RESEARCH

Abstracts and Articles

LINDAMOOD-BELL

EST. 1986

LEARNING PROCESSES™

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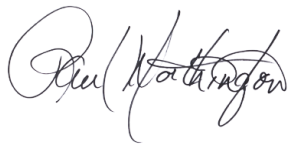
Research Abstracts

Research Articles

Introduction

Over the past thirty-five years, Lindamood-Bell Learning Processes® and our research collaborators have amassed a large body of evidence indicating that all individuals can learn to their potential. In this research summary, you will find peer-reviewed, independent, and collaborative research conducted by the founders of Lindamood-Bell and various universities. These studies have significantly advanced the knowledge and practices about what must be done to meet the needs of individuals who struggle to learn, including those with a diagnosis of dyslexia or autism.

Sincerely,



Paul Worthington
Director of Research and Development

LINDAMOOD-BELL
LEARNING PROCESSES

RESEARCH

The Role of Brain Activity in Characterizing Successful Reading Intervention in Children with Dyslexia

Seeing Stars for Phonological and Orthographic Processing in Reading and Spelling (SI)

On Cloud Nine for Visualizing and Verbalizing for Math

PROFILE:

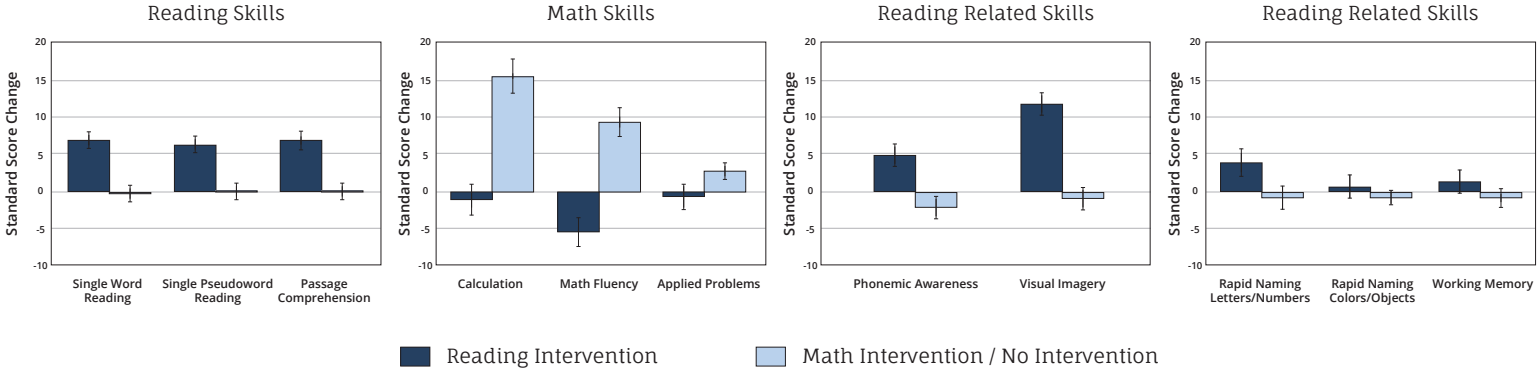
Number of Students: 31 **Age:** 7.4 - 12.6

Programs Implemented:
- Seeing Stars
- On Cloud Nine

Outcome Measures:
- WASI
- Woodcock-Johnson

BACKGROUND:

This NIH-funded study examined the relationship between reading and math skills, and was conducted by the Center for the Study of Learning, Department of Pediatrics at Georgetown University Medical Center. Children with dyslexia were assigned to a phonological- and orthographic-based tutoring period in the Seeing Stars program as well as a within-subjects control period, using the On Cloud Nine math program, to examine intervention-induced changes in reading and math learning behavior as associated with brain activity. The intensive intervention focused on promoting reading through phonological and orthographic skills. The study was designed to examine, 1) intervention-induced changes in behavior and brain activity, and 2) related behavioral and brain activity pre-intervention data that revealed predicted intervention-induced gains in reading and math performance.



The graph above shows standard score changes in behavioral measures following intervention: reading skills, phonological and orthographic reading- related skills, other reading related skills (rapid naming and memory), and math skills. Highlights: Large standard score changes on the calculation and math fluency measure following OCN instruction. Following Seeing Stars intervention, students made large gains on word reading and passage comprehension.

RESULTS:

Overall, the students made strong gains in both reading and math performance, the two skills developed in the intervention. These gains were specific to the reading intervention, as the control math intervention resulted in gains on math but not on reading measures. The study concludes that behavioral changes (growth in reading and reading-related skills) were "significant, specific, and enduring." The researchers also concluded that individual brain changes were too variable among study participants to determine specific patterns of growth in neural activation at the group level.

LOCATION:

Center for the Study of Learning, Department of Pediatrics, Georgetown University Medical Center, Washington, DC, United States

Krafnick, A. J., Napoliello, E. M., Flowers, D. L., & Eden, G. F. (2022). The role of brain activity in characterizing successful reading intervention in children with dyslexia. *Frontiers in Neuroscience*, 16. doi=10.3389/fnins.2022.898661

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RESEARCH

Abnormal Vision Motion Processing Is Not a Cause of Dyslexia

Seeing Stars for Phonological and Orthographic Processing in Reading and Spelling (SI)

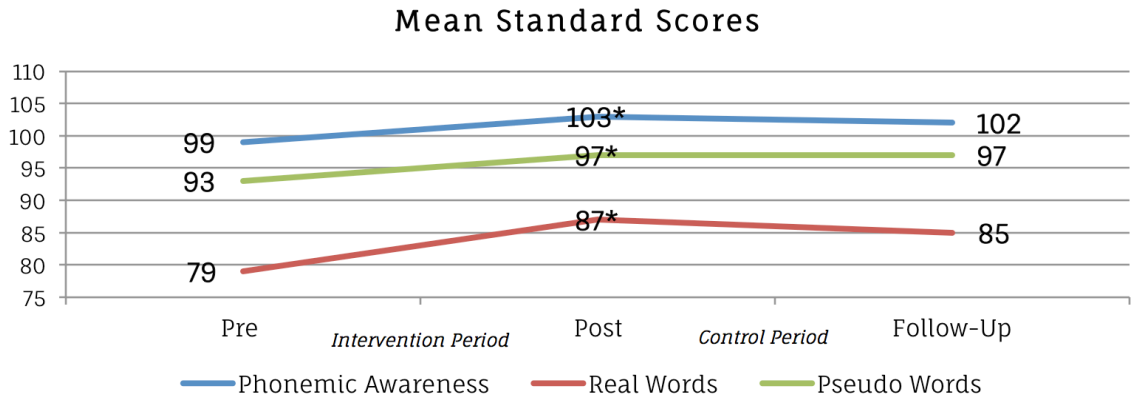
PROFILE:

Number of Subjects: 22
Age: 7–12
Program Implemented:
- Seeing Stars

Outcome Measures:
- Lindamood Auditory Conceptualization Test-3rd
- Woodcock Johnson Tests of Achievement-3rd (Word Identification and Word Attack)
- Brain activity (fMRI)

BACKGROUND:

Georgetown University's Center for the Study of Learning, in collaboration with Lindamood-Bell Learning Processes, conducted an experiment involving children with dyslexia. This study investigated the efficacy of the Seeing Stars program, which develops symbol imagery for reading. Children were pretested on a battery of reading assessments, received approximately 120 hours of Seeing Stars instruction, and were posttested. Eight weeks later the children received follow-up testing. Brain scans were obtained using functional magnetic resonance imaging (fMRI) at the three points in time. Small-group instruction was delivered by specially trained Lindamood-Bell staff. Behavioral (i.e., reading assessment) and neuroimaging results during the intervention period were compared to results during the control period.



