

Pragmatic and Prosodic Processing in Autism

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ZAS 2015

Plan of Action

- Developmental disorders as a window into cognition
 - How to think about developmental disorders
 - What are we “manipulating”?
 - What should we control?
- Three case studies on autism
 1. Prosodic accents
 2. Pronoun interpretation
 3. Scalar Implicature

Developmental disorders as a window into cognition

Things to keep in mind

1. A developmental disorder is rarely isolated to a single module or function
2. Most disorders are not “natural kinds”
3. Developmental profiles change over time

Things to keep in mind

1. A developmental disorder is rarely isolated to a single function or level
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A priori implausibility of modular* deficits

- *Assume* strong modularity with an evolutionary basis (ala Tooby & Cosmides)
 - Mutation in gene X resulted in ability X
 - Ability X still depends on prior systems, existing genes (descent with modification)
 - Mutations in *any* of these other genes → disorder
- All known genes affect multiple brain regions
 - Thus developmental disorders are expected to have wide ranging effects
 - But not *the same* effects: different pathways, gradients in gene expression across the brain

* Modularity is a hypothesis when many components. The focus here is on separation of functional outcomes (not information encapsulation)

Example: Specific Language Impairment

- Is SLI solely a language deficit?
- SLI associated with other deficits
 - Balance, processing rapid acoustic transitions
- Children with SLI typically have lower non-verbal IQ's
- Genetic risk crosses SLI and non-specific language impairment

But see van der Lely on subtypes

More examples

- Williams Syndrome:
 - Pronounced spatial deficits
 - Social abnormalities (excessive trust)
 - Initially slow to acquire language
 - Good language abilities later
- Downs Syndrome
 - Initially slow to acquire language
 - Poor auditory processing
 - Pronounced language deficits later



Things to keep in mind

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Naïve Essentialism

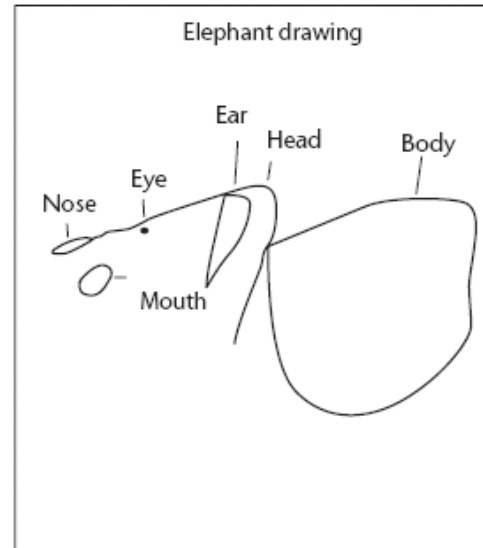
(Susan Gelman, Paul Bloom, Deb Keleman)

- Natural kinds have internal essence
 - Set at birth and unalterable
 - Which generates their external properties
 - Makes all members of a kind “the same” in many ways
-
- Humans strongly biased to interpret biological differences as “natural kinds”

Williams syndrome as natural kind



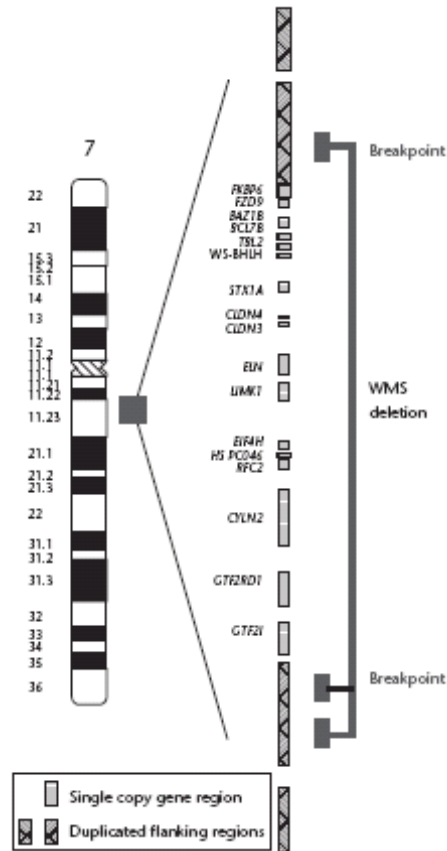
Physical Phenotype



And what the elephant does, it lives in the jungle. It can also live in the zoo. And what it has, it has long grey ears, fan ears, ears that can blow in the wind....

Cognitive Phenotype

Williams Syndrome as natural kind



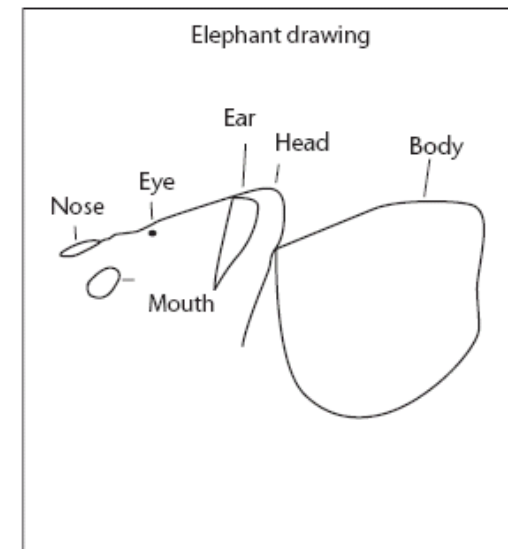
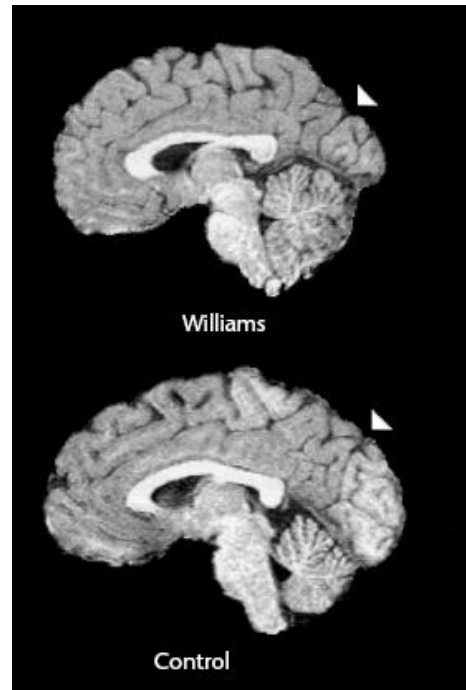
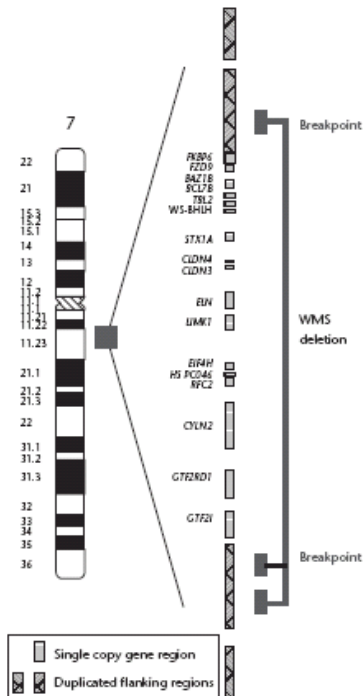
Genetic Characterization



Neuroanatomic Characterization

Williams Syndrome as natural kind

Clean mapping across levels



If you have the full deletion, then you have the neurological differences and the cognitive phenotype

But most developmental
disorders are not like natural
kinds

Dimensional disorders: ADHD, SLI



- Continuous traits
- Clear impairment at extreme
- What constitutes an impairment?

The problem of comorbidity

- About half of young children with Asperger's Syndrome also have a diagnosis of ADHD
- SLI and ADHD frequently co-occur
- Some children with autism have language impairments, some do not
- Genes associated with one disorder are often associated with others

Are these different disorders really discrete?

The problem heterogeneity: example ASD

- Neurophysiological variability
 - Ex: larger brains in 25%
- Genetic variability
 - Estimated 800-1000 genes implicated
 - Many associated with other disorders
- Cognitive variability
 - Family resemblance structure
- Is autism many natural kinds?
 - Unlikely: mushy mapping across levels
- Or overlapping variations on a theme?

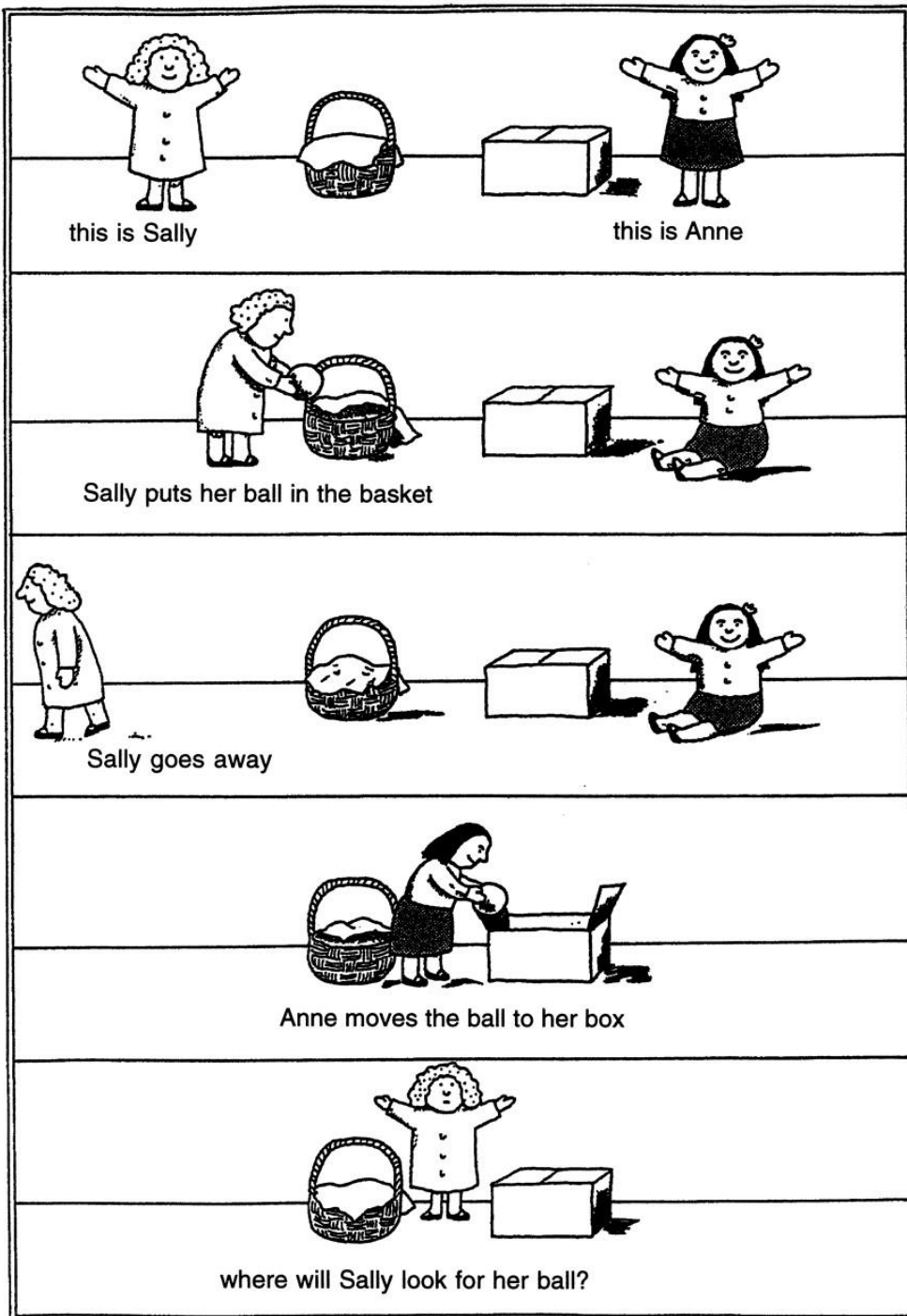
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Developmental profiles change over time

Ex: Language in Williams Syndrome

- Early language development is delayed
- By adolescence normal linguistic behavior
- Possibly via atypical neural and cognitive mechanisms
 - Odd use of vocabulary: no frequency effects
- Ex: Theory of Mind and ASD



The false belief task

(Perner & Wimmer, 1984)

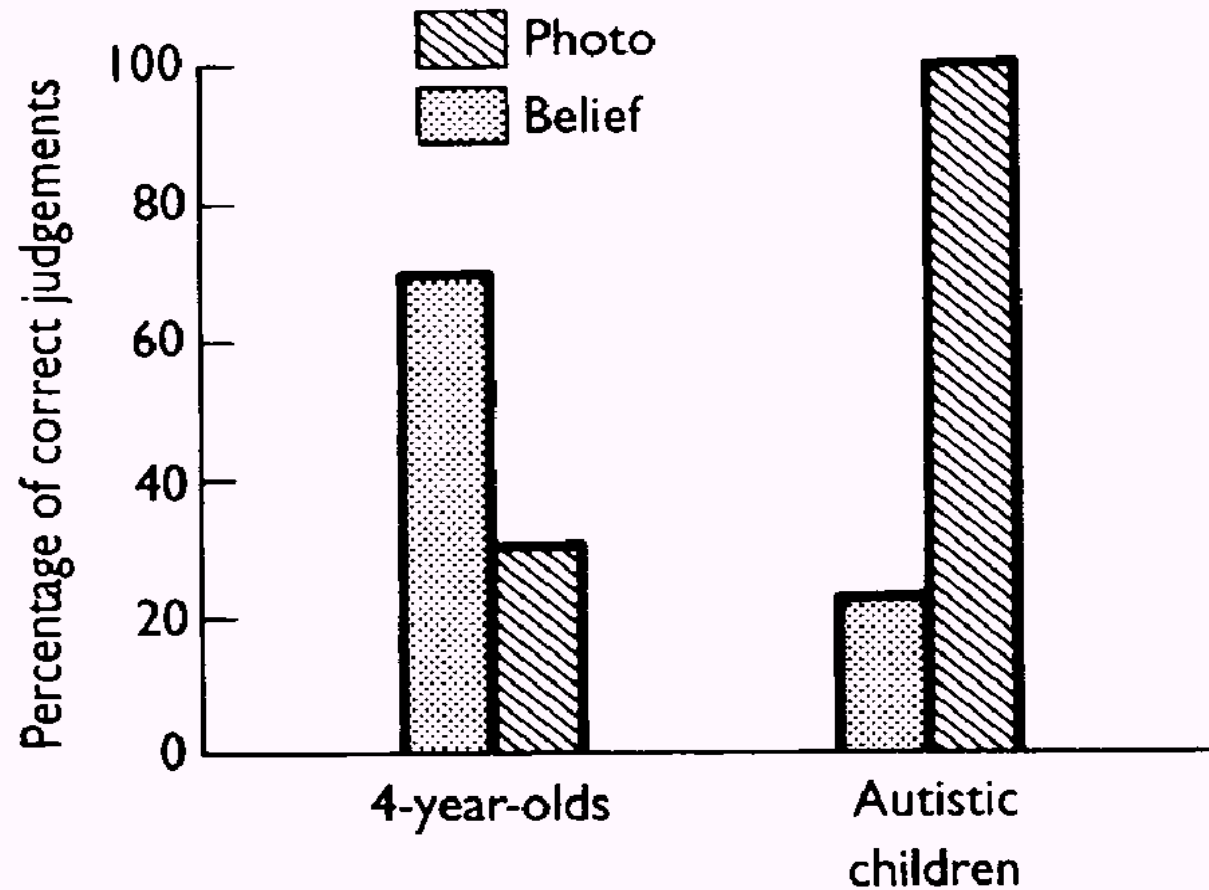
Findings:

Age 3 and under:
Sally will look in the
box (where the ball
actually is).

Age 5 and above:
Sally will look in the
basket (where she thinks
the ball is).

Children's judgements

Beliefs and photos



Leslie & Thaiss (1992)

First-order TOM in ASD changes with verbal age

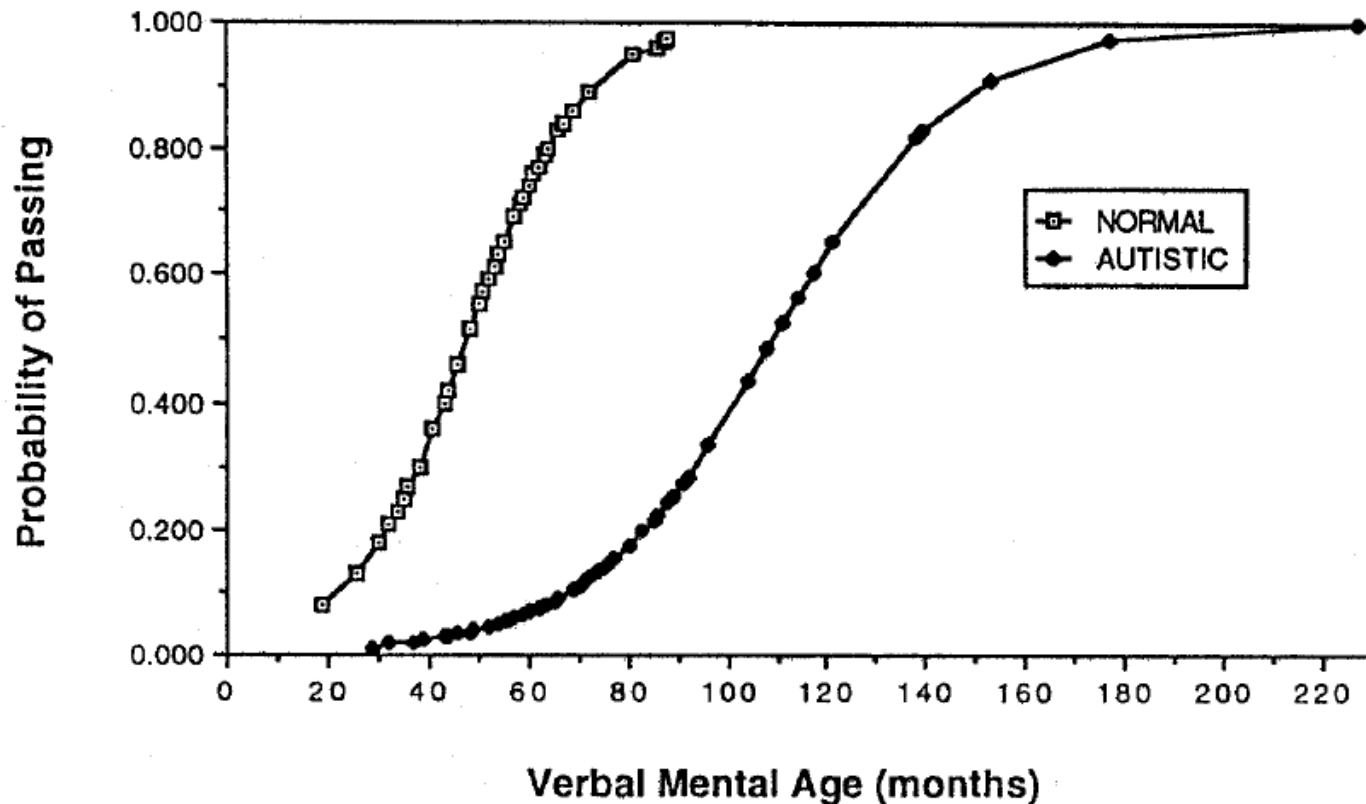



FIG. 1.—Predicted probability of passing both theory of mind tasks by verbal mental age (for autistic and young normal subjects).

