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HELPING PRESERVICE TEACHERS UNDERSTAND DYSLEXIA: A STUDY ON CONCEPTUAL CHANGE AND ENGAGEMENT WITH THREE TEXT CONDITIONS

A DISSERTATION APPROVED FOR
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Abstract

Many states have passed laws mandating pre- and in-service teacher training in dyslexia; however, research suggests the majority of stakeholders continue to hold misconceptions about the definition, causes, identification, treatment, and how dyslexia relates to school-based factors. In this study, three groups of preservice teachers were assessed on their knowledge of dyslexia to determine baseline levels of scientific conceptions (SCs), misconceptions (MCs) and uncertainties (UCs). Next, participants were randomly assigned one of three texts explaining dyslexia (informational [IDA text], refutation text [RT], refutation text with graphics embedded [RT-EG]) to determine how conditions impacted their SCs, MCs, and UCs. After reading, participants were assessed on their knowledge of dyslexia, cognitive engagement during reading, and demographic data was collected. Results indicate significant levels of MCs among preservice teachers regarding (a) the type of treatment needed for students with dyslexia and (b) the MC of dyslexia as a visual disability needing visually-based treatments. After readings, all groups improved in their SCs of dyslexia; however, the RT and RT-EG groups increased SCs more than the IDA text. Only the RT and RT-EG texts decreased MCs statistically significantly with large effect sizes (RT $p < .001$, $\eta_p^2 = .50$; RT-EG $p < .001$, $\eta_p^2 = .32$). All texts decreased UCs; however, the RT and RT-EG conditions produced large effects. Implications for training and future research are discussed. Using refutation-based materials in dyslexia trainings has the potential to increase participant understanding of dyslexia more than informational trainings that do not refute common MCs.

Keywords: teacher knowledge, professional development, dyslexia

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Helping Preservice Teachers Understand Dyslexia: A Study on Conceptual Change and Engagement with Three Text Conditions

Introduction

Around the country, students are failing to learn to read at alarming rates. As measured by the National Assessment of Educational Progress (NAEP, 2020), only 34% of fourth-grade students meet proficient or advanced standards in reading in 2019 in the US. One of the most widely research-supported theories of reading, the simple view (Gough & Tunmer, 1986), suggests reading difficulties can result from a deficit in the larger categories of (1) word recognition (deciphering the printed symbols on the page), (2) linguistic comprehension (understanding the meaning of language, written or oral), or (3) both. Reading difficulties can also be exacerbated by inadequate instruction, especially in the primary grades (Juel, 1988). If students have a specific learning disability (SLD) in language comprehension, researchers use the term *Developmental Language Disorder* (Bishop et al., 2017); if the difficulty falls within the word recognition category, researchers use the term *dyslexia* (Kearns et al., 2019; Lyon et al., 2003; Vellutino et al., 2004). Many states have been passing dyslexia related legislation to identify and alleviate the number of children experiencing reading difficulties (Youman & Mather, 2018). However, previous research suggests the term dyslexia is widely misunderstood among educational stakeholders (e.g., Knight, 2018; Wadlington & Wadlington, 2005) and the general public (Castillo & Gilger, 2018). How can we impact stakeholder understanding of dyslexia? Research in learning science suggests the inclusion of certain components in explanatory texts, such as statements refuting common MCs, may increase reader understanding of a commonly misunderstood concept (Schroeder & Kucera, 2022; Tippett, 2010). Combining this research on (1) the impact of the inclusion of various explanatory components in text-based

interventions and (2) the need for a wide-scale, cost-effective intervention to impact stakeholder knowledge of dyslexia can help to create effective and efficient trainings to improve teacher knowledge and close the research-to-practice gap.

In the paper below, I review what is currently known of dyslexia and knowledge of this research by other stakeholders, including the scientific conceptions (SCs), common misconceptions (MCs), and uncertainties (UCs) commonly held. I then provide a background on conceptual change research, how this research can benefit teacher training in dyslexia, factors affecting conceptual change interventions, what is known about explanatory texts within this field of study, and how interventions may be impacted by cognitive engagement of the material. Understanding the current state of stakeholder conceptions regarding dyslexia and how these compare to SCs may help to create targeted interventions to appropriately and effectively improve participant understanding.

Dyslexia

Characteristics of Dyslexia

Dyslexia is a scientific term that describes an SLD in word recognition despite the individual receiving adequate instruction and not better accounted for by other disability labels, including an intellectual disability. In public schools, this disability is commonly referred to as a SLD in Basic Reading Skills within students' Individualized Education Programs (IEPs) due to schools using consistent language with the funding categories listed within the Individuals with Disabilities Education Improvement Act (IDEIA, 2004). Dyslexia is characterized by a significant difficulty in the ability to pronounce printed words quickly, to sound out unknown words, and spell words accurately (Lyon et al., 2003). However, the term dyslexia does not describe the student's comprehension of these words. Students identified with dyslexia may have

below average, average, or above average language comprehension skills (Adlof & Hogan, 2018). This disability describing a difficulty with language comprehension is referred to as Developmental Language Disorder (DLD). A student may have dyslexia, DLD, neither, or a co-occurrence of both dyslexia and DLD.

Many educators and other stakeholders believe dyslexia is a visual difficulty, or that students with dyslexia see letters backwards or flipped (e.g., Washburn et al., 2011a, 2011b, 2014). However, research into how people learn to read suggests this is not the case. Instead research suggests dyslexia is a language-based disability, with the area of difficulty typically lying in the areas of phonological and orthographic processing. This difficulty involves learning how to connect the smallest units of sound (i.e., phonemes) to letters or letter combinations (graphemes).

Two of the most prominent definitions of dyslexia are from the International Dyslexia Association (IDA; Lyon et al., 2003) and the 5th edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5; American Psychological Association, 2013). Both definitions include accurate or fluent word recognition and poor spelling and decoding abilities as defining characteristics of dyslexia. They also both include the term dyslexia under the category of specific learning disability (Lyon et al., 2003) or a specific learning disorder (American Psychological Association, 2013). The DSM-5 specifically refers to dyslexia as an alternate term for a specific learning disorder in reading that describes a difficulty in decoding and spelling words. Dyslexia is not a subset of students with a decoding disability. Instead, dyslexia refers to all students with a decoding disability, as long as this decoding disability is not better accounted for by another disability, such as an intellectual disability.

Identification

Dyslexia is the term used in research for the categorization of SLD in Basic Reading Skills or Reading Fluency Skills within public schools. Dyslexia is the researcher-created label; SLD in Basic Reading Skills or Reading Fluency Skills is the disability category written into federal law (IDEA, 2004). Although these terms are interchangeable, such as using the terms H_2O and water, the use of the term *dyslexia* as an alternate term to describe an SLD in Basic Reading Skills or Reading Fluency Skills has widespread misunderstanding among the public and stakeholders with many believing the term *dyslexia* could not be identified in schools, or used in school documents, such as IEPs. This misunderstanding prompted the federal government to write a "Dear Colleagues" letter in 2015 (Yudin, 2015) to clarify the use of the term within public schools. Michael Yudin, then the assistant secretary for special education and rehabilitative services, stated, "There is nothing in the IDEA that would prohibit the use of the terms dyslexia, dyscalculia, and dysgraphia in IDEA evaluation, eligibility determinations, or IEP documents" (p. 1). Schools refusing or failing to identify children who have dyslexia for special education services would be a violation of Child Find, a component of this law.

Most researchers agree the most effective method to identify students with dyslexia is a three-pronged approach (Miciak & Fletcher, 2020). This consists of considering (a) the student's low achievement in basic reading skills, (b) the student's response to a generally effective intervention that targets areas of deficit, and (c) other exclusionary factors (viz., ruling out an intellectual disability, inadequate instructional opportunity, or visual or hearing impairments as the cause of reading difficulties).

Treatment for Dyslexia

For students reading English, these basic reading skills include many subcomponents that must be mastered, including the understanding the paired-associate relationship between spoken

sounds (i.e., phonemes) and the printed letter(s) that represent those phonemes (i.e., graphemes). For example, if a student was presented with the unknown, printed word, “fish,” the student may sound it out, pairing the “f” with the sound /f/, the “i” with the sound /ĭ/, and the “sh” with the sound /sh/. Then the student would need to remember and synthesize, or blend, those sounds together to pronounce the word “fish.” If the student were able to map the phonemes to the graphemes in their long-term orthographic memory, the next time this combination of letters was encountered, the student would know the word automatically (i.e., as a sight word). This process of turning an unknown word into a known, sight word is called orthographic mapping. Students with dyslexia may have difficulty with one or all of the parts of this process, namely: (1) connecting phonemes to graphemes, (2) retaining the order and identity of these sounds in their phonological working memory, (3) synthesizing the spoken sounds together to form a cohesive spoken word (i.e., phoneme blending), and/or (4) orthographically mapping unknown words.

Teaching reading to students with dyslexia includes targeting specific areas of weakness and teaching systematically to those target areas. Considering dyslexia describes a great difficulty in acquiring basic reading skills, intervention should consist in one or more of the following areas, depending on the student’s individual weaknesses and in addition to typical classroom reading instruction: (1) letter-sound correspondences, (2) phonemic awareness, (3) decoding skills, (4) irregular high-frequency words, and (5) reading connected text. Students with dyslexia may also have a co-occurring disability in language comprehension (i.e., Developmental Language Disorder), which would require additional intervention in areas such as vocabulary, syntax, content area knowledge, and/or story structure.

Origins of Dyslexia

Research suggests dyslexia is a neurobiological difference within individuals (Lyon et al., 2003). Although the genetic component is not yet well understood, risk of dyslexia increases if one or more parent or sibling has dyslexia with about 53% of variability in reading scores accounted for by genetic components (Hensler et al., 2010). However, dyslexia is not a categorical difference, such as pregnancy. Instead, it exists on a continuous distribution. Students falling towards the lower end of basic reading skills (e.g., phonemic awareness, oral reading fluency) without other factors (e.g., intellectual disability, visual and auditory acuity) accounting for this low performance are said to have dyslexia. The exact cut off is decided on by policymakers and individual districts and schools in order to allocate special education funding. Students on either side of this arbitrary cut off are not distinctly different from one another and need very similar intervention intensity. However, qualifying for the label of dyslexia (i.e., SLD in basic reading skills) provides students access to funding for special education services.

Although dyslexia is commonly defined in the scientific literature, research has found that many groups of individuals within the US, including the general public (Castillo & Gilger, 2018), pre-service and in-service teachers (Knight, 2018; Ness & Southall, 2010; Wadlington & Wadlington, 2005; Washburn et al., 2011a, b, 2014), and teacher educators (Wadlington & Wadlington, 2005; Worthy et al., 2018), hold MCs and UCs their understanding of dyslexia. Below, I will review the current state of research on assessment of dyslexia knowledge.

Assessment of Dyslexia Knowledge

To appropriately help educational stakeholders better understand dyslexia as per state laws surrounding dyslexia training, screening, identification, and intervention, we must first understand their current conceptualizations. Research teams have measured knowledge of dyslexia in the US in various ways with no specific standardized survey widely used across

research teams; however, some employed similar questions, similar scaling, or both. Some of these teams include Wadlington and Wadlington (2005), Washburn and colleagues (2013), and Peltier and colleagues (2020). These teams have mainly used closed-ended, Likert-type items to measure educational stakeholders' understanding of dyslexia.

Wadlington and Wadlington (2005) created a closed-ended instrument, the Dyslexia Belief Index (DBI), to measure undergraduate students', graduate students', and faculty members' understanding of dyslexia within a college of education. The 32-item survey consisted of questions regarding the (a) definition and origin, (b) characteristics, (c) treatment, (d) school environment, and (e) impact of the disability. Participants (n = 250) rated each statement about dyslexia on a Likert-type scale of one to four (1 = know it's false, 2 = probably false, 3 = probably true, or 4 = know it's true). Items that were false were reverse coded. The scale had a possible total score of 120. Washburn's and colleagues' (2013) created a survey, modeled after the DBI, was a 19-item survey to measure understanding of dyslexia in 101 preservice teachers in the US. with a four-point Likert-type scale (4 = definitely true, 3 = probably true, 2 = probably false, 1 = definitely false). The survey had a total of 76 possible points after false statements were reverse coded. Peltier and colleagues (2020) then created the Dyslexia Knowledge Questionnaire (DKQ), with questions modified from previous surveys (e.g., Wadlington & Wadlington, 2005; Washburn et al., 2013), then later modified it (DKQ-2; in review) for a total of 37-items to better understand more nuanced conceptions of dyslexia within 4 categories: (1) origins, (2) characteristics, (3) treatment, and (4) identification. Peltier and colleagues also added the response of "unsure" to the DKQ-2 to create a 7-point Likert scale. The presence of including "unsure" enabled the team to better understand the difference between participant's MCs, SCs, and UCs (i.e., gaps in conceptions) around various dyslexia concepts.

Each of these teams found similar SCs held by participants: (a) dyslexia impacts a student's reading and spelling skills, (b) dyslexia is not dependent on a student's IQ, and (c) students with dyslexia need specialized instruction. Common MCs identified by each of these teams revolve around participants believing the MCs that dyslexia is (a) a visual or perceptual disability, (b) students with dyslexia see letters jumping or twisting on the page, and (c) students with dyslexia benefit from colored lenses, overlays, or specialized fonts. It is unclear the similarities in UCs from this body of work due to the differing cut points to Likert scales employed in the surveys themselves.

Although we know some common misconceptions held by participants in previous studies, there is currently a paucity of research in how to improve stakeholder understanding of this highly misunderstood topic. Conceptual change research, or the research into how individuals change from believing a MC to a SC, may help to alleviate this issue.

Conceptual Change

Learning results from the interaction between the new information a person is taught and their previous conceptual ecology (Posner et al., 1982). Conceptual change, or understanding how new knowledge is assimilated with or existing knowledge is accommodated to, has been a robust area for theory and research over the last half century. Posner and colleagues (1982) described the classical theory of a conceptual change model (CCM), of which "people's central, organizing concepts change from one set of concepts to another set, incompatible with the first" (p. 211). In this theory, people may either (a) assimilate new information with previous conceptions to form synthetic mental models (Vosniadou, 2009) that are a compromise of the old and new information or (b) accommodate, or restructure, their central concepts to understand the new information successfully. According to the CCM, this knowledge restructuring (Murphy &

Mason, 2006), or more radical form of conceptual change, is more likely to occur under four conditions: (a) dissatisfaction with existing conceptions, (b) the new conception is intelligible, (c) the new conception seems initially plausible, and (d) the new conception suggests fruitfulness in future areas of inquiry (Posner et al., 1982).

The CCM received criticism for failing to include motivational factors (Dole & Sinatra, 1998). Dole and Sinatra proposed a new model of conceptual change, the Cognitive Reconstruction of Knowledge Model (CRKM). The CRKM combined the CCM with previous models which included motivational factors, such as engagement. They postulated the learner's degree of engagement with the new information would predict the depth of conceptual change (i.e., strong, weak, or none). Although this model moved the field to consider engagement with the message, it failed to account for the role of other affective or unconscious factors that may impact automatic evaluations within conceptual change.

Gregoire (2003) proposed the Cognitive-Affective Model of Conceptual Change (CAMCC), specifically modeled around interventions with teachers experiencing conceptual change during educational reforms. In this model, Gregoire accounts for the role of automatic evaluations and attitude change to better explain conceptual change in teachers' subject matter beliefs. Gregoire theorizes that teachers who do not experience discomfort while receiving new information will not have a reason to engage with the message deeply and "process the [information] any further" (2003, p. 166). Previous research on moods during information processing suggest positive moods may be associated with shallow information processing (i.e., based on heuristics) and negative moods may be associated with deeper, systematic processing (Forgas, 2019). In line with this, the CAMCC proposes that when a teacher is confronted with novel information, if the presentation of the message is perceived as a threat to their own identity

(Schlenker, 1982), it may produce a negative mood (e.g., dissatisfaction or discomfort) and lead to the possibility of either deeper conceptual change or no conceptual change (i.e., rejection of the message).

Importantly, Gregoire notes, the possibility of deeper conceptual change here is mediated by teachers' efficacy beliefs, or the teacher's beliefs about their capabilities to produce effects (Bandura, 1994). He theorizes teachers not only need high engagement with the message, dissatisfaction with their current belief system, but also the belief in their own ability to learn and implement a new system of beliefs. Presenting the new information clearly, as intelligible, plausible, and fruitful to their future pursuits while creating this dissatisfaction with their current practices, as the CCM echoes (Posner, et al., 1982), will increase the likelihood teachers are able to engage with the message and deeply process the new information. This could lead to the highest probability that the new information would impact the arrangement of their existing schema, forming a different, yet more accurate, conceptual ecology around the target topic.

Interventions to Affect Conceptual Change

Various intervention types have been built on the foundation of these conceptual change theories, including group discussions (Eryilmaz, 2002), hands-on activities (e.g., Lee & Law, 2001; Reiner & Eilam, 2001), explanations of observations (Chinn & Malhotra, 2002) or of MCs (e.g., Diakidoy & Kendeou, 2001), conflict maps (e.g., Tsai, 2003), videos (e.g., Hayes et al., 2003), explanatory texts (e.g., Mason & Boscolo, 2004), and a specific type of explanatory text, refutation (Guzzetti et al., 1993) texts (RTs). These all have the potential to (1) promote dissatisfaction with the participant's current conceptions, (2) increase intelligibility, plausibility, and fruitfulness of the new conceptions, and (3) increase engagement in the message. These conditions can increase the probability in which deep conceptual change occurs (Dole & Sinatra,

1998; Gregoire, 2003; Posner et al., 1982). Text-based interventions may be especially easy to disseminate and test among educational stakeholders. Because of this, I will now review the findings on RTs, the common critiques of RTs in the field, and the components that may make them more effective in promoting conceptual change.

Refutation Texts

RTs are a common and effective intervention in conceptual change research (Maria & MacGinitie, 1987; Schroeder & Kucera, 2022, Tippett, 2010). A synthesis of research in this area by Tippett (2010) states that RTs have been found to be "one of the most effective text-based means for modifying readers' MCs," (p. 951). Schroeder and Kucera (2022) found RTs had a positive, moderate effect (g = .41) as compared with other learning conditions across fields of study. Due to the prevalence of MCs regarding dyslexia, RTs may be an especially helpful training tool to fulfill state laws mandating dyslexia awareness training for pre- and in-service teachers. An RT is typically written in an explanatory format; however, in addition to explaining the SCs, RTs are designed to explicitly challenge the reader's MCs. They include a statement of the common MC, the direct refutation of common MC, then contrast the MC with the SC (Tippett, 2010). The SC is explained fully so that the reader understands it as an intelligible, fruitful, and plausible concept. This format corresponds to implications from the CCM, CRKM, and CAMCC; readers are more likely to experience deep conceptual change when they are engaged with the material (Dole & Sinatra, 1998) so they can experience the opportunity for deep conceptual change. This would require the reader to be dissatisfied with their current MC, followed by a presentation with the SC as intelligible, plausible, and fruitful (Posner et al., 1982) so the reader's sense of self-efficacy with the SC can be increased (Gregoire, 2003).

When compared experimentally to expository texts on the same topic that do not directly refute common MCs, groups reading RTs show a statistically significant increase in their learning (Schroeder & Kucera, 2022; Tippett, 2010). Researchers have postulated the differential improvement in knowledge gain when using RTs versus other non-refutation expository texts is due to the RT's structure which sparks readers to activate their prior knowledge (i.e., potential MCs) on the targeted topic before new information is presented (Broughton et al., 2010). They believe this activation of prior MCs in conjunction with the presentation of new information helps readers to improve the integration of the conflicting information and restructure their conceptual ecology. When the readers' schema, or knowledge structures, are directly contradicted with new information, the reader may become dissatisfied with their current conceptions and attempt to accommodate their schema to the new information.

Peltier and colleagues (2020) created a RT that combated the most common MCs held regarding dyslexia. In the study, preservice teachers completed a survey assessing their conceptions of dyslexia, then read either a researcher-created RT or a non-refutation informational text on dyslexia, completed the dyslexia survey immediately following the reading, and then completed the dyslexia survey once more after a four-week delay. Researchers found that while both conditions statistically significantly improved participants' conceptions, the participants in the RT condition significantly outperformed the non-RT condition. Both groups declined in their SCs after four weeks; however, the RT condition remained statistically significantly higher than the non-RT condition and both conditions remained statistically significantly higher than pretest scores. This study shows promise in improving participant conceptions of a commonly misunderstood term. However, more research needs to be done to

determine how to best help participants accommodate schema to align with SCs and retain these SCs over a longer time.

Critiques of Refutation Texts

There have been salient critiques of using RTs to improve conceptual understanding. First, researchers have found that when people are exposed to false information, this may increase the likelihood they remember the false information as true (Skurnik et al., 2005; Skurnik et al., 2007). In addition, when misinformation was repeated multiple times, credited to a trustworthy source, or a time lag between the misinformation and the SC, researchers have found individuals were less likely to hold SCs (Walter & Tukachinsky, 2020). Finally, researchers have examined a "backfire effect" when participants are assigned to read a RT on a topic the reader holds close to their own identity (Trevors et al., 2016). Considering "for whom, under what conditions, and how" (Harden et al., 2015) can help researchers to determine a method of training that minimizes these downsides.

In a recent meta-analysis of empirical studies effects on the influence of misinformation, Walter's and Tukachinsky's (2020) findings suggest corrective messages, which are similar to RTs, were found to be more successful when they are (a) coherent, (b) consistent with the audience's worldview, and (c) delivered by the source of the misinformation itself" (p. 155). They also concluded "if the misinformation was attributed to a credible source, the misinformation has been repeated multiple times prior to correction, or when there was a time lag between the delivery of the misinformation and the correction," (p. 155) the corrective messages were less successful. This information can assist researchers when developing RTs and other trainings around topics in which MCs are commonly held by participants.

Further Considerations for RT Creation

Embedding Graphics within Texts

Another line of research highlights the benefits and specifications for using graphics to improve reading comprehension. Mayer (1989) found that "systematic illustrations can help unknowledgeable readers to focus attention on explanative information in text and build connections" to improve transferability (p. 245). In these situations, illustrations accompanying explanatory text had large effects on learning transfer. Mayer highlights these conditions again in his 1994 text; (a) the learner lacks prior knowledge, (b) the text is explanative rather than a list of facts, (c) the illustration is explanative and coordinates with the steps in the text, and (d) the test evaluates understanding of the concept, such as transfer in problem-solving tasks, rather than recall of discrete facts.

In 1990, Mayer and Gallini conducted three experiments to determine what types of explanative illustrations improved performance while reading expository passages on how scientific devices work. They found including both labeled descriptions for parts and illustrated descriptions for steps improved recall for conceptual information and creative problem solving. These advantages specifically impacted participants with lower prior knowledge. Therefore, with more novice learners and an explanative text, illustrations that include labeled parts and descriptive steps embedded are more likely to impact conceptual understanding of the topic.

Generative Theory of Learning

Wittrock (1974, 1989) proposed a generative theory of learning, that states individuals "tend to generate perceptions and meanings that are consistent with their prior learning," (1974, p. 88). Under the paradigm of Piaget's (1952) theory of constructivism, Wittrock theorized learners must actively construct meaning when presented with new information. This conflicted with behaviorist approaches in which environment directly and automatically influenced learning

and proposed instead the driving factor behind learning included the individual's own metacognitive processing via mental schemata, or prior knowledge and experiences. In order for readers to comprehend what they are reading, they must use generative cognitive processes that "create meaning by building relations: (a) among the parts of the text and (b) between the text and what we know, believe, and experience," (Wittrock, 1989, p. 347).

In Wittrock's Generative Theory of Learning, effective reading comprehension should be rather thought of as like writing, as a generative process, instead of simply receiving information from a printed page. Wittrock's Generative Theory of Learning has relevant implications for teaching using texts, including, at the forefront, the necessity to guide readers to actively process text by engaging in generative processes. Implication for teaching can include asking individuals to generate summaries of the new information, generating analogies to the new information, and to teach individuals the metacognitive skills of how to engage in these strategies on their own (Mayer, 2010). Researchers may consider asking participants to give a written or oral summary of information presented throughout RT interventions in order to help participants actively process information.

