Targeting Brain Plasticity in Autism using a Reading Intervention

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Cognition, Brain, and Autism Laboratory

CIRA

AUTISM RESEARCH INSTITUTE
Autism is Treatable

ARI Webinar; September 27, 2023

1

Conflict of Interest

Some of the data I am presenting today are partly funded by the Lindamood-Bell Learning Processes. In addition, the reading intervention used in our studies (Visualizing and Verbalizing) was provided by the Lindamood-Bell Learning Processes through their various centers across the country. However, no representatives of the company were involved in data analysis or development of this presentation, nor did the company exert any control or restrictions regarding research activities.

2

Overview

1. Descriptions of Language and Communication in Autism
2. Brain, Language, & Reading Comprehension in Autism
3. Neuroplasticity
4. Using Reading Intervention to change the Brain

3

Descriptions of Language & Communication in Autism

4

PATHOLOGY

AUTISTIC DISTURBANCES OF AFFECTIVE CONTACT

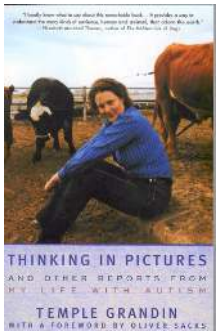
By LEO KANNER

Leo Kanner's Participant 1:
Donald Triplett

Often, he would utter random words of phrases. Words had a "literal, inflexible meaning" to Donald, and he was unable to recognize and apply the denotation of a word to another context; each word had a definite, designated definition and association in his mind. For the most part, conversations with Donald consisted of a barrage of questions.

5

"During the last couple of years, I have become more aware of a kind of electricity that goes on between people. I have observed that when several people are together and having a good time, their speech and laughter follow a rhythm. I have always had a hard time fitting in with this rhythm, and I usually interrupt conversations without realizing my mistake. The problem is that I can't follow the rhythm"



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Descriptions of Language in Autism

1. **Absence of verbal abilities** (e.g., the failure to acquire spoken language during the lifespan), which is the outcome for between 50–75% of autistic individuals (Rapin, 1991)
2. **Early language delays**, with words first produced at an average age of 38 months (Howlin, 2003), rather than the typical time of 12–18 months.
3. **Atypical features** of language production, including echolalia and jargon (Tager-Flusberg & Calkins, 1990)
4. **High-level discourse and pragmatic abilities** (Bartak, Rutter, & Cox, 1975; Bartolucci, 1982; Lord & Paul, 1997).

Rapin & Dunn (2003); Brain Development

7

Neuropsychiatric Disease and Treatment Dovepress REVIEW

Language and Speech Characteristics in Autism

Ioannis Vogindroukas[1], Margarita Stankova[1], Evripidis-Nikolaos Chelas[2], Alexandros Proedrou[1]

1. ASD with **pragmatic language impairments** without any other language difficulties (functional language difficulty)
2. ASD in **comorbidity with DLD** and other developmental disorders (a disorder in language and speech development)
3. ASD in **comorbidity with intellectual disability** with a global lag in language and general intelligence
4. ASD with **severe difficulties in the development of social communication** and social interaction and secondary language difficulties because of non-use of language as a communicative tool

Vogindroukas et al. (2022); Neuropsychiatric Disease & Treatment

8

Joint Attention & Language Development


CORRELATION MATRIX FOR JOINT ENGAGEMENT AND WORD COMPREHENSION AT EACH TIME POINT

Joint Engagement	Word Comprehension						
	9	10	11	12	13	14	15
9 months	−.20	.05	.24	.27	.25	.21	.18
10 months	−.21	.09	.31	.39	.36	.34	.27
11 months	.14	.41*	.46*	.43*	.44*	.43*	.39
12 months	.53**	.45*	.31	.31	.45*	.52**	.58**
13 months	.17	.40*	.47*	.48*	.47*	.39	.27
14 months	.04	.15	.15	.13	.13	.16	.16
15 months	.10	.34	.26	.23	.24	.23	.26

* $p < .05$, two tailed. ** $p < .01$, two tailed.

