The role of natural experiments in psycholinguistics

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There are two reasons for this. First, it is very easy to say something stupid or confusing when writing in bullet points. Second, I would like to make sure that you have the correct citation for any of the research that I describe, since much of it is currently under review or in preparation.

Please note: we may have skipped the studies of prosody in autism

Plan of Action

I. International adoption as natural experiment
   – What role do maturation and cognitive development play in lexical and syntactic development?

II. Using developmental disorders as a tool for studying cognition
   – What are we "manipulating"? What should we control?

III. Natural experiments in pragmatics and prosody
   – Autism and a little SLI

I. International adoption as a natural experiment

Carissa Shafto

Jean Crawford

Joy Geren

Children’s language develops rapidly and predictably

More…
Mommy…
Horse

One word stage

Baby eat…
Baby down chair..
Eat cookies…

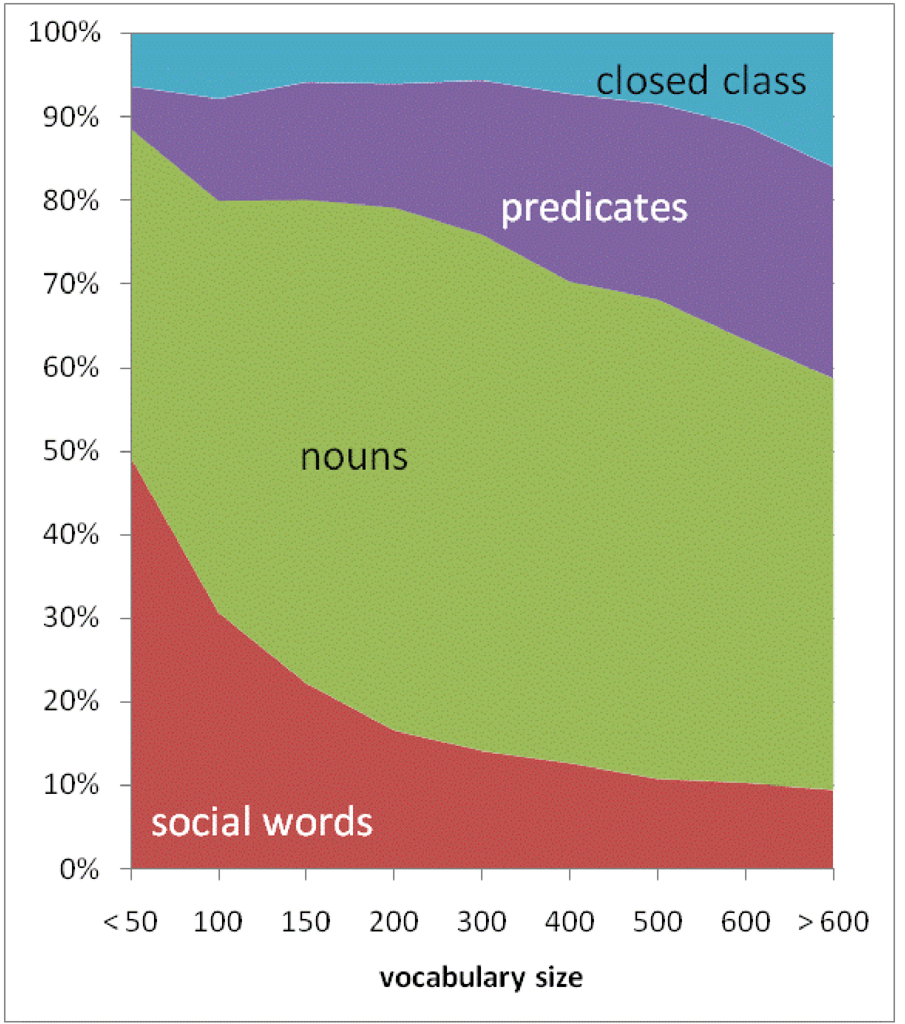
Telegraphic speech

Complex speech

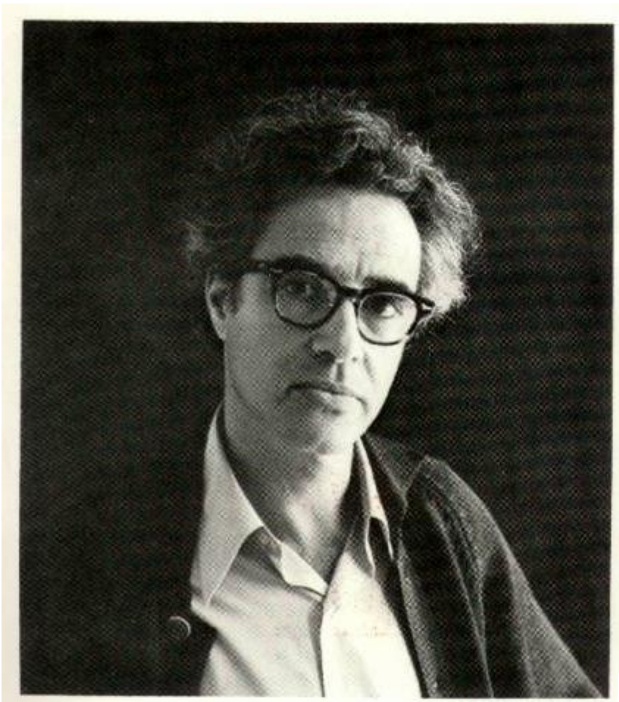
I just sit down like this …and spill right here Mommy

As children get older they learn different kinds of words

Shifts in vocabulary composition

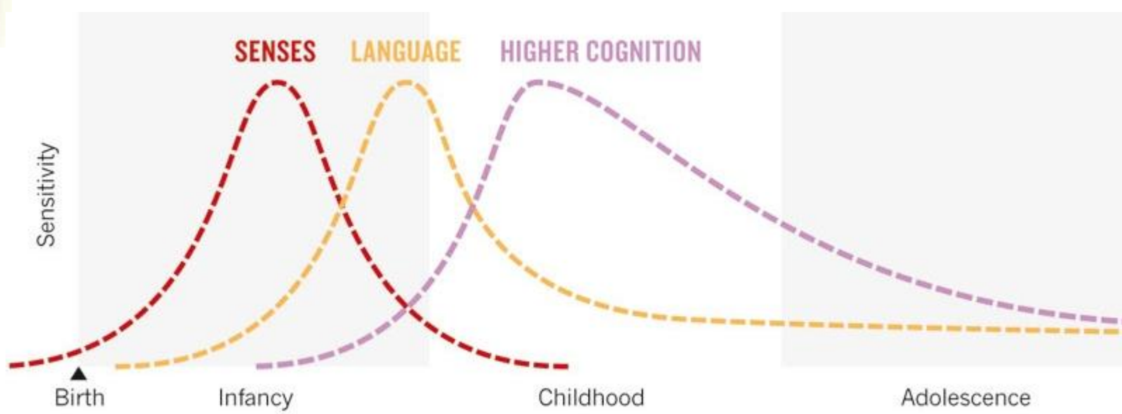


Eric Lenneberg's critical period hypothesis



Biological maturation causes

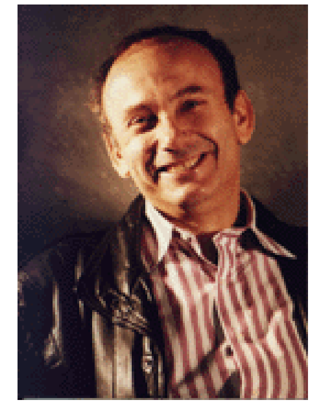
- Emergence of language in young children
- Decline in language learning ability in adolescence



Developmental theories for stages in child language

- Syntax matures (Wexler)
- Broad changes in cognitive ability (Piaget)
- Memory capacity expands
- Words are learned in the order in which concepts develop

Lenneberg, 1967; Macnamara, 1972; Sinclair, 1974; Bronckart & Sinclair, 1973; Cromer, 1974; Slobin, 1973; Fenson & Ramsay, 1980; Gleitman, 1981; Sugarman, 1982; Huttenlocher et al., 1983; Shore, O'Connell, & Bates, 1984; Shore, 1986; Brownell, 1988; O'Reilly, Painter & Bornstein, 1997; Bauer et al., 1998; Wexler, 1999; Ganger, Pinker, Chawla & Baker, 2004



Ken Wexler

Jean Piaget

<u>Contingent acquisition</u> an alternative account

- Stages reflect steps in solving a problem
- Should occur in *any* learner who uses the same procedure
- Lila Gleitman: stages in word learning reflect increasing knowledge of grammar
- Liz Bates: stages in utterance length reflect increasing knowledge of words

Lila Gleitman

Liz Bates

Gillette, Gleitman, Gleitman & Lederer, 1999; Bates & Goodman, 1997; Snedeker & Gleitman, 2004; Snedeker, Geren & Shafto, 2007

Gleitman's account of word learning

Step 1: Novice

- Doesn't know many other words
- Guesses the meaning from situation, eye gaze and pointing
- Learns only concrete words
  - Nouns for objects
  - People's names
  - Social gestures

gorp → apple

Gleitman's account of word learning

Step 2: Noun Knower

- Uses known words to figure out new ones
- Can learn concrete relational words
  - Action verbs
  - Spatial prepositions
  - Adjectives
- Begins to learn grammar

man… **gorps**… *you*… *apple*

→ **give**

Gleitman’s account of word learning

Step 3 : The Linguistic Sophisticate

- Learning relational words → acquisition of grammar
- Uses grammar of sentence to learn new word
- Can learn abstract words
  - Verbs for mental states
  - Articles (the, a)
  - Auxilliary verbs (do, can)

