

**The Science of Improved Language Comprehension:  
*Brain Connectivity and Autism Spectrum Disorder***

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Autism spectrum disorder (ASD), according to the Mayo Clinic, “is a serious neurodevelopmental disorder that impairs a child's ability to communicate and interact with others. It also includes restricted repetitive behaviors, interests, and activities. These issues cause significant impairment in social, occupational and other areas of functioning.” As many as 42% of children with ASD are reported to have impairment in both verbal expression and comprehension abilities.<sup>1</sup> The Center for Disease Control records the rate of ASD diagnosis to be one in 68, giving insight to the vast number of children affected by ASD and the associated language deficits.<sup>2</sup>

Not surprisingly, the language comprehension deficits of students with ASD impact the performance in classroom environment. The ability to understand the English language is foundational to success within the curriculum utilized in the United States’ educational system. As a result, students who struggle with language comprehension often falter in their educational performance. They fall behind academically and frequently experience psychosocial problems, which in turn affect relationships with their peers and teachers. There is, however, a solution to this challenge. Students with ASD can improve their language comprehension through a scientifically-based and research-validated program.

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<sup>1</sup> "Verbal Expression and Comprehension Deficits in Young Children With Autism." ResearchGate. Web. 19 Jan. 2016.

<sup>2</sup> "Data & Statistics." Centers for Disease Control and Prevention. Centers for Disease Control and Prevention, 12 Aug. 2015. Web. 19 Jan. 2016.

## **History**

Language comprehension is a complex brain process. Multiple parts of the brain are involved and the connection between them is fundamental to comprehension. The Dual Coding Theory (DCT) of cognition, researched and developed by Allan Paivio of the University of Western Ontario, stipulates that both visual and verbal representations of words, sentences, and paragraphs are necessary for memory and language comprehension. A person must be able to associate images with words, and vice-versa, for effective cognitive processing to take place. Connections between the imaginal areas of the brain and the verbal or language areas of the brain are the critical, functional process for comprehension. Albert Einstein attested to this fact saying, “If I can’t picture it, I can’t understand it.”

Only in recent years have language comprehension deficits begun to be identified as a specific type of learning disability (e.g., hyperlexia). Previously, the symptoms of comprehension deficits were acknowledged, such as poor recall or difficulty with expression, but the underlying cause was not. As a consequence, treatment was limited to “language only” strategies that attempted to mitigate and remediate the symptoms, instead of addressing the cause of the deficit—a deficit in being able to create mental representations (images).

While some children with ASD have a tremendous ability for compartmentalized memory, their capacity is typically limited to specific subject domains. For example, a child might have an uncanny ability to recall baseball statistics but struggles to retain information from a simple reading paragraph. Another child could demonstrate the ability to decode words at a level much higher than anticipated, but cannot extract meaning from the material. This apparent disparity fosters a misconception of the true nature of the language comprehension deficit in students with ASD, when in reality, it is caused by a weakened connection between the imagery generating and language parts of the brain.

## **Key Educational Issues**

### *The US Education Model*

Language is the basis for teaching and learning in the United States. All learning requires a basic foundation of language comprehension, regardless of the subject matter. Textbooks and oral instruction rely primarily on language to communicate the curriculum. Furthermore, the teaching process often relies on delivering content through language-based repetition. The premise is that if students exhibiting at-risk language comprehension skills are exposed to the material enough times, he or she will learn it.

This approach, however, ignores the underlying processes and the necessary connectivity between the imagery and verbal centers in the brain. When these centers do not adequately communicate, due to a weak or underdeveloped ability to generate images, no amount of repetition of content-based instruction will remedy language comprehension deficits. Consequently, many students fall further and further behind academically because they do not understand what is being presented in the classroom.

Students navigate a continual cycle of instruction where comprehension is tested (not taught), resulting in reward or penalty, depending on the test results. When a student is not capable of learning due to language comprehension deficits, the results can be devastating academically, socially, and emotionally. This is especially true for students on the Autism spectrum.

