and their motivation to read. Prior research has addressed this subject matter (Alexander-Passe, 2006; Mugnaini et al., 2009; Yanhong et al., 2020), however, further study is necessary to gain a comprehensive understanding of the effects, particularly within the Greek educational context. Moreover, additional research should be undertaken to compare the efficacy of tutor-led CTD and computer-assisted CTD in order to determine the more suitable approach for students with dyslexia. Finally, future research could expand to encompass high school students with dyslexia, with the aim of evaluating the efficacy of computer-assisted CTD in facilitating the acquisition of complex definitions necessary for comprehending subjects like computer science and biology.

Conclusion

This study presents many possibilities for effective teaching strategies in a classroom setting, as the results showed that both teacher and computer assisted instructional strategies can effectively facilitate word learning in students with dyslexia. Given that the utilization of PowerPoint accelerated the correct reading of words for all participants, it is critical that children with dyslexia be instructed employing cutting-edge technologies that facilitate multisensory learning. During the discussions between the tutor and the participants' parents revealed the challenge of delivering personalized services and intensive teaching to their children due to the related high costs. Research suggests that educators and schools can benefit from the use of inexpensive and user-friendly digital tools, such as the PowerPoint software to enhance the reading skills of children with reading difficulties (Barber et al., 2018; Bennett et al., 2017; Council et al., 2019; Gibson et al., 2014). Furthermore, studies have shown that the incorporation of digital tools into school strategies can effectively support personalized learning for children with dyslexia, helping them overcome challenges related to vocabulary (Andreev et al., 2009; Athanaselis et al., 2014; Bittencourt et al., 2016; Gibson et al., 2014; Papastergiou, 2009). Multiple studies referenced in the literature review have demonstrated that students with dyslexia exhibit enhanced learning outcomes when information is presented through multiple sensory channels simultaneously (Boardman, 2020; Nijakowska, 2013; Schlesinger & Grey, 2017; Supriatna & Ediyanto, 2021). The incorporation of innovative methods into the Greek educational system, which predominantly relies on traditional teaching approaches, will specifically aid in fostering skills in reading among students with dyslexia. Simultaneously, integrating positive reinforcement in both digital and conventional methods of instruction will enhance reading motivation for children with dyslexia. As B.F. Skinner suggested, “We shouldn’t teach great books; we should teach a love of reading. Knowing the contents of a few words of literature is a trivial achievement. Being inclined to go on reading is a great achievement” (Evans, 1968, p. 73).

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Table 1

PowerPoint presentation

Slides 1-4

PowerPoint Slide	**Voice Output**	**Transitions Timing**
Ας μάθουμε καινούριες λέξεις	“Let’s learn new words”	1. Slide changes after one sec
Θυμήσου αν δεν ξέρεις την λέξη περίμενε και θα την πω	“Remember, if you do not know the word, wait and I’ll tell you"	2. Slide changes after two sec This slide appears after every three words
αθλητής 	“Read this word”	3. Slide changes after one sec in 0-sec delay and after five changes in 5-sec delay
αθλητής	The word is “athlete”	4. The correct answer slide.

Table 1

PowerPoint presentation

Slides 5-6

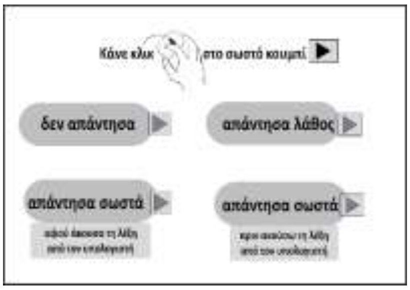
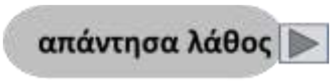
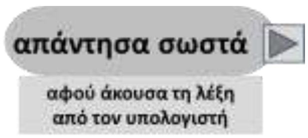
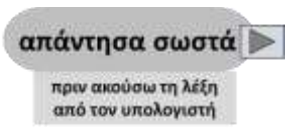
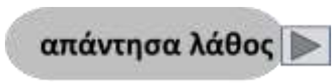
PowerPoint Slide	Voice Output	Transitions Timing
	“Click on the right button”	5. The differentiated reinforcement interactive slide. It appears one second after the slide-answer.
	1st Button: "I didn't read the word"	
	2nd Button: "I read the word incorrectly"	
	3rd Button: "I correctly read the word after hearing it from the computer "	
	4th Button: "I correctly read the word before hearing it from the computer."	
	The word is ‘athlete’	6. The slide appears when the student presses either the 1st or the 2nd button.  

Table 1

PowerPoint presentation

Slides 7-9

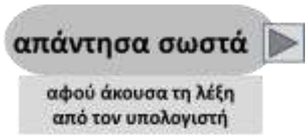
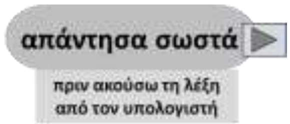
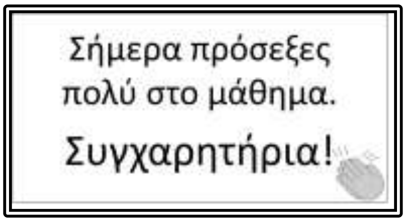
PowerPoint Slide	Voice Output	Transitions Timing
	"Good trying!"	7. The slide appears when the student presses the 3rd button. 
	"Awesome!"	8. This slide appears when the student presses the 4th button. 
	"You've been quite attentive today, so congrats	9. The final slide of each software-assisted session.

Table 2

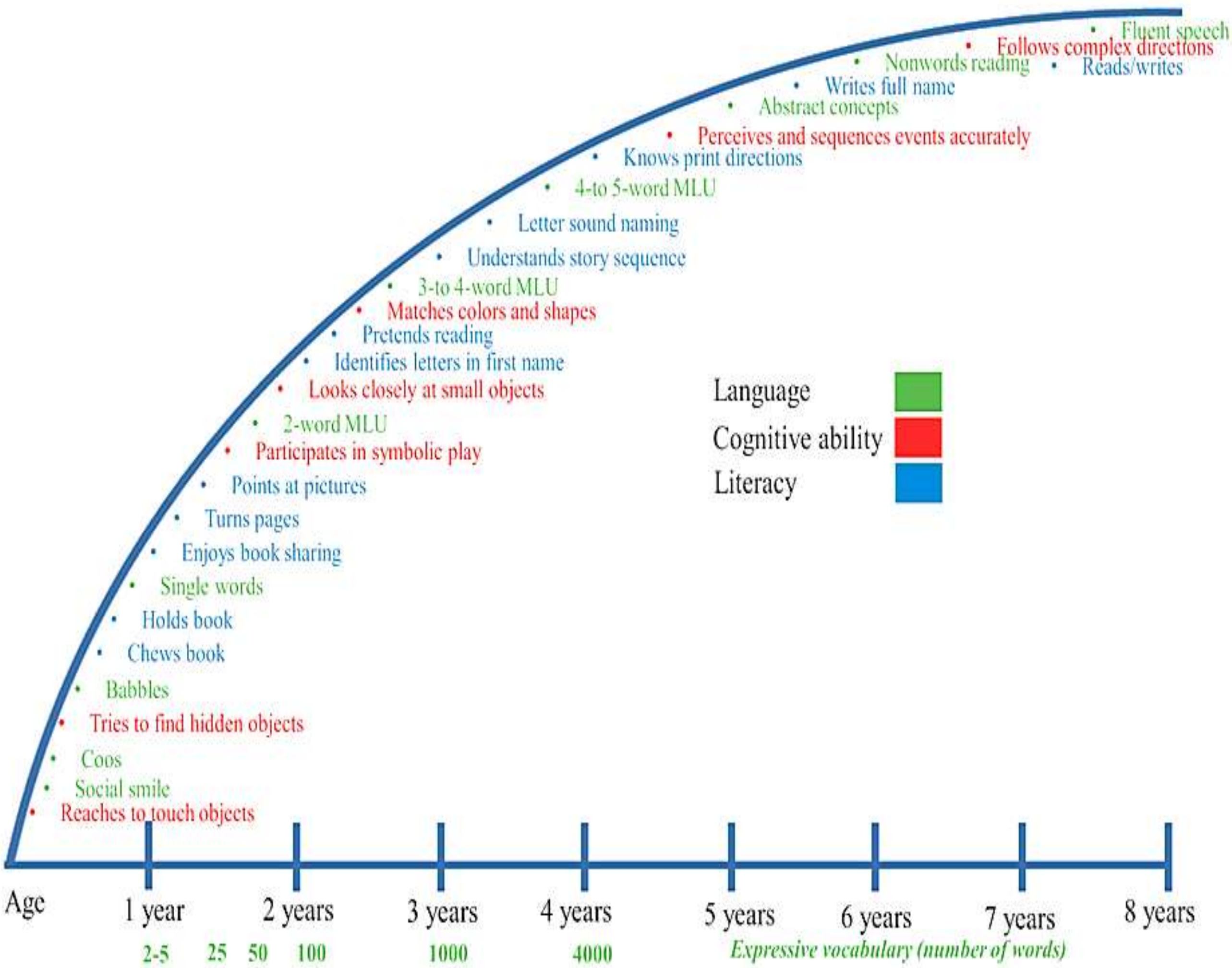
Participants' average accuracy reading rates in each condition

	James	Robert	Patricia
** TL % Correct	75%	80%	78%
# of Sessions required to meet criterion	–	–	–
*SA % Correct	77%	85%	79%
# of Sessions required to meet criterion	14	12	15
Preferred SA % Correct	91%	93%	89%
Generalization % Correct	100%	100%	93%

*TL = tutor-led instruction; SA= software-assisted instruction

Figure 1

Milestones in Reading Acquisition



Note. Milestones in reading acquisition during ages zero to eight years in the three different domains that underlie reading: language (green), cognitive ability (red), and literacy abilities (blue) along age (x-axis). Adapted from: *How to create a successful reader? milestones in reading development from birth to adolescence,* by Horowitz-Kraus, 2017 (p. 540), Acta Paediatrica. Copyright 2017 by Oslo Acta Paediatrica. MLU= Measure of Linguistic Productivity: calculated by collecting 100 utterances spoken by a child and dividing the number of morphemes by the number of utterances.

