Abstract

This paper provides an overall review of the role of imagery in the acquisition of language abilities from antiquity to the present time. Specifically, the purpose of this study was to find if the utilization of the Dual Sensory Coding Theory (i.e. as a multi-sensory intensive intervention strategy) improved oral and written comprehension ability.

The included research article contained both large scale and small-scale studies with a theoretical base utilizing Pavio's Dual Coding Theory (DCT). A single case study of a young man is covered providing documentation of positive growth from two years of age until his transition into high school. This student possessed good decoding skills but was unable to comprehend oral language and written text.

A structural visual imagery-based sensory intervention demonstrated both structural and functional changes in the recent neuroscientific studies at the University of Alabama (2015-2017). Comprehension skills demonstrated a positive change through educational intervention. Intensive targeted interventions have proven to strengthen connections between the imagery and verbal cortical centers.

Effect of Mental Imagery in the Acquisition of Language Abilities

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Language comprehension, simply defined, is the ability to connect to and interpret meaning of both written and oral language. Children in school are bombarded with complex language input. They are required to remember and recall facts, evaluate, supply the main ideas, and make inferences and predictions. Language comprehension underlies the reading process and oral language. It is based in the sensory system (Catts et al., 2002; Carretti et al., 2013; Center et al., 1999).

Social interaction, emotional functioning, and academic functioning are affected by comprehension. The areas of expressive writing, reading comprehension and complex classroom instructions are exacerbated by difficulties in comprehension. These areas will grow in importance and complexity for students, especially in the upper grades when they are required to read to understand and learn on a more independent level. Students who struggle to acquire reading skills can quickly fall behind and never catch up. Reduced reading experience can also have long-lasting effects (Huettig et al., 2017).

Students will be held back academically when reading for information, especially when it becomes increasingly important; and when motivation to read for instruction and/or pleasure is also diminished (Berkeley et al., 2011; Nation & Norbury, 2005; Yuill & Oakhill, 1991; National Reading Panel, 2000; Boudreau & Hedberg, 1999; Catts, 1991). Wahlberg and Magliano (2004) implied that understanding text is an important skill because it allows a person to function independently in society and provides access to greater employment opportunities.

Unfortunately, language comprehension difficulties may go unnoticed because some students develop accurate and fluid word reading ability, and the assumption is made that they understand the meaning of language (Cain & Oakhill, 2007; Applegate et al., 2009; Cartwright, 2010). This appears to be the difficulty of the student followed in this article's case study. Oral language skills are fundamental skills for reading comprehension as noted by (Catts et al., 1999; Yuill & Oakhill,1991; Rayner et al., 2001)

and these investigations found comprehension deficits appeared not just in reading but, also in listening skills. Nation & Norbury (2005) estimated that 5%-10% of school-age children are poor comprehenders. Storch and Whitehurst (2002) discussed the necessity of preschool and primary grade teachers to support acquisition of language abilities as they also supply code related instruction that is critical to successful reading.

Effects of intervention have been examined to help students to improve language comprehension (Fricke et al., 2012; Lervag et al., 2017). Improved oral language skills appear to directly lead to improvements in reading comprehension skills for both younger students (Fricke et al.) and older children (Clarke et al., 2010). See also (NICHD Early Child Care Research Network, 2005; Oakhill & Cain, 2012). Listening comprehension was a predicator of both early and later growth of reading comprehension as determined from using data from a large-scale longitudinal study (Lervag et al.). Smiley et al., 1977, found that reading and listening comprehension were highly correlated. Justice et al., 2008 noted that differentiated instruction was lacking for children who are most at risk due to language and early literacy delays. Therefore, early age identification of children with listening skill challenges is critical and these students need to be provided intervention with attention to cognitive skills (Vellutino et al., 1996; Velluntino & Scanlon, 2001; Peterson et al., 1996; Gettinger & Steiber, 2012; Torgesen, 2002) in order to correlate with their ability to understand spoken language.

Reading research has frequently demonstrated that students have their literary foundations from spoken language skills (Serry et al., 2008). Because speech-language pathologists are often the first specialists who encounter preschool children, they could play an important role in preventing reading difficulty (Boudreau & Hedberg, 1999).

Since listening comprehension difficulties can be detected at an early age, but, reading comprehension challenges commonly occur at a later age, it would be important to provide intensive

instruction to young children struggling with listening comprehension. Discourse level oral language skills such as listening comprehension develop when children are exposed to rich oral language at school and at home. Rich language experiences assist in developing their oral language skills (Hart & Risley, 1995). Hoover & Gough (1990) contend that oral language comprehension, according to the simple view of reading, is one of two skills necessary for text comprehension. Gough (1996) discussed the necessity of the two skills necessary to be a proficient reader: the ability to decode at word level and the ability to abstract meaning from print. The simple view of reading (Hoover & Gough) predicts that students with poor oral comprehension will not be proficient readers despite good decoding skills. Friedlanger (2013) further suggested that despite clear evidence on the importance of oral language, this challenge is often not recognized by teachers and is not included in some textbooks. Knowledge of what language and early literacy skills need to be taught in preschool have been documented in *A Report of the National Early Literacy Panel* (Shanahan & Lonigan, 2008; Snow et al., 1998). Therefore, early age identification of children with listening challenges is critical because these students need to be provided intensive intervention with attention to cognitive skills. Vaughn, Cirino, et al. (2010); Vaugh, Denton, et al. (2010) reviewed the literature on intensive intervention and suggested that interventions are an effective and responsible approach for students with severe reading disabilities. Students must learn that strategies are an important tool to assist understanding. The main purpose of reading and listening is gaining meaning and knowledge.

Fuchs (2007), cautions that children in preschool must receive specific, standard instructional practices and not just be placed in three diagnostic groups (RTI's three tiers). However, improving Tier I is critically important (Chard et al. (2008). To bring children up to scale, developmental work needs to provide "measures, curricula, media websites, technical assistance and management" to improve the implementation of RTI programs (Greenwood, et al., 2011). Review of typical programs (i.e., Pre-K, Title I, Head Start, and tuition based) provided information. A multisite study informed by such data,

Greenwood et al. found that Tier I instruction received in all four settings was low, and there was indeed room for improvement.

In reference to the purpose of this case study it should be noted that a complex relationship exists between non-phonological language skills and early reading skills (Catts et al., 1999, 2001; Velluntino et al., 1991; Bishop & Adams, 1992). However, a substantial amount of research attention has been focused on phonological processing issues. This is especially true in relationship to reading comprehension (Catts et al., 2022; Snowling et al., 2000; Hoover & Gough, 1990). Non-phonological aspects of language can be overlooked as key indicators for predicting reading outcomes (Kamhi & Catts, 2005).

Snow (2002, p. 11) defined reading comprehension as "the process of extracting and constructing meaning through interaction and involvement with written language". The Reading Study Group further stated that the ultimate goal of reading "is drawn from the complex processes involved in word reading (decoding words) and listening comprehension (understanding meanings)". See Snow (2002).

Basic language skills underpin development of both written and oral language comprehension (NICHD, 2005). Comprehension skills develop simultaneously with basic language skills and have their roots in early narrative comprehension (Cain & Oakhill, 2007). Bishop (2001) contends that reading comprehension is constrained by language impairments. Even if students have excellent decoding skills these children will not become proficient readers if they lack basic language skills (Kelso et al., 2007).

The brain is a multisensory organ and can only receive information from our senses (Pribram, 1991). Individual variations are noted in the development of intellectual operations (Piaget & Inhelder, 1971). Sensory cognitive research has proven data on how genetic differences in individuals can affect the conscious awareness of multisensory information (Nation & Snowling, 1998, 1999; Nation et al.,

2002). For the purposes of this article individual differences have been found more prominent in students with language challenges (Serry et al., 2008; Norbury & Nation, 2011; Nation et al., 2004; Catts et al., 1999) and those identified as “poor readers” (Long & Chong, 2001; Kelso et al., 2007; Cain & Oakhill, 2007). The included single case study in this paper focuses on the clinical management of a young student entering second grade diagnosed with Pervasive Development Disorder Not Otherwise Specified (PDD-NOS). This diagnosis describes children who exhibited at least one characteristic of Autism Spectrum Disorder (ASD), but do not meet all of the specified diagnostic criteria (American Psychiatric Association, 2000). The student was experiencing both oral and written challenges in comprehension. The problem under investigation is to see whether there is any relationship between the use of an imagery strategy to improve comprehension performance during reading and listening activities. This student possessed excellent decoding skills well above age and grade level expectations at the end of first grade in both single word and continuous text reading.

Comprehension may be fixed by biological makeup or partially influenced by experience and knowledge (Perfetti & Goldman, 1976; Perfetti et al., 1996; Yuill & Oakhill, 1991; Nation et al., 2002; Oakhill, 1984; Nation & Snowling, 1999; Kim & Phillips, 2014; Friedlander (2013); Storch & Whitehurst, (2002).

There are relatively few research articles available describing the cognitive correlates of listening comprehension as compared to the cognitive correlates of reading comprehension. Kim & Phillips (2014) specifically addressed the cognitive foundations of listening comprehension (e.g., inhibitory control, theory of mind and comprehension monitoring). A later study (Kim, 2016) demonstrated that inference skills, grammatical knowledge, and verbal working memory predict and determine listening comprehension. Kim’s 2016 study also demonstrated the role of attention in listening comprehension.

Furthermore, in respect to reading comprehension, Perfetti et al. (2005, p. 228) argued that "issues of cognitive architecture in reading comprehension are important, complex, and contentious: We will not discuss this further". Please refer to p. 229 within Figure 13.1 to explain and clarify reading comprehension components.

Similarly, this paper will not concentrate on either the cognitive architecture in reading comprehension or listening comprehension since the emphasis of this study is the use of imagery to remediate comprehension challenges. However, these specific areas diagnosed in relation to the case study student will be discussed.

The included long term anecdotal report in this paper focuses on the clinical management of a young student entering second grade diagnosed with PDD-NOS. He was experiencing both oral and written challenges in comprehension. The question under investigation is to see whether there is any relationship between the use of an imagery strategy to improve comprehension performance during reading and listening activities.

Early Reading Comprehension Research

Reading comprehension research began to receive scientific attention in the 1970s. The majority of text comprehension research during the last two decades has emphasized the cognitive conceptualization of reading. Reading is purposeful and active and engages the reader (Pressley & Afflerback, 2009; Durkin, 1993). Before the 1970's explicit teaching of text comprehension occurred only in content areas and not during formal reading instruction (Durkin, 1978). Beginning readers were seldom taught cognitive strategies to assist them during reading activities (Pressley & Hilden, 2004). Baumann et al., 1992 strongly suggested that past research supports the importance of cognitive strategy training to improve students' comprehension. Similarly, "The best way to pursue meaning is through conscious, controlled use of strategies" (Duffy, 1993, p. 223). Dickenson, et al., 2003; Dickenson

& McCabe, 2001 argued that the system of interrelated language and cognition systems that children create as they first become literate may become increasingly well-organized with time. If there are significant gaps in some part of the system at an early point, they may fail to create the robust system of literacy needed for later literacy acquisitions. They concluded that preschool, kindergarten, and primary grade teachers should strive to support acquisition of language abilities as they also supply code-related instruction that is essential to reading success. This was also previously discussed by Storch & Whitehurst (2002).

Paivio (1972, 1986) and Clark & Paivio (1991) proposed that knowledge is composed of complex associative networks of verbal and imaginal representations. Students could increase their memory content of texts when instructed to construct mental images (Pressley 1976, 1977; Levin, 1973). A further suggestion by Van de Ven (2009), was that these comprehension problems within reading instruction may be due in part because the sensory aspect in reading has been given limited attention. Instead of just relying on reading words during text processing, the use of multiple sense modalities (i.e., visual, auditory, haptic/kinesthetic, gustatory, olfactory, emotion) will help create non-verbal representations (mental images) to assist in the understanding of text (Sadoski & Paivio, 2001, 2013; Van de Ven). The creation of mental images is based on all sensory experiences (Sadoski & Paivio, 2001). Students read a text to understand what they're reading and construct memory representations, (Duffy & Roehler, 1989), so they can put this understanding to use. For example, the olfactory sense modality can trigger dormant memories and invoke and bridge past experiences as well as emotional issues from past events.

Generalization is needed across text genres (e.g., narrative, and expository, as well as in texts covering specific areas of context). These strategies guide students as they attempt to read and write. Expository texts (i.e., informational texts) are more complex than narrative texts and appear to be less coherent (Wiley et al., 2005; Kucan & Beck, 1996). Sykes (1999) found that teacher's quality and

expertise consistently and accurately predicted student achievement. Systemic reform must be accompanied by strong professional development. Effective instruction will be enhanced by the level of the teacher's specialized body of knowledge.

Significant gains on measures of reading comprehension are noted when explicit teaching of text comprehension strategies is compared to students trained with conventional instructional procedures (Pressley et al., 1989). Wittrock (1981) noted that reading comprehension is increased approximately by fifty percent in a study of fourth graders. He attributed this increased comprehension rate to the use of "verbal" and "imagined" association when students read textual information. This training assists the readers to achieve a gradual internalization and independent mastery of those processes (Alamsi et al.,1994; Durkin, 1978*). The National Reading Panel: Reports of the Subgroups* (April 2000, NIH Pub. No. 00-4754) studies the scientific basis of text comprehension in the areas of teacher's preparation for educators to effectively instruct students (Chapter 4, Comprehension, Part II, Text Comprehension). In Table I of the NIH publication (p. 4-43) mental imagery is listed as a category of comprehension instruction because "Readers improve memory and comprehension of text". Seven studies were reviewed and examined by the panel (see p. 4-76 & 4-77, table 7 and the evaluation on p. 4-77 for more details).

Another factor to consider is the fact that teachers may not be using effective comprehension strategies without themselves having received adequate preparation in instruction (Durkin 1978) and may lack the knowledge on how to differentiate instruction for diverse learners (Kluth, 2003). Dole et al. (1991) distinguished proficient readers from students who struggle in reading by their utilization of metacognitive reading strategies. Metacognition is described by Flavell (1979) as cognition about cognition. It increases the long-term appropriate use of strategies (Cavanaugh & Borkowski, 1979) when strategy instruction is metacognitively embellished (e.g., instruction included information about usefulness of the trained strategy). Metacognitively oriented instruction was found to be more

beneficial to students who received at least four years of curriculum that emphasized deep comprehension and strategies (Thiede et al., 2012; Dignath & Buttner, 2008). "Metacognitive control in reading is often referred to as comprehension monitoring, which involves deciding whether or not one understands (evaluation) and taking appropriate steps to correct comprehension that are *[sic]* detected (regulation)" (Baker et al., 2015, p. 72). For more information on Metacognitive Reading Strategies see Schraw et al., 2006; Sperling et al., 2012; Williams & Atkins 2010. This persistent comprehension problem is evidenced as too many children fail to become proficient readers (Borkowski, et al., 1976; Duffy, et al., 1987) as Snow (2002) noted during educational experiments. These students will struggle throughout school and will likely evidence difficulties in employment, in social aspects, and other life issues. For many students moving beyond the word, phrase or sentence level is a complex process (Graesser et al., 1994). Reading complex and extended text will present problems for many students when they are required to independently learn and understand. Integration of new information and resolving conflicting information found in different sources are literary requirements at intermediate and secondary levels as well as for college students (Biancarosa & Snow, 2006).

Without a doubt, a continuing challenge to educators is to directly link theory and practices. The specific cognitive theory, Dual Coding Theory (DCT), reviewed in this article has been employed by Bell (1991a; 1991b; 1991c) and Bell & Bonette (2006a; 2006b) to design a structured curriculum which assists students to make meaning from what they have read or heard. The effectiveness of this strategy training depends on both the educators and students. Opportunities to explicitly practice metacognitive control and apply It to all subject areas is paramount (Thiede et al., 2010; Thiede et al., 2012). The planned curriculum by Lindamood Processes (Bell, 1991c; Bell & Bonnette, 2006b) employs DCT since it utilizes both the imagery and verbal brain centers. See steps of the: Visualizing & Verbalizing for Language Comprehension & Thinking Program (Bell 1991b (revised); Talkies, Visualizing Verbalizing for Oral Language Comprehension & Expression Program (Bell & Bonetti, 2006a) in Appendix A.