Note: *Statistically significant (p ≤ .05)

RESULTS:

On average, pre- to posttest results were statistically significant on all three reading assessments, and activity in the area of the brain associated with visual processing (right V5/MT) also increased significantly after the intervention. Post- to follow-up results (behavioral and neuroimaging) were not significant; demonstrating that the improvements were specific to the intervention. The results of this study illustrate that Lindamood-Bell instruction in the Seeing Stars program leads to increased brain activity and improved reading for children with dyslexia.

LOCATION:

Center for the Study of Learning, Georgetown University Medical Center, Washington, D.C., USA

Olulade, O. A., Napoliello, E. M., & Eden, G. F. (2013). Abnormal visual motion processing is not a cause of dyslexia. Neuron, 79(1), 180-190. doi:10.1016/j.neuron.2013.05.002

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RESEARCH

Gray Matter Volume Changes following Reading Intervention in Dyslexic Children

Seeing Stars for Phonological and Orthographic Processing in Reading and Spelling (SI)

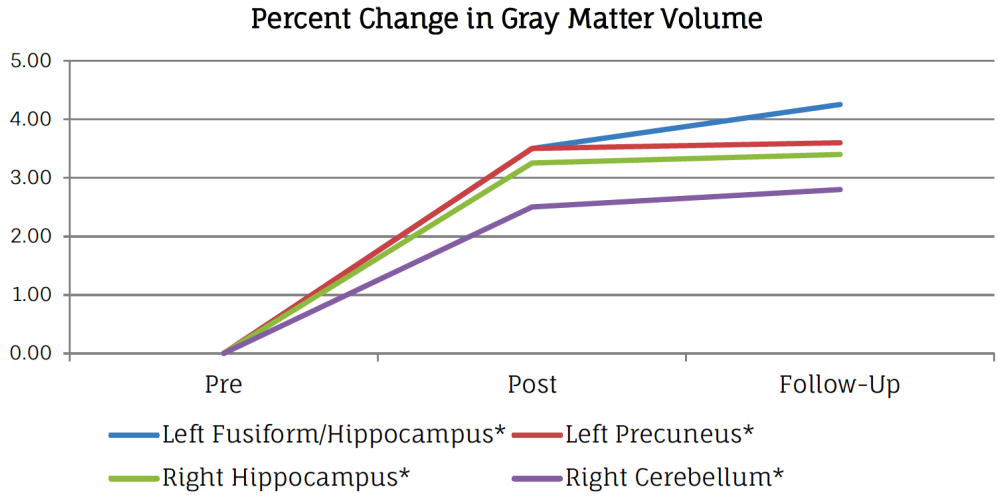
PROFILE:

Number of Subjects: 11
Age: 7-11
Program Implemented:
- Seeing Stars

Outcome Measures:
- Brain Structure (fMRI)
- Rapid Automatized Naming
- Lindamood Auditory Conceptualization Test-3rd
- Woodcock-Johnson (Word Identification and Word Attack)
- Symbol Imagery Test

BACKGROUND:

Georgetown University's Center for the Study of Learning, in collaboration with Lindamood-Bell Learning Processes, conducted a neuroscientific experiment involving children with dyslexia. This study investigated the efficacy of the Seeing Stars program, which develops symbol imagery for reading. Children were pretested on a battery of reading assessments, received eight weeks of Seeing Stars instruction, and were posttested. Eight weeks later the children received follow-up testing. Brain scans were obtained using functional magnetic resonance imaging (fMRI) at the three points in time. Instruction was delivered by teachers who received professional development in Seeing Stars.



Note: *Statistically significant (p ≤ .05)

RESULTS:

On average, pre- to posttest results were statistically significant in all brain regions and on all reading assessments. Post- to follow-up results (neuroimaging and behavioral) were not significant; demonstrating that the improvements were specific to the intervention. In addition, follow-up results showed that improvements were maintained. The results of this study illustrate that Lindamood-Bell instruction in the Seeing Stars program leads to increased brain structure and improved reading for children with dyslexia.

LOCATION:

Center for the Study of Learning, Georgetown University Medical Center, Washington, D.C., USA

Krafnick, A. J., Flowers, D. L., Napoliello, E. M., & Eden, G. F. (2011). Gray matter volume changes following reading intervention in dyslexic children. Neuroimage, 57, 733-741. doi:10.1016/j.neuroimage.2010.10.062

LINDAMOOD-BELL
LEARNING PROCESSES

RESEARCH

Neural Changes Following Remediation in Adult Developmental Dyslexia

Seeing Stars for Phonological and Orthographic Processing in Reading and Spelling (SI)

Visualizing and Verbalizing for Language Comprehension and Thinking (V/V)

Lindamood Phoneme Sequencing Program for Reading, Spelling, and Speech (LiPS)

PROFILE:

Number of Subjects:
- 9 Lindamood-Bell
- 10 Control

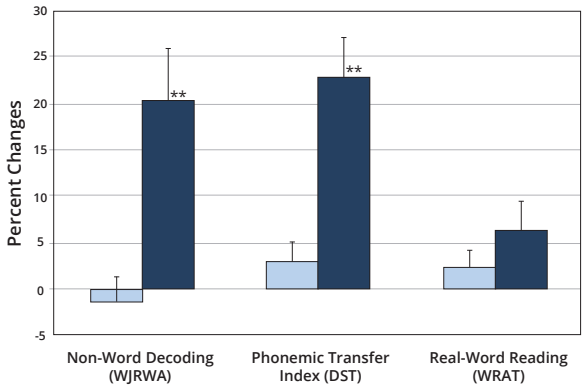
Programs Implemented:
- Seeing Stars
- Lindamood Phoneme Sequencing
- Visualizing and Verbalizing

Outcome Measures:
- Test of Auditory Analysis Skills
- Symbol Imagery Test
- Brain Activity (fMRI)

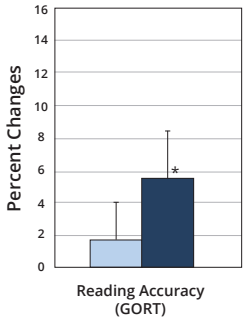
BACKGROUND:

Georgetown University's Center for the Study of Learning, in collaboration with Lindamood-Bell Learning Processes, conducted an experiment involving adults with dyslexia. This study investigated the efficacy of the Seeing Stars, Visualizing and Verbalizing, and Lindamood Phoneme Sequencing programs, which develop symbol imagery, concept imagery, and phonemic awareness. Subjects were pretested on phonological processing assessments, received approximately 112 hours of Lindamood-Bell instruction, and were posttested. In addition, pre- and posttest brains scans were obtained using functional magnetic resonance imagings (fMRI). Instruction was delivered by specially trained Lindamood-Bell staff.

Single Word Decoding



Secondary Reading Skills



Non-Intervention Group
Intervention Group

* p < .05
** p < .005

RESULTS:

On average, Lindamood-Bell subjects demonstrated greater improvements, statistically, than comparison subjects as correlated with behavioral gains in reading. In addition, Lindamood-Bell subjects had comparatively larger increases in brain activity than comparison subjects. The results of this study support the Dual Coding Theory model of cognition and illustrate that instruction in the Lindamood-Bell programs lead to improved reading and increased strength in activation areas.