Figure 2

The Three-Term Contingency (ABC)

Examples of Word Reading

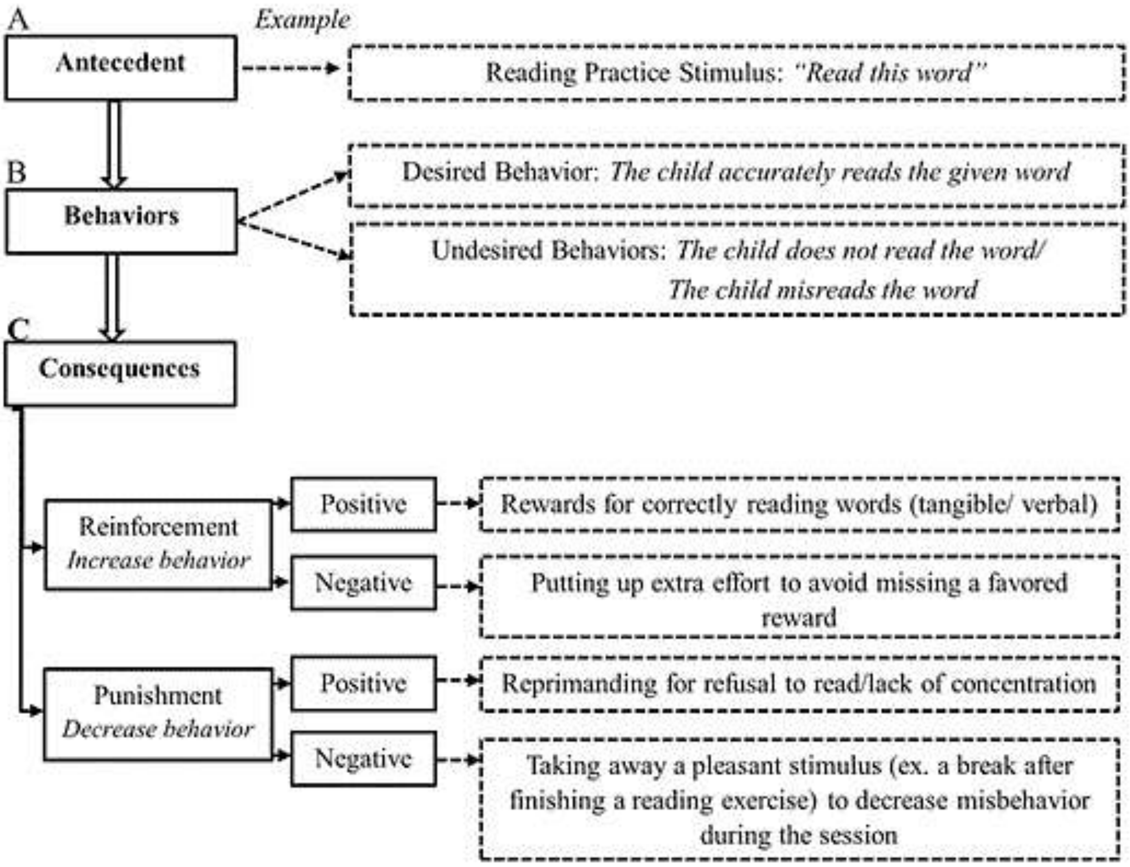


Figure 3

The mean percentages of Correct and Incorrect Responses per Condition

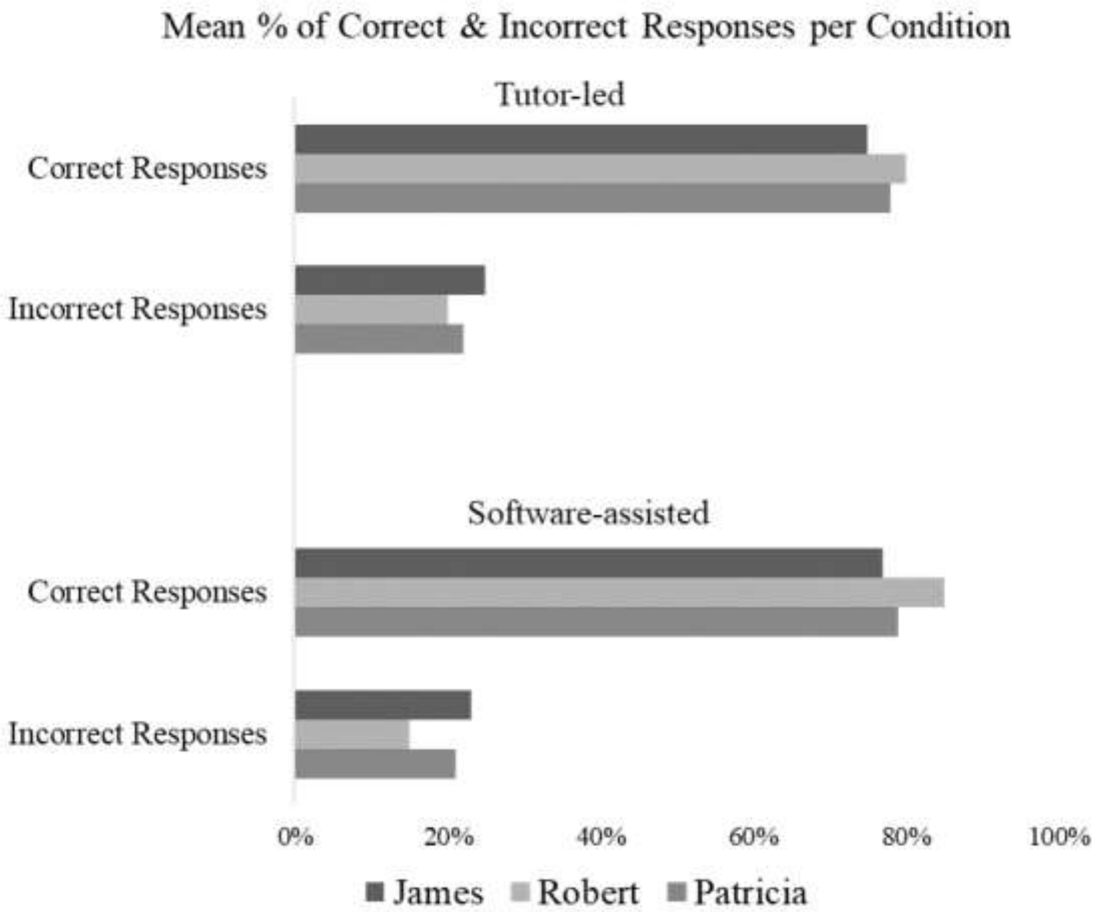
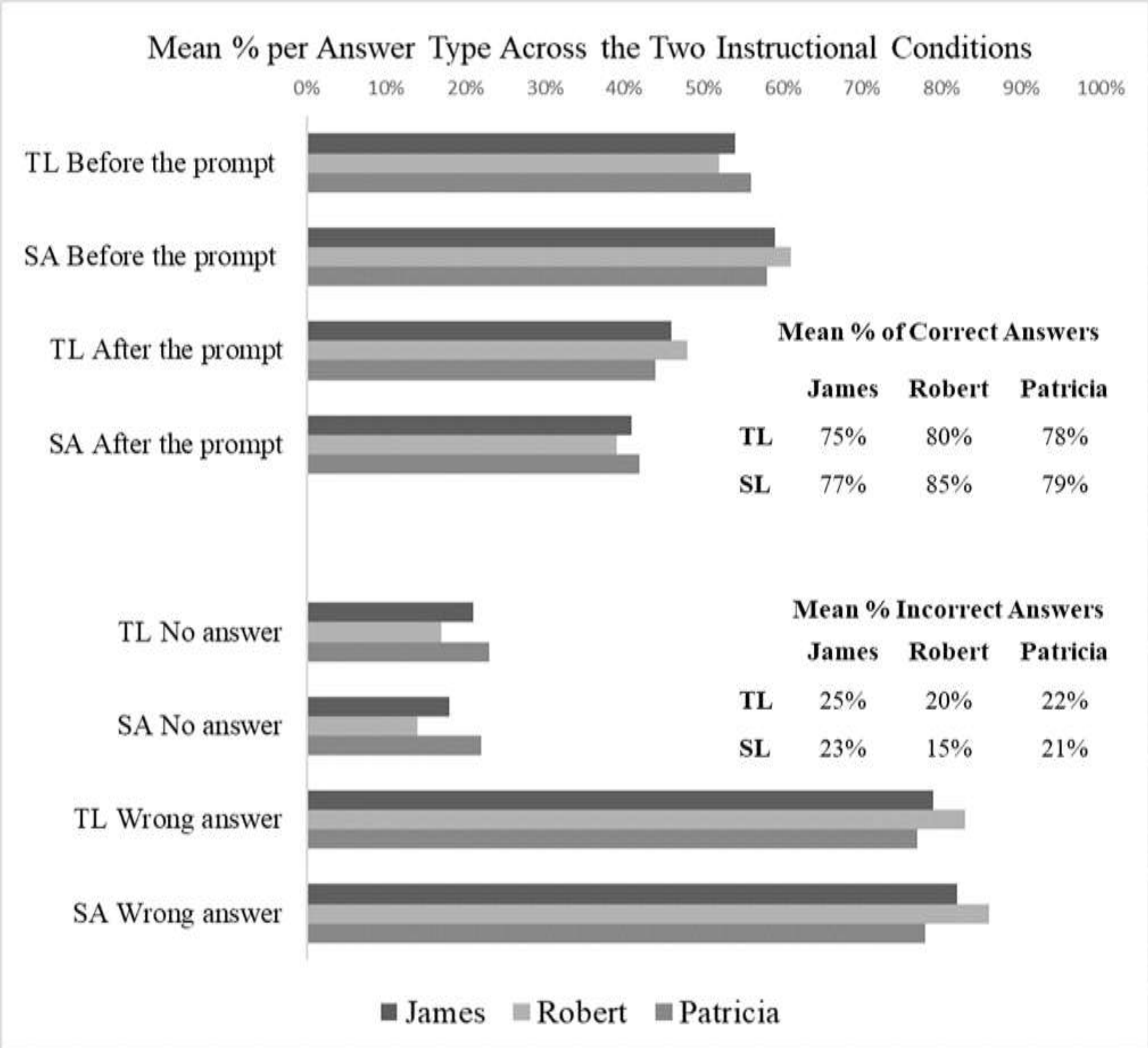