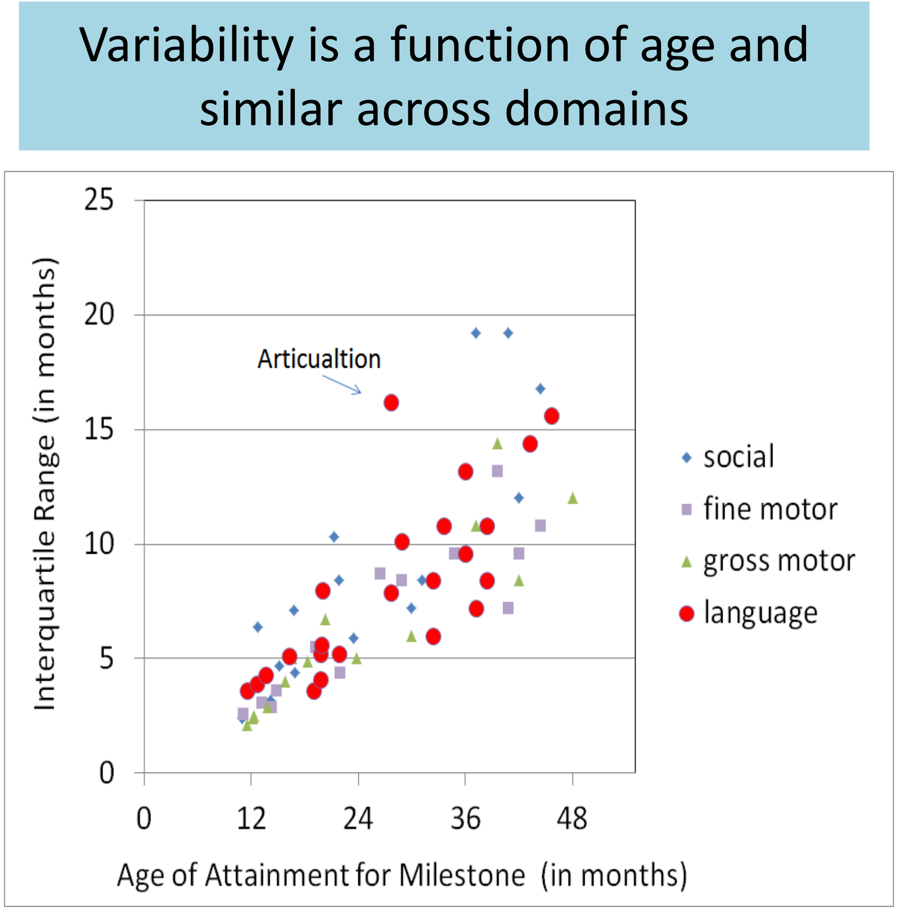
The man **gorps** *that the apple is red.*

→ **think**

How can you tell which theory is true?

All theories should predict correlation across domains

Language is no more (or less) variable than other domains



Methodological Morals

- Space your groups
- Don't expect sudden discontinuities with age
- Optimal distance between groups is proportional to age

Means and interquartile ranges from Denver Developmental Screening Exam and MCDI

How can you tell which theory is true?

All theories should predict correlation across domains

All theories are consistent with variability

International adoption as a natural experiment

Adopted preschoolers

- Are older have the cognitive abilities required for later stages
- Learning in same context as an infant

Contingent Acquisition → same stages as infants

Maturational Account → older children should skip stages (or encounter new problems)

Our studies

- Our participants
  - adopted from China and Russia
  - 2 ½ to 5 ½ at arrival

- Compared to infants
  - Native English speakers
  - 1 to 2 ½ years
  - matched for vocabulary size

Stages of language development

- One word stage
  - Single words used to express range of ideas
  - Social words
  - Nouns
  - Frozen phrases

One-word stage

Stages of language development

- Telegraphic speech
  - 2 to 4 words
  - Mostly nouns and verbs
  - Missing “grammatical words”
  - Sometimes neutral vowels (uh) produced instead

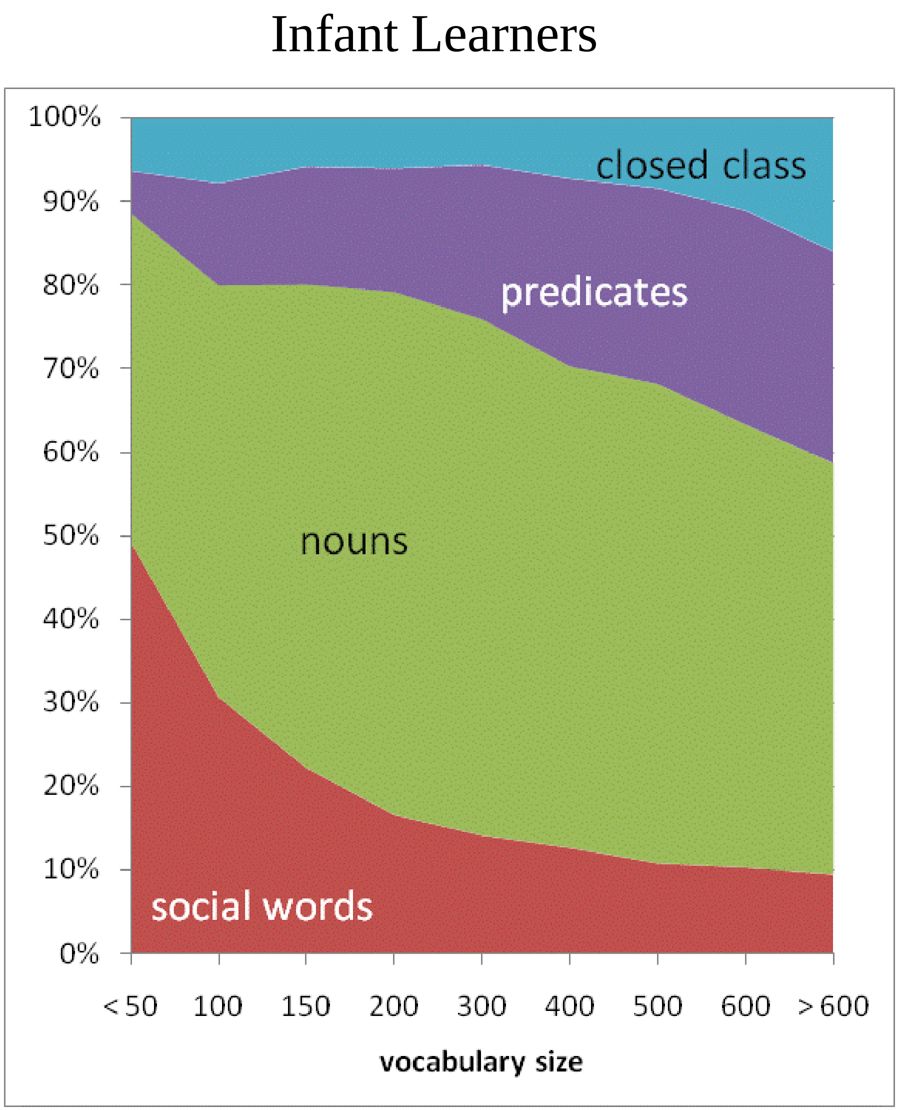
Telegraphic stage

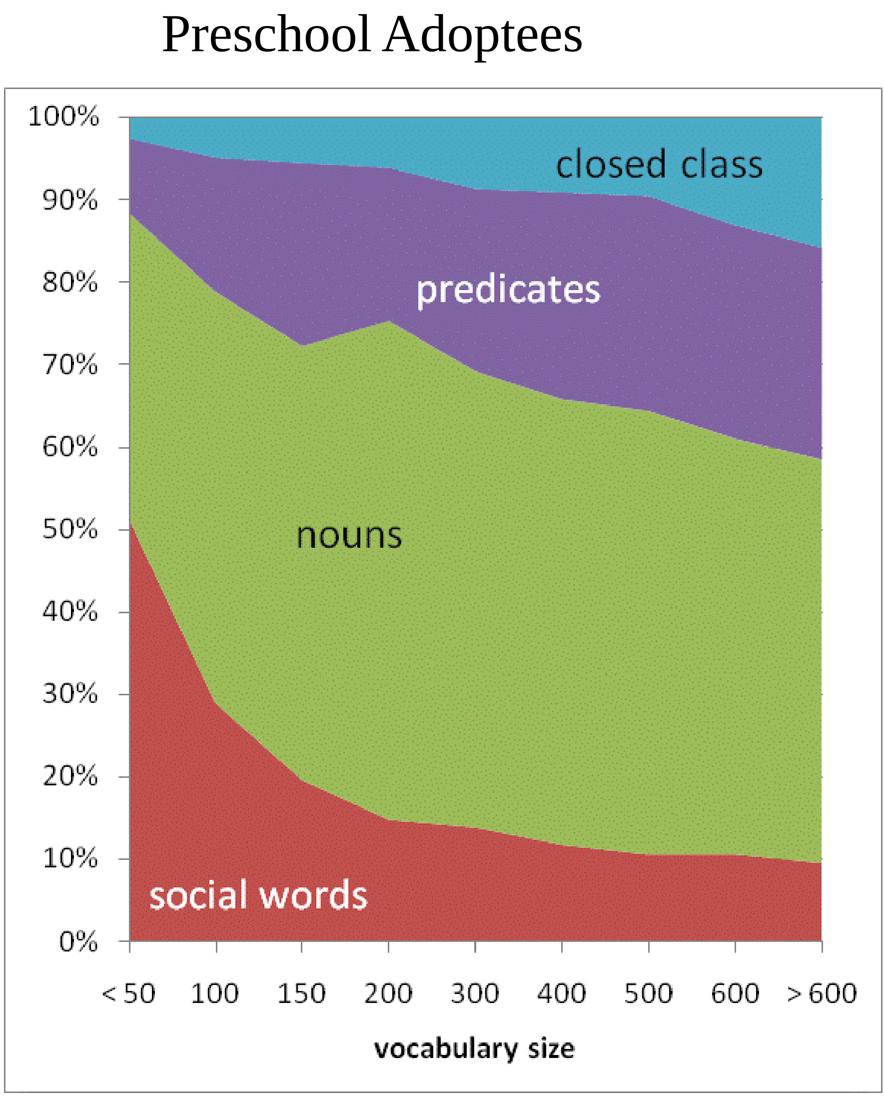
Stages of language development

- Complex speech
  - Variety of sentence types
  - Use of grammatical words
  - Errors limited and language specific
    - Absence of do-support (“I no play that”)
    - Wrong case for pronouns (“Me go”
    - Subject drop

