

## Taking a Closer 'Look' at Receptive Language Skills in Children with Autism Spectrum Disorder: The Benefits of Eye-Gaze Methods

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## Plan for Today

- The big picture: autism spectrum disorder (ASD)
- What does it look like to assess receptive language?
  - What challenges do we encounter?
  - How might we address them?
- Another way to measure comprehension: "looking while listening"
- What can eye movements tell us?
- Looking ahead: clinical implications



## Acknowledgements

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## Acknowledgements

- Corey Ray-Subramanian, Heidi Sindberg, Amy Esler, Courtney Karasinski
- Videos are used in this presentation only with parent permission

## The Big Picture



- Neurodevelopmental disorder diagnosed in early childhood
- Most recent prevalence estimate: 1/59 children

<https://www.cdc.gov/ncbddd/autism/data.html>

Diagnostic criteria for ASD (299.00) in the DSM 5:  
What 2 'domains' of behaviors are considered here?

<https://www.cdc.gov/ncbddd/autism/hcp-dsm.html>

Diagnostic criteria for ASD (299.00) in the DSM 5:  
What 2 'domains' of behaviors are considered here?

- Social Communication
  - Difficulties with back-and-forth conversation, eye contact, facial expressions, gestures
  - Trouble with social initiations and/or responses
  - Difficulties developing and maintaining social relationships
- Repetitive Behaviors and Restricted Interests
  - Repetitive speech
  - Insistence on sameness
  - Preoccupation with unusual objects
  - Perseverative interests
  - Hyper- or hypo-reactivity to sensory input

<https://www.cdc.gov/ncbddd/autism/hcp-dsm.html>

Video Examples

Pop Quiz on ASD diagnostic updates! True or False?

- 1. Even though the current DSM-5 lists only 2 domains of autism symptoms, the DSM-IV listed 3.

True.

- In the DSM-IV: social interaction and communication were listed separately.
- Now, they are one: "Social Communication."
- DSM-5 domains for autism:
  - Social Communication
  - Restricted interests/Repetitive behaviors

True or False?

- 2. Individuals on the autism spectrum may currently be given one of several diagnostic labels, including Asperger syndrome, PDD-NOS, and autistic disorder.

False.

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### True or False?

- 3. A diagnosis of ASD may include a qualifier of how severe an individual's symptoms are.

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True. Levels of support across both domains

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### Diagnostic criteria for ASD (299.00) in the DSM 5

- A. Difficulties with **Social Communication**
- B. **Repetitive Behaviors and Restricted Interests**
- C. Symptoms present during **early development\***
- D. Symptoms cause **clinically significant\*** impairment in social, occupational, or other important areas of current functioning
- E. Behaviors are **not better explained by\*** intellectual disability or global developmental delay

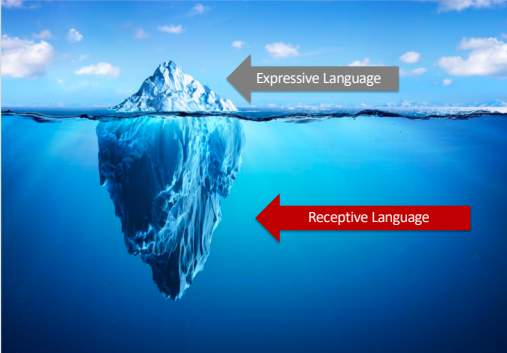
<https://www.cdc.gov/ncbddd/autism/hcp-dsm.html>

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### What do we *not* see in these criteria?

- Difficulties with **language**
  - Pragmatics/social use of language? Yes.
  - Receptive & expressive language, vocabulary & grammar? No.
- Even though not part of diagnostic criteria, lots of children with ASD have language delays
  - Early sign of autism
  - Negative impact on social relationships, academic outcomes, quality of life

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Charman et al., 2003, *Journal of Child Language*; Luyster et al., 2008, *JADD*; Loucas et al., 2008, *JCPP*; Volden et al., 2011, *AJSLP*


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### Plan for Today

- The big picture: autism spectrum disorder (ASD)
- What does it look like to assess receptive language?