The Visualizing & Verbalizing (V & V) Program (1986, 1991), a multisensory cognitive curriculum, teaches students systematic imagery and practices strategies in order to improve and remediate comprehension literacy issues. It emphasizes dual coding, the imagery connection that underlies comprehension and thinking, while specifically developing concept imagery (e.g., the ability to create an imaged gestalt, or whole, from language, as previously discussed in this article by Bell (1991a; 1991b; 1991c) and Bell and Bonetti (2006a, 2006b). Johnson-Glenberg (2000) utilized specific training procedures from the V & V Program for research centering on the use of verbal versus nonverbal strategies with students who exhibit reading comprehension challenges. All students displayed adequate coding skills with poor comprehension ability. The V & V group answered significantly more implicit inferential open-ended questions when compared to the RT group (i.e., reciprocal teaching group).

In the Talkies Program (Bell and Bonetti, 2006a, 2006b) the goal is to bring the sensory input of imagery to a conscious level and to connect that imagery to language processing. "Talkies has a pattern of lots of little steps within big steps" (p. XI). It is a primer for students for which V & V would be too challenging. It is ideal for preschool children, students with autism and those young pupils with language impairment history. The sequential steps purposely provide repetitive practices and overlapping of materials, receptive and expressive practice, and imagery practice to help establish comprehension and expressive language. The use of gestures helps to link imagery with language.

Socratic questioning (e.g., an inquiry technique) is utilized in both Talkies and V & V as it provides sequential stimulation and assists the development of gestalt imagery to help improve reading comprehension. The Socratic approach to questioning is based on the practice of disciplined, thoughtful dialogue (Elder & Paul, 1998; Elder, 2022; Beach, 2004; Bell, 1991b, 1991c,; Bell & Bonnetti, 2006a, 2006b). Specific instructional procedures of these programs are described in order to develop sensory-cognitive functions that "support and enhance" both oral and written language processing (Bell, 1991a;

Lindamood, Patricia, 1986). The conscious level of sensory feedback and integration is elicited through Socratic questioning. The use of this questioning technique while teaching reading comprehension appears to change the student's perception from a passive participator to an active participant, especially during the question and answers discussion session. It also helps students to improve their critical thinking skills through stages, while learning how to organize and develop existing ideas. Beach feels a special relationship exists between critical thinking and Socratic questioning as both lead to new knowledge and wisdom. Both critical thinking and Socratic questioning share a common end. Critical thinking gives a student a comprehensive view of how the mind functions in pursuit of an idea, while Socratic questioning takes advantage of that overview to frame questions essential to the quality of that pursuit. Socratic questioning systematically instructs students to form mental images and describe them in increasing detail. Students can progress to larger units of language (e.g., pictures, words, phrases, sentences, to extended text). It also assists oral language weakness by bringing the words together to form imaged gestalts. The verbalization will be organized and the expression itself will flow more easily and fluently.

In this case study the student's primary weakness appears to be a dysfunction in all areas of comprehension literacy. The focus of treatment should be on the primary weakness. He experiences weakness in the ability to express himself and describe what he is thinking, seeing, and feeling. His language comprehension disorder is noted in both written and oral language. Understanding and interpreting what he reads and what he hears, as was previously discussed, will affect him throughout his life as well as in educational performance.

The method of teaching reading versus the process of reading was clearly differentiated by Patricia Lindamood et. al (1997). They found by developing sensory-cognitive factors a conceptual base is established to assist students to become more successful readers and listeners. Small steps of reasoning help develop concepts. "This illustrates the conscious level of sensory feedback and

integration that must be experientially elicited through Socratic questioning" (Lindamood et al., 1997, p. 143).

Despite good decoding, many students (i.e., the case study student) do experience weak gestalt imagery (e.g., processing parts rather than the whole) from verbal stimuli, whether written or spoken. Symbol imagery processes the parts (letters), which is well developed in Tom and concept imagery processes the whole (gestalt). A gestalt creates a mental representation of the whole. It constructs a mental model of the situation that a writer or speaker is describing. Individuals with good comprehension appear to have automaticity in gestalt imagery and appear to comprehend with ease. Bell (1991a) noted, as previously discussed, that a gestalt is an organized whole unit that is more than the sum of its parts. Poor comprehenders experience difficulties in bringing the words together to form an imaged gestalt. Bits and pieces are processed but not the entire concept. Barnes et al. (2007) demonstrated that some children cannot naturally compensate for the absence of this rudimentary comprehension skill but can be positively affected by providing support to improve the student's ability to understand. Wolgast & Barnes-Holmes (2018) specifically noted metacognitive training as a method to negate this inability to be an active comprehender which good comprehenders utilize automatically. "Strategy research suggests that less competent learners may improve their skills through training and strategies evidenced by most successful learners" (Karbalaei, 2011, p. 5). Engaging in metacognition is a necessary factor when students utilize comprehension strategies like imagery (Block & Pressley, 2002). Since text comprehension is complex it requires integration of many different types of information to form an accurate mental representation (Kintsch & Rawson, 2005; Williams and Atkins (2010); Van Kraayenoord et. al (2012); Zipke et. al (2009).

The gestalt is the underlying issue of this article. The only reason to read or listen to language and take in verbal stimuli is to get meaning. If only a few parts have been grasped the main idea can't be discerned. A gestalt is an organized whole unit that is more than the sum of its parts (Bell, 1991a).

Bringing the whole together is not automatic for all students (Bell, 1991a; Pressley, 1977; Piaget & Inhelder, 1971). Higher order information can't be grasped if only parts have come to conscious awareness (Pribram, 1971, 1991). According to Pribram bringing the sensory imagery to consciousness is necessary for a student who needs a strategy to comprehend language. Therefore, words have no meaning, individually or connected, to form concepts without the input of sensory information.

The cognitive parts-to-whole issue (cognitive theory) was noted by Bell (1991a, 1991c); Bell & Bonetti (2006b); Lindamood, P. (1986); Lindamood et al., (1997) as a result of their extensive experience in language and literacy instruction. As previous discussed, Paivio's research and cognitive conceptualization of reading involves the activity of two distinct cognitive subsystems, a verbal system which specializes directly with language (logogens) and, a nonverbal system specialized for dealing with nonlinguistic objects and events (imagens). Within the verbal and nonverbal representative systems are associative links; between the two systems are referential connections. (See Sadoski & Paivio, 2013, 2nd edition, p. 37) for figure 3.1. This is general model of DCT shows the verbal and nonverbal systems including representational units and their referential and associative interconnections as well as connections to sensory input and response output systems. From *Mental Representations: A Dual Coding* Approach by Allan Paivio (1986), Figure 4.1 (p. 67). The coding mechanisms of these two subsystems are integrated (Sadoski & Paivio 2001, 2004, 2007, 2013, Sadoski & Krasny 2018).

Language comprehension underlies the reading process and oral language. It is based in the sensory system. In some individuals it makes processing gestalts difficult because the entirety of a concept is not processed in these students, just bits and pieces are retained.

Creating mental images during text reading can be compared to making a personal movie or utilizing a multisensory blackboard, which assists a student in both verbal and spatial tasks (Sadoski & Paivio, 2004). While making these mental images in the mind, past sensory memories from stories,

events, and feelings, can be reviewed in the mind (Long et al., 1989). Information stored in long-term-memory includes information from all sensory modalities that are relevant to the text. A richer multisensory model will be activated when processing information through both the verbal and non-verbal channels. When bridging information from the text, the reader's mental representation will support the process of comprehension and build a deeper understanding (Sadoski & Paivio, 2004).

Typical classroom instruction still tends to tell information, rather than questioning at the sensory level for discovery and sensory-language connections. The goal for Tom (i.e., the student studied) was to bring the sensory input of imagery to the conscious level and connect that imagery to language processing. Socratic questioning (e.g., an inquiry technique) assists in this process as it provides sequential stimulation. All thoughts rest on other thoughts in response to a question (Beach, 2004). In former years listening to the radio and recorded stories created auditory stimuli that promoted imagery. Today, television viewing provides images but does not stimulate images. It also takes away many opportunities to read, to experience storytelling, and to take part in language interaction time, especially in the family setting.

Paivio's Dual Coding Theory

This section will contain an explanation of Paivio's Dual Coding Theory which refers to the content of memory representations.

Paivio's Dual Code Theory (DCT), a general theory of cognition, refers to the content of internal representations in memory. It assumes these mental representations retain properties derived from perceptions in our various sensory modalities rather than being amodal (i.e., abstract). The mental representations refer to internal forms of information used in memory. Mental representations are organized into two separate coding systems: verbal information and nonverbal representations (e.g., referred to as images [Paivio, 1971, 1972, 1986, 1991, 2007, 2010; Sadoski & Paivio, 2001, 2004, 2007,

2013; Sadoski, 1985, 2004; Sadoski et al., 1988, 1991, 2012; Sadoski & Krasny, 2018; Paivio & Yuille, 1969]). A systematic program of research of forty years gradually evolved into DCT. This research has been extensively documented by Paivio.

Within the DCT theory one coding system specializes in language (verbal); the other coding system deals with non-linguistic events (e.g., nonverbal or imagery system). These systems can operate independently, in parallel, or in a connected integrated way. A key component to this theory is that imagery can evoke language and that language can evoke imagery (Sadoski et al., 1988). Verbal and nonverbal systems can independently function but have the capacity to cooperate through interconnections. ". . . all cognition including perception, memory, meaning, and knowledge must be accounted for by the operations off the representations within and between the two codes, and such an accounting can explain a great variety of literacy activities" (Sadoski & Paivio 2001, p. 66). An extension of the organizational characteristics of the verbal and nonverbal imagery systems is the ability to produce and increase higher order skills. They include the organization of incoming information and the ability to manipulate and transform information into new forms of higher order structures (i.e., logogens and imogens). For instance, connections between the verbal and nonverbal systems (imagery) would illustrate that a picture of a cat would activate the image of a cat in nonverbal systems and in turn, activate referentially related logogens in verbal systems and vice versa (Sadoski & Paivio, 2013). DTC (embodied theory) retains some of the concrete qualities of the external experiences which are derived from our five senses. To say that cognition is embodied means that it arises from bodily interactions with the world. From this point of view, cognition depends on the kinds of experiences that come from having a body with particular perceptual and motor capacities that are inseparably linked and that together form the matrix within which memory, emotion, language, and all other aspects of life are meshed (Thelen et al., 2001, p. 1). There are other imbodied theories but, they differ from DCT

> "…in at least one important way. Embodied theories in general do not distinguish the qualitative differences in the verbal and nonverbal codes that predict and explain phenomena such as the differences in the way we process concrete and abstract language, picture language effects in multimedia learning and so on" (Sadoski & Paivio, 2013, p. 5).

Cognitive processing that occurs in embodied cognition within DCT occurs in all sensory modalities (Wilson, 2002). Earlier work by Karl Pribram, 1971, who has conducted over forty years of research, stated that the amount of sensory processing available to a person is a primary factor in learning to read. Sensory cognition factors can be identified, stimulated, and applied to facilitate language and literacy development.

Lakoff and Johnson (1999) as well as Piaget & Inhelder (1971) maintain that all knowledge and reason is rooted in sensual experience. Another well-known educational theorist Maria Montessori (1967) acknowledged the bodily and sensory nature is essential to experience in learning. In DCT mental representations and processes are assumed to be derived from sensory experience and stored in modality specific form. They retain some of their original perceptual information. Cognition is based in sensory experiences and our modalities can be explained as sensorimotor in nature.

Sadoski & Paivio (2013) explained that reading comprehension is a theoretical construct because it is not directly obvious to the eye or ear. Embodied principles can be applied to reading and can be understood in observable experiential terms. They are available to all our sensory modalities. These researchers added the word "embodies" to move away from abstract, amodal theories of cognition and, to emphasize that cognition processes are rooted in the physical body's interaction with the world. There are other models of cognitive theory similar to DCT but they differ in methods of interaction. Baddeley's (1989) model explains that integration of verbal and nonverbal information occurs via the central executive, while DCT allows direct interaction between these two systems.

Modality Specific Representations

These modality specific representations can be derived from oral and written language, or they can be nonverbal. The nonverbal representations include images of nonlinguistic things that we have seen, heard, felt, tasted, touched, and smelled. DCT differs from other theories because it emphasizes the functional differences between the interconnected verbal and nonverbal codes.

Mental representations are organized in both the verbal and nonverbal codes. See Sadoski & Paivio (2004, p. 5) for a table depicting Orthogonal Relationship Between Mental Codes and Sense Modalities. They display both verbal and nonverbal encodings for each sense modality. For example, a visual verbal encoding such as a cat (the visual word form) or a mental representation of the visual letter form such as C. The nonverbal visual encoding might be "a cat cleaning his paws." The auditory verbal encoding could be a phoneme such as /b/ or the word pronunciation such as /bat/. The nonverbal auditory encoding might be the sound of a bat hitting a thrown ball, or the sound of a cat licking up milk in his bowl. A haptic verbal encoding might be the motor activities when handwriting the cursive form of cat or the sensation while touching the raised dots in Braille. (See Tomasino & Rumiati, 2013; Hertrich et al., 2016 for more information on the role of motor representations in language understanding). A haptic nonverbal encoding could be the heat and smoothness produced from a cup of hot cocoa. Using gestures (a nonverbal kinesthetic act) also assists a person's understanding to increase learning (Bell & Bonetti, 2006a, 2006b; Minoque & Jones, 2006; Block, et al., 2008; Wilson, 2002).

In the olfactory and gustatory sense modalities there are no verbal representations but, nonverbal representations can be experienced such as smell and taste memories. There has been some confusion and misunderstanding in research literature about the distinction between mental models and sensory modalities. DCT has been inaccurately defined as being about verbal and visual codes. A

correct explanation would be the distinction between verbal and nonverbal (imagery) codes and between the visual modalities and the other sense modalities (e.g., auditory, haptic, gustatory, and olfactory) as noted by Sadoski & Paivio 2001, 2013).

Mental Imagery Assists Comprehension

"A mental image is a perceptual representation or ideational picture of a perceptual experience, remembered or imagined" (Harris & Hodges, 1995, p. 152). Imagery use in literacy has been utilized since antiquity. (See Appendix B, Historic Perspective of Imagery).

A very positive impact of mental imagery training was noted in a large-scale reading intervention program (Sadoski & Willson, 2006). Imagery instructions may be more important for some populations than others (Levin, 1973). There has been a recent wave in researching wider comprehension deficits noted in poor readers, typically developing students, and students with specific language impairment (SLI). (Oakhill & Patel, 1991; Bishop & Adams, 1992). Developmental difficulties with reading comprehension were also noted by Nation & Norbury (2005) in students displaying specific impairments in reading comprehension, students with ASD, and children with specific language impairment.

SLI

Students with SLI were presented with two stories visually (in a sequence of pictures) and in spoken text. (Bishop & Adams, 1992). The students displayed lower levels than age-matched controls in ability to respond to questions on story content. These researchers felt that the lack of forming coherent and integrated representation impairs memory for story comprehension and specific story details.

Joffe et al., (2007) study demonstrated that children with SLI can be taught to generate mental images to represent story details. The visualization technique enhanced story comprehension by noting mental imagery enhanced both literal and inferential understanding. They further stated that the formation of self-generated images should be emphasized as children will not always be able to rely on text illustrations.

Specific Comprehension Deficits (Poor Readers)

Johnson-Glenberg's (2000) controlled experiment research studied fifty-nine grade three to grade five students who exhibited high decoding ability with low comprehension skills. Three groups participated in this research: a control group, a RT group (i.e., reciprocal teaching on comprehension strategies devised by Palinscar & Brown (1984), and the visualizing verbalization (V & V) program group (i.e., emphasis on associating language with multisensory mental images). An attempt was made to hold the V & V and RT training variables as constant as possible. Results noted that the V & V and the RT groups made significant gains on eleven reading, memory, and cognition processing measures whereas the untreated group made only one significant gain. When the RT and V & V groups were compared the RT group gained more on explicit factual material while the V & V group demonstrated higher gains in areas of inference and the ability to integrate concrete and imagery mediated information. Please note that the V & V programs utilizing the DCT of Paivio was the comprehension strategy utilized for Tom's supplemental instruction. Tom did not process information easily during spoken and written language comprehension. It appeared as if information went, "in one ear and out the other," (Patricia Lindamood, November 1986, *Visualizing and Verbalizing for Language Comprehension and Thinking,* p. ix [Forward]).