LOCATION:

Georgetown University Medical Center, Washington, D.C., USA, Wake Forest University Medical Center, Winston-Salem, NC, USA

Eden, G. F., Jones, K. M., Cappell, K., Gareau, L., Wood, F. B., Zeffiro, T. A., & Flowers, D. L. (2004). Neural changes following remediation in adult developmental dyslexia. Neuron, 44, 411-422. https://doi.org/10.1016/j.neuron.2004.10.019

White Matter Microstructural Plasticity Associated with Educational Intervention in Reading Disability

Seeing Stars for Phonological and Orthographic Processing in Reading and Spelling (SI)

PROFILE:

Number of Subjects: 41
Age: 7-9 years old
Lindamood-Bell Programs Implemented:
- Seeing Stars

Outcome Measures:
- Symbol Imagery Test
- TOWRE-2
- WRMT-3

BACKGROUND:

The Massachusetts Institute of Technology (MIT) McGovern Institute for Brain Research and Department of Brain and Cognitive Sciences, in collaboration with Lindamood-Bell Learning Processes, conducted a randomized controlled trial involving young children with reading disabilities and difficulties. This experiment investigated the efficacy of the Seeing Stars® program, which develops symbol imagery for reading. This study investigated the relationship between reading outcomes and white matter connections that facilitate communication between brain regions critical for proficient reading. Researchers collected reading scores and diffusion-weighted images at the beginning and end of summer for 41 children with reading disabilities who had completed either 1st or 2nd grade. Children were randomly assigned to either receive an intensive reading intervention (n = 26; Seeing Stars from Lindamood-Bell which emphasizes orthographic fluency) or be deferred to a wait-list group (n = 15), enabling researchers to analyze how white matter properties varied across a wide spectrum of skill development and regression trajectories.

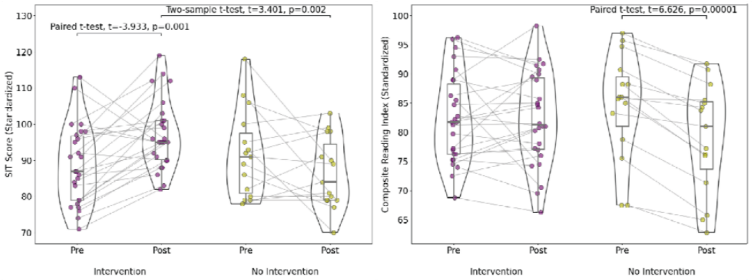


Figure 2: Changes in Symbol Imagery Test (SIT; left) and Composite Reading Index (right) scores for intervention (purple) and non-intervention (yellow) participants. Paired t-tests were used to compare pre and post scores within groups, and two-sample t-tests were used to compare scores at a given time point across groups. Significant tests ($p < 0.05$) are annotated in the figure.

RESULTS:

On average, the intervention group had larger gains in reading than the non-intervention group, which declined in reading scores. The authors' findings suggest that responses to intensive reading instruction are related predominantly to white matter plasticity in tracts most associated with reading.

LOCATION:

McGovern Institute for Brain Research and Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology, Cambridge, MA, USA

Meisler, S. L., Gabrieli, J. D. E., & Christodoulou, J.A. (2023). White Matter Microstructural Plasticity Associated with Educational Intervention in Reading Disability. bioRxiv. https://doi.org/10.1101/2023.08.31.553629

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RESEARCH

Socioeconomic Status and Reading Disability: Neuroanatomy and Plasticity in Response to Intervention

Seeing Stars for Phonological and Orthographic Processing in Reading and Spelling (SI)

PROFILE:

Number of Subjects:
- 40 Seeing Stars
- 25 Control

Age: 6-9

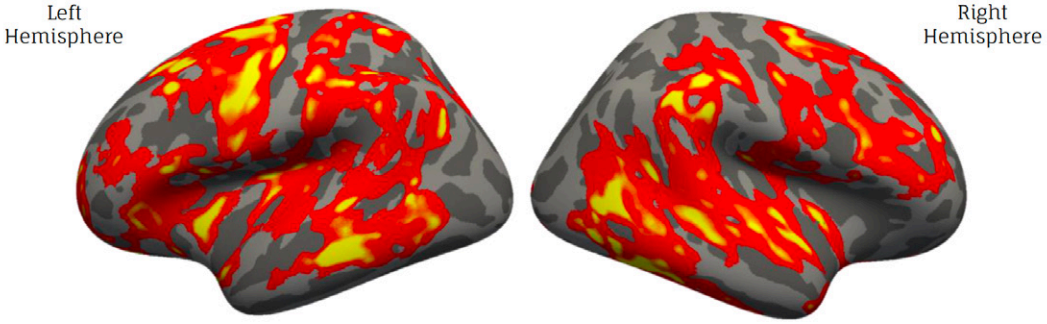
Program Implemented:
- Seeing Stars

Outcome Measures:
- Brain Activity (fMRI)

BACKGROUND:

The Massachusetts Institute of Technology (MIT) McGovern Institute for Brain Research and Department of Brain and Cognitive Sciences, in collaboration with Lindamood-Bell Learning Processes, conducted a randomized controlled trial involving young children with reading disabilities (RD) and difficulties. This experiment investigated the efficacy of the Seeing Stars program, which develops symbol imagery for reading. Children were randomly assigned to intervention (Seeing Stars) or non-intervention (control) groups. Before and after, all children received functional magnetic resonance imaging (fMRI) to measure cortical thickness. Over a six-week period of time, children in the Seeing Stars group received between 100 and 120 hours of instruction that was delivered by specially trained Lindamood-Bell staff.

Brain (Cortical) Growth



Note: Figure used with author's permission.

RESULTS:

Brain regions (red and yellow areas) grew significantly thicker in children whose reading scores improved (n=20) after Seeing Stars instruction. In addition, children from lower-socioeconomic status (SES) families were more likely to benefit from instruction than children from higher-SES families, and children with more severe reading disability exhibited the most improvement in reading scores. "These findings indicate that effective summer reading intervention is coupled with cortical growth, and is especially beneficial for children with RD who come from lower-SES home environments" (p.1).

LOCATION:

McGovern Institute for Brain Research and Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology, Cambridge, MA, USA

Romeo, R. R., Christodoulou, J. A., Halverson, K. K., Murtagh, J., Cyr, A. B., Schimmel, C., … Chang, P. (2017). Socioeconomic status and reading disability: Neuroanatomy and plasticity in response to intervention. Cerebral Cortex, 28, 2297-2312. doi:10.1093/cercor/bhx131

LINDAMOOD-BELL
LEARNING PROCESSES

RESEARCH

Impact of Intensive Summer Reading Intervention for Children with Reading Disabilities and Difficulties in Early Elementary School

Seeing Stars for Phonological and Orthographic Processing in Reading and Spelling (SI)

PROFILE:

Number of Subjects:
- 23 Seeing Stars
- 24 Control

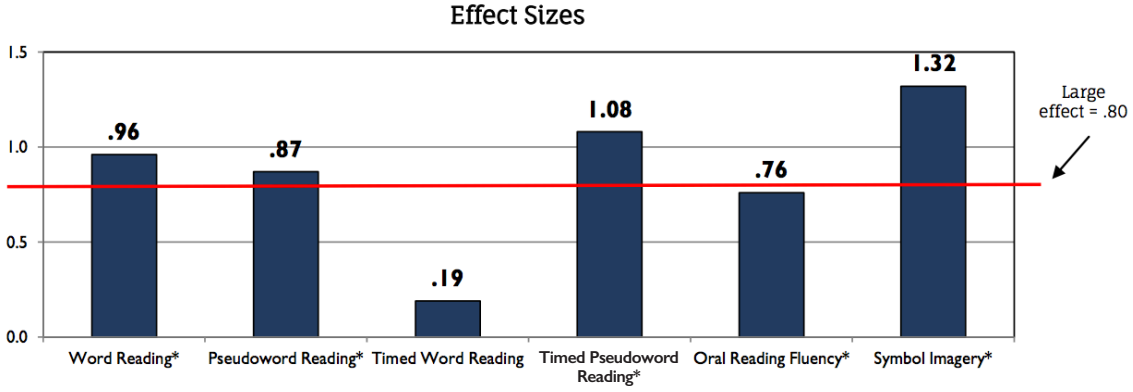
Age: 6-9

Program Implemented:
- Seeing Stars

Outcome Measures:
- Woodcock Johnson Tests of Achievement-3rd (Word Identification and Word Attack)
- Test of Word Reading Efficiency-2nd (Sight Word Efficiency and Phonemic Decoding Efficiency)
- Dynamic Indicators of Basic Early Literacy Skills (Oral Reading Fluency)
- Symbol Imagery Test