### *Social and Psychological Impacts*

Not only are students with language comprehension deficits prone to academic struggles, they also face related social and emotional challenges. They are likely to ask questions

repeatedly, attempting to grasp information they do not retain or understand. Similarly, students with ASD fail to connect to the larger picture of the classroom objectives and are likely to make unrelated comments. Teachers may mistake these behaviors as intentionally disruptive and take disciplinary steps. Peers often find the behaviors offensive and distance themselves socially, resulting in alienation of the student with ASD.

#### *Timing*

The prevailing educational model requires students to demonstrate failure to access the curriculum prior to making interventions and accommodations via special education plans. Brain plasticity—the brain’s ability to modify its structure—is at its highest capacity in childhood. This indicates the necessity of intervening as soon as language comprehension deficits are identified. Language comprehension is fundamental to all learning—inside the classroom and out—thus warranting the swiftest and most robust intervention available.

#### **Research-validated Solutions**

The need to engage in more effective ways to address language comprehension deficits is *essential* given the rise in ASD diagnoses and the associated comprehension problems. As such, the educational system in the United States must begin to adopt a more effective means of both identifying those deficits and remediating the underlying brain process, not merely treating the symptoms. Current research is opening the doors to scientifically-based and scientifically-validated interventions.

#### *Functional Activation*

Marcel Just, of Carnegie Mellon University, and Nancy Minshew, director of the Center of Excellence in Autism Research, have identified what they call the under-connectivity hypothesis of Autism. Their hypothesis posits that the neural connections in a brain with autism are poorly connected and/or synchronized. Just and Minshew’s findings reveal that complex tasks, such as spatial reasoning and language comprehension, are more difficult for persons with ASD due to poor communication between the brain regions that govern them.

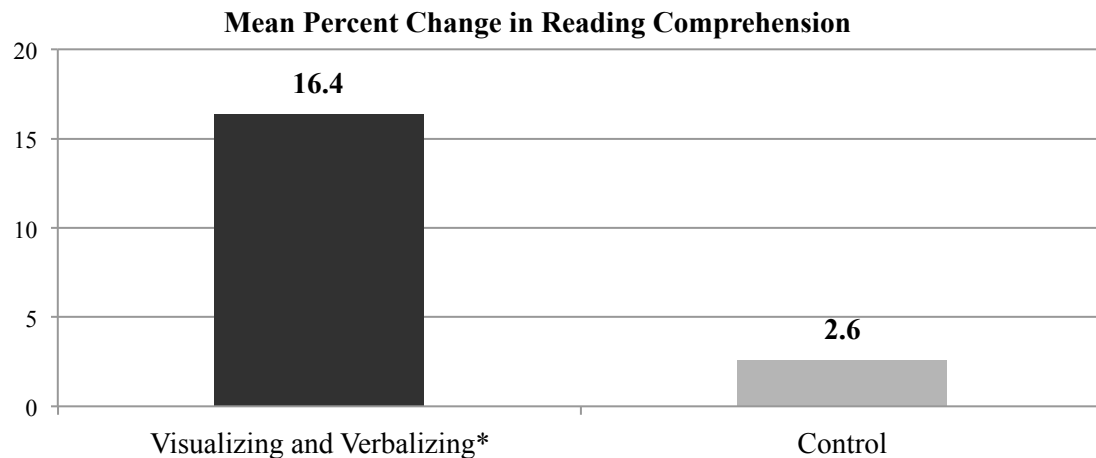
Remediating this deficiency requires functional activation: cognitive exercises that electrochemically stimulate the brain’s ability to send messages to and from the areas required to code the incoming language into mental representations (imagery) and then verbally. This enhances the structural integrity of the brain. By strengthening the dendrites and axons—the conduit mechanisms of the brain—information is more readily transferred between the required regions of the brain, allowing images to be associated with words and vice-versa.

#### *Visualizing and Verbalizing program*

DCT emphasizes the need for both the mental representational and the verbal cortical areas to be stimulated for optimal language comprehension. Paivio’s theory has been accepted for more than four decades but has more recently been examined through the lens of neurology to observe functional brain connectivity. Nanci Bell’s Visualizing and Verbalizing program develops what she calls concept imagery—the ability to create an imagined or imaged gestalt from language—as a basis for comprehension and higher order thinking. The development of concept imagery improves reading and listening comprehension, memory, oral vocabulary, critical thinking, and writing.

