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Elyse R. Picker
Washington University School of Medicine in St. Louis

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EXPLORING THE LINK BETWEEN VISUALIZATION SKILLS AND READING IN DEAF AND HARD OF HEARING CHILDREN

By

Elyse R. Picker

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Mary Shortal, MA, Independent Study Advisor

Abstract: This paper reviews the current literature on visualization and mental imagery as a reading comprehension strategy. The purpose of this literature review is to assess how this strategy may be implemented in the classroom with children who are deaf and hard of hearing to improve reading comprehension ability.

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Abbreviations

D/hh – Deaf and hard of hearing

DCT – Dual Coding Theory

NRP – National Reading Panel

RT – Reciprocal Training

SLI – Specific Language Impairment

TD – Typically developing

V/V – Visualizing/Verbalizing

Epigraph

"The phrase 'mind's eye' captures the complexity of how the brain transforms the words on a page into mental images. The pictures that form in your mind as you read can bring a story to life or help make sense of complex subject matter." (Wilson, 2012).

Introduction

Reading is a two-fold process: the ability to decode print and understand what one is reading. This second part is reading comprehension and without it, one is not actually reading. Over the last several decades, researchers in educational psychology have come to understand the importance of the comprehension component and have questioned whether or not these two skills always develop together. Can one be a good decoder without comprehension or alternately, a good comprehender without the ability to decode? Among students, these skills are typically highly correlated but there are some populations of children who struggle with the skills necessary to either decode or comprehend (Oakhill, Cain and Bryant, 2003). In other words, when most children learn to read, they either develop the skills to both decode and comprehend or they do not. Yet there are students who are adequate decoders who still perform poorly on measures of reading comprehension because they are not making the necessary connections between words as they form sentences, paragraphs and entire texts.

It can be argued that a child who is performing well on measures of reading comprehension is by default an adequate decoder, because without knowing the words it is impossible to comprehend the written message. However, these skills can be isolated if given a listening comprehension task. That is, take the decoding portion away, and these students are able to comprehend when someone is reading to them (Oakhill et al., 2003). Reading comprehension is a critical skill for success in school and beyond, yet many students are reading below grade level. Research has shown that poor reading ability has been associated with poor school performance in general, behavioral problems and poor mental health (Marley and Szabo, 2010). This makes a strong case for the reading comprehension strategies which have been developed for all students but specifically those who are struggling.

In 2000, the National Reading Panel (NRP) published a comprehensive overview of thirty years of research on reading comprehension, in which it states, "A reader reads a text to understand what is read, to construct memory representations of what is understood, and to put this understanding to use." To be a good reader, one must go beyond decoding to form connections between the words they are reading, the author's intent and their own prior knowledge (Gambrell & Jawitz, 1993). The NRP reviewed data from studies investigating 16 reading comprehension strategies, which when taught explicitly, can serve as tools for children to increase their ability to understand what they read. Seven of these strategies were determined to have enough research confirming their effectiveness in helping typical readers. Beyond this, other strategies were determined to have the potential to help struggling readers.

Mental imagery is one such strategy that the NRP believes could be a beneficial alternative for students who have comprehension deficits (NICHHD, 2000). They also concluded that there has been a lack of mental imagery research with younger children (Marley and Szabo, 2010); a time when teaching these skills may have a significant impact on later reading success. This lack of research in young children was summarized by McTigue (2010), who noticed that many of her second grade students weren't automatically forming mental images while reading or listening to a story and she didn't know how to explicitly teach it. Other researchers have supported mental imagery as a comprehension strategy worth teaching students who are failing to make connections when they read, resulting in an inability to recall information, make predictions and answer literal and inferential questions. Creating mental images helps readers become more emotionally involved when reading by using visual, auditory and other sensory input to give words meaning (Zimmerman & Hutchins, 2003).

While good readers may naturally form mental images while reading, teaching it explicitly to those who are struggling may improve their ability to make inferences and remember what they read (Gambrell & Jawitz, 1993), in turn helping students to form connections between texts and possibly have an impact on writing ability as well. Oakhill, et al. (2003) note that, "Skilled comprehenders build better-integrated and informationally richer text representations." From this perspective, teaching mental imagery is one potential pathway to improving the mental representations one creates while reading. Explicitly teaching mental imagery was a recommendation stemming from the National Reading Panel's investigation as an effective way to increase reading comprehension (Wilson, 2012). Dual Coding Theory (DCT) provides significant support behind mental imagery as a reading comprehension strategy, by linking two systems in the brain: the verbal system and the visual system. This theory helps explain the connections between comprehension, retaining information and the role of visual or mental images (Joffe, Cain and Maric, 2007).