Autism as tool for studying pragmatics



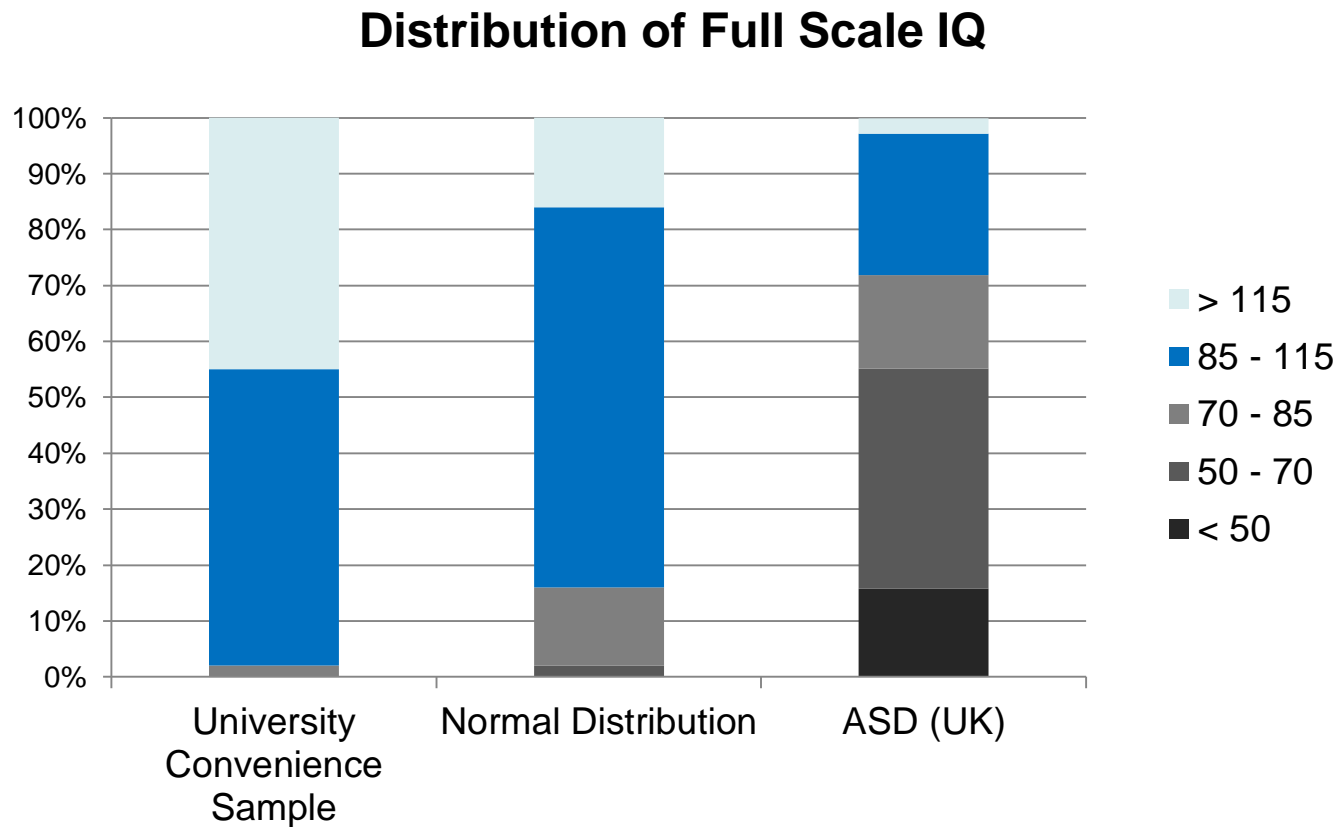
Hans Asperger with a patient at the University Children's Hospital in Vienna, 1977; Asperger saw autism as a continuum.

“ The nature of these children is revealed most clearly in their behaviour towards other people. Indeed, their behaviour in the social group is the clearest sign of their disorder and the source of conflicts from earliest childhood.”

Hans Asperger

Autism is not merely a deficit in
social reasoning

Most children with autism have an intellectual disability

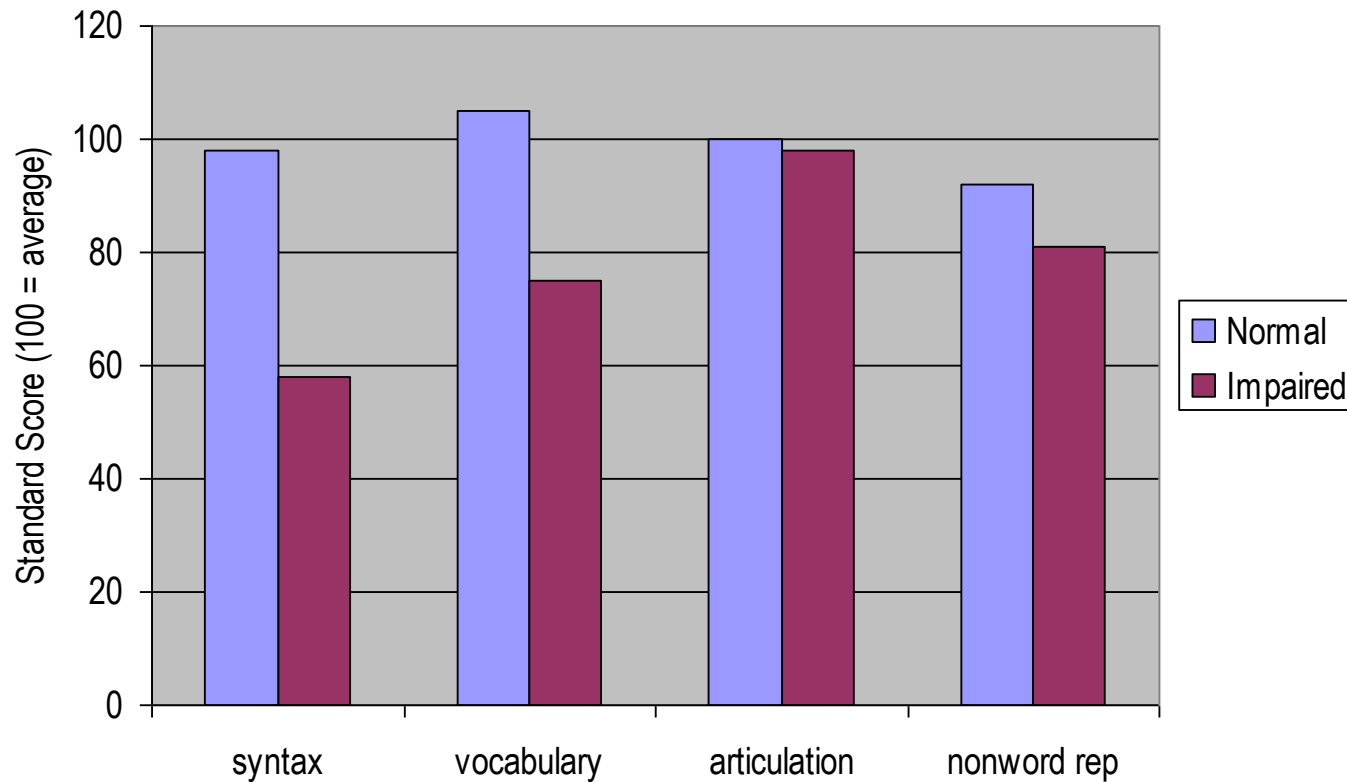


Convenience sample estimated based on my experience matching from an existing university lab data base. ASD data taken from Charman et al., 2011. Sample from late 1990's

Language development in autism varies greatly

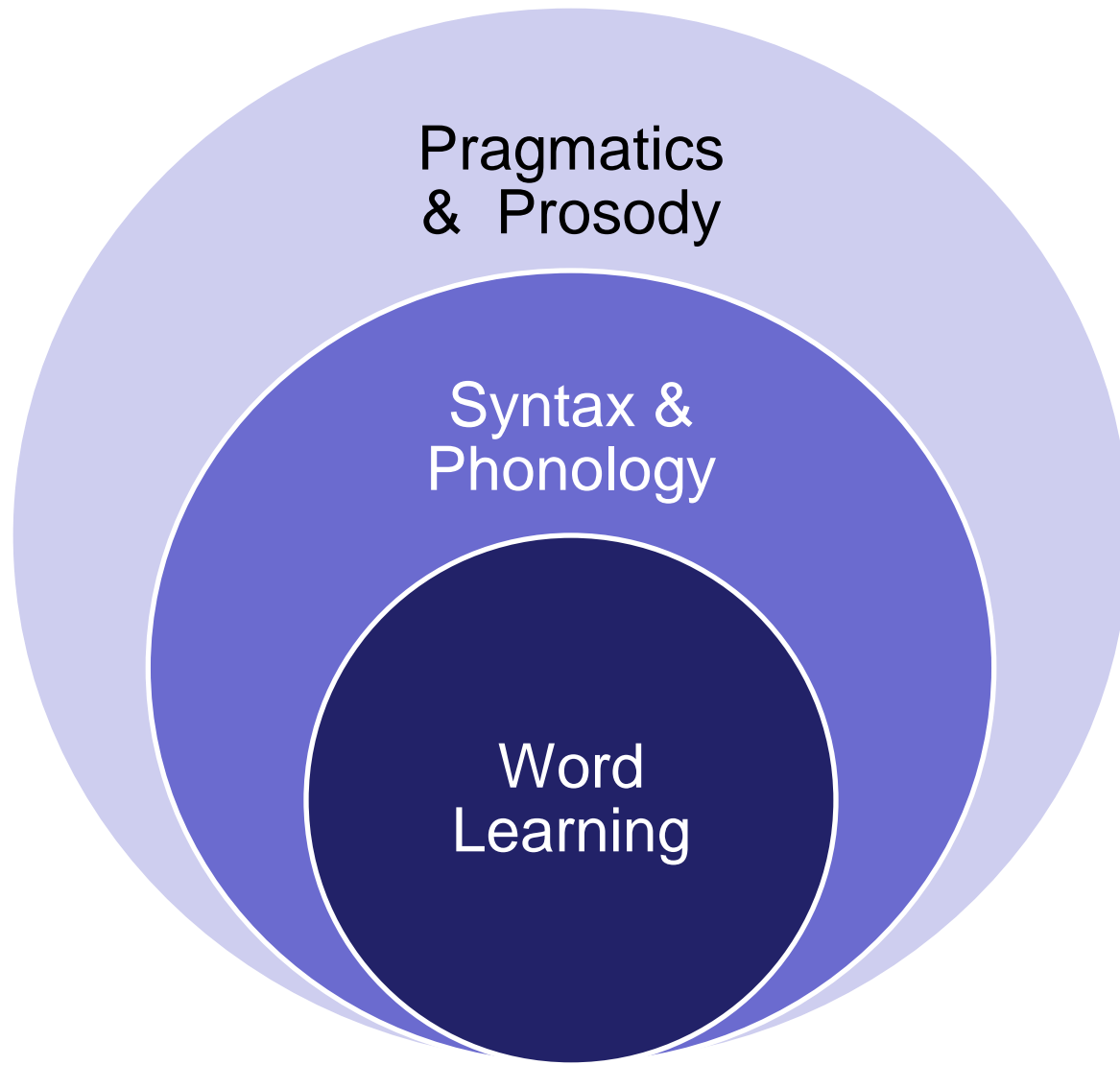
- No speech
- Limited speech
 - Small number of words, used in limited contexts
 - Acquired via intensive interventions
 - Echolalic
- Functional speech
 - Delayed in onset
 - Formal system may reach mature levels in adolescence or adulthood
- Some children show no apparent delays in acquisition

Autism with (or without) impairment in the formal linguistic system



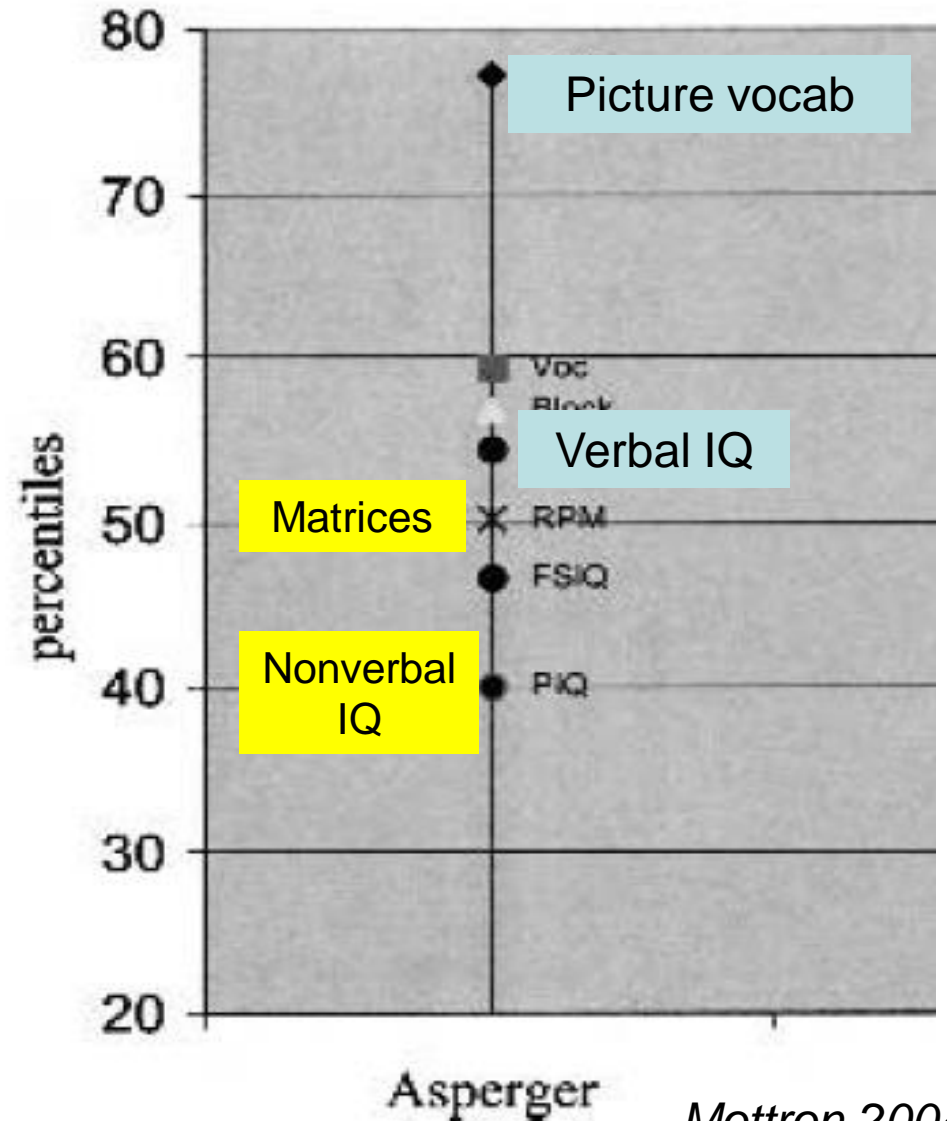
Kjelgaard & Tager-Flusberg (2001)

Communicative deficits in autism



Common matching tests overestimate IQ

- Vocabulary matching is not IQ matching
- Solution
 - Need full scale IQ
 - Or match on most ***relevant*** ability



Common, casual, matching strategies are inadequate

Ex: reduced activation in humor related regions when processing puns (Kana & Wadsworth, 2012)

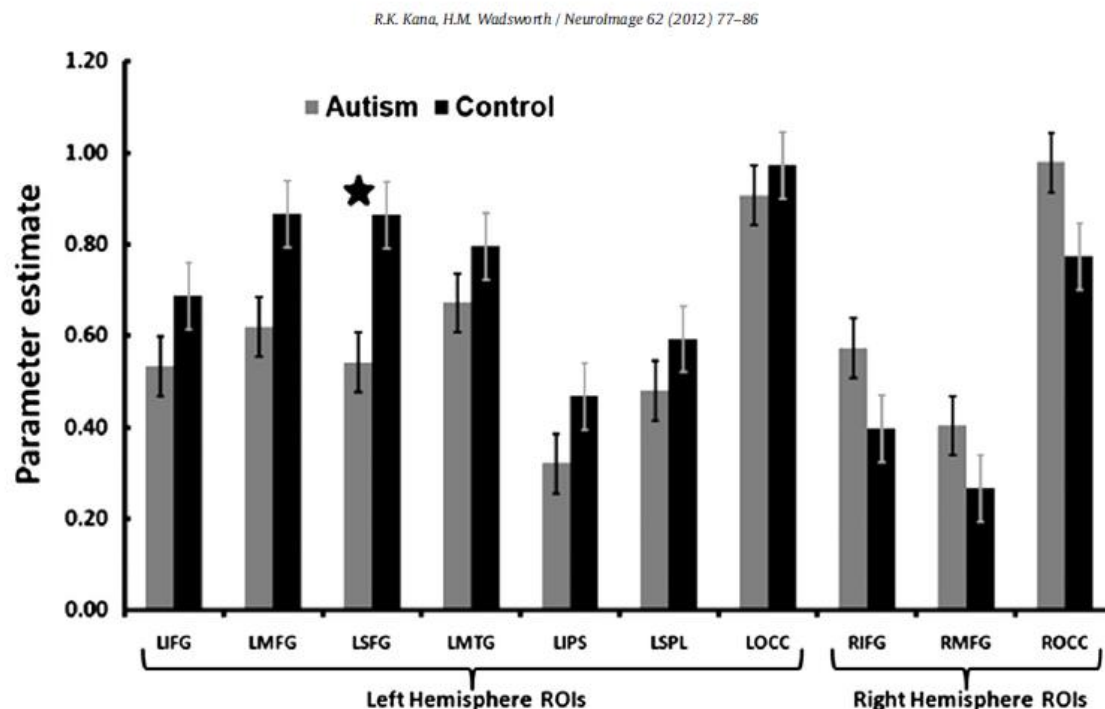


Fig. 4. Parameter estimates. Graph displaying the parameter estimates (beta-weights) from 10 ROIs. This graph displays the significant increase in beta-weights for the control group in the LSFG. It also displays the trend toward greater levels of activation in all left hemisphere regions for controls and the trend toward greater levels of activation in all right hemisphere regions for the autism group.

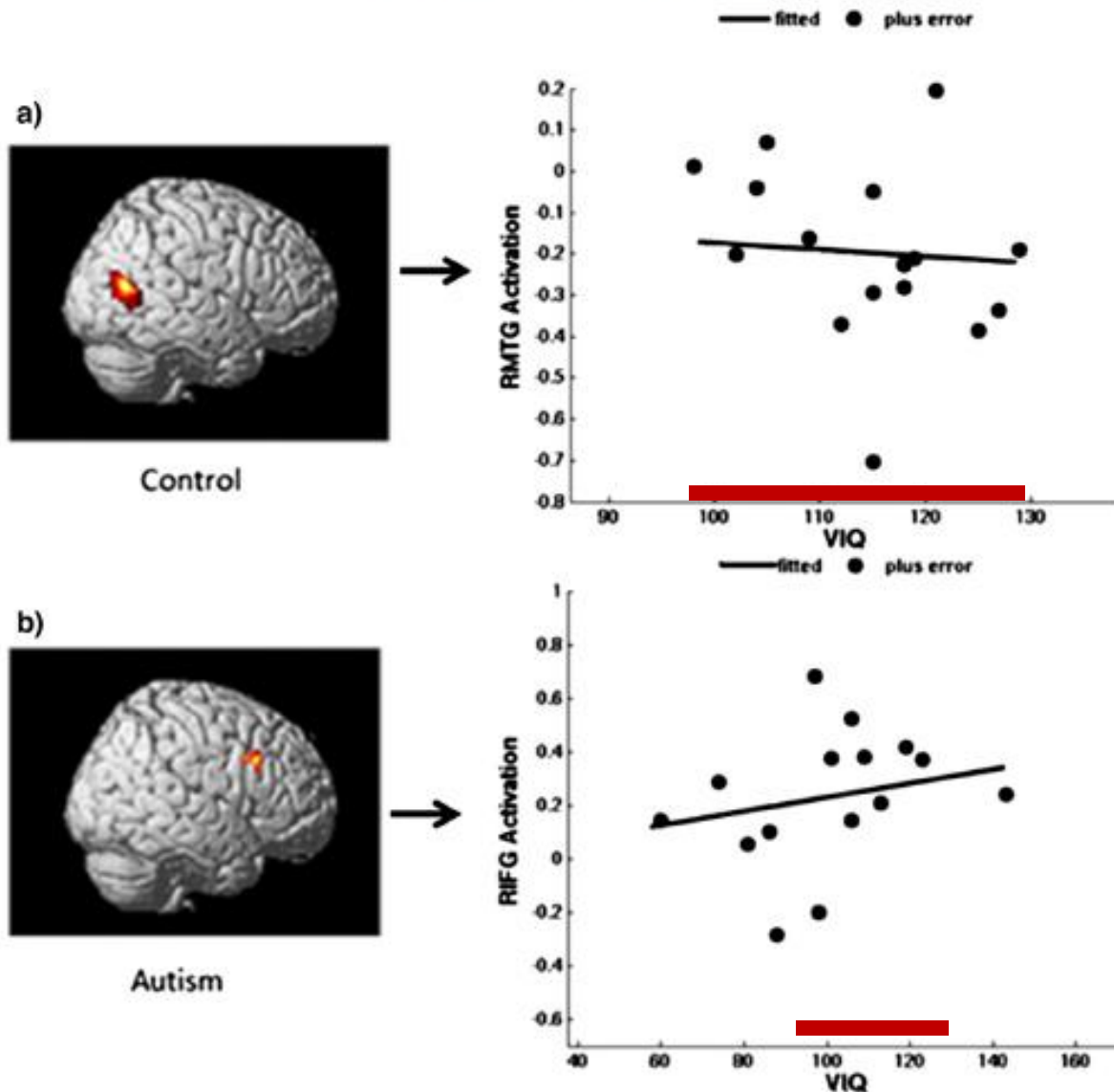


Fig. 3. Correlation between language skills and activation. Figure displaying the activation in core right hemisphere language regions in the within-group regression of activation with VIQ score. A) Displays the negative correlation between VIQ score and activation within the right posterior language region (RMTG) ($r = -0.65$). B) Displays the positive correlation trend between activation in the right frontal region (RIFG) and VIQ score ($r = 0.31$) ($p < 0.001$; $k = 64$).