The University of Alabama at Birmingham chose the Visualizing and Verbalizing program to conduct a study to assess the legitimacy of DCT and the neurological validity of its premises as applied to ASD students. In summary, the results proved promising for bolstering the brain’s ability to comprehend language. Here is a recap of the research project:

- *Participants and controls.* Fifty-three children participated in the study: 22 typically-developing students and 31 students who had been diagnosed with ASD by a licensed clinical psychologist. The 31 subjects with ASD were randomly assigned to two groups. Sixteen of the 31 ASD students received the instruction. The second group consisted of the other 15 who did not receive the instruction. The typically-developing students also did not receive the instruction. The three groups provided a point of comparison between typically-developing students, those with ASD, as well as a comparison between the ASD students who received the instruction and those who did not. Other studies attempting to address neurological changes resulting from targeted reading intervention have observed only a single participant, thus reducing the ability to assess the interventions' efficacy in a larger population.
- *Study duration and intensity.* Participants in the experimental study underwent ten weeks of intensive instruction using Nanci Bell's Visualizing and Verbalizing program, a curriculum designed to stimulate the conceptual imagery associated with written or spoken language. The material stimulates all facets of language comprehension: reading and listening comprehension, memory, oral vocabulary, critical thinking, and writing. Students received four hours of instruction from Lindamood-Bell staff, five days a week, for 10 weeks.
- *Neurological observations and results.* All 53 study participants were subject to two functional MRI (fMRI) scans to document their brain function(s), at the beginning of the 10-weeks, and again at the end. The initial scans of typically-developing students showed strong connectivity between the imaginal and verbal cortical centers whereas those of the ASD students revealed only loose connectivity between the centers. At the conclusion of the study, when all students were re-scanned, the imaginal-verbal connection showed marked improvement in those who had received the Visualizing and Verbalizing program. Those students who did not receive the instruction showed no substantive change in the connection between cortical centers (whether ASD or typically developing).
- *Behavioral observations and results.* Reading comprehension assessments were also administered to all three groups of participants at the beginning and end of the study. Typically-developing students performed better than both ASD groups at both testing times. After 10 weeks, the 16 ASD students who received the intensive instruction showed significant improvement (16.4%) on the comprehension test. Those ASD students who did not receive instruction had little change (2.6%) and had lower scores than those of the typically-developing students.



\*Statistically significant ( $p = .0006$ ).

Murdaugh, D. L., J. O. Maximo, and R. K. Kana. 2015. "Changes in intrinsic connectivity of the brain's reading network following intervention in children with autism." *Human Brain Mapping*. doi: 10.1002/hbm.22821.

The 10-week study demonstrated the necessity of a strong connection between the imaginal and verbal cortical centers of the brain for language comprehension. Allan Paivio's Dual Coding Theory was neurologically observable through fMRI scans of students receiving intensive instruction using a high-imagery/verbalization instructional process. Students with ASD, who struggle to comprehend language, can have a strengthened connection between the brain regions necessary for improvements in memory and language comprehension.

#### *Objectives and benefits of intervention*

The primary goal of both parents and educators of children with ASD is to provide them with the best means to live a fulfilling life with meaningful relationships and the increased ability to grasp what's happening the world around them. The current methods for remediating language comprehension deficits (and the associated behavioral/psychosocial problems) may not necessarily address the underlying impaired neurological process.

When students fall behind their peers academically and socially by a year or more, rigorous and intense interventions geared toward the brain's required learning mechanisms will prove necessary to close the gap. Weekly appointments for 20-60 minutes simply won't be sufficient. The University of Alabama at Birmingham study recorded notable improvements with a sensory-cognitive brain-based intervention for four hours per day, five days a week, for 10 weeks. Adopting the mindset that intense and lengthy intervention is necessary is pivotal to success.