Dual Coding Theory

When considering multimedia learning, or the use of text, or verbal information, and pictures, or nonverbal information (Mayer, 2002), Paivio proposed a theory of Dual Coding (1986; Clark & Paivio, 1991) to explain how readers process information. Paivio theorized individuals can process information through two cognitive channels, or modalities: a verbal channel and a nonverbal channel. In the verbal channel, all language-based information is included, whether printed, spoken, or thought. These individual verbal chunks of information processed he termed logogens. In the nonverbal pathway, all non-language-based information is

processed, with the individual chunks of information referred to as imagens. Connections learners make within modalities are termed associative connections; connections learners make across modalities are termed referential connections. Both associative and referential connections are theorized to strengthen the memory trace and improve recall and understanding of the concept attended to. Implications for teaching using multimedia material are to include the use of both relevant text and relevant illustrations to improve comprehension and learning.

Cognitive Theory of Multimedia Learning

Mayer and colleagues (1995), based on Paivio's (1986; Clark & Paivio, 1991) work on dual-coding theory and Wittrock's (1974, 1989) work on generative theory, proposed the Cognitive Theory of Multimedia Learning. The Cognitive Theory of Multimedia Learning includes three cognitive conditions for learning from both verbal and nonverbal information to occur. First, the learner must *select*, or attend to, the relevant information to build a verbal representation of the text base and nonverbal, or visual, representation of the images. Second, the learner must *organize* the information they selected in an appropriate way. They must organize selected verbal information into a coherent verbal mental model and selected imaginal information into a coherent pictorial mental model. This would include creating associative connections within modes (Clark & Paivio, 1991). Third, the reader must *integrate* the two modes of information, or make referential connections (Clark & Paivio, 1991) to establish a connection between each aspect in the verbal and pictorial mental models, and prior knowledge, or schema, into one, coherent situation model of the text base. These processes occur throughout the reading of the text; integrating new information with prior schema to build a coherent mental model evolves as the reader moves through the text, selecting and organizing relevant information. Implications for using multimedia texts to impact learning include prompting the

reader to process the information by generatively, within and across modalities. Implications for designing effective multimedia texts for novices include presenting corresponding information together rather than separately, presenting information in both modalities (i.e., words and illustrations) rather than solely in one, and prompting the reader to generate summaries of the combined visual and verbal information (Mayer & Moreno, 1998).

Seductive Details

Seductive details, or "propositions presenting irrelevant details—[emotionally] interesting, but unimportant information," (Garner et al., 1989, p.43), can detract from the reader understanding the macro propositions, or main ideas, of the expository text. Garner and colleagues (1989) found these seductive details to lower overall comprehension of the macro propositions in expository passages for both adolescents and adults. According to the Cognitive Theory of Multimedia Learning discussed above (Mayer et al., 1995), because readers must select, organize, and integrate information from a multimedia text, damage may be done at any one of these generative steps in comprehension (Harp & Mayer, 1998).

In three experiments, Harp and Mayer (1998) found that by helping students to *select* information, whether by highlighting, numbering, or telling them to pay attention to specific information in the text, did not alleviate the negative impact the seductive details had on comprehension. In the same manner, providing supports for the reader to *organize* information, whether by telling readers what to look for and how to organize it, or by modifying the passage itself to heavily signal the main ideas or by placing all the seductive details at the beginning of the passage, also did not alleviate the negative impact of the seductive details within the expository text. However, they found strong evidence that seductive details cause a diversion from integrating the information with schema, activating inappropriate background knowledge

and causing the reader to organize their mental model around an inappropriate central conception. For example, when all seductive details are all presented at the beginning of a passage, this effect is seen more greatly; readers begin to organize their mental model around an irrelevant topic. However, when seductive details are all placed at the end of a passage, performance equates to reading a passage without any seductive details at all. Research since also suggests that using pre-warnings (telling readers seductive details are present; Eitel et al., 2018) and pre-questions (questions before reading that emphasize the relevant details in the text; McCrudden, 2018) may negate the negative impact of seductive details on comprehension.

Sanchez and Wiley (2006) extended this work, examining whether working memory plays a role on the impact of seductive details within text. Their findings suggest individuals with low working memory are especially susceptible to text with seductive details, and individuals with low working memory look more at seductive illustrations within text and spend a longer time looking at the seductive illustrations than individuals with high working memory. They hypothesized this may be due to the lowered ability of individuals with lower working memory to utilize executive control to maintain their original goal for comprehension or integrating the text into a coherent mental model around a chosen central conception.

Implications for designing multimedia text include (1) ensuring only relevant information and illustrations are included, (2) guiding readers to activate only relevant background knowledge to begin to organize their mental model appropriately, and (3) including pre-questions designed to activate relevant background knowledge and guide readers to relevant information in the upcoming text.

Cognitive Engagement

Dole and Sinatra (1998) theorized in their CRKM model that conceptual change is impacted by motivational factors, such as participant's engagement with the message. Gregoire (2003) also theorized participant engagement played a role in the depth of conceptual change possible. Dole and Sinatra (1998) specifically suggest that out of the three common type of engagement in the literature (cognitive, affective, behavioral), cognitive engagement is most important for conceptual change. In order for participants to grapple with the new information presented in the message and facilitate dissatisfaction (Posner et al., 1986) with their current conceptualization, they theorize participants must cognitively engage with the message.

Considering the process of deep conceptual change requires cognitive engagement (Chi, 2008; Dole & Sinatra, 1998), I seek to explore effects on participants' conceptual change and cognitive engagement with various text types within the intervention to determine if cognitive engagement is a significant predictor of knowledge change. Heddy and colleagues (2018) developed and validated a cognitive engagement scale to be used within conceptual change interventions, the Conceptual Change Cognitive Engagement Scale (CCCES). The CCCES measures three factors affecting cognitive engagement: message characteristics, individual difference variables, and personal relevance. As the goal of this study is to test three different text-based messages, I will use the first factor (viz., cognitive engagement with the message) to measure if the various conditions differently affect participant engagement and if engagement is a significant predictor of conceptual change.

Purpose

Results have been fairly consistent in the types of information participants seem to understand and the MCs they hold. However, studies have just begun to understand what participants think they know as compared to what they are unsure about (Peltier et al., 2022) and

how to dispel participant MCs of dyslexia (Peltier et al., 2020c). This study will serve a few purposes. First, it will provide data regarding the difference between concepts participants are unsure about and those in which they hold either SCs or MCs. Second, it will investigate whether an informational text (IDA text), a brief researcher-created RT, or an extended researcher-created RT with embedded graphics (RT-EG) is differentially effective for impacting participants' SCs, MCs, or UCs regarding dyslexia on a knowledge assessment featuring closed-ended items.

Problem Statement

Around the country, students are failing to learn to read at alarming rates. As measured by the National Assessment of Educational Progress (NAEP; 2019), only 34% of fourth-grade students meet proficient or advanced standards in reading in 2019 in the US. The simple view of reading (Gough & Tunmer, 1986), one of the most widely supported theories of reading, suggests reading difficulties can result from a deficit in either (1) word recognition (deciphering the printed symbols on the page), (2) linguistic comprehension (understanding the meaning of language, written or oral), or (3) both. Reading difficulties can also be exacerbated by inadequate instruction, especially in the primary grades (Juel, 1988). If a student has a specific learning disability (SLD) in the domain of language comprehension, researchers use the label *Developmental Language Disorder* (Bishop et al., 2016); if the difficulty falls in the domain of word recognition, researchers use the label *dyslexia* (Kearns et al., 2019; Lyon et al., 2003; Vellutino et al., 2004). Although dyslexia, or an SLD in basic reading skills, is the most commonly identified learning disability, research has documented widespread MCs among educational stakeholders, including preservice teachers, in-service teachers, and teacher educators (e.g., Peltier et al., 2020c; Wadlington & Wadlington, 2005; Washburn, 2017; Worthy, 2016)

To properly address dyslexia, it is important for teachers to be adequately trained about dyslexia. Given this significance of teacher training on dyslexia, educational policy groups and legislatures have invested concerted effort to mandate pre- and in-service teacher training on dyslexia as well as screening and intervention processes within public schools to identify students at-risk of dyslexia. Recently, all but one state has passed laws defining dyslexia and/or mandating pre- and in-service teacher training, screening, and/or intervention for dyslexia (National Center on Improving Literacy, 2020). Although laws require pre-service and in-service teachers' participation on dyslexia training, we have a paucity of research on the effectiveness of these trainings. Research is needed to determine if those participating in dyslexia awareness training are increasing SCs and decreasing MCs and UCs by attending those mandated sessions. Effective and cost-efficient ways of disseminating trainings are needed on a large-scale; however, laws have been passed before research has determined if trainings are effective and/or efficient for the participants within the trainings. Consequently, despite these mandates, it is not surprising that research suggests the majority of pre- and in-service teachers still hold many MCs and UCs regarding dyslexia (Peltier et al., 2020c; Washburn et al., 2017; Worthy et al., 2016).

Participant SCs of Dyslexia

Washburn and colleagues (2017), who surveyed 271 novice teachers on an open-ended item, "What is dyslexia?", found that 40% of participants provided an accurate response to an open-ended item about the characteristics of dyslexia with an SC referring to language and literacy difficulties. This finding is similar to Peltier and colleagues' (2020c) study. They surveyed 97 preservice teachers using a survey consisting of 20 dyslexia-related items using a Likert-type scale and found about half (50.5%) of participants understood the SC that a difficulty with processing sounds in language is one of the major deficits found in students with dyslexia.

They also found about 75% of participants held SCs regarding dyslexia as it related to federal special education law (i.e., “Dyslexia is recognized as a type of specific learning disability that can receive special education services by the federal government”).

One qualitative study that began to reveal teachers’ understanding of dyslexia was conducted by Worthy and colleagues (2016). The researchers used interviews to examine teachers’ conceptions of dyslexia in Texas—the first state to have a dyslexia law and one with a complex history of mandated training and legislation around dyslexia. Their participants included 32 elementary (K-5) literacy educators and took place in the spring of 2015. They found teachers reported having a strong sense of responsibility to teach students with dyslexia; they understood they would have students with dyslexia in their general education classes. However, many reported UCs and MCs regarding dyslexia and a lack of clarity in their district’s policies and procedures around dyslexia as a barrier to their success.

Participant MCs of Dyslexia

Although 40% of participants in Washburn and colleagues’ (2017) study responded with accurate knowledge, the authors also found that 53% of participants responded with at least one MC about dyslexia relating to visual characteristics (e.g., students with dyslexia see words and letters backwards) when asked about its characteristics. This problematic finding is echoed by Peltier and colleagues’ (2020c) study. They found the majority (64%) of participants believed the MC that seeing words and letters backwards was a characteristic of dyslexia and 53.5% of participants held the MC that eye-tracking exercises would effectively remediate dyslexia. Peltier and colleagues (2020c) attempted to intervene to improve conceptualization of dyslexia with preservice teachers. They found, compared to an explanatory text, a researcher created RT statistically significantly improved preservice teacher knowledge of dyslexia. Although there

was some learning loss from both groups after a four-week delay, the RT condition continued to have statistically significantly more correct responses than the explanatory text condition.

Similar to the findings by Washburn and colleagues (2017) and Peltier and colleagues (2020c), Worthy and colleagues noted that a majority of participants held MCs regarding visual-perceptual characteristics and treatment (e.g., "I feel like [dyslexia is] blurred up letters" and "I would try different color layovers [to help them read]").

Present Study

Results have been fairly consistent in the types of information participants seem to understand and the MCs they hold. However, studies have just begun to understand what participants understand as compared to UCs they hold. We also need more information on effective interventions to improve conceptualization of dyslexia. This study will not only collect data on SCs preservice teachers can identify, UCs they hold, and common MCs, but it will also experimentally examine whether a RT intervention is more effective in improving conceptualization of dyslexia with or without embedded graphics.

In the present study, I will seek to quantitatively determine (a) the amounts of SCs, MCs, and UCs related to the term *dyslexia* preservice teachers hold at the time of pre-assessment, (b) if an informational text (IDA, 2019), researcher created RT, and/or a researcher-created RT-EG will differently and/or significantly affect preservice teachers' dyslexia SCs, MCs, and UCs at an immediate posttest, and (c), whether engagement levels are differential across conditions or if they moderate increased SCs across conditions.

Hypotheses

Considering the previous research into pre- and in-service teachers' conceptualizations of dyslexia (Peltier et al., 2020c; Washburn et al., 2017; Worthy et al., 2016), for research question

(a) I predict participants will hold common MCs regarding the visual-perceptual characteristics of dyslexia. They may be more unsure about how dyslexia relates to laws or genetics. I predict the most commonly held SCs will be that dyslexia affects the decoding aspects of reading; however, participants may hold MCs that dyslexia describes a deficit in both decoding and language comprehension.

For research question (b), I predict both the RT and the RT-EG would improve SCs, decrease MCs, and decrease UCs. I predict that the informational IDA text will increase SCs and decrease UCs; however, it will not decrease MCs. I predicted the RT-EG would statistically significantly improve SCs and decrease MCs and UCs then compared with the other two text conditions due to increased engagement with the materials. However, considering the RT-EG was longer, there may be a wider variance in participants' engagement with the text itself, which may lead to a lower mean increase in participant SCs than the RT.

For the final research question, I predict the graphics will cause the RT-EG text to increase engagement statistically significantly above the IDA text and the RT. I also predict engagement will moderate conceptual change shown by an increase in total SCs reported, in line with the CRKM theorizing that high engagement is needed for deep conceptual change (Dole & Sinatra, 1998).

Method

Participants and Context

All participants were enrolled in teacher education professional sequence coursework from a flagship institution in the mid-south region of the US. Undergraduate students in this study (n = 64) were pursuing a teaching certification in education at the time of the study. The University's Institutional Review Board has approved the study. For demographic information

for participants see Table 1. Chi-square tests revealed none of the variables differed significantly from each other among text conditions at the .05 level with the Bonferroni correction applied.

Table 1

Demographic Information

Variable	Categories	Frequency (Percent)
Sex		
	Women	54 (84.4%)
	Men	9 (14.1%)
Age		
	19	5 (7.8%)
	20	24 (37.5%)
	21	28 (43.8%)
	22	5 (7.8%)
	23	2 (3.1%)
Major		
	Elementary Education	31 (48.4%)
	Special Education	2 (3.1%)
	Language Arts Education	7 (10.9%)
	Math Education	2 (1.5%)
	Science Education	1 (1.6%)
	Social Studies Education	7 (10.9%)
	Music Education	14 (21.9%)
Race/Ethnicity		
	Asian	1 (1.6%)
	Black/African American	2 (3.1%)
	Caucasian/White	37 (57.8%)
	Hispanic/Latinx	3 (4.7%)
	Native/American Indian	1 (1.6%)
	Two or More	5 (7.8%)
	Other	1 (1.6%)
	No Answer	14 (21.9%)
Number of Literacy Courses Taken		
	0	31 (48.4%)
	1	17 (26.6%)
	2	10 (15.6%)
	3	6 (9.4%)

Materials

Dyslexia Knowledge Questionnaire-3

The Dyslexia Knowledge Questionnaire-2 (DKQ-2; Peltier et al., 2022) was first adapted from the Dyslexia Knowledge Questionnaire (DKQ; Peltier et al., 2020a) to add 17 additional Likert-scaled items to improve breadth of relevant information and sensitivity. For this study, answer choices have been further modified to *yes*, *no*, or *unsure* to ask participants to categorize their own conception instead of drawing an arbitrary cut point on a continuous Likert-scaled response to determine UC. I chose this questionnaire because it was designed to measure participants' knowledge of dyslexia by harvesting questions from previous studies on pre- and in-service teacher knowledge of dyslexia. The survey was vetted by an expert in the field of dyslexia, reading, and special education in previous research (Peltier et al., 2022). It is a comprehensive measure containing questions relating to the identification, characteristics, treatment, and origins of dyslexia. In this sample, the Dyslexia Knowledge Questionnaire-3 (DKQ-3) has adequate internal consistency at pretest ($\alpha = .76$) and posttest ($\alpha = .79$).

CCCES-Modified

I have harvested the first 16 questions from the CCCES (Heddy et al., 2018) to include the 14 questions which measured participants' cognitive engagement of the message and the two questions regarding participant attention in order to measure cognitive engagement with the text message and participant attention during reading. This measure was abbreviated from the original 27 questions to lessen the burden of time spent by participants on the study and to measure the targeted aspects of cognitive engagement which most likely would be affected by the differences within the intervention conditions. A total CCCES-Modified score will be summed from the Likert-scaled items for a total engagement score. The two questions on participant attention are negatively worded and will therefore be reverse scored before summing

the items. The CCCES-Modified has very good internal consistency when measured at posttest (α = .92)

Intervention Conditions

The RT will be developed for this study from an RT used in a previous study on conceptual change regarding the term dyslexia (Peltier et al., 2020b). This text was created by identifying common misconceptions from previous studies on stakeholder knowledge of dyslexia and refuting them, then providing the scientific conception to help the reader build a new conceptual model of the possibly previously misunderstood concept.

For this study, I created an extended version of this RT and hired a graphic designer to embed graphics to create the RT-EG. This was designed in a popular press style with the intention of engaging readers and illustrating key concepts. The graphic novel, entitled, "Debunk Misconceptions over Dyslexia," includes a caricature of a mouse who follows the reader through eight common myths. Each myth is written in bigger font. Each myth and scientific conception is illustrated; for example, when the text discusses the myth that dyslexia is a categorical difference, a pregnancy stick is juxtaposed with a spectrum of black to white, followed by different animals' silhouette in decreasing height to illustrate the scientific conception of how dyslexia is identified within a continuous distribution. Using these drawings to illustrate key points is consistent with Paivio (1986)'s theory of dual coding and the work of Mayer and Moreno (1998) on the cognitive theory of multimedia learning. In these theories, these illustrations may help the reader to code the information in two modes, if they are able to select, organize, and integrate it in a meaningful way. However, with the myths being highlighted as bigger font at the forefront of each page, and the scientific conceptions not consistently highlighted in the same manner, these may act as seductive details such that Harp and Mayer

(1998) described. The caricature of the mouse may also act as a seductive illustration, pulling the reader's attention away from the main point of the story. Although, with the preassessment administered first, readers may be attuned to the purpose of the text and therefore may be able to better select the requisite information (McCrudden, 2018).

The International Dyslexia Association (IDA) created and disseminated a text, entitled *Dyslexia Basics*, on their website (2019). This text explains dyslexia in an informational format; however, it does not directly refute common MCs. It was used for the comparison condition, referred to as the IDA text in this study. As reported in Peltier and colleagues' (2020) work, it is of similar word count and reading level as the RT.

Procedures

I approached potential participants during their teacher education professional sequence classes. If participants consented, I passed out the DKQ-3 (pretest). Each text condition had a text ID number on top corresponding to the condition and the specific copy within the condition to allow matching of pre- and post-tests (e.g., 1-2 [IDA text, copy 2], 2-11 [RT, copy 11], 3-17 [RT-EG, copy 17]). I then instructed participants to write the text ID number on the top of the page, complete the pretest, then read the text condition. Once they had read the text condition assigned, participants were instructed to raise their hand to return the text and receive the posttest packet (i.e., CCCES-modified, DKQ-3 posttest, demographic information). Again, the participants were instructed to write the same text ID number at the top of the posttest. After complete, participants were instructed to turn in both the pretest and posttest packet.

Data Collection and Analysis

The pre- and post-test were matched using the text ID number as they were entered into SPSS. The items on the DKQ-3 that were worded as false were reverse coded. There were 21

participants in the IDA text condition, 21 participants in the RT condition, and 22 participants in the RT-EG condition. For research question one, descriptive statistics were used to determine the frequency of SC, MC, and UC responses at pretest per item. For research question 2, all SC responses to items were totaled within each participant (min = 0, max = 37) to create a SC pretest total and a SC posttest total. This was also done for MCs and UCs at pre- and posttest times for each participant. Six new variables were created (viz., SC_Pre_Total, SC_Post_Total, MC_Pre_Total, MC_Post_Total, UC_Pre_Total, UC_Post_Total). For example, the SC_Pre_Total was created by summing up one point on the pre-assessment for each SC held (answer marked "yes", after recoding false items), with a total possible range of 0 SCs to 37 SCs. For research question 3, the CCCES-Modified items were summed (i.e., 14 cognitive engagement questions were kept as entered, two attention questions were reverse coded to account for negative wording) to create a new variable (CCCES-Modified_Total).

Results

Preservice Teacher Conceptualization of Dyslexia

To answer the first research question, descriptive statistics were run to determine the amounts of SCs, MCs, and UCs related to the term dyslexia preservice teachers held. The most commonly held SC in my sample was "*Students with dyslexia have difficulty with reading and spelling words*," (93.8% SC, 1.6% UC) indicating most participants can identify the distinguishing attribute associated with the term, dyslexia. However, the most commonly held MC among preservice teachers was that "*Students with dyslexia should be taught coping strategies, such as using context cues or pictures to help decode words*," (87.5% MC, 7.8% UC) indicating participants held a MC relating to the central instructional plan for students with dyslexia. The next three most commonly held MCs are all regarding dyslexia as a visual

difficulty, such as "*Seeing letters or words backwards,"* (84.4%, 7.8% UC), "*Dyslexia is primarily a visually-based reading disability*" (68.8% MC, 10.9% UC) or that "*Students with dyslexia have poor word-level reading skills typically due to poor visual processing skills*" (67.2% MC, 23.4% UC), indicating the causes and central characteristics of dyslexia are commonly misunderstood by preservice teachers. See Table 2 for a complete list of SCs, MCs, and UCs per item, sorted by most common MCs at preassessment.

Table 2

Highest Percent of MCs at Pretest

	SC	MC	UC
34. ***Students with dyslexia should be taught coping strategies, such as using context cues or pictures to help decode words.***	4.7%	87.5%	7.8%
8. ***Seeing letters and words backwards is a characteristic of dyslexia.***	7.8%	84.4%	7.8%
7. ***Dyslexia is primarily a visually-based reading disability.***	20.3%	68.8%	10.9%
11. ***Students with dyslexia have poor word-level reading skills typically due to poor visual processing skills.***	9.4%	67.2%	23.4%
32. ***Students with dyslexia normally learn to read most quickly through the exposure to audio recordings while following along in the printed text.***	4.7%	65.6%	29.7%
17. Visual-perceptual deficiencies are not components of the dyslexia diagnosis.	9.4%	57.8%	32.8%
33. ***Students with dyslexia primarily need instruction in reading comprehension strategies.***	15.6%	56.3%	28.1%
28. ***Students with dyslexia need specialized dyslexia fonts in order to read printed words more accurately.***	18.8%	56.3%	25.0%
9. Students with dyslexia do not see words jumping around on the page.	25.0%	48.4%	26.6%
25. ***Eye tracking exercises are usually effective in remediating dyslexia.***	10.9%	45.3%	43.8%
10. ***Dyslexia is a condition in which individuals see words jumping around on the page.***	25.0%	45.3%	29.7%
35. ***If a student with dyslexia hasn't learned to read efficiently by third grade, intervention should focus primarily on coping mechanisms like screen readers and learning high-frequency words by sight.***	21.9%	42.2%	35.9%
30. ***Students with dyslexia normally learn to read most quickly with methods that focus on memorizing the shape of whole words***	10.9%	40.6%	48.4%

26. ***Colored lenses and colored overlays are research-based accommodations to help students with dyslexia.***	17.2%	37.5%	45.3%
15. ***Dyslexia should usually be diagnosed by a pediatrician.***	21.9%	37.5%	40.6%
27. Colored lenses or overlays usually do not help improve reading accuracy in people with dyslexia.	17.2%	34.4%	48.4%
1. Difficulty manipulating sounds in spoken language is one of the major deficits found in students with dyslexia	35.9%	32.8%	31.3%
23. If you put average to poor readers with a similar IQ on a scale, those with dyslexia would mostly represent the readers scoring at the lower end of that scale.	43.8%	31.3%	25.0%
13. ***Most pediatricians are trained to perform diagnostic evaluations to determine if a child has dyslexia.***	39.1%	29.7%	31.3%
19. Another name for a specific learning disability in basic reading skills is dyslexia.	50.0%	29.7%	20.3%
12. Dyslexia is primarily a language-based reading disability	43.8%	28.1%	28.1%
2. ***Students identified with dyslexia usually have difficulty with listening comprehension.***	39.1%	26.6%	34.4%
18. ***It is usually not possible to identify a child with dyslexia until the third grade.***	35.9%	25.0%	39.1%
22. Dyslexia is not hereditary.	23.4%	23.4%	53.1%
21. Parents with dyslexia are likely to have children with dyslexia.	25.0%	21.9%	53.1%
5. Students identified with dyslexia usually have average to above-average listening comprehension.	35.9%	18.8%	45.3%
20. ***Dyslexia is not recognized in public schools as a learning disability eligible for special education services.***	54.7%	18.8%	26.6%
16. Dyslexia should usually be identified by a school psychologist.	40.6%	15.6%	43.8%
24. ***Dyslexia identification has a clearly well-defined cut-off. Students either have dyslexia or they do not.***	59.4%	14.1%	26.6%
14. Dyslexia is recognized as a type of specific learning disability that can receive special education services by the federal government.	73.4%	12.5%	14.1%

6. ***Students identified with dyslexia usually have average to above-average phonemic awareness.***	43.8%	10.9%	45.3%
31. Students with dyslexia primarily need instruction in phonemic awareness and phonics.	57.8%	9.4%	32.8%
29. After effective reading intervention, the brain activation patterns of a student reading with dyslexia changes to more like that of a typically developing reader.	57.8%	7.8%	34.4%
37. ***Teaching spelling to students with dyslexia is not recommended since spelling is an area of great difficulty.***	64.1%	7.8%	28.1%
36. ***Teaching phonics is not a helpful approach to teaching reading to students with dyslexia.***	51.6%	4.7%	43.8%
3. Students identified with dyslexia usually have difficulty with phonemic awareness.	71.9%	4.7%	23.4%
4. Students with dyslexia have difficulty with reading and spelling words.	93.8%	4.7%	1.6%

Note. Items recoded because they were presented as false are in ***bolded italics.***

Effects Across Time by Condition on SCs, MCs, and UCs

For research question two, I tested if an informational text (IDA, 2019), researcher created RT, and/or a researcher-created RT-EG would differently and/or significantly affect preservice teachers' dyslexia SCs, MCs, and UCs at an immediate posttest. For mean change of number of items participants reported per category (SC, MC, UC) from pre- to posttest, see Table 3.