BACKGROUND:

The Massachusetts Institute of Technology (MIT) McGovern Institute for Brain Research and Department of Brain and Cognitive Sciences, in collaboration with Lindamood-Bell Learning Processes, conducted a randomized controlled trial involving young children with reading disabilities and difficulties. This experiment investigated the efficacy of the Seeing Stars program, which develops symbol imagery for reading. Children were randomly assigned to intervention (Seeing Stars) or non-intervention (control) groups. All children were pre- and post-tested on a battery of reading measures. Over a six-week period of time, children in the Seeing Stars group received between 100 and 120 hours of instruction that was delivered by specially trained Lindamood-Bell staff. Gains made by the Seeing Stars group were compared to gains made by the control group. Effect sizes were calculated to determine the magnitude of the differences between the groups.



Note: *Statistically significant ($p \leq .05$).

RESULTS:

Large effects were realized on four of the six measures, with Oral Reading Fluency being near the large threshold, and statistical significance ($p \leq .05$) favoring the Seeing Stars group was reached on five of the six measures. A very large effect size ($\eta_p^2 = .60$) was realized on a composite across all measures, which was also significant ($p \leq .001$) in favor of the Seeing Stars group. The results of this study illustrate that instruction in the Seeing Stars program supports the development of phonological and orthographic processing resulting in improvements in reading for children with reading disabilities and difficulties.

LOCATION:

McGovern Institute for Brain Research and Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology, Cambridge, MA, USA

Christodoulou, J. A., Cyr, A., Murtagh, J., Chang, P., Lin, J., Guarino, A. J. … Gabrieli, J. D. (2015). Impact of intensive summer reading intervention for children with reading disabilities and difficulties in early elementary school. Journal of Learning Disabilities, 50(2), 115-127. doi:10.1177/0022219415617163

Intensive Summer Intervention Drives Linear Growth of Reading Skills in Struggling Readers

Seeing Stars for Phonological and Orthographic Processing in Reading and Spelling (SI)

PROFILE:

Number of Students:

- 31 Seeing Stars

Age: 6-12

Program Implemented:

- Seeing Stars

Outcome Measures:

- Woodcock-Johnson IV (Basic Reading Skills & Reading Fluency)
- Test of word Reading Efficiency (Index)

BACKGROUND:

One of the major achievements of research in reading is the development of evidence-based intervention programs for struggling readers. Neuroscientific reading behavioral interventions studies typically utilized a pre-post design only to examine efficacy. Such study designs preclude the study of growth trajectories over the course of the intervention program. This new study conducted with the Institute of Learning Sciences Laboratory at the University of Washington analyzed reading growth curves for dyslexics using the Seeing Stars intervention approach. A cohort of 31 children (6–12 years) with reading difficulties (N = 21 with dyslexia diagnosis) was randomly selected for 160 hours of intervention occurring over 8 weeks. Measures were taken over 4 sessions assessing decoding, oral reading fluency, and comprehension.

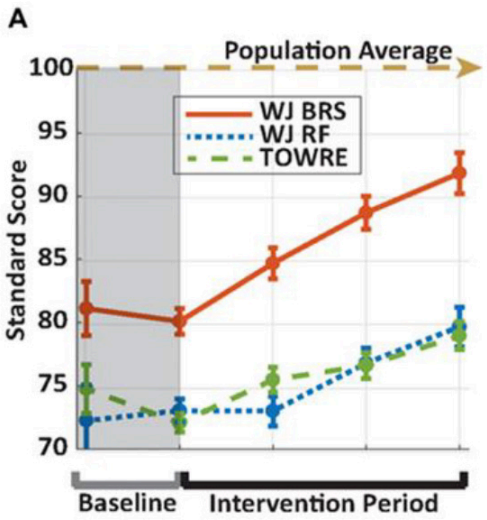


Fig. 2. (A) Mean growth of composite reading skills. Growth curves are plotted using the intercept and slope estimates from a linear mixed-effects model with session as a categorical variable. The dashed lines represent measurements during the baseline period. Results show growth across reading measures during the intervention period, and no change (or a decline) in scores during the baseline period.ASD-EXP group.

Note: Figured used with permission.

RESULTS:

Using a Mixed-effects model of longitudinal measurements essentially revealed a "linear dose-response relationship between hours of intervention and improvement in reading ability, with significant linear growth on every measure of reading skill and none of the measures showing non-linear growth trajectories". More specifically, decoding skills showed substantial growth [Cohen's d = 0.85, with fluency and comprehension growing more gradually [d = 0.41. These findings contrasted with stability or decline seen during a pre-intervention baseline period, seen in the group of age, and reading skill-matched control participants. Reading skills increased linearly with each hour of intervention, carrying practical implications for decision making around intervention policy and practice.

Donnelly, P. M., Huber, E., & Yeatman, J. D. (2019). Intensive summer intervention drives linear growth of reading skill in struggling readers. Frontiers in Psychology, 10, 1900. doi:10.3389/fpsyg.2019.01900

LINDAMOOD-BELL
LEARNING PROCESSES

RESEARCH

Rapid and Widespread White Matter Plasticity During an Intensive Reading Intervention

Seeing Stars® for Phonological and Orthographic Processing in Reading and Spelling (SI)

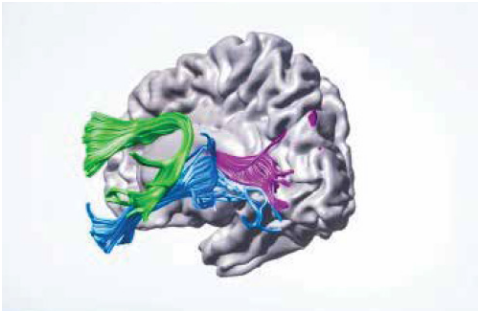
PROFILE:

Number of Subjects: 24
Age: 7-12
Program Implemented:
- Seeing Stars

Outcome Measures:
- Brain Structure (MRI)
- TOWRE-2
- Woodcock–Johnson Basic Reading Composite

BACKGROUND:

The Institute for Learning and Brain Sciences at the University of Washington conducted a study examining growth in reading skills and neural connections (white matter) as a result of intensive reading intervention to develop the sensory-cognitive function of symbol imagery. This study is the first to measure white matter during an intensive reading intervention for dyslexics comparing children's learning with their brains' changes. Children who struggled with reading and/or had a diagnosis of dyslexia received eight weeks of intensive reading intervention at a Lindamood-Bell® Learning Center. Subjects took a series of reading tests before and after the intervention and underwent MRI scans at the beginning, middle, and end. A control group of children with mixed reading skill levels did not receive the reading intervention.



The study focused on the arcuate fasciculus (green), where language and sounds are processed; the left inferior longitudinal fasciculus (blue), where visual inputs, such as letters on a page, are transmitted throughout the brain; and the posterior callosal connections (pink), which link the two hemispheres of the brain (illustration used with permission).

RESULTS:

For study participants who took part in the development of symbol imagery for phonological and orthographic processing, reading skills improved by an average of one full grade level. Diffusion MRI data collected during instruction indicates that there were large-scale changes in white matter conductivity correlating with the gains in reading. Further, the study identifies white matter tracts that may predict the ease with which a child learns how to read. Subjects in the control group showed no changes. The results of this study illustrate that Lindamood-Bell Learning Center instruction in the Seeing Stars program led to increased brain structure conductivity and improved reading for children with reading difficulties including dyslexia.