Figure 4

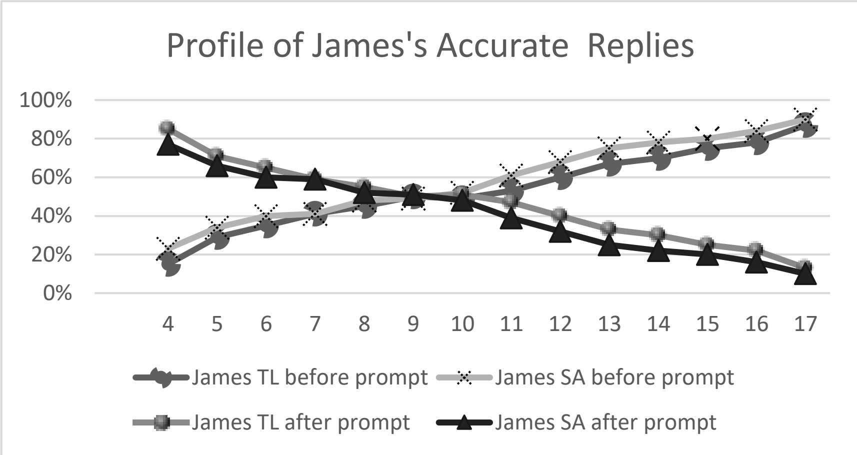
The mean percentages per answer type across the two instructional conditions

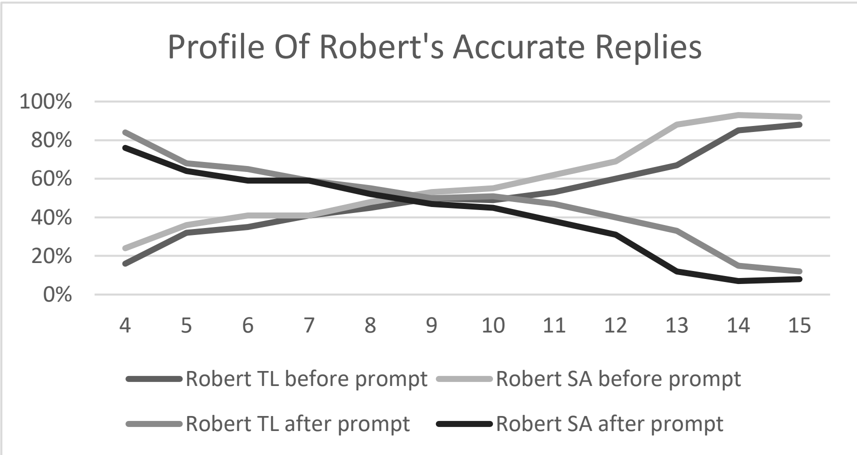


Note. TL = tutor-led instruction; SA= software-assisted instruction

Figure 5

Profile of Accurate Student Responses





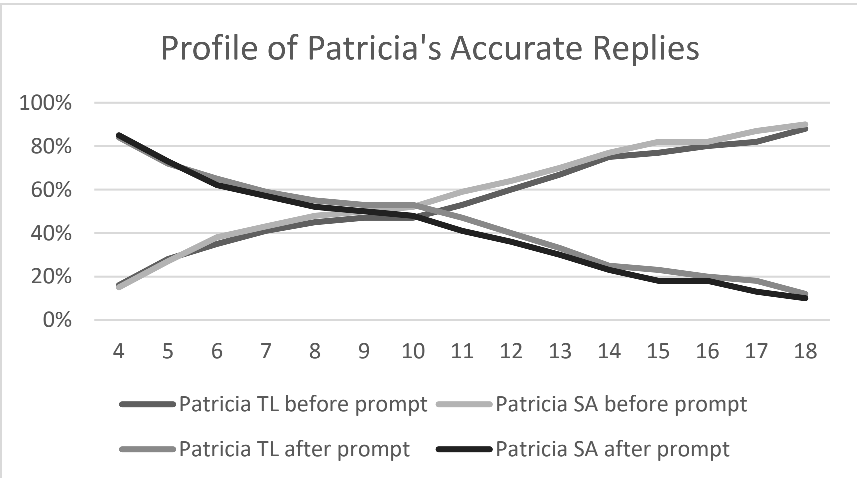


Figure 6

James's reading accuracy rates under the software-assisted (SA)

and tutor-led (TL) conditions

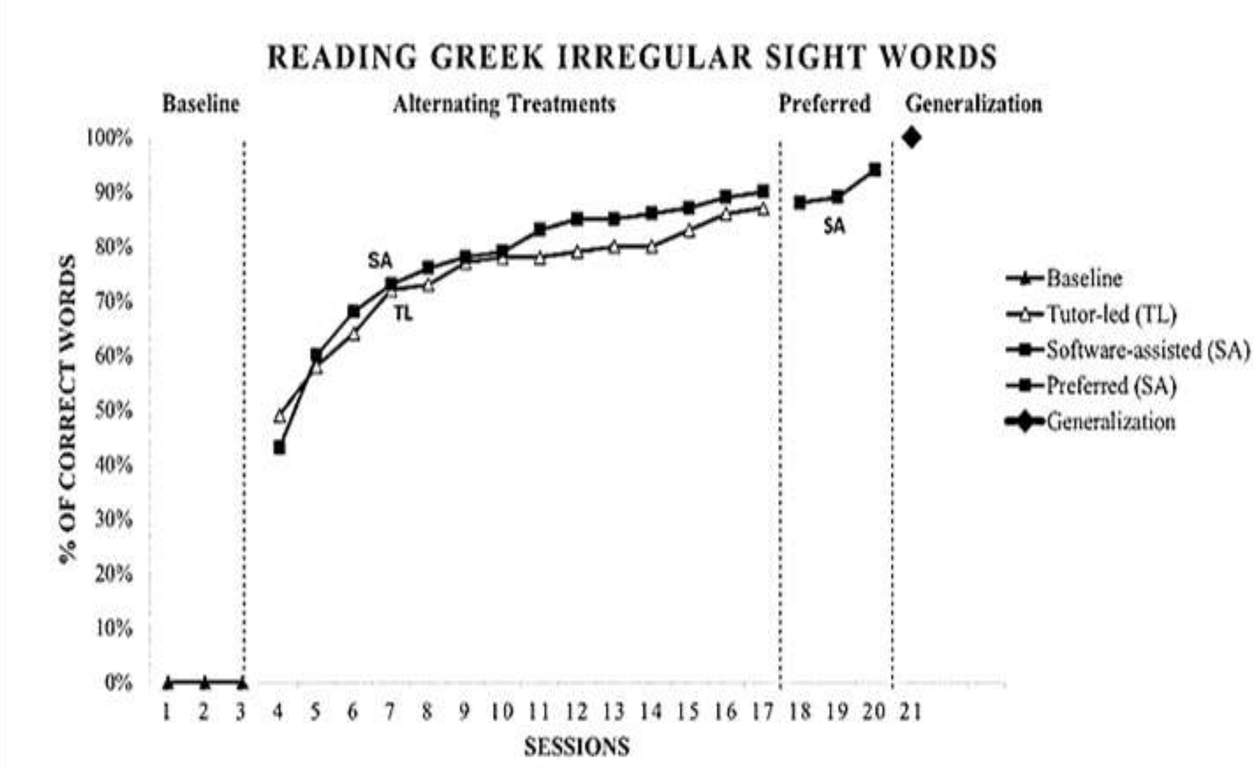


Figure 7

Robert's reading accuracy rates under the software-assisted (SA) and tutor-led (TL) conditions