The dirty secret behind many published effects

“not significantly different” does not mean “plausibly similar”

ASD group has:

- lower mean (60% vs. 83%)
- greater range
- participants with standard scores outside the normal range (5 below 25% vs. 0)

With good matching, many differences disappear
in high-functioning populations

No deficit in the interpretation of ironic remarks in teens

(Colich et al., 2010)



"John and Linda want to go swimming at the beach"



"When they get there, the sky is blue and sunny. John says, 'What a perfect day!'"

OR



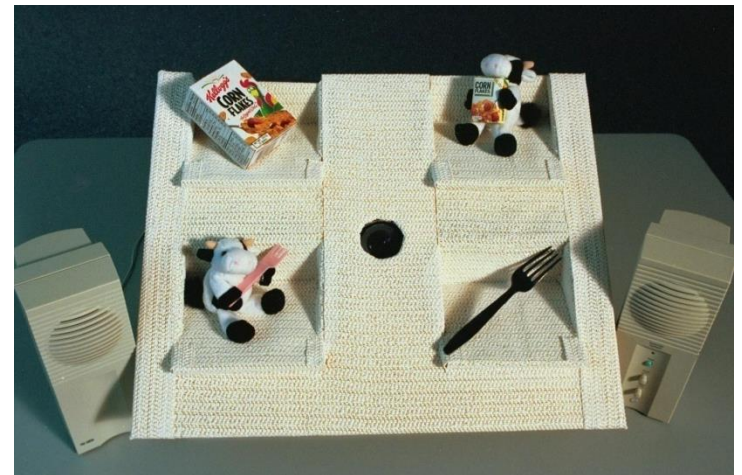
"When they get there, the sky turns dark and rainy. John says, 'What a perfect day...'"

TD: 94% correct

ASD: 97%

No differences in RT's

Moment to moment language comprehension in autism (ASD)



Our approach

- Focus on prosody and pragmatics
 - Argued to be specifically impaired in autism
- Focus on children with strong core language
 - Simplifies interpretation of findings
- Begin with low level, simple phenomena
 - Work toward more complex

Properties of the “experiment”

Manipulation of some set of social cognitive and communicative abilities (boundaries unknown)

Controlling for structural language and general intelligence

Confounds:

- Known: anxiety, executive function deficits, i.a.
- Unknown: inevitable
- Some of these confound are probably causes or facets of the variable we wish to manipulate

II. A few case studies of language comprehension in autism

1. Prosodic processing in ASD

Pragmatic and non-pragmatic
functions

Working hypothesis

- There is no global prosodic impairment in highly verbal autism
 - Depends which level of representation prosody is constraining

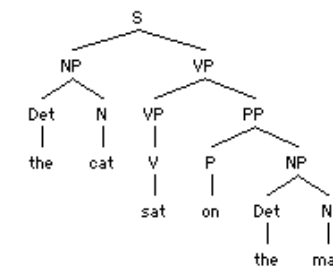
What does prosody do?



pragmatic interpretation

semantics

$\exists x [\text{cat}(x) \wedge \text{on mat}(x)]$
 $\wedge \forall y [\text{cat}(y) \wedge \text{on mat}(y)] x=y$



syntax

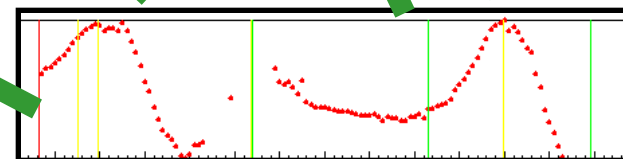
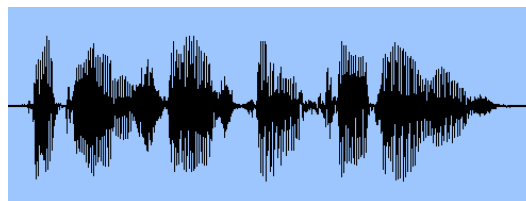
lexicon

/kæt/: noun, singular, animate
/sæt/: verb, past, intransitive
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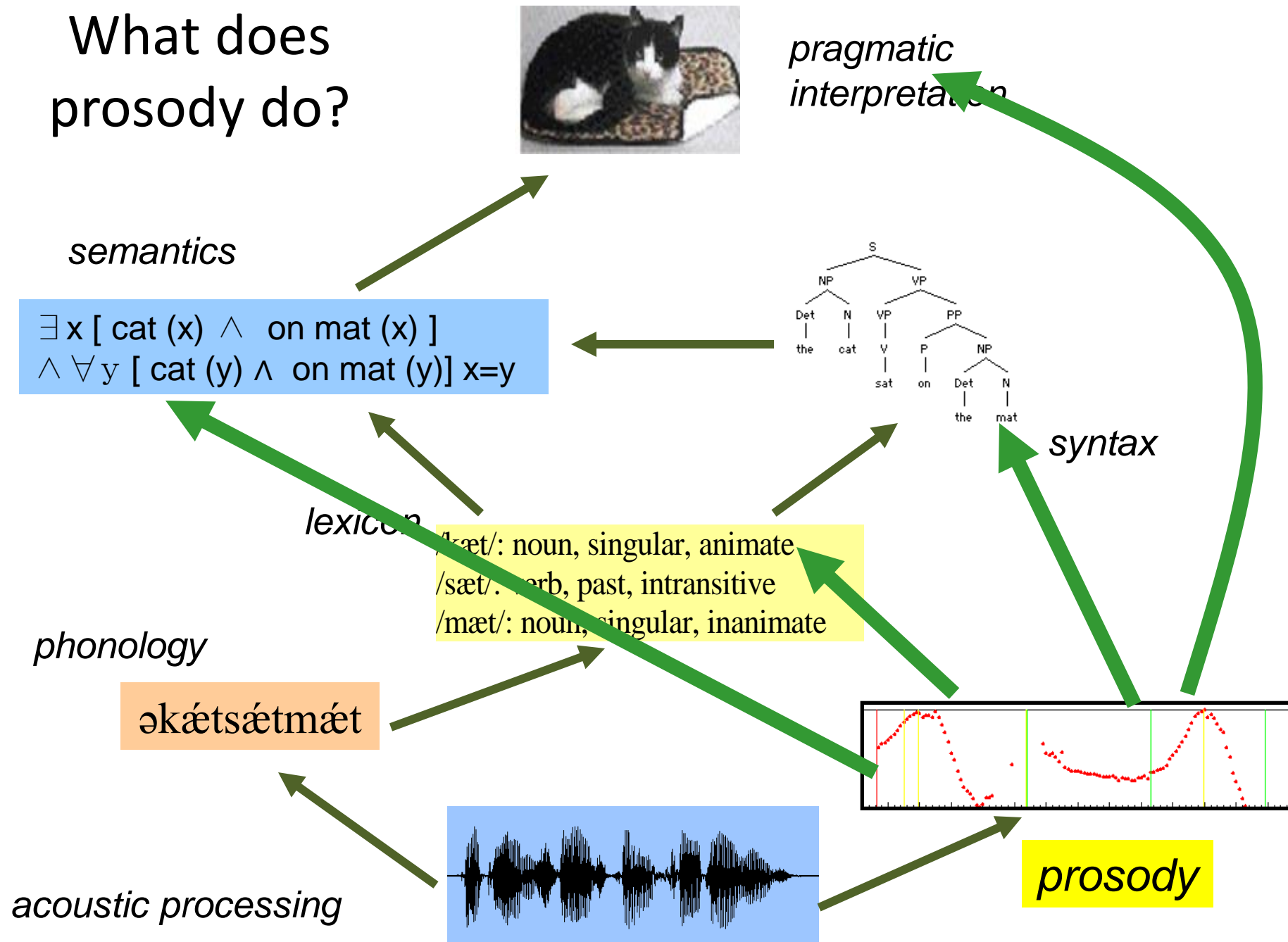
phonology

əkætsætmæt

acoustic processing



prosody



Working hypothesis

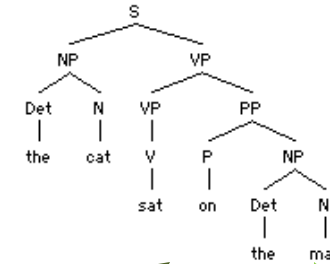
- There is no global prosodic impairment in highly verbal autism
 - Depends which level of representation prosody is constraining
- If that level is spared, use of prosody will be spared
 - Prosody for syntax or word identification
- If that level is impaired, use of prosody will be
 - Prosody as cue to emotional state or speaker's intent



pragmatic interpretation

semantics

$\exists x [\text{cat}(x) \wedge \text{on mat}(x)]$
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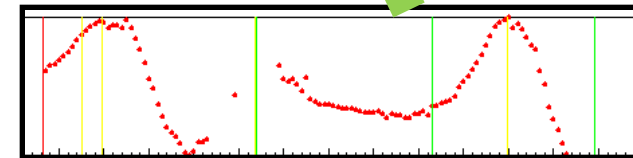
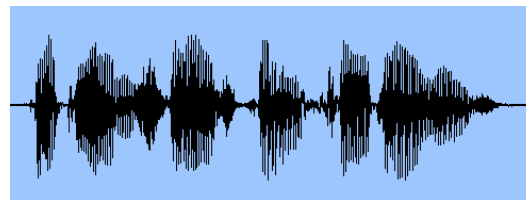
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prosody

Study 1: prosody and syntax

- Snedeker & Yuan paradigm (blocked design)
- 48 children with autism (8 – 17 yrs)
 - ADOS confirmed diagnoses
 - CELF (language) scores above 80
 - Full scale and verbal IQ above 80 (WAIS)
- 48 typically developing controls
 - Matched on CELF scores and age



Paradigm

(Snedeker & Yuan, 2008)

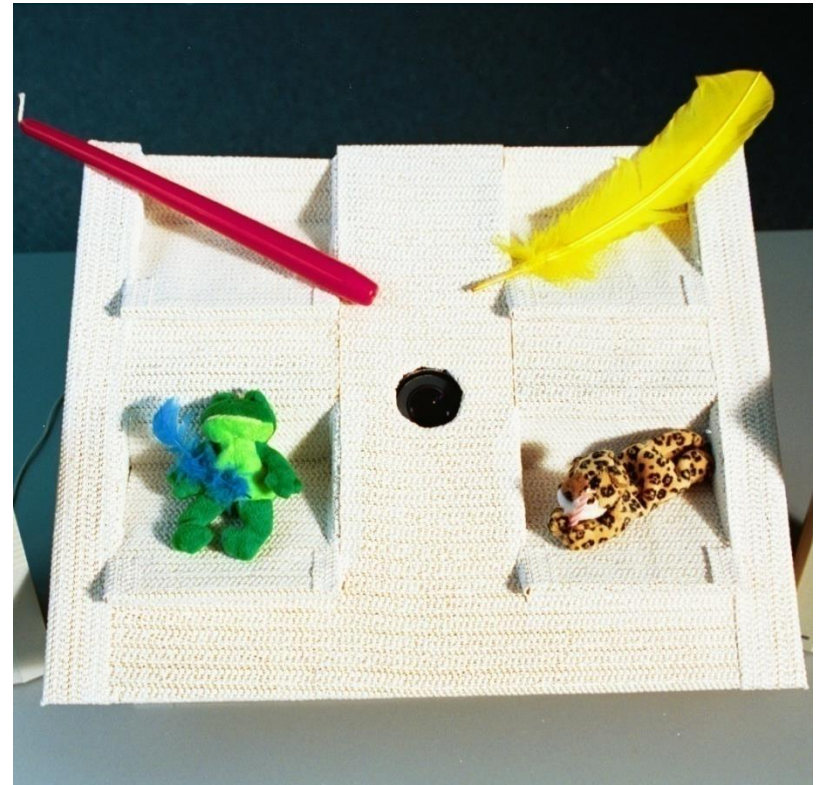
- Instrument Prosody

*You can feel the frawwg....
....with the feather*

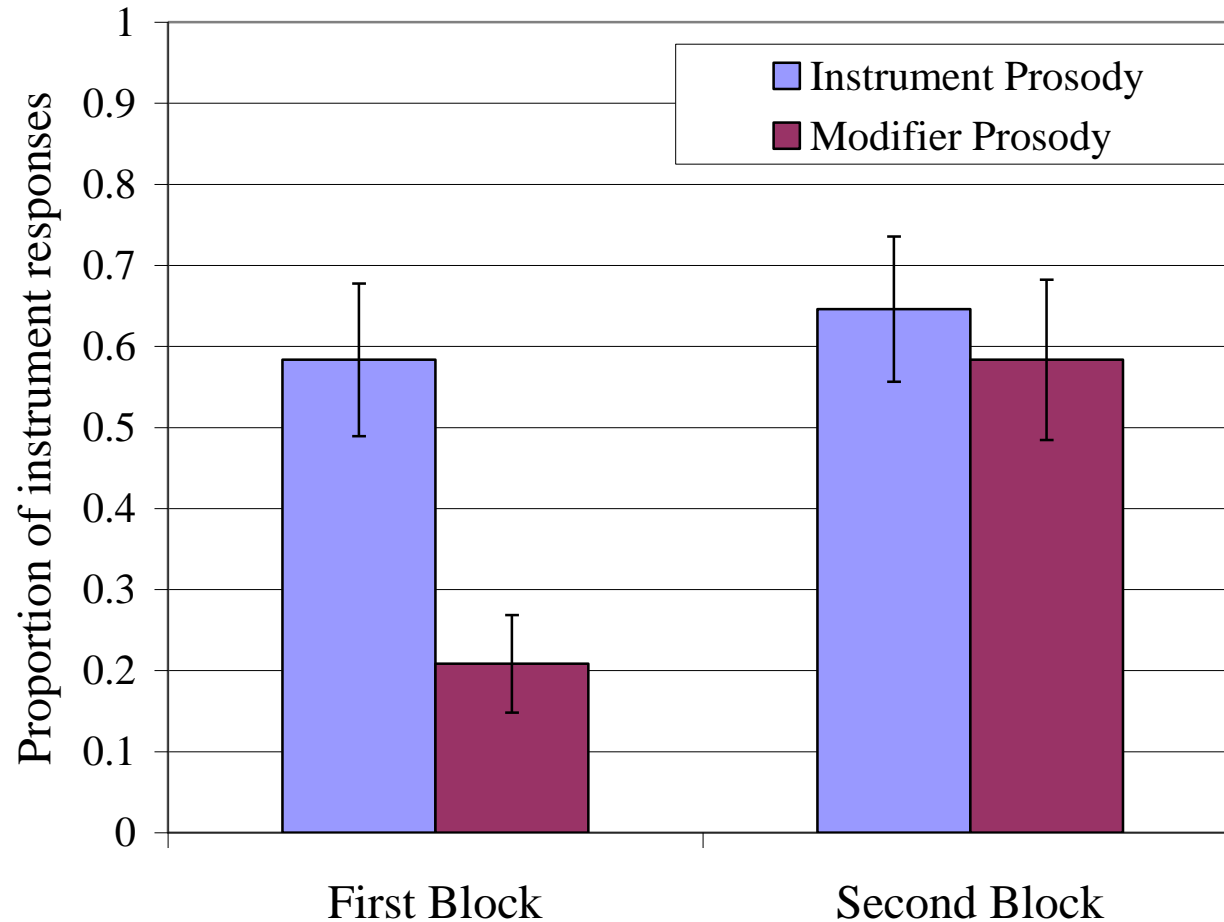
- Modifier Prosody

*You can feeeeel....
....the frog-with-the-feather*

- Blocked Design

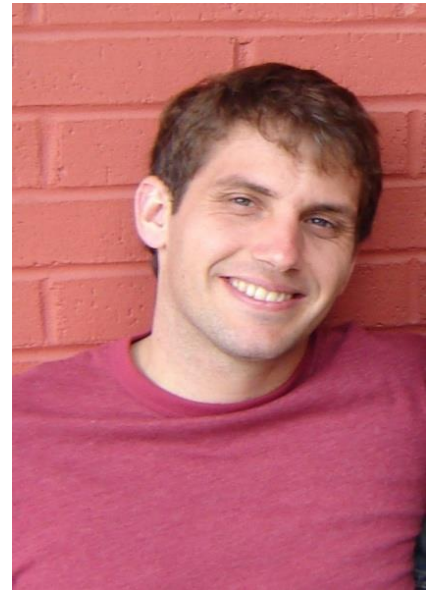


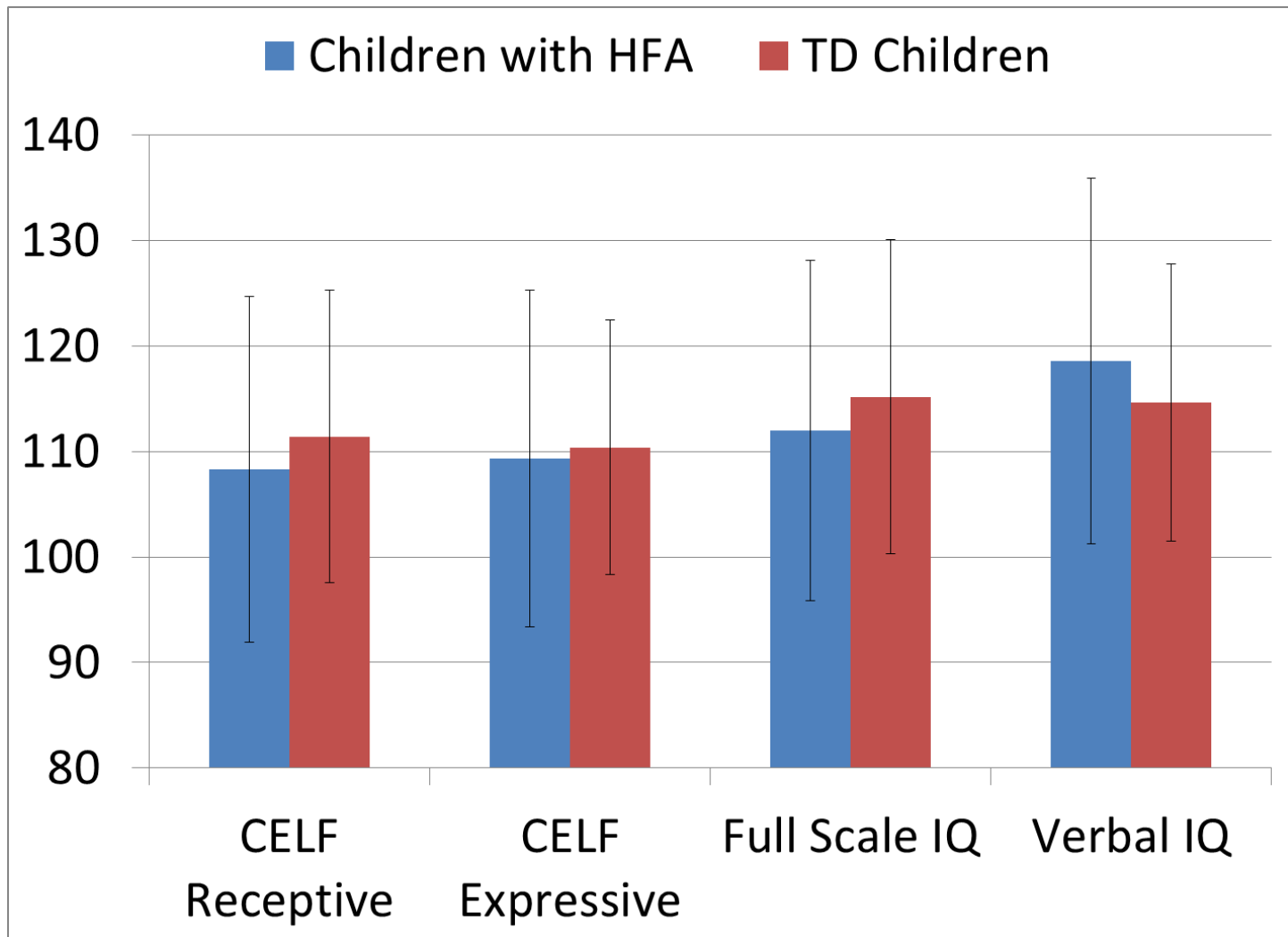
Preschoolers use prosody but only for the first block of trials