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### Think-Pair-Share

- How do you assess receptive language skills in children with ASD?

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### How might we assess receptive language in children with ASD?




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### Assessing receptive language is tricky


- It's not quite as straightforward as assessing spoken language



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### What kind of responses do we usually look for?

- Pointing to pictures
  - Show me "wrist."
- Following directions
  - Close the book, give it to me, and then stand up
- Answering questions
  - What color was Buddy's blanket?
- Selecting objects from an array
  - Give me the car



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Sometimes, these methods work pretty well

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Sometimes they don't

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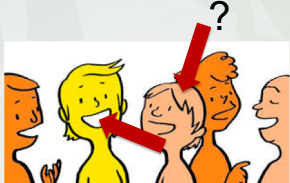
### What's going on here?

- Well...he didn't get that item correct
- But why?
  - Because he didn't know what the cup was?
  - Or for some other reason?
- Understanding language doesn't actually involve pointing, giving objects, following directions, or answering questions
- Those are just the behaviors we use as a sign that comprehension occurred


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### Assessing receptive language is **inherently** difficult

- We aren't measuring receptive language/comprehension directly. We're measuring it indirectly.
- Success requires language knowledge AND the ability to produce prompt, contingent responses



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### Think-Pair-Share

- What are some of the difficulties you have encountered when attempting to assess language comprehension in children with ASD?
- How have you addressed these difficulties?

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### Video

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### Failing to answer correctly could be due to a lack of language knowledge, or to...

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### Failing to answer correctly could be due to a lack of language knowledge, or to...

- Limited motivation to do what the examiner says
- Active desire to avoid doing what the examiner says
- Difficulty pointing to pictures
- Inattention, distractability
- Rigidity, difficulty transitioning between activities (e.g., not wanting to give a toy back)
- Dysregulation/over-stimulation
- Anxiety, discomfort in unfamiliar places

Brady et al., 2014, *AAC*; DiStefano & Kasari, 2016; Kasari et al., 2013, *Aut Res*

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What happens if we don't have an accurate picture of a child's receptive language abilities?

- Inaccurate evaluation information
- Inaccurate treatment goals
- Difficulty tracking progress during intervention
- Difficulty adapting your treatment strategies

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Video

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Video

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Some strategies we might use

- Involve the parent
- Don't involve the parent
- Move around the room
- Sit at the table
- Use a visual schedule
- Limit distractions
- Use toys and snacks
- Consider alternatives to finger pointing
- Incorporate movement

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It's challenging when children aren't able to show us what they know

- It may help to tell the parent/caregiver that you realize this is happening

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Standardized, examiner-directed assessments have some limitations

- They are socially mediated, by definition
- For many children, they may have low sensitivity (floor effects)
- They have relatively high task demands
- They are based on behaviors that occur after comprehension has actually take place

Sometimes, these methods work pretty well

Sometimes they don't

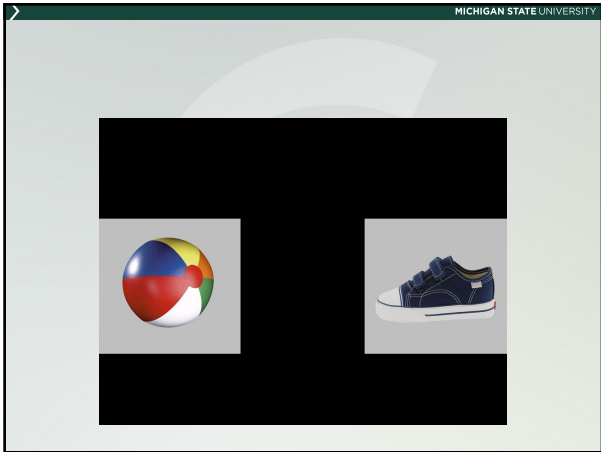
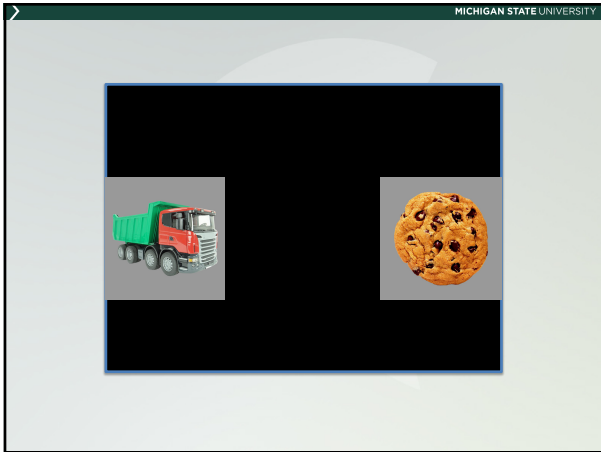