Children who are deaf and hard of hearing are one such student population that has historically been found to have below grade level reading (Schirmer & McGough, 2005; Gentry, Chinn & Moulton, 2004/2005) and as such would likely benefit from explicit comprehension strategy instruction. With regards to mental imagery instruction, very little research has been conducted with students who are d/hh, especially those using listening and spoken language to communicate. However, the research that does exist provides evidence that these children would benefit from mental imagery instruction (Schirmer, 1993; Schirmer & McGough, 2005, Gentry et al., 2004/2005), although this research was with children who communicate primarily via American Sign Language.

In addition, mental imagery research and interventions with other groups of below grade level readers suggests that parallels can be drawn between these groups and students who are d/hh. For example, poor readers in general (Gambrell & Bales, 1986, Sadoski & Willson, 2006), reluctant readers (Hibbing & Rankin-Erickson, 2003), and students with specific language impairment (Joffe, et al., 2007) have all demonstrated improvements in reading comprehension following mental imagery training or instruction in forming mental images while reading. In both research studies and anecdotal classroom evidence, researchers and teachers alike have noted that students who struggle with reading comprehension tend to struggle with working memory tasks (Joffe et al., 2007, Oakhill et al., 2003), difficulty accessing general knowledge (Joffe et al., 2007), and use up energy with decoding the words (Hibbing & Rankin-Erickson, 2003, Oakhill et al., 2003). This paper will look at the relationship between mental imagery and reading comprehension, and how explicitly teaching this strategy could benefit students who are d/hh in a listening and spoken language program.

Theoretical Background

For good readers, the ability to create mental images, or visualize, while reading is an automatic process. Successful readers may not realize they are doing it and as such, it can be overlooked as a strategy to explicitly teach poor readers. What's more is that struggling readers may not even know they should be constructing mental images while reading; they are merely decoding the words off the page (Hibbing and Rankin-Erickson, 2003). However, as research over the past few decades has shown, the ability to visualize is a key component to comprehension (NRP, 2000, Johnson-Glenberg, 2000.) Paivio's Dual Coding Theory, originally developed in the 1970s, is a general theory of mind with direct application to literacy (Sadoski & Paivio, 2007). DCT suggests that two coding systems, the verbal and the visual, work together to

form associations in the mind. When a reader decodes the words, he forms referential connections between the words and the mental images they conjure up (Clark & Paivio, 1991). For example, when you read a word you think about what that word means but you also make a connection to a visual representation of that word. If you were to read the word *alligator* you know what an alligator is – an animal that lives in the water, it can be dangerous, etc. Most readers will also automatically picture an alligator in their mind's eye. The specific visual representation will vary among readers, but it still exists. Now elaborate this to reading sentences, paragraphs and full texts and if you are a skilled reader, you will likely form constant visual images in your brain while reading. It is these images that help build comprehension, as you are better able to see the connections between characters, recall information about setting and plot, and make inferences and predictions (Gambrell & Bales 1986, Gambrell & Jawitz, 1993, Wood & Endres, 2004).

DCT forms the backdrop of almost all mental imagery related research since the 1970s, and continues to be discussed today as a critical component of explicit teaching strategies in the classroom. In addition to this theory linking verbal and visual information, researchers have more recently begun to explore functional MRI scans to investigate areas of activation in the brain when reading. Just, Newman, Keller, McEleney & Carpenter (2004) contributed to this body of research by examining differences in brain activation when subjects read high imagery versus low imagery sentences[1]. Findings from this study showed that high imagery sentences resulted in greater activation in certain areas of the brain related to visuospatial processing as well as more connections between different areas of the brain, compared to low imagery

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[1] High imagery sentences required mental imagery, for example, "The letter W rotated 180 degrees and written in lower case, looks like the letter m." Low imagery sentences only required general knowledge, for example, "Although now a sport, marathons started with Greek messengers bringing news."

sentences. Specifically, high imagery sentences showed connections between areas that process information visuospatially and linguistically.

Reading Comprehension in Deaf and Hard of Hearing Children

Research has shown that historically, children and adults who are deaf and hard of hearing achieve lesser degrees of reading ability compared to those with typical hearing. Most research cites the well-known statistic that students with hearing loss enter adulthood reading at a fourth grade level (Connor & Zwolan, 2004, Easterbrooks & Beal-Alvarez, 2012, Marschark et al., 2011, Miller, Kargin & Guldenoglu, 2012). There are many factors which contribute to reading development, including comprehension-monitoring, working memory and ability to activate prior knowledge (Gambrell & Bales, 1986, Oakhill et al., 2003, Miller et al., 2012). With the advent of universal newborn hearing screening, early intervention, digital hearing aids and cochlear implants, the question now is whether the current generation of d/hh children will achieve reading levels on par with their hearing peers or will the fourth grade reading level statistic continue to be the norm (Easterbrooks & Beal-Alvarez, 2012).