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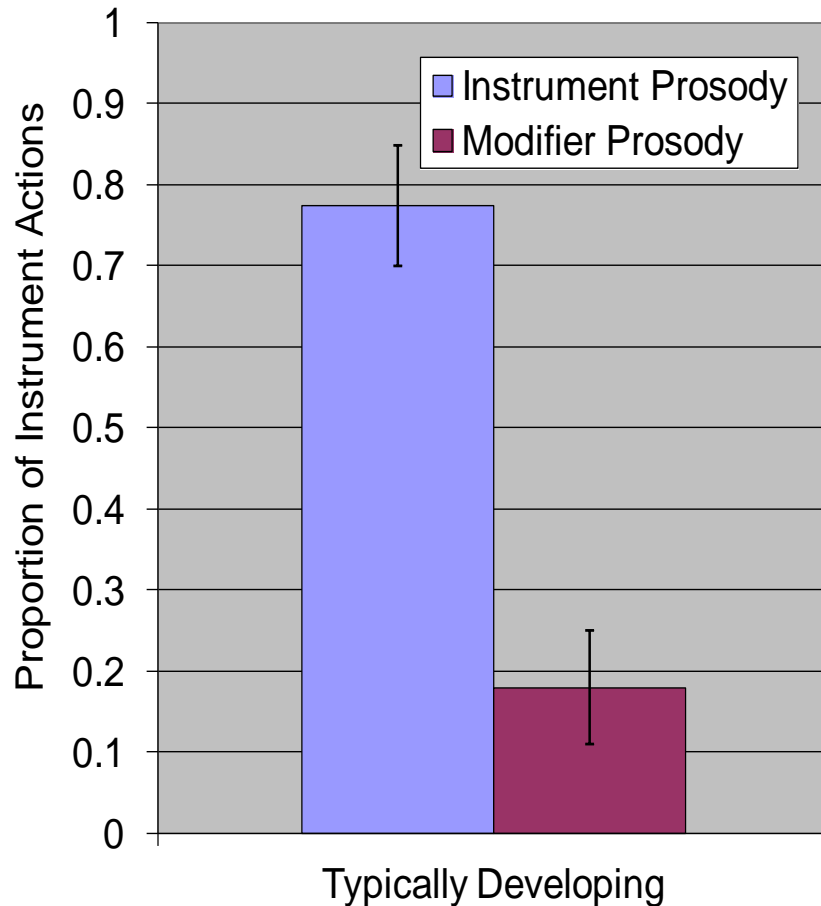




Prosody affects syntactic analysis (actions)

Typically-developing Children

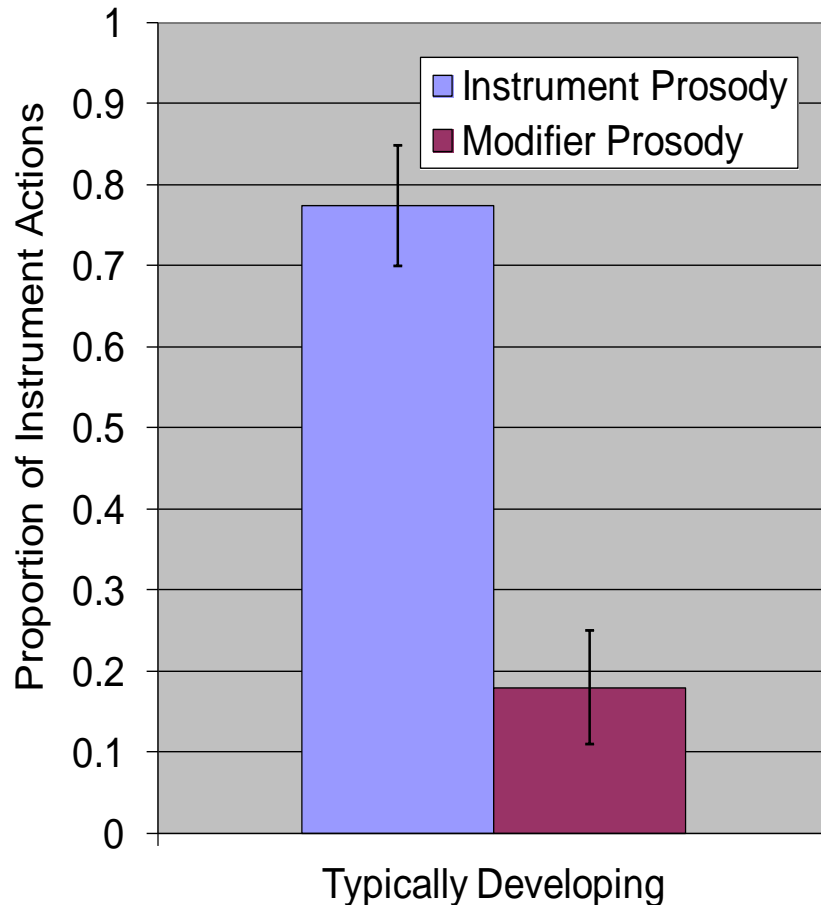
8-17 years (block 1)



Prosody affects syntactic analysis (actions)

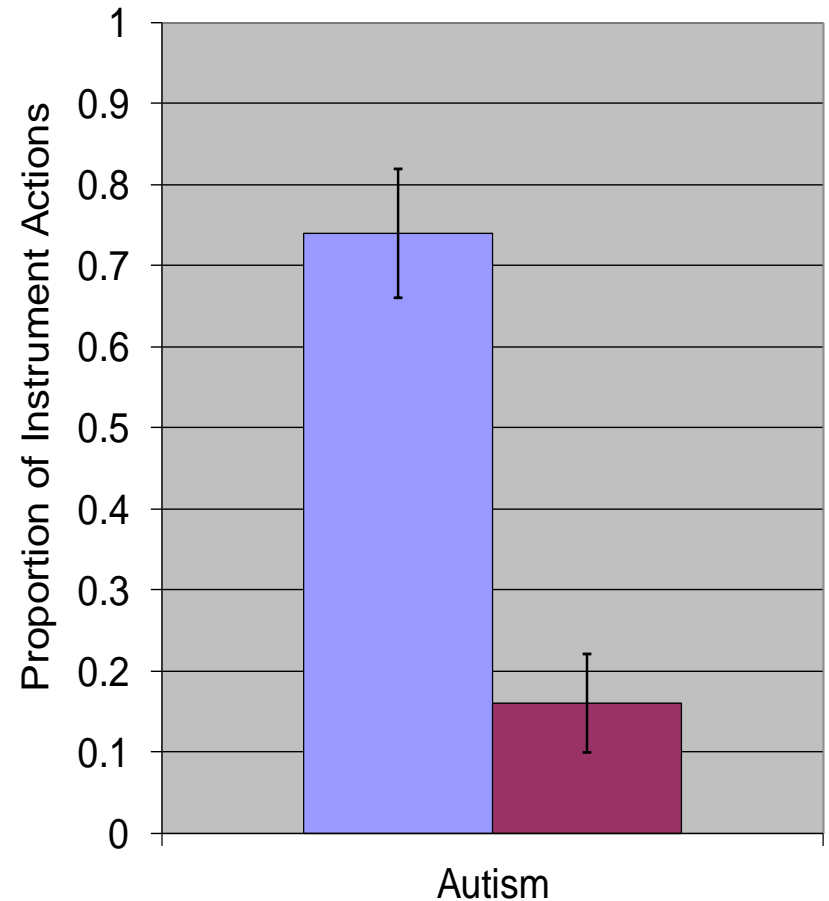
Typically-developing Children

8-17 years (block 1)



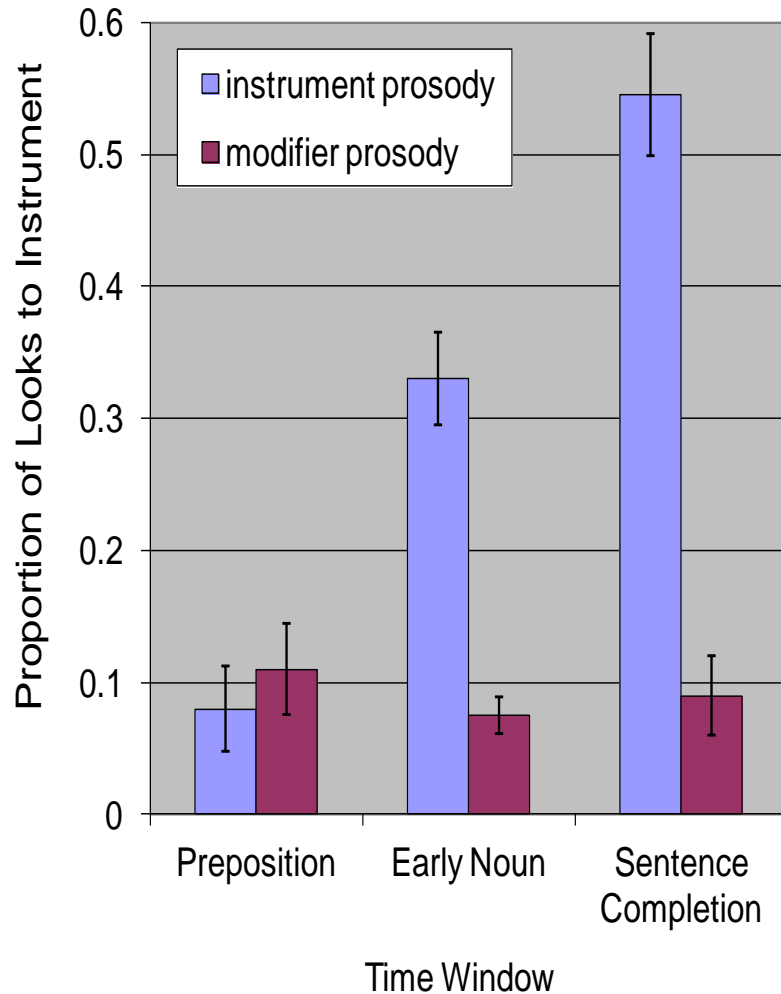
Children with Autism

8-17 years (block 1)



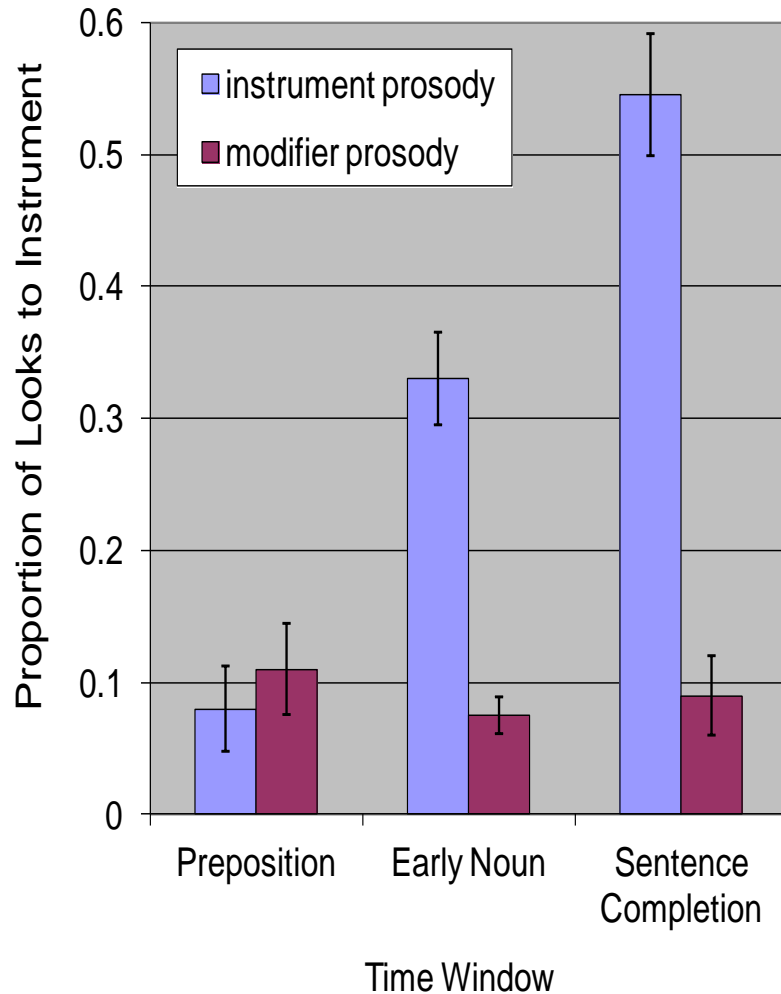
Eye movements demonstrate rapid use of prosody

Typically-Developing Children
8-17 years

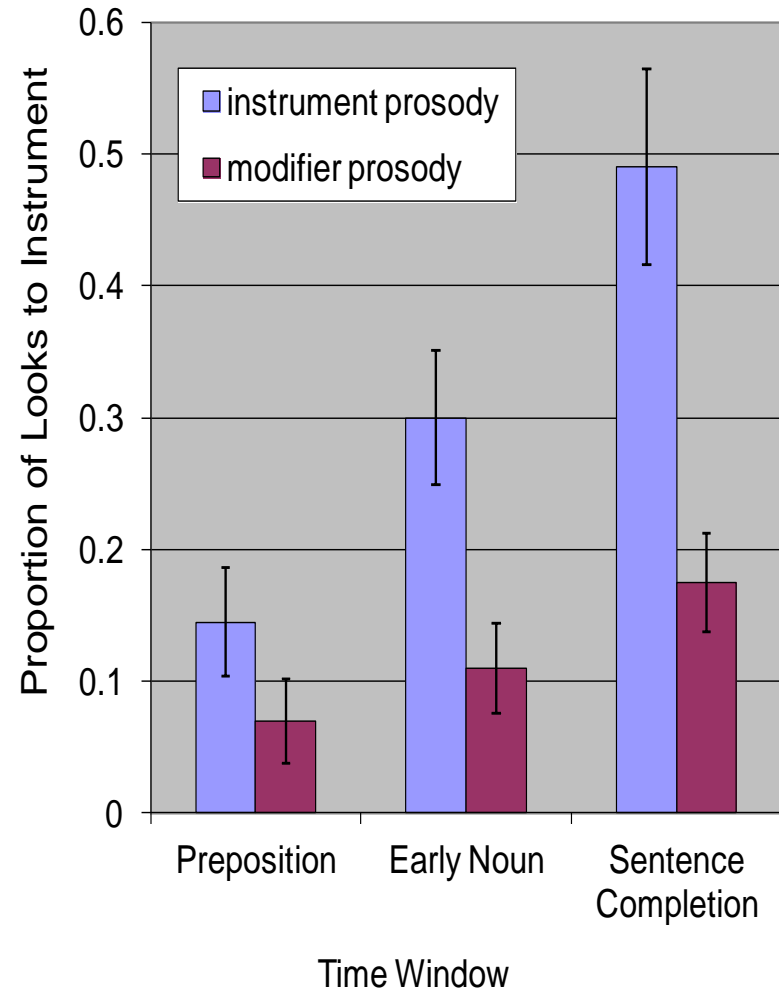


Eye movements demonstrate rapid use of prosody

Typically-Developing Children
8-17 years



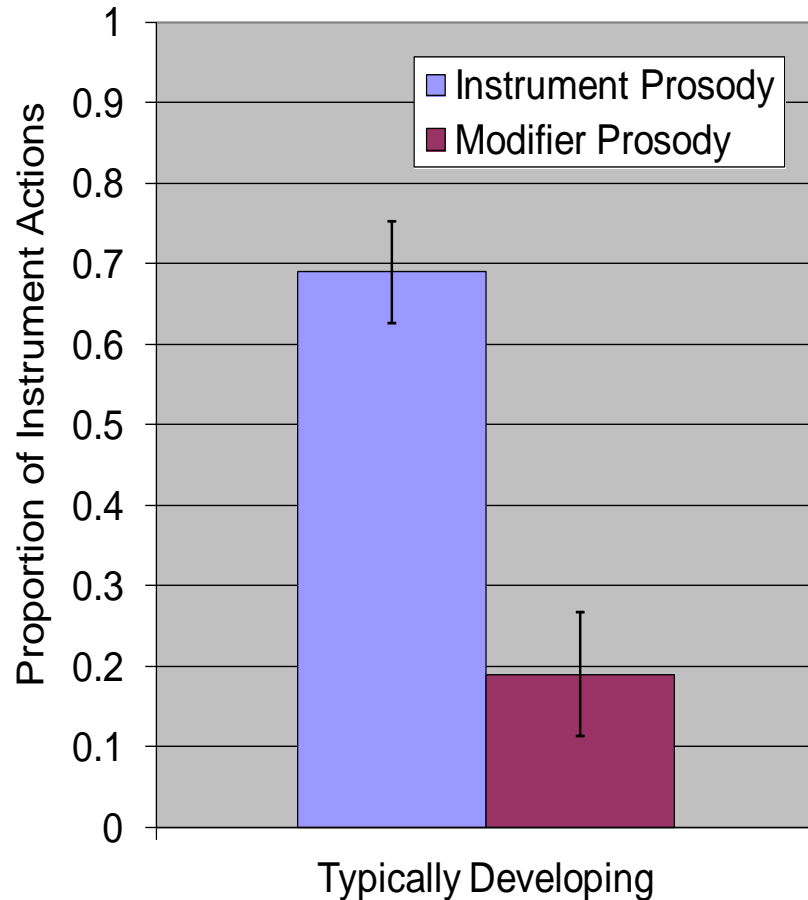
Children with Autism
8-17 years



Typically-developing children do not perseverate

Typically-developing Children

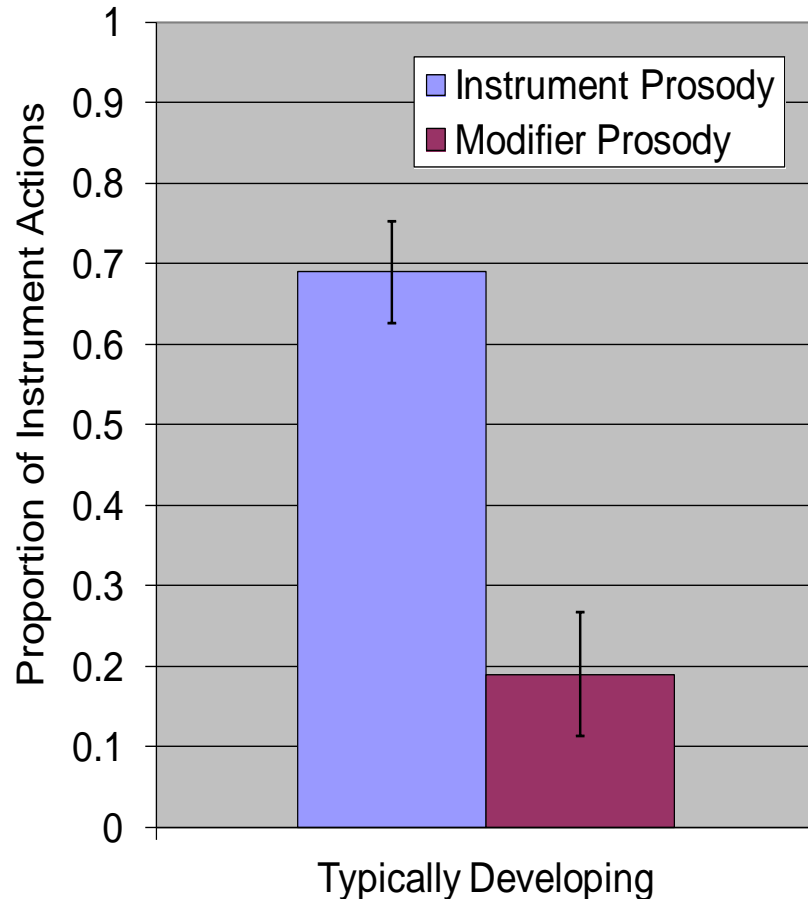
8-17 years (block 2)



Typically-developing children do not perseverate but children with ASD do (until 13)

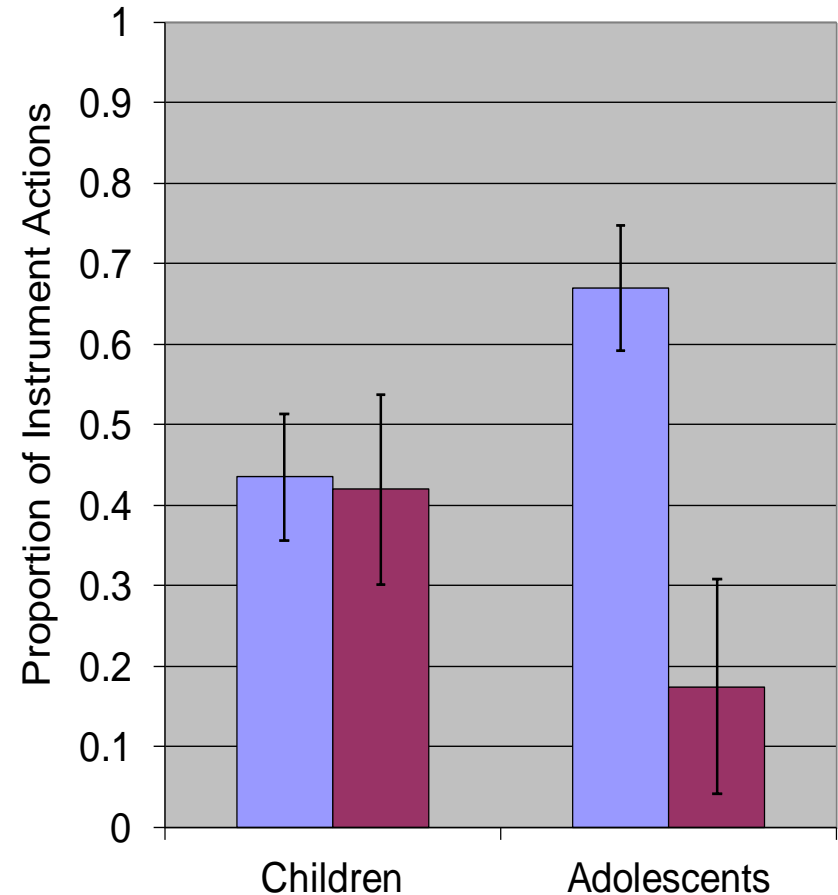
Typically-developing Children

8-17 years (block 2)