LOCATION:

Institute for Learning and Brain Sciences, Department of Speech and Hearing Sciences, University of Washington, Seattle, WA, USA

Huber, E., Donnelly, P. M., Rokem, A., & Yeatman, J. D. (2018, February 22). White matter plasticity and reading instruction: Widespread anatomical changes track the learning process. Nature Communications. Preprint doi:10.1101/268979

LINDAMOOD-BELL
LEARNING PROCESSES

RESEARCH

The Causal Relationship between Dyslexia and Motion Processing

Seeing Stars for Phonological and Orthographic Processing in Reading and Spelling (SI)

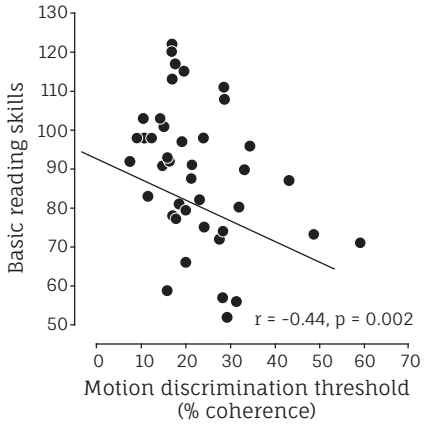
PROFILE:

Number of Subjects: 47
Age: 7–12
Program Implemented:
- Seeing Stars

Outcome Measures:
- Woodcock-Johnson IV
- Word Identification
- Word Attack

BACKGROUND:

As one part of ongoing Lindamood-Bell Learning Processes (LBLP®) intervention studies with dyslexics, the University of Washington's Institute for Learning and Brain Science examined anew the causal relationship between motion sensitivity and reading skills. This relationship has been debated for many years. This specific study used one of LBLP's intensive reading intervention programs (Seeing Stars) to test the causal relationship between learning to read and the comparative growth in reading as related to visual motion processing in dyslexics.



Note: Figured used with permission.

RESULTS:

Two interesting findings were revealed. First, motion sensitivity remained stable over the course of the intervention regardless of the deficit revealed. Additionally, motion sensitivity deficits, where noted, did not negatively impact the learning process (see graph). Dyslexics with poor motion sensitivity showed the same improvement in reading skills as children with typical motion sensitivity. The authors concluded that the findings call into question the view that motion processing deficits are due to poor reading experience. Interestingly, while a significant feature of the intervention used relied on the stimulation and synthesis of orthographic and phonological processing, the authors speculate that motion processing deficits are among a collection of correlated risk factors for reading difficulties. They further note that dyslexia is most likely a multifaceted impairment in learning to read, a view consistent with the rationale behind the Seeing Stars intervention used in this study, which posits that being able to mentally manipulate the symbols for reading plays an equally critical role in learning to read as manipulating the sounds of the English language. In sum, the data show that, while the reading intervention enhanced reading abilities, learning to read did not correlate to motion sensitivity.

LOCATION:

University of Washington, Institute for Learning and Brain Science, Seattle, WA, USA

Joo, S., Donnelly, P. M., & Yeatman, J. D. (2017). The causal relationship between dyslexia and motion perception reconsidered. Scientific Reports, 7, 4185. doi:10.1038/s41598-017-04471-5

"Decoding Versus Comprehension": Brain Responses Underlying Reading Comprehension in Children with Autism

Visualizing and Verbalizing for Language Comprehension and Thinking (V/V)

PROFILE:

Number of Subjects:
- 18 Visualizing and Verbalizing
- 13 Control

Age: 8-13

Program Implemented:
- Visualizing and Verbalizing

Outcome Measures:
- Brain activation (fMRI)
- Gray Oral Reading Tests-4th (comprehension)

BACKGROUND:

Despite intact decoding ability, deficits in reading comprehension are relatively common in children with autism spectrum disorders (ASD). However, few neuroimaging studies have tested the neural bases of this specific profile of reading deficit in ASD. This fMRI study, in collaboration with Lindamood-Bell, examined activation and synchronization of the brain's reading network in children with ASD and specific reading comprehension deficits during a word similarities task. Thirteen typically developing children and eighteen children with ASD performed the task in the MRI scanner. No statistically significant group differences in functional activation were observed; however, children with ASD showed decreased functional connectivity between the left inferior frontal gyrus (LIFG) and the left inferior occipital gyrus (LIOG). In addition, reading comprehension ability significantly positively predicted functional connectivity between the LIFG and left thalamus (LTHAL) among all subjects. The results of this study provide evidence for altered recruitment of reading-related neural resources in ASD children and suggest specific weaknesses in top-down modulation of semantic processing.

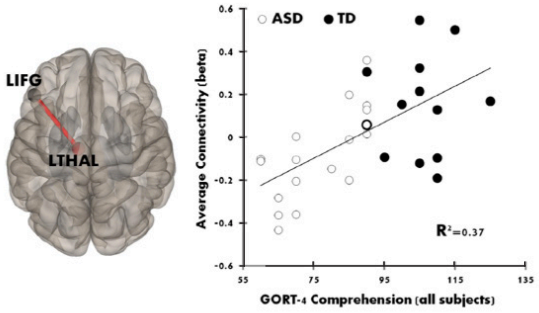


Fig. 4. GORT-4 comprehension scores significantly positively predicted functional connectivity between LIFG and LTHAL among all children with ASD.

Note: Figured used with permission.

RESULTS:

The results of this study provide evidence for altered recruitment of reading-related neural resources in ASD children and suggest specific weaknesses in top-down modulation of semantic processing. In summary, ASD children with reading comprehension deficits exhibited altered functional connectivity among brain regions associated with semantic retrieval and semantic categorization during a word similarities task, when compared to typically developing children. These results, combined with previous evidence of top-down semantic processing weaknesses among individuals with ASD, suggest that neural deficits in semantic processing may underlie reading comprehension deficits in this population. This study has important implications for elucidating the neural mechanisms of reading comprehension deficits in this subgroup of ASD. The deficits of this group are often unnoticed, as their decoding level is commensurate with their overall cognitive functioning; educators may struggle to identify and address comprehension deficits in the presence of intact decoding (Nation & Angell, 2006). This is one of only a few studies that have examined reading comprehension in this particular subgroup of children with ASD. Future research should further examine the neural correlates of higher level reading tasks within this population for early identification for reading intervention.

Bednarz, H. M., Maximo, J. O., Murdaugh, D. L., O'Kelley, S., & Kana, R. K. (2017). "Decoding versus comprehension": Brain responses underlying reading comprehension in children with autism. Brain and Language, 169, 39-47. .

Changes in Intrinsic Local Connectivity After Reading Intervention in Children with Autism

Visualizing and Verbalizing®
for Language Comprehension
and Thinking (V/V)®

PROFILE:

Number of Subjects:
- 14 Visualizing and Verbalizing
- 14 Wait-list Control

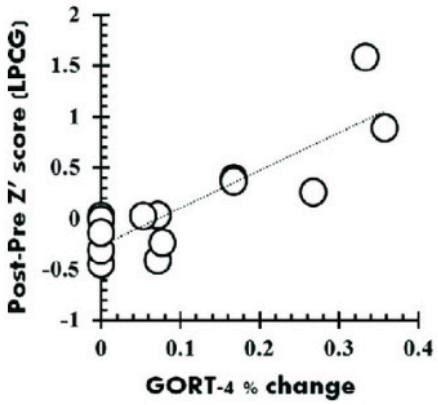
Age: 8-14

Program Implemented:
- Visualizing and Verbalizing

Outcome Measures:
- Brain connectivity (fMRI)
- Gray Oral Reading Tests-4th (comprehension)

BACKGROUND:

The current study takes a translational neuroimaging approach to test the impact of a structured visual imagery-based reading intervention on improving reading comprehension and assessing its underlying local neural circuitry. Behavioral and resting state functional MRI (rs-fMRI) data were collected from children with Autism Spectrum Disorder (ASD) who were randomly assigned to an Experimental group (ASD-EXP; n=14) and a Wait-list control group (ASD-WLC; n =14). Participants went through an established reading intervention training program (Visualizing and Verbalizing for Language Comprehension and Thinking or V/V; 4 hours per day, 10 weeks, 200 hours of face-to-face instruction). Local functional connectivity was examined using a connection density approach from graph theory focusing on brain areas considered part of the Reading Network.