Emerging syntax

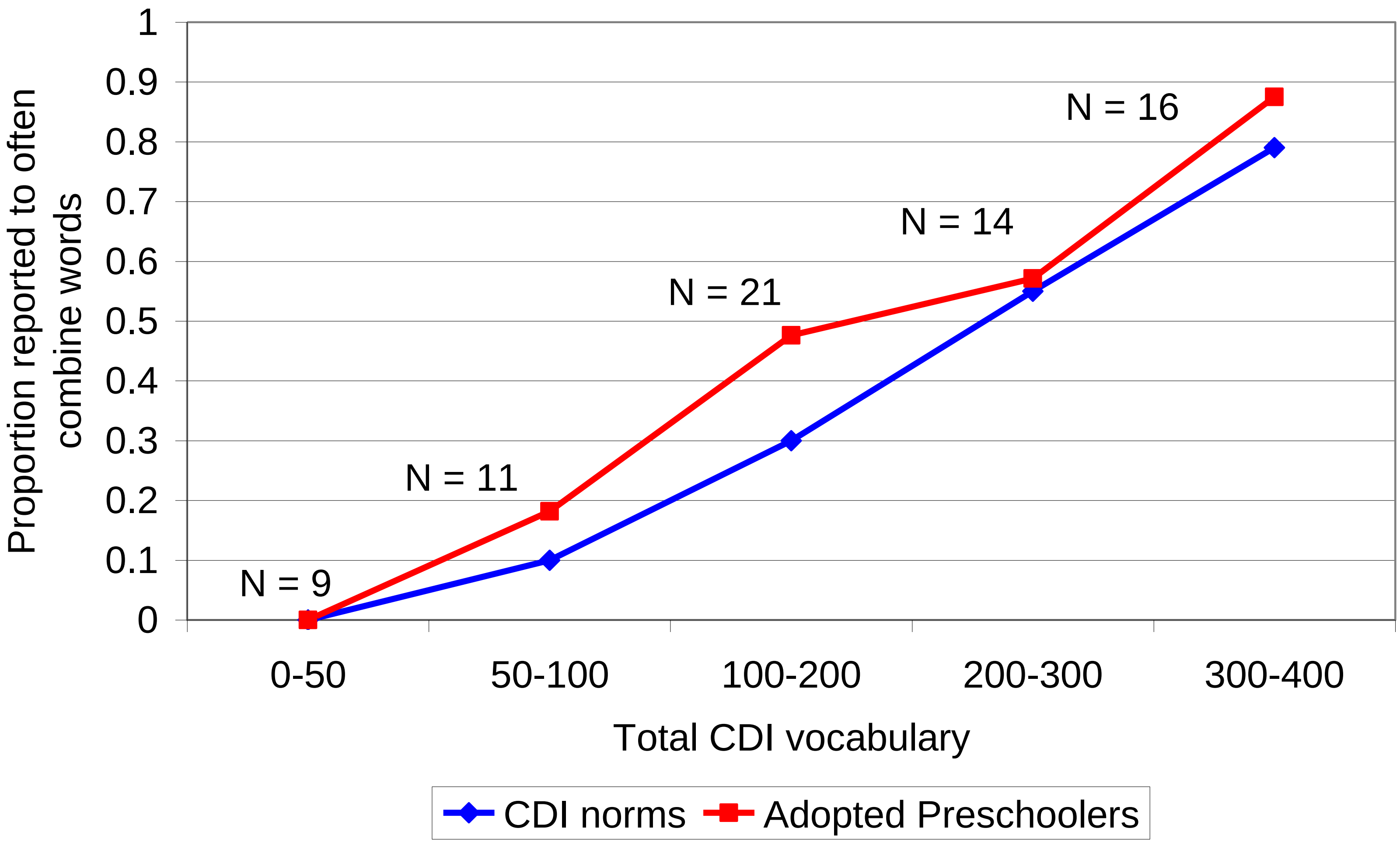
Infants and preschoolers show the same changes in vocabulary





Adoptees go through one-word stage right after arrival

Telegraphic speech emerges at 50 - 200 words



But Jesse, that's just *words* what about *real* syntax

Optional infinitives?

The optional infinitive hypothesis

- Between 2;0 to 3;6 children produce ungrammatical infinitive verbs (OI's)
- Omit affixal tense morphemes
  - Girl play(s) with toy --One time I watch(ed) this movie
- Omit suppletive tensed verbs (copulas & auxiliaries)
  - She (is) making a cake --They (are) so funny
- Phenomenon is present in many languages
  - Analysis is controversial

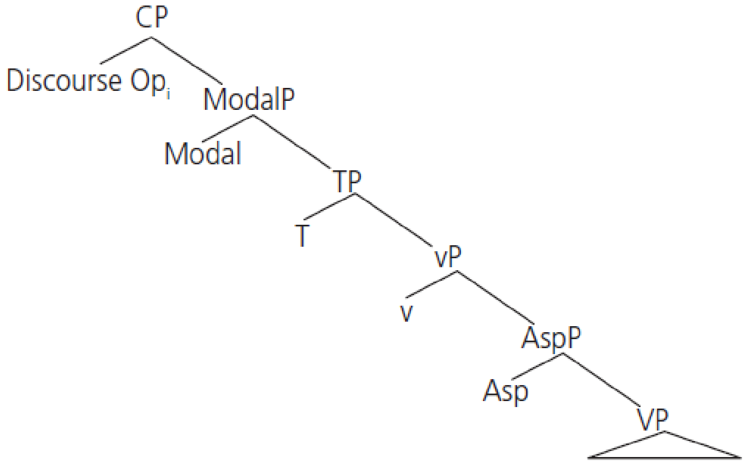
The optional infinitive hypothesis

- Wexler's claim:
  - Optional infinitives reflect an immature grammar
  - resolves via maturation
- Prediction: optional infinitives should be absent in more mature learners

Various theories about the nature of the deficit:

- Truncated structures
- Optional structures
- Failure to check features

I won't address this

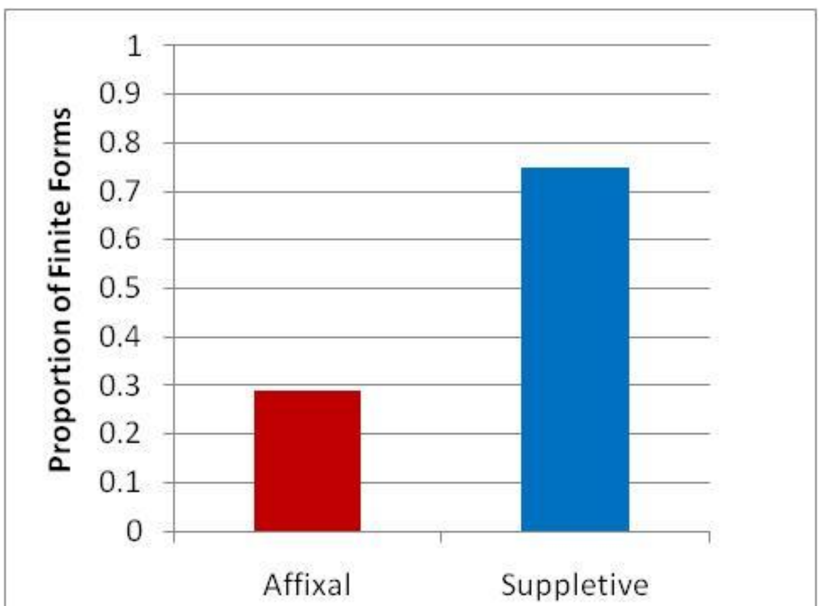


Do older children have optional infinitives?

see also Paradis & Crago, 2000; Gavruseva, 2002/2004; Haznedar, 2001; Pardis, Rice, Crago & Marquis, 2008

Ionin & Wexler (2002)

- Immigrant L2 English
- 3;4 to 13;10
- 1 to 3 years exposure



Claims:

- Older children have mature tense (suppletive forms)
- Some other deficit causes problems with the affixal forms
  - More “surface level”

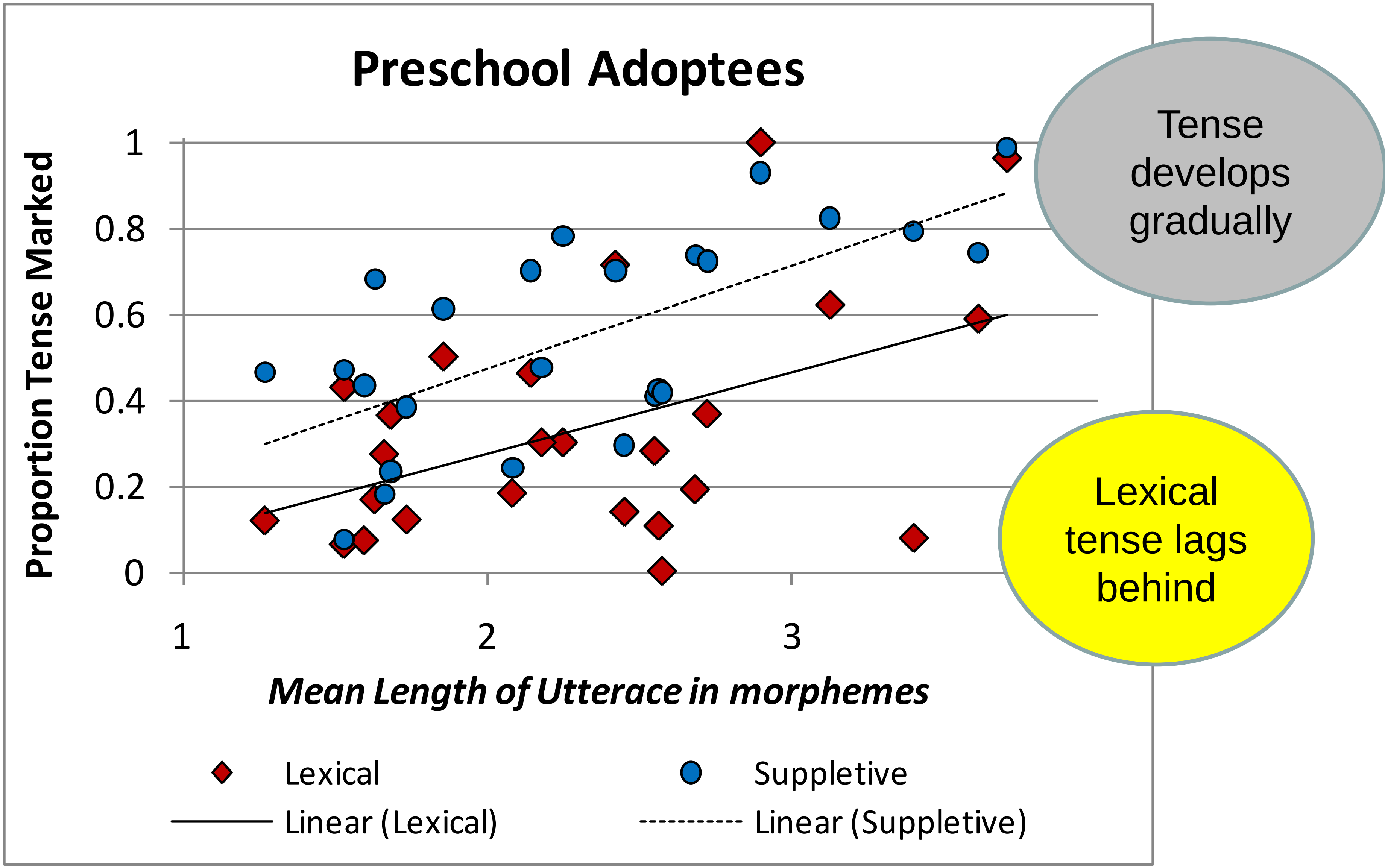
My concerns

- Control group needed
- Do suppletive = lexical in infants?
- School learners get different input
- Later changes in plasticity may impede acquisition