Carpenter, Nagell, & Tomasello (1998)

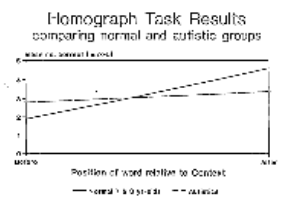
9

The Homograph Task

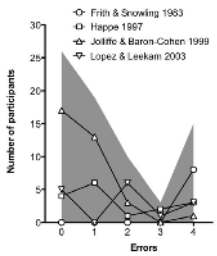
- **Homographs:** words with the same spelling but different meanings in different contexts.
- The girls were climbing over the hedge. Mary's dress remained spotless, but in Lucy's dress there was a big tear.

There was a big *tear* in her dress

There was a big *tear* in her eye



Happe (1997)



Brock & Caruana (2015)

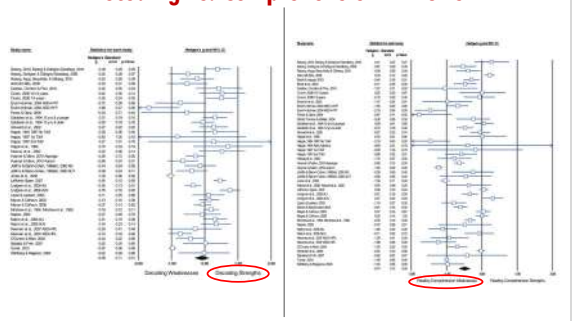
10

What components of Reading Comprehension fail in Autism

- Difficulty in reading comprehension maybe associated with the cognitive profile of the reader. The difficulty can emerge from:
  - Difficulty in perspective-taking (Baron-Cohen et al., 2001)
  - Difficulty in Inference construction (Saldana & Frith, 2007)
  - Difficulty in mentalizing (theory-of-mind)
  - Difficulty in linguistic information processing (Gold et al., 2010)
  - Difficulty in pragmatic aspects of language (Joliffe & Baron-Cohen, 2000; Duvall et al., 2023)

11

Decoding vs. Comprehension in Autism



Brown et al. (2013); Journal of Autism & Developmental Disorders

12

"Reading skill is acquired quickly, but the children read monotonously and a story or moving picture is experienced in unrelated portions rather than its coherent totality."
(Kanner, 1943, p. 250)

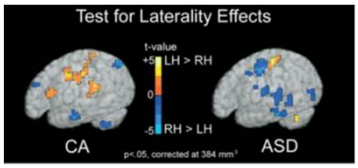
13

Brain, Language, & Reading Comprehension in Autism Spectrum Disorder (evidence from brain imaging)

14

Deviant Functional Magnetic Resonance Imaging Patterns of Brain Activity to Speech in 2–3-Year-Old Children with Autism Spectrum Disorder