Do eye movements provide insight into comprehension?

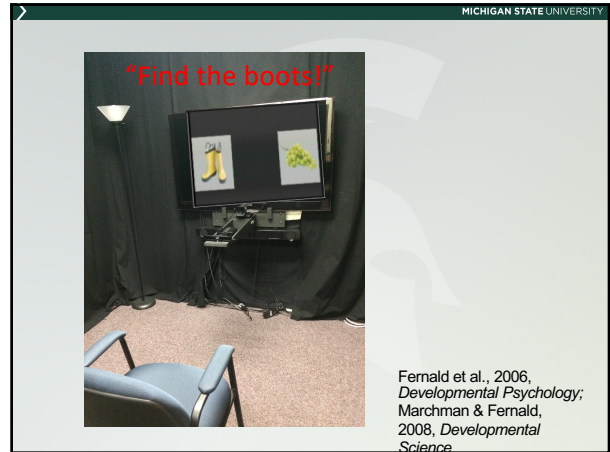
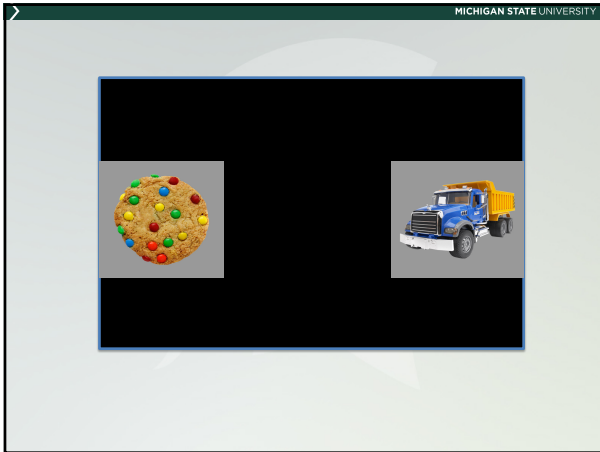


Aslin, 2013, *Infancy*; Fernald et al., 2006, *Developmental Psychology*; Marchman & Fernald, 2008, *Developmental Science*; Naigles & Tovar, 2012, *Journal of Visualized Experiments*; Houston-Price et al., 2007, *Journal of Child Language*

Plan for Today

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  - How might we address them?
- Another way to measure comprehension: "looking while listening"





**We asked:**

- Can eye gaze in children with ASD provide evidence of their language comprehension?
  - **Is this method feasible?**
- Is children's real-time language processing associated with their language comprehension?
  - **Is this method valid?**

Fernald et al., 2006, *Developmental Psychology*;  
Marchman & Fernald, 2008, *Developmental Science*;  
Fernald & Marchman, 2012, *Child Development*

**Participants**

- 34 children with ASD
- 3-6 years old
- Wide range of skills
- Completed:
  - Looking while listening
  - PLS-4 (Auditory Comprehension)