Recent research from Geers and Hayes (2010) shows that in at least some populations of d/hh students with cochlear implants, reading ability is beginning to catch up to hearing peers. In their study of high school students followed longitudinally, 37% of participants (commensurate performers) were reading at a ninth-grade level or higher based on reading comprehension assessments[2]. However, 17% of the study group (challenged performers) demonstrated poor reading comprehension suggesting that cochlear implantation alone does not eliminate difficulties in reading ability. While overall reading comprehension scores were positive, study

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[2] Piat Individual Achievement Test-Revised (PIAT-R) and the Test of Reading Comprehension (TORC)

participants struggled in the paragraph comprehension section. This finding suggests that when reading longer sections of text, d/hh students may still have difficulty understanding what they are reading. In addition, almost half of the participants scored in the "capable performers" group, defined as reading at the fourth to eighth grade level. These children were seen as making progress, yet still exhibited delays compared to typically hearing peers. While the ability of this group to make gains in reading is a positive one, it is tempered by the fact that print materials in the United States (e.g., newspapers, magazines, consent forms) are typically written at the eighth grade level (Easterbrooks & Beal-Alvarez, 2012).

In an analysis of reading outcomes based on state-wide assessments, findings suggest that many d/hh students are in fact reading above the much-assumed fourth grade level. Looking at data from seven states, Easterbrooks & Beal-Alvarez (2012) report that the mean percentages for students meeting proficiency in reading ranged from 35.7% to 81.4%. In addition, states reporting data by grade showed that more than half of d/hh students read above the fourth grade level, continuing into the middle and high school years. The data from this analysis is promising, although the authors conclude that due to variances in how each state defines "meeting proficiency" and "exceeding proficiency" in reading, more research is warranted to confirm progress in d/hh students.

Reading comprehension is also linked to comprehension-monitoring and working memory. It has been suggested that the ability to visualize enhances comprehension-monitoring, an executive function that enables a reader to understand and organize what he is reading (Gambrell & Bales, 1986). In other words, the ability to visualize aids both understanding of what is being read and enables the reader to identify when she is struggling to understand what she reads. Poor comprehension-monitoring has also been suggested as an area of deficit in d/hh

students. In a study of reading habits among deaf and hearing college students, Marschark et al., (2012) found that deaf college students were more likely to report greater hours spent reading but recognized fewer book and magazine titles compared to hearing college students. While not the focus of their study, they speculated that deaf students may read at a slower pace, spend more time understanding what they've read, and have less awareness of mistakes in comprehension compared to their hearing peers.

Poor comprehenders have been shown to have poor working memory (Oakhill et al. 2003), which may contribute to d/hh students difficulties with reading comprehension. When reading passages, one must be able to store enough information in working memory to be able to process information within sentences, paragraphs and entire texts (Nittrouer, Caldwell, Lowenstein, Tarr & Holloman, 2012). Working memory in d/hh students has been found to be below average compared to hearing peers. Yet it may not be the case that all d/hh students struggle with working memory. A study of complex working memory in teenagers with CIs and teenagers with normal hearing found that both groups performed equally well on several measures (Geers, Pisoni & Brenner, 2013). When it comes to executive functioning skills, identifying d/hh children who struggle with working memory and then targeting ways to improve it may ameliorate later difficulties with reading comprehension (Nittrouer et al., 2012). This relates back to mental imagery because storing information in working memory is essential to visualizing story elements.

Lastly, the ability to activate prior knowledge is a critical component to reading comprehension. It is well documented that students who are d/hh have reduced vocabularies compared to their hearing peers and are less likely to acquire information via observation and overhearing others. When reading, one acquires new information from text but also accesses

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prior knowledge to understand what is being read; it is this bidirectional effect that can limit reading comprehension in d/hh students (Marschark et al., 2012). Students with more prior knowledge are more likely to form richer connections between what they know and what they read. Limitations in prior knowledge, such as those often found in d/hh students, can thereby limit reading comprehension ability (Oakhill et al., 2003).

Research on Visualization as a Reading Comprehension Strategy

For poor readers, visualization, or creating mental images, is a reading comprehension strategy that must be explicitly taught. Research investigating different approaches has concluded that reading comprehension can improve as a result of direct strategy instruction (Joffe et al., 2007, Marley and Szabo, 2010, Wilson, 2012). However it is unclear as to which approaches are best suited for the classroom and if some children would benefit from one approach over another. Mental imagery training typically consists of explicitly teaching children, often in small groups, to create pictures in their mind based on highly descriptive sentences and paragraphs (Joffe, et. al., 2007). Another approach is to use illustrations of the text or manipulatives as a bridge to teaching mental imagery (Marley and Szabo, 2010, Gambrell and Jawitz, 1993). In studies with deaf students who use ASL as their primary mode of communication, research has looked into different combinations of print, illustrations and ASL and their impact on reading comprehension (Gentry, Chinn and Moulton, Winter 2004/2005).