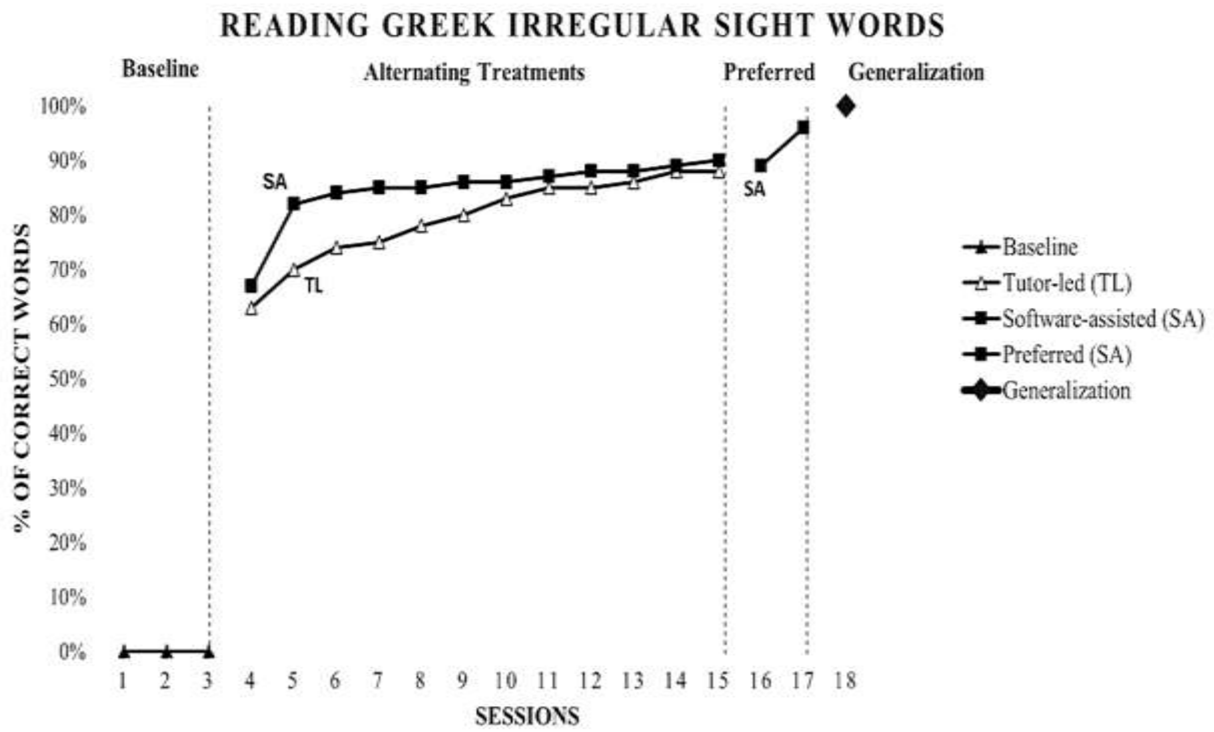
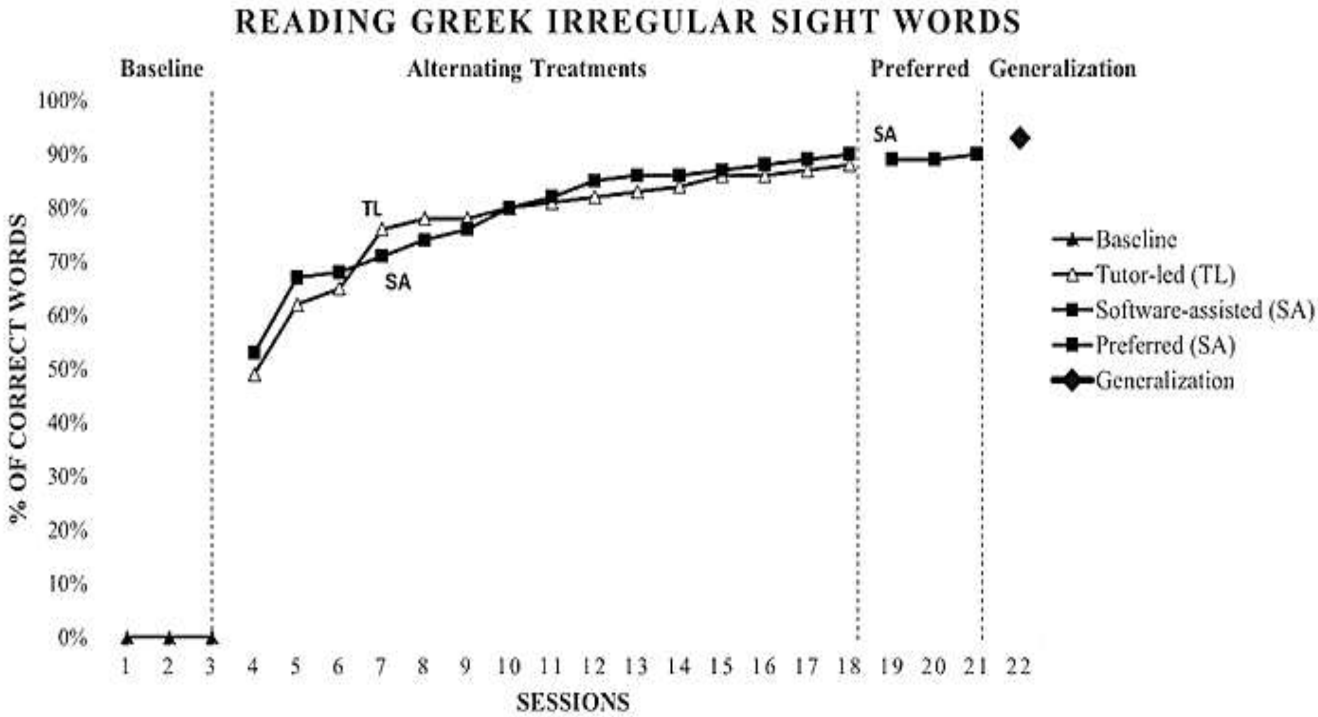


Figure 8

Patricia's reading accuracy rates under the software-assisted (SA) and tutor-led (TL) conditions



APPENDIX A

Parental Agreement

ΕΝΤΥΠΟ ΣΥΝΑΙΝΕΣΗΣ ΓΟΝΕΑ

Σύγκριση δύο πειραματικών μεθόδων διδασκαλίας για την εκμάθηση λέξεων σε μαθητές Γ' τάξης Δημοτικού με δυσλεξία

1. Σκοπός της ερευνητικής εργασίας
Σκοπός της παρούσας μελέτης είναι η σύγκριση της αποτελεσματικότητας και της αποδοτικότητας δύο μεθόδων διδασκαλίας με στόχο την εκμάθηση ελληνικών απαιτητικών λέξεων σε μαθητές της Γ' Δημοτικού με διάγνωση δυσλεξίας. Η πρώτη μέθοδος περιλαμβάνει τη διδασκαλία με τη βοήθεια δασκάλου και η δεύτερη τη διδασκαλία με τη βοήθεια παρουσιάσεων σε PowerPoint. Οι λέξεις που θα διδαχθεί το παιδί σας εμπεριέχονται στο Σχολικό Βιβλίο Ιστορίας της Γ' Δημοτικού και στο ηλεκτρονικό βιβλίο «Ο μικρός Ρήγας και τα μυστικά σύμβολα της Χάρτας».

2. Διαδικασία
Το παιδί σας θα συμμετάσχει σε 6 έως 8 ωριαία μαθήματα που θα πραγματοποιηθούν στον χώρο σας. Η μέθοδος διδασκαλίας υπό την καθοδήγηση του δασκάλου θα γίνεται με κάρτες στις οποίες θα βρίσκεται τυπωμένη μία λέξη με την εικόνα που την απεικονίζει. Η μέθοδος διδασκαλίας με τη βοήθεια του PowerPoint θα γίνεται υπό την επίβλεψη του δασκάλου και θα περιλαμβάνει παρουσιάσεις με slides στα οποία θα βρίσκονται οι λέξεις με τις αντίστοιχες εικόνες. Και οι δύο μέθοδοι θα εφαρμόζονται στην ίδια συνεδρία. Με τη συναίνεσή σας, οι συνεδρίες θα ηχογραφηθούν. Τα δεδομένα θα φυλάσσονται με ευθύνη του ερευνητή. Μπορείτε να αρνηθείτε να ηχογραφηθείτε. Ο ερευνητής θα μεταγράψει τις ηχογραφήσεις και μπορεί να σας προμηθεύσει με ένα αντίγραφο του απομαγνητοφωνημένου κειμένου κατόπιν αίτησής σας. Έχετε το δικαίωμα να ελέγξετε και να επεξεργαστείτε την απομαγνητοφώνηση. Προτάσεις οι οποίες έχετε ζητήσει από τον ερευνητή να παραλειφθούν δε θα χρησιμοποιηθούν και θα διαγραφούν από όλα τα αντίστοιχα αρχεία. Τα απομαγνητοφωνημένα αποτελέσματα της έρευνας θα δημοσιευθούν μόνο έντυπα και όχι ψηφιακά χωρίς να συμπεριληφθούν πληροφορίες που θα αποκαλύπτουν την ταυτότητα του παιδιού σας. Εάν είναι αναγκαίο να γίνουν αναφορές σε συγκεκριμένα άτομα, θα είναι πάντοτε με ψευδώνυμο και χωρίς καμιά αναφορά στο σχολείο όπου φοιτά το παιδί σας.