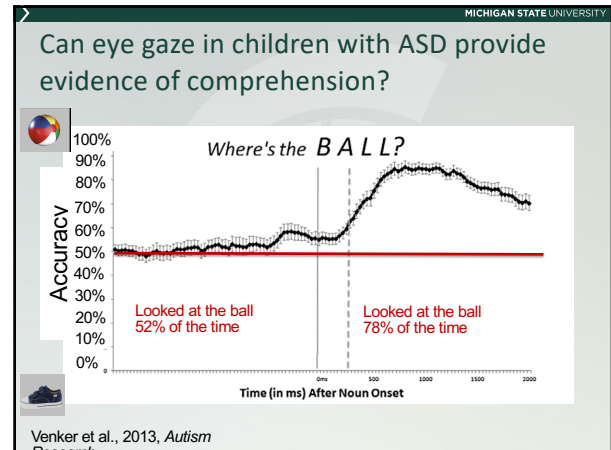
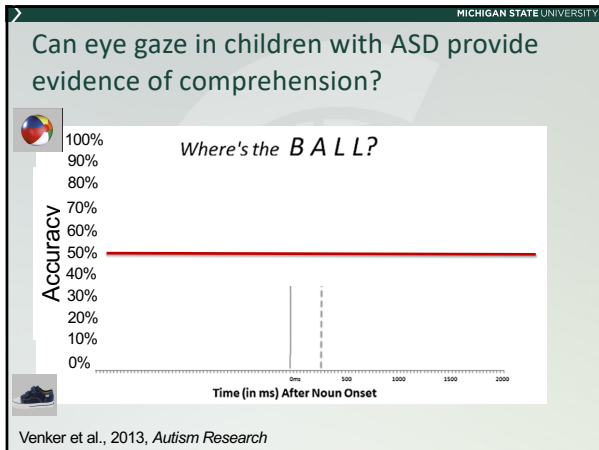


**Measuring Comprehension**

- For each moment in time: was the child looking at the named image (target) or the unnamed image (distracter)?

$$\text{Accuracy} = \frac{\text{looking time to target}}{\text{looking time to target} + \text{distracter}}$$





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- ### Is children's real-time language processing associated with their language comprehension?
- Yes! Children with higher accuracy in the LWL task also had higher raw scores on the Auditory Comprehension subtest of the PLS-4 ( $r = .62, p < .05$ )
  - Processing accuracy was associated with receptive vocabulary 3 years earlier ( $r = .59, p < .05$ )
- Venker et al., 2013, *Autism Research*

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- ### Conclusions
- Eye-gaze methods can measure real-time language comprehension in children with ASD
  - Real-time processing is associated with language comprehension on the PLS-4
  - Exciting! What next?
- 
- Venker et al., 2013, *Autism Research*

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- ### How powerful is this "looking-while-listening" tool?
- We started out with words the kids probably knew, just to see if it would work.
  - But what about words they aren't reported to know?
  - Can LWL reveal **emerging** word understanding?

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- ### Participants
- 22 children with ASD
  - 2-3 years old
  - Wide range of skills
  - Completed:
    - Looking while listening
    - Parents filled out the MacArthur Communicative Development Inventories
- Venker et al., 2016, *Journal of Autism and Developmental Disorders*

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The looking-while-listening task included words like:

- Shoe
- Hat
- Ball
- Duck
- Dog
- Chair
- Slide



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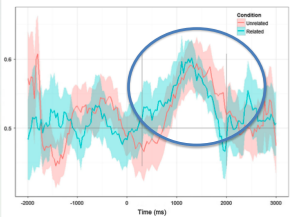
\*\*\*\*\*

- Instead of using looking-while-listening for words the children already knew, we looked only at the words they were reported by their parents *not* to know

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What did we find?

- In the looking-while-listening task, did children show comprehension of words they were reported by their parents not to know?
- Yes!



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What does this mean?

- Children with ASD have emerging understanding of certain words, even if they do not consistently demonstrate that knowledge to their parents
- Looking while listening may reveal emerging lexical knowledge in young children with ASD that might otherwise be overlooked

Venker et al., 2016, *Journal of Autism and Developmental Disorders*

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- What this finding *doesn't* mean is that parents do a bad job of judging their children's language comprehension

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Some Benefits of Parent/Caregiver Report Measures

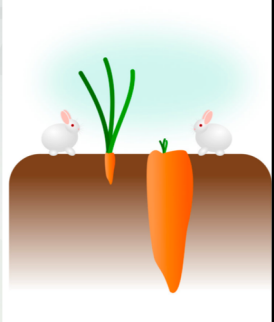
- Increased efficiency
  - The child doesn't have to do a thing!
- Increased ecological validity
  - Judged by a familiar person
  - Based on interactions in a natural context

Think of a child you know who doesn't say very many words. Does that child understand the word:

- More?
- Mine?
- Cookie?
- Go?
- Rocking chair?
- Egg?
- Uncle?
- Bring?
- Splash?
- Tomorrow?
- Morning?
- Why?