Typically Developing Children

Pressley (1976) examined imagery from a development level perspective and found it to be more effective in the upper elementary level of development (Ellis & Monaghan, 2002). Concrete

concepts are easy to develop but abstract concepts require maturity to access. Pressley's experiment with typically developing eight-year-olds was conducted to determine if they would benefit from instruction in mental imagery. The children were told that a good way to remember things is make "pictures in your head". They were encouraged to create representational images and were assured that their personal images would assist their ability to remember if they faithfully represented the text meaning. Instructions were scaffolded. The children were trained first with sentences containing two elements, then three elements, and finally to longer prose texts. The teacher's input regarding imagery faded gradually as students became more competent creating their own mental images. Students receiving the imagery training were better able to respond to story content questions than the control group (non-instruction group).

Three experiments involving visual imagery training were conducted by Oliver (1982) to determine if this strategy would improve reading comprehension in elementary school children (third to sixth graders). These results indicated that students should be instructed in the metacognitive skill of visual imagery to improve comprehension.

Sadoski et al., 1993, felt the student's ease of imagery usage was the overwhelming variable most related to comprehensibility and recall.

Students with ASD

Autistic students can display a paradoxical combination of good word identification coupled with poor comprehension ability. See studies for more information: (Goldberg, 1987; Patti & Lupinetti, 1993; Randi et al., 2010). The term "hyperlexia" has been formulated to describe extreme cases, those of a savant-like nature. Ostrolenk et al., (2017) completed a systematic review of hyperlexia highlighting that it is strongly associated with autism (84% of cases on the spectrum) and, that it is mediated by the

extended use of the perceptual expertise system. The initial search in this review resulted in seventy-five papers (database searching and 21 additional records found in reference list).

Cognitive style differences in children with ASD may affect reading comprehension. Difficulty integrating information in context (i.e., from a text or external knowledge) can place constraints on comprehension ability (Frith, 2003).

Research Findings

Most of this research centered on the use of the visual modality to create nonverbal mental representations (Gambrell & Bales, 1986). This process occurs within students' minds and cannot be observed. The mental representations in working memory do retain some of the concrete sensory experiences from which they were derived (Sadoski & Paivio, 2013).

Recall is aided by students who report a greater number of images (Sadoski, 1985). Mental images appear to play a central role in chunking information in memory and are formed and revised continuously during the act of reading (Kintsch, 1998; Kintsch, W. & Kintch, E. 2005). Building rich and elaborate situations in models of text is an effective strategy to improve text comprehension. However, Kintsch's single code theory assumes that text content in memory is basically abstract and amodal while DCT has two codes, verbal and nonverbal, which together account for knowledge of language and knowledge of the world.

Long et al., (1989) also conducted research on the importance of imagery development during reading activities. Their findings suggest that it appears to assist the capacity of working memory by chunking information, by making comparisons, and as a tool for coding and storing meaning from the text.

Large Scale Study

As previously mentioned, an independent evaluation of a large-scale study in Pueblo City School, Pueblo, Colorado was conducted by Sadoski and Willson (2006). Their systematic approach was to use Lindamood-Bell Learning Processes (LBLP) developmental and remedial programs for curricular comprehension and professional development programs. The Comprehensive School Reform (CSR) clinical model was incorporated in this large multicultural urban school district (PSD 60) to ascertain its effect on student reading achievement. Sadoski & Willson examined grades 3-5 achievement (1998 – 2003) to see if state mandated reading scores improved. The comprehension part of the program involved the use of the V & V technique; Seeing Stars (SS) Program was the primary decoding part of the program. The multisensory aspect of the associating mental images and language is found in both intervention programs and is consistent with DCT, a scientific theory (Sadoski & Pavio 2001, 2013). Similar schools in Colorado were compared after six years of Lindamood-Bell instruction and it was determined that Pueblo Schools were 96 points above the average of comparison schools. According to Joffe et al., 2007, this study noted a very positive impact of imagery training of reading comprehension. For more information on the Pueblo study refer to Owen, Keith (2004).

The student case history followed in this article will delve more into the lifestyle of an autistic child with highly developed decoding skills and poor comprehension ability (both written and oral language comprehension).

Theoretical Constructs of DCT

Theoretical constructs which correspond to the elementary units within each system are labeled logogens in the verbal system, and imagens in the nonverbal system. They are assumed to have a neurological basis and are the building blocks or basic units within the DCT framework. See Sadoski & Paivio, 2013, p. 37 for figure 3.1, “Dual coding theory: verbal and nonverbal representation systems”.

The cognitive building blocks, or the basic representational units of DCT, in the nonverbal system are imagens, alternatively called nonverbal encodings, mental images, or nonverbal representations (Attneave, 1974). An imagen could represent a natural object, the sound of that object, a part of that object or a natural grouping of objects. The basic representational units of DCT in the verbal system are called logogens and can be described as verbal representations, mental language, inner speech, and verbal encodings (Morton, 1979). Morton stated that a logogen could correspond to a phoneme, grapheme, word, phrase, or a larger familiar unit such as words making a sentence or sentences making connected text. These alternative terms or jargon presented above are listed because different researchers and authors frequently use them in their work to represent the two basic units in DCT. The structural processing of logogens and imagens in DCT "imply each other; structure derives from perceptual processing and behavioral usage, and, as it develops, structure constrains processing" (Sadoski & Paivio, 2013, p. 35).

DCT Processing Levels

The two separate mental subsystems or codes have different organizational and processing characteristics. The verbal code is organized sequentially into longer and longer language units while the nonverbal code is organized into increasingly longer holistic nested units. The basic processing levels in reading as found in DCT are:

Representational: (A) the initial activation of one or both systems; (B) direct activation of mental representations and are labeled logogens in the verbal system: images in the nonverbal system.

Referential: (A) the activation of connections between systems; (B) concreteness is a key stimulus factor as mental imagery is more likely to be produced by concrete language.

Associative: (A) activation of connections within a system; (B) example of associative networks of organized vocabulary items.

All mental representations retain some of the concrete qualities of the external experience from which they derive (DeKoning & van der Schoot, 2013). The codes are activated directly by perception or indirectly through connections within and/or between the codes. Activation and processing can occur at any of the three levels discussed above. The activation of a mental representation initiates processing in the cognitive system for meaning to occur. As we experience different aspects of comprehension the memory structures are activated (i.e., processed). Mental imagery forms an important aspect of context by representing knowledge of the world. The mental connections between language and the nonverbal experience to which it refers serve to provide concrete referents for the language.

For example, if one is thinking about a summer ocean beach scene, you would see the colors of the ocean water, the sand, the sky; hear the roar of the waves; feel the scratchy sand on your feet; smell the salty air; recall the taste of ocean water that you swallowed when hit by a wave. You might also have an emotional fear if a forceful wave previously knocked you down. Language and imagery are not generated from an abstract base (i.e., amodal). Knowledge and meaning occur through direct interconnections between the systems. Individual patterns can be altered by individual differences and external instruction. Both the degree and kind of processing can be experienced (Paivio, 2007). For a general model of DCT see Sadoski & Pavio (2013, p. 37, figure 3.1).

US Literacy Concerns

Reading standards have come under close scrutiny since 1981, as some students appear unprepared for the rigors of high school and college curricular, technical school and employment opportunities (National Association of Educational Progress, NAEP, 2019). The previous standard for the United States was the ability to read a simple sentence. This definition has changed and is presently defined "as the ability to use printed and written information to function in society, to achieve one's goals, and to develop one's knowledge and potential" (National Assessment of Adult Literacy, NALS, National Center for Educational Statistics, NCES, 2019). It was reported that 13- 17year-old students struggled with inferential and interpretive comprehension by the NAEP. The NAEP is recognized as the "gold standard" of large-scale assessment of academic achievement which includes reading achievement and is referred to as "The Nation's Report Card " (2013). Durkin (1981) reviewed five basal reading series to see how reading comprehension was taught. It was noted at this time comprehension instruction consisted of "testing" for comprehension. Pressley (1998) found that some opportunities to practice strategies were provided in respect to comprehension instruction but, overall, there appeared to be very little teaching of comprehension within the school's curriculum. The explicit teaching of text comprehension was not done during formal reading instruction, but sometimes conducted in content areas (Durkin, 1978).

Low literacy levels were also previously reported in 1992 for adults. 48% of Americans, as found by NALS, 1992, do not have functional reading skills. In the same year colleges and universities reported that 30 to 40% of freshman were reading below the seventh-grade level. There appears to be a need for much more comprehensive instruction at the secondary level and beyond as noted by Pressley, et al., 1992.

1997 In 1997 the National Reading Panel (NRP) was formed as a response to a congressional directive to review scientific literature to determine the most effective methods to teach reading to children.

2000 According to the report from the National Reading Panel (NRP, 2000) almost 20% of the students in the United States face severe reading difficulties prior to third grade. See National Institute of Health (NIA) Publication No. 00-4754, Washington, DC: U.S. Government Printing Office. In Chapter 4, Part II: Text Comprehension of the NRP, 203 studies were reviewed and examined after meeting the Panel's criteria for inclusion as scientific studies. These studies adopted rigorous research methodological standards. Five studies reviewed for comprehension specifically centered on the use of "mental imagery" (Chapter 4, pgs. 60-61) as a strategy for comprehension. The NRP report reviews scientific evidence in normal readers with respect to text comprehension. The panel also noted that the studying of cognition assisted in the development of practical strategies, over a period of approximately three decades, in order to improve students' comprehension. It also stated that achievement is assisted by providing prereading intervention in kindergarten. The same recommendation was proposed by the National Institute of Child Health & Human Development (NICHD), 2005. There is a growing need for preventive prereading intervention directed at kindergarten children who are at risk for reading problems (Velluntino & Scanlon, 2001; Velluntino, Scanlom, Sipay et al., 1996; Velluntino et al., 1998; 2006; 2007). This is important to help children to achieve at reading according to NICHD's report. School readiness was also a topic of concern by both the National Center for Educational Statistics (NCES) (2007) and the National Early Literacy Panel (2008). Greenwood et al. (2011) concluded that the quality of instructional support in preschool programs with language and early literacy goals was low and variable. Listening comprehension was one domain included within this study.

2001 The No Child Left Behind Act (NCLB: 2002, p.11) concluded that it was necessary "to ensure that every student can read at grade level, or above, not later than the end of grade 3". This is important in elementary curriculum because by grade 4 students are expected to read to learn, not learn to read, as found in the lower grades of elementary school. NCLB requires students with autism spectrum disorder (ASD) to perform at a higher level than previously required. Only 1% of students are exempt from taking standardized tests (Federal Department of Education) while the ASD population continues to rise. See Klein, 2023; Hickok, 2002.

2002 The Rand Study Group (2002) defines comprehension as a process of extracting and then constructing meaning from text. An important factor found in proficient readers was their ability to mentally visualize text content, as noted by Snow (2002), in Reading for Understanding Toward an R & D program in reading comprehension.

2004 Individuals with Disabilities Educational Improvement Act (IDEIA) was reauthorized (https:sites.ed.gov.idea>about-idea). Its goal was to reduce the number of students who are identified as having learning disabilities. Response to Intervention (RTI) was a recommended practice in this authorized special education law. RTI followed a research-based approach to the identification and support of students and included a general education initiative, presently called RTI. In December 2015 Congress passed the Every Student Succeeds Act through Public Law 114-95.

2005 The National Governors Association (NGA, 2005) reported that 40% of high school graduates lack the literacy skills employers seek.

2010 National Governors Association Center for Best Practices & Council of Chief State Officers convened, in a state level endeavor, (Common Core State Standards [CCSS]), which had the literary purpose to integrate reading, writing, speaking and language. This standards' document

is increasingly specific about requirements in each area and expects teachers to integrate the Core Standards into their instructional routines. It highlights the importance of strong professional development (Piasta et al., 2009). Teachers will need the knowledge and skills to implement metacognitively oriented reading interventions (Williams & Atkins, 2010). Essential components include research-based instruction and successive tiers of intervention. As too many students are unprepared for college, careers and life (CCSS Appendix A, 2010, p. 3) it requires 55% of middle school students' reading to be anchored in informational texts; and 76% of high school reading should be informational texts. By the end of twelfth grade, students should read proficiently and independently (CCSS for English Language Arts, 2010, p. 5). Informational text presents challenges for reading comprehension as they have distinct and complex text structures when compared to literary fiction (Maloch & Horsey, 2013).

Students normally settle for shallow levels of representation. Training is needed to adjust their metacognitive expectations and focus on the deepest levels (RAND Reading Study Group, Snow 2002). The CCSS emphasis is an "independent ability" for students in both reading and the use of complex informational text.

2012 The National Assessment for Educational Statistics (NCES), is known as The Nation's Report Card: 2010, noted:

> Thirty-five years of persistent low achievement scores in the United States, a general flattening of reading achievement progress, or the lack of progress for some students with learning difficulties. Finally, it reported that interventions during adolescence were generally ignored while solely emphasizing early education interventions (NAEP, 2013 [20402-6328] p. 191).

2013 The National Center for Educational Statistics (NCES) reading results demonstrated that adolescents lack the literacy skills necessary to succeed in high school, college, and the workplace.

Eighth grade recent student scores in literacy skills demonstrated a 36% score at or above the proficient level; 64% score at the basic level or below.

Twelfth grade recent scores in literacy skills demonstrate a 38% score at or above proficient level; 62% scoring at the basic level or below.

2019 National Assessment of Educational Progress (NAEP) Reading Comprehension Assessment (Literary & Informational Texts). The average reading score declined between 2019 and 2017 as reflected at all selected percentiles except for the 90th percentile in grade 4 and at all selected percentiles in grade 8. Lower performing eighth graders showed greater score losses than middle and higher performers.

Fourth grade average reading score was lower compared to 2017. 34% performed at or above the basic level (partial mastery of the proficient level skills).

Eighth grade scores were three points lower when compared to 2017. 73% performed at or above the NAEP basic level; 4% performed at the Advanced level.

Twelfth grade average score was two points lower in comparison to 2015 NAEP reading average score. The average score was seven points lower when compared to 1992.

"The research results to date support inferences about NAEP performance and academic preparedness for college at the national level" (NAEP, 2019, p. 4). https://www.nationreportcard.gov/reading/?reading=12.

2019 Secretary of Education (DeVos, 10/30/2019) said “Two out of three of our nation’s children aren’t proficient readers, and the gap between the highest and lowest performing students is widening” https://www.breitbart.com/politics/2019/10/30/nations-report-card-no-progress-in-either-mathematics-or-reading-performance-in-decade/.

2021 Governing Board Statement on Postponement of NAEP 2021.

At the Governing Board’s November 19-20 meeting, NCES presented compelling data, which convinced board members that COVID-19 related conditions prevent NCES from administering NAEP safely to a sufficient and representative sample, and reporting results in a valid and reliable manner consistent with NCES’s statistical standards and the NAEP Authorization Act. Thus, the Governing Board believes a 2022 administration of NAEP reading and mathematics at grades 4 and 8 would be more likely to provide valuable and valid data about student achievement in the wake of COVID-19 to support effective policy, research, and resource allocation.

For more information see https://www.nagb.gov/news-and-events/news-releases/2020/governing-board-statement-on-postponment-of-naep-2021.html.

At this point what does research demonstrate in respect to this decision by the governing board? Since the advent of the COVID-19 pandemic children’s daily routines: educational, social and family lifestyles have been disrupted.

Early child development, especially in language development may be impacted, especially in receptive and expressive skills. This area of study has not been widely accessed. However, a longitudinal observational study on early childhood development notes “preliminary of reduced

verbal performance when compared to pre pandemic born children" as noted by Charney et al., 2021. For more information see Rocha (2001); Deoni, et al., 2022.

Also, not widely assessed, is the specific effect of mask use during the pandemic. For more research information on effects of masks on school children's health see: Sonnichen et al., 2022; Bourke et al., 2023; Mull, 2021; Truong et al., 2021; Tohidast et al., 2020.

Earlier NCES reading results in 2013 previously discussed in this article, demonstrated the basic level of reading to be at or below 64% for eighth grade students. Results of the twelfth-grade students show 62% reading at the basic level or below. The National Governors Association (2005) stated that 40% of high school graduates lack the necessary literacy skills sought by employees. See for more information, National Governors Association (2005), Reading to Achieve: A Governor's Guide to Adolescent Literacy. Washington DC: Author. For information on evidenced-based practices demonstrated to improve reading comprehension outcomes for middle and high school students, see https://ncesed.gov/pubsearch/pubsinfo.asp?pubid=2013456, as well as Torgesen et al., 2007; and Biancarosa & Snow, 2006. Many of these recommendations can be utilized as strategies for informational fictional or procedural text.