As students make gains in language comprehension, they become better able to manage their own learning. Self-regulation in learning is foundational to successful learning throughout formal education and life outside the classroom. Students can begin to visualize what they learn—utilizing both the imaginal and verbal cortical centers—and apply it to all subjects. When the neurological pathways of the brain have been strengthened to support the learning process, they naturally reinforce themselves over the course of all other learning—continuously stimulating the imagery-language connection. The goal, of course, is to have a lasting effect on not just the academic but also the psychosocial learning.

## Resources

Identifying brain-processing issues is imperative to remediating language comprehension deficits. While the current educational model doesn't often distinguish between the symptoms and the causes as it relates to methods of support, both parents and educators are wise to assess the root of the problem. To evaluate whether a child has impaired concept imagery, consider the following indicators, taken from Nanci Bell's book, Visualizing and Verbalizing (used with permission):

1. *Difficulty with critical, logical, abstract thinking and problem solving.*  
Individuals appear unable to draw conclusions or make inferences due to lacking a connection to the larger picture.
2. *Difficulty with written language comprehension.*  
Individuals struggle to comprehend the main ideas from text though decoding skills are adequate. Students may test poorly except when merely factual data is being challenged.
3. *Difficulty with oral language comprehension.*  
Individuals may show disinterest in orally-presented material or an ability to attend to oral presentations. These individuals may be labeled as inattentive listeners.
4. *Difficulty following directions.*  
Individuals grow easily confused by directions involving more than one or two steps. They seem unable to retain the instructions.
5. *Difficulty in expressing language orally.*  
Individuals may recount stories out of sequence or articulate unimportant details. Their language seems scattered or disconnected.
6. *Difficulty expressing language in writing.*  
Individuals' writing doesn't reflect sequential thoughts leading to a coherent point. They may have difficulty understanding the purpose of a question, rendering a clear answer impossible.
7. *Difficulty grasping humor.*  
Literal interpretation of language precludes understanding of language-based humor, though physical humor does not. Individuals may laugh at inappropriate times.
8. *Difficulty interpreting social situations.*  
Individuals fail to grasp the non-verbal communication, leaving them with only isolated parts of information to guide behavior, resulting in inappropriate social expression.
9. *Difficulty with cause and effect.*  
Whether in social or academic situations, individuals who process only parts of information being communicated, not the whole, cannot grasp how the part relates to the whole. Verbal discussion of a problem may prove ineffective.
10. *Difficulty with attention and focus.*  
Individuals may not be able to sustain focus or attention in learning or even in social situations.
11. *Difficulty responding to a communicating world.*  
Individuals appear to find language a confusing puzzle or altogether meaningless and consequently opt to withdraw themselves and may end up isolated socially.
12. *Difficulty with mental mapping.*  
Individuals may find following a map difficult and get lost easily.

While none of these symptoms alone indicates weak conceptual imagery as an underlying cause of language comprehension deficits, they do raise the flag of concern. If multiple factors are present, they give reason for further investigation or referral to a professional for evaluation.

### **Summary**

Language comprehension deficits for children with Autism Spectrum Disorder are not necessarily permanent. Deficits in language comprehension can be improved through stimulating and strengthening the connection between the verbal and imaginal centers of the brain. As predicted by the Dual Coding Theory, the Visualizing and Verbalizing program develops concept imagery—the ability to create an imaged gestalt, or whole, from language. This approach recognizes the brain process that underlies language comprehension and remediates impairment with a scientifically-validated intervention. Language comprehension is foundational to learning—both social and academic—in the educational environment. With a better understanding of subject matter and social relationships, students are poised for greater success in all areas of life.

### ***About the Author:***

Lindamood-Bell believes that all children and adults can learn to their potential. For nearly 30 years, their research-validated instruction has consistently changed the lives of individuals with learning challenges such as dyslexia, ADHD, and autism. In addition to their nearly 100 Learning Centers and Seasonal Learning Clinics nationally and internationally, their efforts include research collaborations with MIT, UAB, and previously with Wake Forest, and Georgetown University. Lindamood-Bell has been recognized by the U.S. Department of Education, Time, US News and World Report, Neuron, NeuroImage, CNN, and PBS. Lindamood-Bell and all of their Learning Centers are accredited by AdvancED. Visit [lindamoodbell.com](http://lindamoodbell.com) to learn more.

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