Table 3

Mean Change of SCs, MCs, and UCs Per Text Condition

	SCs	MCs	UCs
IDA text	4.71	-1.57	-3.14
RT	13.50	-7.19	-7.48
RT-EG	14.67	-4.91	-8.55
Overall	10.96	-4.56	-6.42

Effects Across Time by Condition on SCs

A repeated measures analysis of variance (ANOVA) was performed using time (SCs on pre- to post-test) as the within subjects factor and text condition (IDA text, RT, RT-EG) as the between subjects factor. Sphericity is assumed as there are only two time points in the repeated measures ANOVA. From pre- to posttest, all text conditions statistically significantly improved their SCs, with a mean improvement from 12.82 SCs out of 37 SCs total (34.65% SCs) at pretest to 23.78 SCs out of 37 SCs total (64.27% SCs) at posttest (IDA text mean = 13.86, SD = 4.65; RT mean = 12.19; SD = 4.69; RT-EG mean = 12.41, SD = 5.74). The results of the repeated measures ANOVA indicated the interaction between time by text condition on the rate of increase of SCs held by participants was statistically significant, F (2, 61) = 19.28, $p < .001$, with

a large effect size of η_p^2 = .39. To examine the nature of the interaction, simple effects were examined for the amount of SCs held on the DKQ-3 from pre- to post-test.

Table 4

Effects Across Time by Condition on SCs

			95% Confidence Interval	
Text Condition	Mean	Std. Error	Lower Bound	Upper Bound
IDA Pretest	13.857	1.105	11.648	16.066
IDA Posttest	18.571	0.888	16.796	20.347
RT Pretest	12.19	1.105	9.982	14.399
RT Posttest	26.857	0.888	25.082	28.632
RT-EG Pretest	12.409	1.079	10.251	14.567
RT-EG Posttest	25.909	0.867	24.175	27.643

Pretest scores did not differ across text conditions. However, participants in the RT condition (mean = 26.86; SD = 4.67; p = .01) and the RT-EG (mean = 25.91; SD = 4.31, p = .03) condition scored significantly higher on SCs after reading the text than the IDA text condition (mean = 18.57; SD = 3.03) at posttest, indicating the RT and RT-EG conditions were more effective than the IDA text at improving SCs. The IDA text did statistically significantly improve SCs from pre- (mean = 13.86, SD = 4.65, 95% CI [11.65, 16.07]) to posttest (mean = 18.57, SD = 3.03, CI [16.80, 20.35]) at $p < .001$ with a large effect size of η_p^2 = .19. The RT condition ($p <$ .001, η_p^2 = .70) and the RT-EG condition ($p < .001$, η_p^2 = .67) were statistically significantly effective at improving SCs from pretest to posttest as well, with very large effect sizes. See Table 4 and Figure 1, 2, and 3 for more information. These results show the implementation of the RT and RT-EG text conditions resulted in greater improvement in SCs from pre- to post-test, though the IDA text did significantly increase SCs across time as well.

Figure 1

Estimated Marginal Means of SCs Across Time

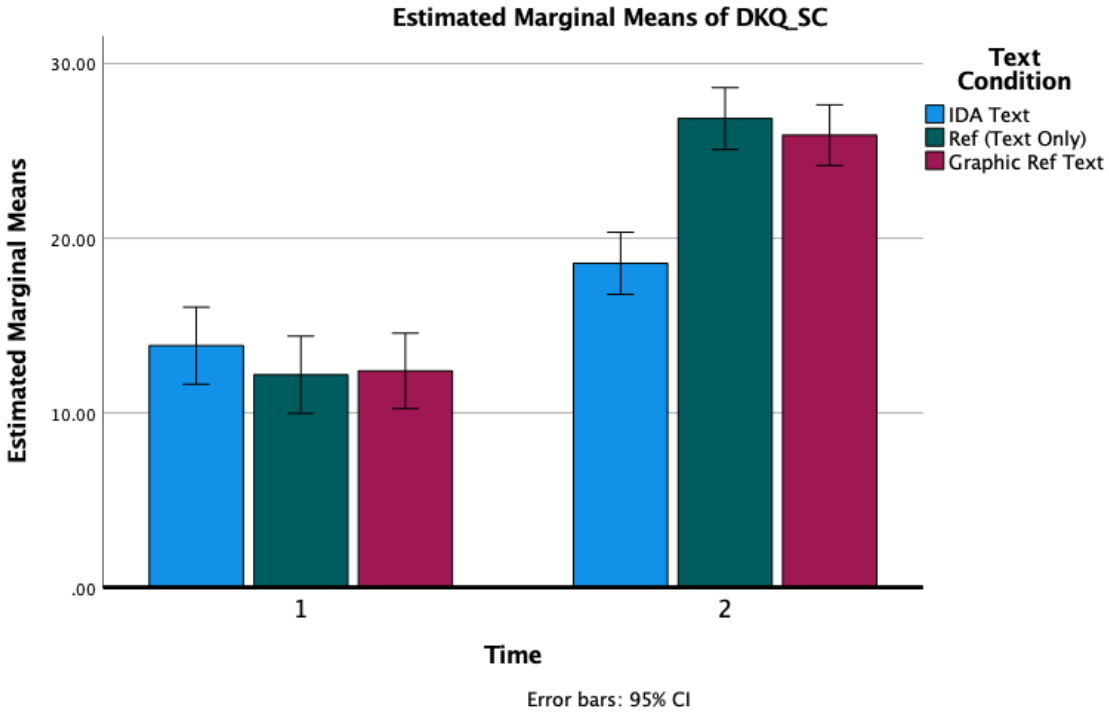


Figure 2

Histogram with a Fitted Bell Curve of SCs Per Text Condition at Pretest Across Time

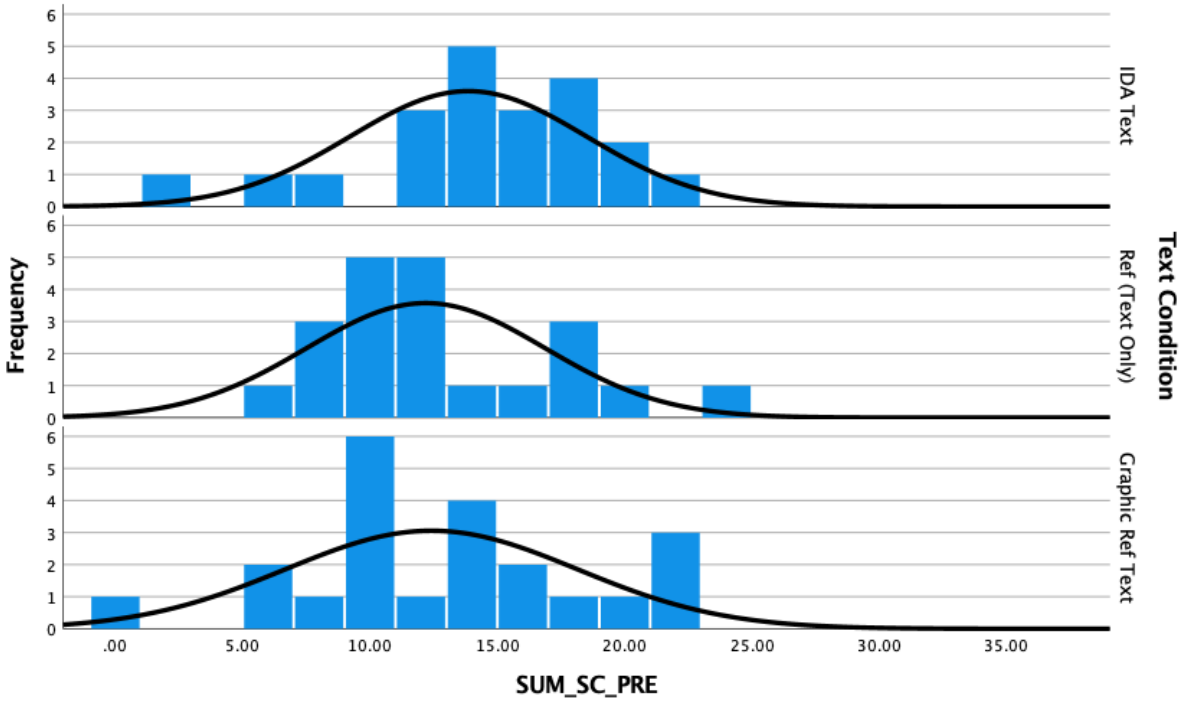
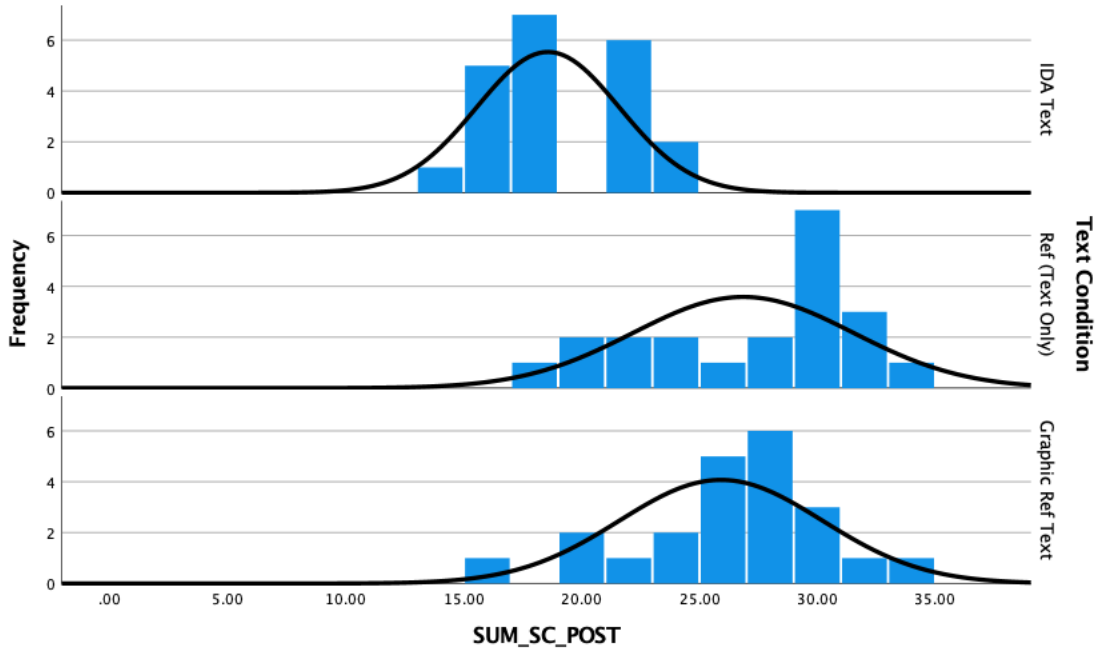


Figure 3

Histogram with a Fitted Bell Curve of SCs Per Text Condition at Posttest Across Time



Effects Across Time by Condition on MCs

A repeated measures ANOVA was performed using time (MCs on pre- to post-test) as the within subjects factor and text condition (IDA text, RT, RT-EG) as the between subjects factor. Sphericity is assumed as there are only two time points in the repeated measures ANOVA (IDA text mean = 12.57, SD = 4.63; RT mean = 12.38; SD = 3.04; RT-EG mean = 12.64, SD = 4.5). The results of the repeated measures ANOVA indicated the interaction between time by text condition on the rate of increase of MCs held by participants was statistically significant, $F(2, 61) = 9.24$, $p < .001$, with a large effect size of $\eta_p^2 = .23$. To examine the nature of the interaction, simple effects were examined for the amount of MCs held on the DKQ-3 from pre- to post-test.

Table 5

Effects Across Time by Condition on MCs

			95% Confidence Interval	
Text Condition	Mean	Std. Error	Lower Bound	Upper Bound
IDA Pretest	12.571	0.9	10.772	14.371
IDA Posttest	11	0.903	9.195	12.805
RT Pretest	12.381	0.9	10.582	14.18
RT Posttest	5.19	0.903	3.386	6.995
RT-EG Pretest	12.636	0.879	10.878	14.394
RT-EG Posttest	7.727	0.882	5.964	9.491

Pretest scores did not differ across text conditions. However, participants in the RT condition (mean = 5.20; SD = 3.79) scored significantly lower on MCs after reading the RT-EG or the IDA text (mean = 11.00; SD = 4.09) at posttest ($p = .02$). The RT-EG condition (mean = 7.73; SD = 4.48) was not statistically significantly different from either the IDA text condition ($p = .43$) or the RT condition ($p = .60$); however, the posttest RT-EG condition's MCs (mean = 12.64, SD = 4.49, 95% CI [10.88, 14.39]) were statistically significantly lower than pretest

(mean = 7.73, SD = 4.48, 95% CI [5.96, 9.49]), indicating the RT-EG condition had a large effect on decreasing MCs ($p < .001$, $\eta_p^2 = .32$). The IDA text was not statistically significantly effective at lowering MCs from pretest (mean = 7.73, SD = 4.48, 95% CI [10.77, 14.37]) to posttest (mean = 7.73, SD = 4.48, 95% CI [9.20, 12.81]) with $p = .10$. The RT condition had a very large effect of lowering MCs from pre- to posttest at $p < .001$, $\eta_p^2 = .50$. See Table 5 and Figure 4, 5, and 6 for more information.

Figure 4

Estimated Marginal Means of MCs Across Time

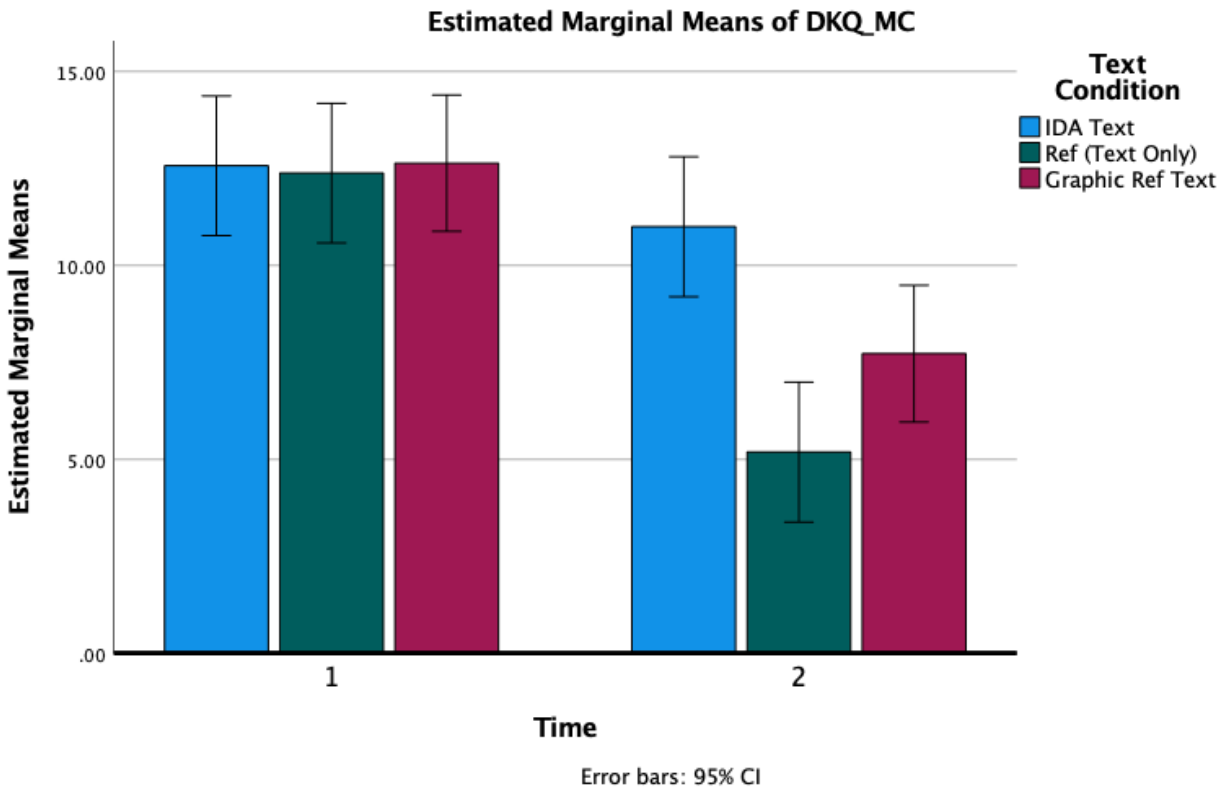


Figure 5

Histogram with a Fitted Bell Curve of MCs Per Text Condition at Pretest Across Time

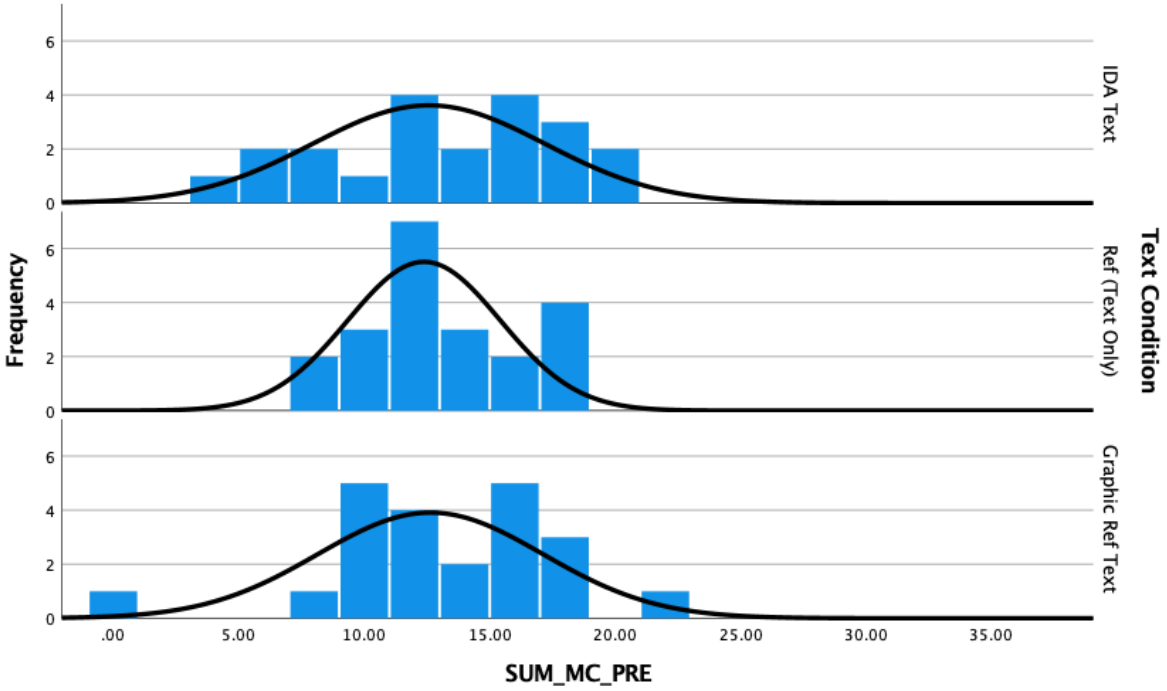
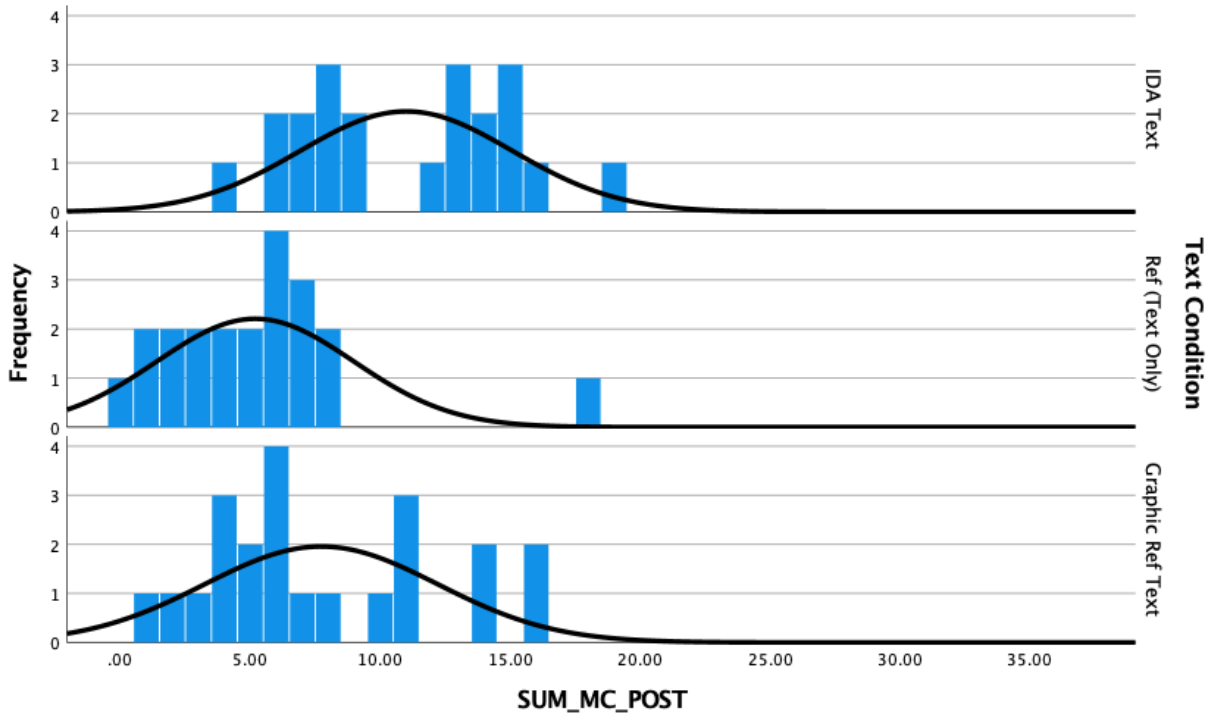


Figure 6

Histogram with a Fitted Bell Curve of MCs Per Text Condition at Posttest Across Time



Effects Across Time by Condition on UCs

A repeated measures ANOVA was performed using time (UCs on pre- to post-test) as the within subjects factor and text condition (IDA text, RT, RT-EG) as the between subjects factor (IDA text mean = 10.57, SD = 8.23; RT mean = 12.43; SD = 5.75; RT-EG mean = 11.91, SD = 8.61). Sphericity is assumed as there are only two time points in the repeated measures ANOVA. The results of the repeated measures ANOVA indicated the interaction between time by text condition on the rate of increase of UCs held by participants was statistically significant, $F(2, 61) = 3.94$, $p = .025$, with a medium effect size of $\eta_p^2 = .11$. To examine the nature of the interaction, simple effects were examined for the amount of UCs held on the DKQ-3 from pre- to post-test.