Children with specific language impairment are one population of students that struggle with reading comprehension. Specific language impairment (SLI) is the diagnosis given to children who struggle with language-related learning but have no other deficits (retrieved from http://www.nidcd.nih.gov/health/voice/pages/specific-language-impairment.aspx). It has

also been found that students with SLI are poor comprehenders of both written and spoken language. A study by Joffe et. al., (2007) used a mental imagery training approach to assess story comprehension in a group of students with SLI and a group of same age controls. Their study was based on the premise of the dual-coding theory in that teaching students with SLI to utilize their visual coding system may reduce the demands on their verbal coding system.

This study consisted of two groups of children, all from the same primary school outside of London, England. The SLI group consisted of nine children, mean age of 9.6 years and 16 typically developing (TD), age-matched controls, mean age of 9.1 years. Within the SLI group, each participant scored below average on two of three language measures (British Picture Vocabulary Scale, 2nd edition, Clinical Evaluation of Language Fundamentals, 3rd edition Receptive and Expressive, and the Picture Completion Subtest of the Wechsler Intelligence Scale for Children – III). All children in the typically developing group were within or above the average range. The investigators designed an intervention with a pre- and post-assessment, with the hypothesis that explicit mental imagery training would improve SLI students' ability to answer literal and inferential questions about a story.

The SLI group received 2 assessment sessions pre-intervention, 5 training sessions (the intervention) and 1 assessment session post-intervention. The TD group received 1 assessment session pre-intervention, no training sessions, and 1 assessment session post-intervention. During the pre-intervention period, the participants in both groups were exposed to two short stories on different topics familiar to children this age, developed by Bishop and Adams (1992) for use with students with SLI. Participants were told that first they would read the story and then answer questions about it. Stories were read to the children while they followed along with the

print in front of them. Following each story, the print was removed and children were asked a series of 7 literal and 7 inferential questions.

For the intervention phase, the SLI group received five 30-minute training sessions over a 3 week period. The TD group did not receive an intervention. The participants received the training via small group instruction, which provided explicit instruction on mental imagery. They were told that they would learn to think in pictures to help them understand what they read.

Visual prompts were utilized in initial sessions to demonstrate what they should visualize and the use of prompts was decreased until none were used during the final two sessions. Early sessions (one through three) utilized highly descriptive individual sentences followed such as, *'The large, pink pig was eating hot, brown potatoes.'* The students were first asked what they remembered about the sentence. Then, specific questions were asked based on what the students said:

- What color was the pig?

- Was the pig big or small?

- What was the pig eating?

- What color were the potatoes?

- Could you see the steam coming out of the potatoes?

Later sessions (four and five) focused on visualizing from short stories, such as: *'The little girl went to the zoo with her mom. She liked elephants. She threw her sandwiches to the hungry elephants. The tall, fat zookeeper was cross. He said: 'Do not feed the animals'.* Again, the students were first asked what they remembered about the story, followed by specific questions:

- Who went to the zoo?

- Which animals did the girl like?

- Who was cross?

- What did the zookeeper look like?

In addition, participants were asked questions to help them describe the images they saw in their head, such as what the girl looked like, how old she was, what was she wearing, how many elephants were there, etc.

During the post-intervention, two different short stories were read to the groups. The TD group received the same instructions as in the pre-intervention (that they would read a story and then answer questions about it). The SLI group was given these instructions plus a reminder to make pictures in their heads while listening to the story and following along with the print. The stories used during the post-intervention assessment were of the same level and style as those in the pre-intervention.

The results of this study found that mental imagery training did improve the SLI group's ability to recall information and answer questions about the story. In the pre- and post-assessments, a total of 28 points each was possible for literal and inferential questions. With regards to answering literal questions, scores increased ten points from a mean of 8.56 to 18.56 in the SLI group, and this increase was significant (compared to 17.88 to 23.06 in the TD group). For inferential questions, mean scores increased from 8.78 to 12.44 (compared to 21.12 to 20.69 in the TD group). In comparison to the TD group, the SLI scores are still quite low. The authors explained their findings by suggesting that the type of mental imagery training they conducted during the intervention served best to increase the SLI participants' ability to remember the

explicit details of the story. However, there was less improvement in their ability to think beyond those details to predict, make inferences or draw conclusions about the story.