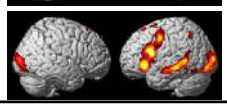
Elizabeth Redcay and Eric Courchesne



Sam ran from the *bank* when the angry robber hurried out with the money

Autism

Sam ran from the *bank* when the huge alligator jumped out with a fish



Control

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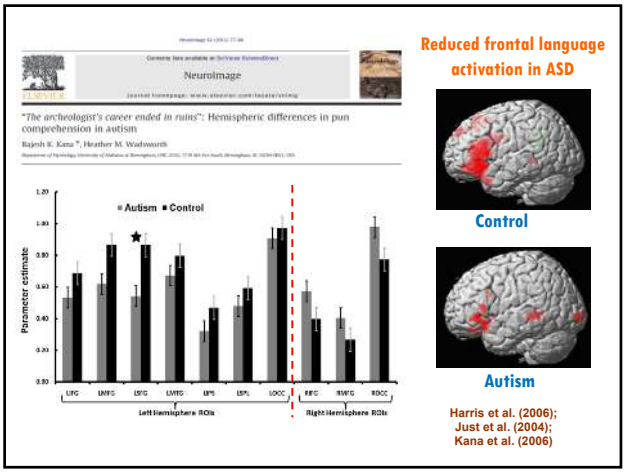
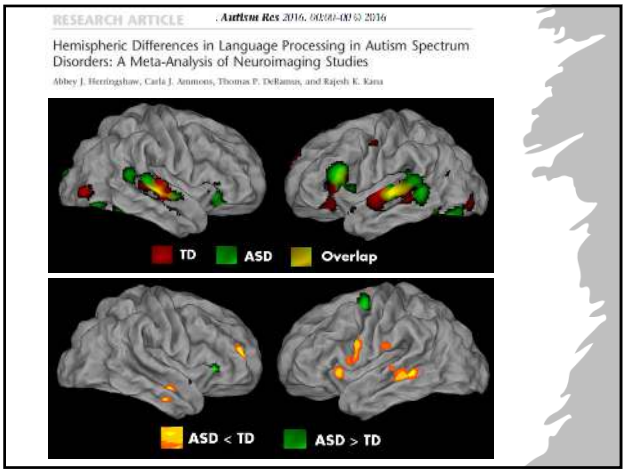
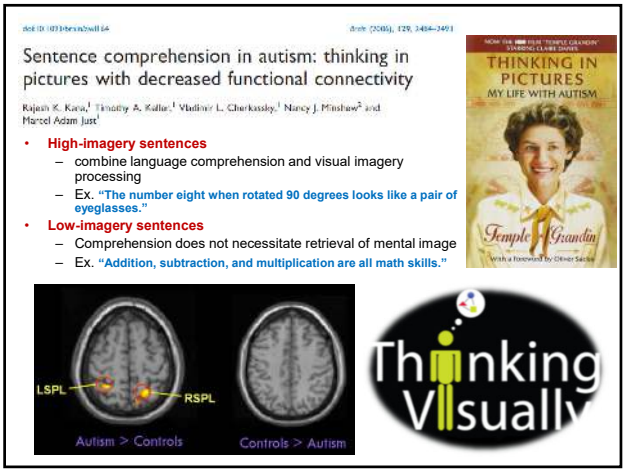

Neuroimage
"The archeologist's career ended in ruins": Hemispheric differences in pun comprehension in autism
Rajesh K. Kana *, Heather M. Wadsworth
Autism Control
Parameter estimate
Left Hemisphere ROIs
Right Hemisphere ROIs
Reduced frontal language activation in ASD
Control
Autism
Harris et al. (2006);
Just et al. (2004);
Kana et al. (2006)

16


RESEARCH ARTICLE
Autism Res 2016, 00:000–000 © 2016
Hemispheric Differences in Language Processing in Autism Spectrum Disorders: A Meta-Analysis of Neuroimaging Studies
Abbey J. Herringshaw, Carla J. Ammons, Thomas P. DeRamus, and Rajesh K. Kana
TD
ASD
Overlap
ASD < TD
ASD > TD

17

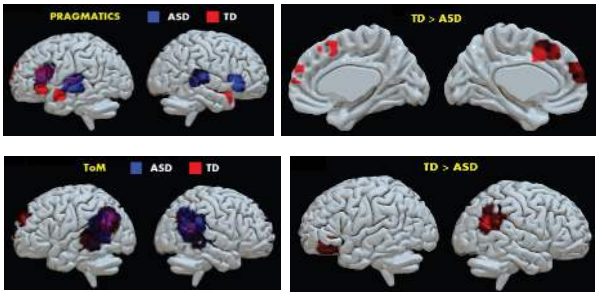

Sentence comprehension in autism: thinking in pictures with decreased functional connectivity
Rajesh K. Kana, Timothy A. Keller, Vladimir L. Cherkassky, Nancy J. Minshew and Marcel Adam Just
High-imagery sentences
combine language comprehension and visual imagery processing
Ex. "The number eight when rotated 90 degrees looks like a pair of eyeglasses."
Low-imagery sentences
Comprehension does not necessitate retrieval of mental image
Ex. "Addition, subtraction, and multiplication are all math skills."
THINKING IN PICTURES
MY LIFE WITH AUTISM
Temple Grandin
LSPL
RSPL
Autism > Controls
Controls > Autism
Thinking Visually

18

RESEARCH PAPER SOCIAL NEUROSCIENCE
https://doi.org/10.1080/17470919.2023.2242095
Routledge Taylor & Francis Group