3. Προστασία προσωπικών δεδομένων και καταγραφή αποτελεσμάτων
Η καταγραφή των αποτελεσμάτων της έρευνας και η δημοσίευσή τους θα πληροί όλες τις απαραίτητες προϋποθέσεις για την προστασία προσωπικών δεδομένων των παιδιών. Συγκεκριμένα, στη δημοσίευση των αποτελεσμάτων θα χρησιμοποιηθούν ψευδώνυμα (αγγλικά τυχαία ονόματα). Οι μόνες πληροφορίες που θα καταγραφούν είναι το φύλλο και η ηλικία του παιδιού. Τα παιδιά θα ενημερωθούν πριν την έναρξη των μαθημάτων για τη διαδικασία και θα συμμετάσχουν μόνο εφόσον το επιθυμούν.

Ο ερευνητής θα σεβαστεί την ελευθερία του παιδιού να διακόψει τη συμμετοχή του ανά πάσα στιγμή.

4. Εθελοντική Συναίνεση
Η συμμετοχή του παιδιού σας στην έρευνα είναι εθελοντική. Είσαστε ελεύθεροι να μην συναινέσετε ή να διακόψετε τη συμμετοχή του παιδιού σας οπότε επιθυμείτε.

5. Ενδεχόμενοι κίνδυνοι μελέτης
Δεν υπάρχει κανένας ενδεχόμενος κίνδυνος από τη συμμετοχή των παιδιών σας στην έρευνα.

6. Αναμενόμενα οφέλη
Η συμμετοχή στην έρευνα θα βοηθήσει το παιδί σας να διαβάζει με ευκολία και με ακρίβεια απαιτητικές λέξεις που συναντώνται συχνά στα σχολικά βιβλία και στα παιδικά μυθιστορήματα. Επιπλέον, θα παρέχει τη δυνατότητα να επαναλάβετε στο σπίτι όποια μέθοδο διδασκαλίας προτιμήσει το παιδί καθώς η διαδικασία είναι απλή.

Για τον γονέα Α: Διάβασα το έντυπο αυτό, κατανοώ τις ερευνητικές διαδικασίες και συναινώ να συμμετάσχει το παιδί μου στην έρευνα. Ναι …. Όχι …

Ημερομηνία: __/__/__

____
Ονοματεπώνυμο και υπογραφή γονέα Α

Για τον γονέα Β: Διάβασα το έντυπο αυτό, κατανοώ τις ερευνητικές διαδικασίες και συναινώ να συμμετάσχει το παιδί μου στην έρευνα. Ναι …. Όχι …

Ημερομηνία: __/__/__

____

Ονοματεπώνυμο και υπογραφή γονέα Β

\

Parental Agreement - Consent Form in English

A comparison of two experimental methods of instruction for word acquisition in third-grade students with dyslexia

1. Research aim

The current study aims to examine the efficacy and efficiency of two teaching techniques for teaching Greek irregular words to third-grade students with dyslexia. The first method employs tutor-led instruction, whereas the second uses PowerPoint slideshows to teach. The words that that your child will learn are included in the 3rd grade History Textbook as well as the e-book "Young Rigas and the Secret Symbols of Charta."

2. Method

Your child will attend 6 to 8 o40 min courses at home. The teacher will guide the teaching approach, which will consist of flashcards with a word and a picture. The PowerPoint teaching technique will comprise presentations with slides including the words and their related visuals. Both approaches will be used at the same time. The sessions will be recorded with your permission. The researcher will be solely responsible for the data. You have the right to decline to be recorded. The researcher will transcribe the recordings and, upon request, will supply you with a copy of the transcript. You have the option of reviewing and editing the transcript. Suggestions that you have ordered the researcher to leave out will be ignored and erased from any relevant files. The survey findings will be published in printed copy only (not online) and will not include any information that discloses your child's identity. If specific individuals must be referred to, they will always be done so under a pseudonym and without any connection to the school your child attends.

3. Personal data protection and data recording

The recording and dissemination of the study's results will meet all of the criteria for the protection of children's personal data. In particular, pseudonyms (random English names) will be utilized in the results release. The only information that will be recorded is the child's gender and age. Children will be told about the procedure prior to the commencement of the course and will only participate if they want to. The researcher will respect the child's right to withdraw from the study at any time.

4. The voluntary nature of participation

Your child's involvement in the study is entirely optional. You have the right to refuse to agree or withdraw your child's involvement at any time.

5. Potential study risks

There are no risks associated with your child's participation in the research.

6. Expected benefits

Participating in the study will enable your child to read difficult words found in textbooks and children's literature with ease and precision. Furthermore, because the process is easy, it will allow you to replicate whatever training approach your child wants at home.

For Parent A: I have read this form, understand the research protocols, and give my permission for my child to participate in the study. Yes .... No ...

Date: __/__/__

____
Parent A's name and signature

Parent B: I have read this form, understand the research protocols, and give my permission for my child to participate in the study. Yes .... No ...

Date: __/__/__

____
Parent B's name and signature

APPENDIX B

Audio Release Form

ΕΝΤΥΠΟ ΣΥΓΚΑΤΑΘΕΣΗΣ ΓΙΑ ΛΗΨΗ ΚΑΙ ΧΡΗΣΗ ΟΠΤΙΑΚΟΥΣΤΙΚΟΥ ΥΛΙΚΟΥ ΚΑΙ ΠΡΟΣΩΠΙΚΩΝ ΔΕΔΟΜΕΝΩΝ ΑΝΗΛΙΚΩΝ

Δέχομαι οικειοθελώς να μαγνητοσκοπηθεί το παιδί μου κατά τη διάρκεια του πειράματος που διεξάγει η Δήμητρα Μάλλιου. Αντιλαμβάνομαι ότι οι κασέτες θα χρησιμοποιηθούν μόνο για το σκοπό της έρευνας και προκειμένου να ελεγχθεί η συμφωνία μεταξύ των δύο παρατηρητών που συμμετέχουν στο πείραμα. Όλες οι συνεδρίες θα ηχογραφηθούν με τη χρήση ψηφιακής συσκευής εγγραφής φωνής Sony (σειρά ICD-PX).

Οι ηχογραφημένες συνεδρίες θα ταυτοποιηθούν με τη χρήση των ψευδώνυμων (αγγλικά τυχαία ονόματα) που έχουν οριστεί για τους συμμετέχοντες. Οι κασέτες θα αποθηκευτούν στην κατοικία της ερευνήτριας έως το τέλος της καταγραφής των αποτελεσμάτων. Μετά τη συλλογή των δεδομένων οι κασέτες θα καταστραφούν.

Για τον γονέα Α: Διάβασα το παρόν έντυπο, κατανόησα τα ερευνητικά πρωτόκολλα και δίνω την άδειά μου για τη συμμετοχή του παιδιού μου στη μελέτη.

Ημερομηνία: __/__/__

____

Όνομα και υπογραφή γονέα Α

Γονέας Β: Έχω διαβάσει το παρόν έντυπο, έχω κατανοήσει τα ερευνητικά πρωτόκολλα και δίνω την άδειά μου για τη συμμετοχή του παιδιού μου στη μελέτη.

Ημερομηνία: __/__/__

____

Όνομα και υπογραφή γονέα Β

Audio Release Form in English

I consent voluntarily to the filming of my child throughout the experiment that Dimitra Malliou conducts. It is to my knowledge that the recordings shall remain unused beyond the verification of accord between the two observers participating in the experiment and for the purposes of research. Every session will be documented utilizing an ICD-PX series Sony digital voice recorder.

A pseudonym (random English name) will be allocated to each participant in order to distinguish the recorded sessions. The researcher will retain the cassettes at their place of residence until the completion of the results recording process. Once data has been collected, the recordings will be disposed of.

For Parent A: I have read this form, understand the research protocols, and give my permission for my child to participate in the study. Yes .... No ...

Date: __/__/__

____

Parent A's name and signature

Parent B: I have read this form, understand the research protocols, and give my permission for my child to participate in the study. Yes .... No ...

Date: __/__/__

____

Parent B's name and signature

APPENDIX C

Informed Consent Comic Book – Caption (pp. 1-11)