It is also important to note that in this study, the participants were listening to the story rather than reading it on their own. While they had the text to follow along, they did not have to decode while creating the mental images. Additional research where children read the stories themselves would be a logical next step in mental imagery training.

Investigators have questioned whether or not providing illustrations with text is an effective way to increase a reader's ability to learn to create their own mental images. In a study with fourth grade students all reading at grade-level, Gambrell and Jawitz (1993) compared reading comprehension in four groups of 30 students each: general memory from print only (the control group), attention to text illustrations, induced mental imagery or induced mental imagery and attention to text illustrations. Their hypothesis was that each strategy individually (illustrations or mental imagery) is similar in their ability to aid comprehension of the text and that pairing the two strategies together would further enhance comprehension.

Results found that the combined approach – induced mental imagery and attention to illustrations – led to significantly greater free recall of story elements (setting, characters, plot, resolution) and significantly greater ability to answer explicit and implicit questions about the text when compared to the control group. This suggests that when students have access to illustrations and are prompted to imagine story events, they are better able to process the print and recall key elements. However, as students move from primary to secondary grades, text illustrations are not always available. As such, it is noteworthy that when looking at free recall of story events, the imagery-only group also performed significantly better than the control group.

They also performed better than the illustrations-only group, but the difference was not statistically significant.

Another approach to helping children learn to use mental imagery is incorporating manipulatives into reading and understanding. Marley and Szabo (2010) based their study on the indexical hypothesis, which postulates that physical manipulation enables children to better encode and recall new information that they read. With specific regard to mental imagery, they investigated whether providing an opportunity to act out a story with manipulatives would better help children create mental images while reading compared to viewing related text illustrations. The subjects in this study included 38 kindergarten and 38 first-grade students, with half of the students from each grade level receiving training in using manipulatives to act out a short story while the other half viewed illustrations of the same story.

During the first training session, the manipulatives group listened to a story then acted it out with manipulatives, while the illustrations group listened to the story then looked at a picture of the story. In the second training session, the manipulatives group listened to the story, and then instructed to picture the story in their head before using the manipulatives to act it out. The illustrations group received the same instructions but then viewed a picture of the story. For the third and final training session both groups listened to the story and were then instructed to picture the story in their head.

After each training session, the participants were asked to recall everything they could from the story and then respond to specific questions. The authors found that in training sessions one and two, children who were exposed to the manipulatives were better able to recall story details than those in the illustrations group. During the third training session, when participants

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relied solely on their capacity to form mental images, the manipulatives group recalled more story elements than did the illustrations group and the difference was significant. This finding supports their hypothesis that use of manipulatives improves memory of story events to a greater extent than illustrations and that it likely improves the ability to create mental images while reading.

Gentry, Chinn and Moulton (2004/2005) conducted a study with 28 deaf students, similar to Marley and Szabo, comparing different reading situations and the impact each had on reading comprehension. This study with deaf students (ranging in age from 9 to 18 years) included only those who communicated via American Sign Language, read at a 3rd to 4th grade level and had average non-verbal intelligence. The four reading situations in this study were print only, print and pictures, print with a digital video of sign language, and print, pictures and a digital video of sign language. While there was no mental imagery instruction as part of this study, it still fits within the DCT framework as there is some evidence that pictures can enhance reading comprehension, although not to the same extent as mental imagery (Marley & Szabo, 2010). Each student was exposed to each of the four reading situations in random order, each with a different story. Following each presentation, they retold the story via sign language. Story retellings could garner a total of 26 points based on how extensive and detailed the child was in remembering what they had read. The results from this study found that story retellings were the most complete when participants read the text with associated pictures. Mean scores across all participants were 7.92 (print only), 16.32 (print with pictures), 10.0 (print with ASL), 15.88 (print with pictures and ASL) so as with the Marley and Szabo study, exposure to print also led to the lowest recall scores. The addition of pictures to print resulted in statistically significant increases in ability to retell the story as did pictures and ASL. However, just the addition of ASL

to print led to a slight but not statistically significant difference compared to print only. While this was a small study, it does provide evidence that students who are deaf can also benefit from pictures associated with print and as a result may also benefit from mental imagery instruction in the same way hearing students do.

As a result of research by Paivio, Sadoski and others in the 1970s and 1980s, specific curricula based on mental imagery have been created for classroom use. One of the most well-known of these is the Visualizing and Verbalizing program designed by Patricia Lindamood and Nanci Bell. Their program is based on findings that mental imagery improves comprehension because forming images helps with information storage and retrieval, in turn increasing one's ability to recall information about what has been read (Bell, 1991). The specifics of the Visualizing/Verbalizing program will be discussed in more detail in the next section. However, the program has been the subject of educational research, investigating actual outcomes for students who have used it. In a study by Johnson-Glenberg (2000), Visualizing/Verbalizing (V/V) was directly compared to another comprehension strategy training program, Reciprocal Teaching (RT) which does not have a mental imagery component. In a second study by Sadoski and Willson (2006), the Lindamood-Bell Learning Processes (LBLP) reading program, which encompasses the V/V technique, was evaluated across an urban school district.