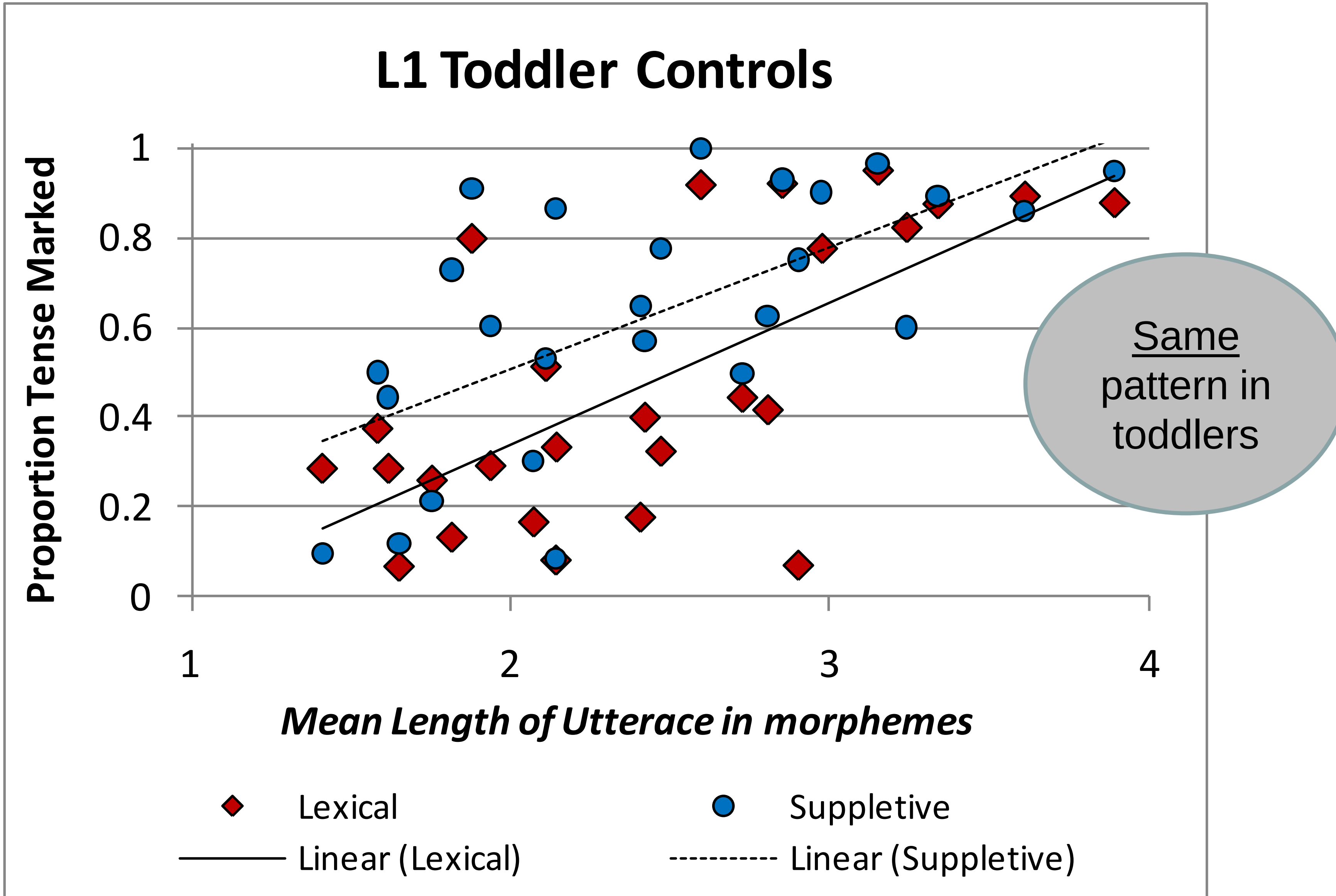
Tense marking in preschool adoptees

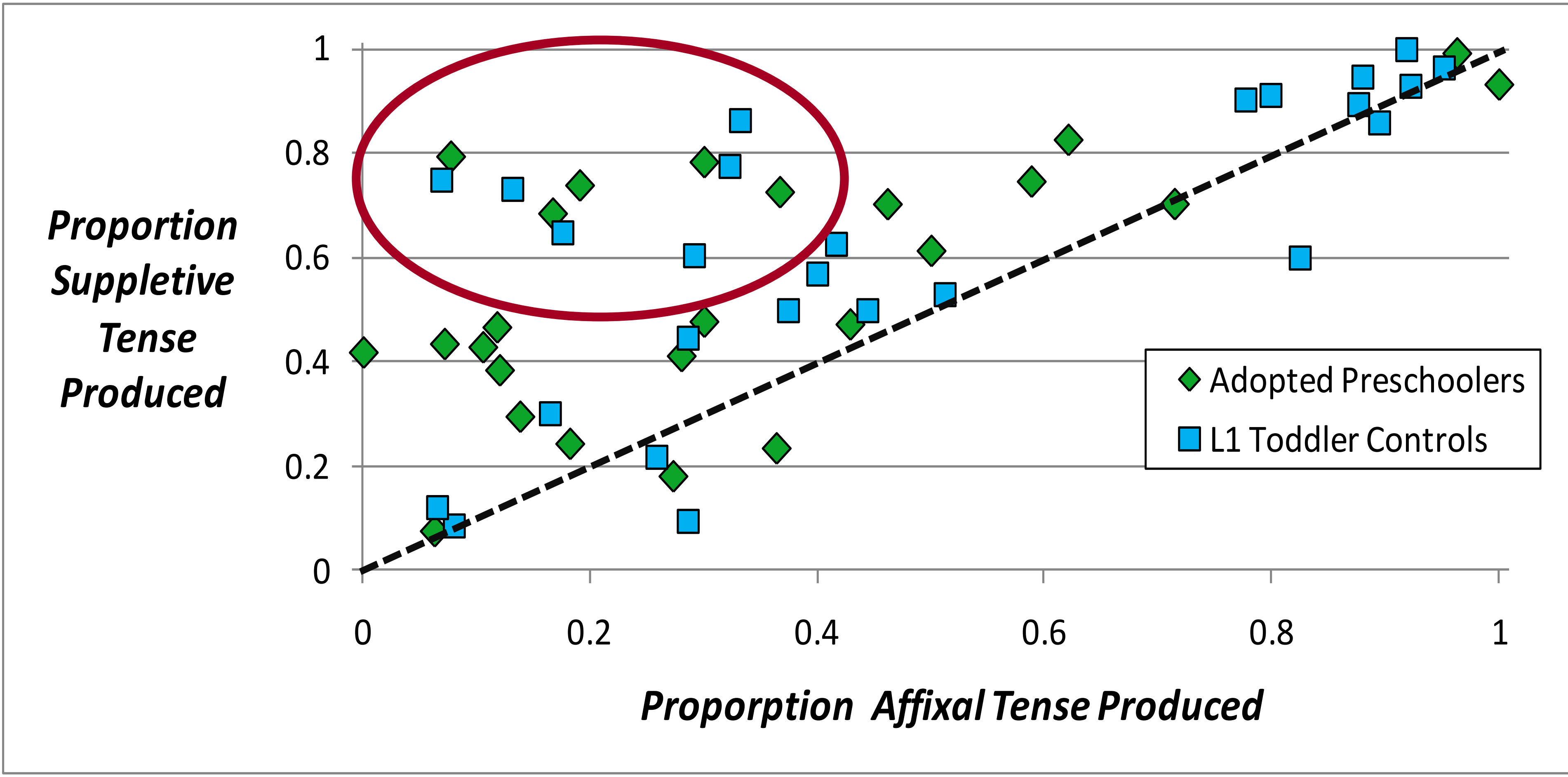
- Sample
  - 8 older adoptees
  - CHILDES infant controls matched on mean length of utterance (MLU)
- All child utterances coded
- Analysis of mandatory contexts for tense (N=7889)
  - Affixal tense
    - Past tense (*He stop)* and 3rd sing (*Jimmy like legos)*
  - Suppletive tense
    - Copular *be* (*This a horsie) and* Aux (*You going in jail)*

Work with Jean Crawford



Preschool Adoptees
Proportion Tense Marked
1
0.8
0.6
0.4
0.2
0
1
2
3
Mean Length of Utterace in morphemes
Lexical
Suppletive
Linear (Lexical)
Linear (Suppletive)
Tense develops gradually
Lexical tense lags behind


L1 Toddler Controls
Proportion Tense Marked
1
0.8
0.6
0.4
0.2
0
1
2
3
4
Mean Length of Utterace in morphemes
Lexical
Suppletive
Linear (Lexical)
Linear (Suppletive)
Same pattern in toddlers



Hierarchical logistic model:

MLU (p < .005, OR = 2.84, reliable in each group)

Suppletive vs. Lexical (p < .005, OR = 2.28, reliable in each group)