Table 6

Effects Across Time by Condition on UCs

			95% Confidence Interval	
Text Condition	Mean	Std. Error	Lower Bound	Upper Bound
IDA Pretest	10.571	1.67	7.232	13.911
IDA Posttest	7.429	0.806	5.816	9.041
RT Pretest	12.429	1.67	9.089	15.768
RT Posttest	4.952	0.806	3.34	6.565
RT-EG Pretest	11.909	1.631	8.647	15.171
RT-EG Posttest	3.364	0.788	1.788	4.939

Pretest scores did not differ across text conditions. However, there were statistically significant differences in participants UCs at post-test across conditions. All conditions decreased UCs statistically significantly after the text intervention (IDA text: $p = .03$, $\eta_p^2 = .07$; RT: $p < .001$, $\eta_p^2 = .30$; RT-EG: $p < .001$, $\eta_p^2 = .37$). The RT-EG (mean change = -8.55 UCs) and RT (mean change = -7.48 UCs) conditions were statistically significant at $p < .001$ and the IDA text (mean change = -3.14 UCs) condition was at $p = .03$. The RT-EG and RT conditions both had very large effect sizes on decreasing UCs, at $\eta_p = .37$ and $\eta_p = .30$ respectively, and the IDA text condition had a medium effect of $\eta_p = .07$. The participants who read the RT-EG text had statistically significantly fewer UCs at posttest than the participants who read the IDA text condition ($p = .002$, CI [-6.841, -1.29]). There was no other significant difference between text conditions. See Table 6 and Figure 7, 8, and 9 for more information.

Figure 7

Estimated Marginal Means of UCs Across Time

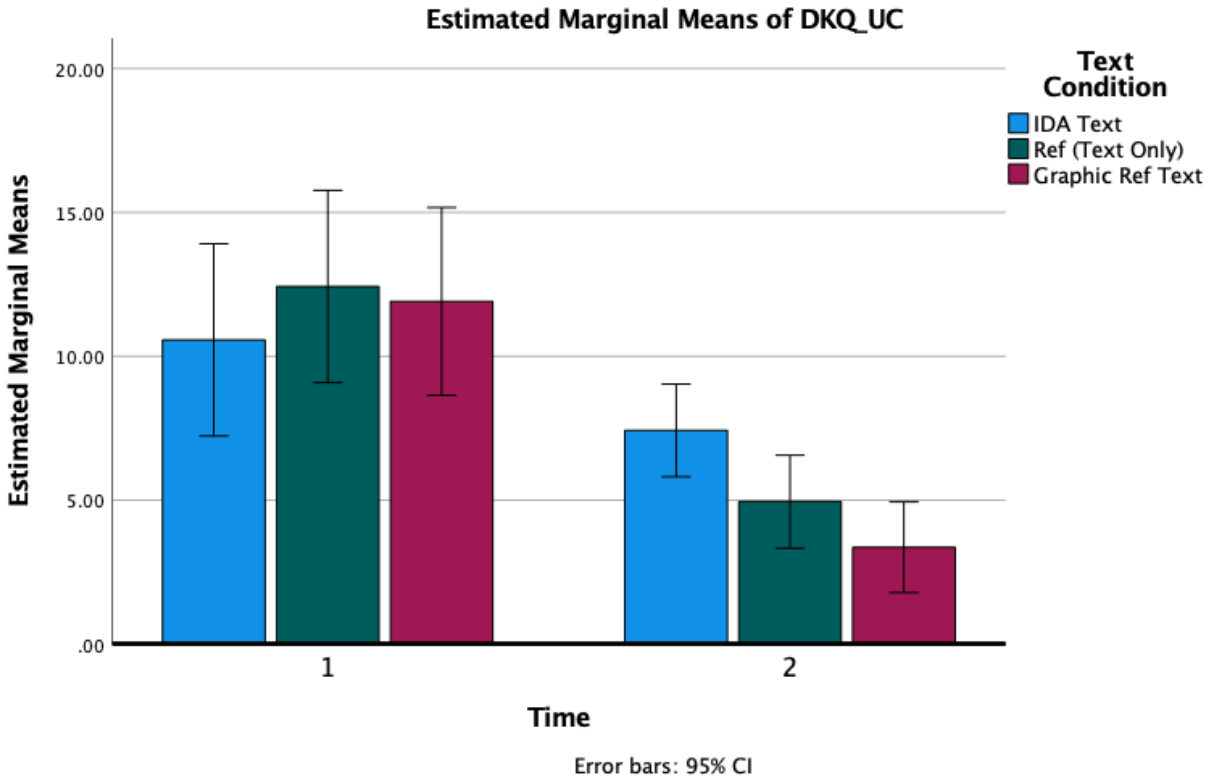


Figure 8

Histogram with a Fitted Bell Curve of UCs Per Text Condition at Pretest Across Time

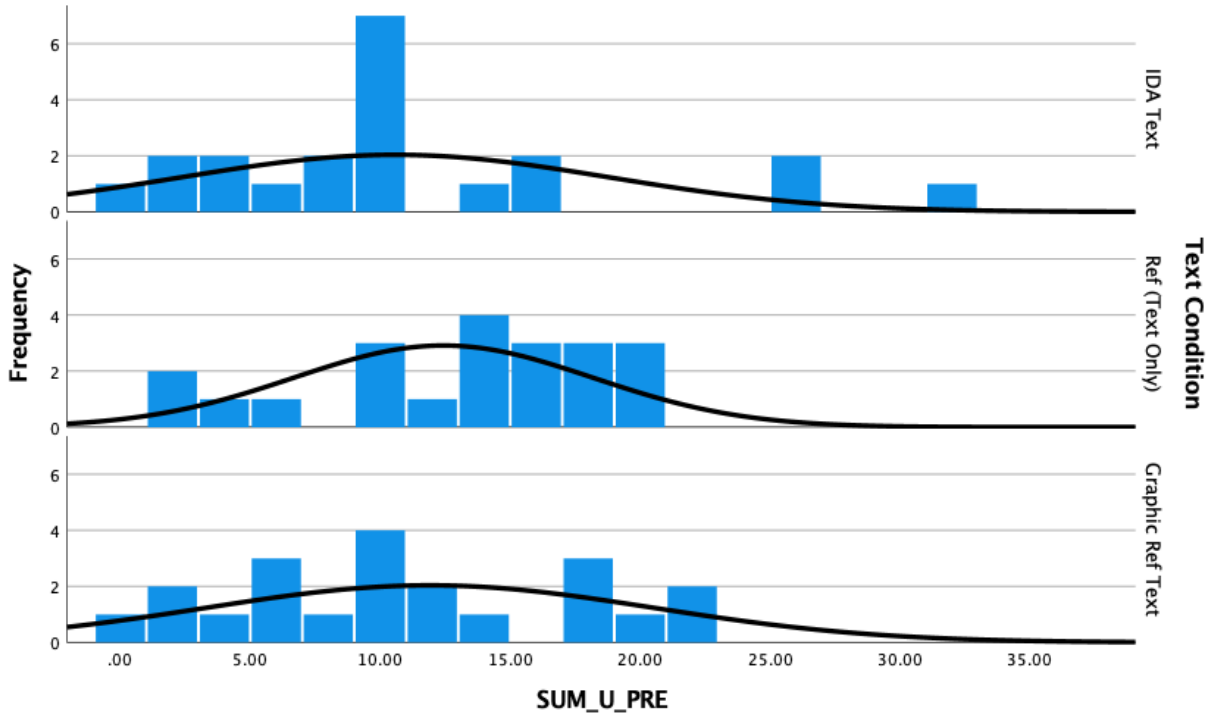
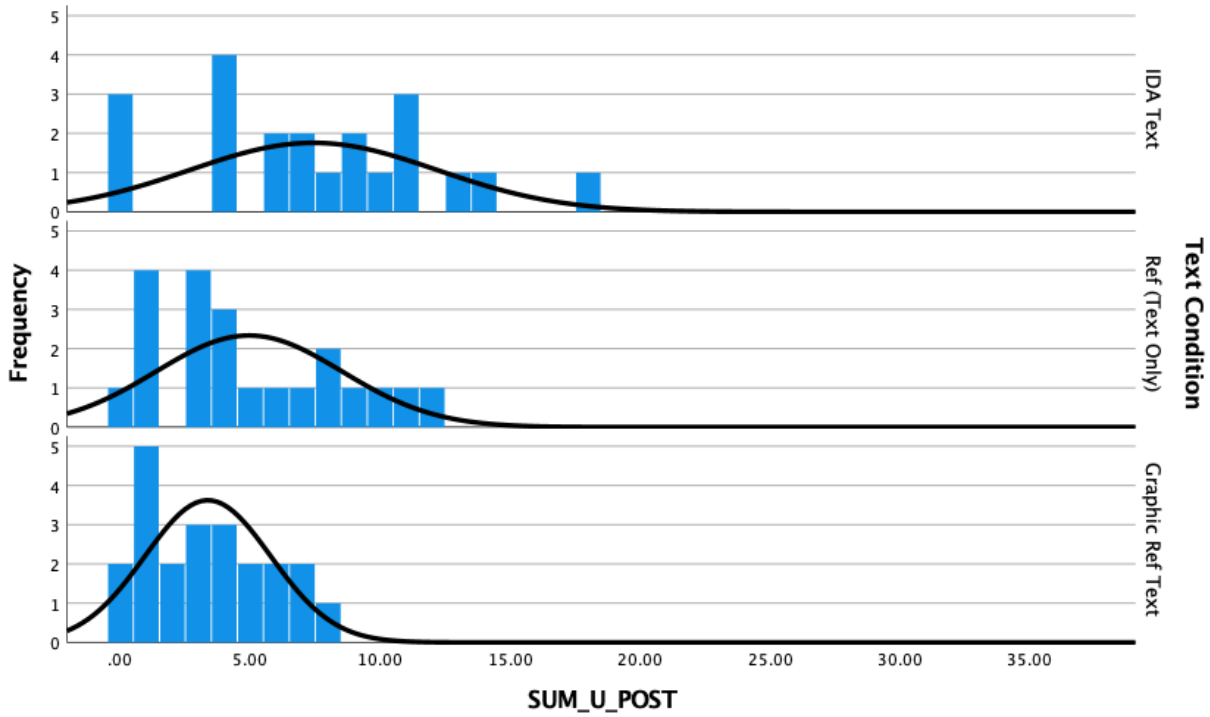


Figure 9

Histogram with a Fitted Bell Curve of UCs Per Text Condition at Posttest Across Time



Engagement Levels Relation to Text Condition and Increases in SCs

For research question three, I measured whether engagement levels are differential across conditions or if they moderate increased SCs across conditions.

Cognitive Engagement Levels Across Conditions

To answer the first part of the third research question and determine if cognitive engagement was differential across conditions, I ran a one-way ANOVA to determine statistical significance of CCCES-Modified_Total scores across text conditions (IDA text mean = 53.24, SD = 12.97; RT mean = 58.48, SD = 14.00; RT-EG mean = 52.77, SD = 13.25). Levene's test was not statistically significant (p = .97). I found no statistically significant differences across text conditions $F(2, 63) = 212.72$, p = .31, indicating text condition did not impact reported cognitive engagement. See Table 7 for participants' mean, standard deviation, and variance by item on the CCCES-Modified assessment.

Table 7

Descriptives by Item on the Conceptual Change Cognitive Engagement Scale-Modified

Item	Mean	Std. Deviation	Variance
While reading the text, I considered whether the information was well organized.	3.4531	1.28396	1.649
While reading the text, I considered whether the information was easy to understand.	4.0938	1.01916	1.039
While reading the text, I considered whether the information was clear and intelligible.	4.0469	1.01465	1.03
While reading the text, I considered whether the information flowed well.	3.625	1.13389	1.286
While reading the text, I thought about whether the information was credible.	3.2344	1.34214	1.801
While reading the text, I thought about whether the information was believable.	3.1094	1.3583	1.845
While reading the text, I thought about whether the information made logical sense.	3.5	1.33333	1.778
While reading the text, I thought about whether the information was reasonable.	3.375	1.30323	1.698
While reading the text, I thought about whether the source of the information was credible.	2.875	1.37437	1.889
While reading the text, I thought about whether the source of the information was trustworthy.	2.8437	1.2998	1.689
While reading the text, I thought about whether the source of the information was believable.	2.7813	1.29061	1.666
While reading the text, I thought about whether the information was understandable.	3.7344	1.14424	1.309
While reading the text, I thought about whether the information was intelligible.	3.5312	1.15427	1.332
While reading the text, I thought about whether the information was clear.	3.7031	1.16401	1.355
I was having trouble paying attention to the text while reading it.	3.4688	1.16794	1.364
I was distracted by other thoughts while reading the text.	3.4219	1.23191	1.518

Note. Items reverse coded are designated in ***bolded italics.***

Cognitive Engagement Levels in Relation to Change in SCs

To answer the second part of the third research question, I tested whether reported cognitive engagement levels during reading predicted scientific conception gain scores. To do this, I subtracted SC_Pre_Total from SC_Post_Total for each participant to create the variable SC_Gain_Score. Then, I ran a linear regression with SC_Gain_Score (possible range -37 to 37) as the dependent variable and CCCES-Modified_Total (possible range 16-80) as the independent variable. Considering the cognitive engagement levels were not differential across conditions, text condition was not included in the model. The mean gain score was a gain of 11 SCs with a SD of 7.16 SCs. The mean CCCES-Modified_Total was 54.80 Likert-scaled points (mean of 3.43 points per item) and a SD of 13.45 Likert-scaled points (mean of .84 points per item). Results indicated cognitive engagement did not statistically significant predict gain in SCs from pre- to posttest ($F[1, 63] = .727$, $p = .40$, $R^2 = .10$).

Discussion

The purpose of this study was to determine, within this sample of preservice teachers: (1) which SCs, MCs, and UCs participants commonly hold regarding dyslexia, (2) if the text interventions (i.e., IDA text, RT, RT-EG) are differentially effective in increasing participant SCs and decreasing MCs and UCs at an immediate posttest, and (3) if cognitive engagement levels are differential across conditions and/or moderate the gain in SCs across conditions. First, I will discuss participants' common MCs, SCs, and UCs regarding dyslexia. Knowing this information can lend insight into how to better target common MCs in future dyslexia trainings. Next, I will summarize the effects of the three text interventions on participants' SCs, MCs, and UCs. This can help to determine which text condition was most effective in increasing SCs while decreasing MCs and UCs in order to most effectively communicate information during dyslexia

trainings. Finally, I will explain the findings on cognitive engagement levels as it related to text conditions and improvement in SCs.

Summary of Results

Preservice Teachers' Baseline Conceptions of Dyslexia

In this study, the most common MCs held by participants in the sample included: (1) the type of treatment appropriate for students with dyslexia (i.e., *Students with dyslexia should be taught coping strategies, such as using context cues or pictures to help decode words*, MC; *Students with dyslexia normally learn to read most quickly through the exposure to audio recordings while following along in the printed text*, MC; *Students with dyslexia primarily need instruction in reading comprehension strategies*, MC) and (2) dyslexia as a visual disability, as relating to characteristics and instruction for dyslexia (e.g., *Seeing letters and words backwards is a characteristic of dyslexia*, MC; *Students with dyslexia have poor word-level reading skills typically due to poor visual processing skills*, MC; *Students with dyslexia need specialized dyslexia fonts in order to read printed words more accurately*, MC). These MCs regarding dyslexia as a visual disability were consistent with previous findings on preservice teacher knowledge of dyslexia (Washburn, 2013); however, the findings surrounding the misconceptions held about the type of treatment for students with dyslexia, such as mentioned above that did not deal with visual difficulties, were not found in previous literature. Most of the previous surveys of preservice teacher knowledge of dyslexia did not inquire about common misconceptions for instructional methods appropriate for students with dyslexia. This uncovers an important finding that although preservice teachers understand that dyslexia affect reading and spelling, they may not understand the underlying skills with which it affects (viz., phonological processing, decoding and encoding skills). Teacher educators should be sure to dispel the MCs that dyslexia

is a visual difficulty (seeing word or letters backwards or moving) as opposed to language-based difficulty (connecting sounds to letters). They should also refute the MC that students with dyslexia need to learn to read in a different way than students without dyslexia; making clear to preservice teachers that dyslexia describes a difficulty in learning to decode and encode, this difficulty lies in the area of connecting letters to sounds, and effective treatment for students with dyslexia includes intensive intervention in phonic-based decoding and encoding strategies. They should also make clear that dyslexia does not describe a difficulty with comprehension. If a student is having difficulty with listening comprehension apart from decoding or fluency, this would better be described by the term Developmental Language Disorder (Bishop et al., 2017).

The most common SCs held were: (1) definition of dyslexia as relating to a difficulty with reading and spelling words (i.e., *Students with dyslexia have difficulty with reading and spelling words*, SC*),* (2) relation of dyslexia to special education law (i.e., *Dyslexia is recognized as a type of specific learning disability that can receive special education services by the federal government*, SC), and (3) instruction for students with dyslexia to primarily include phonemic awareness and phonics (e.g., *Students with dyslexia primarily need instruction in phonemic awareness and phonics*, SC). The overall impact of dyslexia as being related to reading and spelling is commonly reported in previous studies (e.g., Washburn et al., 2017); however, the SC that dyslexia is recognized by special education law is less commonly reported. Peltier and colleagues (2020) found this as well; however, this sample was taken from the same university as the current study where participants have taken a required special education course that covers these topics and may not replicate to other samples.

It should be noted that within the type of instruction for students with dyslexia, participants held many UCs as well, with about a third to half of participants citing UCs in this

area. The most common UCs held included: (1) the heritability of dyslexia (e.g., *Dyslexia is not hereditary*; MC), (2) visually-based treatment for dyslexia (e.g., *Colored lenses or overlays usually do not help improve reading accuracy in people with dyslexia*, SC), (3) how phonics and phonemic awareness relate to dyslexia (e.g., *Students identified with dyslexia usually have average to above-average phonemic awareness*, MC), and (4) the role of schools in identifying students with dyslexia (e.g., *Dyslexia should usually be identified by a school psychologist*, SC). In previous studies, many of these UCs were reported as MCs (e.g., Wadlington & Wadlington, 2005, Washburn et al., 2017). This could be because participants did not have the choice of unsure, because participants in this sample had different conceptions of dyslexia than in previous research, or a combination of both.

Effects of Text Conditions on Conceptual Change

After participating in the text-based interventions, participants in all conditions statistically significantly improved their SCs, with a mean improvement of 11 out of 37 questions on the DKQ-3. However, participants in the RT and RT-EG conditions statistically significantly improved beyond participants in the IDA text condition, improving 13-15 on average as compared with a five-item improvement in the IDA text condition. Refutation text conditions were more effective in improving overall SCs among preservice teachers. This is consistent with the conceptual change theory (Posner et al., 1982) stating that greater conceptual change occurs if participants are first dissatisfied with their current conceptions. The RT and RT-EG both refuted common MCs before presenting the relevant SCs, which may have allowed for the opportunity for more adoption of SCs in relation to their conception of dyslexia, as proposed by the CCM (Posner et al., 1982), CRKM (Dole & Sinatra, 1998), and CAMCC (Gregoire, 2003) producing greater conceptual change.

As hypothesized, text conditions were differential in dispelling misconceptions. Both the RT and RT-EG statistically significantly decreased the number of MCs from pre- to posttest with large effect sizes. This may be because the refutation text directly refuted the common misconceptions, eliciting the participants to create dissatisfaction with their current conceptions of dyslexia (Posner et al., 1982). However, the IDA text condition did not have a statistically significant effect on decreasing MCs, most likely because the content of the text did not create dissatisfaction (Posner et al., 1982) by directly addressing common MCs. Rather, the IDA text focused primarily on presenting SCs. Because of this, participants may have left not understanding how their MCs related to the SCs presented in the text (Vosniadou, 2009), producing less conceptual change overall.

Finally, all text conditions statistically significantly decreased UCs from pre- to posttest. However, the RT-EG and RT conditions both had very large effect sizes on decreasing UCs, while the IDA text condition had a medium effect. This may be because participants in the IDA text condition continued to be unsure of some of the MCs that were not directly addressed within the IDA text. They may have remained unsure of propositions that were either not addressed in the IDA text or those that were in direct opposition to the propositions presented in the text and were unable to assimilate this new information to their existing knowledge structures (Vosniadou, 2009).

Embedded Graphics Effect on Learning

Although the refutation text with embedded graphics significantly improved SCs, dispelled MCs, and decreased UCs, it was not statistically significantly different than the refutation text without graphics as hypothesized. This could be for a few reasons. One reason could be that some of the illustrations and emboldened text present could have a seductive effect

on participants' recall (Harp & Meyer, 1998), meaning the drawing attention to the myth as opposed to the scientific conception could prompt participants to remember this information as more important or begin to build their conceptual ecology around this concept rather than the scientific conception. The caricature of the mouse present throughout the graphic novel may also have pulled participant attention away from the smaller text describing the scientific conception. The illustrations that presented the key points may have increased participant retention and understanding, as Clark and Paivio (1991; Paivio, 1986) hypothesized through dual coding theory; however, with the some illustrations focusing on the myth aspect and some focusing on the scientific conception, the inconsistency may have had an inconsistent effect on participant understanding, increasing it over the refutation text as through dual coding theory (Clark & Paivio, 1991), yet decreasing it with the effect of the myth text emboldened and mouse caricature, as hypothesized by the seductive details effect (Harp & Mayer, 1998).

Cognitive Engagement as Related to Conceptual Change

Cognitive engagement during reading, as measured by the items for cognitive engagement with the message from the CCCES (Heddy et al., 2018) was not associated with text condition assigned. This may be due to participants being presented with the intervention during a preservice teacher education course in which they are used to reading texts for a purpose, and reporting similar levels of cognitive engagement throughout reading. Refutation texts, though they significantly increased conceptual change, did not predict increased cognitive engagement levels among participants. This suggests that although all participants were similarly cognitively engaged regardless of the text condition assigned, the refutation texts presented information in a way that allowed for greater conceptual change. This possibly was because it helped participants to connect their previous MCs and UCs with the new SCs presented, allowing them to create a

more coherent conceptual ecology and connected schema of dyslexia (Piaget, 1952; Wittrock, 1989).

Another noteworthy finding, participants reported cognitive engagement during reading did not predict conceptual change across text conditions. Participants who reported high cognitive engagement and those who reported low cognitive engagement both had high and low levels of conceptual change. There was no association between reported cognitive engagement and increased SCs from pre- to posttest. This is not consistent with my previous hypothesis that engagement would moderate conceptual change, in line with the CRKM (Dole & Sinatra, 1998) and CAMCC (Gregoire, 2003) theorizing that high engagement is needed for deep conceptual change. This may be because of the participant demographic this study was drawn from, being undergraduate preservice teachers during an education course, the topic it was regarding, or the way the construct of cognitive engagement was measured in this study. Future research should seek to tease apart these factors.

Limitations

Results should be interpreted with some limitations in mind. The final sample included 64 undergraduate students within one teacher preparation program in the mid-south are of the US. It is not known if a larger and more diverse sample of preservice teachers would produce similar results. It is also unknown if various stakeholder groups, including in-service teachers in various stages of their careers, would respond differentially to the intervention conditions. Second, although the instruments were used in previous research, they have been modified from the original assessment in ways previously specified and do not currently have psychometric validity evidence in their current form. Finally, although previous research with the IDA text and RT (Peltier et al., 2020) suggests these effects persist, though decrease slightly, after four weeks,

it is not known how the effects found in the current study would continue in future follow up assessments. Future studies should determine how these effects may be impacted differentially across time.