In the first study, investigators were interested in methods of improving reading comprehension in students who were adequate decoders but poor comprehenders. This study addressed two questions: does small group strategy training improve comprehension and if so, does the strategy they are trained in matter? To see if the strategy itself matters, the students were divided into two groups, one received the RT program and one received the V/V program. RT encompasses summarization, clarification, prediction, and question generation. The V/V

program encourages students to "make movies in their heads" while reading. Both groups were compared to a third control group receiving no intervention. Fifty nine third through fifth grade students were recruited for this study. Participants were identified by their teachers as 1) having average to high IQ scores, 2) being good decoders but difficulty following written and oral directions, 3) giving low quality recalls, 4) being inflexible in their thinking and 5) frequently asking questions such as, "What are we supposed to be doing?" Students with emotional-behavioral problems and ADD/ADHD were excluded from the study, as were students who received daily resource room services. Assessments given at the beginning of the study confirmed that these students were adequate or better decoders with below average comprehension abilities (based on their performance on the Wide Range Achievement Test – Word Recognition subtest and Gates-MacGinitie comprehension score).

Students in the two strategy training groups each received 28 30-minute sessions over a 10 week period during the school day. During the training sessions, the RT group was introduced to the four components (summarizing, clarification, prediction, and question generation) over the first four weeks. After that point, the students used all four components together and moved from short stories to chapter length stories by the end of training. In the V/V group, students were "trained to create mental images from the text and to discuss these images with the group," (Johnson-Glenberg, 2000). Students started with imagining single words, then high imagery sentences and paragraphs. The control group received the same pre- and post-test assessments as the strategy training groups, plus 3 hours of reading comprehension training following the experiment.

Findings from this study concluded that both groups made significant gains in several measures related to reading comprehension, but were unable to determine if one training strategy

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was more effective than the other. Those in the RT group made significant gains in their ability to answer explicit open-ended questions and in question generation (which was specifically taught in the RT training). Those in the V/V group made significant gains on answering implicit open-ended questions. The V/V group also outperformed the RT group and the control group on three other non-comprehension measures that were assessed pre- and post-intervention: DTLA-Following Directions, WISC Digit Span and a paper folding tasks, all of which require visual coding of verbal information to some degree. The study author concluded that poor comprehenders would likely benefit from a combination of strategies, with the V/V approach effective in improving students' inference abilities. While not directly related to reading comprehension, this finding does support the V/V strategy as a way to improve student performance through mental imagery.

In Sadoski and Willson (2006), the Lindamood-Bell Learning Processes (LBLP) reading program was assessed in an urban school district (PSD60) in Colorado to see if schools using the program performed better on the Colorado Student Assessment Program (CSAP) reading scores compared to schools in other districts. Following below state average scores on reading in the PSD60 district, the district implemented the LBLP program in one elementary school as a pilot in 1998. By the 2002-2003 school year, it was being used in 20 elementary schools (and several middle and high schools as well). The LBLP program focuses on decoding, vocabulary and comprehension. The V/V component is used for vocabulary and comprehension, and fully embodies the principles of Paivio's Dual Coding Theory through mental imagery and verbal elaboration while reading words, sentences, paragraphs and longer texts (Sadoski and Willson, 2006). During the years of the study, teachers, principals and other staff received ongoing

training in using the LBLP program via on-site consultants who trained, coached and provided oversight in the schools.

The two main research questions posited in this study were 1) how well did the PSD60 schools perform on the CSAP in grades 3-5 compared to all of Colorado, and 2) how well did the PSD60 Title 1 schools perform on the CSAP in grades 3-5 compared to Title 1 schools in Colorado, between 1998 and 2003. Title 1 schools are those that have a significant percentage of low income and minority students. On average, PSD60 schools' performance on the state reading test improved over time compared to the state as a whole. The same trend was found when comparing just the Title 1 schools in both groups. Over the course of the five years, the number of unsatisfactory and partially proficient scores were replaced with proficient and advanced scores. The findings from this study provide further evidence that teaching children to use mental imagery while reading can improve reading comprehension ability.