2021 The most recent indicator of the nation's progress in adult skills (age 16 and older) in literacy is reported by the NCES. It is a large-scale assessment of adult skills called the Program for the International Assessment of Adult Competencies (PIAAC), Institute of Education, U.S.

Department of Education. See results from the first round of NCES which describes the PIACC as the "most current indicator of the nation's progress in adult skills in literacy, numeracy, and problem solving in technology rich environments" (NCES, 2016). U.S. data collection was released in 2013; results from the combined U.S. PIAAC 2012/2014 data were released in 2016.

These results give the percentage distribution of U.S. adults at 16 to 65 at selected levels of proficiency in three aspects of literacy:

- Below Level One – tests in familiar topics in the ability to locate a single piece of information, 0-175 points
- Level One – respondent reads a short statement and locates a single piece of information given in the question or directive, 176-225 points
- Level Two – respondent integrates two or more pieces of information; respondent contrasts or reasons about requested information, 226 – 275 points
- Level Three – tasks require the respondent to identify, interpret or evaluate one or more pieces of information that can require inference levels, 276-325 points
- Level Four – tasks require respondents to perform multi-step operations to integrate, interpret or synthesize information from complex or lengthy tests, 326 – 375 points
- Level Five – tasks require the respondent to search and integrate information from multiple, dense texts, synthesize points of view or evaluate evidence-based arguments, 376 – 500 points.

Data Released in 2016 (combined U.S. PIAAC 2012/2014 Data)

Year	Percentage Distribution	Level
2012/2014	18%	Level 1 or below
2017	19%	Level 1 or below
2012/2014	33%	Level 2
2017	33%	Level 2
2012/2014	50%	Level 3 or above
2017	48%	Level 3 or above

In PIAAC, results are reported as averages on a 500-point scale or as proficiency levels. Proficiency refers to competence that involves "mastery" of a set of abilities along a continuum that ranges from simple to complex information processing tasks. (NCES, PIAAC Data, 2016).

Based on these assessments and studies it does not appear that the number of students who are identified as having reading disabilities has been reduced. More research needs to identify supplemental comprehension instruction that will assist students to understand increasingly complex texts so that adult outcomes will be improved.

Many of the government sponsored panels in the United States have noted a lack of preparedness for students in respect to college, careers, and life in a technological society. The CCSS stated that "too many students are reading at too low a level (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010) and are concerned about students' understanding of complex informational texts (CCSS Appendix A, p. 3). Also see "the literacy of America's college students" (2006) the National Survey of America's College Students (NSACS) which examined literacy along three dimensions, prose literacy, document literacy, and quantitative literacy. Students were tested "nearing the end of the college program" (Baer et al., 2006, January).

Ensuring that students can read and use complex informational texts "independently and proficiently" by the end of grade 12 is a challenge to the educational community. Furthermore, the NRP (2000) specifically recommended that students be taught metacognitive skills as part of their reading instruction. Metacognitive skills do not develop automatically with increasing age and experience. Time is needed to enhance comprehension by using curriculum that emphasizes deep comprehension and strategies (Thiede et al., 2012). It is important to compensate students who do not naturally possess rudimentary comprehension skills. These deficits (both cognitive and metacognitive) require carefully

considered interventions and are effective when taught individually or in combination (NRP, 2000). (See Michalsky et al., 2009; Zipke et al., 2009; Williams & Atkin, 2010; Van Keer & Verhaeghe, 2005; Thiede et al., 2012; Van Kraayenoord et al., 2012 for further research on metacognitive skills).

The NRP (2000), noted in the report of the subgroups, that lessons presented with both cognitive and metacognitive strategies shown through meta-analysis are effective when individually taught or in combination. Comprehensive meta-analysis produces a positive result on metacognitive knowledge and control but, also on reading comprehension. It was also specifically noted by the panel that mental imagery is a category of reading comprehension because the readers improve memory and text comprehension.

An interesting suggestion by Vellutino, Scanlon & Tanzman (1998) was that only 1.5 – 3.0% of struggling students have learning disabilities (LD). They felt that readers who are struggling readers had received "inadequate pre-literacy experience, inadequate instruction, or some combination, of both" as noted by MacPhee et al., 2015, p. 172.

Single Case Study: Report of clinical management of a young male student from preschool through high school transition

Tom is a fourteen-year-old young man, presently with Autism-Mild; ADHD-Inattentive Type; Specific Learning Disability in reading; and Generalized Anxiety Disorder. He lives in an intact supportive family (mother, father, younger sister, and a one-year-old puppy). Tom's home environment provides rich literacy experiences: access to books, which place an emphasis on reading and writing materials, and frequent family interactions and family trips and discussions (Snow et al., 1998; Teale & Sulzby, 1986; Whitehurst & Lonigan, 1998; Hart & Risley, 1995). He does not take any medication. Developmental milestones appeared normal until Tom was one and one half. Severe language

development delays were noted at this time and Tom's parents were also concerned with newly developed eating problems. Hypersensitivity to sounds was a further concern. Prenatal history was unremarkable. Tom was born at 40 weeks gestation via cesarian section secondary to breech positioning. Birth weight was eight pounds. Postnatal complications were denied. Medical history was significant for peanut allergy. General health was reported to be good. Tom was a happy chubby infant who enjoyed food and frequently smiled. At this time, he displayed an obsessive interest in symbols (i.e., numbers and letters); however, he did not appear engaged when listening to a story read to him. It is reported that, later in the same day, he would pick up the book, sit on a sofa and slowly page through the book.

At two years of age (11/28/2008) Tom was evaluated privately by a Speech Language Pathologist with the following observations:

> His first words were heard at one year of age. At this time Tom is not combining words. According to his mother, Tom has about five words in his vocabulary. She first noticed him not speaking much at 18 months of age, but the pediatrician advised her to wait until he was two years of age before evaluating him. Parents continued to be concerned, therefore, requested assessment. (See Appendix C for summary and test scores on 10/28/2008).

Early Intervention System services were then requested by parents. It was determined that Tom was eligible for speech/language and academic services. No reports are available but, summary statement is included in Appendix C (9/10/09). Services were provided in the home setting twice each week.

Tom attended a Preschool Multiply Handicapped class in a public-school setting for two years after being diagnosed as a student with Pervasive Development Disorder, Not Otherwise Specified (PDD-

NOS). The school district he attends has a high rate of autism, with one-in-fourteen 8-year-old children on the autistic spectrum. This was reported in the *Asbury Park Press* (Washburn, June 20, 2021) as researched by the Federal Centers for Disease Control's Autism Monitoring Network. His kindergarten year was comprised with a half day in the multiply handicapped setting followed by a half day in a regular kindergarten class, to give him socialization experience within a regular education curriculum. During his kindergarten year Tom narrated from memory a production of The Little Red Hen on a small stage within his classroom before students, families, and principal.

He was then evaluated (5/10/13) by a private Speech Language Pathologist and Pediatric Feeding Specialist. Home services were provided once a week for sixty minutes from 5/10/12 to 5/10/13. The evaluation summary noted that:

> Tom, a boy six years, six months of age, presents with a feeding disorder characterized by an inability to accept a wide range of foods for growth and nutritional needs. He presents with a
>
> Receptive Language Disorder characterized by a difficulty with understanding verbally presented information and following directions. Tom presents with an Expressive Language Disorder characterized by a decreased ability to utilize verbal language functionally and efficiently for learning, play and social interaction. Tom presents with an Articulation Disorder characterized by a decreased ability to functionally produce and connect speech sounds for clear and efficient verbal communication. (See Appendix C for tests administered and scores on 5/10/13).

In June of 2013 a Neuropsychological Evaluation was conducted privately at his parents' request because language concerns continued and, because Tom was entering first grade. His parents indicated that he continued to be fascinated by symbols and would watch the television programs of Wheel of Fortune and the Price is Right with great enthusiasm. At this time, he also displayed interest in playing

with small cars, lining them up and counting them, and making ramps for the cars to race down. The complete summary of the June 2013 Neuropsychological is included below:

> Test results indicate a standardized administration of the WISC-IV. Tom obtained a Full-Scale I.Q. of 88; on the WIAT-III results indicated that he was performing at or within grade-based expectations in all areas with the exception of early reading skills and math problem solving. Tom struggled with items that placed a greater demand upon expressive language skills. The CELF-Preschool-2 revealed that he continued to struggle with word structure, increased language demands, and reciprocal conversation skills. In addition, as part of his difficulty with expressive language, Tom has a difficult time quickly retrieving language. It is very likely that Tom does not understand some classroom instructions, particularly the more complex ones. He is unable to express himself at an appropriate developmental level. Although, according to these results, he has been able to learn according to his potential in some areas, the areas of
>
> expressive writing and reading comprehension are very important ones that will grow in importance and complexity in the coming years. Therefore, focused intervention strategies and careful monitoring is warranted as he progresses in elementary school. Lastly, Tom continues to meet criteria for an Autism Spectrum Disorder with associated language deficits based upon his history, previous evaluations and behavioral observations. While he has made progress, he continues to struggle with symptoms of Atypicality and Withdrawal endorsed by both his mother and his teacher. In addition, he also has deficits in adaptive functioning that should continue to be addressed. In both this evaluation and the previous evaluation (2010) Tom was mildly inattentive and needed prompting to maintain focus on the task at hand. At times he appeared mildly anxious as noted but responded well to short breaks and words of encouragement. (See Appendix C for 2013 administered tests and scores).

Grades One through Five

He entered first grade in the 2013 school year in a regular education public school setting with a shared aide. No aide was provided in second grade. Special education services were provided individually in Speech/Language two times per week, and occupational therapy as well as a pullout resource room program for language arts and mathematics.

Beginning in the fall of second grade Tom received private instruction, two times weekly, after school in the Talkies and the Visualizing and Verbalizing programs (i.e., specialized intensive comprehension programs). In the sixth through eighth grade (i.e., intermediate school) instruction was reduced to once weekly, due to his interest in participation in sports programs (i.e., track, cross-country, and basketball). Remote schooling occurred in mid-seventh grade and part of eighth grade due to the Covid-19 Pandemic when specialized instruction was discontinued.

Third grade records demonstrate an in-class resource setting for language arts, reading and mathematics, with reduced speech/language therapy (monthly) in a group setting and consultative occupational therapy. Tom's remaining years in elementary school reveal the same schedule, except for occupational therapy from which he was discharged.

Tom loved to read aloud and was thought to be a precocious reader but struggled with comprehension both written and oral. A specific discrepancy was viewed between reading words and understanding words and connected text. Understanding text passages is subsumed by understanding word meanings. Both linguistic skills and cognitive skills are affecting Tom's ability to comprehend. Other facets observed were his continued obsessive interest in symbols (letters and numbers), early spontaneous emergence in decoding skills, and the discrepancy between reading comprehension and other cognitive skills.

As Tom progressed throughout elementary school he participated in many activities. Both the activities and behavioral observations will be discussed in this case history section. His "Birthday Book" in second grade contains a comment by a peer, "I know that I'll have a good day in school if Tom is there". He willingly participated in on-stage school spelling bees, joined chorus and made announcements and introductions at school performances. Tom auditioned for the part of Master of Ceremony in the fifth-grade talent show. He was selected for this role and a teacher commented to Tom's parents "He blew everyone else out of the water" during his audition.

Third Grade Evaluations

Tom was evaluated by his Child Study Team in third grade at the triennial reevaluation (September and October 2015). Psychological, Speech and Language, and Educational Assessments were administered as well as a teacher interview (see Appendix C for summary and scores of tests administered).

Tom was also observed and evaluated in one testing session at Eden Autism Services Outreach Department in December of 2015, for an abbreviated evaluation including executive functioning due to parental concerns about continued variable attention span.

> He demonstrated deficits in executive functioning and was best described as meeting the diagnosis for ADHD Inattentive Type in addition to his other diagnoses referenced above. Furthermore, Tom's academic skills were assessed using select subtests from the KTEA-II to further evaluate his reading comprehension. His score fell in the Low Average and was equivalent to a mid-second grade student, as he struggled with inferential reasoning and prediction. To further access Tom's language abilities given his history and ongoing parental concerns, he was administered select subtests from the CASL. Results revealed that his language abilities were largely below age-based expectations, with significant weaknesses in

pragmatic language, inferential language, and application of knowledge in language-based interactions. While he has made significant progress, he continues to also struggle with word structure, increase language demands, and reciprocal conversation skills based on informal observations and results of a recent evaluation by the Child Study Team. Lastly, Tom demonstrated deficits in simple and sustained auditory attention, processing speed, code switching and inhibition. These findings suggest the possibility of Attention Deficit Hyperactive Disorder (ADHD), primarily inattentive. Based on these results, Tom continues to meet criteria for an Autism Spectrum Disorder with associated language deficits based upon his history, previous evaluation, and behavioral observations. In addition, he also has deficits in attention span and executive functioning that should be closely monitored. While his teacher did not endorse symptoms at this time, these deficits appear to be contributing to his overall presentation and should be further evaluated as he makes progress in language abilities. (See Appendix C for scores of tests administered on 12/2015).

It was recommended in the Diagnostic Report (12/28/2015) by Eden Autism Services, that Tom would benefit from Occupational Therapy, as he has made significant progress, but still has areas of weakness that should be addressed. Tom should participate in individual speech therapy at school twice a week, given his language deficits which include expressive language delays, poor word structure, poor sentence structure, pragmatic language deficits, and poor inferential reasoning. He should also participate in group-based speech or social skills therapy to address the application of pragmatic language and related skills which can negatively impact peer interactions. Further recommendations include ’s that Tom’s family should participate in private speech therapy outside of school to further his progress and promote generalization of skills. It is important that there is communication between the school-based therapist and the private therapist. One of the most important issues to keep in mind is that children with Tom’s

profile often give the impression they are much more capable than they are. However, their deficits can affect them in many areas. His teachers should therefore be aware of his cognitive profile and become familiar with his deficits and strengths. Tom continues to struggle with sustained and divided attention that is likely further exacerbated by his language deficits. Therefore, he would benefit from a study skills class when available in the school setting. He would also benefit from breaking down long-term assignments into smaller manageable units.

2015 Language Evaluation Results/School Literacy Language Decision (Third Grade)

Despite the low scores and recommendations noted in the September and December reports in tests of language development (2015), Tom's speech/language therapy at school was reduced from twice weekly (individual) to once monthly (group). The language difficulties appeared severe enough to have continued individual language instruction two times weekly. However, he did receive pragmatic language instruction once monthly in a group setting. See Table 1.

2015 Language Evaluation Results/School Literacy Language Decisions (third grade)

Table 1: Language Evaluation Results from the Child Study Team's Triennial Reevaluation (9/18/15; 9/16/15; 10/16/15 and Neuropsychological Services (12/28/15)

9/18/15 **Illinois Test of Psycholinguistic Abilities 3 (ITPA-3)**

The Illinois Test of Psycholinguistic Abilities 3 was administered to assess Tom's linguistic abilities. Composite scores have a mean of 100 and a standard deviation of 15. A standard score quotient between 85 and 115 is considered within the average range. Tom yielded a Spoken Language Quotient of 83 which falls within a percentile ranking of 13%. (See Appendix C for the subtest and composite quotients enumerated).

9/18/15 Test **of Language Development-1:4 (TOLD-1:4)**

The Test of Language Development (TOLD-1:4) was administered to assess receptive and expressive language skills. Tom achieved a Spoken Language Index of 69 and a Percentile Rank of 2%. A Spoken Language Index Score between 85 and 115 is considered to be within the average range. (See Appendix C for the subtest and composite scores enumerated).

9/16/15 **WJ-III Tests of Achievement**

	SS	AE
Oral Language (Ext)	77	6-6
Oral Expression	87	7-1
Listening Comprehension	68	6-1

10/16/15 **Psychological Reevaluation *Wechsler Intelligence Scale for Children – Fifth Edition (WISC-V)***

Subtest scores summary for the WISC-C (mean score = 10 for each subtest)

Verbal Comprehension	
Similarities	8
Vocabulary	5

(See Appendix C for all composite scores).

12/28/15 **Comprehensive Assessment of Spoken Language (CASL) Diagnostic Evaluation**

Subtest	Standard Score	Qualitative Description
Nonliteral language	74	Borderline
Inference	77	Borderline
Pragmatic judgment	66	Mildly Impaired

(See Appendix C for all composite scores)

Comments/Summaries from Child Study Team Triennial Reevaluation (9/2015)

Tom's resource teacher, when interviewed during the Child Study Team Reevaluation stated, "Tom has a difficult time with summarizing, inferring and higher order questions. He has difficulty expressing his ideas verbally and in writing and can be reluctant to ask questions".