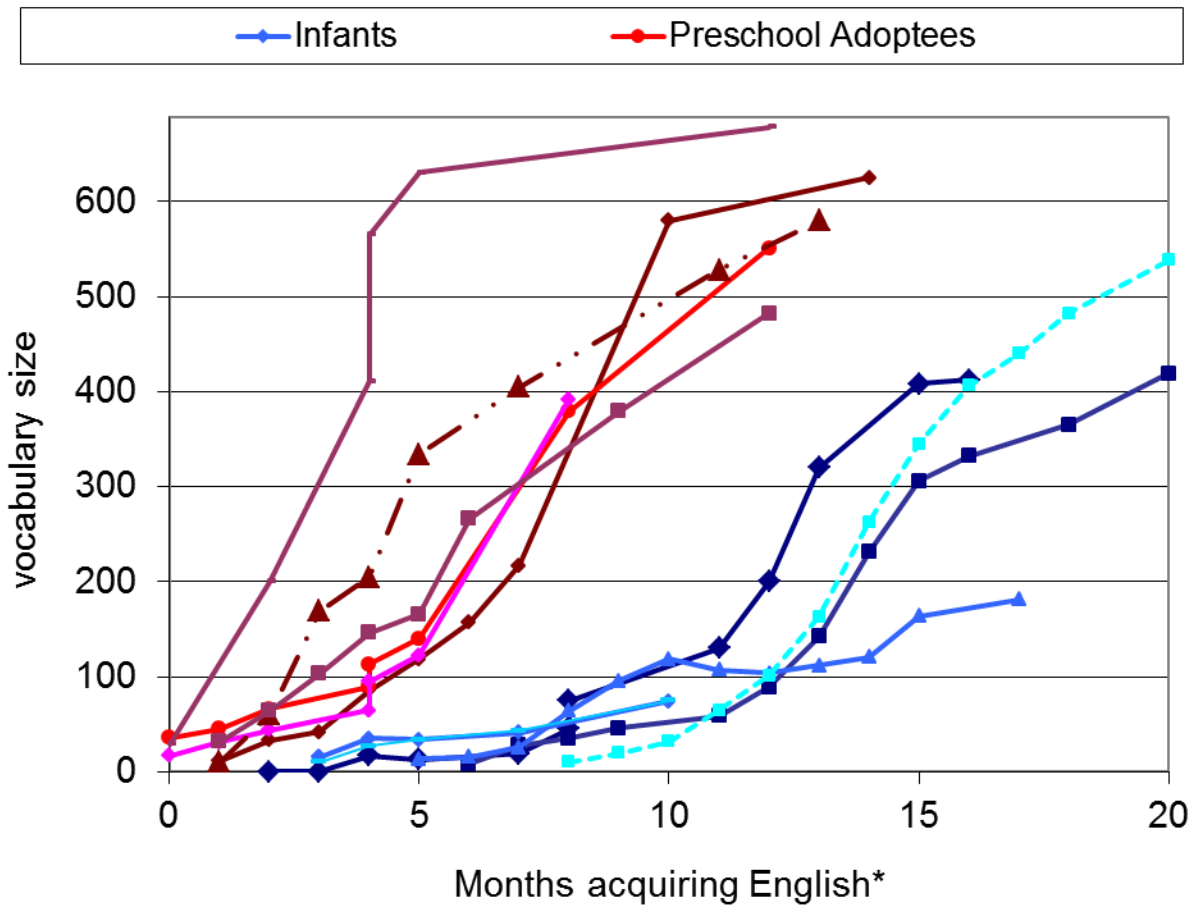
No effects or interactions of adoption (p > .1, t < 1.5)

- "Optional infinitive stage" does not result from immature grammar
  - reflects child's gradual acquisition of the language
  - consistent with processing bias account (e.g., Demuth)
  - input-driven acquisition of tense morphology (e.g., Freudenthal et al., 2006)
  - or a revised version of one of the syntactic hypotheses in which children <u>learn</u> that the operation/structure is necessary

Take home message

- Language acquisition in preschoolers closely parallels infant acquisition
  - Changes in vocabulary composition
  - One-word stage
  - Classic grammatical error patterns
- These patterns reflect the nature of the language learning problem
- No evidence that language matures

But older children learn much faster!



- What we manipulated
  - Biological Age
  - Cognitive Development
  - *Prior Experience with a language*
- What we tried to hold constant
  - Current level of English knowledge (vocab size)
  - Language learning environment (family context, no bilingual informants etc.)

II. Thinking about developmental disorders

Things to keep in mind

1. Development is not unitary
   – disorders do not merely reflect varying degrees intelligence
2. A developmental disorder is rarely isolated to a single module or function
3. Most disorders are not “natural kinds”
4. Developmental profiles change over time

1. Development is not unitary

- Williams Syndrome:
  - Low IQ
  - Pronounced spatial deficits
  - Initially slow to acquire language
  - Relatively good language abilities later
- Downs Syndrome
  - Low IQ
  - Initially slow to acquire language
  - Pronounced language deficits later

Things to keep in mind

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

A priori implausibility of modular* deficits

- <u>Assume</u> strong modularity with an evolutionary basis (ala Tooby & Cosmides)
    - Change gene-A to produce/change 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 <u>the same</u> effects: different pathways, gradients in gene expression across the brain

* This is a different use of modular which focuses on evolutionary history and function (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

Things to keep in mind

1. Development is not unitary
2. A developmental disorder is rarely isolated to a single module or function
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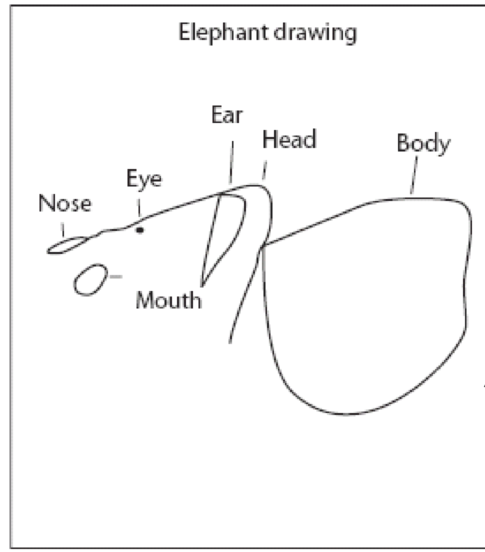
Williams Syndrome

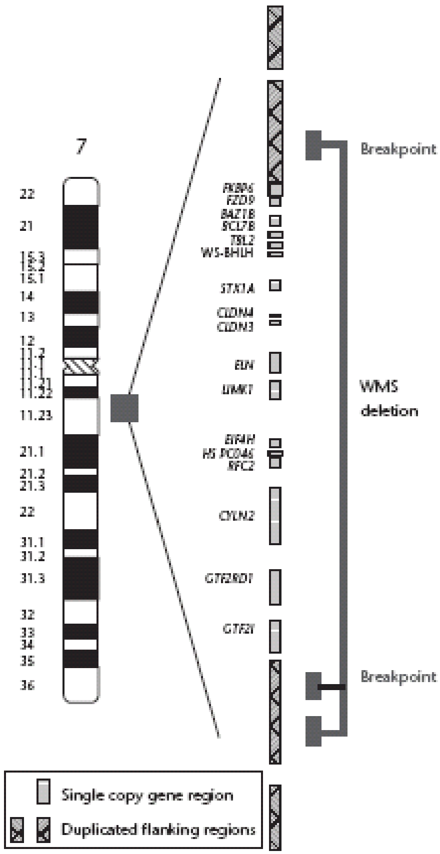


And what the elephant does, it lives in the jungle. It can also live in the zoo. And what it has, it has long grey ears, fan ears, ears that can blow in the wind….

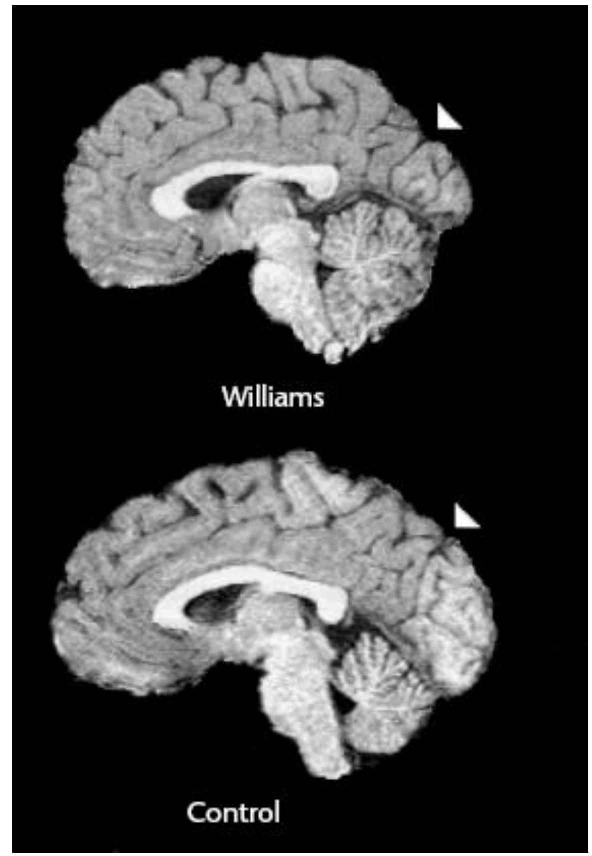
Physical Phenotype

Cognitive Phenotype

Williams Syndrome



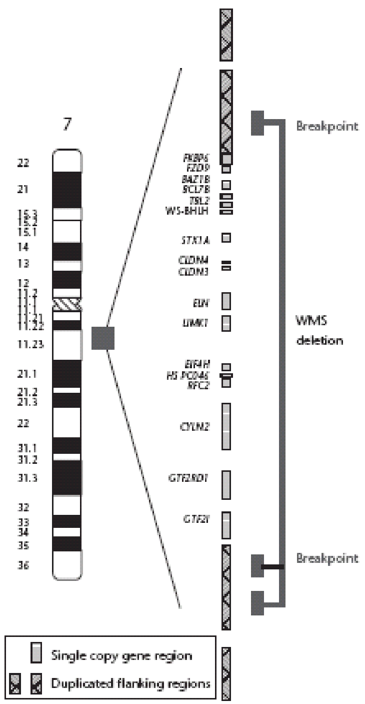
Genetic Characterization



Neuroanatomic Characterization

Williams Syndrome

Clean mapping across levels



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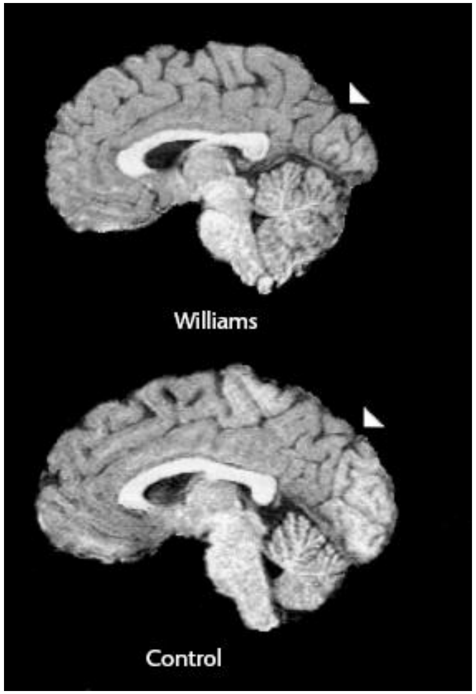