The neurobiological map of theory of mind and pragmatic communication in autism

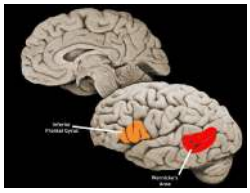
Lauren Duvall[a], Kaitlyn E. May[b], Abby Waltz[c] and Rajesh K. Kana[c]



19

Brain & Language in Autism

- More Wernicke's and less Broca's area activation (perhaps less integrated sentence level processing).
- More right hemisphere activation (suggesting greater difficulty effect).
- More parietal and occipital activation (suggests visually oriented language processing: thinking in pictures).



20

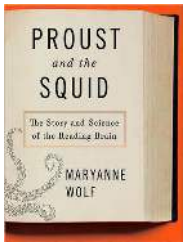
Targeting Brain Plasticity in Autism

21

WE WERE NEVER BORN TO READ.
Human beings invented reading only a few thousand years ago.

And with this invention, we rearranged the very organization of our brain.

Reading is one of the single most remarkable inventions in history



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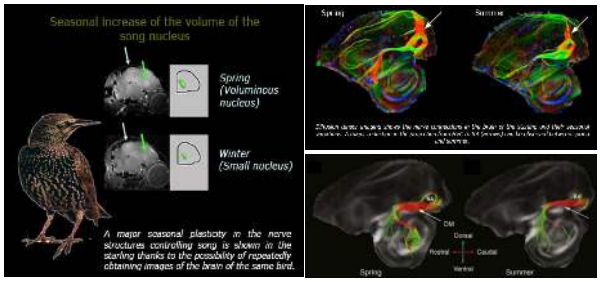
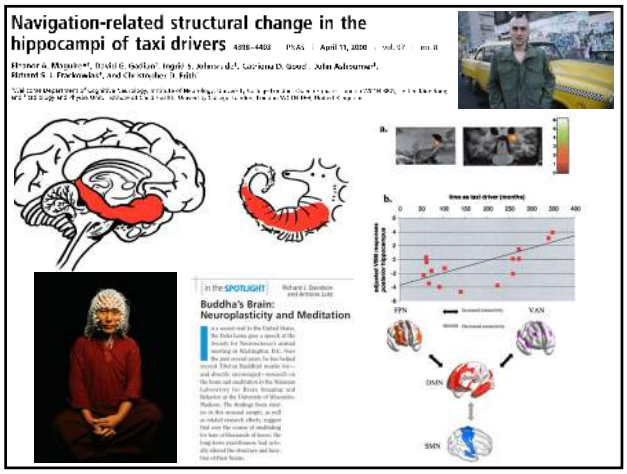
BRAIN PLASTICITY



"The discovery that new neurons can appear in the adult brain may be the most surprising of the last quarter century of neuroscience. The scale of the phenomenon and its significance remain to be established, but it appears that one of the oldest dogmas in the business is not true." **Antonio Damasio**

Van der Linden et al (2009); Trends in Cognitive Sciences

23

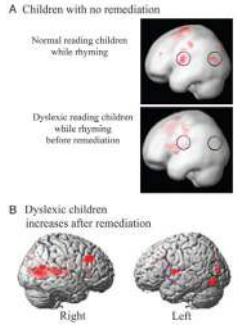


24

Neural deficits in children with dyslexia ameliorated by behavioral remediation: Evidence from functional MRI

Elise Temple[†‡], Gayle K. Deutsch[§], Russell A. Poldrack[¶], Steven L. Miller[†], Paula Tallal[†‡], Michael M. Merzenich[‖‖], and John D. E. Gabrieli[*†]

2860–2865 | PNAS | March 4, 2003 | vol. 100 | no. 5



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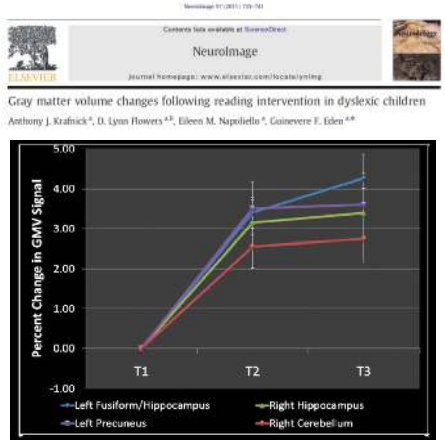
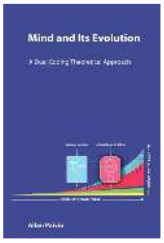