Tom was given two formal receptive and expressive language assessments during the Speech/Language Evaluations. Results indicate Tom's strength for phonemic awareness with sound deletion and rhyming. Weaknesses were revealed for listening, organizing language, grammar usage and semantics. At this time, it appears these weaknesses continue to negatively impact Tom's academic functioning. These assessment results will be presented to the Child Study Team for their consideration.

Summary from the Educational Evaluation states low average range in Reading Comprehension, Oral Expression, and Academic Applications; low range in Oral Language (Extended) and very low range in Listening Comprehension.

Comments and Recommendations from the Diagnostic Evaluation Report (12/2015) Neuropsychological Services

Recommendations:

1. Language Areas

a. Tom should focus on building sight word vocabulary and expanding his basic vocabulary. Pre-teaching vocabulary words before presenting them in print is vital to address his general weakness in this area. In order to extract meaning from text, a strong sense of semantics is required. That is, children must understand what words mean before they can construct an understanding of text passages. Therefore, this must be a priority to address his observed deficits.
b. When Tom appears tuned out or confused, these cues should be recognized in order to provide repetition or some other form of reinforcement of the message. Above all else, avoid embarrassing him in the classroom. When calling on him in class, his teachers need to be aware that he may not understand the question. Several things can be done to combat this. The teacher may need to repeat the question. Reword it, simplify it. Or he/she could warn Tom ahead of time that he/she will call on him in class. In addition, avoid calling on Tom when it is obvious, he does not understand. Finally, phrase in-class questions so that Tom can respond "yes" or "no."
c. Do not give Tom multi-step directions, as he will become confused. As shown by the results of this examination, Tom may at times miss details of complex information that is presented verbally. It is suggested that his teacher ascertain that Tom has understood the instructions so that they can be re-stated in a simpler form if he has not done so. In addition, use of visual strategies is suggested to enhance comprehension.

2. Reading Recommendations
   a. Tom requires continued support/remediation in reading.
   b. Tom may benefit from a reading program like Visualization-Verbalization, given his deficits and underlying diagnosis of ASD. Instruction in visualization should also be incorporated into reading and this could be done utilizing imagination or having him draw pictures of the characters, scene, etc.
   c. Empirical literature (Sadoski & Wilson, 2006; Center et al., 1999; Brown et al., 1995) found statistically significant correlations between visualization training and reading comprehension scores of students when used as part of a multiple-strategy instruction intervention.

These deficits are often observed in children with an Autism Spectrum Disorder and are consistent with Tom's history. They indicate the need for continued speech and language services with a strong focus on pragmatic language and inferential reasoning.

Fifth Grade

Tom's records in the fifth grade (2018) state that he was currently receiving in-class support for reading, writing, science, and social studies. Group speech consultation is received once per month for twenty-five minutes. Occupational therapy services were discontinued. Tom will be attending intermediate school in sixth grade.

A Neuropsychological Evaluation was performed in 2018 (3/2/2018 and 4/10/2018) due to ongoing parental concerns.

Tom's complete history is well documented in his clinical records and while it was reviewed, it will not be detailed in the scope of this report. Tom was diagnosed with Attention Deficit Hyperactivity Disorder Inattentive Subtype and Autism in the past. When he was younger, he reportedly engaged in more hyperactivity, this improved as he matured. There have also been symptoms of Anxiety noted which is commonly observed in children with Autism Spectrum Disorder. He is currently in the fifth grade and has an IEP that states he is receiving in-class support for reading, writing, science, and social studies. He also receives group speech consultation once per month for 25 minutes. Socially he has made a number of friends and participates in extra-curricular activities at this time. Tom is a lovely young man referred for an updated evaluation for educational and treatment planning. His overall cognitive abilities as assessed by the WISC-V fell within the High Average range (FSIQ 115). He had a statistically significant strength in working memory and processing speed. However, he had a relative weakness in vocabulary and his ability to express or recall his breadth of knowledge, which may be related to his history of language delays. Academically Tom's mathematics and written expression were generally within or above grade and age-based expectations. While Tom's

basic reading skills were within expectation, his reading comprehension was an area of weakness as he continued to struggle with inferential reasoning and prediction. Therefore, Tom is best described as meeting the criteria for a Specific Learning Disability in the area of Reading at this time. There is evidence of problems with executive functions and with inattention that are manifested both at school and at home by history. Evidence for this includes his mother's endorsements, self-report history, and comments of previous evaluations. That is his parents report inattention at home, plus executive dysfunction (e.g., shifting tasks, planning, organizing

his environment and materials). Executive dysfunction is considered by many to be the key element in ADHD. Results of the DKEFS suggest that Tom's executive functioning is variable as he struggles with abstraction, impulsivity, variable cognitive flexibility on visual tasks, variable self-monitoring skills on visual tasks, and challenges maintaining a cognitive set on visual tasks, especially as task complexity grows. These results are consistent with his previous diagnosis of ADHD and an Autism Spectrum Disorder. Given Tom's clinical presentation, he was further evaluated for emotional and behavioral health concerns. Based on results of a clinical interview, a review of his history and results of the BASC-3, Tom is best described as meeting criteria for Generalized Anxiety Disorder at this time. He displayed mild symptoms of anxiety including worrying, test anxiety, worrying about academic performance, and feeling anxious in novel situations. His mother also endorsed symptoms of anxiety during the clinical interview and on the BASC-3 (i.e., an integrated system designed to identify a variety of emotional and behavioral disorders of children). Tom's special education teacher also completed the BASC-3 assessment. When asked about his strengths, she described him as the most kind and caring young man. She reported that he assists others, encourages others, and celebrates others. She also reported that he has excellent manners and work habits. When asked about specific behavioral and/or emotional concerns, she reported that Tom can get overwhelmed at times. More specifically, she reported that he tends to fret about the unknown. However, she reported that he has learned to communicate his feelings as the school year progressed. She noted no significant concerns on the BASC-3 but did endorse some isolated symptoms of anxiety and learning problems in the area of reading at this time.

Anxiety can have negative effects on all students but especially those with comorbid ADHD. Students with anxiety problems tend to demonstrate lower levels of academic achievement, as they can suffer from academic anxiety. Even students who do well on classwork and homework

can suffer from test anxiety and do poorly on tests when in a state of anxiety (Bensoussan, 2012). This should be closely monitored as Tom's progresses in school. Based on these results Tom meets criteria for Autism Mild, ADHD Inattentive Type, Specific Learning Disability in Reading and Generalized Anxiety Disorder (GAD). (Refer to Appendix C for tests administered and scores).

Sixth through Eighth Grades

After transitioning to Intermediate School, Tom no longer received direct therapy services. His schedule noted inclusion classes. As previously discussed, in mid-seventh grade he participated in remote schooling due to the Covid-19 Pandemic. At this point supplemental V & V instruction was discontinued. He returned to in-class instruction during eighth grade and was exposed to and contracted the virus. Since Tom is transitioning to high school a summary of his 2021 Neuropsychological Evaluation is included below.

Eighth Grade (4/25/2021) Neuropsychology Evaluation Private Evaluation due to Parental Concerns

Tom is a wonderful young man referred for an updated evaluation for educational and treatment planning as he transitions to high school. His overall cognitive abilities as assessed by the WISC-V fell within the High Average range (FSIQ of 117). He had a statistically significant strength in working memory and processing speed. However, he had a relative weakness in vocabulary and his ability to express or recall his breadth of knowledge which may be related to his history of language delays and remote schooling due to the Covid-19 Pandemic. At this time, Tom exhibits a statistically significant weakness in vocabulary (9%ile). Academically Tom's mathematics and written expression were generally within or above grade and age-based expectations. While Tom's basic reading skills were within or above expectation, his reading comprehension was an area of relative weakness as he continued to struggle with inferential

reasoning and prediction. He also had a tendency to provide the entire paragraph when supplying responses instead of just focusing on the details needed to respond to the question. Therefore, Tom is best described as continuing to meet the criteria for a Specific Learning Disability in the area of reading at this time, as his reading comprehension is discrepant from his FSIQ and his grade level. There is evidence for problems with executive functions and with inattention that are manifested both at school and at home by history. Evidence for this includes his mother's endorsements, self-report history, and comments of previous evaluations. That is, his parents report inattention at home plus executive dysfunction (e.g., shifting tasks, planning, organizing his environment and materials). Executive dysfunction is considered by many to be the key element in ADHD. Results of the DKEFS suggest that Tom's executive functioning is variable as he struggles with abstraction, impulsivity, variable cognitive flexibility on visual tasks, variable self-monitoring skills on visual tasks, and challenges maintaining a cognitive set on visual tasks, especially as task complexity grows. These results are consistent with his previous diagnosis of ADHD and an Autism Spectrum Disorder. Tom continues to meet criteria for Generalized Anxiety Disorder, at this time, as he displayed mild symptoms of anxiety including worrying, test anxiety, worrying about academic performance, and feeling anxious in novel situations. His mother also endorsed symptoms of anxiety during the clinical interview and on the BASC-3, as noted above. This should be closely monitored as Tom progresses in school, especially given the transition to high school. Based on these results, Tom meets criteria for Autism Mild, ADHD Inattentive Type, Specific Learning Disability in Reading, and Generalized Anxiety Disorder (GAD).

Documentation of Student's Progress

See tables 2, 3 and 4 that demonstrate Case Student's progress (i.e., WIAT-III Comparison Chart; WISC-IV [2021] results; Chronological listing of Wechsler Intelligence Score results [i.e., 2013-2021]). These tables present a picture of Tom's educational and cognitive growth after developing sensory-cognitive functioning.

Tables 2 to 4 document Tom's cognitive, academic, and language progress from the second through eighth grade. It appears that he has made significant gains since his initial diagnosis. The initial question posed in this article was, "would the utilization of the DCT theory, as found in the Talkies and V & V curriculum improve Tom's oral and written language comprehension"?

Table 2 provides information on his academic progress in reading, mathematics, written language, and oral language. Comparison to previous scores is also noted.

Table 3 provides a view of Tom's intellectual functioning in five cognitive areas as well as a breakdown of the subtest scores in the VCI composite.

Table 4 demonstrates a chronological listing of Tom's Wechsler Intelligence Scale results from 2013 to 2021. The Verbal Comprehension Index is also compared for those years.

Table 2: Comparison Chart on Academic Progress Reading, Mathematics, Written Language and Oral Language WIAT-III

2018 - 2021 Comparison Chart

Subtest	2018 Standard Score	2021 Standard Score	Percentile Rank	Grade Equivalent	Age Equivalent
Listening	92	108	70 %ile	10.1	16:0
Receptive Vocabulary	99	94	34 %ile	----	----
Oral Discourse	90	118	88 %ile	----	----
Reading Comprehension	87	93	32 %ile	5.0	10:8
Math Problem Solving	100	100	50 %ile	8.7	14:0
Sentence Composition	102	121	92 %ile	>12.9	>19.11
Word Reading	110	107	68 %ile	12.7	>19.11

Essay Composition	105	99	47 %ile	8.4	13:2
Pseudoword Decoding	116	121	92 %ile	>12.9	>19.11
Numerical Operations	117	114	82 %ile	>12.9	>19:11
Oral Reading Fluency	105	105	63 %ile	9.7	16:0
Accuracy	109	107	73 %ile	10.9	>19:11
Rate	105	104	68 %ile	10.7	>19:11
Spelling	117	105	61 %ile	10.5	16:0
Math Fluency Addition	125	123	94 %ile	>12.9	>19:11
Math Fluency Subtraction	137	123	94 %ile	>12.9	>19:11
Math Fluency Multiplication	132	126	96 %ile	>12.9	>19:11

Note: These results were obtained one-on-one, which means they could represent the best he can do, not how he probably does in the classroom.

WIAT-III is a widely used instrument for measuring the development of basic academic skills across reading, mathematics, written language, and oral language. Scores on this instrument are determined by comparing Tom's performance to other children within his grade range. His previous scores are also noted to allow for easy comparison.

Table 3: Neuropsychology Evaluation *Wechsler Intelligence Scale for Children Fifth Edition 4/25/2021*

Subtest from Wechsler Intelligence Scale for Children Fifth Edition (2021)

Composite	Composite Score	Percentile Rank	95% Confidence Interval	Qualitative Description
Verbal Comprehension	100	50 %ile	92-108	Average
Visual Spatial	111	77 %ile	102-118	High Average
Fluid Reasoning	115	84 %ile	107-121	High Average
Working Memory	125	95 %ile	115-131	Very High
Processing Speed	116	86 %ile	105-123	High Average
Full Scale IQ	117	87 %ile	111-122	High Average

Note: Tom was administered ten subtests from the *Wechsler Intelligence Scale for Children-Fifth Edition* (WISC-V). The WISC-C is an individually administered, comprehensive clinical instrument for assessing the intelligence of children ages 6:0 – 16:11. The primary subtest scores contribute to the primary index scores, which represent intellectual functioning in five cognitive areas: Verbal Comprehension Index (VCI), Visual Spatial Index (VSI), Fluid Reasoning Index (FRI), Working Memory Index (WMI), and the Processing Speed Index (PSI). This assessment also produces a Full Scale IQ (FSIQ) composite score that represents general intellectual ability. Tom's FSIQ score is in the High Average range when compared to other children his age (FSIQ=117, 87th percentile) and this score was consistent with previous testing in 2018.

Verbal Comprehension Subtest Score Summary

Subtest	Scaled Score	Percentile Rank
Similarities	14	91 %ile
Vocabulary	6	9 %ile
Information	8	25 %ile

Note: The VCI measures Tom's ability to access and apply acquired word knowledge. Specifically, this score reflects his ability to verbalize meaningful concepts, think about verbal information, and express himself using words. Tom obtained a VCI score within the average range (VCI=100, 50th percentile) and this domain was an area of weakness relative to his other domain scores.

Table 4: Chronological Listing of Tom's Wechsler Intelligence Scale Results

Year	FSIQ	Test	Verbal Comprehension Index
2013	88	WISC-IV	*
2015	86	WISC-V	VCI = 81; 10%ile
2018	115	WISC-V	VCI = 98; 45%ile
2021	117	WISC-V	VCI = 100; 50%ile

**Note.* Because of Tom's underlying diagnosis of an Autism Spectrum Disorder, the Information Subtest was substituted for the Comprehension Subtest. The Verbal Comprehension Index is traditionally comprised of the scores from similarities, vocabulary, and comprehension subtests.

The VCI measures Tom's ability to access and apply acquired word knowledge. Specifically, this score reflects his ability to verbalize meaningful concepts, think about verbal information, and express himself using words. Tom obtained a VCI score within the average range (VCI = 100, 50th percentile) and this domain was an area of weakness relative to his other scored domains.

The FSIQ scores demonstrate a growth of two standard deviations (minus one point) while the VCI shows an increase of 19 composite score points which is an area of weakness relative to his other domain scores. However, his VCI percentile rank grew from the 10th percentile to the 50th percentile rank.

These findings highlight the importance of intensive ongoing comprehension strategy training and its potential to produce lasting effects.

Overall Picture of Case Study Student

Tom is well mannered, cooperative and likes school. He is motivated to do well in school. Tom works diligently to receive the A's evidenced on his report cards. However, he gives a false impression

of understanding more than he does. Tom exhibits some difficulty expressing his thoughts and feelings and understanding figurative language. He does not process what is said to him as well as when things are presented to him visually, or when things are demonstrated. Tom does not always request help when needed and worries about making a mistake. Interpreting verbally presented concepts is a challenge for Tom. The 2021 Neuropsychology Evaluation stated that Tom has weaker verbal learning for "unstructured information".

He enjoys participating in sports. Tom plays league basketball and he made the Intermediate B School Team in eighth grade. Throughout intermediate school he also ran cross country as well as track on the school teams. Tom loves to engage in a discussion on sports and due to his excellent rote memory skills can easily recall team statistics and player information.

He excels in math except for word problems but struggles in higher order inferential skills particularly in reading comprehension and sometimes in oral comprehension. His ability in written composition is somewhat limited due to language delays and or deviance in language especially due to semantics and syntax.

Comorbidity of Reading Disabilities and ADHD

As previously noted, overall in depth cognitive correlates will not be discussed in relationship to comprehension except in relationship where manifested in Tom's case study.