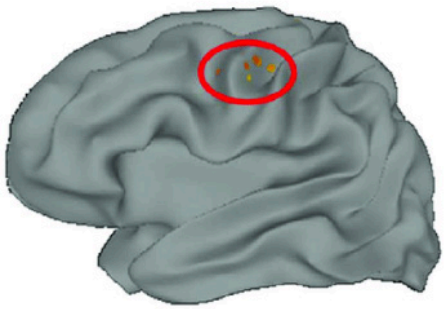


Fig. 2. Significant relationship between changes in reading comprehension abilities (GORT-4 percent change) and changes in local connectivity in the ASD-EXP group.

Note: Figured used with permission.

RESULTS:

The main results are as follows: (I) the ASD-EXP group showed significant improvement, compared to the ASD-WLC group, in their reading comprehension ability evidenced from change in comprehension scores; (II) the ASD-EXP group showed increased local brain connectivity in Reading Network regions compared to the ASD-WLC group postintervention; (III) intervention-related changes in local brain connectivity were observed in the ASD-EXP from pre- to post-intervention; and (IV) improvement in language comprehension significantly predicted changes in local connectivity. The findings of this study provide novel insights into brain plasticity in children with developmental disorders, in this case Autism, using targeted intervention programs.

LOCATION:

Department of Psychology, University of Alabama at Birmingham, Birmingham, AL, USA

Maximo, J. O., Murdaugh, D. L., O'Kelley, S., & Kana, R. K. (2017). Changes in intrinsic local connectivity after reading intervention in children with autism. Brain and Language, 175, 11-17. doi:10.1016/j.bandl.2017.08.008

Reading Comprehension Improvement in Autism

Visualizing and Verbalizing for Language Comprehension and Thinking (V/V)

PROFILE:

Number of Subjects: 65
Age: 8-13
Lindamood-Bell Programs Implemented:
- Visualizing and Verbalizing

Outcome Measures:
- EVT-2
- DTLA-2 and DTLA-4
- Symbol Imagery Test
- WRMT-R
- WRAML-2
- PPVT-4
- GORT-4

BACKGROUND:

This study is one outcome of a larger collaborative research initiative between Lindamood-Bell Learning Processes and the University of Alabama in Birmingham. This research group is the first to report on the effects of the Visualizing and Verbalizing® (V/V®) intervention on reading comprehension in autism literature. The authors of this program note that the V/V intervention is built on the principles of Dual Coding Theory (DCT) of cognition, an established scientific theory that postulates that both visual representations and verbal information are necessary for optimal language comprehension. The authors of this study examined the effectiveness of the Visualizing and Verbalizing program for language comprehension intervention by comparing pre/post reading comprehension scores between two groups of children on the autism spectrum.

RESULTS:

Autistic students in the experimental group significantly improved in their pre- to post-reading comprehension scores, whereas the waitlist group did not. Verbal memory significantly predicted reading comprehension, though the group did not moderate relationships between cognitive test performance and reading comprehension. Results suggest that the V/V intervention may help improve reading comprehension for autistic children with poor language comprehension. Additionally, strategies for improving verbal memory may indirectly enhance reading comprehension in autistic children with this reading profile. This supports previous findings suggesting that the V/V intervention can facilitate reading comprehension improvements in autistic children with average or above average decoding skills and below average reading comprehension skills.

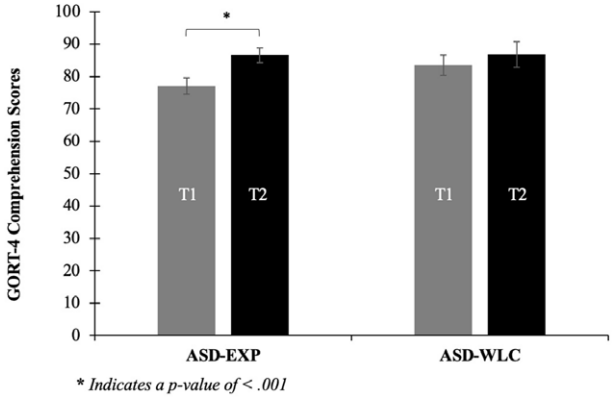


FIGURE 1: Change in reading comprehension, measured by GORT-4, following V/V intervention.

Grey bar: time 1 (pre-test); black bar: time 2 (post-test).

Error bars represent standard error of the mean.

Note. The autistic group that received the intervention in-between testing sessions showed significant improvement in reading comprehension from time 1 to time 2, p<.001, d=.89.

LOCATION:

University of Alabama, Birmingham

Beckerson, M., Paisley, C., Murdaugh, D., Holm, H., Lemelman, A., Spencer, A., O'Kelley, S., & Kana, R. (2024). Reading comprehension improvement in autism. Frontiers in psychiatry, 15, 1292018. https://doi.org/10.3389/fpsyt.2024.1292018

LINDAMOOD-BELL
LEARNING PROCESSES

RESEARCH

From Word Reading to Multisentence Comprehension: Improvements in Brain Activity in Children with Autism after Reading Intervention

Visualizing and Verbalizing for Language Comprehension and Thinking (V/V)

PROFILE:

Number of Subjects:
- 14 Visualizing and Verbalizing
- 11 Control

Age: 8-14

Program Implemented:
- Visualizing and Verbalizing

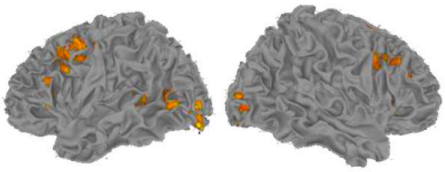
Outcome Measures:
- Brain activation (fMRI)
- Gray Oral Reading Tests-4th (comprehension)

BACKGROUND:

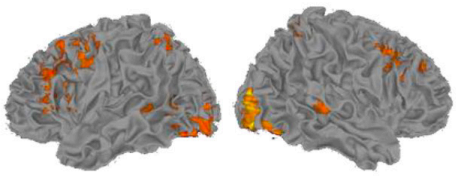
The University of Alabama at Birmingham Department of Psychology, in collaboration with Lindamood-Bell Learning Processes, conducted a randomized controlled trial involving children with autism spectrum disorders (ASD). This experiment investigated the constructs of Dual Coding Theory (DCT) using the Visualizing and Verbalizing (V/V) program, which develops concept imagery for comprehension. Functional magnetic resonance imaging (fMRI) was used to study the effect of V/V on brain activation in areas associated with comprehension. Before and after instruction, children's brains were scanned and they were administered a reading comprehension test. A similar group of children with ASD went through the same procedures but did not receive V/V instruction (i.e., control group). Children in the V/V group received approximately 200 hours of instruction over a 10-week period of time. Instruction was delivered by specially trained Lindamood-Bell staff. The figure below shows brain activation while children read multisentence passages before and after V/V instruction.

Brain Activation

Before



After*



Note: *Statistically significant (p ≤ .05). Figure used with author's permission.