Children with Autism

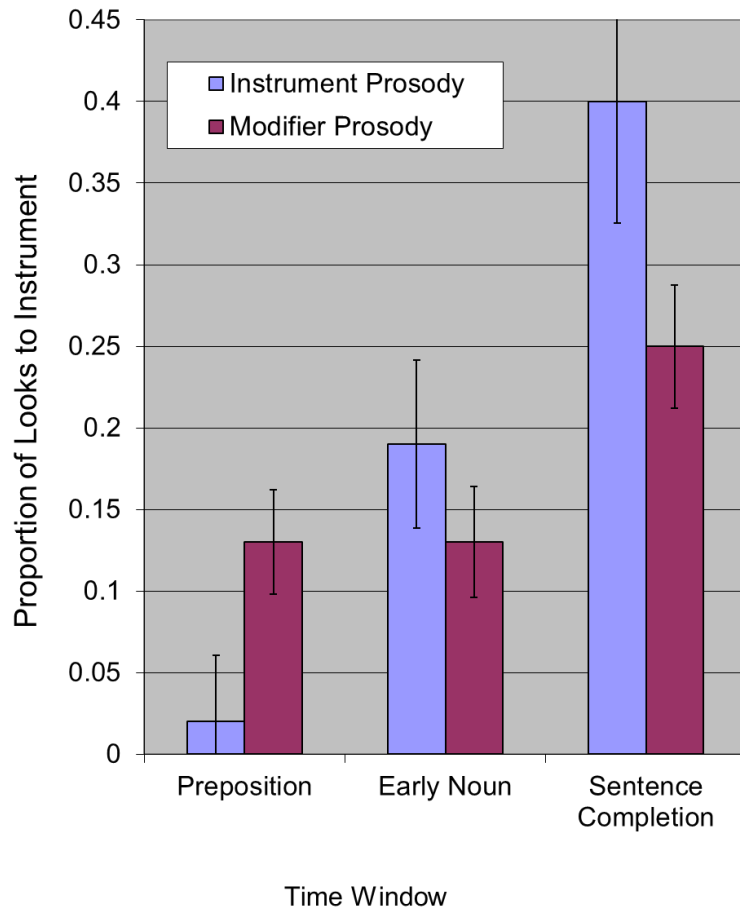
8-17 years (block 2)



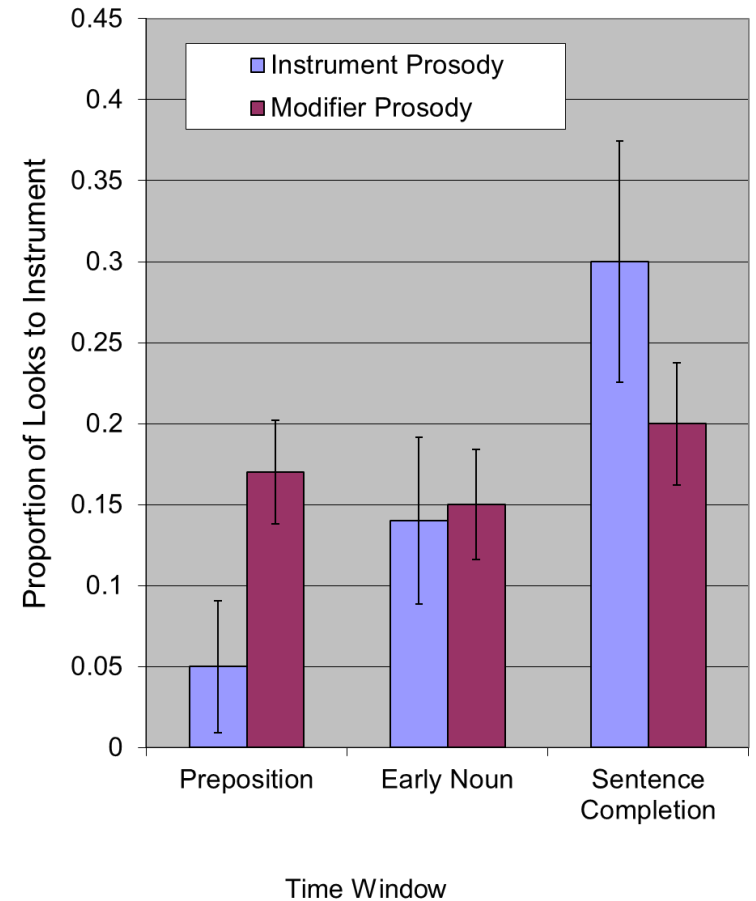
Both groups make the wrong prediction

Children with autism fail to revise

Typically-Developing Children
8-12 years



Children with Autism
8-12 years

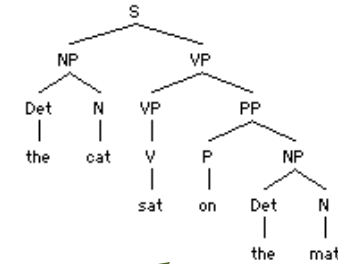




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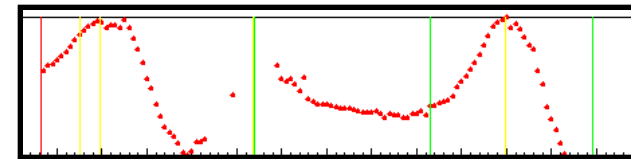
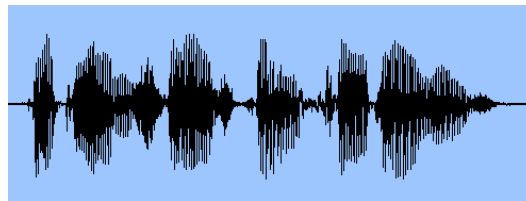
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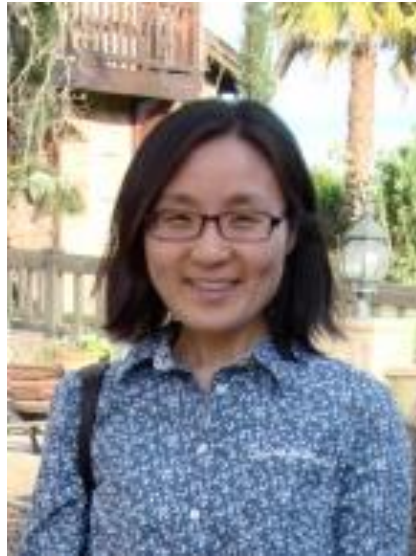


prosody

How do children with autism interpret pitch accents?



Tracy Brookhyser

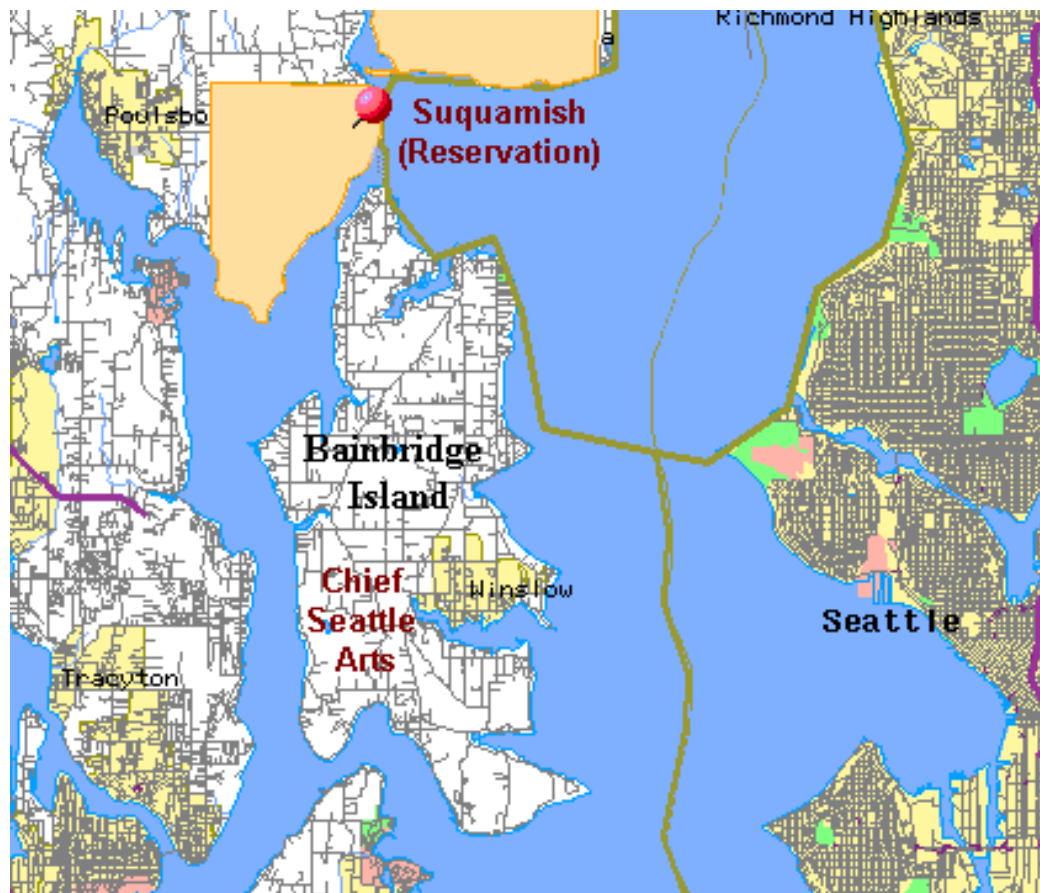


Eun Kyung Lee



Becky Nappa





A: How was your visit to Bainbridge?

B: OK.

My dad bought a BB gun for Oscar.

What should A say next?

A: How was your visit to Bainbridge?

B: OK.

My dad bought a BB gun for ***Oscar***.

But he's only eight!

Was his brother jealous?

A: How was your visit to Bainbridge?

B: OK.

My dad bought a ***BB gun*** for Oscar.

Why did he buy that?

What are you going to do with it?

A: How was your visit to Bainbridge?

B: OK.

My ****dad**** bought a BB gun for Oscar.

How is he doing?

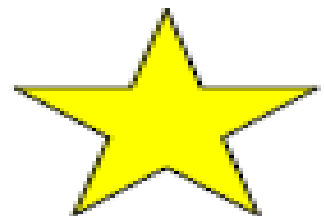
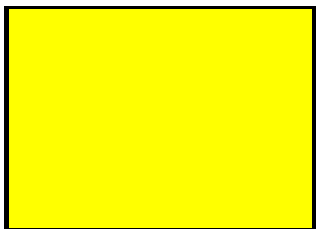
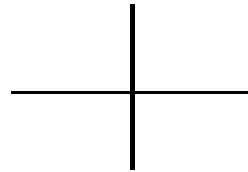
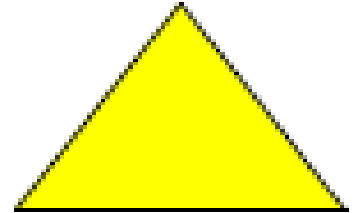
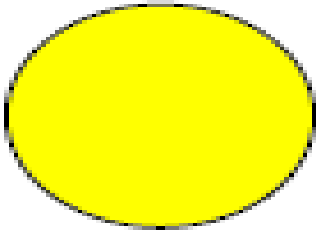
What did your mom say?

- Hypothesis 1: accent signal new referent
 - Put the candle on the square. Put the CANDY/candle....
 - **Click on the orange house. Now click on the RED ____
- Hypothesis 2: accent provides contrast set (Rooth, 1992)
 - Accent marks a variable
 - Replace variable with alternate values
 - To get set of alternatives under consideration

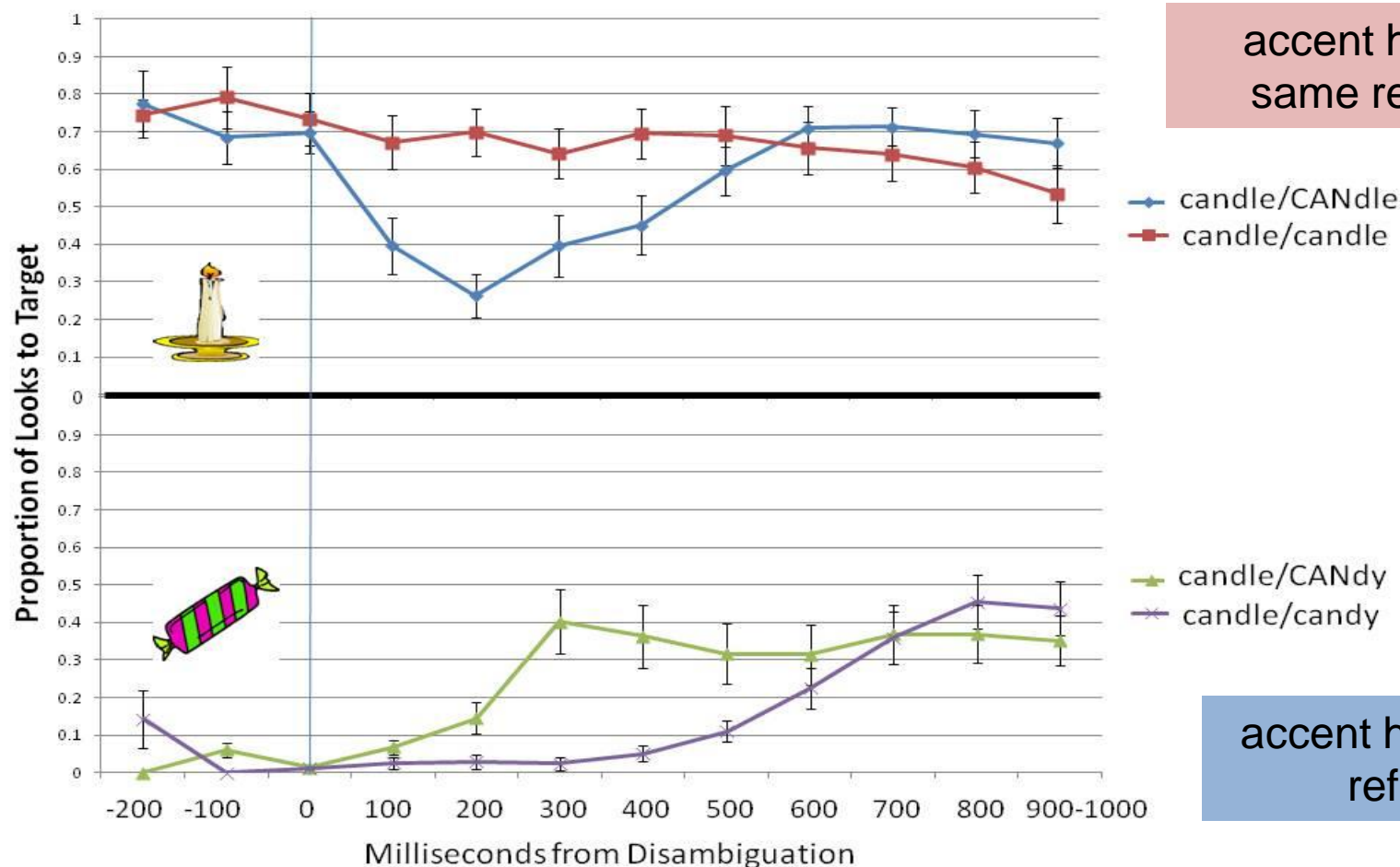
Study 2: prosody & discourse structure

- Two functions of pitch accents (stress)
 - Cue to novelty (Dahan et al., 2002)
 - Cue to contrast set (Ito & Speer, 2008)
- 24 children with autism (5 – 10 yrs)
 - ADOS confirmed diagnoses
 - TROG (syntax) scores above 80
 - Full scale and verbal IQ above 80 (KBIT)
- 24 typically developing controls
 - Matched on TROG scores and age

“Put the candle on the square. Now...”



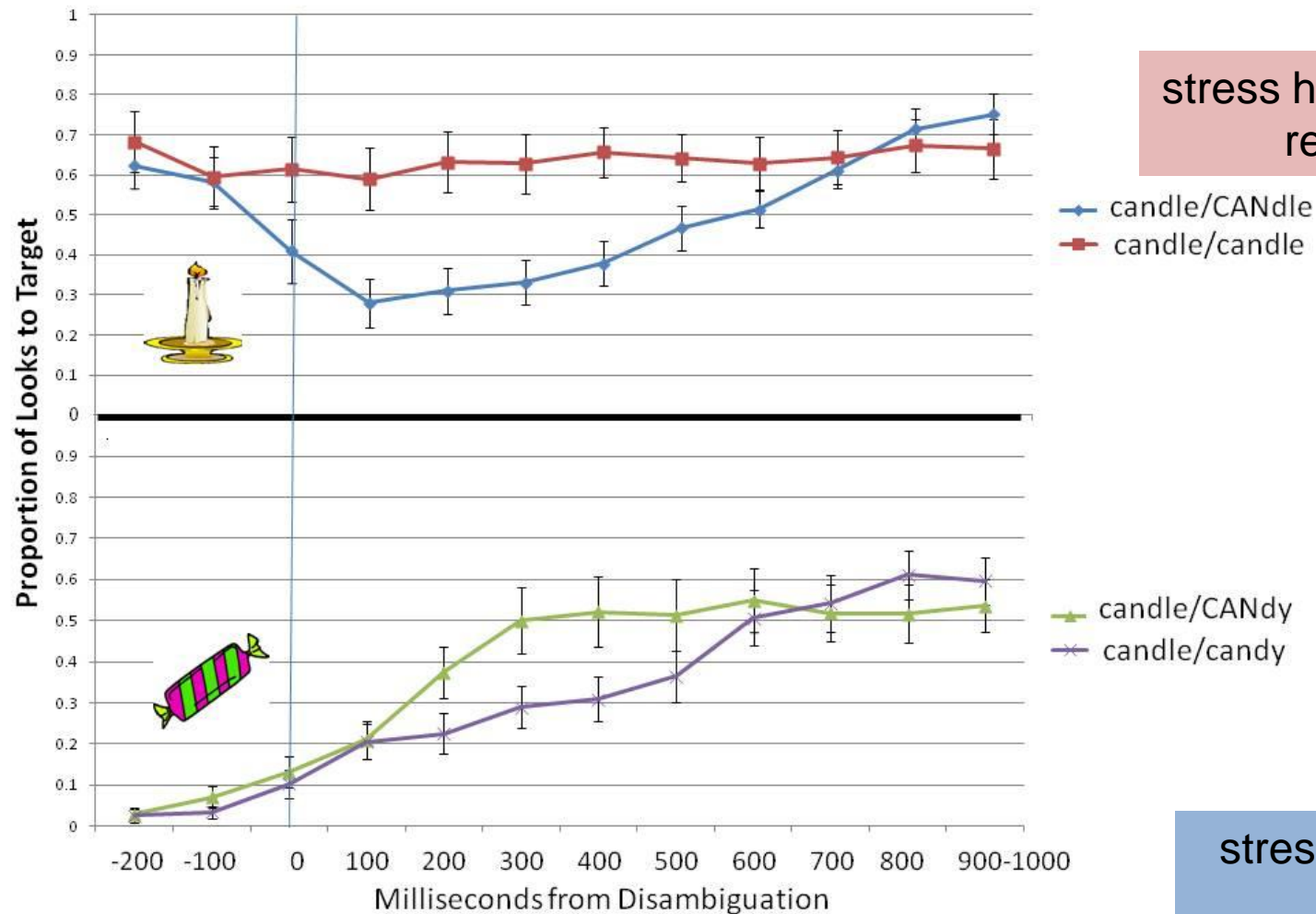
Typical kids use prosodic stress as cue to novelty