Since Tom, the case study student, exhibited attentional deficits in elementary school, specifically noted at the third-grade level, and at home and other environments by history, a short discussion on the comorbidity of reading disabilities (RD) and ADHD will follow. A study was conducted by Langer et al., 2019 questioning how these disorders interact. RD and ADHD are two of the most common developmental disorders of children (e.g., each occurring in approximately five to ten percent

of the population). Both structural and functional MRI(s) were combined in Langer et al. to address the neurological bases. A study by Van Berger et al., 2014, previously demonstrated that no single cognitive deficit can explain all the behavioral symptoms. Langer et al., (p. 2677) concluded that the

> neuroimaging results demonstrated structural and functional atypicality's for COM in regions that are frequently associated with deficits in children with isolated ADHD or RD. A combination of shared and distinctive brain alterations between the clinical groups was identified, supporting the multiple deficit model for ADHD, RD, and its comorbidity.

The behavioral deficits appear to stem from unique functional and structural brain patterns.

Zametkin et al.'s 1990 study investigated how the brain used glucose, its energy source, during a continuous performance task using PET scans. Overall, the ADD group metabolized glucose at rates 8% lower than the control group. "The largest reductions were in the premotor cortex and the superior prefrontal cortex - areas earlier shown to be involved in the control of attention and motor activity". (Zametkin et al., p 2).

Anxiety/Executive Control Processes

Lytle & Todd (2009) noted that research indicates that many individuals with ASD have a heightened stress response. They take longer to recover from stress. Change can be a major stressor with this population (Bob & Konicarova, 2018). Tom's anxiety appears in stressful situations, particularly in high stakes testing.

Tom's Neuropsychology Evaluations (2015 & 2018) discussed executive functioning due to concerns about variable attention span sustained and divided as he struggles with inferential reasoning and prediction, as well as code shifting, processing speed, planning, and the organization of

environmental materials. Langer et al., 2019, specifically covered this topic of decreased brain activation areas that are required for executive functioning. As the task complexity grows, symptoms of anxiety exhibited in Tom are likely further exacerbated by his language deficits. See Langer et al. for further information on the COM regions involved in executive functioning.

Cartwright's research (1999-2010) centered on children who need to be more flexible when thinking about print. When thinking is purposeful, deliberate mental activities must be utilized to help achieve the goal. Cartwright's flexible thinking intervention specifically developed to improve reading comprehension in students assists children to integrate multiple kinds of information during the reading process. Cartwright worked with "word callers" who focus on decoding not on understanding text. Refer to her book *Word Callers: small group and one to one interventions for children who read but don't comprehend*, 2010, which describes a flexible thinking skill intervention for "word callers" who are typically less cognitively flexible than their peers.

Careful Developmental History

Bob & Konicarova (2018); Roeyers et al., (1998); Brugha (2018a, 2018b) discussed the necessity of a careful developmental history. Tom's parents have carefully obtained, provided, and shared their son's chronological records to give educators and readers of this article a complete vignette of this case study's student. Individual clinical characteristics are noted in evaluations throughout Tom's case study and Appendix C and, provide "a richer clinical description" of this young man.

Papadopoules et al. (2014) stated that linguistic and cognitive processes are both sets of skills that should be considered in the early identification of reading difficulties and have been documented in Tom's case study.

Reading Comprehension Instruction Transformed by Neuroimaging

Children on the spectrum are especially challenged during reading comprehension activities. Many of these students are skilled at decoding, while encountering challenges when required to understand text. The end goal of reading is to move beyond the word-reading processing capacity (which requires limited processing capacity) and then shift cognitive processes when reading for understanding (Kendeou et al., 2012). Comprehension processes are more complex and require more effort than decoding.

Students with ASD can experience deficits in communication, social skills, as well as deficits in cognitive processing. Their reading profile differs from typically developing (TD) children and interventions need to be designed differently (Randi et al., 2010; Murdaugh et al., 2017).

As early as 1965, Geschwind proposed that diminished connectivity between distinct functional systems in the brain was casual in both reading and language disorders. Recently, the field of cognitive neuroscience (i.e., a branch of neuroscience that studies intellectual activation) has utilized neuroimaging to identify reading processes in the brain during reading research. Advancements in technology allow researchers to identify and monitor brain activity during reading comprehension research. A variety of reading comprehension tasks (word, sentence and extended text) can be applied to identify brain regions that are engaged when text processing occurs (Parris & Block, 2015, p. 126-129; Sadoski & Paivio, 2013, p. 79-89). Increased functional connection can be established as well as establishing additional recruitment of brain regions outside of the reading network, as a result of targeted intensive interventions during reading in children with ASD (Murdaugh et al., 2015).

Piaget & Inhelder's (1971) substantial body of research on children(s) thinking attempted to explain knowledge and the acquisition of knowledge. This theory supports the tenet that cognitive

development occurs in stages and knowledge development in the brain develops over a time period. Knowledge is not static. The neuroimaging technology of today has documented Piaget's theory of triangulation since neuroimaging technologies demonstrate during the process of reading comprehension that multiple brain centers are activated (Parris & Block, 2015).

Since the advent of brain imagery technology has allowed researchers to see multiple regions activated when reading processes occur, it provides information in relationship to the functional behavior (i.e., reading comprehension) studied in this article. Developing effective instructional techniques are possible and can be confirmed. The use of mental imagery in literacy learning has been well established in research literature (Clark & Paivio, 1991; National Reading Panel, 2000; Pressley, 1977; Sadoski & Paivio, 2001, 2004, 2007; Wittrock, 1981). Alternative brain activation can be demonstrated through neuroimaging in order to view the subprocesses during reading comprehension. As a result of these targeted interventions, positive gains can result in comprehension ability of children with ASD.

Direct Research Utilizing Constructs of DCT

The next four neuroimaging research experiments (see Tables 5, 6, 7 and 8) conducted at the University of Alabama (Murdaugh et al., 2015; Murdaugh et al., 2016; Maximo et al., 2017; and Murdaugh et al, 2017) investigated the constructs of DCT by using the V & V program to develop oral and written language in children with ASD. This intervention is a practical application of the principles of DCT (i.e., that cognition involves the activation of two distinct subsystems, a verbal system and a nonverbal system (imagery). The V & V intervention relies primarily on visual nonverbal methods, a relative strength in individuals with ASD. Paivio (2007) explained they are also able to create

"associative connections;" they are both apart from each other but can cooperate to form linked pairs of words and images. These linked pairs make retrieval much easier. Cognitive load is reduced and working memory capacity is increased. It helps to develop both oral and written comprehension skills. It is best described as a direct, explicit, cognitive, accumulative, and multi-sensory approach.

This profile is evidenced as noted in Torgesen's et al. (2001) study as previously discussed in this article by both Paivio (1991) and Sadoski & Paivio (2001, 2004, 2007, 2013). The use of nonverbal sensory input to form imaged gestalts (i.e., concept imagery) when engaged in written or oral language as stressed in the Lindamood Programs (Bell & Bonetti, 2006b; Bell 1991a, 1991c) assists during processing complex information as noted during the research conducted at the University of Alabama. These four studies (see Tables 5, 6, 7 and 8) emphasized the need for targeted interventions for children with ASD demonstrating profiles of adequate decoding skills and statistically poor reading comprehension. The neuroplasticity of brain areas underlying reading in students with ASD (Mody & Belliveau, 2012) was also demonstrated by these intensive neuroimaging studies at the University of Alabama (2015-2017). Until the advent of neuroimaging technology, it was not possible to positively document the effectiveness of DCT intervention changes in brain circuitry to increase higher-order learning skills. (see tables 5-8, pages 64-67).

Unable to insert in this format. Tables are attached at end of Neuroimaging section and Executive Summary.

Observations Regarding Tables 5, 6, 7 and 8

The overall testing at the neurobiological level during the research studies at the University of Alabama demonstrated significant improvement in higher order thinking skills as compared to the control groups after receiving a structured visual imagery-based sensory intervention. It appears than

nonverbal sensory input (e.g., DCT) was an appropriate intervention to change brain circuitry during reading tasks. This indicates that comprehension skills demonstrated a positive change through educational intervention. Imagery strategies would appear to assist students to reach their potential in the acquisition of comprehension skills. Sadoski & Willson (2006) noted that few of the educational research studies focused on instructional programs with a theoretical base as compared to DCT.

Murdaugh et al., 2017, p. 311 study concluded:

> Given the different reading profile of children with ASD, reading interventions need to be designed differently for these children. Future research should continue to follow these children long-term to determine the extent to which these neural changes are permanent in order to continue to develop and adapt age-appropriate individualized reading interventions for individuals with ASD.

Neuroimaging Study/Activation of Semantic Representations

A fifth study at the University of Alabama was conducted by Bednarz et al., (2017) using fMRI to examine the activation and synchronization of semantic representations. The specific goal was to find the neural process involved in semantic processing in the brain's reading network. Brain regions described as the Reading Network include "inferior occipital gyrus, fusiform gyrus, superior temporal (STG), pre/postcentral gyrus, intraparietal sulcus (IPS), supplementary motor area (SMA), inferior frontal and middle frontal gyrus (IFG, MFG), and thalamus (THAL)" (Lohmann, 2010; Turkeltaub et al., 2011; Koyama et al., 2011, p. 12). Since decoding and word identification are foundational to the process of comprehension, students with ASD and TD were administered a task of word similarities. Intact decoding abilities were present in the subgroup of ASD students who also exhibited deficits in reading comprehension. The researchers wanted to uncover at the word level the mechanisms related to

semantic processing and see if neural differences occurred when comparing the ASD students to the TD students. The results of this study provide evidence of a "neural substrate" (i.e., evidence for altered recruitment of reading related neural resources in children with ASD) "and suggests specific weakness in top-down modulation of semantic processing" (Bednarz et al., p. 39). The task utilized was independent of text integration and relates to general cognitive processing alterations in the ASD population.

Imagery Debate

The previously presented sections of this article discussed the application of Paivio's dual coding theory which refers to the content of memory representations. The format of the representations used in mental imagery will be briefly discussed below. Since the 1960's and 1970's the nature of mental representation has been debated. The format refers to the nature of the code used to represent the "mental representation" and is the central point of this debate (Pearson & Kosslyn, 2015).

The two main opposing theories in this debate are Zenon Pylyshyn's propositional theory (2002, 2003) and Stephin Kosslyn's theory on the spatial representational theory of imagery processing (1996). Overall, the imagery debate is whether imagery is based on spatial mechanisms such as those involved in perception, or on mechanisms related to language called propositional mechanisms. Kosslyn's position is that mental images are distinct from language because they depict, not describe information. On the other hand, Pylyshyn's propositional theory proposes that mental relationships between objects are represented by language-like symbolic internal representations (i.e., symbol structure theory) and not by mental images.

For more information on the debate centering on how images are physically realized in the brain please refer to:

Kosslyn et al. (1984)

Kosslyn & Shin (1992)

Kosslyn et al. (1993)

Kosslyn & Koenig (1995)

Kosslyn, S.M. (1996)

Kosslyn et al. (1999)

Kosslyn et al. (2001)

Mellet et al. (1998)

Pylyshyn, Z. (1973)

Pylsyshyn, Z. (1979)

Pylsyshyn, Z. (1981)

Pylsyshyn, Z. (1988)

Pylsyshyn, Z. (2002)

Pylsyshyn, Z. (2003)

Tye, M. (1991)

Discussion/Executive Summary

The purpose of this study was to find if the utilization of the DCT theory (i.e., as a multi-sensory intensive intervention strategy) improved oral and written comprehension ability in students who are challenged in this area.

It appears to be an effective and responsible approach as answered by the consistent statistically significant supporting evidence presented in the many research experiments and data presented in this article. Evidence on significant post-test gain in FSIQ [two standard deviations (minus one point)] and VIQ (from 10 to 50 percentile) has been noted in the case study student who was trained to use a mental imagery strategy over a period of six and three-fourths years. Signs of neuroplasticity did not appear to fade in the case study student. However, they appeared to increase slightly after being affected by the COVID-19 pandemic when imagery instruction ceased. Refer to Table

4 for years 2018 & 2021 comparison of Wechler Intelligence Scale Results (FSIQ & VCI scores). Overall, these findings highlight the importance of intensive nonverbal sensory awareness training and ongoing support.

Summary of previously disclosed supporting evidence as listed below

Tom's oral and written comprehension development is consistent with numerous evidence and studies endorsing the use of the DCT Theory as his FSIQ scores demonstrate a statistically significant strength of two standard deviations (minus one point) while the VCI shows an increase of 19 composite score points which is an area of weakness relative to his other domain scores. However, his VCI percentile rank grew from the 10th percentile to the 50th percentile rank.

A. A large-scale study produced statistically significant gains in a multi-cultural urban setting in Pueblo, Colorado.
B. Specific research studies on the use of imagery to improve comprehension difficulties (both large and small scale).
C. Neural changes demonstrated both structural and functional changes in the recent neuroscientific studies at the University of Alabama (2015-2017) based on the utilization of nonverbal sensory input (i.e., which is the conceptual basis of DCT). These studies were undertaken to document the importance, if any, in students with ASD who were experiencing challenges in both written and oral comprehension. Neuroimaging techniques provided converging evidence that imagery is a legitimate representational tool. It also demonstrates the positive use of a specific theoretical base.
D. Oral language skills are the foundation for reading comprehension. Rayner et al., 2001, suggested that comprehension of text is limited to the degree of children's language competency.

E. A good strategy is not rote but requires engaging interaction between student and teacher. Students should know the purpose of strategy; how and why they work; and when and where they should be utilized. The construction of strategies is a complex process which facilitates students to obtain memory from text.

Since 1981 United States agencies (i.e., NCES, NAEP, NALS, PIAAC, NRP, RAND Study Group, and CCSS) have reviewed reading scores and expressed concerns over higher level skill challenges in reading comprehension, particularly in high school and college students, as well as adults. Targeted multisensory cognitive skills are recommended as a strategy for higher level comprehension difficulties since reading standards have come under scrutiny.

Furthermore, the history of imagery in literacy was traced from ancient to present times concluding with a brief discussion on the current state of the "imagery debate".

It is hoped that the sensory-language connection will be considered and implemented in classrooms with students who experience oral and written comprehension challenges. Intensive interventions were one of the significant components of RTI for students with severe reading difficulties. Generalization of metacognitive strategies and application to all subject areas will enhance reading comprehension skill as part of effective plan of instruction to aid in improving reading comprehension in students who do not naturally possess rudimentary comprehension skills. The weakened connection between the imagery and verbal cortical centers will be strengthened. It will assist these students in their ability to understand what they are reading.

The scientific data reported in this article has provided evidence to bridge a specific cognitive theory (DCT) to educational practice (i.e., the instructional strategy, the intervention of mental imagery) to improve both oral and written comprehension in students.

Acknowledgements

The author is grateful for the following people and institutions for providing help in accessing research articles: Paul Worthington (i.e., Director of Research & Development, Lindamood-Bell).

Melanie Bobrowicz, Steve Copp, Charles Gottlieb & Sloane Boyce (Ocean County Library, N.J.)

Cheryl Litwinczuk, Sister Barbara Williams, R.S.M., & Steven Maricic (Georgian Court University Library, Lakewood, NJ)

Anna L. Birchler (Translation Assistance, High School South, Toms River, NJ

Table 5: Changes in Intrinsic Connectivity of the Brain's Reading Network following Intervention in Children with Autism

University of Alabama

Authors	Subjects	Intervention	Technique	Purpose	Results After Intervention
Murdaugh, Maximo & Kana (2015)	Children with ASD 10-11 years (all groups) WASI VIQ 91.3 ± 9.19 (ASD-EXP) WASI VIQ 92.1 ± 13.21 (ASD-WLC) WASI VIQ 98.9 ± 15.50 (TD) WASI FSIQ 94.7 ± 12.98 (ASD-EXP) WASI FSIQ 97.2 ± 15.53 (ASP-WLC) WASI FSIQ 97.6 ±12.08 (TD)	V & V	rsfMRI resting state functional magnetic	· This study used resting state functional magnetic resonance imagery (rsfMRI) to identify changes in neural circuitry underlying language processing in children with ASD. · Furthermore, a seed-based approach was utilized to assess the connectivity of both Broca's Wernicke's area with the rest of the brain. · The authors utilized a spatial map, called the Koyama Reading Network (Koyama et al., 2010) based on the core language regions they identified while utilizing rsfMRI during reading tasks involved with children during their research.	1. Stronger functional connectivity of Broca's & Wernicke's areas when using group independent component analysis (GICA) and seed-based analysis was noted. Improvement in reading comprehension correlated with this greater connectivity. 2. In addition, increased right superior temporal gyrus (STG), and the Wernicke's area and left IFG-orbital (LIF-G) were also correlated with greater improvement in reading comprehension. 3. This study supports the utilization of resting state rsfMRI for investigating reading networks and has direct relevance for the understanding of reading disorders such as ASD. 4. Past intervention, noted additional recruitment of regions outside of the reading network. 5. Findings provide valuable insights into brain neuroplasticity.