Potential Drawbacks of Parent/Caregiver Report Measures

- Vulnerable to inaccuracy
  - Overestimation
  - Underestimation
- Interpreting behaviors in children with ASD is HARD
- It's not common to set up situations that elicit comprehension without cues (e.g., gestures)
- Some words are harder



Adapting a parent vocabulary checklist to acknowledge the difficulty of the task


- "Please circle whether your child understands, understands and says, or neither understands nor says the following words. **For each word, also circle how certain you are about your response.**"

Book	Understands	Understands and says	Neither		
Level of Certainty	Very Uncertain	Uncertain	Neutral	Certain	Very Certain
Bowl	Understands	Understands and says	Neither		
Level of Certainty	Very Uncertain	Uncertain	Neutral	Certain	Very Certain
Chair	Understands	Understands and says	Neither		
Level of Certainty	Very Uncertain	Uncertain	Neutral	Certain	Very Certain
Cookie	Understands	Understands and says	Neither		
Level of Certainty	Very Uncertain	Uncertain	Neutral	Certain	Very Certain

Parent report might align really closely with how children perform in looking while listening


- We just weren't giving parents the chance to report their level of certainty before
- Which might reflect how well the child knows each word

So, looking while listening is perfect!



Of course not.

- No measure is perfect!
- Even though looking while listening doesn't require behavioral responses like pointing or answering questions, it is vulnerable to data loss – times when kids aren't looking at the screen or we aren't able to tell where they are looking



Repetitive Motor Movements

Squinting or Peering

Whole Body Rocking

Excessive Movement




Data loss is bad

- Losing information about where kids are looking makes this approach less valuable

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### Do different systems produce different rates of data loss?

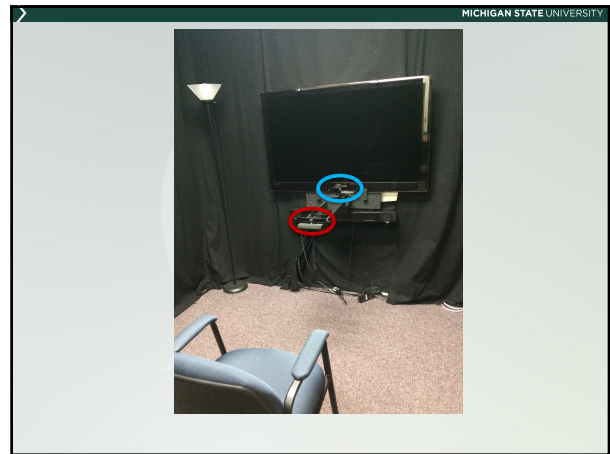
Automatic Eye Tracking



+

Manual Gaze Coding





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### How does automatic eye tracking determine gaze location?

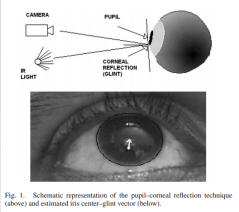


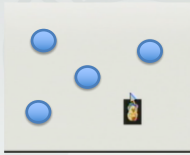
Fig. 1. Schematic representation of the pupil-corneal reflection technique (above) and estimated iris center-gaze vector (below).

- Create corneal reflections with near-infrared lights
- Recorded by internal camera
- Processing algorithms determine gaze location

Staut, J., & Sidha, S. A. (2011). Iris center corneal reflection method for gaze tracking using visible light. *Biomedical Engineering, IEEE Transactions on*, 58(2), 411-419.