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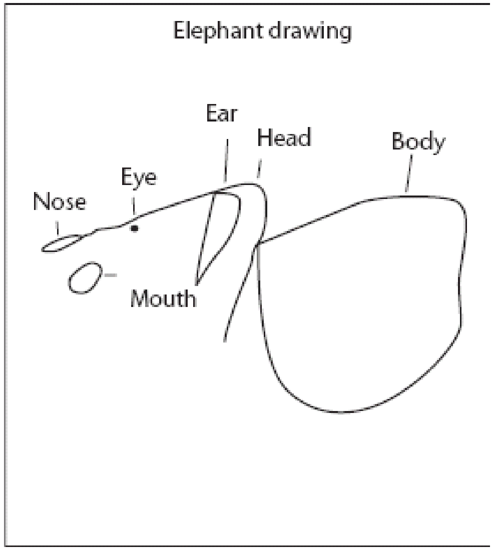
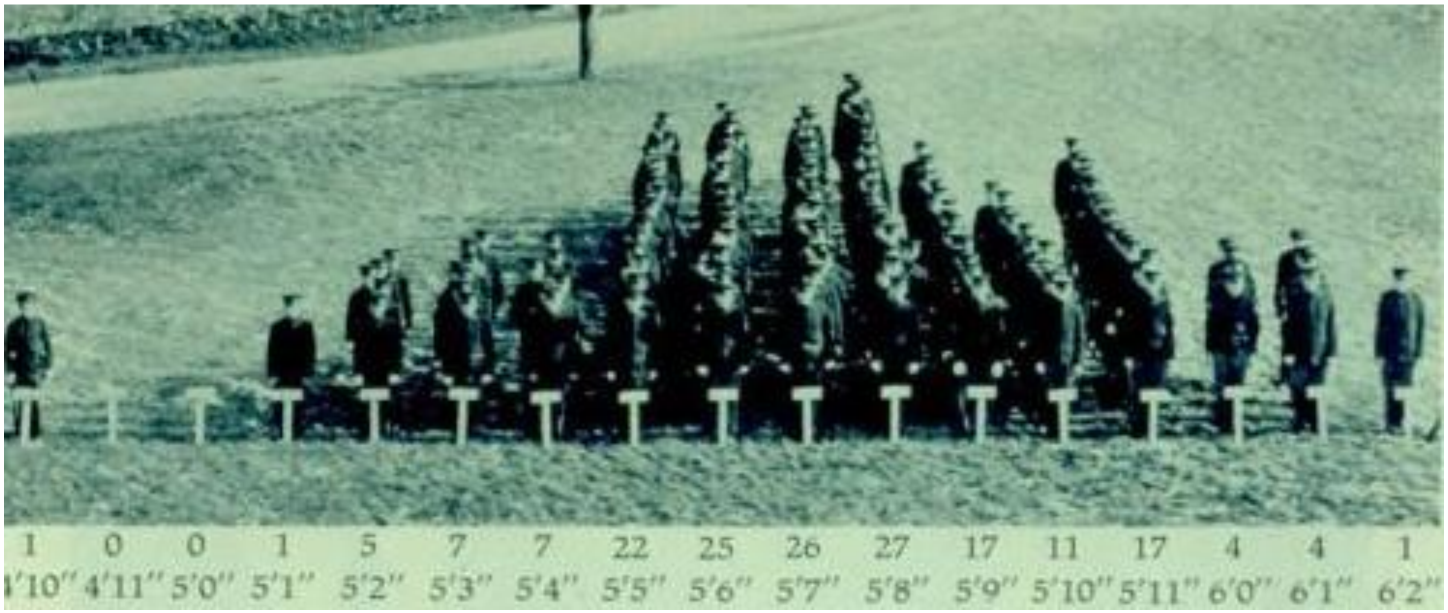


If you have the full deletion, then you have the neurological differences and the cognitive phenotype

In contrast, 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

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

Things to keep in mind

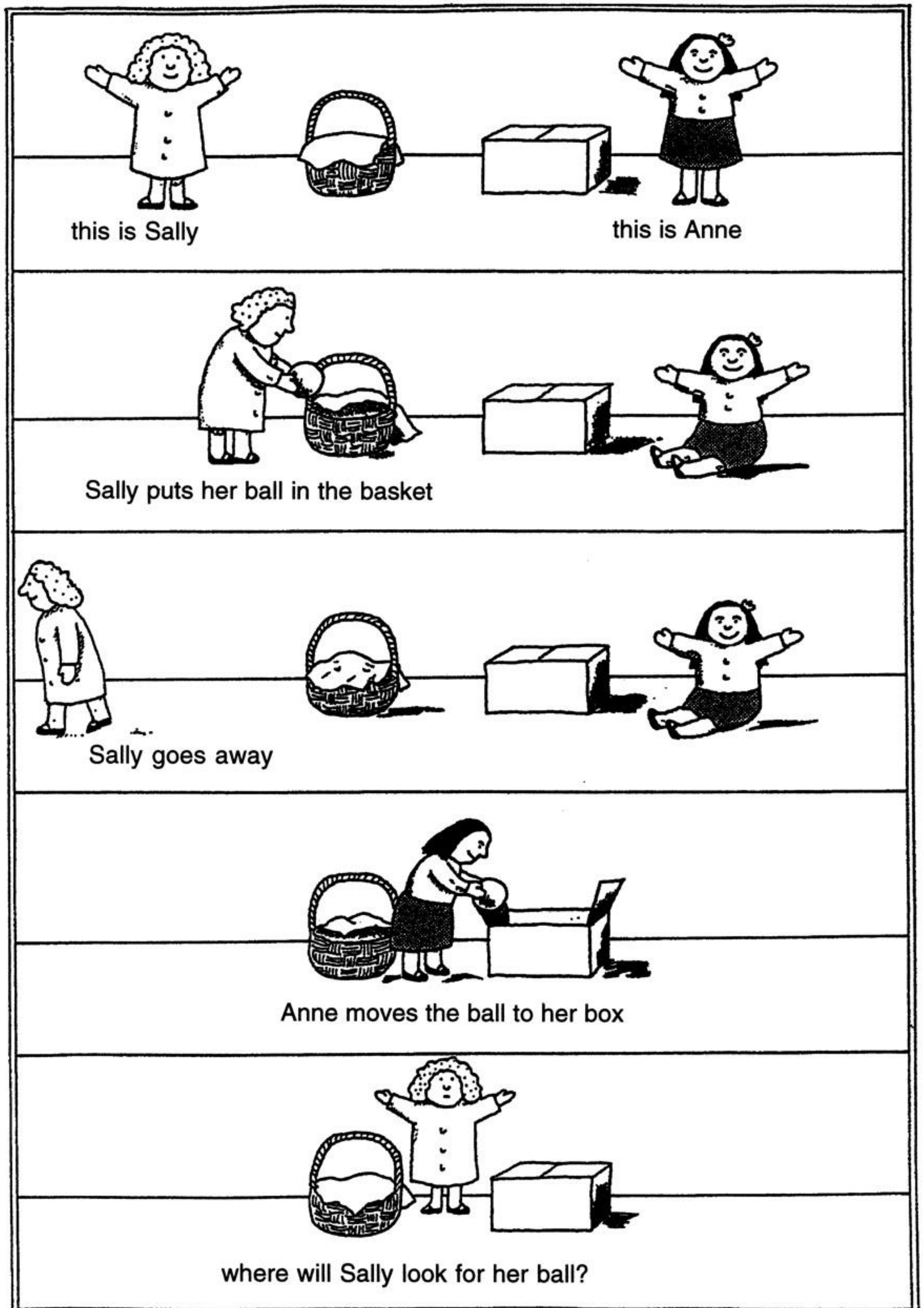
1. Development is not unitary
2. A developmental disorder is rarely isolated to a single module or function
3. Most disorders are not “natural kinds”
4. Developmental profiles change over time

Developmental profiles change over time

Ex: Language in Williams Syndrome

- Early language development is <u>delayed</u>
- 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