Implications for Training

Laws across the US mandate pre- and in-service teacher training on dyslexia creating dyslexia handbooks for stakeholder consumption, and screening and intervention procedures for identifying students at-risk for dyslexia with more laws being enacted each year (Youman & Mather, 2018). There is also a significant body of research that suggests both pre- and in-service teachers (Knight, 2018; Ness & Southall, 2010; Peltier et al., 2020; Wadlington & Wadlington, 2005; Washburn et al., 2011a, b, 2014) and other educational stakeholders (Castillo & Gilger, 2018; Wadlington & Wadlington, 2005; Worthy et al., 2018) hold significant misconceptions about this term.

When designing training materials, states, teacher preparation providers, and professional learning designers should ensure common misconceptions are connected in a coherent way to the presentation, refuted, and the scientific conceptions are explained in an intelligible, plausible, and fruitful way (Posner et al., 1982). When possible, these should be followed-up with sessions how these concepts apply to specific state level policies, district procedures, or school curricula and resources to help participants create a more coherent understanding of the SC of the term dyslexia into their previously built conceptual ecology, accommodating previous schema when necessary into new knowledge structures built around the SCs (Piaget, 1952; Wittrock, 1989).

Implications for Future Research

Currently, there is a paucity of research on how to effect conceptual change of dyslexia. Though effective trainings are needed to begin to shift stakeholder understanding of this

commonly misunderstood term, ways in which we can do so need to be further identified and tested by scientific study. Both refutation-based texts in this study (RT and RT-EG) facilitated greater conceptual change than the informational text, consistent with previous research comparing refutation texts to informational texts on topics in which misconceptions are prevalent (Schroeder & Kucera, 2022; Tippett, 2010) and specifically on the topic of dyslexia among preservice teachers (Peltier et al., 2020). Future research can improve on these results in a variety of ways: (a) including a more diverse sample (preservice teachers in various areas across the US, in-service teachers, administrators, teacher educators) to determine if effects are differential across participants, (b) comparing various instructional delivery formats (text-based, presentations, interactive activities) to determine the most efficacious way to deliver the content, (c) looking closer at individual differences in participant response to the intervention, (d) incorporating qualitative aspects into studies to understand a more nuanced view of the conceptual change process for various populations and conditions, and (e) assessing how effects may change across time.

Also, in order to determine the mechanism of action within the graphic text, future research could focus on a few areas. Researchers could focus on one myth, attempting to use a graphic designed for popular press against a condition in which the Cognitive Theory of Multimedia Learning (Meyer et al., 1995) is taken into account. For example, areas to be manipulated may include the sole inclusion of relevant graphics, taking out the caricatures, including only illustrations which focus on key concepts contrasting the misconception and scientific conceptions, emboldening the scientific conception in larger print, and guiding questions beforehand to focus participants on the relevant information in each upcoming section.

Future research should also determine if these methods increase long-term retention as hypothesized in the Dual Coding Theory by Clark & Paivio (1991).

Conclusion

This study advanced the current body of literature on preservice teacher knowledge of dyslexia by adding information regarding preservice teachers in the mid-southern US, after dyslexia laws have been passed across the US (Youman & Mather, 2018). These results also extend the body of literature into understanding the differences between not only participant SCs and MCs, but also UCs (Peltier et al., 2020). Finally, this study found that text condition did not impact cognitive engagement during reading and that reported cognitive engagement level during reading did not predict conceptual change among participants.

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Appendix A. Refutation Text Embedded Graphics

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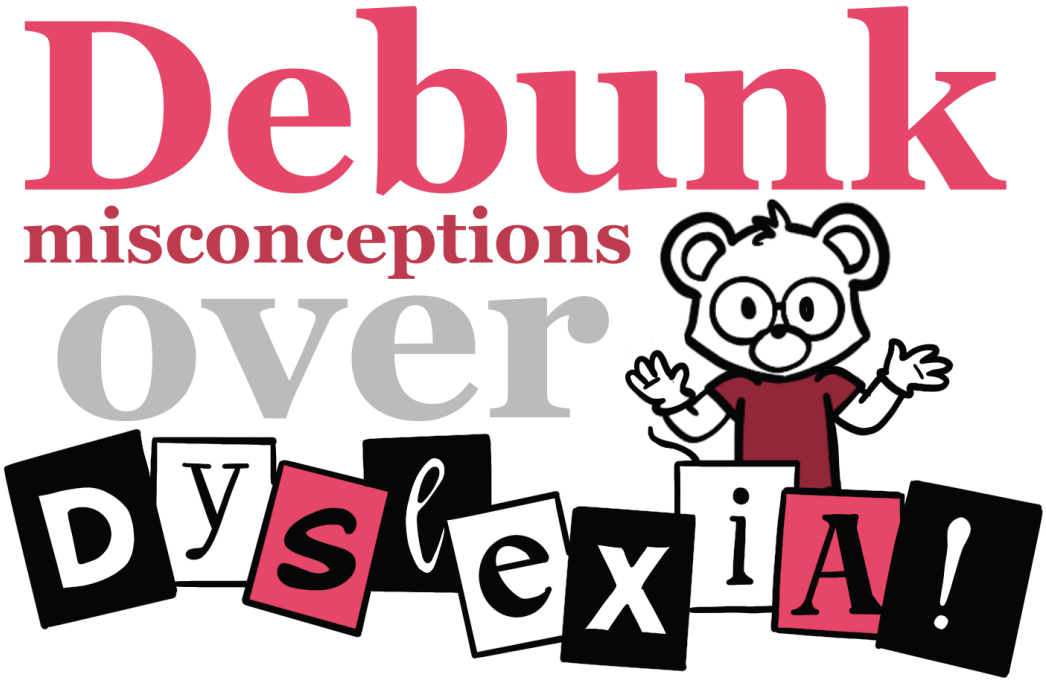
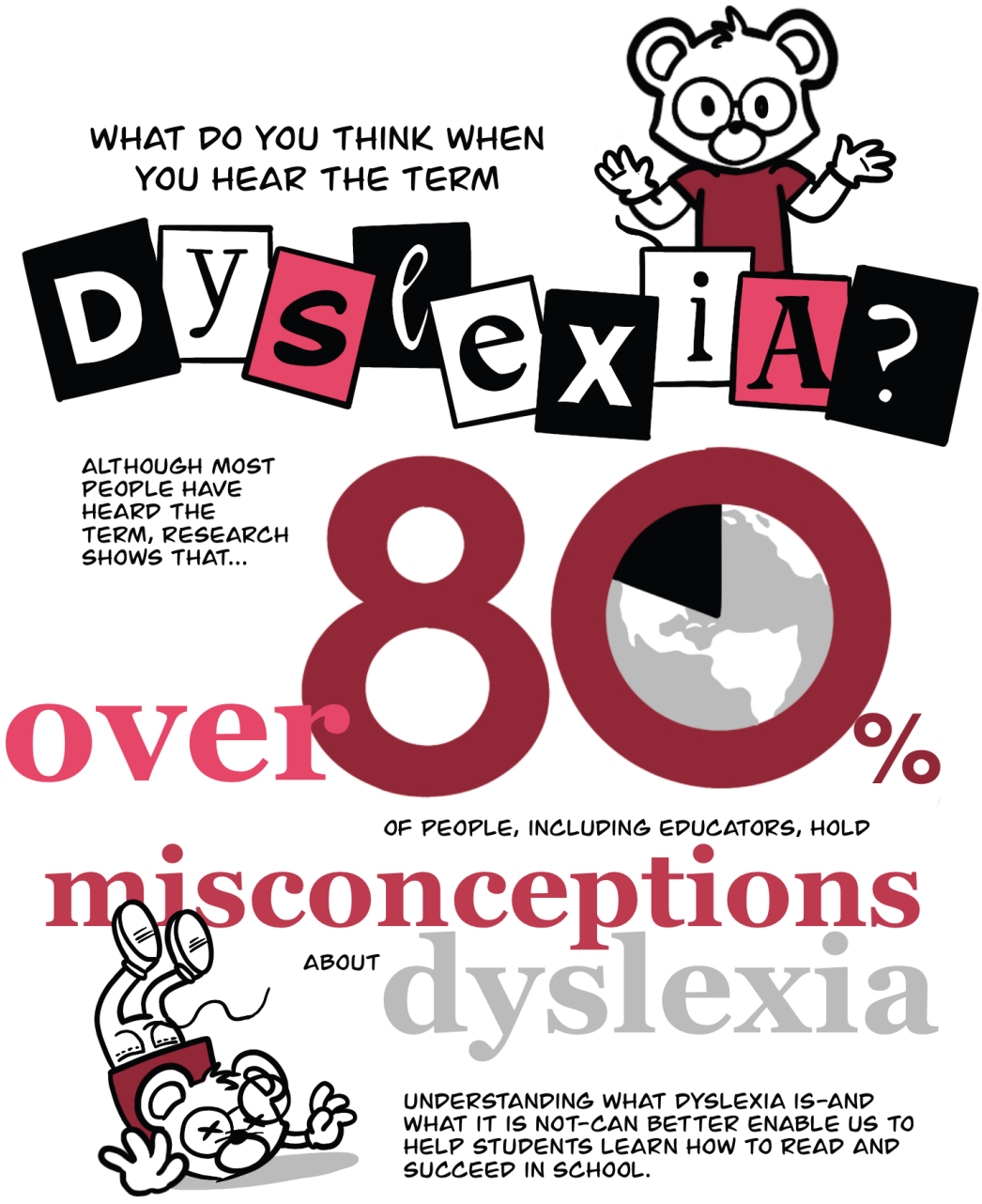
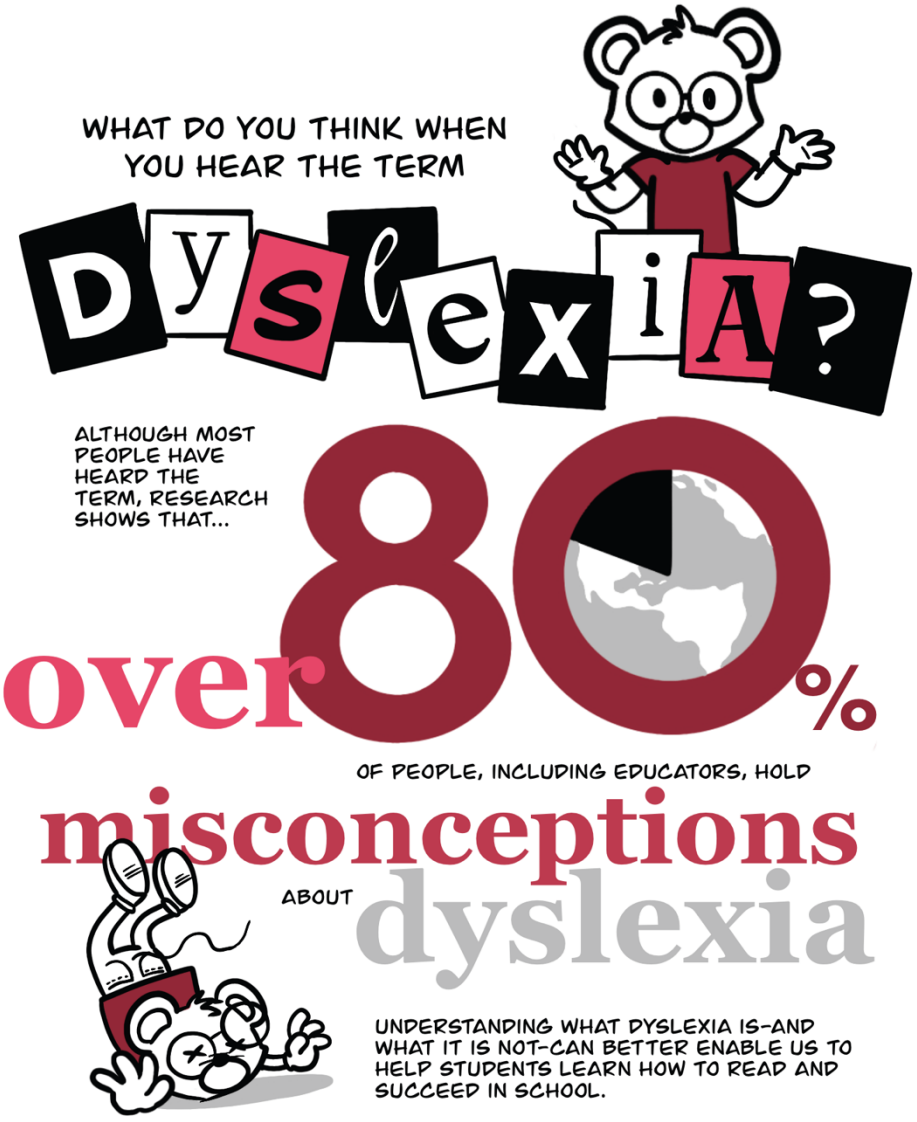



WHAT DO YOU THINK WHEN YOU HEAR THE TERM
DYSLEXIA?
ALTHOUGH MOST PEOPLE HAVE HEARD THE TERM, RESEARCH SHOWS THAT...
over 80%
OF PEOPLE, INCLUDING EDUCATORS, HOLD
misconceptions
ABOUT
dyslexia
UNDERSTANDING WHAT DYSLEXIA IS-AND WHAT IT IS NOT-CAN BETTER ENABLE US TO HELP STUDENTS LEARN HOW TO READ AND SUCCEED IN SCHOOL.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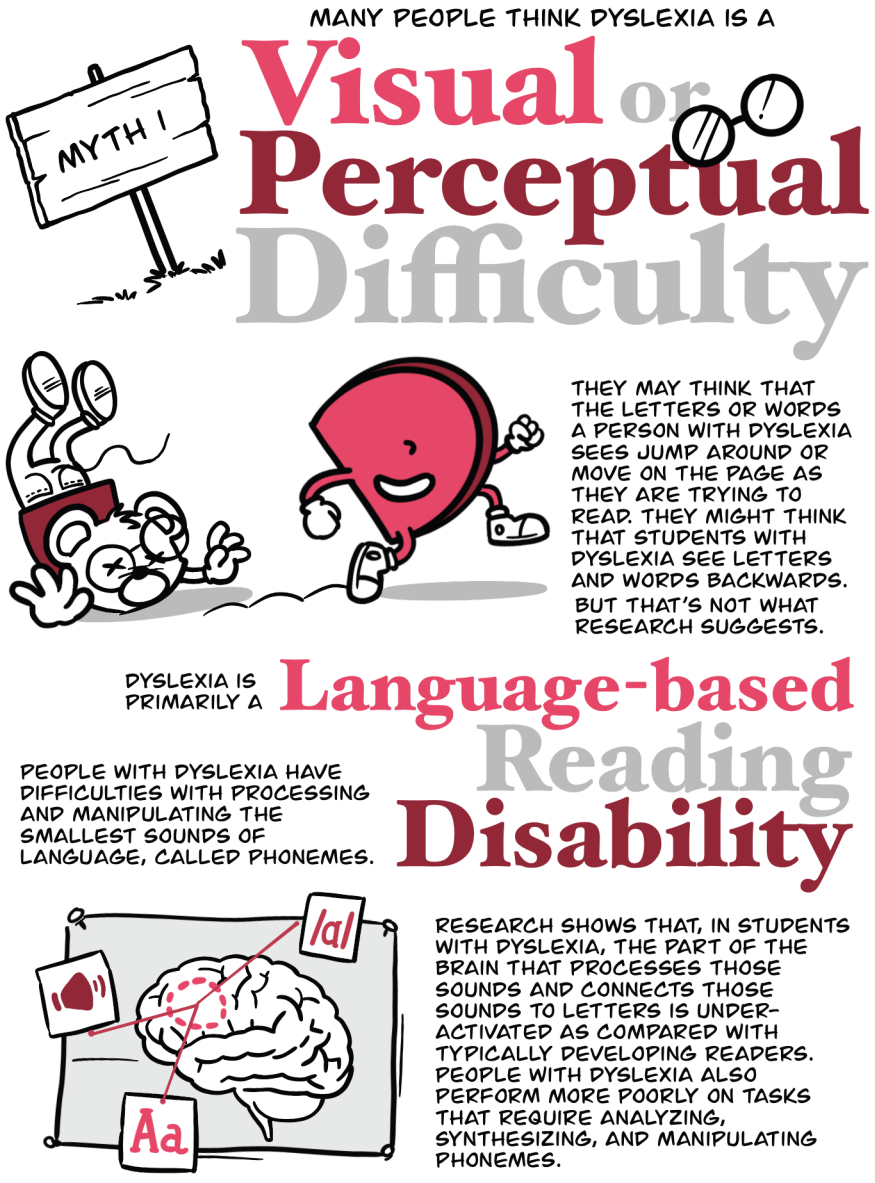
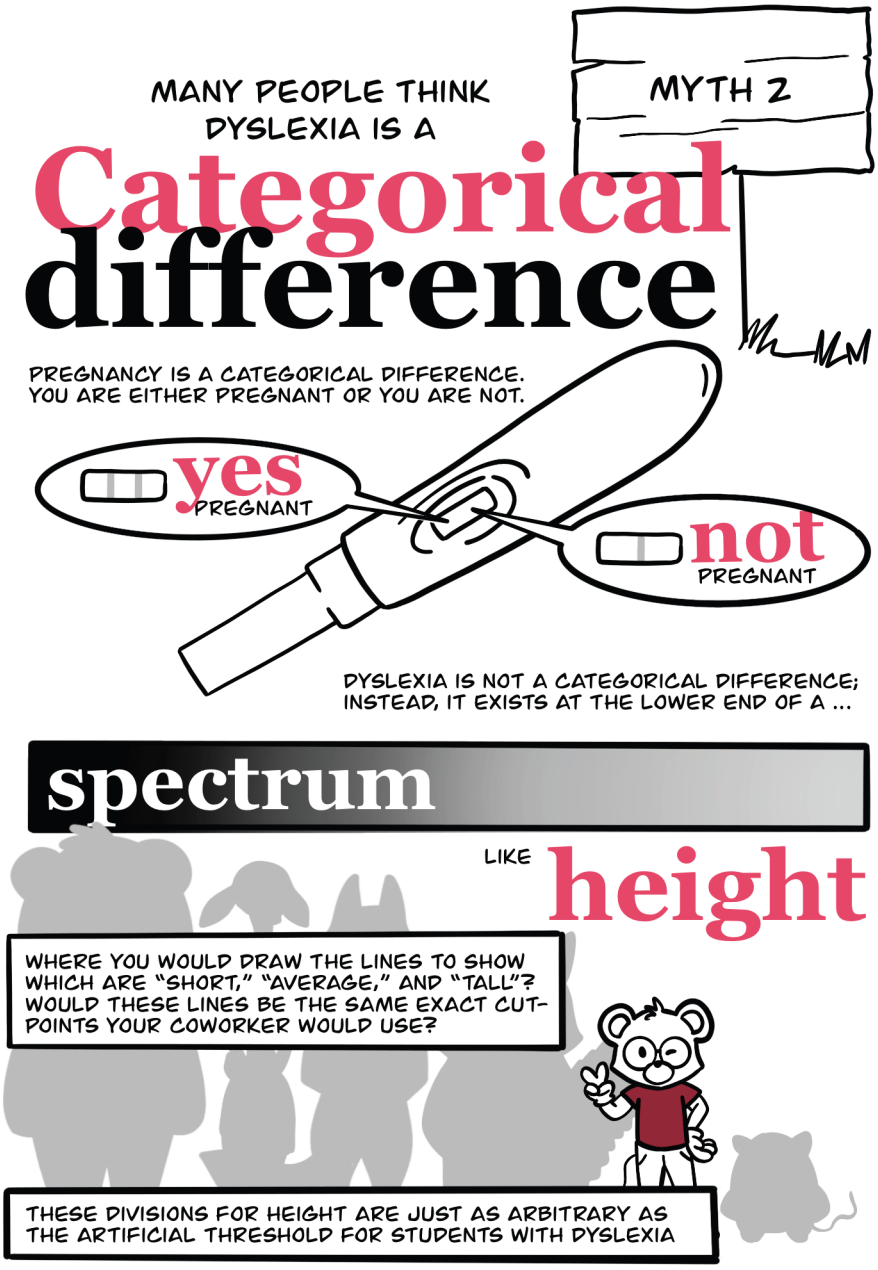
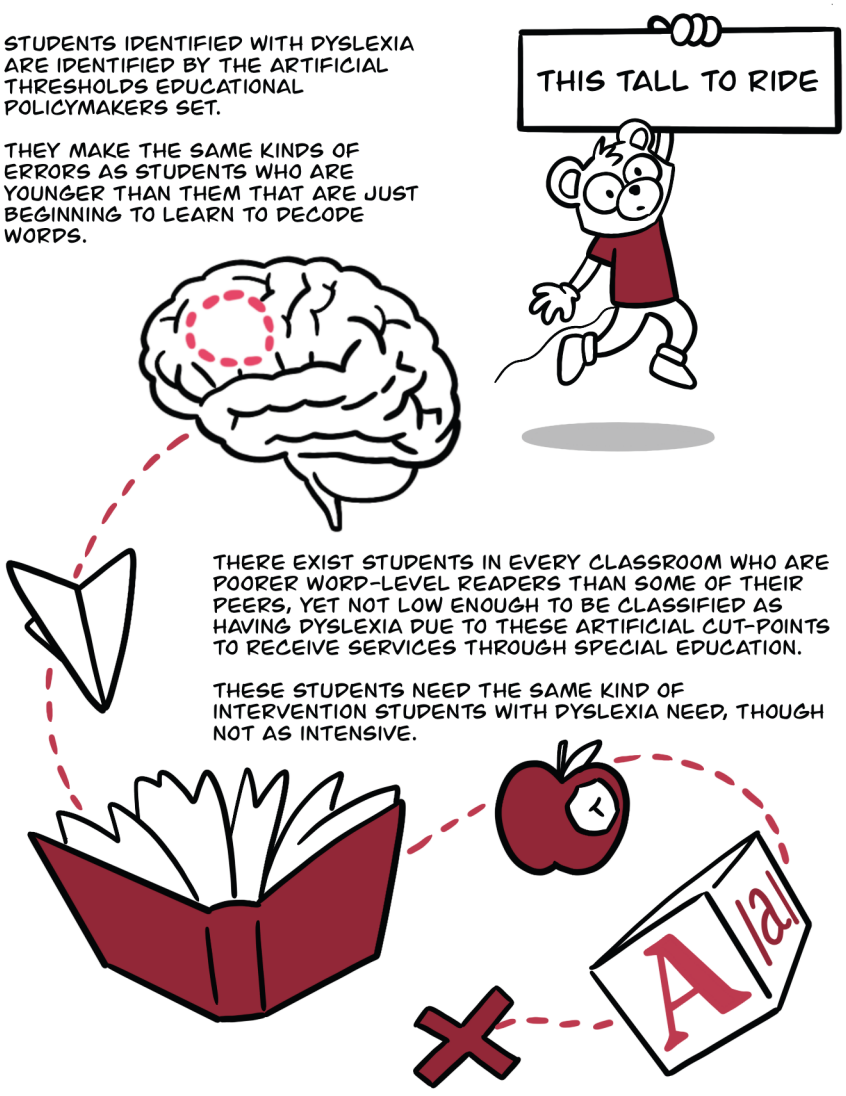
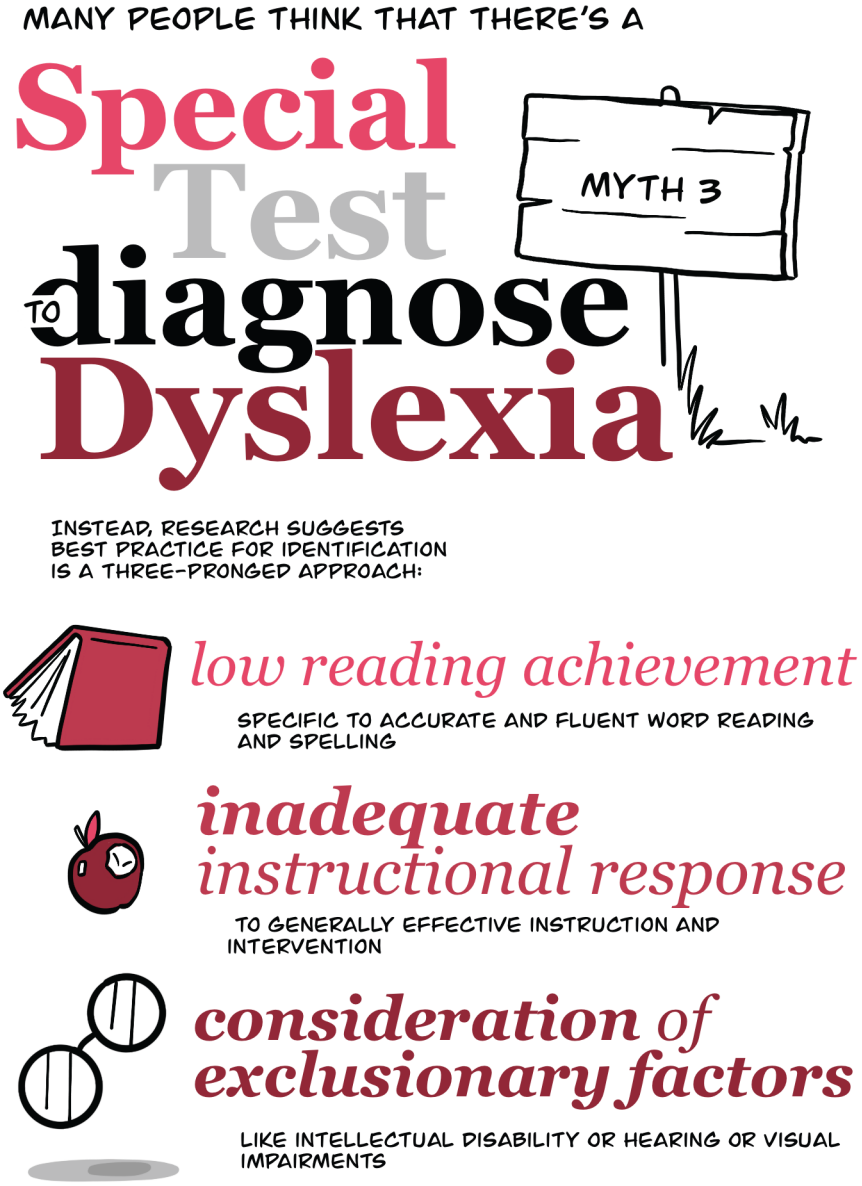