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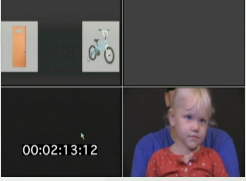
### Calibration for automatic eye tracking



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### How does manual coding determine gaze location?

- Code: is gaze to the left image, right image, between images, or away?



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### We asked:

- Do automatic eye tracking and manual gaze coding produce different rates of data loss?

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## Participants

- 51 children with ASD
- **2-3 years old**
- Wide range of skills
- Completed:
  - Looking while listening
  - Automatic eye tracking and manual gaze coding were used to measure where kids were looking

Venker et al., 2016, *Journal of Autism and Developmental Disorders*

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## Looking While Listening



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## What did we find?

- Do automatic eye tracking and manual gaze coding produce different rates of data loss?
- Yes.
- Manual coding produced more usable trials and more information per trial
- It also excluded fewer children than automatic eye tracking\*

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## Why did manual coding retain more data?



Figure 6. Track box. The track box is the volume in which the eye tracker is able to track the eyes. Thus, the subject is able to move the head freely and still remain trackable as long as the eyes are still within the box.

[tobii.com/Global/Analysis/Training/Metrics/Tobii\\_Test\\_Specification\\_Accuracy\\_and\\_PrecisionTestMethod\\_version%202\\_1\\_1\\_.pdf](http://tobii.com/Global/Analysis/Training/Metrics/Tobii_Test_Specification_Accuracy_and_PrecisionTestMethod_version%202_1_1_.pdf)

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## Conclusions

- Each system has advantages
- Manual coding limits missing data
- Goal: to improve eye tracking technology in research and clinical settings
  - Ensure that all children are able to use this technology

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## There are things we can do to improve attention and limit data loss

- Ahead of time
- During the task

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Going to visit the

L<sub>1</sub>, I<sub>1</sub>, N<sub>1</sub>, G<sub>2</sub>, O<sub>1</sub>, L<sub>1</sub>, A<sub>1</sub>, B<sub>3</sub>!

A Social Narrative

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UNIVERSITY | And Disorders

The Lingo Lab is a place at Michigan State University where people learn new things.

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We ask a lot of questions, like:

How do kids learn language?  
Why do some kids have trouble learning?  
What we can do to make learning easier?

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The people who work at the Lingo Lab are called researchers. They love hanging out with kids and learning new things!

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The Lingo Lab is in the Oyer Speech and Hearing Building on the MSU campus.

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We will go downstairs to get to the lab.  
We can take the stairs or the elevator.

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In this room, I will watch short 'movies' with pictures and sounds.

I can sit on my mom or dad's lap while I watch the movies.




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I need a break



At the Lingo Lab, it is ok to take a break whenever I need one.







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The people at the Lingo Lab are so happy that I am helping them learn new things!

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### Visual Schedule

_____ 's Schedule		
Picture Pointing		<input type="checkbox"/>
Movie		<input type="checkbox"/>
Game		<input type="checkbox"/>
Movie		<input type="checkbox"/>
Play!		<input type="checkbox"/>
Talking		<input type="checkbox"/>


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### Video

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1. We've learned a lot about noun comprehension. What about verbs?

- Verbs can be hard to learn
- What do children with ASD know about verbs?
- Do they use information in verbs to think ahead?

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Participants

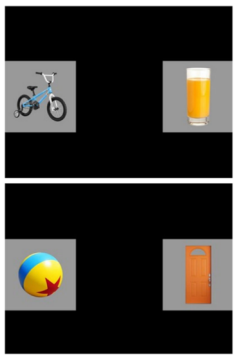
- 20 children with ASD
- 4-5 years old
- Wide range of skills
- Completed:
  - Looking while listening

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Verb Comprehension

Find the bike!  
Ride the bike!  
Drink the juice!

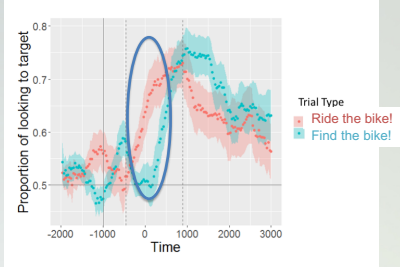
Find the door!  
Throw the ball!  
Open the door!