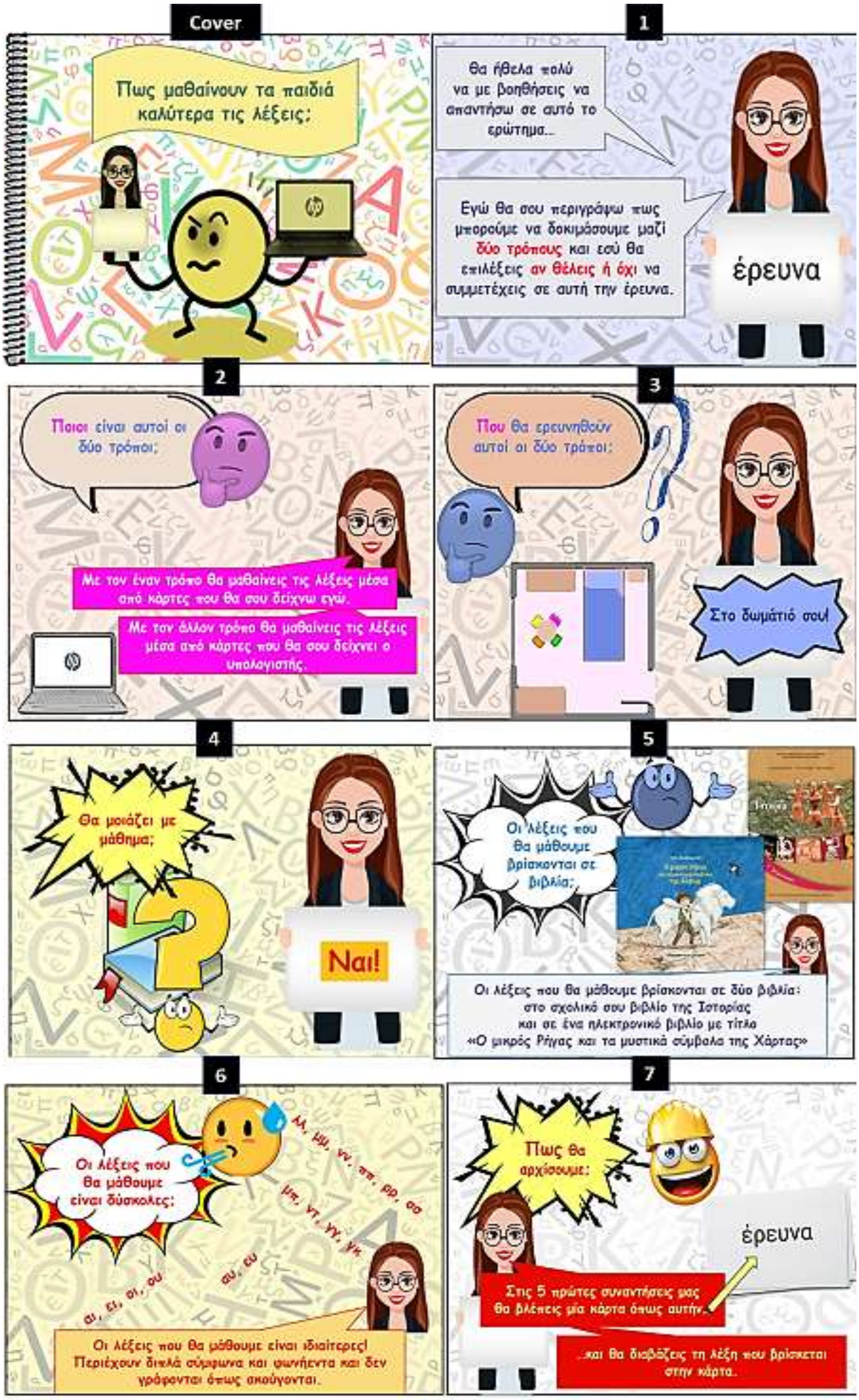
Page	Topic	Tutor/emoji dialogue	Aim
Cover	The purpose of the study		to state clearly the aim of the research
1	Who is involved	Tutor: *"I would love to help me answer this question... I'll describe how we can try two ways together and you will choose whether or not to participate in this study."*	to understand who is involved in this research project.
2	The two methods	Emoji: *Which are the two methods?* Tutor: *In one method you will learn the words from the cards I will show you....* *In the other method you will learn the words through cards shown by the computer.*	to describe the two instructional methods
3	Setting	Emoji: *Where will the two methods be examined?* Tutor: *At your room!*	to define the research setting
4	The sessions' quality	Emoji: *Will it be like a lesson?* Tutor: *Yes!*	to explain the nature of the sessions
5	The words' sources	Emoji: *Are the words we'll be learning found in books?* Tutor: *The words we'll be learning can be found in two books: your school History textbook and an eBook titled "Young Rigas and the secret symbols of Charta".*	to inform participants about the origins of the words
6	The words' complexity	Emoji: *Are the words we'll learn difficult?* Tutor: *The words we will learn are distinctive! They contain double consonants and vowels and are spelt differently than they sound*	to explain the words' irregularity
7	The Baseline process	Emoji: *How do we start?* Tutor: *In our first 5 meetings you will see a card like this one ...and you'll read the card's word."*	to explain the collection of baseline data procedure
8		Emoji: *What if I can't read the words correctly?* Tutor: *The words you incorrectly read will be placed in these two boxes, so we can learn them well in the following lessons... and the words you correctly read will be placed in these two boxes*	
9	The intervention phase	Emoji: *What are we going to do in the next lessons?* Tutor: *We'll learn the words in two ways in each of our lessons... With cards that I'll show you...* *and cards that the computer will show you.*	to familiarize the student with the alternating instructional conditions
10	Tutor-led material	Tutor: *The cards I'll show you, will look like this one.*	to familiarize the student with the material that will be utilized in the two conditions
11	Software-assisted material	Tutor: *The cards the computer will show you will look like this one.*	

Informed Consent Comic Book – Caption (pp. 12-21)

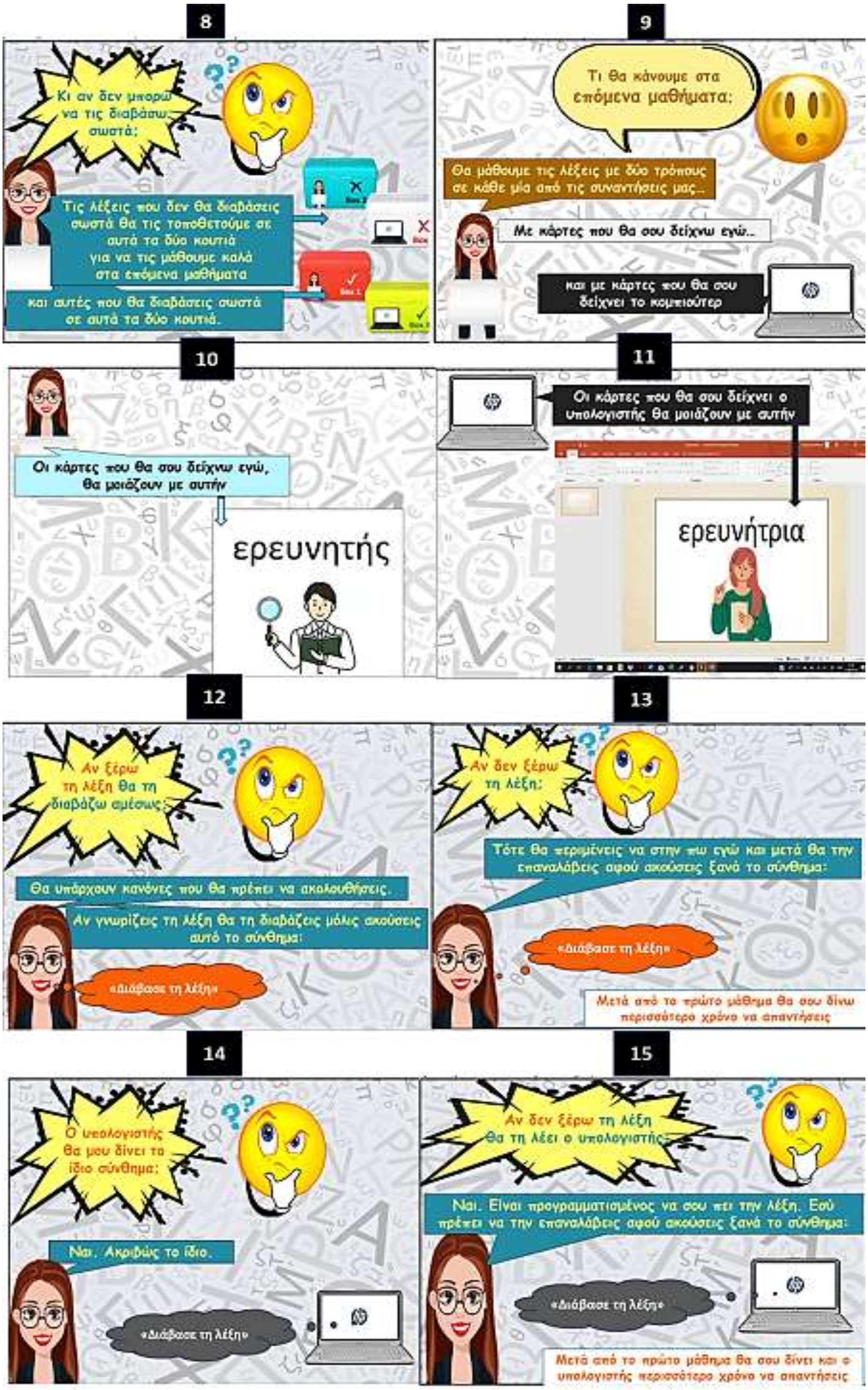
Page	Topic	Tutor/emoji dialogue	Aim
12	The tutor-led Prompt	Emoji: *If I know the word, will I read it right away?* Tutor: *There will be rules you have to follow. If you know the word, you'll read it as soon as you hear this cue: "Read the word"*	to communicate the guidelines of the tutor-led CTD condition to the student
13	The tutor-led CTD process	Emoji: *What if I don't know the word?* Tutor: *Then you'll wait for me to tell you and then you'll repeat it after you hear the cue again: "Read the word"* *After the first session I'll give you more time to answer.*	
14	The software-assisted prompt	Emoji: *Will the computer voice give me the same cue?* Tutor: *Yes, exactly the same.- "Read the word"*	to communicate the guidelines of the software-assisted CTD condition to the student
15	The software-assisted CTD process	Emoji: *If I don't know the word will the computer voice say it?* Tutor: *Yes. It is set up to tell you the word. You must repeat it after hearing the cue again: "Read the word"* *After the first session the computer will give you more time to answer.*	
16	Differential reinforcement process	Emoji: *Do I press a button to find out my answers?* Tutor: *You press one of the four buttons you will see after the answer appears on your computer.*	to give the guidelines of the software-assisted differential reinforcement procedure
17	The voluntary nature of participation	Emoji: *Can I quit if I get tired?* Tutor: *Without a doubt. You are free to give up lessons at any time…There will of course be a recess between the two ways of learning the words, where you can engage in your favorite activity.*	to understand his/her voluntary role in this study and that he/she can refuse to answer any questions, and be free to stop participating at any time.
18	Generalization phase and benefits of the study	Emoji: *What will I get from these lessons?* Tutor: *You will be able to read the words correctly and realize that reading is not tedious. This will become clear after reading one chapter from the History textbook and one from the eBook after the completion of the lessons.*	to understand the benefits of reading accuracy acquisition and to get informed about generalization process.
19	Documentation of the study	Tutor: *Before I ask if you want to participate in this study, I want you to know that the lessons will be videotaped. However, only I will have access to the recorded conversations*	to understand that if his/her voice is recorded, the tape will be kept private and confidential..
20	Obtain informed consent	Tutor: *I'd want to know whether you have any questions or if you believe you've been adequately briefed and understand the procedure. Fill in the corresponding box on the next page with a check mark.*	to feel informed about this research /to understand that he/she can ask questions at any time
21	Obtain participation consent	Tutor: *Since you've been informed, I'd like to ask whether you'd like to take part in the study. Fill in the corresponding box on the next page with a check mark.*	to realize that by filling the YES box he/she agrees to participate in this study.