26

"I accept the obvious truism that language played a critical role in our giant leap as a species, but language never worked its magic alone and it cannot do so now. Instead, it has always depended on a silent partner that provides it with something to talk about, a general cognitive system that had evolved to a high level before it invited language in as a co-player in the evolutionary scene.

I see language as a benevolent, octopus-like parasite whose tentacles invaded the brain and was empowered by it to survive and thrive to the point where it could contribute something useful to its host. Nonverbal mind and verbal mind thus became interlocked in a synergistic relation that evolved into the nuclear power source of our intellect."

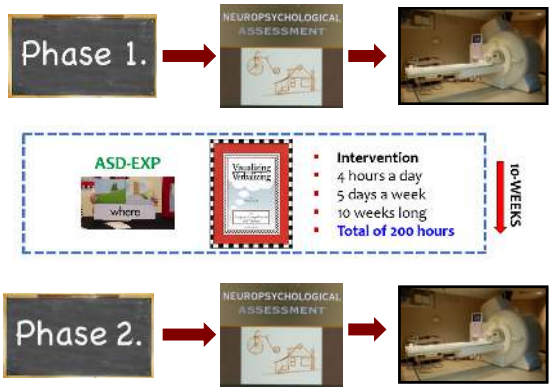
-Allan Paivio (2006)



27

Visualizing & Verbalizing Reading Intervention in Autism Spectrum Disorder

28



*ASD-WLC group received intervention after the study was completed

29

ASSESSMENT PROTOCOL	
CONSTRUCT	**MEASURE**
Intellectual Ability	WASI (30 min) VIQ = > 75
Reading Comprehension Screening Measures	Slosson Oral Reading Test - Revised (SORT-R) (10 min) > 37th % Gray Oral Reading Test - 4th Edition (GORT-4) (20 min) < 37th %
Receptive Language	Peabody Picture Vocabulary Test – 4thEdition (PPVT-4) (15 min)
Expressive Language	Expressive Vocabulary Test – 2nd Edition (EVT-2) (15 min)
Oral Language Comprehension and Word Association Knowledge	Detroit Tests of Learning Aptitude – 4th Edition (DTLA-4) Oral Directions and Word Opposites subtests (20 min)
Phonological Processing	Symbol Imagery Test (10 min) Woodcock Reading Mastery Test – Revised (WRMT-R) – Word Attack subtest (10 min)
Problem Solving Skills	Elementary Test Of Problem Solving – 3rd Edition (TOPS-3) (25 min)
Verbal and Visual Memory	Wide Range Assessment of Memory and Learning – 2nd Edition (WRAML-2) (30 min)
Symptom Severity	Social Responsiveness Scale (SRS) – Parent Rating (10 min) Social Communication Questionnaire (SCQ) – Parent Rating (10 min)
TOTAL ASSESSMENT TIME (child)	**3 hours, 8 min (185 min)**

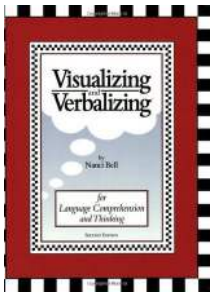
30

READING INTERVENTION

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

The sequential steps of the program:

1. Picture to Picture
2. Word Imaging
3. Sentence Imaging
4. Sentence by Sentence Imaging
5. Sentence by Sentence with Interpretation
6. Multiple Sentence Imaging, Paragraph Imaging, Paragraph by Paragraph Imaging