Teaching Visualization as a Reading Comprehension Strategy

While educational research studies have found that explicitly teaching mental imagery as a reading comprehension strategy can improve children's ability to retain and recall information from text, how does this transfer to the classroom? As Pressley (2001) summarized, most classroom teachers spend time testing students' reading comprehension but not actually teaching reading comprehension. Teaching mental imagery to young second grade students was something McTigue (2010) felt unprepared for when telling a story orally to her class with no illustrations. When some students couldn't understand that they could create a picture in their head that differed from the teacher's picture, she began explicitly teaching them how to create mental images. Research has found that while children are first learning to read, teaching mental

imagery while listening to stories can be more effective than while reading on their own because the effort dedicated to decoding is eliminated (McTigue, 2010). Other classroom teachers have drawn on research, specifically that of Dual Coding Theory, to improve their students ability to create mental images while reading. Hibbing and Rankin-Erickson (2003) have found in their years of teaching that good readers are those who naturally form mental images while reading and readers who struggle to do this are often students with learning disabilities, an observation that is backed up by research. In a summary of teaching approaches they have implemented in their classroom, these two authors and teachers discuss the success they have had by telling students to visualize a television screen in their mind, make drawings of what they picture, and when provided to make good use of the text illustrations. Another approach they use with older students is exposure to picture books and movies before introducing a text on a topic they may know little about. This helps to build background knowledge so that when reading the text, they have a starting point for building connections between what they read and what they know. The ability to incorporate prior knowledge is a key component to building comprehension (Joffe et al., 2007) so this technique is one way to do this in students who have limited information to draw upon.

The television screen analogy used by Hibbing and Rankin-Erickson is not unlike the "Brain Movies" strategy devised by Wilson (2012), which is directly based on Paivio's DCT research. She discusses her teaching strategy as one that not only helps to improve reading comprehension, but can also carry over to writing as students are more likely and willing to use descriptive language in writing exercises related to what they have read. When selecting texts for students to read and make "brain movies," research has found that those using concrete and

sensory-rich language are best when students are just beginning to use this strategy (Wilson 2012, Gambrell & Bales, 1986).

Research has found that few teachers are using mental imagery as a teaching strategy in a full class situation but rather when individual students are struggling with reading comprehension. In Johnson-Glenberg's (2000) study comparing V/V to R/T, only two of the 12 teachers of the student participants mentioned that they used mental imagery, and then only with students who were far behind their peers in reading comprehension. Programs such as Visualizing / Verbalizing are often implemented on a remedial basis with one-on-one or small group instruction, but can also be adapted to whole class instruction (Bell, 1991). The Into the Book program in Wisconsin teaches visualization as one of eight reading comprehension strategies as part of their state-wide reading curriculum. Both of these programs are based on decades of reading comprehension research.

When implementing V/V in a small group setting within a larger classroom, Bell recommends daily instruction using a modified version of the six steps used when working with individual students. These six steps help students progress from illustrations provided by the teacher to reading full pages of text (with no illustrations) followed by answering comprehension questions.

1. Picture-to-Picture: Each student in the group takes turns describing what they see in a picture provided by the teacher.
2. Word Imaging: The teacher provides a prompt and each student takes turns visualizing it and then describing it with words.

3. Sentence by Sentence, Multiple Sentence Imaging: Students take turns visualizing and then verbalizing a sentence, another student may use the structure words[3] to reword, another student may give a picture summary and then another student will give a word summary. The students can then take turns with who takes on each role and will build up to multiple sentences at once.

4. Paragraph Imaging: Each student in the group reads a full paragraph, summarizes it and then responds to comprehension questions.

5. Paragraph-by-Paragraph Imaging: Students take turns reading paragraphs and using the colored square technique[4] to recall their images.

6. Page Imaging: Each student reads a full page of text, discusses the images they made with the group, and answers comprehension questions orally or in writing.

These six steps can also be applied to a full class working with all students as part of an overall reading or language instruction period. Bell (1991) cautions that when teaching a full class, some additional management techniques must be applied so that all students are given a chance to visualize. Otherwise, the teacher will only be able to assess the progress of those students who get called on to answer questions. These techniques include having students think to themselves first, have the entire group respond at once, and letting all students who know the answer have a chance to raise their hand first before calling on any individual student.