Table 6: From Word Reading to Multi-sentence Comprehension: Improvements in Brain Activity in Children with Autism after Reading Intervention

University of Alabama

Authors	Subjects	Intervention	Technique	Purpose	Results after Intervention
Murdaugh Maximo Cordes O'Kelley Kana (2017)	Children with ASD Age range 8-14 years. All participants had at least a Verbal IQ score of 75	V & V	fMRI	Three tasks (word, sentence, and multi-sentence processing tasks) in a pre-post design were utilized to determine what specific neural processes are most affected by the intervention.	1. Post intervention revealed that the ASD EXP group showed greater activation in bilateral precentral gyrus and the postcentral gyrus, visual processing regions (e.g., occipital cortex, fusiform (gyrus) and frontal regions. 2. In the word task, left thalamus and the right angular gyrus (AG) activation was unique to the ASD-EXP group post intervention. 3. Sentence tasks showed differential activation of core language areas (e.g., IFG, IPL) post intervention. 4. The multi sentence task increased task complexity. It showed changes in core language areas (left inferior frontal gyrus and left interior parietal lobule). The most improvement noted in students' w/ASD was the ability to strengthen bilateral connectivity between frontal regions.

Table 7: Changes in Intrinsic Local Connectivity After Reading Intervention in Children with Autism
University of Alabama

Authors	Subjects	Intervention	Technique	Purpose	Results after Intervention
Maximo Murdaugh O'Kelley Kana (2017)	All participants mean age 10.5 years SD = 1.5 ASD-EXP children assigned to participate in the V & V intervention either between their first and second imaging sessions. Verbal IQ 90.8 ± 9.8 (72-108) Full IQ 94.0 ± 13.8 (78-109) Performance IQ 103.4 ± 19.0 (72-134) ASD-WLC Children assessed after completing both imagery sessions Verbal IQ 91.9 ± 13.3 (77-126) Full IQ 94.0 ± 15.8 (85-140) Performance IQ 102.3 ± 17.8 (88-145)	V & V	rsfMRI	To access changes in intrinsic local functional connectivity of Koyama's Reading Network in regions of interest (ROI) Koyama et al., 2011. To test the impact of a structured visual imagery-based reading intervention on improving reading comprehension and assessing its underlying local neural circuitry.	1. After intervention improvement in language comprehension was noted which significantly predicted changes in local brain connectivity in Reading Network Regions (i.e., ASD-EXP group). 2. This study provides novel insights into brain plasticity in high functioning children with ASD after utilizing the targeted intervention program (V & V). 3. The V & V intervention relies heavily on mental imagery skills, which require modality-specific mental representations derived from sensory experience in this case, motor planning for visual imagery. 4. The ASD-EXP group showed significant improvement in reading comprehension as evidenced from a change in comprehension scores.

Table 8: The Impact of Reading Intervention on Brain Responses Underlying Language in Children with Autism

University of Alabama

Authors	Subjects	Intervention	Technique	Purpose	Results after Intervention
Murdaugh Deshpande Kana (2016)	Ages 8-13 ASD & TD children WASI VIQ 91.0 ± 8.91 (ASD-EXP) WASI VIQ 92.1 ± 13.70 (ASD-WLC) WASI VIQ 96.1 ± 12.31 (TD) WASI FSIQ 94.1 ± 11.23 (ASD-EXP) WASI FSIQ 97.9 ± 15.91 (ASD-WLC) WASI FSIQ 96.2 ± 10.89 (TD)	V & V	fMRI	· To take advantage of strength in visual spatial processing and improve language comprehension in children with ASD. · Investigate intervention related change in sentence comprehension, brain activators, and functional connectivity. · To utilize research on brain plasticity on higher order language skills.	1. Significantly increased brain connectivity in ASD-EXP groups between Broca's and Wernicke language areas. 2. Study lends support of specialized strength-based intervention (V/V) to increase higher-order learning skills. 3. Of particular interest was assessing changes in activation related to high-imagery sentences, as building visual imagery was the focus of this intervention.

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Appendix A Visualizing and Verbalizing Steps

Step 1. Summary of Climate
Step 2. Summary of Picture to Picture
Step 3. Summary of Word Imaging
Step 4. Summary of Single Sentence Imaging
Step 5. Summary of Sentence by Sentence Imaging
Step 6. Sentence of Sentence by Sentence HOTS (begin developing higher order thinking skills)
Step 7. Summary of Multiple Sentence Imaging
Step 8. Summary of Whole Paragraph Imaging
Step 9. Summary of Paragraph by Paragraph Imaging
Step 10. Summary of Whole Page Imaging
Step 11. Summary of Chapter and Lecture Noting
Step 12. Summary of Writing from Visualizing/Verbalizing

Bell, N. (1986, 1991) Visualizing and Verbalizing for Language Comprehension and Thinking pp. 245-260). San Luis Obispo, CA.: Gander Educational Publishing.

For a detailed explanation of each sequential step refer to pgs. 245-260 (N. Bell, 1991). The tasks range from very simple to more complex ones.

Talkies Steps

Step 1. Climate (establish)
Step 2. Sensory-Language Play
Step 3. Talking Words
Step 4. Talking Sentences
Step 5. Simple Picture to Picture
Step 6. Simple Word Imaging
Step 7. Simple Sentence Imaging
Step 8. Talking Picture Stories
Step 9. Simple Sentence by Sentence

Bell, N. & Bonetti, C., (2006). Talkies Visualizing & Verbalizing for Oral Language Comprehension and Expression, (pp. 198-223). San Luis Obispo, CA: Gander Publishing.

For a detailed explanation of each sequential step refer to pgs. 198-225 (N. Bell & C. Bonetti, 2006). The tasks range from very simple to more complex ones.

Appendix B Historic Perspective of Imagery

Visual imagery has been utilized as an effective way to communicate both abstract and concrete ideas for thousands of years. Imagery made memory easy.

Simonides	Taught people the use of imagery to improve memory	556 – 468 B.C.
Plato	Mental images on a wax table stressed the abstract and verbal	470 – 399 B.C.
Aristotle	When the mind is impressed by a perception the process of perception imprints an image upon the mind	384 – 322 B.C.
Cicero	Wrote on a tablet to visualize pages and their lines so when speaking it was like reading aloud	106 – 43 B.C.
Quintilian	Used familiar locations (loci) with images during oratory to assist memory	35 – 96 A.D.
Augustine	Trained in rhetoric Used vivid imagery in arguments	354 – 430 A.D.
Aquinas	"Man's mind cannot understand thoughts without images of them"	1225 – 1274 A.D.
Dante	Was concerned with imagery as a means to understand abstractions such as good, evil, justice and prudence	1265 – 1321 A.D.
Comenius	First fully illustrated book	1592 – 1670 A.D.

Stressed sense experience before verbal classification

Philosophers stressed the classic tradition of imagery in memory despite the emphasis during this time on the use of reason

Francis Bacon		1561 – 1626 A.D.
Rene Descartes		1596 – 1650 A.D.
Gottried Leibniz		1646 – 1716 A.D.
Rousseau	Emphasized extensive sensory experience first	1712 – 1778 A.D.
Kant	The mind impresses schematic, conceptual order on sensory data	1724 – 1804 A.D.
Pestalozzi	Key to efficient learning was a set of images, concepts, or sensorimotor patterns from which were induced abstract principles	1746 – 1827 A.D.
Beethoven	"I am almost convinced that no earthborn being can ever hope to set down by means of sounds, words, color, or in a sculpture, the heavenly pictures that rise before his awakened imagination."	1770 – 1827 A.D.
Mozart	"A piece would grow in him until the whole, though it be long, stands almost complete and finished in my mind, so that I can survey it, like a fine picture or a beautiful statue, at a glance. Nor, do I hear in my imagination the parts successively, but I hear them,	1776 – 1791 A.D.

	as it were, all at once."	
William James	Static meaning of concrete words consist of sensory images awakened	1842 – 1910 A.D.
John Dewey	Literacy learning was based on actual experience and inquiry; both real and imaginal experimentation to build abstract concepts from concrete experience	1859 – 1952 A.D.
Rudolf Steiner	Placed mental imagery at the center of comprehension	1861 – 1925 A.D.
George Herbert Mead	In both oral and written language imagery and imagination are central in meaning	1863 – 1931 A.D.
Edward Titchener	My mind, in its ordinary operations, is a fairly complete picture gallery, not of finished paintings, but of impressionist notes	1867 – 1927 A.D.
Montessori	Developed a scientific pedagogy based on sensory observation with the development of mental images. Abstract concepts come from concrete experiences	1870 – 1952 A.D.
Einstein	Made his thinking concrete with the sensory cognitive functions of mental imagery. "If I can't picture it, I can't understand it."	1879 – 1955 A.D.
Piaget	Favored a perceptual base to memory. Schemata became internalized in the form of imaged thought. The hierarchy of image levels may correspond to developmental levels	1896 – 1980 A.D.

Rudolf Arnheim	Experiences deposit images. He maintained that vision and perception are creative, active understanding, and, we organize perceptions into structures and form images with which to understand.	1904 – 2007 A.D.
Edmund Burke Huey	Reading should always be for meaning and serve the growing needs and interests of pupils. It is critical to the actual though processes.	1908 – 1968 A.D.
Michael Pressley	Puts imagery in a developmental perspective.	1915 – 2014 A.D.
Joseph Webman	You stimulate thought through the use of imagery. It is critical to the actual thought processes.	1916 – 1997 A.D.
Karl H. Pribram	Imaging processes demand neurological underpins.	1919 – 2015 A.D.
Allan Paivio	Researched, developed Dual Coding Theory (DCT). Performance is mediated by the joint activity of the verbal and nonverbal system (i.e., mental imagery). Cognition is the interplay between these two systems. Both types of information are stored separately in long term memory.	1925 – 2016 A.D.
Merlin Wittrock	Increased reading comprehension occurs (i.e., by approximately 50%) when verbal and imaginal relations are associated. Students learn best as active participants in the learning process.	1981 – 2007 A.D.

Mark Sadoski	Dual Coding Theory in reading and writing.	1945 –
Steven Michael Kosslyn	Imagery relies on topographically organized organized regions of the cortex, which supports depictive representations.	1948 –
Sports Psychology		
Coach John Wooden	"I believe in learning by repetition to the point that everything becomes automatic. Rehearsal of an action influences the likelihood that a person will compute that action."	1910 – 2010 A.D.
Mohammed Ali	A man who has no imagination has no wings. "If my mind can conceive it, my heart can believe It, then I can achieve." Utilized visualization in sports.	1942 – 2016 A.D.
Just Using Imagery		
President Gerald Ford	"I watched a lot of baseball on radio."	1913 – 2006 A.D.
This articles author	On the radio I watched Eloise riding up and down the elevator at the Plaza Hotel in New York City, while she mingled with the hotel's inhabitants	

Appendix C Summaries/Evaluations Scores

10/28/2008 Speech Language Assessment Summary

A 2.0 year old male presented with moderately to severely impaired receptive language skills and severely impaired expressive language skills. Speech sound production skills could not be adequately assessed due to reduced language skills, however, appeared to be severely delayed. Pragmatics, attention, turn taking and play skills also appeared significantly reduced. Mouthing of toys and reduced imitation were also observed.

The Rossetti Infant Toddler Scale:

Receptive language skills 12 months

Expressive language skills 9-month range with scatters to 12 months

8/4/2009 Center for Neurological and Neurodevelopmental Health

Determined underlying (static) encephalopathy associated with developmental language

disorder. No report available.

9/10/2009 Educational Evaluation – Brigance Preschool Screen II, Battelle Development Inventory

Tom scored average in the area of gross motor and below average in the area of self-care, personal responsibility, and academic domain.

7/6/2010 Center for Neurological and Neurodevelopmental Health Psycho-developmental Evaluation

Neuropsychological Evaluation not available. Mentioned in 2013 Neuropsychological Report. Tom's complete history is included in previous evaluations and will not be reviewed in the scope of this report. Tom has been followed by Neurology and Neuropsychological Services since 2010 and carries a diagnosis of Encephalopathy (static), PPD-NOS with associated language and feeding deficits and behavior dysregulation. He has made significant progress in language since his initial evaluation in 2010 and currently participates in private speech therapy services once a week for 60 minutes.

4/12/2012 Center for Neurological and Neurodevelopmental Health Psycho-Developmental Evaluation

Assessment presented and determined "the continual presence of an autism spectrum disorder." No reports available.

5/10/2013 Goldman Fristoe Test of Articulation-2 was administered. This test measures Tom's

ability to produce sounds in the beginning, middle and ending positions of single words.

Raw score: 16

Standard score: 82 (-1 ½ standard deviations)

Percentile Rank: 11 (very low average)

Test-age Equivalent: 4 years, 1 month

5/10/2013 The Clinical Evaluation of Language Fundaments – Preschool 2 (CELF Preschool 2)

was administered with the following results. This test is normed on children up to 6 years of age. We utilized this test even though Tom is 6 years, 6 months of age to gain a better

understanding of Tom's language abilities and functional limitations.

Sentence Structure – Raw score 12, Percentile Rank 2, Age Equiv 3y 11m

Word Structure – Raw score 8, Percentile Rank .4, Age Equiv 3y 2m

Expressive Vocabulary – Raw score 12, Percentile Rank 1, Age Equiv 3y 5m

Concepts & Following Directions – Raw score 9, Percentile Rank 1, Age Equiv 3y 11m

Recalling Sentences – Raw score 10, Percentile Rank 2, Age Equiv 3y, 9m

Word Classes-Receptive (Ages4-6) – Raw score 17, Percentile Rank 9, Age Equiv 5y 3m

Word Classes – Expressive (Ages 4-6) – Raw score 4, Percentile Rank 1, <4years

6/3/2013 Neuropsychological (Neurology and Neuropsychological Services) WISC-IV

Subtest	Scaled Score	Index	FSIQ
Similarities	10	Verbal Comprehension	Full Scale IQ
Vocabulary	7	VCI=91	FSIQ=88
Information	8	27th percentile	21st percentile
Block Design	10	Perceptual Reasoning	
Picture Concepts	5	PRI=88	
Matrix Reasoning	9	21st percentile	
Digit Span	10	Working Memory	
Letter-Number Seq.	8	WMI = 94 (34th percentile)	
Coding	6	Processing Speed	
Symbol Search	12	PSI = 94 (34th percentile)	

The Verbal Comprehension Index (VCI) is a measure of verbal concept formation, verbal reasoning, and knowledge acquired from a student's environment. Tom's Standard Score of 91 (27th percentile) falls in the lower limits of the Average range and is traditionally comprised of the scores from Similarities, Vocabulary, and Comprehension subtests. However, given Tom's underlying diagnosis of an Autism Spectrum Disorder, the Information subtest was substituted for the Comprehension subtest. Tom had a relative strength on the Similarities subtest, which assessed abstract verbal reasoning and required only brief one word responses.

6/03/2013 WIAT-III Academic Achievement

The WIAT-III is a widely used instrument for measuring the development of basic academic skills across reading, mathematics, written language, and oral language. Scores on this instrument are determined by comparing Tom's performance to others in his grade range.

Subtest	Standard Score	Grade Equivalent	Percentile Rank
Early Reading Skills	88	K.2	21st
Numerical Operations	95	K.5	37th
Math Problem Solving	81	PK.9	10th
Alphabet Writing Fluency	101	K.7	53rd
Spelling	109	1.2	73rd

These results were obtained one-on-one, which means they could represent the best he can do, not how he probably does in the classroom.

6/3/2013 Clinical Evaluation of Language Fundamentals Preschool, Second Edition CELF-Preschool 2)

The CELF-Preschool 2 provided a measure of language development relative to other children Tom's age. It comprises tests of both receptive (comprehension/understanding of spoken language) and expressive (spoken) language. The child was asked to do things like repeat increasingly longer sentences verbatim (Recalling Sentences), formulate sentences based on picture prompts (Formulated Sentences), and identify how pairs of words are related (Word Classes).