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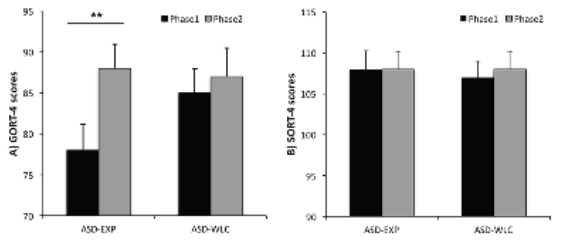
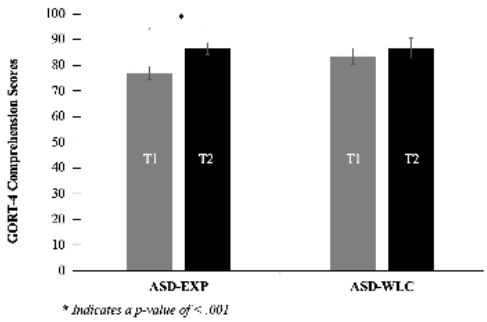


Mean scores for A) GORT-4 and B) SORT-R for ASD-EXP and ASD-WLC at each time point $^{**}p < .01$.

32

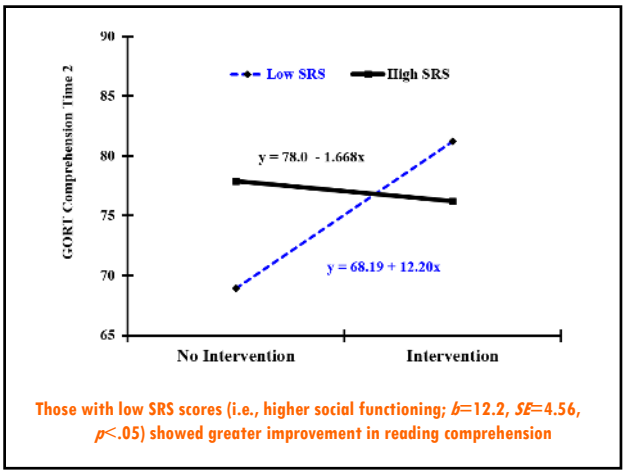
Pre-to-Post Change in Reading Comprehension



** Indicates a p-value of < .001*

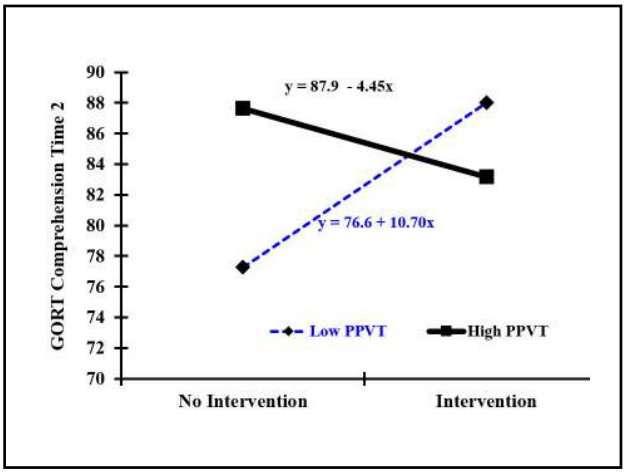
Beckerson et al. (under review)

33



Those with low SRS scores (i.e., higher social functioning; b=12.2, SE=4.56, p<.05) showed greater improvement in reading comprehension