Appendix D

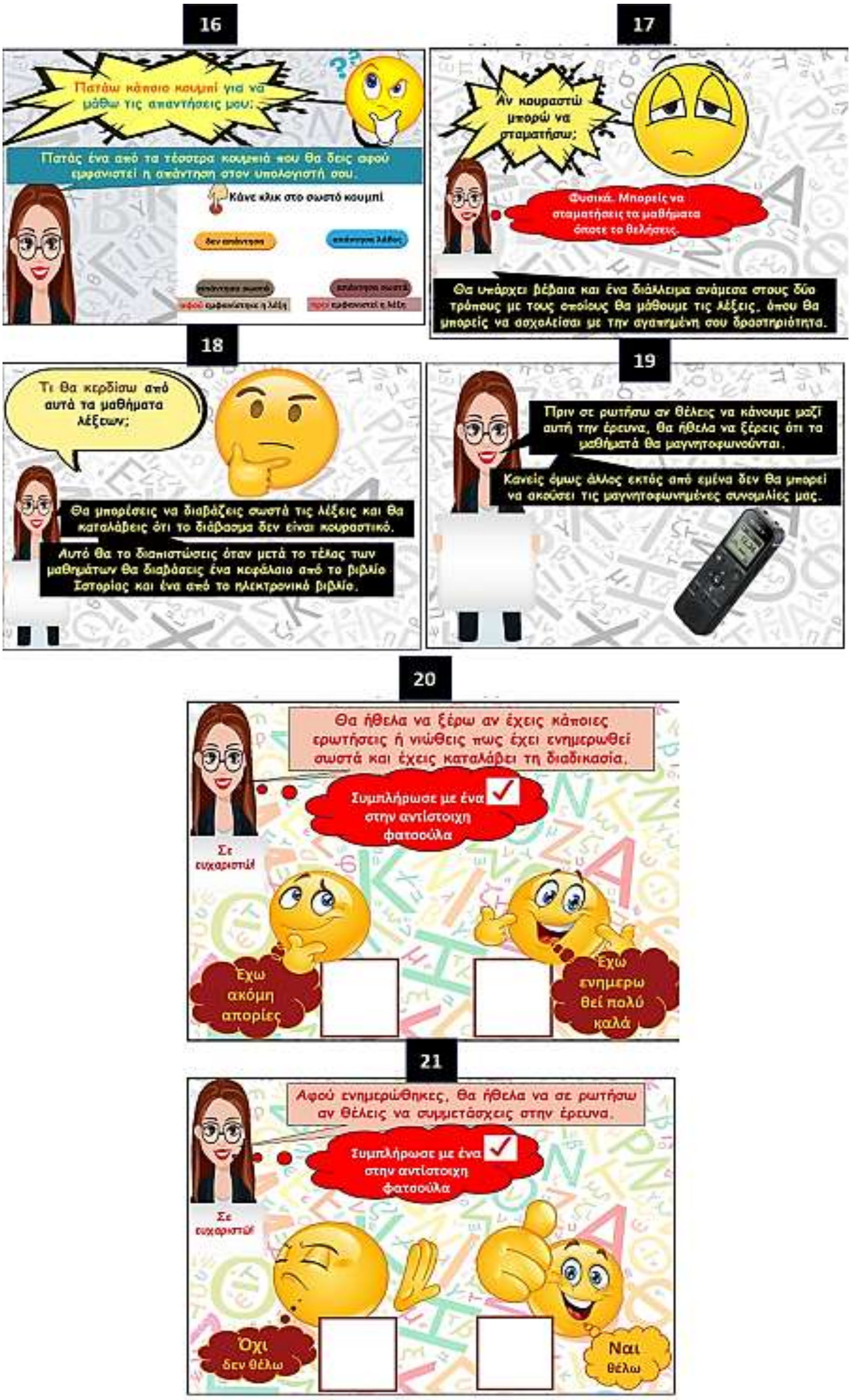
Informed Consent Comic Book (pp. 1-7)



Informed Consent Comic Book (pp. 8-15)



Informed Consent Comic Book (pp. 16-21)



APPENDIX E

Word List A

Set A		
120 Words from 3rd grade History Textbook (chapter 1, section 2, pp. 26-34)		
1. αγγεία	41. ζώνη	81. πήγαινε
2. αίμα	42. ήρωας	82. πήρε
3. ακοίμητος	43. θανατηφόρα	83. πλησιάσει
4. αμέτρητα	44. θεϊκή	84. πρόθυμα
5. αναγκάστηκε	45. θυσίασε	85. προλάβαιναν
6. ανέβαινε	46. ιέρεια	86. πρωταγωνιστή
7. ανθρώπους	47. ιππασία	87. ρεύμα
8. ανίκητος	48. καταγωγή	88. σείστηκε
9. απείραχτος	49. κατάκαιγε	89. σήκωσε
10. αρχαία	50. κατέβαινε	90. σημαίνει
11. άσχημα	51. κάτοικοι	91. σκότωσε
12. ατρόμητος	52. κατορθώματα	92. σκύλος
13. βαρύ	53. κήπος	93. στείλει
14. βασίλισσα	54. κινδύνευε	94. συγχωρέσουν
15. βοηθήσει	55. κοιμόταν	95. συμβούλεψε
16. βρήκε	56. κόλλησε	96. συμφιλιώθηκε
17. βρυχήθηκε	57. κρύφτηκε	97. συμφορές
18. γεννήθηκε	58. κυβέρνησε	98. συμφώνησε
19. γλίτωσαν	59. κυνήγησε	99. συνάντησαν
20. γρήγορη	60. λαιμό	100. συνήλθε
21. γυρίσει	61. μαντείο	101. σώμα
22. δέχτηκε	62. μεγάλωσε	102. σωροί
23. δηλητήριο	63. μεσαίο	103. ταύρο
24. δίκαιος	64. μήλα	104. τελευταίο
25. δώδεκα	65. μπήκε	105. τέσσερα
26. έδειξε	66. μυθολογία	106. τραυματίσουν
27. εισόδους	67. μύριζαν	107. τύλιξε
28. έκλεισε	68. νίκησε	108. τυράννους
29. ελεύθερος	69. νύχτα	109. υπηρετήσει
30. έμειναν	70. ξάπλωσε	110. υπήρχε
31. εξαντλήθηκε	71. ξεψυχήσει	111. υποσχεθεί
32. εξολόθρευσε	72. ξύπνησε	112. φύλαγαν
33. επιτέθηκε	73. ολόκληρο	113. φύτρωναν
34. έστειλε	74. ονειρεύονταν	114. φωλιά
35. έτρωγε	75. όρμησε	115. χιτώνα
36. ευεργεσίες	76. ορμητικά	116. χρυσά
37. ευτυχισμένος	77. παιδιά	117. χτυπά
38. ευχαριστήσει	78. πάλευαν	118. χύθηκε
39. έφυγε	79. παντρεύτηκε	119. χώρες
40. ζήλευε	80. παρέσυραν	120. ώμους