Venker, Edwards, Saffran, & Ellis Weismer, JADD, 2019

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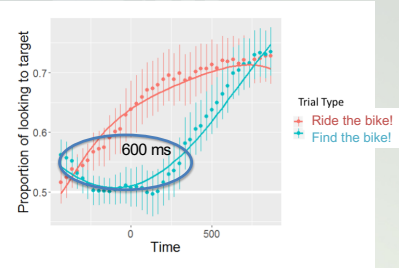
Verb Comprehension:  
Using Verbs to Think Ahead



Venker, Edwards, Saffran, & Ellis Weismer, JADD, 2019

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Verb Comprehension:  
Using Verbs to Think Ahead



Venker, Edwards, Saffran, & Ellis Weismer, JADD, 2019

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What does this tell us?

- Children with ASD can use information in verbs to think ahead
- Similar patterns of comprehension to children with typical development
- Suggests a benefit of providing semantically rich language input (children are using it!)

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### 2. How can we motivate children to show us what they know in a looking while listening task?

- Video

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In children who are typically developing, this adaptation increases validity

- Stronger association between parent report (CDI) and performance in the 'wiggle' version of looking while listening than in the standard version

Killing & Bishop, *Developmental Science*, 2008

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Book	Understands		Understands and says		Neither
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Cookie	Understands		Understands and says		Neither
Level of Certainty	Very Uncertain	Uncertain	Neutral	Certain	Very Certain

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### 3. How can looking while listening show us about the earliest stages of word learning?

- "Gazzer"
- "Modi"



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### 3. How can looking while listening show us about the earliest stages of word learning?

- Video

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### What could this tell us?

- Not that we're going to teach kids made-up words 😊
- Implications for treatment strategies for building on the child's interests, following into the child's focus of attention, not directing them elsewhere
- May help provide a foundation for word learning
  - Start with words for things they care about
  - These words may also be more motivating for children to say

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- **Looking ahead: clinical implications**



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## Clinical Implications

- Late talkers
- AAC displays
- Adaptations of standardized assessments
- Simplified language input

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## “Late talkers”

**CHILD DEVELOPMENT**

Child Development, January/February 2012, Volume 83, Number 1, Pages 203-222

**Individual Differences in Lexical Processing at 18 Months Predict Vocabulary Growth in Typically Developing and Late-Talking Toddlers**

Anne Fernald and Virginia A. Marchman  
*Stanford University*

Fernald & Marchman, 2012, *Child Development*

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Fernald & Marchman, 2012, *Child Development*

- “Those late talkers who were more efficient in word recognition at 18 months were also more likely to ‘bloom,’ showing more accelerated vocabulary growth over the following year, compared with late talkers less efficient in early speech processing.”

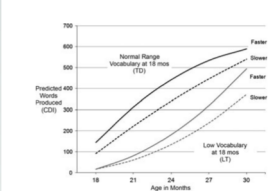


Figure 2. Predicted mean trajectories of quadratic growth in vocabulary from 18 to 30 months as a function of typically developing (dark lines) and late-talking (grey lines) group and faster (+1 SD, solid lines) versus slower (-1 SD, dashed lines) mean reaction times at 18 months.

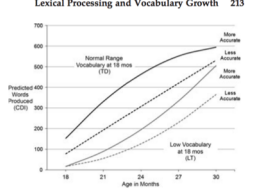


Figure 3. Predicted mean trajectories of quadratic growth in vocabulary from 18 to 30 months as a function of typically developing (dark lines) and late-talking (grey lines) group and higher (+1 SD, solid lines) or lower (-1 SD, dashed lines) mean accuracy scores at 18 months.

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## Eye tracking and AAC

Journal of Speech, Language, and Hearing Research | Research Article | 1 Apr 2014

Enter keywords, authors, JSLHR etc.