RESULTS:

On average, the V/V group exhibited significantly greater brain activation during word, sentence, and multisentence tasks after instruction (multisentence shown in figure). In addition, the V/V group also had a significantly (p = .04) larger change in reading comprehension than the control group. The average standard scores before and after were 77.5 and 87.9 for the V/V group and 84.5 and 84.1 for the control group. Furthermore, researchers found that changes in reading comprehension significantly predicted changes in brain activation. The results of this study illustrate that instruction in the Visualizing and Verbalizing program supports the DCT model of cognition, leading to greater brain activation and improved comprehension for children with ASD.

LOCATION:

Department of Psychology, University of Alabama at Birmingham, Birmingham, AL, USA

Murdaugh, D. L., Deshpande, H. D., & Kana, R. K. (2017). From word reading to multisentence comprehension: Improvements in brain activity in children with autism after reading intervention. Neuroimage, 16, 303-312. doi:10.1002/aur.1503

LINDAMOOD-BELL
LEARNING PROCESSES

RESEARCH

Changes in Intrinsic Connectivity of the Brain's Reading Network Following Intervention in Children with Autism

Visualizing and Verbalizing for Language Comprehension and Thinking (V/V)

PROFILE:

Number of Subjects:
- 16 Visualizing and Verbalizing
- 15 Control

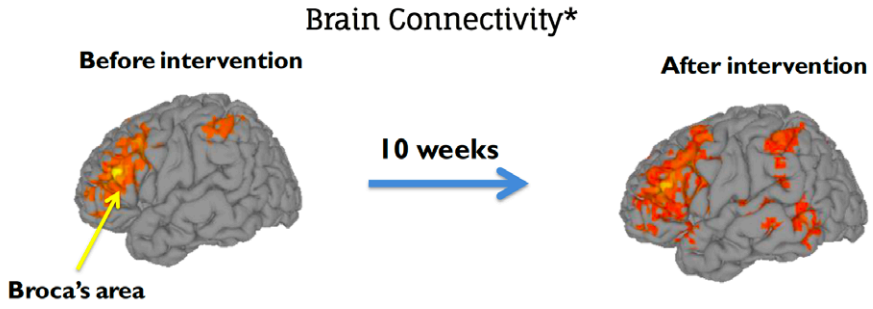
Age: 8-13

Program Implemented:
- Visualizing and Verbalizing

Outcome Measures:
- Brain connectivity (fMRI)
- Gray Oral Reading Tests-4th (comprehension)

BACKGROUND:

The University of Alabama at Birmingham Department of Psychology, in collaboration with Lindamood-Bell Learning Processes, conducted a randomized controlled trial involving children with Autism Spectrum Disorders (ASD). This experiment investigated the constructs of Dual Coding Theory (DCT) using the Visualizing and Verbalizing (V/V) program, which develops concept imagery for comprehension. Resting state functional magnetic resonance imaging (rsfMRI) was used to study the effect of V/V on the connectivity of regions of the brain associated with comprehension. Children with ASD typically have weaker connectivity, or underconnectivity, in these areas of the brain. Before and after instruction, children's brains were scanned and they were administered a reading comprehension test. A similar group of children with ASD went through the same procedures but did not receive V/V instruction (i.e., control group). Children in the V/V group received approximately 200 hours of instruction over a 10-week period of time. Instruction was delivered by specially trained Lindamood-Bell staff. The figure below shows pre- and posttest connectivity for the V/V group.



Note: *Statistically significant ($p \leq .05$). Broca's area is a region of the brain involved in comprehension.
Figure used with author's permission.

RESULTS:

On average, the V/V group exhibited significantly greater brain connectivity after instruction than the control group. In addition, the V/V group also had a significantly (p = .0006) larger change in reading comprehension than the control group (16.4% and 2.6% respectively). Furthermore, researchers found that improvements in reading comprehension were correlated with increases in brain connectivity. The results of this study illustrate that instruction in the Visualizing and Verbalizing program supports the DCT model of cognition, leading to greater brain connectivity and improved comprehension for children with ASD.

LOCATION:

Department of Psychology, University of Alabama at Birmingham, Birmingham, AL, USA

Murdaugh, D. L., Maximo, J.O., & Kana, R.K. (2015). Changes in intrinsic connectivity of the brain's reading network following intervention in children with autism. Human Brain Mapping, 36, 2965-2979. doi:10.1002/hbm.22821

LINDAMOOD-BELL
LEARNING PROCESSES

RESEARCH

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

Visualizing and Verbalizing for Language Comprehension and Thinking (V/V)

PROFILE:

Number of Subjects:
- 13 Visualizing and Verbalizing
- 13 Control

Age: 8-13

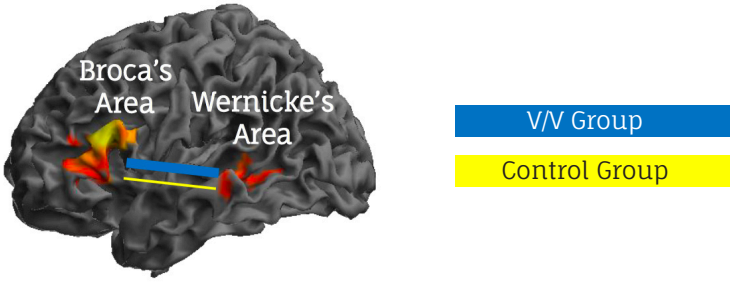
Program Implemented:
- Visualizing and Verbalizing

Outcome Measures:
- Brain activation/connectivity (fMRI)
- Gray Oral Reading Tests-4th (comprehension)

BACKGROUND:

The University of Alabama at Birmingham Department of Psychology, in collaboration with Lindamood-Bell Learning Processes, conducted a randomized controlled trial involving children with autism spectrum disorders (ASD). This experiment investigated the constructs of Dual Coding Theory (DCT) using the Visualizing and Verbalizing (V/V) program, which develops concept imagery for comprehension. Translational functional magnetic resonance imaging (fMRI) was used to study the effect of V/V on sentence comprehension, brain activation, and functional connectivity. Children with ASD typically have weaker connectivity, or underconnectivity, in the areas of the brain associated with language. Before and after instruction, children's brains were scanned and they were administered a reading comprehension test. A similar group of children with ASD went through the same procedures but did not receive V/V instruction (i.e., control group). Children in the V/V group received approximately 200 hours of instruction over a 10-week period of time. Instruction was delivered by specially trained Lindamood-Bell staff. The figure below shows increased brain connectivity between Broca's and Wernicke's language areas for the V/V group (thicker blue line) compared to control group (thinner yellow line) during a task of visual imagery sentence comprehension. The thickness of the lines represents the magnitude of connectivity between the two brain areas.

Increased Brain Connectivity



Note: Figure used with author's permission.

RESULTS:

The strength of connectivity was significantly greater ($p < .05$) for the V/V group. In addition, the V/V group also had a significantly larger change ($p = .05$) in reading comprehension than the control group (13.9% and 3.9% respectively). Furthermore, researchers found a significant positive correlation between improvements in reading comprehension and brain activation. The results of this study illustrate that instruction in the V/V program supports the DCT model of cognition, leading to greater brain connectivity and improved comprehension for children with ASD.