Subtest	SS	Percentile	Classification	Age Equivalent
Recalling Sentences	3	1st	Extremely Low	3:6
Word Structure	2	.4th	Extremely Low	3:2
Expressive Vocabulary	4	2nd	Borderline	3:11

6/3/2013 Behavioral Assessment Scale for Children-2 (BASC-2)

These results indicate that both his teacher and mother view Tom as having deficits that are commonly observed in autism spectrum disorder. However, his teacher views him as having greater concerns in the areas of adaptive behaviors, which may be due to her direct observation of social interactions with peers and academic demands. Therefore, it is not surprising that impairments in language are closely related to academic and emotional functioning. For example, children with language problems many times have difficulty in the social realm, as they are not able to partake in the fast repartee that is common in social interactions. For Tom, this is exacerbated by his comorbid symptoms associated with ASD. In practical terms, it is very likely that Tom does not understand some classroom instructions, particularly the more complex ones. In addition, he is unable to express himself at an appropriate developmental level.

2015 Child Study Team Triennial Re-evaluation

Recent Evaluations Summary: Toms was evaluated by his local Child Study Team in September of 2015 including psychological testing, academic testing, and a speech and language evaluation. Results suggested deficits in listening, organizing language, grammar usage, and semantics. Cognitive skills on the WISC-V were scattered with a relative weakness in verbal skills and fluid reasoning. Lastly, results of the WJA-III suggested deficits in listening comprehension, oral language, reading comprehension, and variable math skills.

10/16/2015 Wechsler Intelligence Scale for Children-Fifth Edition (WISC-V) Scores Summary

Scale	Standard Score	Percentile Rank	Confidence Interval	Classification
Verbal Comprehension	81	10	75-90	Low Average
Visual Spatial	92	30	85-100	Average
Fluid Reasoning	82	12	76-90	Low Average
Working Memory	103	58	95-110	Average
Processing Speed	98	45	89-107	Average
Full Scale	86	18	81-92	Low Average

10/16/2015 Psychological Re-Evaluation Wechsler Intelligence Scale for Children – Fifth Edition (WISC-V) continued:

Subtest Scores Summary for the WISC-V (mean score = 10 for each subtest)

Verbal Comprehension		Visual Spatial	
Similarities	8	Block Design	10
Vocabulary	5	Visual Puzzles	7
Fluid Reasoning		**Working Memory**	
Matrix Reasoning	7	Digit Span	11
Figure Weights	7	Picture Span	10

Subtest Scores Summary for the WISC-V (mean score = 10 for each subtest) - *Continued*

Processing Speed	
Coding	9
Symbol Search	10

9/16/2015 Educational Re-Evaluation (Child Study Team) Woodcock Johnson-III Tests of Achievement

Cluster/Domain	Standard Score	Age Equivalent
Total Achievement	95	8-7
Broad Reading	95	8-5
Basic Reading Skills	110	10-1
Reading Comprehension	80	7-3
Broad Written Language	105	9-6
Written Expression	98	8-8
Oral Language (Ext)	77	6-6
Oral Expression	87	7-1
Listening Comprehension	68	6-1
Broad Math	89	8-2
Math Calculation Skills	100	8-11
Math Reasoning	92	8-3
Academic Skills	108	9-7
Academic Fluency	102	9-1
Academic Applications	80	7-5

9/18/2015 Speech and Language Re-Evaluation (Child Study Team)

The Test of Language Development (TOLD-1:4) was administered to assess receptive and expressive language skills. Tom achieved a spoken language index of 69 and a percentile rank of 2%. A spoken language index score between 85 and 115 is considered to be within the average range. Below are the subtests and composite scores enumerated. A subtest scaled score between 8 and 12 is considered within the average range.

Subtest Performance	Scaled Score	Percentile Rank	Composite Performance	Index Score	Percentile Rank
Sentence Combining	7	16%	Spoken Language	69	2%
Picture Vocabulary	5	5%	Listening	76	5%
Word Ordering	3	1%	Organizing	68	1%
Relational Vocabulary	5	5%	Speaking	83	13%
Morphological Comp.	6	9%	Grammar	72	3%
Multiple Meanings	7	16%	Semantics	73	3%

9/18/2015 Illinois Test of Psycholinguistic Abilities 3 (ITPA-3)

The Illinois Test of Psycholinguistic Abilities 3 was administered to assess Tom's linguistic abilities. Composite scores have a mean of 100 and a standard deviation of 15. A standard score quotient between 85 and 115 is considered within the average range. Tom yielded a spoken language quotient of 83 which falls within a percentile ranking of 13%. Below are the subtests and composite quotients enumerated. A subtest standard score between 8 and 12 is considered within the average range.

Spoken Subtest	Standard Score	Percentile Rank
Spoken Analogies	5	5
Spoken Vocabulary	3	1
Morphological Closure	6	9
Syntactic Sentences	7	16
Sound Deletion	11	63
Rhyming Sequences	13	84

9/18/2015 Teacher Interview

The resource room teacher provided a statement of Tom's academic progress, as she served as his resource room teacher last year and remains his resource teacher this year as well. His teacher explained, "Tom is a hard-working student. He always tries his best. His strengths are listening, spelling, and remembering facts. He has a difficult time with summarizing, inferring and higher order questions. Tom has difficulty expressing his ideas verbally and in writing and can be reluctant to ask questions."

12/28/2015 Diagnostic Evaluation Report (Neuropsychological Service).

Tom is an 11 year, 2-month-old boy who was referred for an evaluation to obtain an updated assessment of his academic, language functioning, and executive functioning for treatment and educational planning. His scores on the WISC-V administered by his child study team indicated that there is variability across domains and that he struggled with items that placed a greater demand upon expressive language skills. These findings are consistent with his underlying diagnosis and history of language delays.

Tom's academic skills were assessed on the WJA-III by the Child Study Team and suggested deficits in oral language, listening skills, reading comprehension, and variable math skills. Based on these results, the examiner selected subtests from the KTEA-II to further evaluate his reading comprehension. His score fell in the Low Average range and was equivalent to a mid-second grade student. It should be noted that Tom moved his lips as he read and always had to re-read entire passages before attempting to respond to the comprehension questions. Furthermore, he was not able to answer any questions that involved inferential reasoning or prediction. These results suggest that Tom does not efficiently read for content, as he struggled to fluidly recall details from passages he just read. Therefore, at this time, while he has made progress in phonetic awareness and decoding, he continues to struggle with reading comprehension, fluency, prediction, and inferential reasoning.

Tom should participate in individual speech therapy at school twice a week, given his language deficits which include expressive language delays, poor word structure, poor sentence structure, pragmatic deficits, and poor inferential reasoning. He should also participate in group-based speech or social skills therapy to address the application of pragmatic language and related skills which can negatively impact peer interactions.

Tom continues to struggle with sustained and divided attention that is likely further exacerbated by his language deficits. Therefore, he would benefit from a study skills class when available in the school setting. He would also benefit from breaking down long-term assignments into smaller manageable units.

One of the most important issues to keep in mind is that children with Tom's profile many times give the impression they are much more capable than they are. However, their deficits can affect them in many areas. His teachers should therefore be aware of his cognitive profile and become familiar with his deficits and strengths.

12/28/2015 Comprehensive Assessment of Spoken Language (CASL)

Subtest	Standard Score	Qualitative Description
Nonliteral language	74	Borderline
Inference	77	Borderline
Pragmatic judgment	66	Mildly impaired

12/28/2015 Executive Functioning Test of Everyday Attention for Children (TEA-Ch) Test of Everyday Attention for Children (TEA-Ch)

Subtest	Scaled Score	Est. Percentile Rank
Sky Search		
Number Correctly identified targets	8	25th
Time per target	8	25th
Attention score	9	37th
Score	6	9th
Creature Counting		
Total correct	6	9th
Timing score	5	5th

3/2/2018 & 4/10/2018 Neuropsychological Evaluation

Wechsler Intelligence Scale for Children, 5th Edition

Tom was administered ten subtests from the Wechsler Intelligence Scale for Children, Fifth edition (WISC-V). The WISC-V is an individually administered, comprehensive clinical instrument for assessing the intelligence of children 6:0-16:11. The primary subtest scores contribute to the primary index scores, which represent intellectual functioning in five cognitive areas: Verbal

Comprehension Index (VCI), Visual Spatial Index (VSI), Fluid Reasoning Index (FRI), Working Memory Index (WMI), and the Processing Speed Index (PSI). This assessment also produces a Full

Scale IQ (FSIQ) composite score that represents general intellectual ability. Tom's FSIQ score is in the High Average range when compared to other children his age (FSIQ = 115, 84th percentile).

Composite	Composite Score	Percentile Rank	95% Confidence Interval	Qualitative Description
Verbal Comprehension	98	45th	91-106	Average
Visual Spatial	105	63rd	97-112	Average
Fluid Reasoning	103	58th	96-110	Average
Working Memory	120	91st	111-126	Very High
Processing Speed	111	77th	101-119	High Average
Full Scale IQ	115	84th	109-120	High Average

3/2/2018 & 4/10/2018 Academic Achievement – WIAT-III

WIAT-III is a widely used instrument for measuring the development of basic academic skills across reading, mathematics, written language, and oral language. Scores on this instrument are determined by comparing Tom's performances to other children in his age range.

Subtest	Standard Score	Percentile Rank	Grade Equivalent	Age Equivalent
Listening Comprehension	92	32	4.7	9.10
Receptive Vocabulary	99	47		
Oral Discourse	90	25		
Reading Comprehension	87	19	2.4	7:8
Math Problem Solving	100	50	6.4	11:4
Sentence Composition	102	55	6.9	12:4
Word Reading	110	75	8.4	13:8
Essay Composition	105	63	7.5	12:6
Pseudoword Decoding	116	86	>12.9	>19:11
Numerical Operations	117	87	8.2	13:8
Oral Reading Fluency	105	63	6.7	12:4
Accuracy	109	73	7.0	12:8
Rate	105	63	7.2	13:0
Spelling	117	87	9.2	14:0
Math Fluency Addition	125	95	>12.9	>19:11
Math Fluency Subtraction	137	99	>12.9	>19.11
Math Fluency Multiplication	132	98	>12.9	>19.11

These results were obtained one-on-one, which means they could represent the best he can do, not how he probably does in the classroom.

3/2/2018 & 4/10/2018 Executive Functioning

D-KEFS (selected subtests)	Scaled Score	Qualitative Description
Trail Making		
Visual Scanning	10	Average
Number Sequencing	13	High Average
Letter Sequencing	13	High Average
Number-Letter Sequencing	11	Average
Motor Speed	12	Average
Color Word Interference Test		
Color Naming	15	Average
Error	-	Not Significant
Word Reading	13	Average
Error	-	Not Significant
Inhibition	11	High Average
Error	-	Not Significant
Inhibition/Switching	11	Average
Error	-	Not Significant
Tower Test		
Total Achievement Score	6	Low Average
Rule Violation Per Items	10	Average
Time Per Move Ratio	7	Low Average
Move Accuracy Ratio	7	Low Average
Twenty Questions		
Achievement	11	Average
Questions Asked	13	Average
Abstraction	7	Average
Letter Fluency	11	Average
Category Fluency	10	Average
Category Switching	8	Average
Category Accuracy	10	Average
Design Fluency		
Filled Dots	9	Average
Empty Dots	13	High Average
Switching	5	Borderline
Accuracy	6	Low Average
Set Loss Errors	8	Average

These results suggest that Tom's executive functioning is variable as he struggles with abstraction, impulsivity, variable cognitive flexibility on visual tasks, variable self-monitoring skills on visual tasks, and challenges maintaining a cognitive set on visual tasks, especially as task complexity grows. These results are consistent with his previous diagnosis of ADHD and Autism-Spectrum-Disorder.

3/2/2018 & 4/10/2018 Memory WRAML-2

Memory – to further assess Tom's ability to encode, retain, and retrieve newly presented information, he was administered additional tasks from the WRAML-2.

WRAML-2 Subtest Description	Scaled Score	Qualitative
Verbal Learning	10	Average
Verbal Learning Delayed	10	Average
Verbal Learning Recognition	11	Average
Story Memory	11	Average
Story Memory Delayed	10	Average
Story Memory Recognition	9	Average
Picture Memory	9	Average

Tom's verbal memory skills were assessed using both structured and unstructured verbal memory tasks. On one subtest, he was read the same list of words over four trials and asked to recall as many words as possible under both immediate and delayed conditions. His performance fell within the average range, indicating weaker verbal learning for "unstructured" information (verbal learning = 10). It should be noted these results suggest that his memory is better for structured information which could be related to attention span and distractibility.

4/25/2021 Neuropsychology Evaluation Academic Achievement WIAT-III

WIAT-III is a widely used instrument for measuring the development of basic academic skills across reading, mathematics, written language, and oral language. Scores on this instrument are determined by comparing Tom's performances to other children in his grade range. His previous scores are also noted to allow for easy comparison.

2018-2021 Comparison Chart

Subtest	2018 Standard Score	2021 Standard Score	Percentile Rank	Grade Equivalent	Age Equivalent
Listening Comprehension	92	108	70	10.1	16:0
Receptive Vocabulary	99	94	34		
Oral Discourse	90	118	88		
Reading Comprehension	87	93	32	5.0	10:8
Math Problem Solving	100	100	50	8.7	14:0
Sentence Composition	102	121	92	>12.9	>19:11
Word Reading	110	107	68	12.7	>19.11
Essay Composition	105	99	47	8.4	13.2
Pseudoword Decoding	116	121	92	>12.9	>19:11
Numerical Operations	117	114	82	>12.9	>19:11
Oral Reading Fluency	105	105	63	9.7	16:0
Accuracy	109	107	73	10.9	>19:11

Rate	105	104	68	10.7	>19:11
Spelling	117	105	61	10.5	16:0
Math Fluency- Addition	125	123	94	>12.9	>19:11
Math Fluency- Subtraction	137	123	94	>12.9	>19.11
Math Fluency- Multiplication	132	126	96	>12.9	>19.11

These results were obtained one-on-one, which means they could represent the best he can do, not how he probably does in the classroom.

4/25/2021 Neuropsychology Evaluation Wechsler Scale for Children Fifth Edition

Tom was administered ten subtests from the Wechsler Intelligence Scale for Children Fifth Edition (WISC-V). The WISC-V is an individually administered, comprehensive clinical instrument

for assessing the intelligence of children ages 6:0-16:11. The primary subtest scores contribute to the primary index scores, which represent intellectual functioning in five cognitive areas: Verbal Comprehension Index (VCI), Visual Spatial Index (VSI), Fluid Reasoning Index (FRI), Working Memory Index (WMI), and the Processing Speed Index (PSI). This assessment also produces a Full

Scale IQ (FSIQ) composite score that represents general intellectual ability. Tom's FSIQ score is in the High Average range when compared to other children his age (FSIQ=117, 87th percentile) and this score was consistent with previous testing in 2018.

Subtests from Wechsler Intelligence Scale for Children Fifth Edition (2021)

Composite	Composite Score	Percentile Rank	95% Confidence Interval	Qualitative Description
Visual Comprehension	100	50	92-108	Average
Visual Spatial	111	77	102-118	High Average
Fluid Reasoning	115	84	107-121	High Average
Working Memory	125	95	115-131	Very High
Processing Speed	116	86	105-123	High Average
Full Scale IQ	**117**	**87**	**111-122**	**High Average**

Composite:
Verbal Comprehension Subtest Score Summary

Subtest	Scaled Score	Percentile Rank
Similarities	14	91
Vocabulary	6	9
Information	8	25

The VCI measures Tom's ability to access and apply acquired word knowledge. Specifically, this score reflects his ability to verbalize meaningful concepts, think about verbal information, and express himself using words. Tom obtained a VCI score withing the Average range (VCI = 100, 50th percentile) and this domain was an area of weakness relative to his other domains scored.

Chronological listing of Tom's Wechsler Intelligence Scale Results

Year	FSIQ	Test	Verbal Comprehension Index
2013	88	WISC-IV	*
2015	86	WISC-V	VCI = 81, (10th percentile)
2018	115	WISC-V	VCI = 98, (45th percentile)
2021	117	WISC-V	VCI = 100, (50th percentile)

*Because of Tom's underlying diagnosis of an Autism Spectrum Disorder, the Information Subtest was substituted for the Comprehension Subtest. The Verbal Comprehension Index is traditionally comprised of the scores from Similarities, Vocabulary, and Comprehension Subtests.