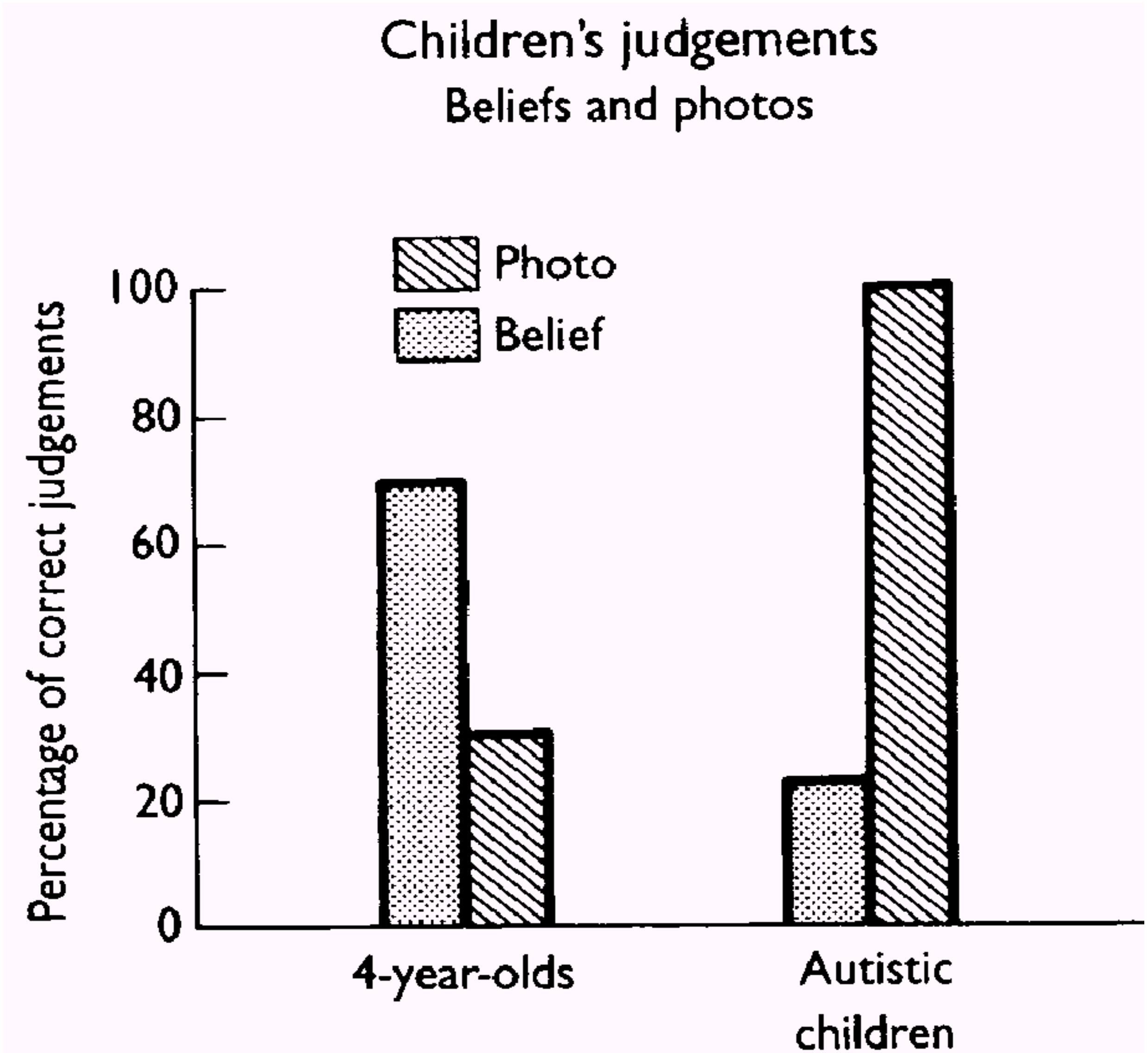
The false belief task

(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).



Leslie & Thaiss (1992)

First-order TOM in ASD changes with verbal age

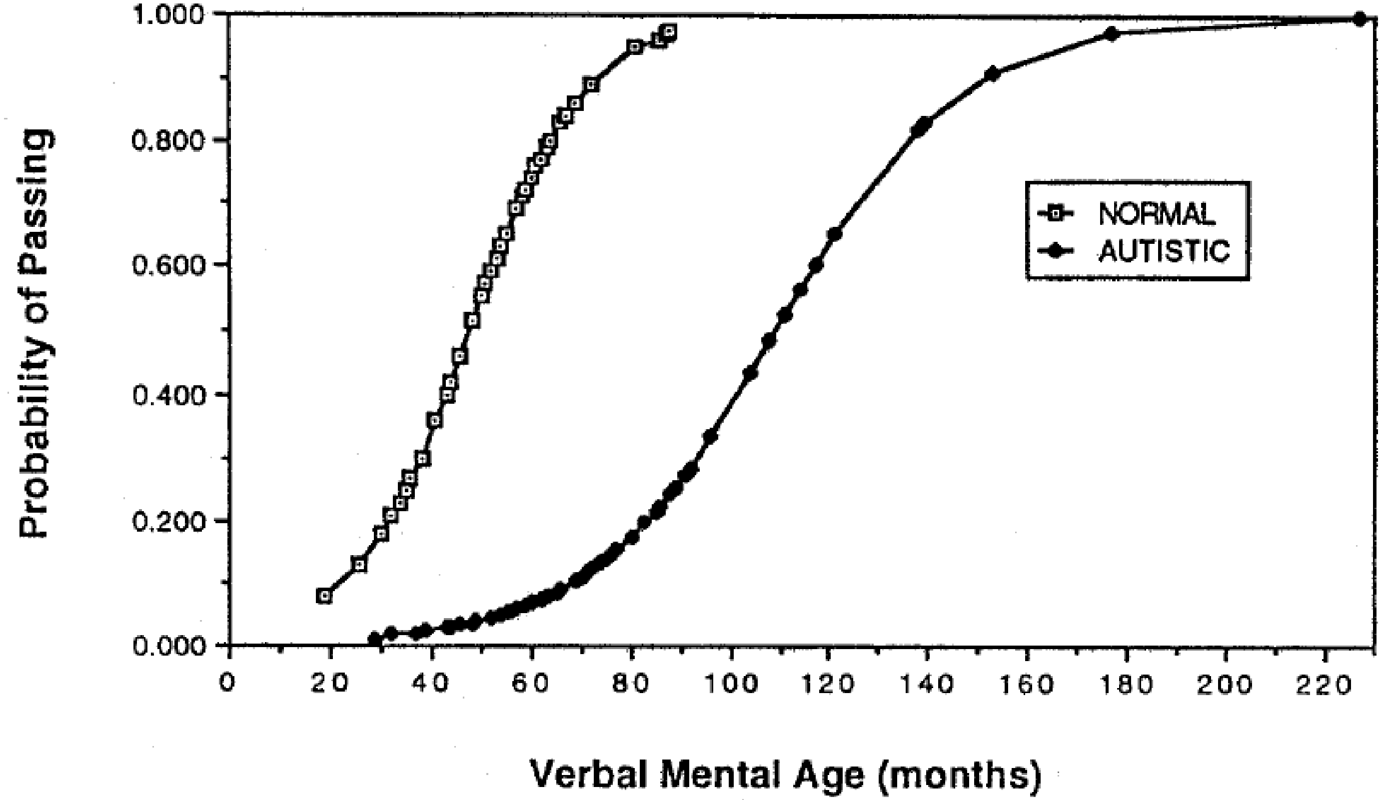
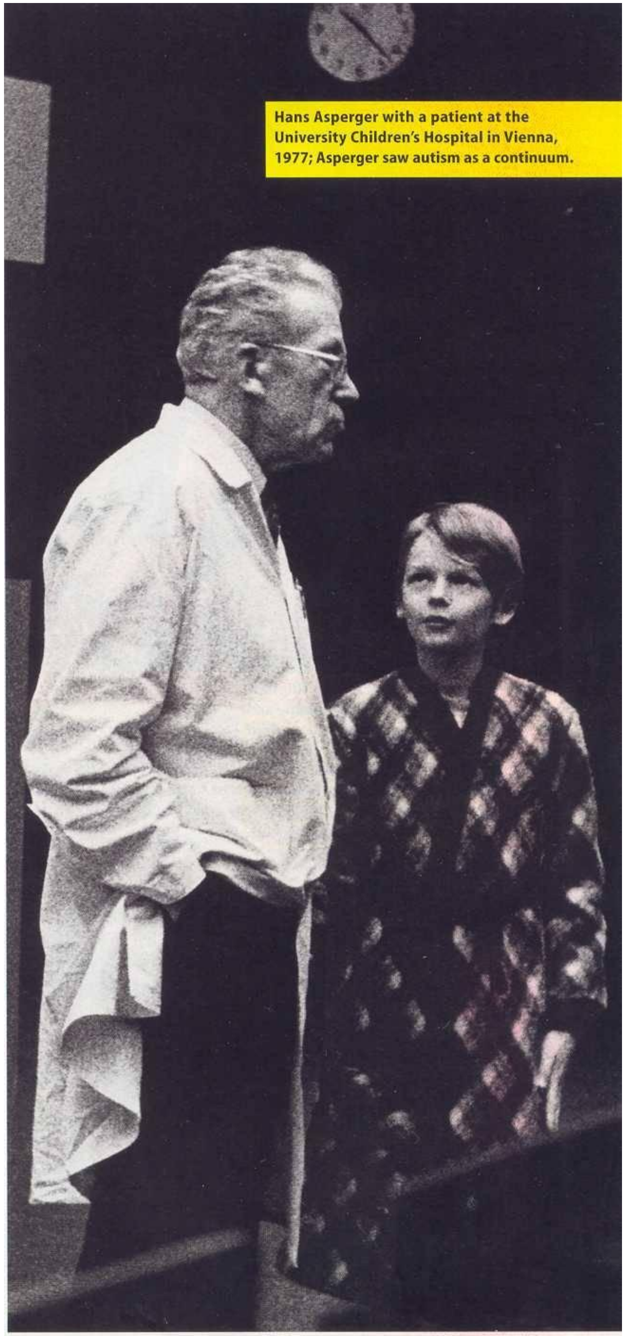


FIG. 1.—Predicted probability of passing both theory of mind tasks by verbal mental age (for autistic and young normal subjects).