MANY PEOPLE THINK DYSLEXIA IS A
MYTH !
Visual or Perceptual Difficulty
THEY MAY THINK THAT THE LETTERS OR WORDS A PERSON WITH DYSLEXIA SEES JUMP AROUND OR MOVE ON THE PAGE AS THEY ARE TRYING TO READ. THEY MIGHT THINK THAT STUDENTS WITH DYSLEXIA SEE LETTERS AND WORDS BACKWARDS.
BUT THAT'S NOT WHAT RESEARCH SUGGESTS.
DYSLEXIA IS PRIMARILY A
Language-based Reading Disability
PEOPLE WITH DYSLEXIA HAVE DIFFICULTIES WITH PROCESSING AND MANIPULATING THE SMALLEST SOUNDS OF LANGUAGE, CALLED PHONEMES.
/a/
Aa
RESEARCH SHOWS THAT, IN STUDENTS WITH DYSLEXIA, THE PART OF THE BRAIN THAT PROCESSES THOSE SOUNDS AND CONNECTS THOSE SOUNDS TO LETTERS IS UNDER-ACTIVATED AS COMPARED WITH TYPICALLY DEVELOPING READERS. PEOPLE WITH DYSLEXIA ALSO PERFORM MORE POORLY ON TASKS THAT REQUIRE ANALYZING, SYNTHESIZING, AND MANIPULATING PHONEMES.

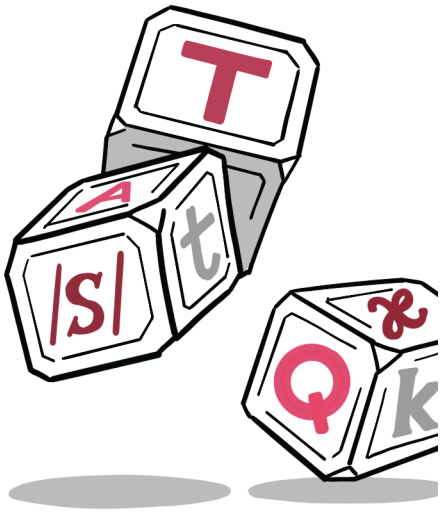

FOR EXAMPLE, IF I ASKED YOU TO BLEND THE INDIVIDUAL SOUNDS, OR PHONEMES, "/S/... /P/... /L/... /A/... /SH/... /T/" AND SAY THE WORD AS A WHOLE, MOST PEOPLE WOULD RESPOND, "SPLASHED." FOR A PERSON WITH DYSLEXIA, BLENDING PHONEMES TO SAY A WHOLE WORD OR BREAKING APART A WORD INTO INDIVIDUAL PHONEMES IS MORE DIFFICULT THAN A TYPICALLY DEVELOPING READER.
/s/
/p/
/l/
/a/
/sh/
/t/
SPLASHED
IN ORDER TO READ A WORD, YOU FIRST MUST IDENTIFY THE SOUNDS AND THEN BLEND THOSE SOUNDS TOGETHER TO SAY THE WORD AS A WHOLE. SIMILARLY, TO SPELL A WORD, YOU FIRST NEED TO DISTINGUISH THE INDIVIDUAL SOUNDS IN THE WORD BEFORE WRITING DOWN THE LETTERS FOR THOSE SOUNDS.


MYTH 2
MANY PEOPLE THINK DYSLEXIA IS A
Categorical difference
PREGNANCY IS A CATEGORICAL DIFFERENCE. YOU ARE EITHER PREGNANT OR YOU ARE NOT.
yes PREGNANT
not PREGNANT
DYSLEXIA IS NOT A CATEGORICAL DIFFERENCE; INSTEAD, IT EXISTS AT THE LOWER END OF A ...
spectrum
LIKE height
WHERE YOU WOULD DRAW THE LINES TO SHOW WHICH ARE "SHORT," "AVERAGE," AND "TALL"? WOULD THESE LINES BE THE SAME EXACT CUT-POINTS YOUR COWORKER WOULD USE?
THESE DIVISIONS FOR HEIGHT ARE JUST AS ARBITRARY AS THE ARTIFICIAL THRESHOLD FOR STUDENTS WITH DYSLEXIA

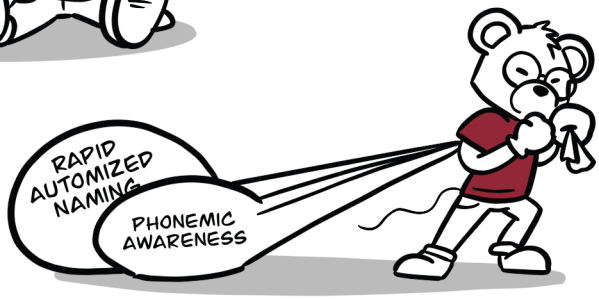

STUDENTS IDENTIFIED WITH DYSLEXIA ARE IDENTIFIED BY THE ARTIFICIAL THRESHOLDS EDUCATIONAL POLICYMAKERS SET.
THEY MAKE THE SAME KINDS OF ERRORS AS STUDENTS WHO ARE YOUNGER THAN THEM THAT ARE JUST BEGINNING TO LEARN TO DECODE WORDS.
THIS TALL TO RIDE
THERE EXIST STUDENTS IN EVERY CLASSROOM WHO ARE POORER WORD-LEVEL READERS THAN SOME OF THEIR PEERS, YET NOT LOW ENOUGH TO BE CLASSIFIED AS HAVING DYSLEXIA DUE TO THESE ARTIFICIAL CUT-POINTS TO RECEIVE SERVICES THROUGH SPECIAL EDUCATION.
THESE STUDENTS NEED THE SAME KIND OF INTERVENTION STUDENTS WITH DYSLEXIA NEED, THOUGH NOT AS INTENSIVE.
A /a/
UNDERSTANDING THIS DIFFERENCE (OR LACK OF DIFFERENCE) BETWEEN STUDENTS IDENTIFIED WITH DYSLEXIA AND STUDENTS NOT IDENTIFIED WITH DYSLEXIA CAN HELP US TO PROVIDE BETTER INSTRUCTION AND INTERVENTION FOR ALL STUDENTS WHO ARE LEARNING TO READ.


MANY PEOPLE THINK THAT THERE'S A
Special Test
to diagnose
Dyslexia
MYTH 3
INSTEAD, RESEARCH SUGGESTS
BEST PRACTICE FOR IDENTIFICATION
IS A THREE-PRONGED APPROACH:
low reading achievement
SPECIFIC TO ACCURATE AND FLUENT WORD READING
AND SPELLING
inadequate
instructional response
TO GENERALLY EFFECTIVE INSTRUCTION AND
INTERVENTION
consideration of
exclusionary factors
LIKE INTELLECTUAL DISABILITY OR HEARING OR VISUAL
IMPAIRMENTS

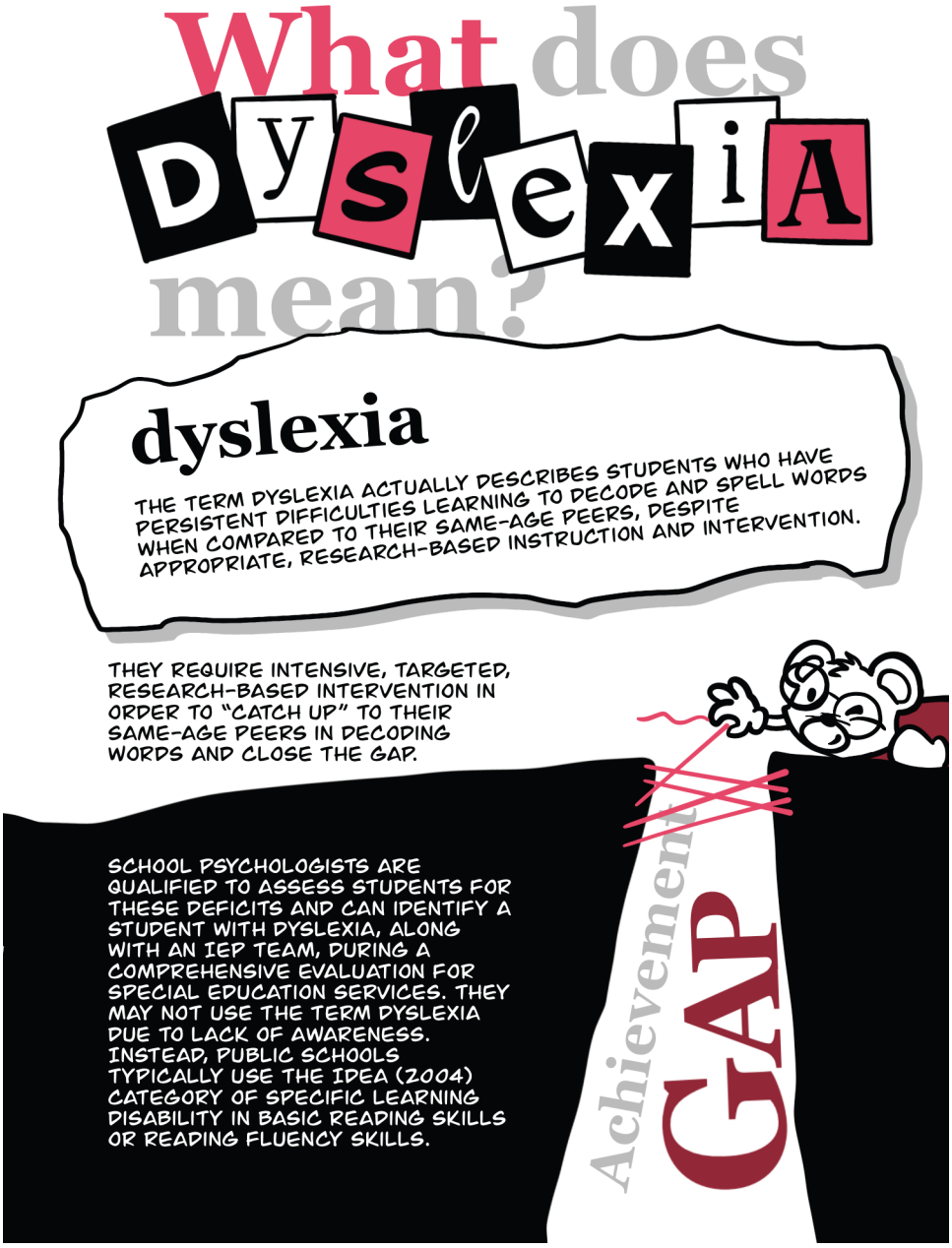
AFTER A SCHOOL-BASED TEAM CONCLUDES A STUDENT'S RESPONSE TO RESEARCH-BASED INTERVENTION IS INADEQUATE IN COMPARISON TO SAME-AGE PEERS, FURTHER ASSESSMENTS IN AREAS RELATED TO THE PHONOLOGICAL CORE SKILLS (LIKE LETTER-SOUND IDENTIFICATION, PHONICS, AND PHONEMIC AWARENESS) ARE REQUIRED TO SHOW THE STUDENT IS SIGNIFICANTLY BELOW AVERAGE.



RAPID AUTOMATIZED NAMING AND PHONOLOGICAL WORKING MEMORY HAVE ALSO BEEN SHOWN TO BE DEFICIT AREAS FOR SOME STUDENTS WITH DYSLEXIA; HOWEVER, RESEARCHERS HAVE NOT FOUND RELIABLE WAYS TO REMEDIATE THESE AREAS DIRECTLY.



INSTEAD, THESE DEFICITS SOMETIMES IMPROVE AS READING IMPROVES. IF THIS STUDENT HAS AREAS OF WEAKNESS IN BOTH PHONEMIC AWARENESS AND RAPID AUTOMATIZED NAMING, THE "DOUBLE-DEFICIT" MAY INDICATE EVEN MORE INTENSIVE INTERVENTION IS NEEDED TO CLOSE THE GAP BETWEEN THE STUDENT'S CURRENT ACHIEVEMENT AND GRADE-LEVEL STANDARDS. THE SCHOOL-BASED TEAM WOULD ALSO NEED TO CONSIDER IF THE STUDENT HAS UNDERLYING DISABILITIES THAT WOULD ACCOUNT FOR THESE DIFFICULTIES WITH WORD READING (LIKE AS AN INTELLECTUAL DISABILITY OR HEARING OR VISUAL IMPAIRMENTS) AND EXCLUDE THEM FROM BEING IDENTIFIED WITH DYSLEXIA.


What does DYSLEXIA mean?
dyslexia
THE TERM DYSLEXIA ACTUALLY DESCRIBES STUDENTS WHO HAVE PERSISTENT DIFFICULTIES LEARNING TO DECODE AND SPELL WORDS WHEN COMPARED TO THEIR SAME-AGE PEERS, DESPITE APPROPRIATE, RESEARCH-BASED INSTRUCTION AND INTERVENTION.
THEY REQUIRE INTENSIVE, TARGETED, RESEARCH-BASED INTERVENTION IN ORDER TO "CATCH UP" TO THEIR SAME-AGE PEERS IN DECODING WORDS AND CLOSE THE GAP.
SCHOOL PSYCHOLOGISTS ARE QUALIFIED TO ASSESS STUDENTS FOR THESE DEFICITS AND CAN IDENTIFY A STUDENT WITH DYSLEXIA, ALONG WITH AN IEP TEAM, DURING A COMPREHENSIVE EVALUATION FOR SPECIAL EDUCATION SERVICES. THEY MAY NOT USE THE TERM DYSLEXIA DUE TO LACK OF AWARENESS. INSTEAD, PUBLIC SCHOOLS TYPICALLY USE THE IDEA (2004) CATEGORY OF SPECIFIC LEARNING DISABILITY IN BASIC READING SKILLS OR READING FLUENCY SKILLS.
Achievement GAP


ACCORDING TO PAST STUDIES, IF APPROPRIATE INSTRUCTION AND INTERVENTION IS PROVIDED IN KINDERGARTEN AND FIRST GRADE,
95%
OF STUDENTS CAN BE TAUGHT TO READ
proficiently
DEPENDING ON WHERE THE CUT-POINTS ARE PLACED IN SPECIFIC STATES OR WITHIN SPECIFIC DISTRICTS TO QUALIFY FOR A SPECIFIC LEARNING DISABILITY IN SPECIAL EDUCATION, THE LABEL DYSLEXIA WOULD DESCRIBE BETWEEN
3-16%
OF THE POPULATION.

SOME PEOPLE THINK YOU CAN HELP A PERSON WITH DYSLEXIA BY...

Colored lenses

Eye-tracking Exercises

Motor-skills Training

THE LARGE BODY OF READING RESEARCH DOES NOT SUPPORT THESE PRACTICES.

INSTEAD, BECAUSE THE CORE DEFICIT OF DYSLEXIA LIES IN THE AREA OF LANGUAGE AND, SPECIFICALLY, HOW THE INDIVIDUAL SOUNDS OF LANGUAGE CONNECT TO LETTERS AND ARE PROCESSED IN THE BRAIN, RESEARCHERS KNOW THAT EFFECTIVE INSTRUCTION INCLUDES

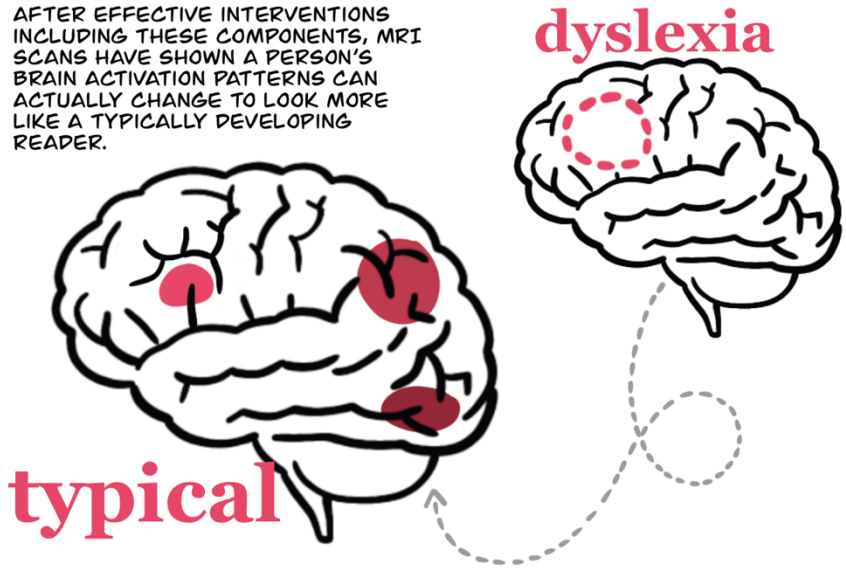
EXPLICIT & Systematic Instruction

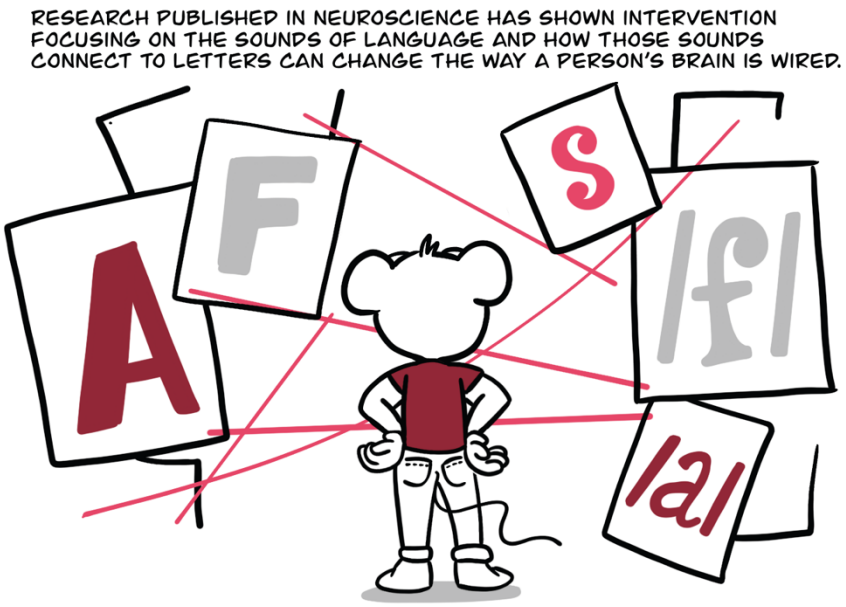
IN **Phonemic Awareness**

(PRACTICE MANIPULATING THE INDIVIDUAL SOUNDS IN OUR LANGUAGE)

& Phonics

(PRACTICE CONNECTING THOSE INDIVIDUAL SOUNDS, OR PHONEMES, TO LETTERS)


AFTER EFFECTIVE INTERVENTIONS INCLUDING THESE COMPONENTS, MRI SCANS HAVE SHOWN A PERSON'S BRAIN ACTIVATION PATTERNS CAN ACTUALLY CHANGE TO LOOK MORE LIKE A TYPICALLY DEVELOPING READER.
dyslexia
typical


RESEARCH PUBLISHED IN NEUROSCIENCE HAS SHOWN INTERVENTION FOCUSING ON THE SOUNDS OF LANGUAGE AND HOW THOSE SOUNDS CONNECT TO LETTERS CAN CHANGE THE WAY A PERSON'S BRAIN IS WIRED.
A
F
S
/f/
/a/

SOME PEOPLE THINK YOU SHOULD USE

flashcard

TO TEACH STUDENTS WITH DYSLEXIA TO MEMORIZE WHOLE WORDS AS

"sight words"

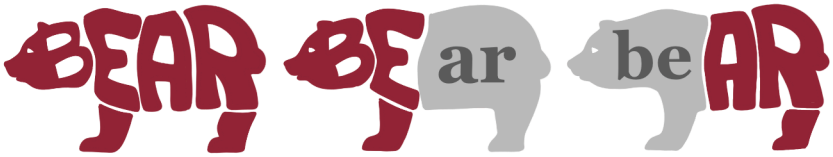
RESEARCH SUGGESTS THAT INSTRUCTION FOCUSING ON HOW SOUNDS ARE REPRESENTED BY LETTERS OR GROUPS OF LETTERS, LIKE

bat

chip

right

FOR EXAMPLE, IF YOU CAN READ THE WORD "BEAR," YOU CAN ALSO READ



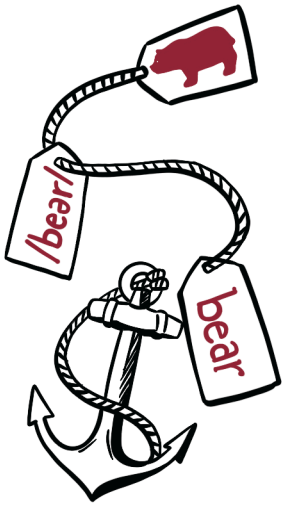
EVEN THOUGH YOU MAY HAVE NEVER SEEN THE WORD IN THAT CONFIGURATION BEFORE. THE SHAPE OF THE WHOLE WORD DOES NOT HELP OR HINDER THE READER; IT IS HOW THE LETTERS CONNECT TO THE INDIVIDUAL SOUNDS BY WHICH READERS LEARN WORDS AUTOMATICALLY.

WE DO NOT LEARN WORDS VISUALLY, BASED ON THE SHAPE OF THE WHOLE WORD, BUT ORTHOGRAPHICALLY AND PHONOLOGICALLY, BASED ON HOW THE LETTERS MAP TO THE INDIVIDUAL SPEECH SOUNDS.

READING RESEARCHERS USE THE TERM

orthographic mapping

TO EXPLAIN HOW AN UNFAMILIAR WORD BECOMES A FAMILIAR SIGHT WORD (A WORD THAT IS RECOGNIZED WITHIN A FOURTH OF A SECOND).