accent hinders
same referent

accent helps novel
referent

Kids with ASD do too

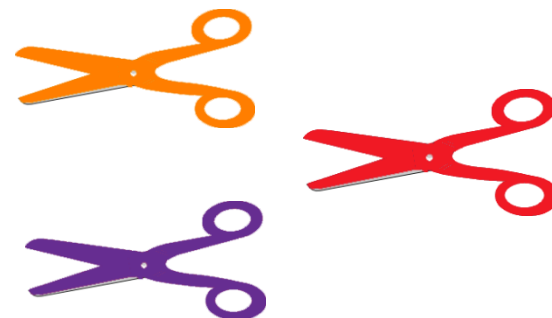
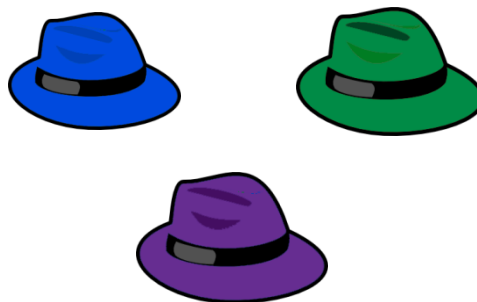
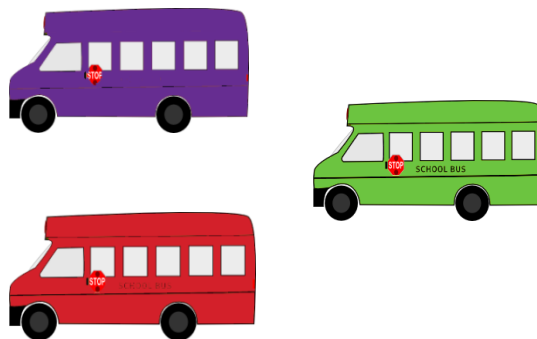
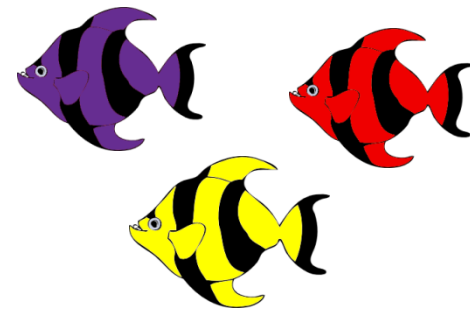
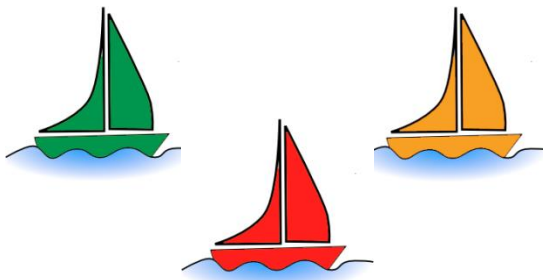


stress hinders same referent

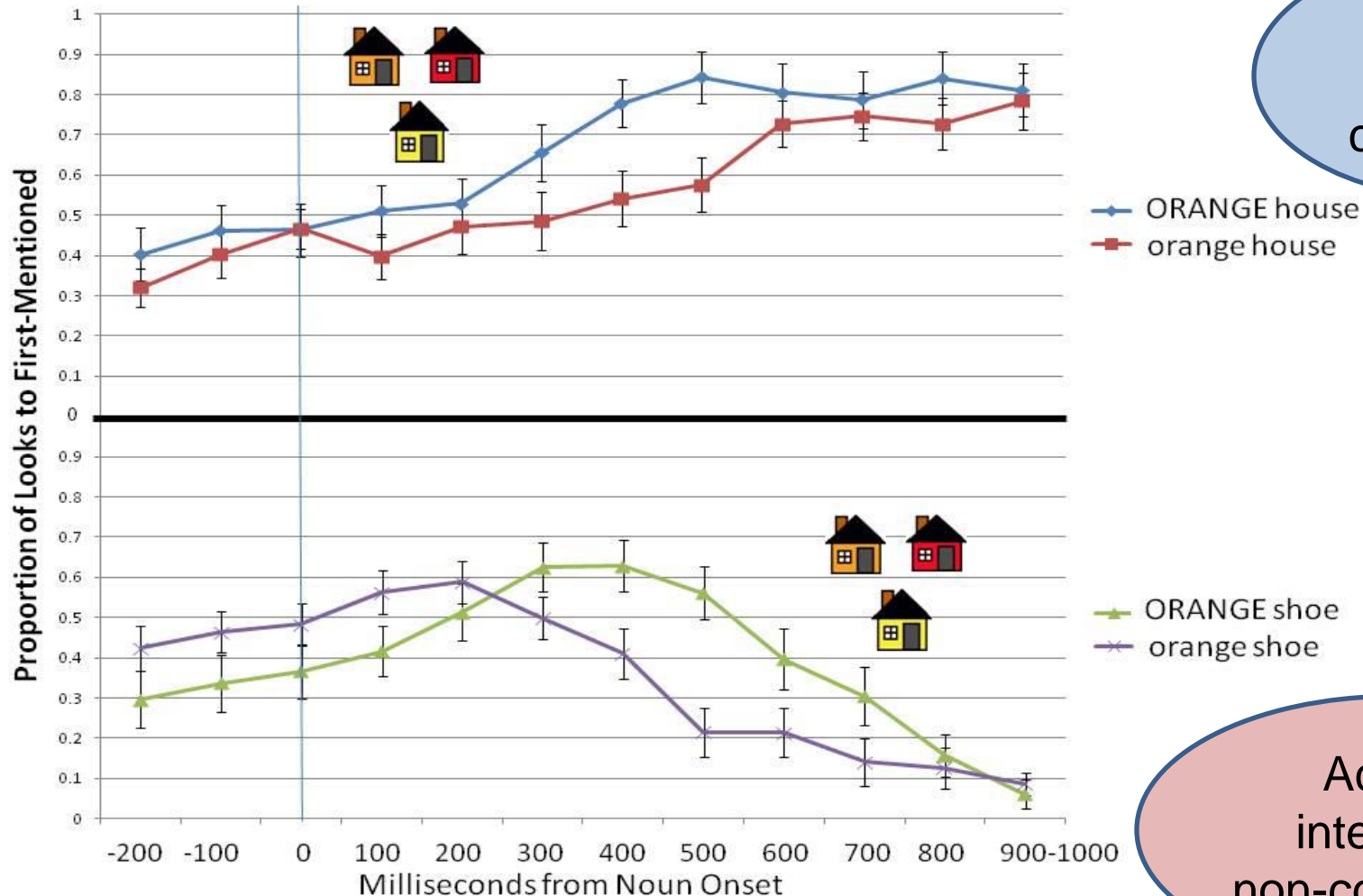
stress helps novel referent



“Click on the yellow house. Now...”



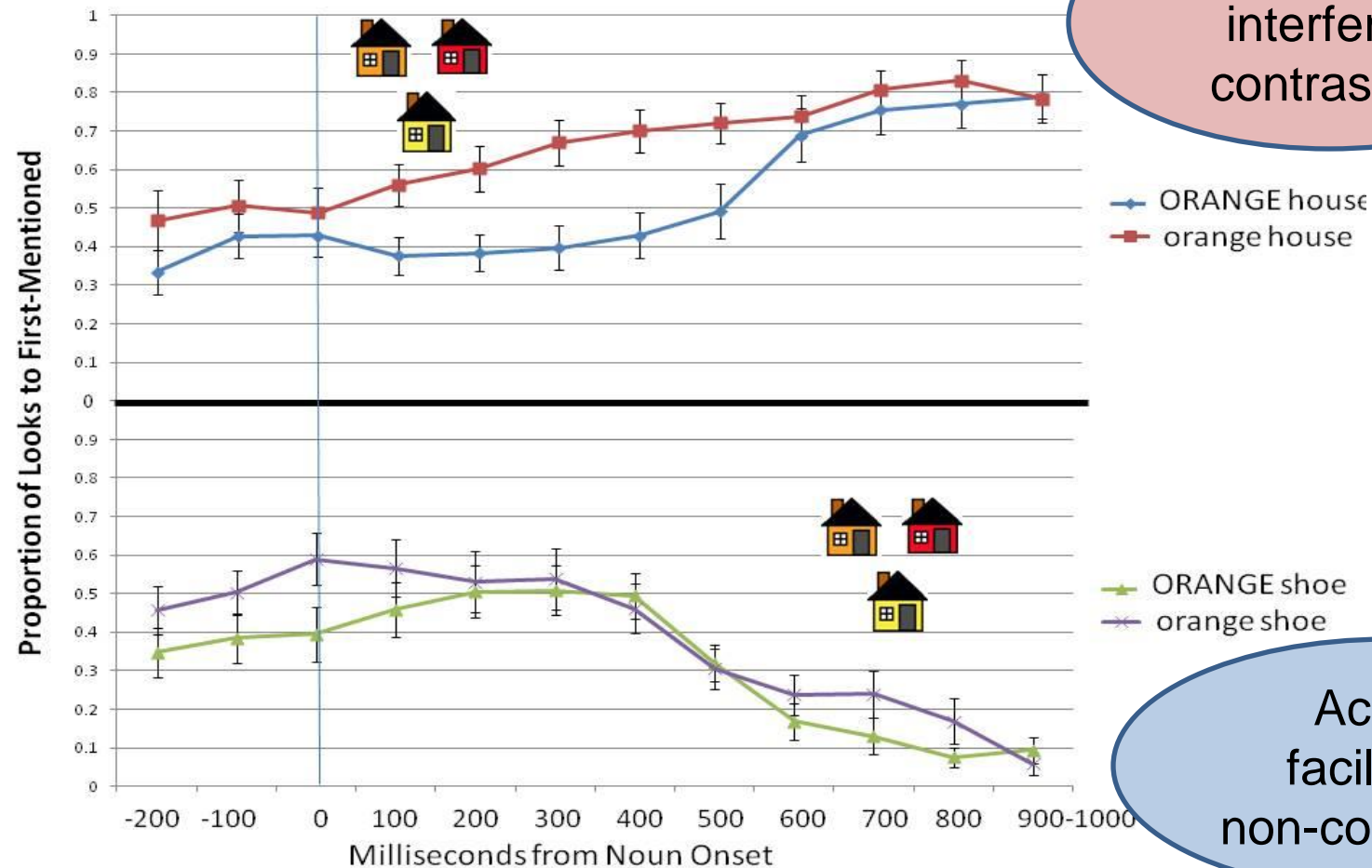
Typical kids use accent to identify contrast



Accent
facilitates
contrastive

Accent
interferes
non-contrastive

Kids with ASD have the opposite response!



Accent
interferes
contrastive

Accent
facilitates
non-contrastive

- Hypothesis 1: accent signal new referent

- Put the candle on the square. Put the CANDY/candle....
- **Click on the orange house. Now click on the RED ____



Kids with ASD

- Hypothesis 2: accent provides contrast set (Rooth, 1992)

- Accent marks a variable
- Replace variable with alternate values
- To get set of alternatives under consideration



Typical 6-10 yo

Prosody and ASD: Conclusions

- Prosodic deficit in highly verbal ASD is not global
 - depends on the function prosody is serving
- Intact sensitivity to prosodic cues to syntax
 - But inhibitory difficulties limit their utility
- Use of prosody for discourse structure is impaired
 - Pitch accent interpreted as signalling novelty
 - Not used to identify contrast set
- Autism is a developmental disorder
 - Nature of deficits changes over time

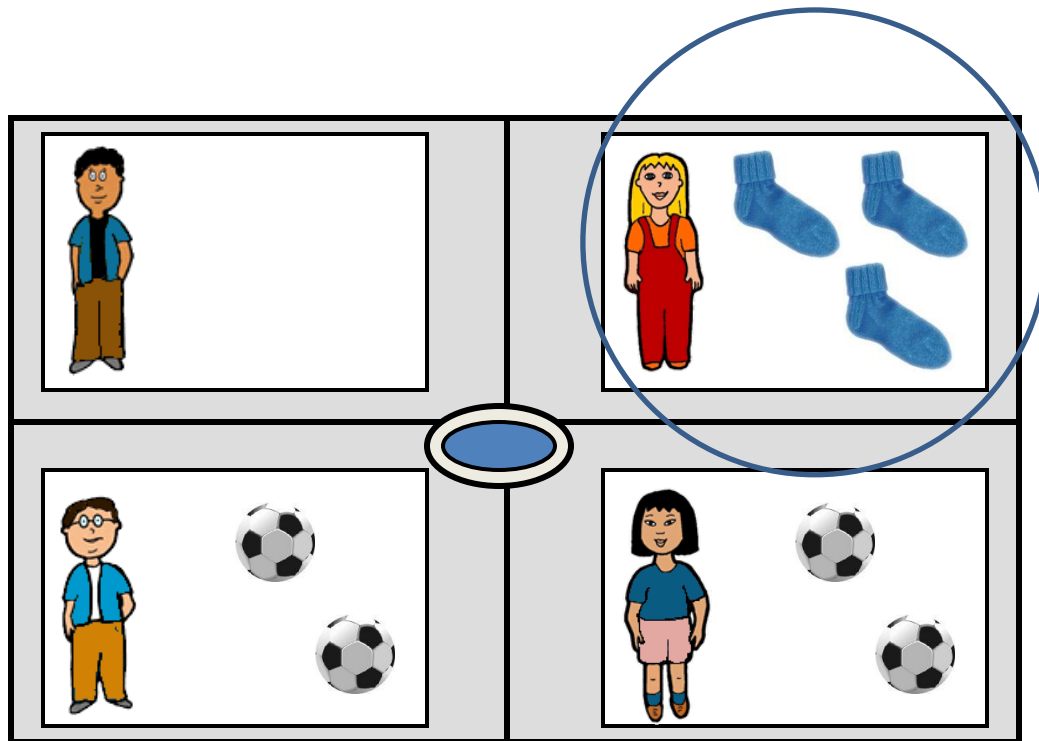
B. Scalar implicature in developmental disorders

My take on SOA for scalar implicature

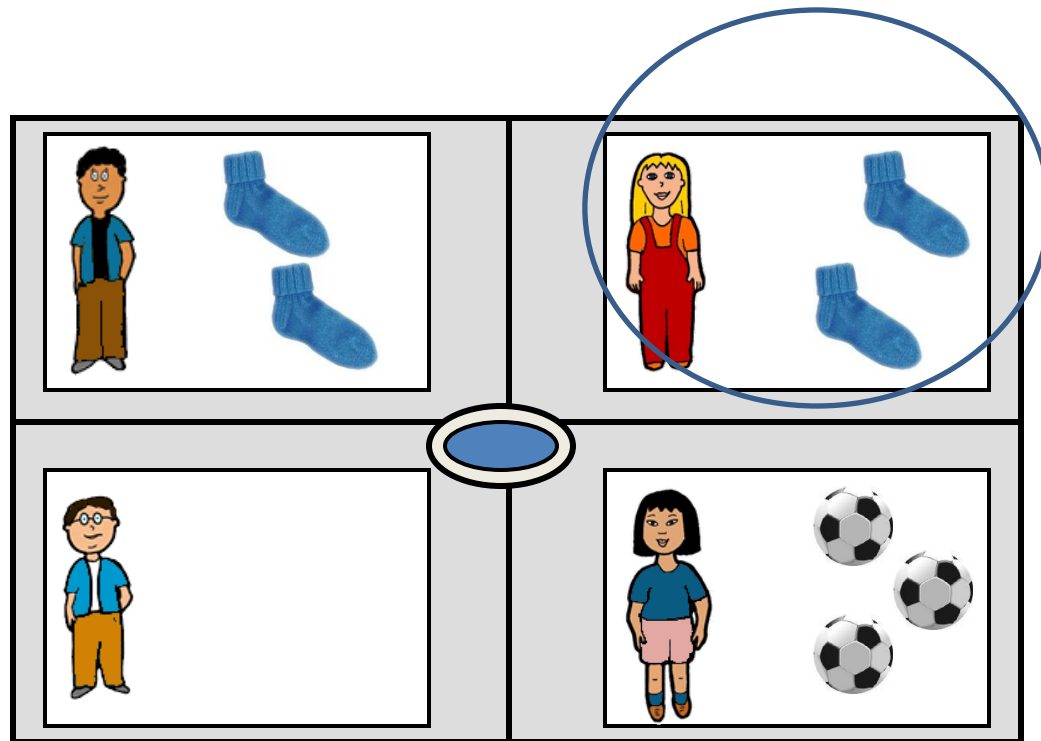
1. Implicature takes some work (bottom up)
2. But the work can be done ahead of time
 - When the conceptual encoding for each message is unambiguous
 - Listener as speaker
3. Thus SI proficiency develops gradually as children become more effective processors
4. And SI breaks down with language skills
 - Consistent with a distinction btw grammatical/social inferences or explicatures/implicatures?

Huang & Snedeker (2009)

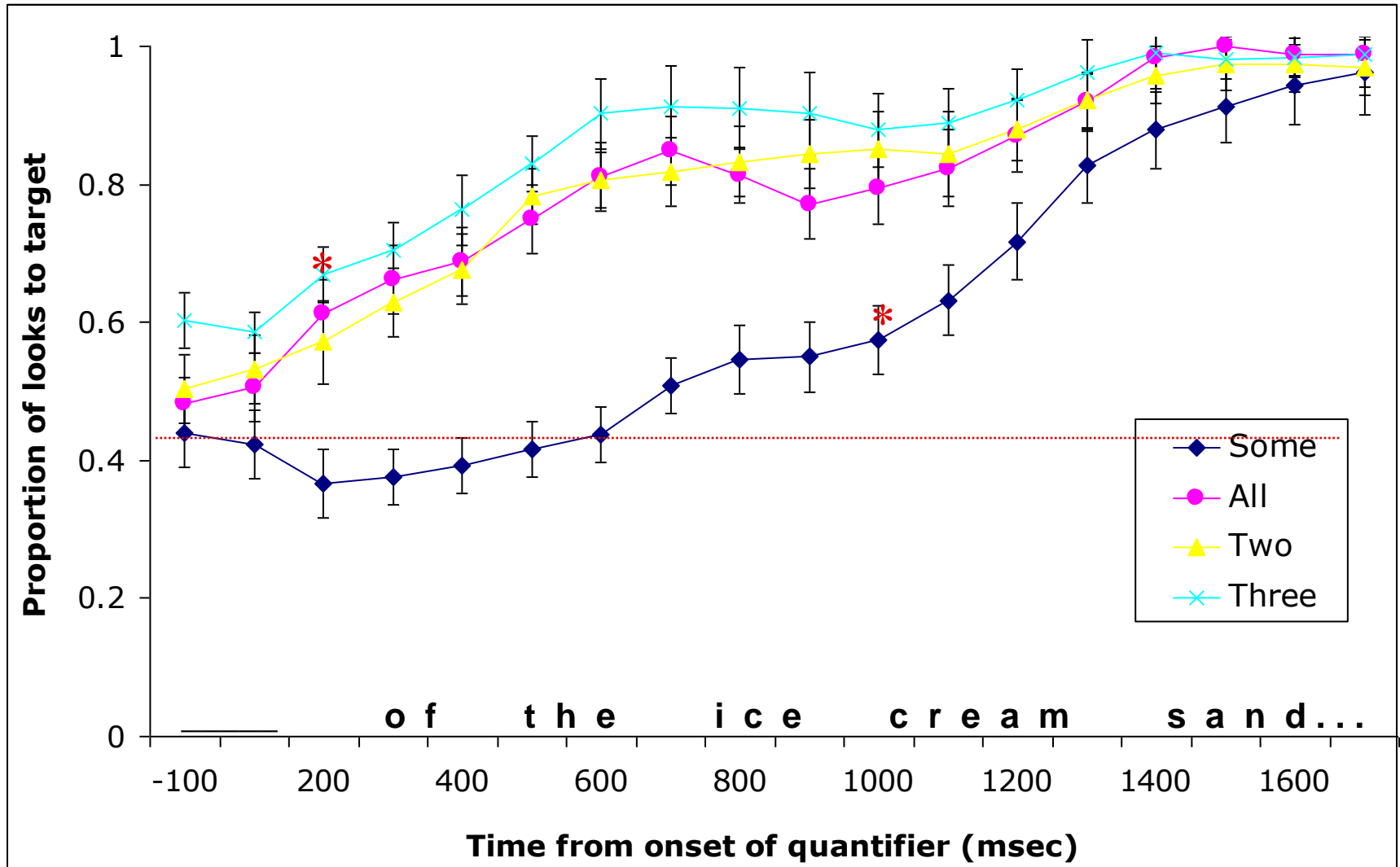
“Point to the girl that has all/three of the socks.”



“Point to the girl that has some/two of the socks.”