LOCATION:

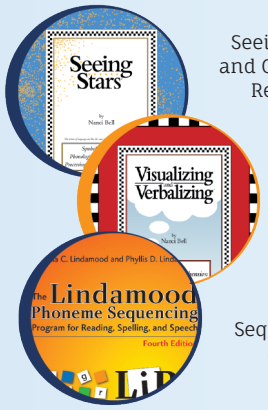
Department of Psychology, University of Alabama at Birmingham, Birmingham, AL, USA

Murdaugh, D. L., Deshpande, H. D. & Kana, R. K. (2015). The Impact of Reading Intervention on Brain Responses Underlying Language in Children With Autism. Autism Research, 9, 141-154. doi:10.1002/aur.1503

LINDAMOOD-BELL
LEARNING PROCESSES

RESEARCH

Effects of a Theoretically Based Large-Scale Reading Intervention in a Multicultural Urban School District



Seeing Stars for Phonological and Orthographic Processing in Reading and Spelling (SI)

Visualizing and Verbalizing for Language Comprehension and Thinking (V/V)

Lindamood Phoneme Sequencing Program for Reading, Spelling, and Speech (LiPS)

PROFILE:

Number of Schools†:
- 13-22 Lindamood-Bell
- 291-684 Comparison

†Sample size varied depending on analysis

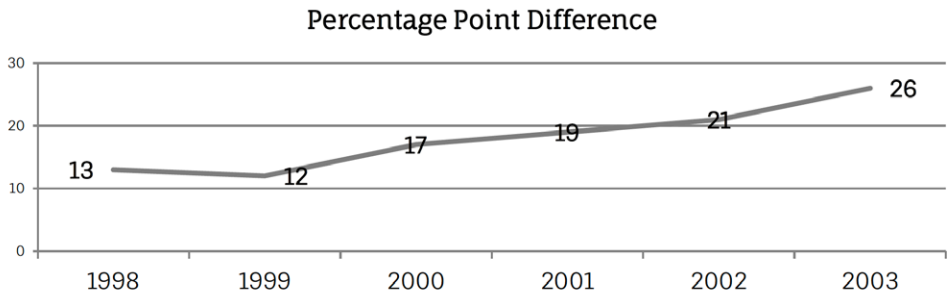
Grades: 3rd-5th

Programs Implemented:
- Seeing Stars
- Lindamood Phoneme Sequencing
- Visualizing and Verbalizing

Outcome Measures:
- Colorado Student Assessment Program (reading)

BACKGROUND:

Pueblo City Schools in Pueblo, Colorado, serve a large percentage of students who are at-risk for reading failure. From the 1998/99 to the 2002/03 school years, Pueblo implemented Lindamood-Bell instruction to address the language processing needs of this student population. Students received Seeing Stars, Visualizing and Verbalizing, and Lindamood Phoneme Sequencing instruction to develop symbol imagery, concept imagery, and phonemic awareness. This study investigated the constructs of Dual Coding Theory (DCT) using the Seeing Stars and Visualizing and Verbalizing programs. Instruction was delivered by Pueblo teachers who received professional development in the programs. Student gains were measured with the state reading test and the results were compared to gains made by students from other, similar schools in Colorado who did not receive Lindamood-Bell instruction. Schools were comparable controlling for school size, free and reduced-price lunch, and minority populations. Third-grade results for Title I schools are provided below.



RESULTS:

The line in the chart above shows the percentage point difference (in percent proficient and advanced on the state reading test) between Pueblo (Lindamood-Bell) schools and comparison schools. By 2003, schools partnering with Lindamood-Bell were 26 percentage points above the average of the comparison schools. The independent evaluators who conducted this research determined that the main effect of Lindamood-Bell instruction was statistically significant ($p < .0001$). The authors state that "[Pueblo] Title I schools outperformed the average of the remaining comparable Title I schools in the state in an increasingly positive way during the years 1998-2003." The results of this study support the DCT model of cognition and illustrate that Lindamood-Bell instruction in the Seeing Stars, Visualizing and Verbalizing, and Lindamood Phoneme Sequencing programs leads to improved reading, which is essential to achieving success with school curricula.

LOCATION:

College of Education and Human Development, Texas A&M University, College Station, TX, USA

Sadoski, M. & Willson, V. (2006). Effects of theoretically based large-scale reading intervention in a multicultural urban school district. American Educational Research Journal, 43(1), 137-154. doi:10.3102%2F00028312043001137

LINDAMOOD-BELL
LEARNING PROCESSES

ARTICLE

Sensory-Cognitive Factors in the Controversy over Reading Instruction

Authors: Patricia Lindamood, Nanci Bell, and Phyllis Lindamood
Publication: Journal of Developmental and Learning Disorders, 1(1)

SUMMARY:

In the early days of education, it was assumed that students coming to school had adequate vision and hearing. Over time it became evident that this was not necessarily the case, and it is now routine for schools to test the visual and auditory acuity of students so families can be advised if there are impairments that require attention. It was then assumed that if students had normal visual and auditory acuity, it was their responsibility to learn the content provided by their teachers.

However, specific levels of sensory-cognitive processing are at least as critical to learning as specific levels of sensory acuity. The advent of sensory-cognitive measures has equipped us as educators to determine if students are processing sensory information consciously enough at the central level to be able to learn, think, and reason. Pribram (1991) clarified this cognitive aspect of perception when he observed that individuals cannot think about something of which they are not consciously aware, and cannot be aware of something not perceived sufficiently at the sensory level to come to consciousness.

Several promising areas for research have been indicated through our clinical experience. The possible contribution of symbol imagery, phonemic awareness, and concept imagery needs to be studied in formal research in the areas of organic disorders such as deafness and hearing impairments, cerebral palsy, cleft palate, and apraxia, as well as strokes, aneurysms, and traumatic brain injury. Much to our surprise, we have observed degrees of improvement that we wouldn't have expected for the limited numbers of such clients that we have served. It appears that lack of conscious awareness of sensory feedback and its conscious integration with language, as needed for sensory-cognitive functions, may have more effect on impaired speech or language within these conditions than the organic condition itself. Areas such as developmental delay, high level autism, resistant cases of functional articulation disorder, and the acquisition of a second language also appear to be fruitful areas for further research.

LOCATION:

Lindamood-Bell Learning Processes, San Luis Obispo, CA, USA

Lindamood, P. C., Bell, N., & Lindamood, P. D. (1997). Sensory-cognitive factors in the controversy over reading instruction. Journal of Developmental and Learning Disorders 1(1), 143-182. Retrieved from http://www.icdl.com/bookstore/icdl-publications/journal-of-development-and-learning

LINDAMOOD-BELL LEARNING PROCESSES

ARTICLE

Gestalt Imagery: A Critical Factor in Language Comprehension

Author: Nanci Bell

Publication: Annals of Dyslexia, 41(1)

SUMMARY:

Reading is cognition. Gestalt imagery contributes to the cognition process of comprehending oral and written language. The imaging factor, discussed for many years in the field of cognitive psychology, appears to be automatic for many individuals and has, perhaps, been assumed to be present for all. This assumed factor, as well as the focus on decoding, the lack of good oral and written comprehension tests, the continuing dispute over context, phonological processing, and sight word instruction has left comprehension without the attention it requires. Instructional procedures to develop comprehension have been in the format of decoding and/or listening and simply answering questions—a format that tests comprehension rather than teaches comprehension.

Historically, because of the psycholinguists' cry for meaning and deep structure, the field of reading has been turned away from excessive concern over surface structure—a focus on decoding only. However, it has since been found that increasing vocabulary and stimulating background knowledge or use of context clues does not guarantee comprehension development.

With specific attention to the integration of imagery and verbalization, it is possible to develop an imaged gestalt from which interpretation and reasoning can be processed. "According to the Dual Coding Theory, meaning consists of the relations between external stimuli and the verbal and nonverbal representational activity they initiate in the individual," Paivio (1986).

It is my hope that this initial inquiry will serve to generate further discussion and research focusing on the diagnosis and development of the imaged gestalt and language comprehension.

LOCATION:

Lindamood-Bell Learning Processes, San Luis Obispo, CA, USA

Bell, N. (1991). Gestalt imagery: A critical factor in language comprehension. Annals of Dyslexia, 41(1), 246-260. doi:10.1007/BF02648089

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