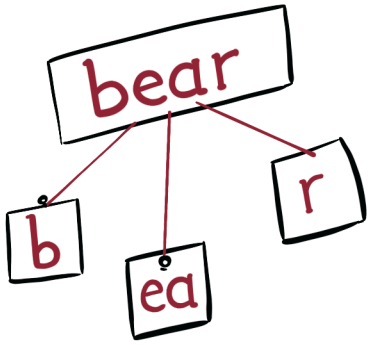
IN ORDER TO MAP ANY WORD, OR LEARN IT AS A SIGHT WORD, YOUR BRAIN MUST ANCHOR LETTERS TO SOUNDS WITHIN THE WORD FORM AREA OF THE BRAIN, OR FUSIFORM GYRUS.

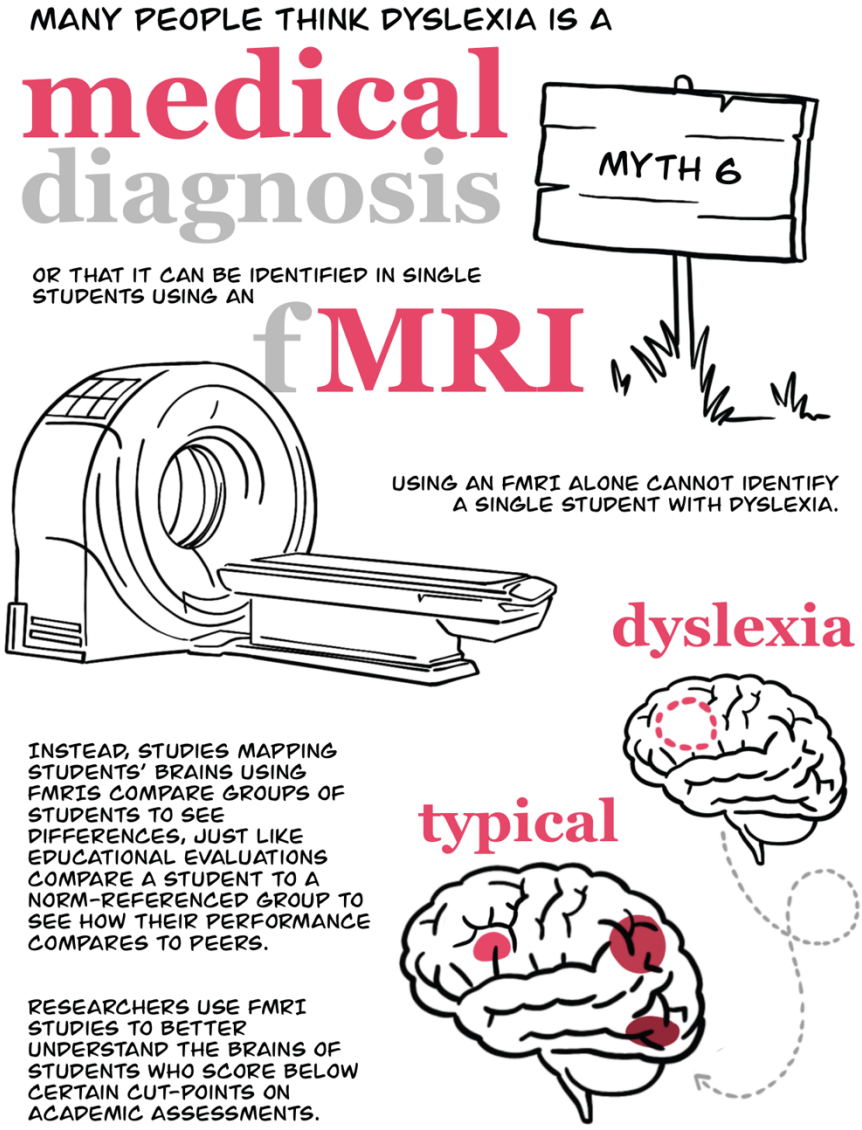
ONCE THESE CONNECTIONS ARE MADE IN THE WORD FORM AREA, THE NEW WORD IS RECOGNIZED WITHIN A FOURTH OF A SECOND AS A FAMILIAR WORD AND YOUR BRAIN INSTANTLY ACCESSES THE SOUNDS THAT ARE ANCHORED TO THAT SPECIFIC LETTER SEQUENCE AND THEN THE MEANING.

IF IT IS NOT RECOGNIZED AUTOMATICALLY, THE WORD MAY BE SOUNDED OUT THEN SYNTHESIZED TOGETHER, BEFORE MEANING IS REACHED. THESE PROCESSES ALL HAPPEN VERY QUICKLY, YET SEQUENTIALLY, IN THE BRAIN.

REMEMBER, TO HELP A STUDENT WITH DYSLEXIA MAP THESE CONNECTIONS MORE EFFICIENTLY AND LEARN TO BE ACCURATE AND FLUENT READERS, TEACHERS CAN CALL ATTENTION TO HOW THE INDIVIDUAL LETTERS IN WORDS CONNECT TO THE SOUNDS WE SAY, NOT HOW THE WHOLE WORD LOOKS VISUALLY.

TEACHERS MAY ALSO USE A METHOD CALLED PHONEME-GRAPHEME MAPPING TO HELP STUDENTS LEARN TO SPELL BASED ON THE SOUNDS IN THE WORD AND COMMON SPELLING PATTERNS THAT ARE EXPLICITLY TAUGHT.




MANY PEOPLE THINK DYSLEXIA IS A
medical
diagnosis
MYTH 6
OR THAT IT CAN BE IDENTIFIED IN SINGLE STUDENTS USING AN
fMRI
USING AN FMRI ALONE CANNOT IDENTIFY A SINGLE STUDENT WITH DYSLEXIA.
dyslexia
typical
INSTEAD, STUDIES MAPPING STUDENTS' BRAINS USING FMRIS COMPARE GROUPS OF STUDENTS TO SEE DIFFERENCES, JUST LIKE EDUCATIONAL EVALUATIONS COMPARE A STUDENT TO A NORM-REFERENCED GROUP TO SEE HOW THEIR PERFORMANCE COMPARES TO PEERS.
RESEARCHERS USE FMRI STUDIES TO BETTER UNDERSTAND THE BRAINS OF STUDENTS WHO SCORE BELOW CERTAIN CUT-POINTS ON ACADEMIC ASSESSMENTS.

SOME PEOPLE THINK THAT SCHOOLS **cannot identify** STUDENTS WITH **dyslexia** OR EVEN SAY THE WORD TO A PARENT.

THIS IS ABSOLUTELY ***UNTRUE!***

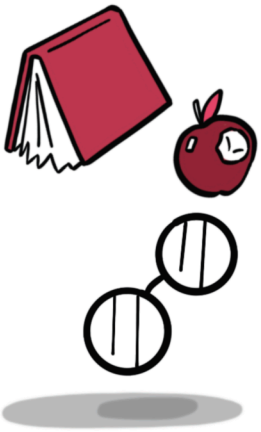
DYSLEXIA IS LISTED BY NAME UNDER THE ***INDIVIDUALS WITH DISABILITIES EDUCATION IMPROVEMENT ACT*** AS A TYPE OF SPECIFIC LEARNING DISABILITY THAT SCHOOLS SHOULD USE TO IDENTIFY STUDENTS TO RECEIVE SPECIAL EDUCATION SERVICES.

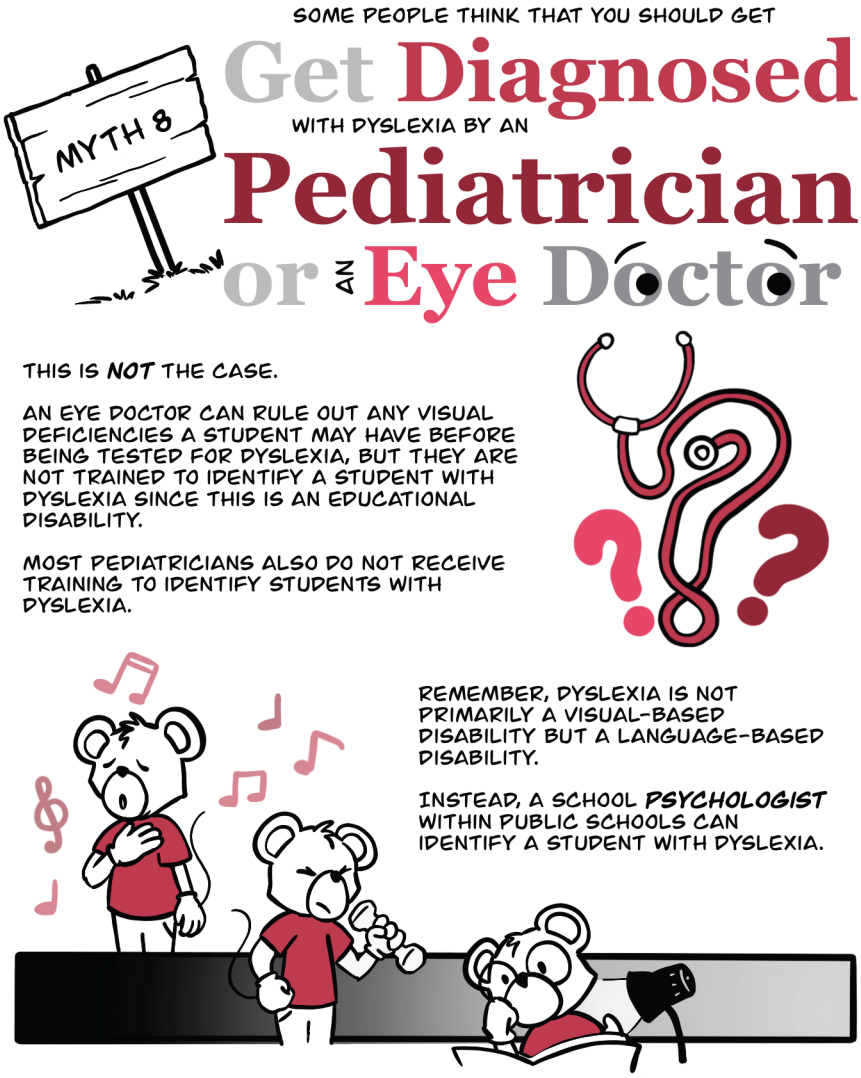
THE WORD DYSLEXIA IS A RESEARCHER-CREATED EDUCATIONAL IDENTIFICATION, NOT A MEDICAL ONE. IT SIGNIFIES THE IDENTIFIED STUDENT HAS AN INCREASED DIFFICULTY IN THEIR ABILITY TO DECODE AND SPELL WORDS.

THERE ARE EIGHT SUBCATEGORIES LISTED UNDER THE CATEGORY OF SPECIFIC LEARNING DISABILITY (SLD) IN IDEIA.

TWO OF THESE CATEGORIES, SLD IN BASIC READING SKILLS AND SLD IN READING FLUENCY SKILLS, ARE SYNONYMOUS WITH THE LABEL DYSLEXIA.

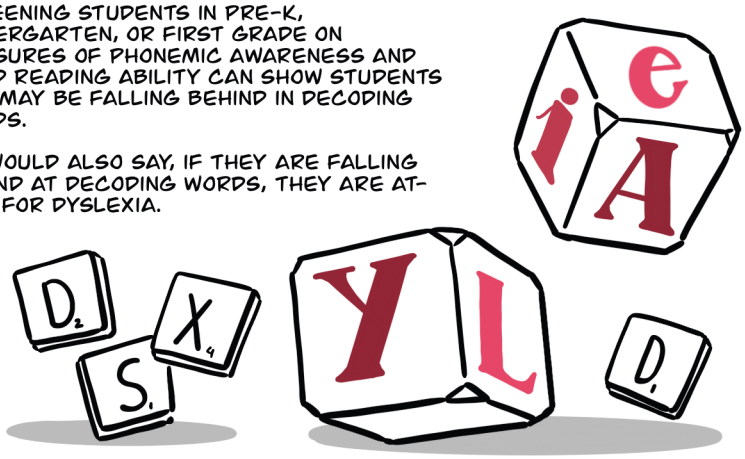
WHETHER THE WORD DYSLEXIA IS WRITTEN ON THE IEP OR NOT, WHEN A SCHOOL IDENTIFIES A STUDENT WITH AN SLD IN BASIC READING SKILLS OR AN SLD IN READING FLUENCY SKILLS, THE SCHOOL IS IDENTIFYING THE CHILD WITH THE RESEARCHER-CREATED TERM, DYSLEXIA. IT IS LIKE USING THE TERM H2O INSTEAD OF WATER.




SOME PEOPLE THINK THAT YOU SHOULD GET
MYTH 8
Get Diagnosed
WITH DYSLEXIA BY AN
Pediatrician
or AN Eye Doctor
THIS IS NOT THE CASE.
AN EYE DOCTOR CAN RULE OUT ANY VISUAL DEFICIENCIES A STUDENT MAY HAVE BEFORE BEING TESTED FOR DYSLEXIA, BUT THEY ARE NOT TRAINED TO IDENTIFY A STUDENT WITH DYSLEXIA SINCE THIS IS AN EDUCATIONAL DISABILITY.
MOST PEDIATRICIANS ALSO DO NOT RECEIVE TRAINING TO IDENTIFY STUDENTS WITH DYSLEXIA.
REMEMBER, DYSLEXIA IS NOT PRIMARILY A VISUAL-BASED DISABILITY BUT A LANGUAGE-BASED DISABILITY.
INSTEAD, A SCHOOL PSYCHOLOGIST WITHIN PUBLIC SCHOOLS CAN IDENTIFY A STUDENT WITH DYSLEXIA.
AS WITH OTHER ABILITIES, SUCH AS SINGING, ATHLETICISM, OR DRAWING, RESEARCHERS HAVE SHOWN THE ABILITY TO READ EXISTS ON A CONTINUUM WHERE MOST PEOPLE FALL WITHIN THE AVERAGE RANGE.

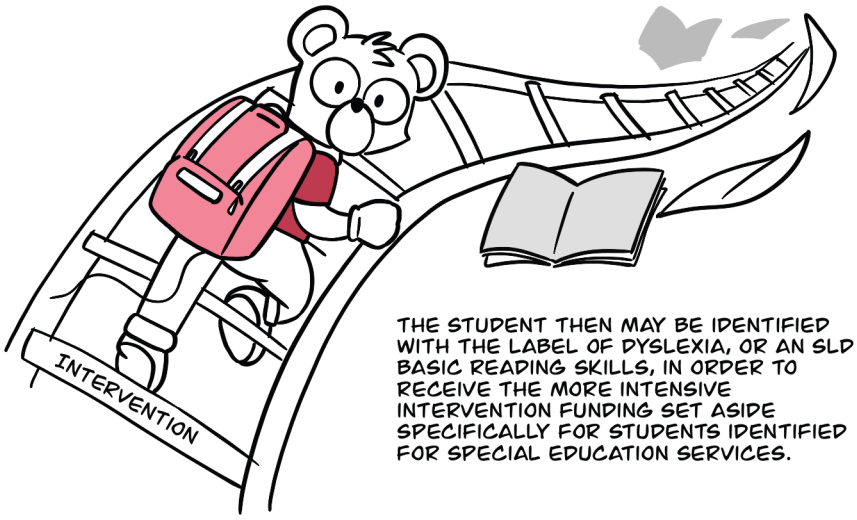
SCREENING STUDENTS IN PRE-K, KINDERGARTEN, OR FIRST GRADE ON MEASURES OF PHONEMIC AWARENESS AND WORD READING ABILITY CAN SHOW STUDENTS WHO MAY BE FALLING BEHIND IN DECODING WORDS.

WE WOULD ALSO SAY, IF THEY ARE FALLING BEHIND AT DECODING WORDS, THEY ARE AT-RISK FOR DYSLEXIA.



THEN, THOSE STUDENTS SHOULD RECEIVE EARLY INTERVENTION TO HELP PREVENT DYSLEXIA OR BEGIN TO CLOSE THE GAP.

IF A STUDENT IS NOT RESPONDING TO A GENERALLY EFFECTIVE INTERVENTION TARGETED TO THE STUDENT'S AREAS OF WEAKNESS, THAT STUDENT MAY NEED TO MORE INTENSIVE, SPECIALIZED INTERVENTION PROVIDED THROUGH SPECIAL EDUCATION SERVICES.



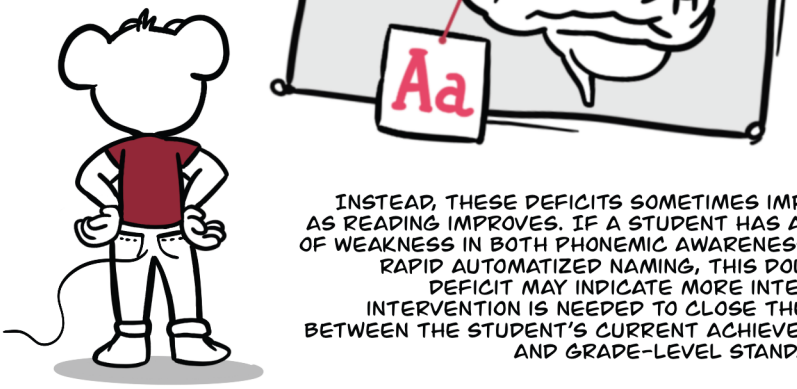
THE STUDENT THEN MAY BE IDENTIFIED WITH THE LABEL OF DYSLEXIA, OR AN SLD IN BASIC READING SKILLS, IN ORDER TO RECEIVE THE MORE INTENSIVE INTERVENTION FUNDING SET ASIDE SPECIFICALLY FOR STUDENTS IDENTIFIED FOR SPECIAL EDUCATION SERVICES.

Remember...

DYSLEXIA CAN BE RECOGNIZED BY ASSESSING A STUDENT IN A VARIETY OF DIFFERENT AREAS RELATED TO THE PHONOLOGICAL CORE SKILLS, LIKE LETTER-SOUND IDENTIFICATION, PHONICS, AND PHONEMIC AWARENESS.

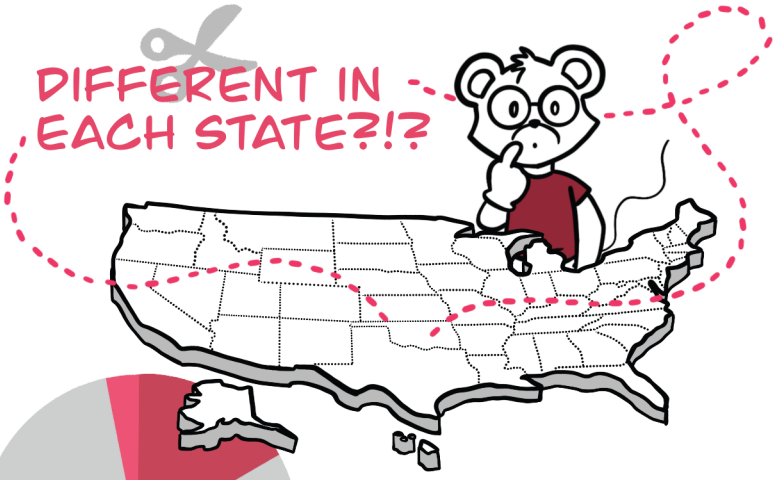
RAPID AUTOMATIZED NAMING AND ***PHONOLOGICAL WORKING MEMORY*** HAVE ALSO BEEN SHOWN TO BE DEFICIT AREAS FOR SOME STUDENTS; HOWEVER, RESEARCHERS HAVE NOT FOUND RELIABLE WAYS TO REMEDIATE THESE AREAS DIRECTLY.

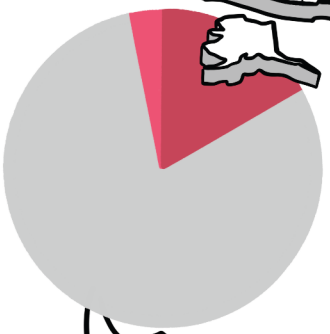
rapid automatized naming & **phonemic awareness**



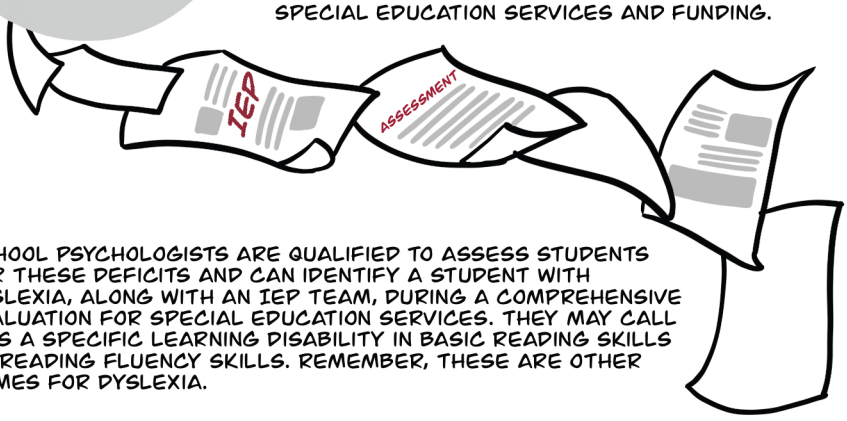
INSTEAD, THESE DEFICITS SOMETIMES IMPROVE AS READING IMPROVES. IF A STUDENT HAS AREAS OF WEAKNESS IN BOTH PHONEMIC AWARENESS AND RAPID AUTOMATIZED NAMING, THIS DOUBLE-DEFICIT MAY INDICATE MORE INTENSIVE INTERVENTION IS NEEDED TO CLOSE THE GAP BETWEEN THE STUDENT'S CURRENT ACHIEVEMENT AND GRADE-LEVEL STANDARDS.

IF THE STUDENT FALLS ON THE LOWER END OF THE CONTINUUM IN THESE AREAS, BUT DOES NOT HAVE OTHER DISABILITIES, SUCH AS INTELLECTUAL DISABILITY OR HEARING OR VISION IMPAIRMENTS, MAKING THIS DIFFICULTY WITH READING AND LANGUAGE UNEXPECTED, THE STUDENT MAY BE ***DIAGNOSED WITH DYSLEXIA.***





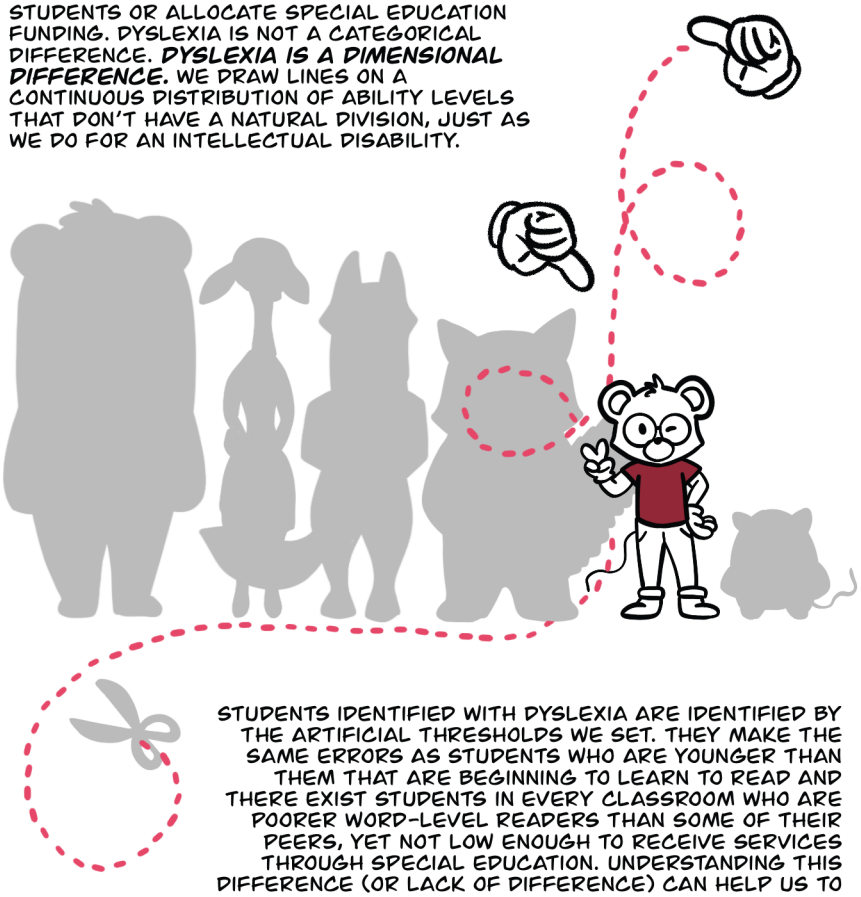
THE EXACT CUT POINT FOR IDENTIFICATION IS NOT CURRENTLY AGREED UPON EVEN AMONG RESEARCHERS, BUT DYSLEXIA DESCRIBES SOMEWHERE BETWEEN **3%** AND **16%** OF THE GENERAL POPULATION. THE CUT POINT IS NORMALLY CHOSEN BY INDIVIDUAL STATE GOVERNMENTS IN ORDER TO ALLOCATE SPECIAL EDUCATION SERVICES AND FUNDING.