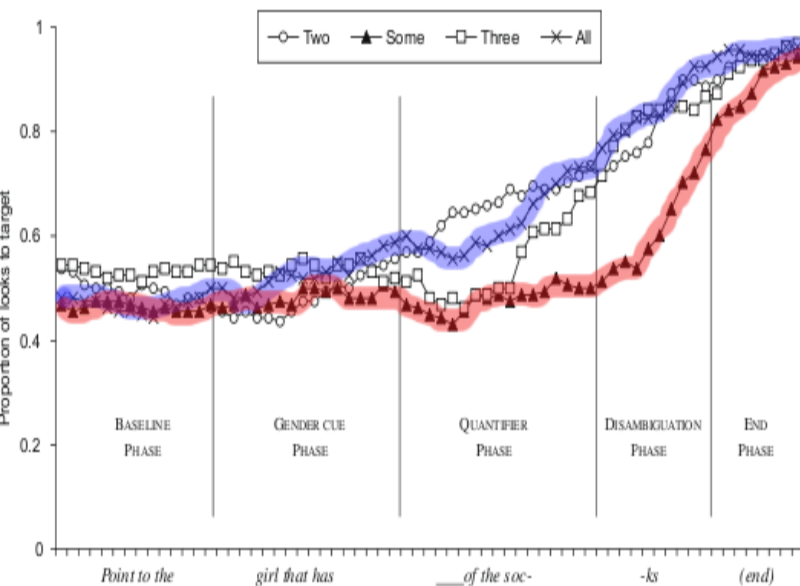


Delay in interpretation for “some” but not “two”



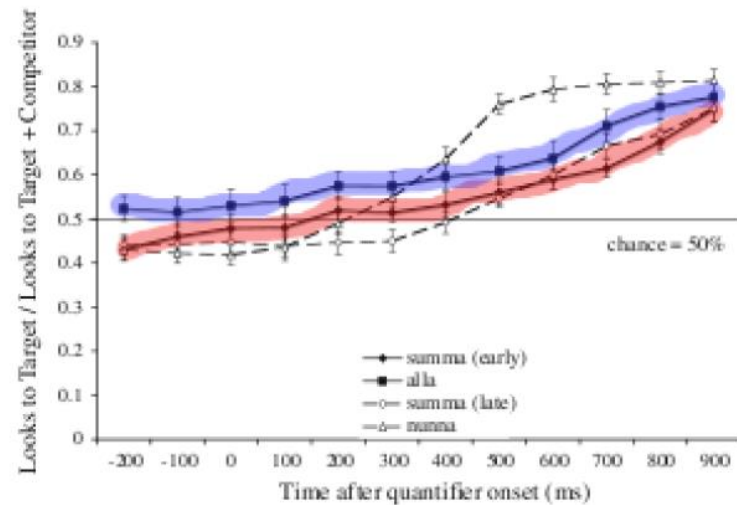
Divergent Findings in Visual World Paradigm

Delayed Upper Bound for “Some”



Huang & Snedeker (2009)

Instant Upper Bound for “Some”

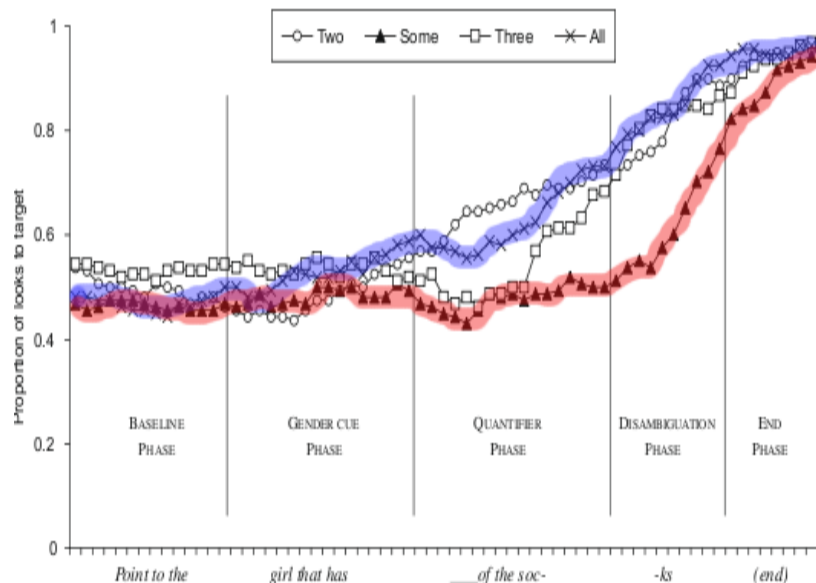


Grodner et al. (2010)

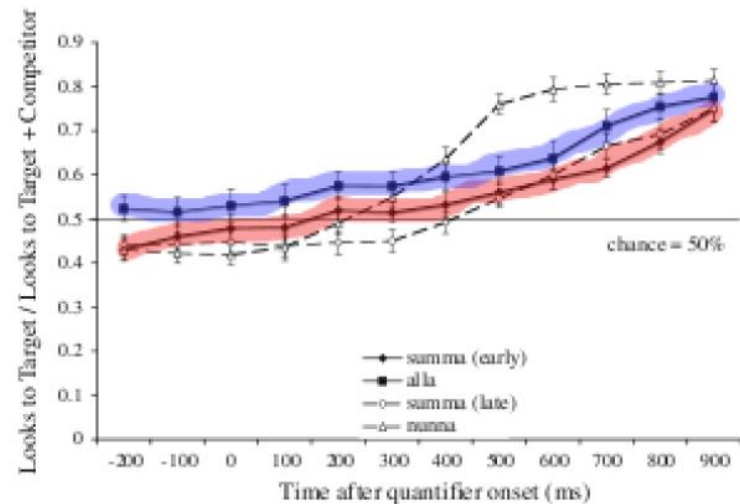
Methodological differences

- Pronunciation “summa” vs. some of
- Embedded in stories vs. not
- Length of experiment
- **Number trials** (Huang, Hahn & Snedeker; Degen & Tanenhaus)

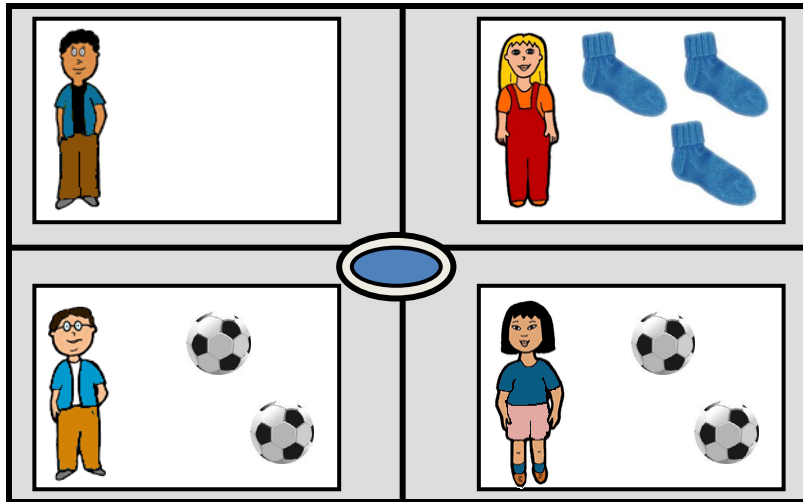
Huang & Snedeker (2009)



Grodner et al. (2010)



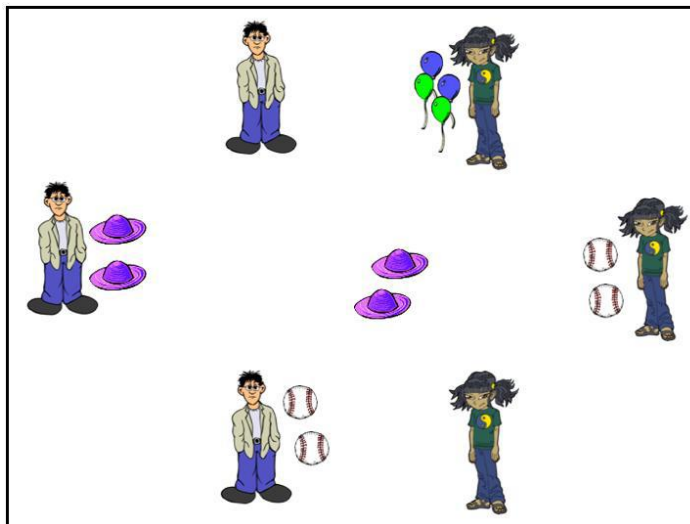
Comparison of studies



Dual Encoding:

The girl with some of the soccer balls
The girl with two of the soccer balls.

SI delayed



Single Encoding:

The girl with some of the balls

Immediate SI

Robust generalization across experiments

Red: slow SI, fast semantic; Green: both fast

Dual Encoding



- H&S, 2009
- H&S, 2011
- Panizza, Huang, Chierchia & Snedeker (2009)
- Huang, Hahn & Snedeker
- Degen & Tanenhaus
- Hartshorne et al

Single Encoding

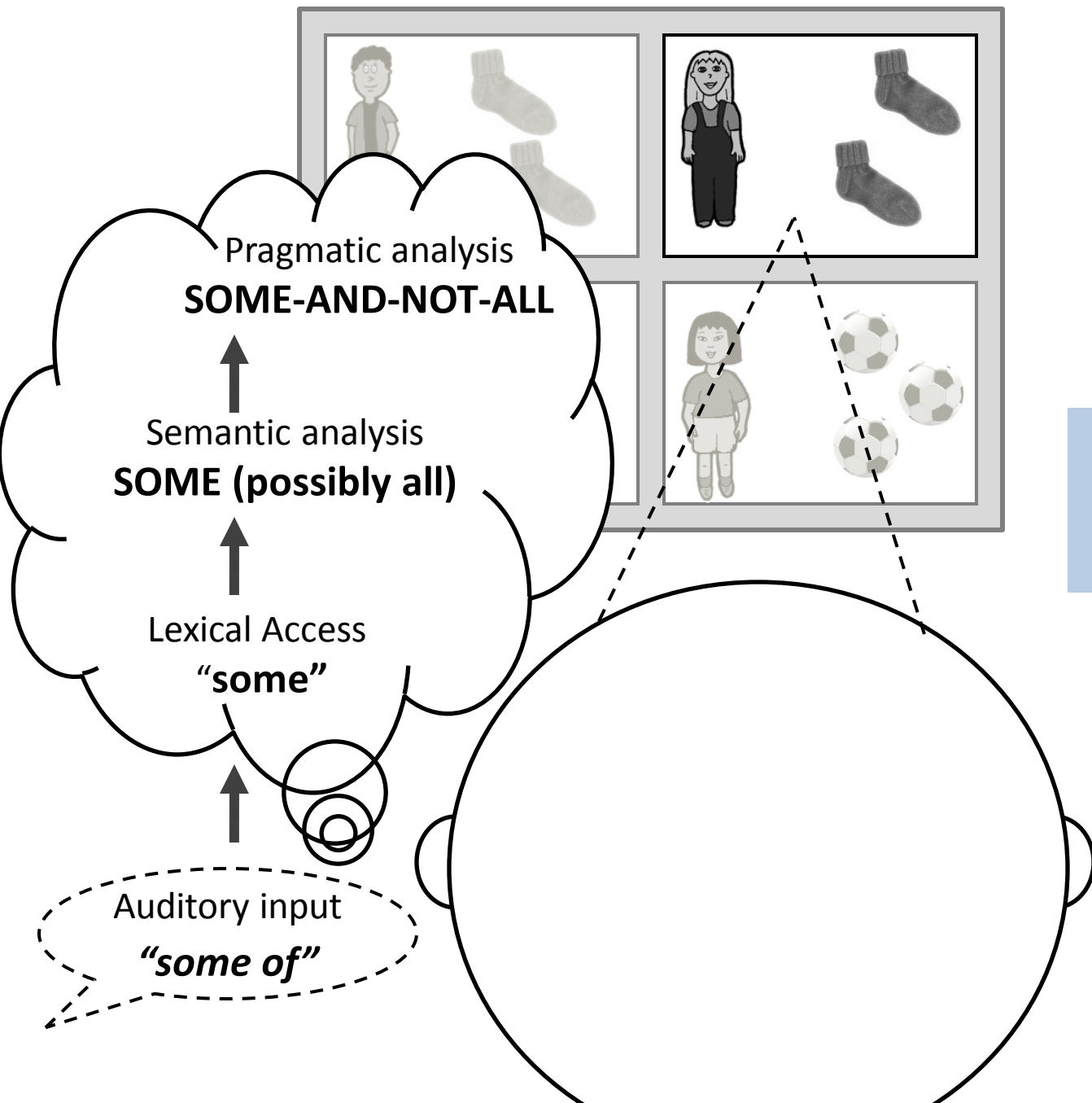
- Grodner et al., 2010
- Breheny, Ferguson & Katsos, (2012)
- Breheny, Ferguson & Katsos (2013)
- Huang, Hahn & Snedeker
- Degen & Tanenhaus
- Hartshorne et al.
- Huang (*most, start, pc*)

Two ways to calculate scalar implicatures

Bottom-up

- Hear “some”
- Retrieve its meaning
- Activate stronger alternative (*all*)  Dependent on context!
- Construct enriched meaning 
- Evaluate / link to context

Remember, this is incremental and interactive
(not “2-stage”)

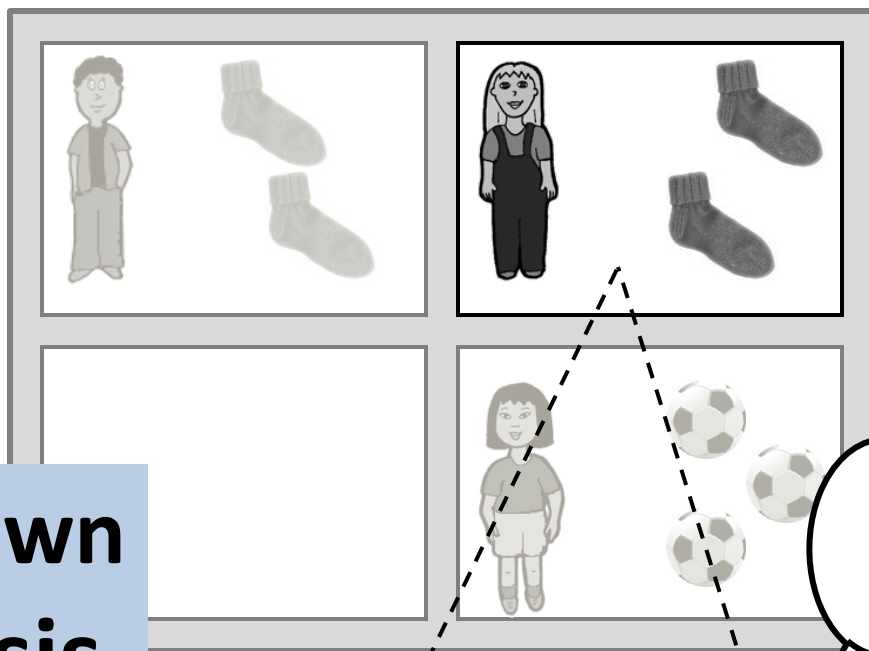


Two ways to calculate scalar implicatures

Top-down

- Listener sees display (knows the situation)
- Encodes a “message level” representation of possible referents (GIRL + SUBSET OF X’S)
- Begins to link to lower levels of representation (semantic, maybe even lexical)

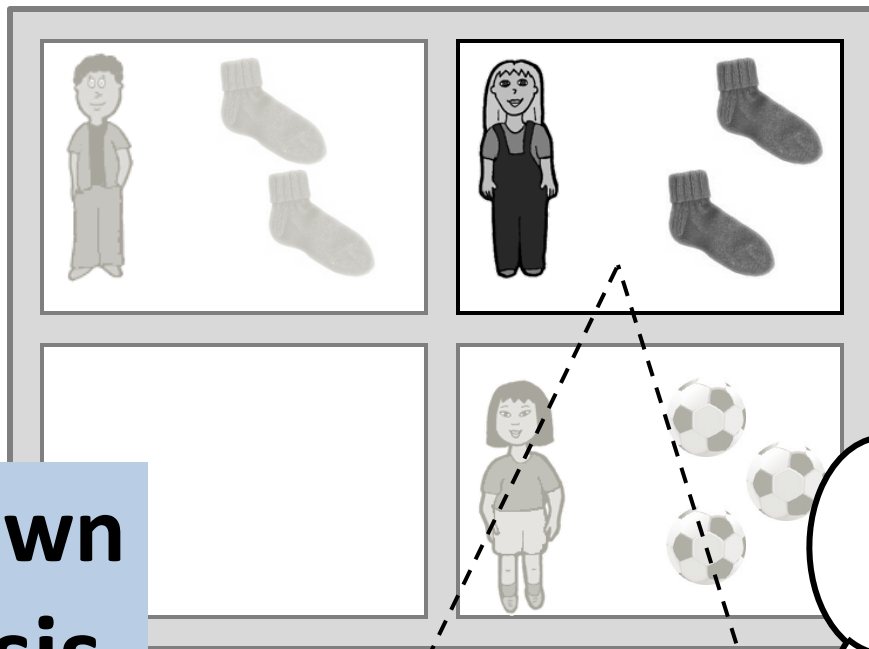
**Top-down
analysis**



Visual input
SUBSET

Pragmatic analysis
SOME-AND-NOT-ALL

**Top-down
analysis**



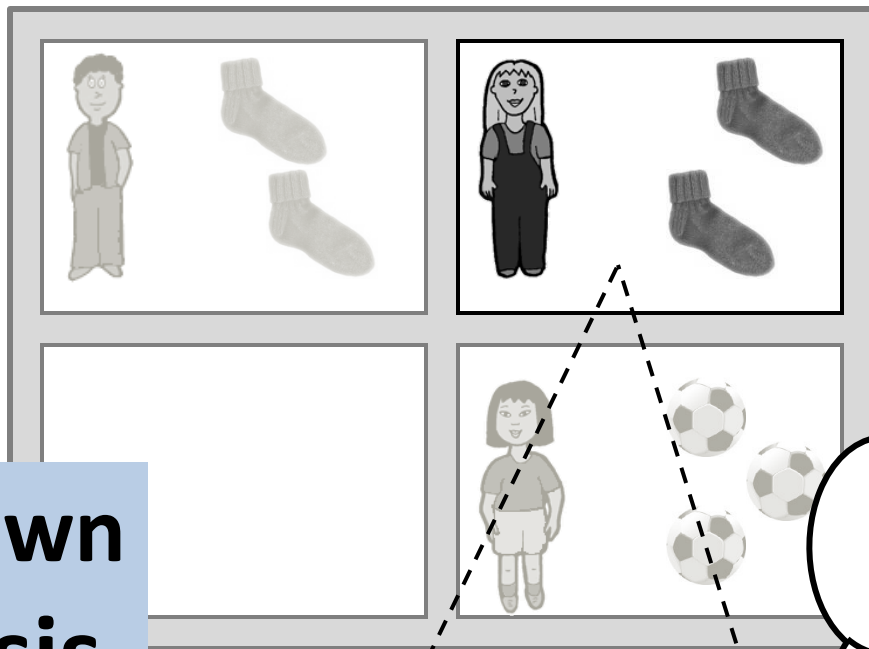
Visual input
SUBSET

Pragmatic analysis
SOME-AND-NOT-ALL

Semantic Analysis
SOME

Lexical access
"some"

Top-down analysis



Visual input
SUBSET

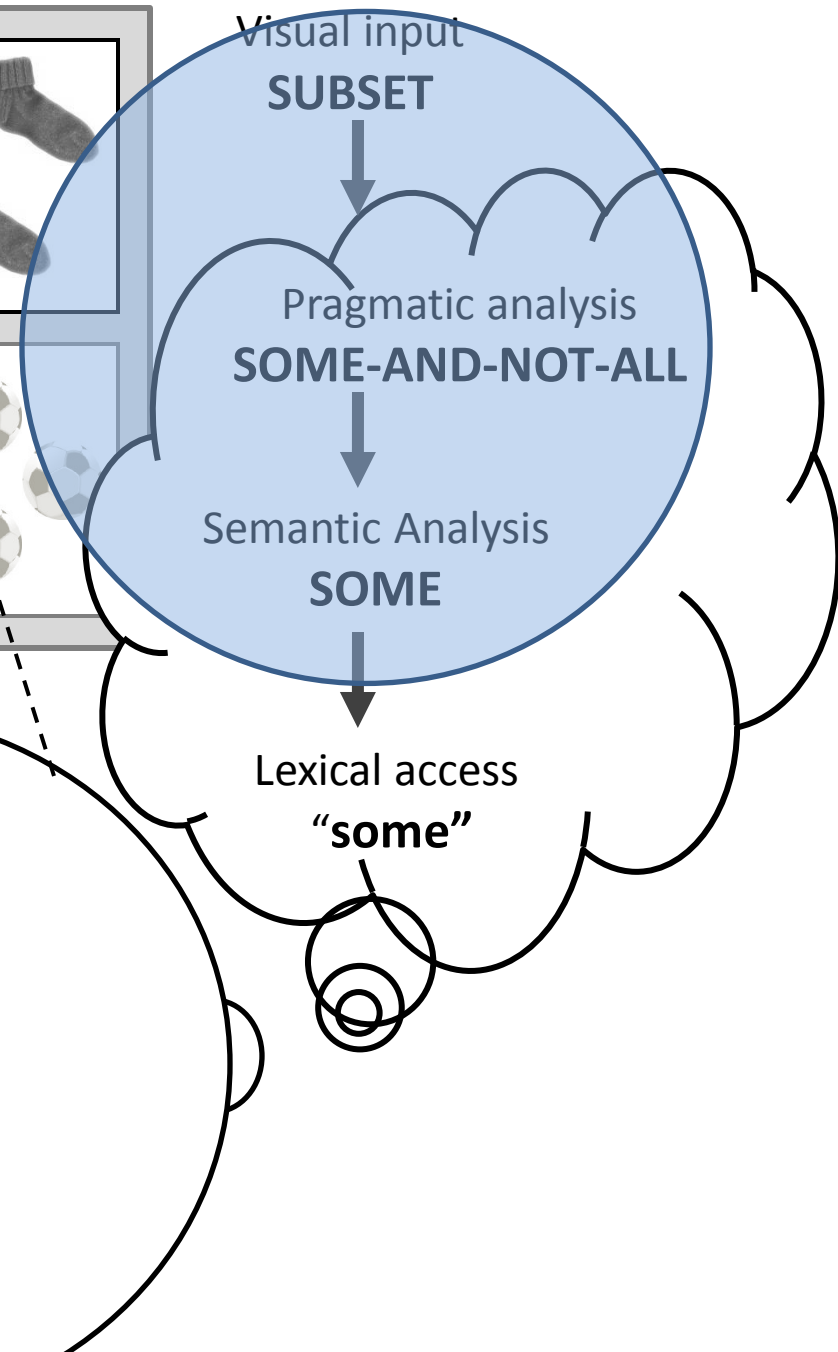
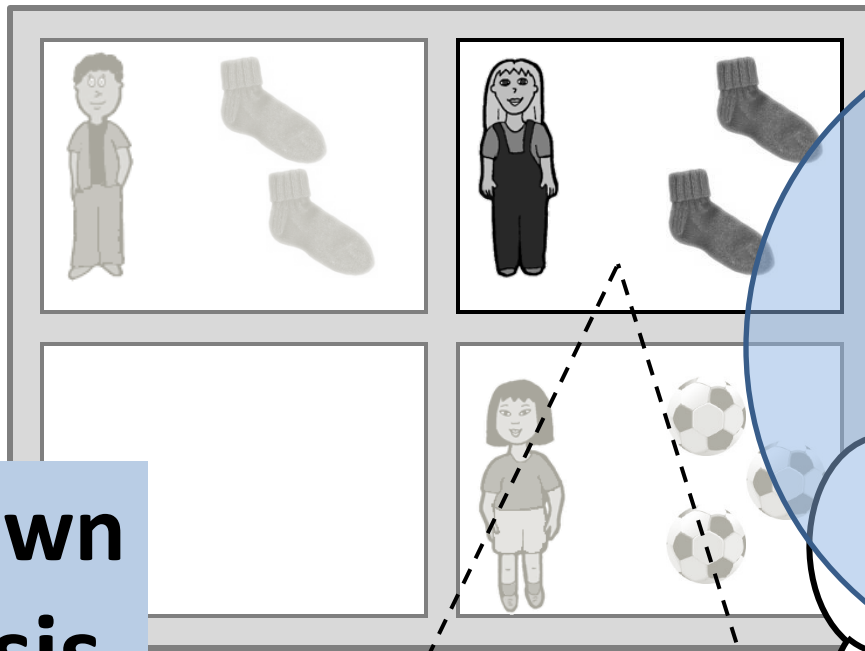
Pragmatic analysis
SOME-AND-NOT-ALL