Journal of **AAC** **Augmentative and Alternative Communication**  
Volume 30, 2014 - Issue 2

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**Eye Tracking Research to Answer Questions about Augmentative and Alternative Communication Assessment and Intervention**

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## Eye tracking and AAC

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**Eye-Tracking Measures Reveal How Changes in the Design of Aided AAC Displays Influence the Efficiency of Locating Symbols by School-Age Children Without Disabilities**

Krista M. Wilkinson, Tara O'Neill, and William J. McIlvane  
[https://doi.org/10.1044/2013\\_JSLHR-L12-0159](https://doi.org/10.1044/2013_JSLHR-L12-0159)

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**Eye tracking and AAC**

- Clustering produced faster fixations to the target AND fewer fixations on non-targets
- Seemingly minor display changes can reliably affect how quickly the AAC user is able to select the target
- Quicker looks to the target symbol were associated with quicker behavioral responses

Wilkinson et al., 2014, JSLHR

**Might it be possible to translate standardized assessments to an eye tracking interface?**

- Looked at: “Feasibility of using eye tracking research technology as a method for measuring spoken word comprehension in children with ASD who are minimally verbal.”

Brady et al., 2014, AAC

Figure 3. Example of gaze patterns to known and unknown words.

Brady et al., 2014, AAC

**How did the children do?**

- Generally, it worked
  - Children with ASD (and TD) looked longer at target than non-target pictures for KNOWN words
  - There were no sig diff in looking at target vs. non-target pictures for UNKNOWN words

Brady et al., 2014, AAC

**What does this mean?**

- “...a child may look at a named item even if they are not sure enough of its meaning to point to it.”
- “...a first step in a line of research aimed at providing researchers and clinicians with a method to utilize alternative responses, such as eye gaze, to indicate implicit understanding by some children with ASD...”

Brady et al., 2014, AAC

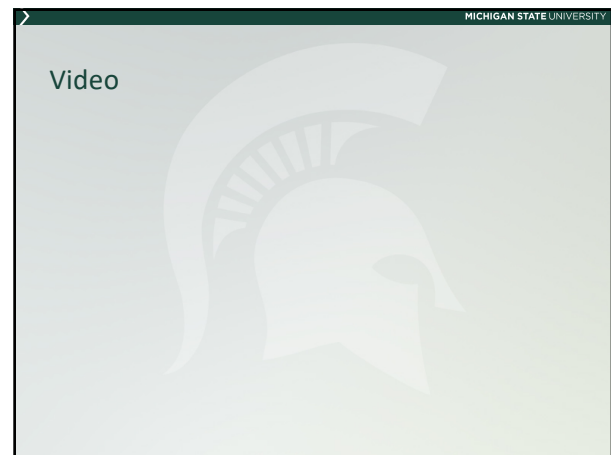
**Examining the effects of different types of simplified language input**

- How do children comprehend different types of simplified language input?

TWO TYPES OF SIMPLIFIED INPUT

Telegraphic input	Grammatical simplified input	
	Shorter	Longer
See car.	Car.	See the car.
More toy?	Toys?	More toys?
Put in box.	In the box.	Put it in the box.
My turn bubbles.	My turn.	It's my turn for bubbles.
Doggie run.	Run.	The doggie's running.
Tractor in barn.	In the barn.	The tractor's in the barn.
Open door.	Open.	Open the door.
Give cup daddy.	Give it to Daddy.	Give the cup to Daddy.
Mommy feed baby.	Feed the baby.	Mommy's feeding the baby.


Venker & Stronach, 2017, ASHA Leader



Examining the effects of different types of simplified language input

- Looking while listening allows us to see things we'll never be able to directly observe in intervention
- And translate that information to consider in clinical practice

Gap between clinical practice and research



Think-Pair-Share

- What are some clinical questions that could be answered using the looking-while-listening approach?
- We have this tool: how could we use it to learn how best to help these children?
  - What other ways could you set up the words and pictures? Make it more naturalistic? Other populations? Other implications?

Looking Ahead: What's Next?

- Evaluation, progress monitoring?
- Eye-tracking glasses for natural settings?
- Book reading
- Selection of treatment targets?

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