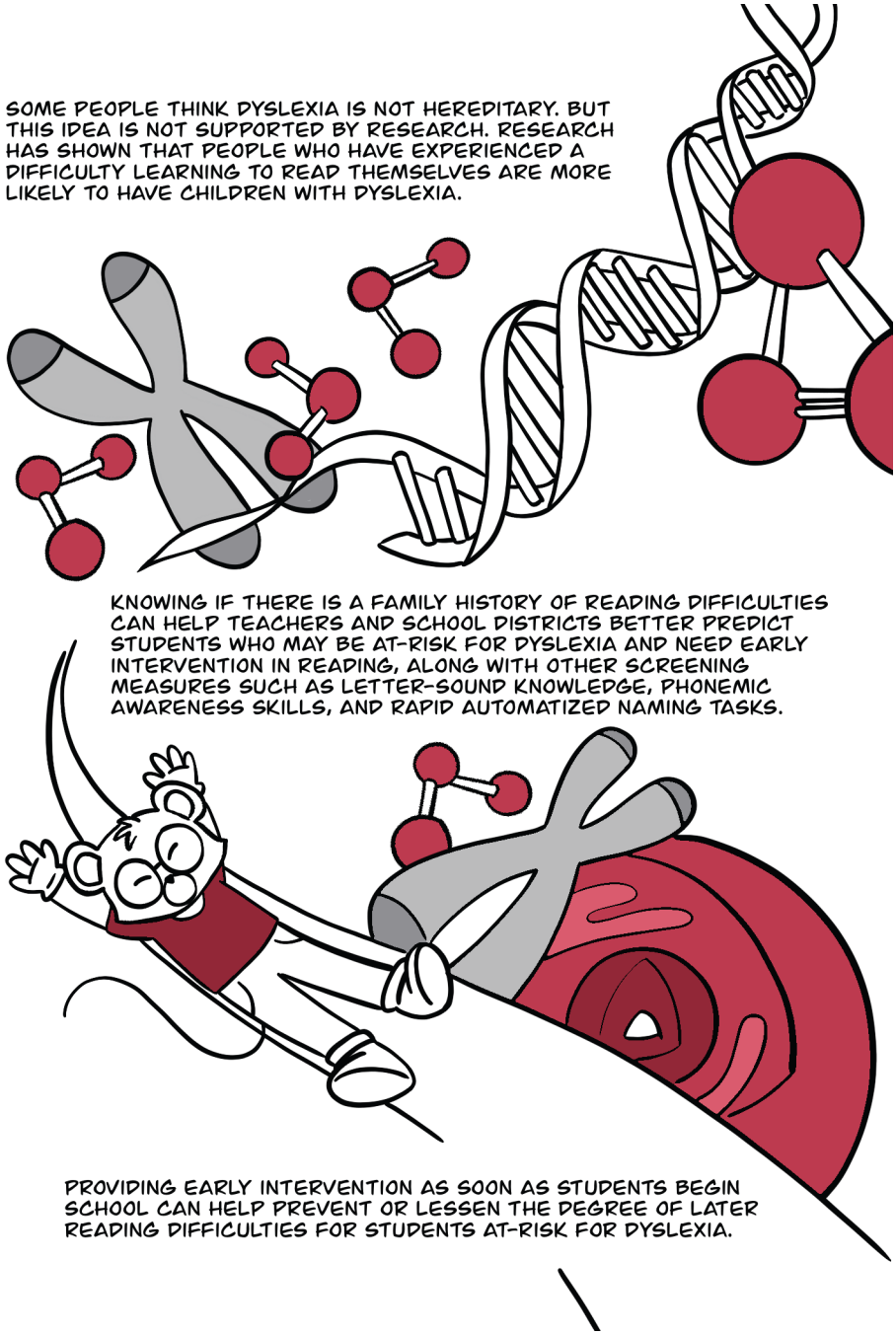
SCHOOL PSYCHOLOGISTS ARE QUALIFIED TO ASSESS STUDENTS FOR THESE DEFICITS AND CAN IDENTIFY A STUDENT WITH DYSLEXIA, ALONG WITH AN IEP TEAM, DURING A COMPREHENSIVE EVALUATION FOR SPECIAL EDUCATION SERVICES. THEY MAY CALL THIS A SPECIFIC LEARNING DISABILITY IN BASIC READING SKILLS OR READING FLUENCY SKILLS. REMEMBER, THESE ARE OTHER NAMES FOR DYSLEXIA.

Remember...

THESE CUT POINTS ARE MAN-MADE AND ARTIFICIAL, EXISTING ONLY TO STUDY SPECIFIC STUDENTS OR ALLOCATE SPECIAL EDUCATION FUNDING. DYSLEXIA IS NOT A CATEGORICAL DIFFERENCE. ***DYSLEXIA IS A DIMENSIONAL DIFFERENCE.*** WE DRAW LINES ON A CONTINUOUS DISTRIBUTION OF ABILITY LEVELS THAT DON'T HAVE A NATURAL DIVISION, JUST AS WE DO FOR AN INTELLECTUAL DISABILITY.

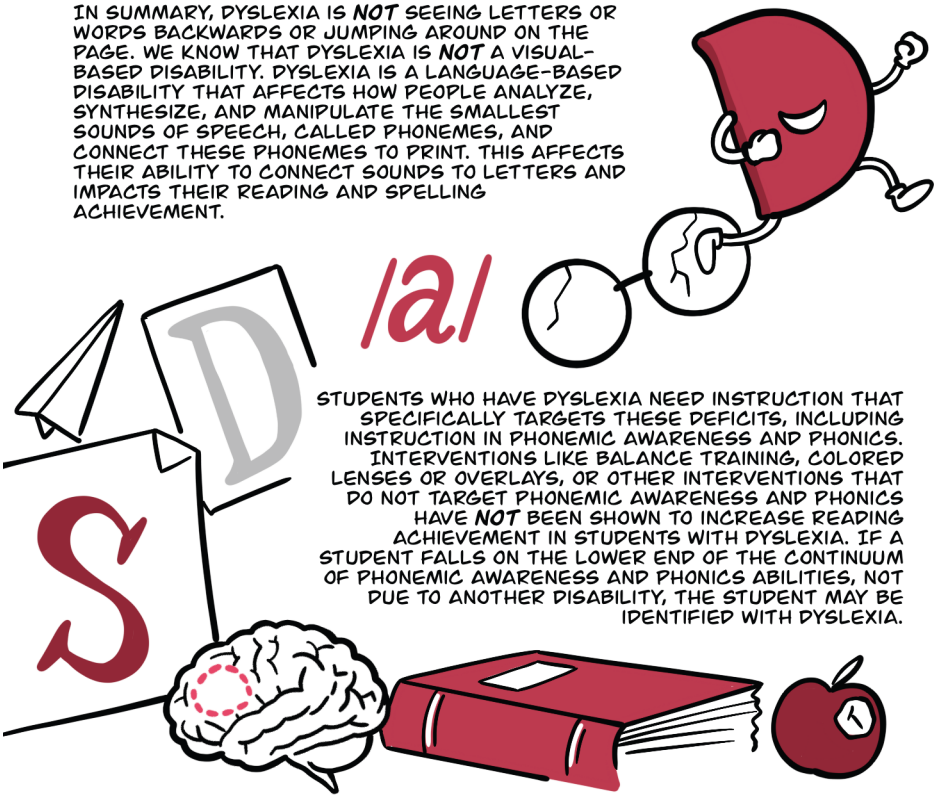


STUDENTS IDENTIFIED WITH DYSLEXIA ARE IDENTIFIED BY THE ARTIFICIAL THRESHOLDS WE SET. THEY MAKE THE SAME ERRORS AS STUDENTS WHO ARE YOUNGER THAN THEM THAT ARE BEGINNING TO LEARN TO READ AND THERE EXIST STUDENTS IN EVERY CLASSROOM WHO ARE POORER WORD-LEVEL READERS THAN SOME OF THEIR PEERS, YET NOT LOW ENOUGH TO RECEIVE SERVICES THROUGH SPECIAL EDUCATION. UNDERSTANDING THIS DIFFERENCE (OR LACK OF DIFFERENCE) CAN HELP US TO PROVIDE BETTER INSTRUCTION AND INTERVENTION FOR ALL STUDENTS WHO ARE LEARNING TO READ.


SOME PEOPLE THINK DYSLEXIA IS NOT HEREDITARY. BUT THIS IDEA IS NOT SUPPORTED BY RESEARCH. RESEARCH HAS SHOWN THAT PEOPLE WHO HAVE EXPERIENCED A DIFFICULTY LEARNING TO READ THEMSELVES ARE MORE LIKELY TO HAVE CHILDREN WITH DYSLEXIA.
KNOWING IF THERE IS A FAMILY HISTORY OF READING DIFFICULTIES CAN HELP TEACHERS AND SCHOOL DISTRICTS BETTER PREDICT STUDENTS WHO MAY BE AT-RISK FOR DYSLEXIA AND NEED EARLY INTERVENTION IN READING, ALONG WITH OTHER SCREENING MEASURES SUCH AS LETTER-SOUND KNOWLEDGE, PHONEMIC AWARENESS SKILLS, AND RAPID AUTOMATIZED NAMING TASKS.
PROVIDING EARLY INTERVENTION AS SOON AS STUDENTS BEGIN SCHOOL CAN HELP PREVENT OR LESSEN THE DEGREE OF LATER READING DIFFICULTIES FOR STUDENTS AT-RISK FOR DYSLEXIA.

Summary...

IN SUMMARY, DYSLEXIA IS ***NOT*** SEEING LETTERS OR WORDS BACKWARDS OR JUMPING AROUND ON THE PAGE. WE KNOW THAT DYSLEXIA IS ***NOT*** A VISUAL-BASED DISABILITY. DYSLEXIA IS A LANGUAGE-BASED DISABILITY THAT AFFECTS HOW PEOPLE ANALYZE, SYNTHESIZE, AND MANIPULATE THE SMALLEST SOUNDS OF SPEECH, CALLED PHONEMES, AND CONNECT THESE PHONEMES TO PRINT. THIS AFFECTS THEIR ABILITY TO CONNECT SOUNDS TO LETTERS AND IMPACTS THEIR READING AND SPELLING ACHIEVEMENT.



STUDENTS WHO HAVE DYSLEXIA NEED INSTRUCTION THAT SPECIFICALLY TARGETS THESE DEFICITS, INCLUDING INSTRUCTION IN PHONEMIC AWARENESS AND PHONICS. INTERVENTIONS LIKE BALANCE TRAINING, COLORED LENSES OR OVERLAYS, OR OTHER INTERVENTIONS THAT DO NOT TARGET PHONEMIC AWARENESS AND PHONICS HAVE ***NOT*** BEEN SHOWN TO INCREASE READING ACHIEVEMENT IN STUDENTS WITH DYSLEXIA. IF A STUDENT FALLS ON THE LOWER END OF THE CONTINUUM OF PHONEMIC AWARENESS AND PHONICS ABILITIES, NOT DUE TO ANOTHER DISABILITY, THE STUDENT MAY BE IDENTIFIED WITH DYSLEXIA.

INSTRUCTION IN PHONICS AND PHONEMIC AWARENESS CAN ACTUALLY HELP A STUDENT'S BRAIN ACTIVATION PATTERNS CHANGE TO BECOME MORE LIKE THAT OF A TYPICALLY DEVELOPING READER WHEN THEY READ. EARLY INTERVENTION IN KINDERGARTEN AND FIRST GRADE IN PHONEMIC AWARENESS AND PHONICS CAN HELP TO PREVENT OR LESSEN THE EFFECTS OF LATER READING DIFFICULTIES FOR STUDENTS AT-RISK OF DYSLEXIA.

NOW THAT YOU KNOW WHAT DYSLEXIA IS AND HOW THESE STUDENTS CAN BE TAUGHT TO READ, GO SPREAD THE WORD!

Appendix B. Refutation Text

ID: 2

Dyslexi……uh?

What do you think of when you hear the term, "dyslexia"? Although most people have heard the term, research shows that over 80% of people, including teachers, hold misconceptions about dyslexia. Understanding what dyslexia is can better enable us to help these students learn how to read.

Many people think dyslexia is a visual or perceptual difficulty. They may think that the letters or words a person with dyslexia sees jump around or move on the page as they are trying to read. They might think that students with dyslexia see letters and words backwards. But that is not what has been shown by research. In actuality, dyslexia is primarily a language-based reading disability, not a visual-based disability. People with dyslexia have difficulties with processing and manipulating the smallest sounds of language, called phonemes. Research shows that, in students with dyslexia, the part of the brain that processes those sounds and connects those sounds to letters is under-activated as compared with typically developing readers. People with dyslexia also perform more poorly on tasks that require analyzing, synthesizing, and manipulating phonemes.

For example, if I asked you to blend the individual sounds, or phonemes, "/s/… /p/… /l/… /a/… /sh/… /t/" and say the word as a whole, most people would respond, "splashed." For a person with dyslexia, blending phonemes to say a whole word or breaking apart a word into individual phonemes is more difficult than a typically developing reader. In order to read a word, you first must identify the sounds and then blend those sounds together to say the word as a whole. Similarly, to spell a word, you first need to distinguish the individual sounds in the word before writing down the letters for those sounds.

Some people think you can help a person with dyslexia by giving them colored overlays or colored lenses, or even provide the person with dyslexia eye tracking exercises (as to correct some vision deficiency). Other people may think dyslexia can be remedied with balance training or by working on a student's gross motor skills (like crawling or throwing a ball). The large body of reading research does not support these practices. Instead, because the core deficit of dyslexia lies in the area of language and, specifically, how the individual sounds of language are processed in the brain, researchers know that effective instruction includes explicit and systematic instruction in phonemic awareness (practice manipulating the individual sounds in our language) and phonics (practice connecting those individual sounds, or phonemes, to letters). After effective interventions including these components, MRI scans have shown a person's brain activation patterns can actually change! Research published in neuroscience has shown intervention focusing on the sounds of language and how those sounds connect to letters can change the way a person's brain is wired.

Many people think you should use flashcards to teach students with dyslexia to memorize whole words as "sight words," but learning words based on their visual properties is not the most effective way or consistent with research on how we learn new words. Research in

neuroscience and reading shows that instruction focusing on how letters connect to individual sounds is actually how our brains learn to recall words. For example, if a student can instantly read the word "bear," he can read "BEAR" or bEaR." The shape of the whole word does not help or hinder the reader; it is how the letters connect to the individual sounds by which readers learn words automatically. Reading researchers use the term "orthographic mapping" to explain how an unfamiliar word becomes a familiar, sight word (a word that is recognized within a fourth of a second). In order to map a word, or learn it as a sight word, your brain must anchor letters to sounds within in the visual word form area. Once these connections are made in the visual word form area, the word is recognized within a fourth of a second as a familiar word and your brain instantly accesses the sound of the word that is anchored to that specific letter sequence. Remember, to help a student with dyslexia map these connections more efficiently and learn to be accurate and fluent readers, teachers can call attention to how the individual letters in words connect to the sounds we say, not how the whole word looks visually.

Some people think that schools cannot identify students with dyslexia or even say the word, "dyslexia" to a parent. This is absolutely untrue! Dyslexia is listed by name under the Individuals with Disabilities Education Improvement Act (IDEIA; 2004) as a type of specific learning disability. IDEIA (2004) is the law that mandates all students with disabilities have access to a free and appropriate public education. The federal government even wrote a letter to school leaders in October 2015 clarifying this point and reminding them that there is nothing prohibiting them from using the term "dyslexia" in IDEIA evaluations, eligibility determinations, or IEP documents. Students with dyslexia can qualify for special education services as a specific learning disability.

Some people think dyslexia is easy to identify or there is one specific test for it. Some people may even think that you should get diagnosed with dyslexia by an eye doctor! This is not the case. An eye doctor can rule out any visual deficiencies a student may have before being tested for dyslexia, but they are not qualified to diagnose someone with dyslexia. Remember, dyslexia is not primarily a visual-based disability but a language-based disability. As with other abilities, such as singing, athleticism, or drawing, researchers have shown the ability to read exists on a continuum where most people fall within the average range. Dyslexia can be recognized by assessing a student in a variety of different areas related to phonics and phonemic awareness. If the student falls on the low end of the continuum in these areas, but has patterns of strengths in other areas that make this difficulty with reading and language unexpected, the student may be diagnosed with dyslexia. The exact cut point is not currently agreed upon even among researchers, but it is somewhere between 3% and 10% of the general population. School psychologists are qualified to assess students for these deficits and can identify a student with dyslexia.

Many people think dyslexia is not hereditary. But this idea is not supported by research. Research has shown that people with dyslexia are more likely to have children with dyslexia. A child with one parent with dyslexia is about 40% to 60% likely to have dyslexia themselves.

In summary, dyslexia is not seeing letters or words backwards or jumping around on the page. We know that dyslexia is not a visual-based disability. Dyslexia is a language-based disability that affects how people analyze, synthesize, and manipulate the smallest sounds of language, called phonemes. This affects their ability to connect sounds to letters and impacts their reading and spelling ability. Students who have dyslexia need instruction that targets these deficits, including instruction in phonemic awareness and phonics. Interventions like balance training, colored lenses or overlays, or other interventions that do not target phonemic awareness and phonics have not shown to increase reading achievement in students with dyslexia. If a student falls on the low end of the continuum of phonemic awareness and phonics abilities, unexpected in relation to their other academic and cognitive abilities, the student may be diagnosed with dyslexia. Instruction in phonics and phonemic awareness can actually help a student's brain activation patterns change to become more like a typically developing reader when they read. Now that you know what dyslexia is and how these students can be taught to read, go spread the word!

Appendix C. International Dyslexia Association Text

ID: 1

What is dyslexia?

Dyslexia is a language-based learning disability. Dyslexia refers to a cluster of symptoms, which result in people having difficulties with specific language skills, particularly reading. Students with dyslexia usually experience difficulties with other language skills such as spelling, writing, and pronouncing words. Dyslexia affects individuals throughout their lives; however, its impact can change at different stages in a person'slife. It is referred to as a learning disability because dyslexia can make it very difficult for a student to succeed academically in the typical instructional environment, and in its more severe forms, will qualify a student for special education, special accommodations, or extra support services.

What causes dyslexia?

The exact causes of dyslexia are still not completely clear, but anatomical and brain imagery studies show differences in the way the brain of a person with dyslexia develops and functions. Moreover, most people with dyslexia have been found to have problems with identifying the separate speech sounds within a word and/or learning how letters represent those sounds, a key factor in their reading difficulties. Dyslexia is not due to either lack of intelligence or desire to learn; with appropriate teaching methods, students with dyslexia can learn successfully.

How widespread is dyslexia?

About 13–14% of the school population nationwide has a handicapping condition that qualifies them for special education. Current studies indicate that one half of all the students who qualify for special education are classified as having a learning disability (LD) (6–7%). About 85% of those students have a primary learning disability in reading and language processing. Nevertheless, many more people— perhaps as many as 15–20% of the population as a whole—have some of the symptoms of dyslexia, including slow orinaccurate reading, poor spelling, poor writing, or mixing up similar words. Not all of these will qualify for special education, but they are likely to struggle with many aspects of academic learning and are likely to benefit from systematic, explicit, instruction in reading, writing, and language.

Dyslexia occurs in people of all backgrounds and intellectual levels. People with dyslexia can be verybright. They are often capable or even gifted in areas such as art, computer science, design, drama, electronics, math, mechanics, music, physics, sales, and sports.

In addition, dyslexia runs in families; parents with dyslexia are very likely to have children with dyslexia. For some people, their dyslexia is identified early in their lives, but for others, their dyslexia goes unidentified until they get older.

What are the effects of dyslexia?

The impact that dyslexia has is different for each person and depends on the severity of the condition andthe effectiveness of instruction or remediation. The core difficulty is with word recognition and reading fluency, spelling, and writing. Some individuals with dyslexia manage to learn early reading and spelling tasks, especially with excellent instruction, but later experience their most debilitating problems when more complex language skills are required, such as grammar, understanding textbook material, and writing essays.

People with dyslexia can also have problems with spoken language, even after they have been exposed togood language models in their homes and good language instruction in school. They may find it difficult to express themselves clearly, or to fully comprehend what others mean when they speak. Such language problems are often difficult to recognize, but they can lead to major problems in school, in the workplace,and in relating to other people. The effects of dyslexia reach well beyond the classroom.

ID:__1___

How is dyslexia diagnosed?

Before referring a student for a comprehensive evaluation, a school or district may choose to track a student's progress with a brief screening test and identify whether the student is progressing at a "benchmark" level that predicts success in reading. If a student is below that benchmark (which is equivalent to about the 40th percentile nationally), the school may immediately deliver intensive and individualized supplemental reading instruction before determining whether the student needs a comprehensive evaluation that would lead to a designation of special education eligibility. Some students simply need more structured and systematic instruction to get back on track; they do not have learning disabilities. For those students and even for those with dyslexia, putting the emphasis on preventive or early intervention makes sense. There is no benefit to the child if special instruction is delayed for monthswhile waiting for an involved testing process to occur. These practices of teaching first, and then determining who needs diagnostic testing based on response to instruction, are encouraged by federal policies known as Response to Intervention (RTI). Parents should know, however, that at any point they have the right to request a comprehensive evaluation under the IDEA law, whether or not the student is receiving instruction under an RTI model.

A comprehensive evaluation typically includes intellectual and academic achievement testing, as well as an assessment of the critical underlying language skills that are closely linked to dyslexia. These include receptive (listening) and expressive language skills, phonological skills including phonemic awareness, and also a student's ability to rapidly name letters and numbers. A student's ability to read lists of words in isolation, as well as words in context, should also be assessed. If a profile emerges that is characteristic of readers with dyslexia, an individualized intervention plan should be developed, which should include appropriate accommodations, such as extended time. The testing can be conducted by trained school or outside specialists.

What are the signs of dyslexia?

The problems displayed by individuals with dyslexia involve difficulties in acquiring and using written language. It is a myth that individuals with dyslexia "read backwards," although spelling can look quitejumbled at times because students have trouble remembering letter symbols for sounds and forming memories for words. Other problems experienced by people with dyslexia include the following:

- Learning to speak
- Learning letters and their sounds
- Organizing written and spoken language
- Memorizing number facts
- Reading quickly enough to comprehend
- Persisting with and comprehending longer reading assignments
- Spelling
- Learning a foreign language
- Correctly doing math operations

Not all students who have difficulties with these skills have dyslexia. Formal testing of reading, language,and writing skills is the only way to confirm a diagnosis of suspected dyslexia.

How is dyslexia treated?

Dyslexia is a lifelong condition. With proper help, many people with dyslexia can learn to read and write well. Early identification and treatment is the key to helping individuals with dyslexia achieve in school andin

ID:__1___

life. Most people with dyslexia need help from a teacher, tutor, or therapist specially trained in using a multisensory, structured language approach. It is important for these individuals to be taught by a systematic and explicit method that involves several senses (hearing, seeing, touching) at the same time. Many individuals with dyslexia need one-on-one help so that they can move forward at their own pace. In addition, students with dyslexia often need a great deal of structured practice and immediate, corrective feedback to develop automatic word recognition skills. For students with dyslexia, it is helpful if their outside academic therapists work closely with classroom teachers.

What are the rights of a person with dyslexia?

The Individuals with Disabilities Education Act 2004 (IDEA), Section 504 of the Rehabilitation Act of 1973,and the Americans with Disabilities Act (ADA) define the rights of students with dyslexia and other specific learning disabilities. These individuals are legally entitled to special services to help them overcome and accommodate their learning problems. Such services include education programs designed to meet the needs of these students. The Acts also protect people with dyslexia against unfair and illegaldiscrimination.