Semantic Analysis
SOME

Lexical access
"some"

Auditory input
"some of"

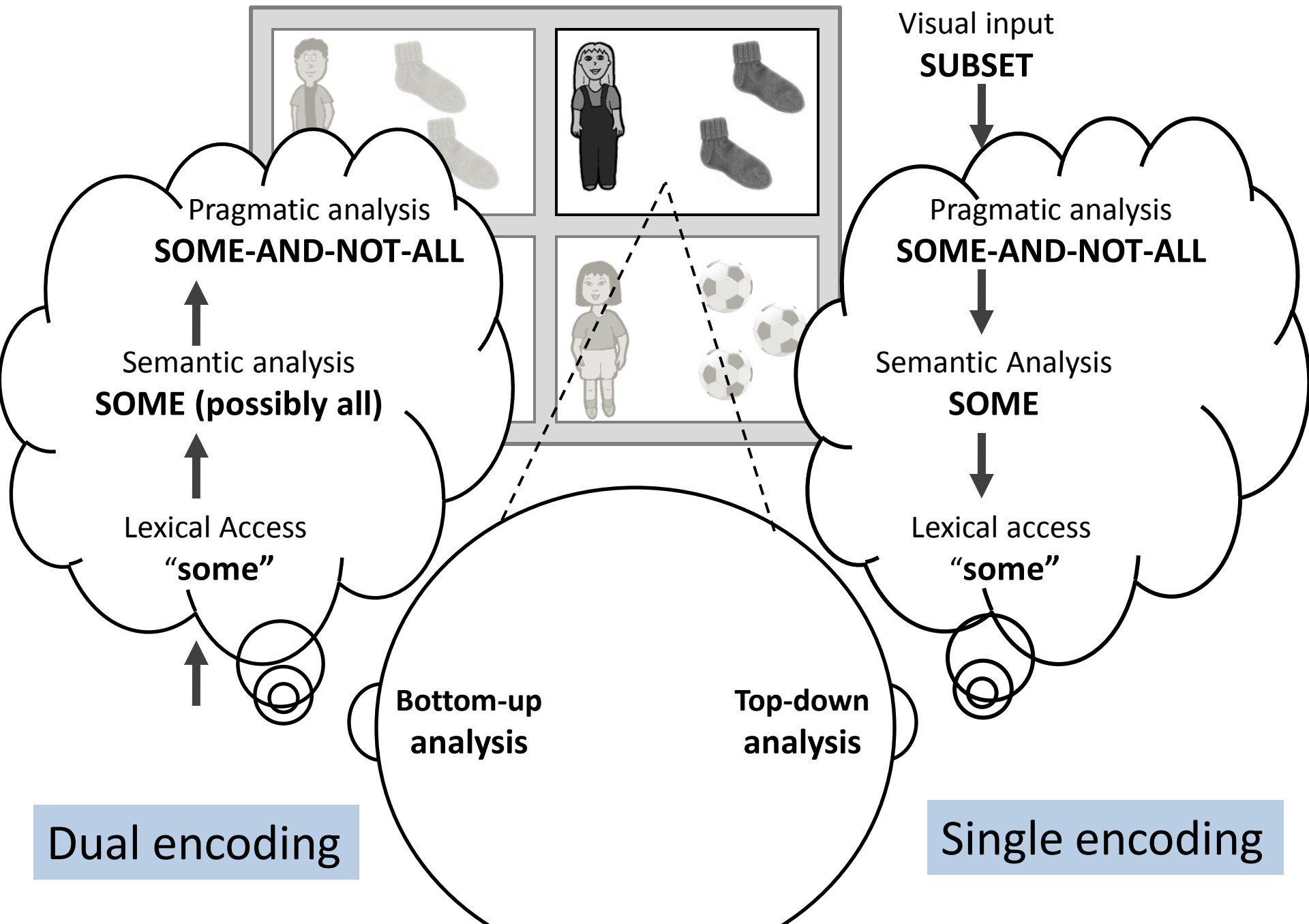
Top-down analysis



Auditory input
"some of"

Predictions

- Bottom-up
 - Scalar upper bound delayed relative to lexically encoded upper and lower bounds
 - Occurs when verbal encoding is difficult
 - Messages more unpredictable to comprehender
 - Multiple construals of given referent
- Top-down
 - Scalar upper bound guide reference resolution as rapidly as lexical bounds
 - Occurs when a verbal encoding is easy
 - Facts already known to listener (visual world)
 - Single salient construal of each referent in task



My take on SOA for scalar implicature

1. Implicature takes some work (bottom up)
2. But the work can be done ahead of time
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 - Listener as speaker
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Autism and scalar implicature

- Adults and teens with autism make SI's as often as language-matched controls (Pijnaker et al., 2008; Chevallier et al., 2010).

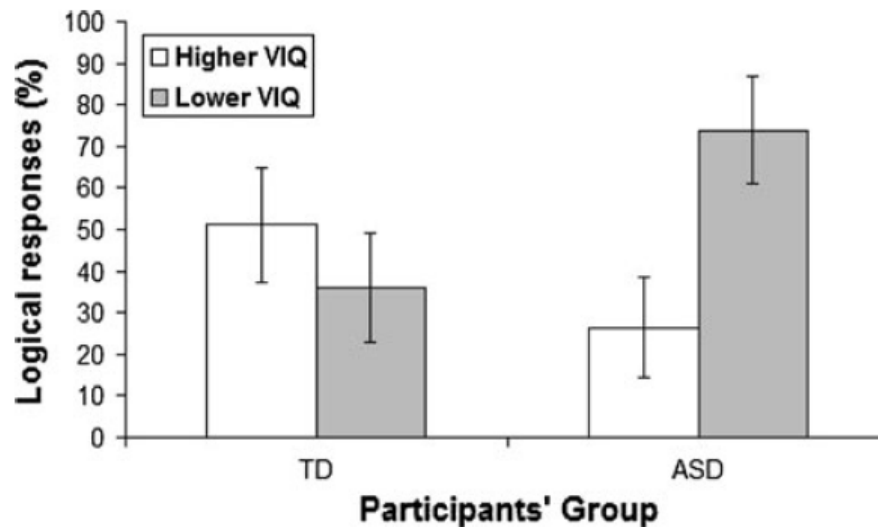


Fig. 1 Percentage of inclusive answers in the Or TT condition as a function of VIQ category (higher VIQ, lower VIQ) and group (TD, ASD)

Autism and scalar implicature

- Adults and teens with autism make SI's as often as language-matched controls (Pijnaker et al., 2008; Chevallier et al., 2010).
- Early deficit could disappear by 13
 - Ex: Deficits in Theory of Mind task only present until verbal mental age of 6-7 (Happe, 1995)
 - SI improves from 4 to 10 years
- Do persons with autism use the same process?

Our study

(Hahn, Huang & Snedeker, in prep)

- Goals

- Assess likelihood of calculating scalar implicature at an age where it is rapidly changing (box task)
- Determine whether mechanisms of comprehension are similar (visual world task)

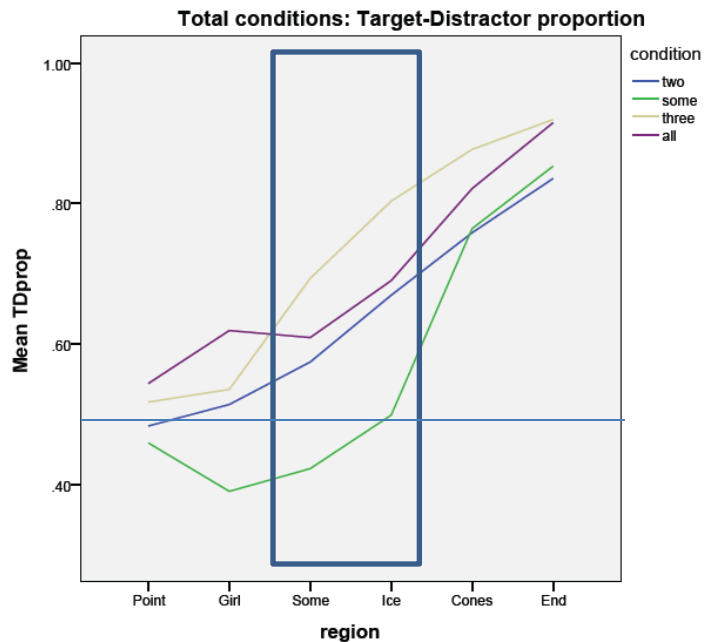


Noemi Hahn

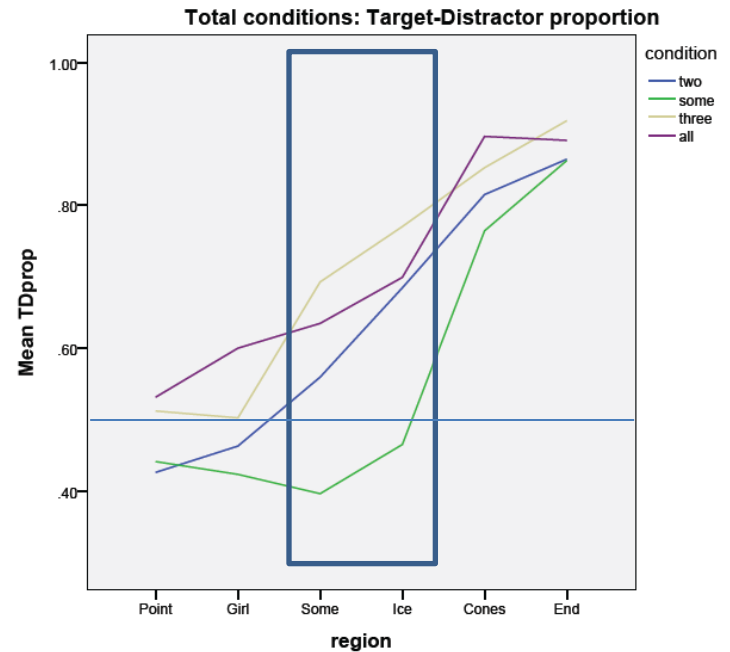
- 6-9 year olds children

- 40 with High Functioning Autism
- 40 Typically Developing
- Matched on: age, gender, CELF syntax scores

Same online processing profile



Typically Developing

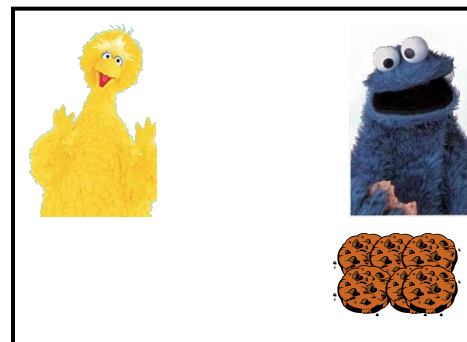
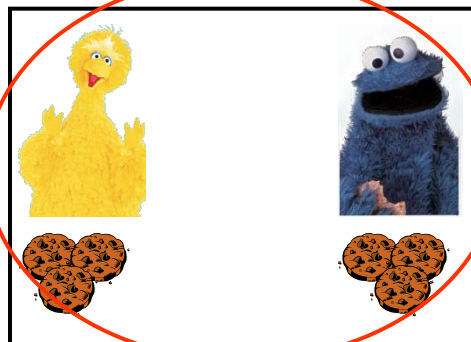
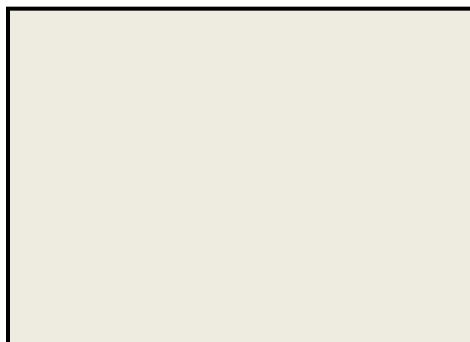


Highly Verbal ASD

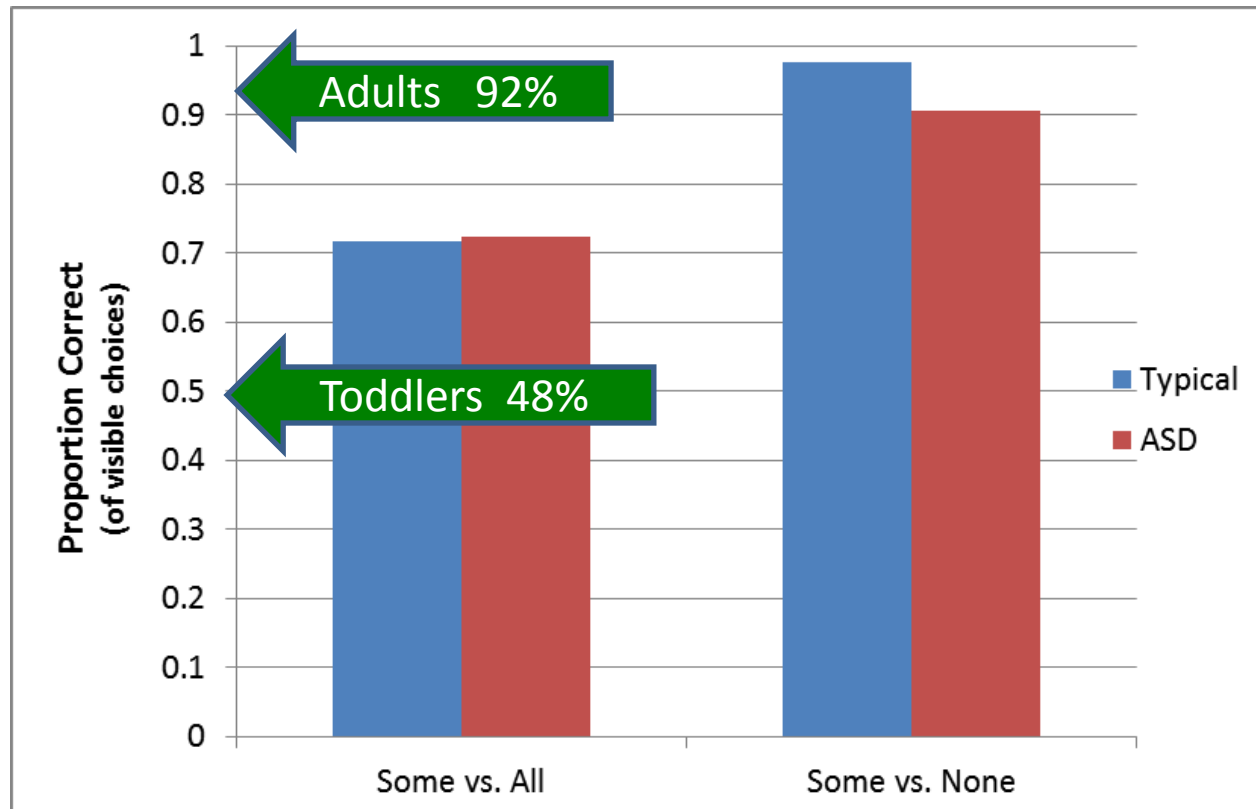
Some -----

Box task: some, implicature supporting

- *“Can you give me the box where Cookie Monster has some of the cookies?”*
 - Implicature match present



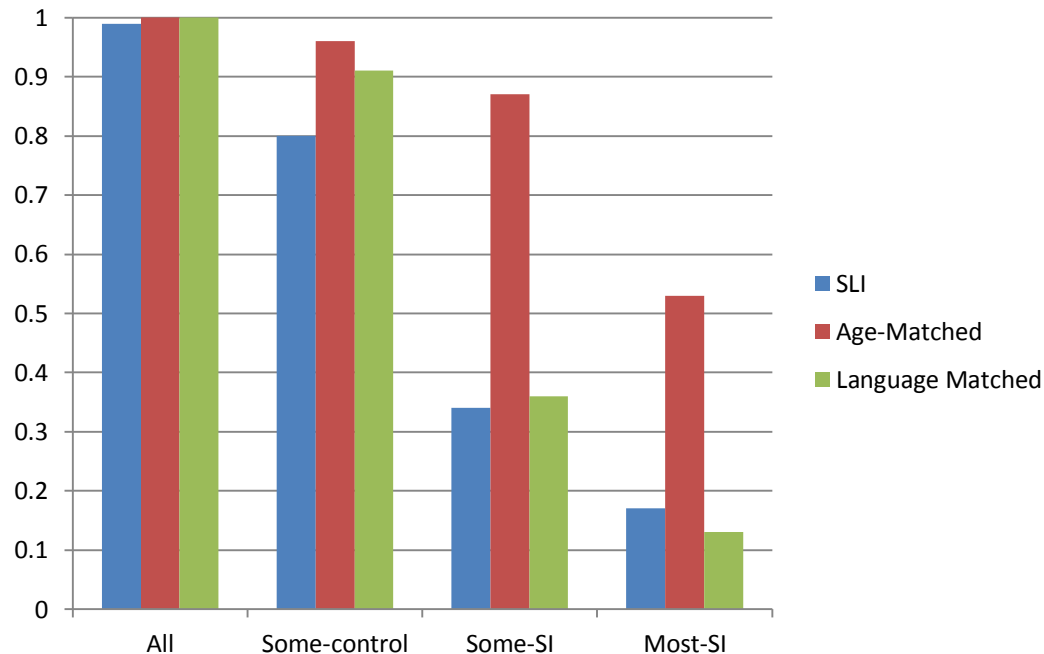
During the period where SI is developing children with ASD perform as well as controls



“The box where CM has some of the cookies”

SI is linked to language level

Katsos, Roqueta, Clemente & Cummins (2011)



See also Pijnaker et al., 2009

The only evidence that SI is linked to ASD....

- Nieuwland, Dittman & Kuperberg (2010)
 - “Some people have lungs/pets”
 - N400 at *pets*
 - Correlates with AQ communication scale (not social scale)
- My suspicion:
 - In college students, communication scale may capture differences in language skills not social reasoning
 - NB: Noveck’s correlations are with the ASQ social scale, Grodner is also seeing correlations between ASQ-social and perspective taking

Concrete conclusions.....

- Children with autism have no difficulty with scalar implicature
- Or the use of prosody for mid-level language
- But they have real difficulty interpreting prosodic focus
 - Focus is everywhere
 - Could cause communicative breakdowns

Thank you!

- National Science Foundation & Simons Foundation
- Collaborations and Inspiration: Yi Ting Huang, Sylvia Yuan, John Trueswell, Joy Geren, John Trueswell, Lila Gleitman
- Assistance from: Amanda Worek, Carlyn Friedberg, Carissa Shafto, and dozens of interns