34



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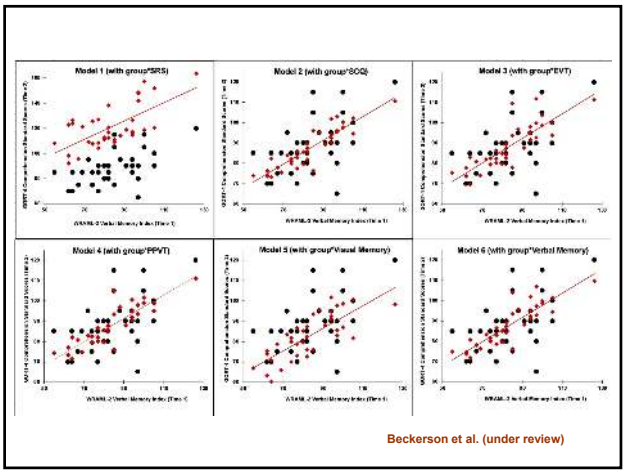
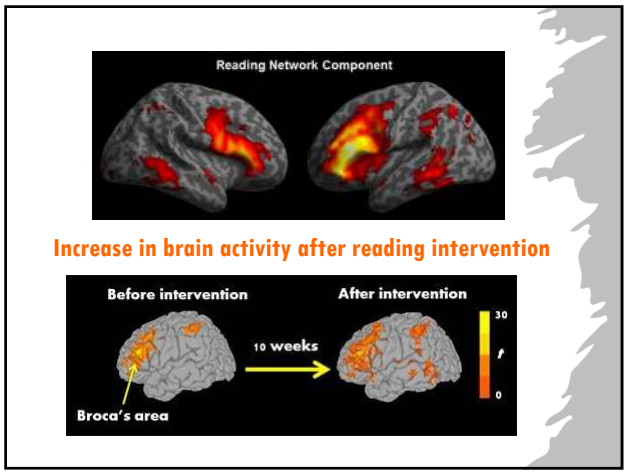
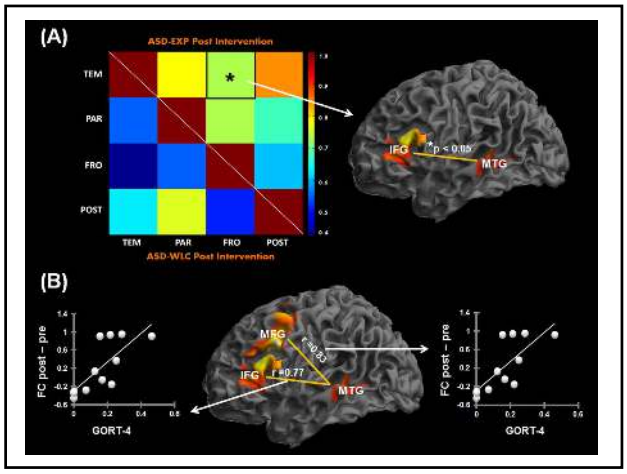


Beckerson et al. (under review)

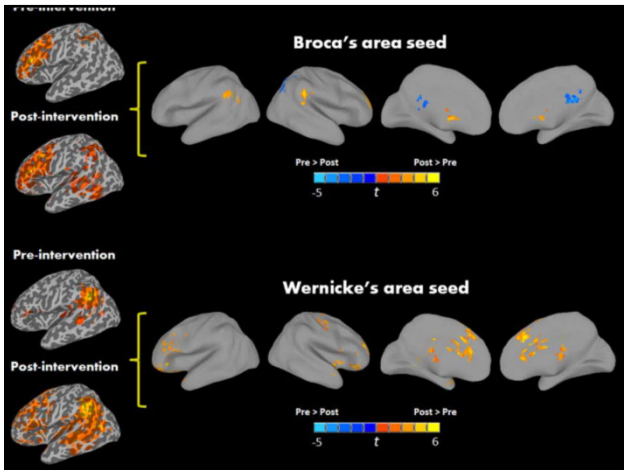
36


Reading Network Component
Increase in brain activity after reading intervention
Before intervention
After intervention
10 weeks
Broca's area
30
t
0

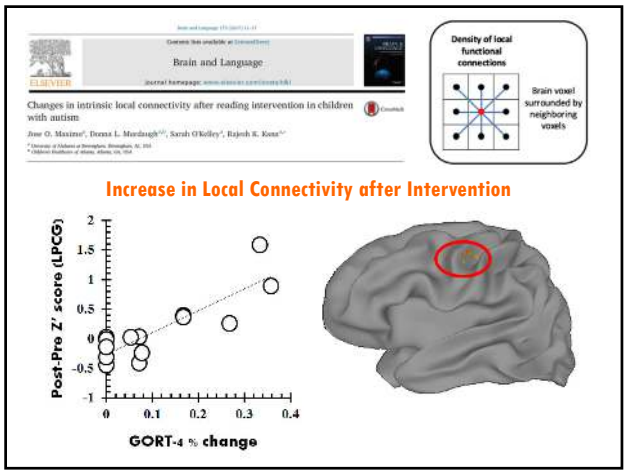
37


(A)
ASD-EXP Post Intervention
TEM
PAR
FRO
POST
IFG
MTG
*p < 0.05
ASD-WLC Post Intervention
(B)
FC post – pre
GORT-4
MFG
IFG
MTG
r = 0.77