The Into the Book program implemented in Wisconsin public schools for Kindergarten through fourth grade (http://reading.ecb.org/teacher/visualizing/index.html) highlights

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[3] The V/V program trains students to use twelve "structure words" to help form mental images: what, size, color, number, shape, where, movement, mood, background, perspective, when, and sound.
[4] The colored paper squares serve as a tool to help students connect each sentence in a paragraph to their imagery. When recalling their visualization, they point to each square one at a time with each square representing a different visual image.

visualization, or creating mental images, as one of eight[5] reading comprehension strategies that

teachers should explicitly teach their students. The website for this program includes a detailed

section on each strategy with separate information for students and teachers. On the teacher

side, the visualization strategy page focuses on six objectives for the students when using this

strategy along with rubrics for grading use of imagery when reading both fiction and non-fiction

texts. These six objectives are summarized here:

1. Can the student communicate the visualization using any of the five senses in a
   way that enhances what they have read and understood?
2. Can the student communicate using visualization before, during and after
   reading?
3. Can the student communicate that the process of visualization helps them go
   deeper into the text?
4. Can the student communicate that when visualizing, they are able to use
   descriptive words from the text as well as their own prior knowledge?
5. Can the student communicate how text and illustrations work together?
6. Can the student demonstrate their visualization in more than one way (e.g.,
   language, visual arts, music, drama, dance or technology)?

Teachers are provided with materials to help teach visualization to their class. These

materials include videos of other students talking about their mental imagery while reading,

exercises for listening to and reading stories followed by discussing the images, and instructing

students to "make movies in their head" while listening to stories. One specific exercise gives

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[5] The eight reading comprehension strategies are: Prior Knowledge, Making Connections, Questioning, Visualizing, Inferring, Summarizing, Evaluating and Synthesizing.

students the opportunity to transfer their mental images to an actual picture using computer software to bring their images to life. While the Into the Book program is based on research on mental imagery and Dual Coding Theory, there has been no formal evaluation of the program to date. However, teacher commentary from the program website discussion board indicates that teachers are finding it to be helpful with many of their students.

Application to Deaf and Hard of Hearing Students

Research in mental imagery from the 1970s suggest that students who benefit the most from imagery instruction are those whose primary deficit is in reading comprehension while those who have poor decoding abilities benefit the least (Levin, 1973). This suggests that in children who are deaf / hard of hearing, mental imagery instruction is a strategy best suited for those who are good decoders but are still struggling with comprehension. As recent research has shown, children who are d/hh are making gains in reading yet continue to have difficulty with whole text comprehension compared to typically hearing peers (Geers & Hayes, 2010). With this knowledge, how can mental imagery instruction be incorporated into the d/hh classroom so that these students are better prepared for academic success in the mainstream?

1. *Mental imagery training:* As discussed in studies by Joffe, et al., (2007) mental imagery training can improve student ability to answer comprehension questions, specifically literal questions. While the goal for our students should be answering higher level, inferential questions about a text, understanding literal questions must be mastered first. Drawing from this study, teachers can select highly descriptive sentences and short paragraphs and train students to think about the images they see related to the words.

2. *Use of manipulatives:* Based on Marley & Szabo (2010), incorporating manipulatives into reading lessons can be a starting point for students who struggle to form their own mental images. This could be a particularly useful way to teach this strategy to younger students who are reading stories with concrete

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language easily represented by objects. This approach also helps the teacher see students are struggling if their manipulation of the objects is inconsistent with the story.

3. *Think alouds:* As evidenced by the instructions in the Visualizing Verbalizing technique (Bell, 1991), students can listen to how the teacher describes a picture and then base their own descriptions off of a teacher prompt. This could be done by starting class each day with a picture and giving students an opportunity to practice describing it. The same skill can then later be practiced with simple sentences before moving onto short paragraphs.

4. *Incorporating multimedia presentation of content:* Using related content (e.g., picture books, movies, and photographs) can help build knowledge of a topic in areas that students have limited or no experience with. Several approaches to this are discussed in Hibbing & Rankin-Erickson (2003) and can be incorporated into instruction as needed. This approach could be particularly helpful when teaching content areas (science, social studies) where students may not have the prior knowledge to draw on while reading.

5. *Student drawings:* Giving students the chance to draw what they see while reading can help students realize that they should be visualizing. Teachers can then have students talk about their picture and how it relates to the written text, which gives students practice using descriptive language and informs the teacher of any disconnects between the text and what the student comprehended.

6. *Working memory tasks:* For d/hh students, focusing on improving working memory via gradually increasing ability to repeat sentences of greater length could then carry over to ability to recall information while reading.

In conclusion, mental imagery as a reading comprehension strategy and teaching students that they can and should visualize what they read, could contribute to improved reading comprehension in students who are deaf and hard of hearing. As with students with typical hearing, some d/hh students are average to above-average readers and have good reading comprehension abilities. However, it is well known that even with today's advances in technology and earlier identification of hearing loss, d/hh children as a whole still lag behind

their hearing peers in reading comprehension to some degree (Easterbrooks & Beal-Alvarez, 2012). By drawing on Dual Coding Theory, providing opportunities for d/hh students to activate both verbal and visual learning may lead to improved outcomes in reading comprehension and as a result, overall academic success.

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