APPENDIX F

Word List B

Set B

120 Words from Onassis Foundation eBook " Young Rigas and the secret symbols of Charta“ (pp. 27-35)

1. αθλητής	41. έσκυψε	81. παλληκάρια
2. ακατανόητα	42. έτοιμη	82. πάνω
3. ακούστηκε	43. ευγένεια	83. παρότρυνε
4. αλλαγές	44. ευτυχώς	84. περήφανοι
5. ανέβηκε	45. ζευγάρι	85. πετάχτηκε
6. ανήκεις	46. ζητωκραύγαζε	86. πηγή
7. ανθρώπινο	47. ζωγραφιά	87. πίστευαν
8. άνοιξε	48. ζωντανή	88. πλημμύρισε
9. ανοιχτό	49. ηθοποιοί	89. προηγούμενο
10. απάντησε	50. ήθος	90. προλάβει
11. απήγγειλαν	51. ήχος	91. πρώτα
12. αποτυπώθηκε	52. θάλασσα	92. πρωτοπόρος
13. αποτύπωμα	53. θαρραλέοι	93. Πυθία
14. αριστούργημα	54. θαύματα	94. ρώτησε
15. βγαίνει	55. θεριεύει	95. σηκώθηκε
16. βήμα	56. θυμάσαι	96. σήμερα
17. γενάρχης	57. θυσιαστήρια	97. στάθηκε
18. γενναιότητα	58. καινούργιος	98. σύμβολο
19. γλύτωσε	59. καλύτερο	99. σύννεφο
20. γνώσεις	60. καλύφθηκαν	100. συντρόφευαν
21. γυμνάζονταν	61. κανείς	101. σχολεία
22. γυναικεία	62. κατακλυσμό	102. ταχύτητα
23. γύρω	63. κατάμαυρο	103. τηρούσαν
24. δημιουργικές	64. κατασκεύασε	104. τοίχος
25. διαζώματα	65. κάτω	105. τραγωδίες
26. δύναμη	66. κείμενα	106. τρέμει
27. εκείνο	67. κιβωτό	107. τρυπάει
28. έκπληκτα	68. κληρονομιά	108. τσαλακώνεται
29. ελευθερίας	69. κομμάτια	109. τύλιξε
30. Έλληνες	70. κρατήσουν	110. τυπωμένο
31. ελληνικά	71. κύμα	111. υψηλά
32. εμφανίστηκε	72. λευκούς	112. φώναξε
33. ένιωσε	73. λοιπόν	113. χαραχθεί
34. εννέα	74. μεγαλοπρεπής	114. χειροκροτεί
35. έννοιες	75. μιλήσει	115. χρειάζεται
36. ενότητας	76. μυαλό	116. χρησμούς
37. επανάσταση	77. νοήματα	117. χώρο
38. επιβιώσουν	78. ορθώθηκε	118. ψέλλισε
39. επικοινωνώ	79. ορχήστρα	119. ψιθύρισε
40. επιστήμες	80. παιδεία	120. ψυχή

APPENDIX G

Baseline Index Cards

APPENDIX H

Baseline Index Card Boxes

APPENDIX I

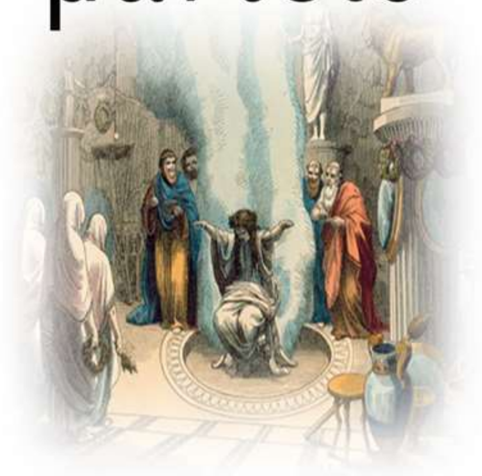
Tutor led Flashcards

αγγεία

παντρεύτηκε

ιππασία

μαντείο



APPENDIX J

Constant Time Delay Data Sheet

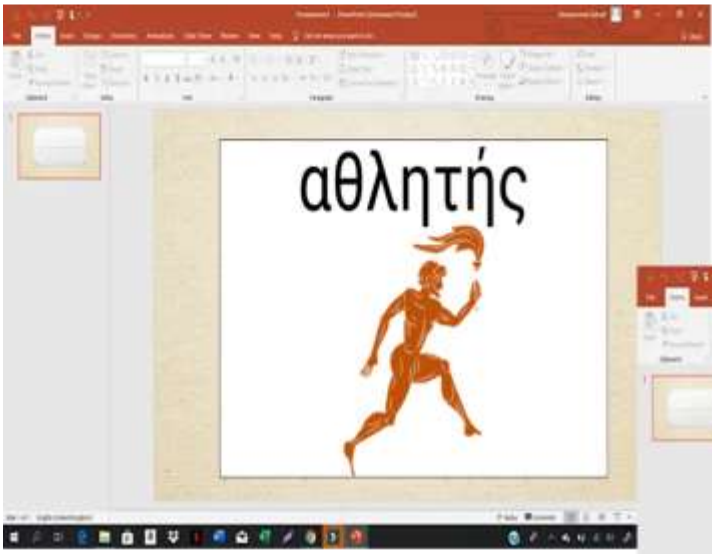
✓ Correct Response
x Incorrect Response
0 No Response

Constant Time Delay Data Sheet Example

Student:				Instructor Dimitra				
	Date: Setting: Delay: 0 sec		Date: Setting: Delay: 5 sec		Date: Setting: Delay: 5 sec		Date: Setting: Delay: 5 sec	
Words	Before Prompt	After prompt	Before Prompt	After prompt	Before Prompt	After prompt	Before Prompt	After prompt
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
Number								
%								

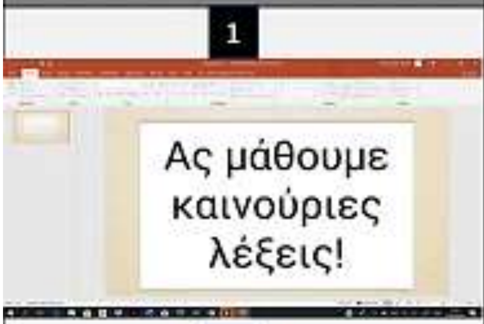
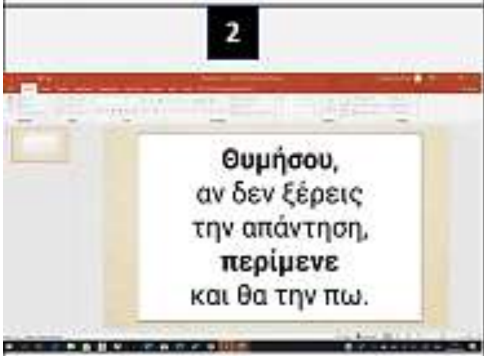
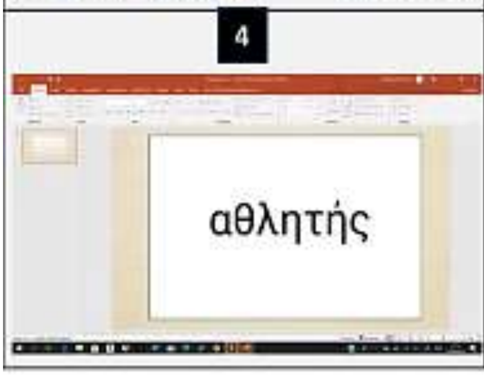
APPENDIX K

Software assisted PowerPoint Slides

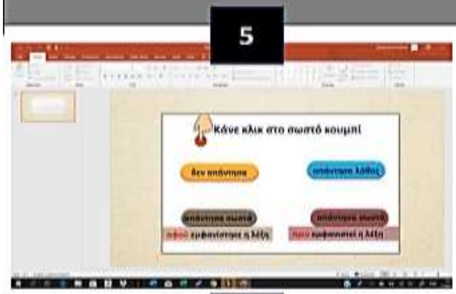
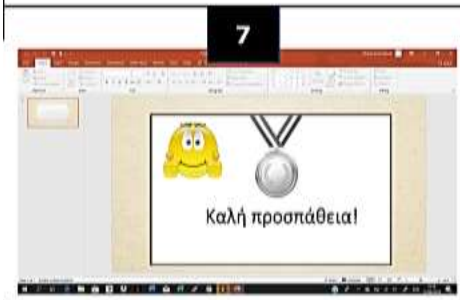
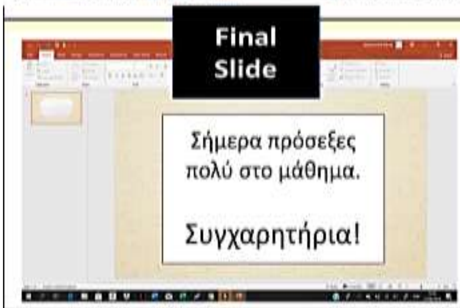


APPENDIX L

Software assisted PowerPoint Presentation *(slides 1-4)*

PowerPoint Slide	Computer Voice Output	Transitions Timing
	*"Let's learn new words".*	Slide changes automatically after one-second pause.
	*"Remember, if you do not know the answer, wait and I'll tell you".*	Slide changes automatically after a one-second pause. This slide appears after every three words.
	*"Read this word."*	O-sec delay: slide changes automatically after one-second pause. 5-sec delay: slide changes automatically after five-second pause.
	*"The word is 'athlete'*	

Software assisted PowerPoint Presentation *(slides 5-9)*

PowerPoint Slide	Computer Voice Output	Transitions Timing
	"Click on the right button"	It appears one second after the slide-answer
	*"The word is 'athlete'.*	It appears when the student presses either the first or second button
	*"Good trying!"*	It appears when the student presses the third button
	*"Awesome!"*	It appears when the student presses the fourth button
	***"You've been quite attentive today, so congrats!"***	**This is the final slide of each software-assisted session**

APPENDIX M

Generalization Data Sheet

✓ Correct Word
x Incorrect Word

Student:

Generalization Data Sheet		
Words	**History Textbook**	**eBook**

APPENDIX N

Likert Scale Questionnaire

APPENDIX O

Likert Scale Scoring Excel Spreadsheet

Participants	1st Question	2nd Question	3rd Question	4th Question	5th Question	6th Question
1						
2						
3						
Total						