38


Broca's area seed
Post-intervention
Pre-intervention
Pre > Post
Post > Pre
-5
t
6
Wernicke's area seed

39



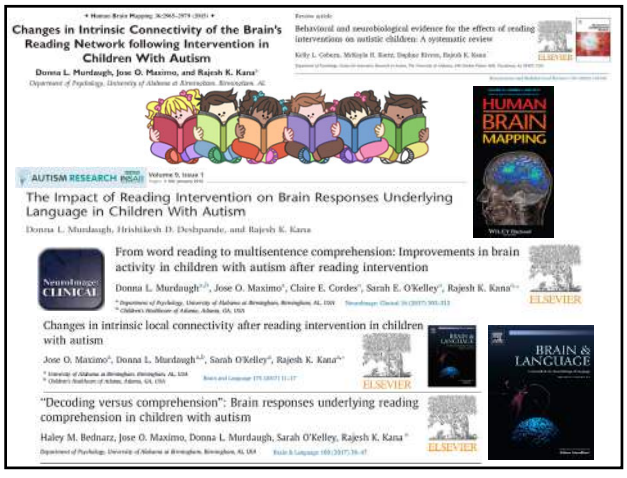
40

Summary

- **Reading comprehension improved in autistic children as a result of 10-week V/V Intervention**
- **Improvement in comprehension was predicted by verbal memory, social responsiveness, and picture vocabulary (PPVT)**
- **Improvement in reading comprehension was found to be associated with functional connectivity between Broca's and Wernicke's areas.**

Visualizing and Verbalizing® for Language Comprehension and Thinking®

41



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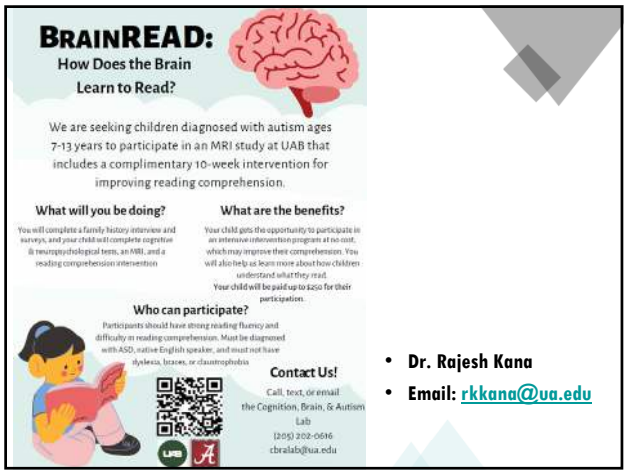
BRAINREAD:
How Does the Brain Learn to Read?
We are seeking children diagnosed with autism ages 7-13 years to participate in an MRI study at UAB that includes a complimentary 10-week intervention for improving reading comprehension.
What will you be doing?
You will complete a family history interview and surveys, and your child will complete cognitive & neuropsychological tests, an MRI, and a reading comprehension intervention
What are the benefits?
Your child gets the opportunity to participate in an intensive intervention program at no cost, which may improve their comprehension. You will also help us learn more about how children understand what they read.
Your child will be paid up to $250 for their participation.
Who can participate?
Participants should have strong reading fluency and difficulty in reading comprehension. Must be diagnosed with ASD, native English speaker, and must not have dyslexia, braces, or claustrophobia
Contact Us!
Call, text, or email the Cognition, Brain, & Autism Lab
(205) 202-0616
cbralab@ua.edu
Dr. Rajesh Kana
Email: rkkana@ua.edu

43


NIH
National Institutes of Health
NSF
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NIDCD #5R01DC016303;
NSF #FAIN-2019120
Lindamood-Bell Learning Processes;
University of Alabama College of A&S

44