Happe, 1995

Autism as tool for studying pragmatics

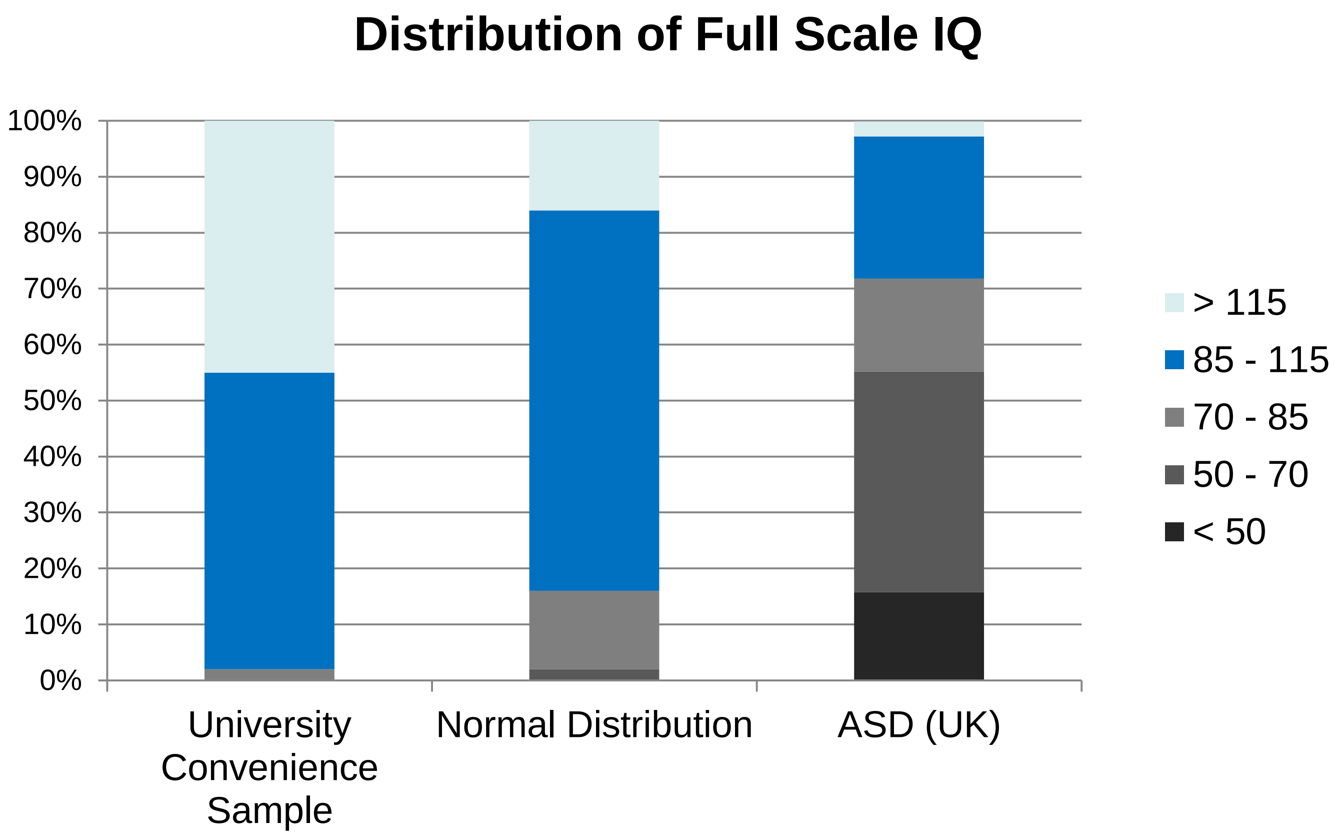


" The nature of these children is revealed most clearly in their behaviour towards other people. Indeed, their behaviour in the social group is the clearest sign of their disorder and the source of conflicts from earliest childhood."

Hans Asperger

Autism is not merely a deficit in social reasoning

<u>Most</u> children with autism have an intellectual disability

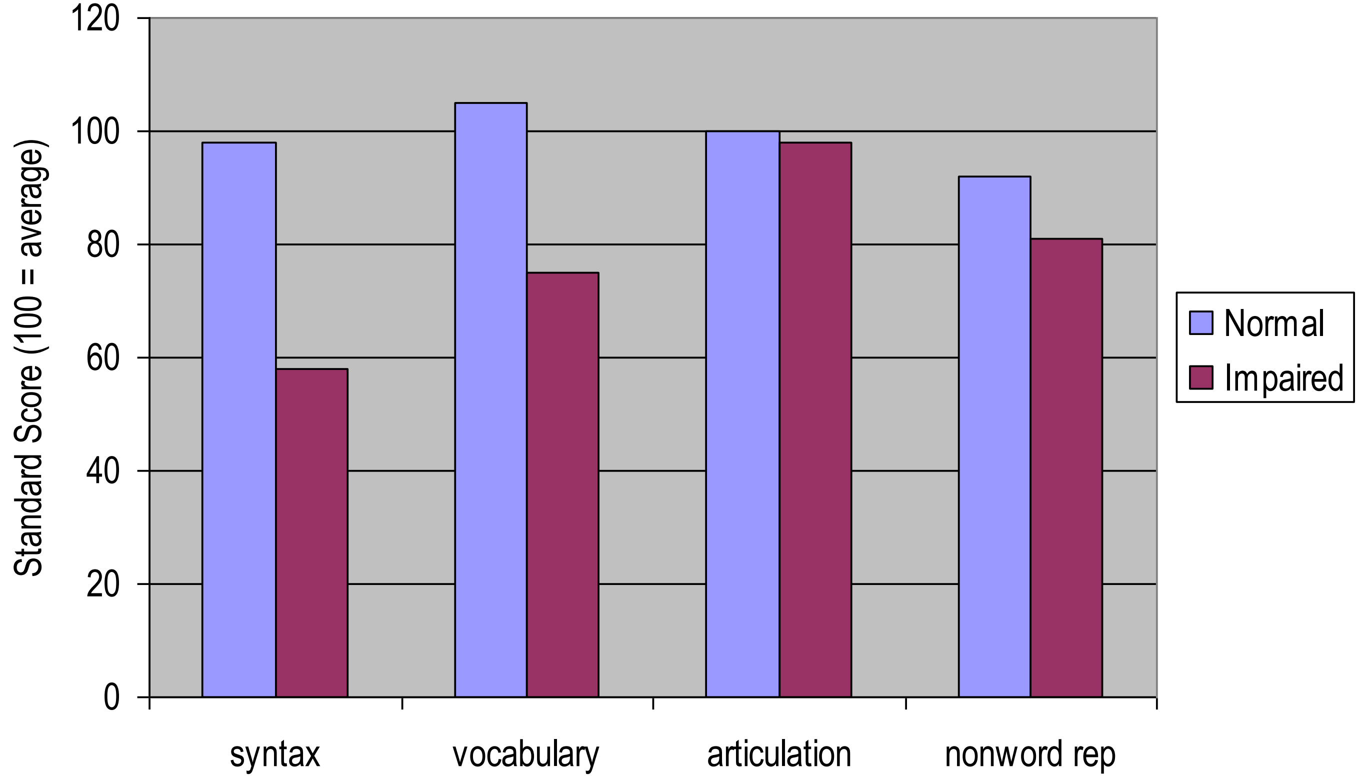


Convenience sample estimated based on our experience matching from an existing university lab data base.
ASD data taken from Charman et al., 2011. Sample from late 1990’s

Language development in autism varies greatly

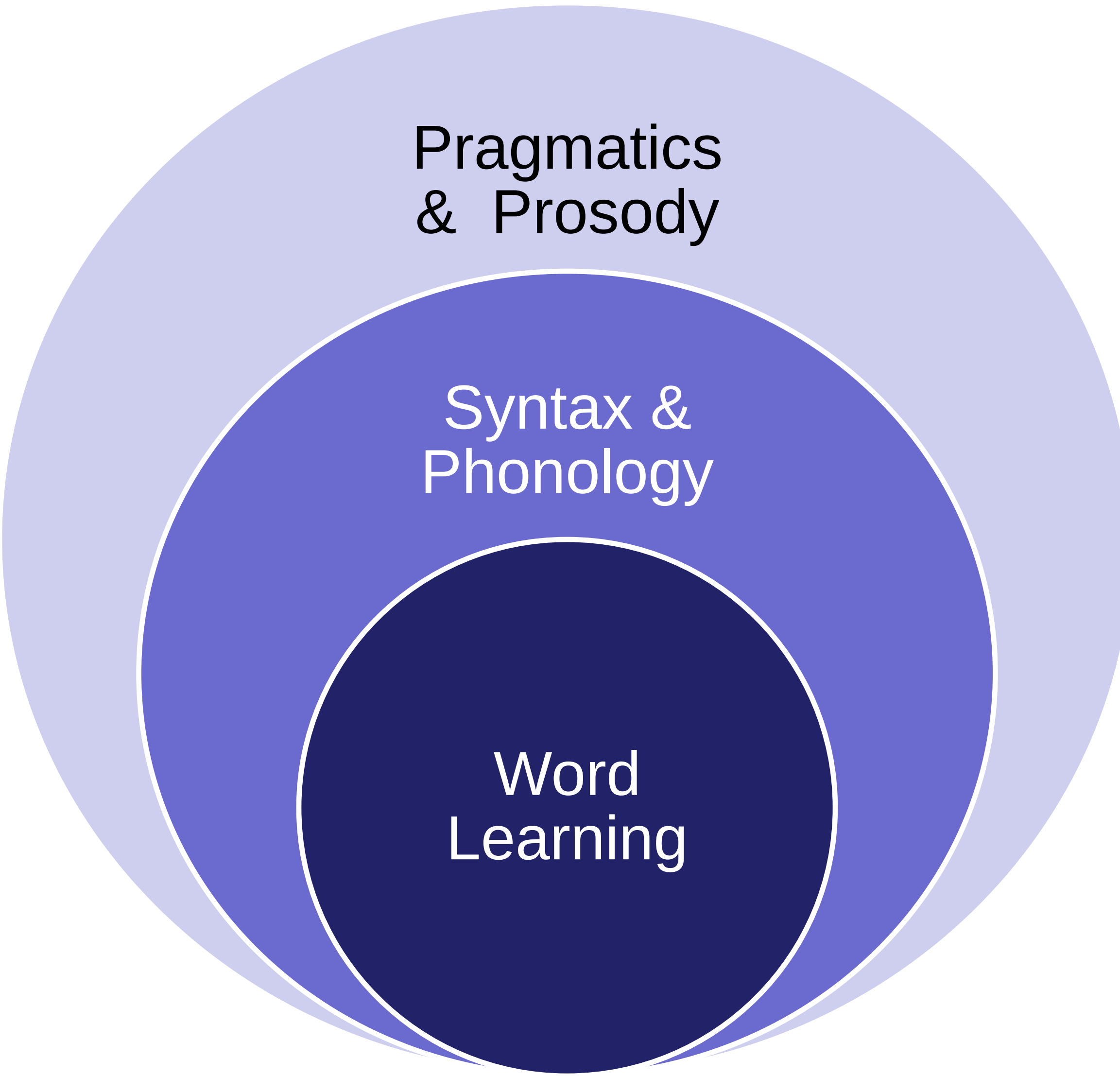
- No speech
- Limited speech
  - Small number of words, used in limited contexts
  - Acquired via intensive interventions
  - Echolalic
- Functional speech
  - Delayed in onset
  - Formal system may reach mature levels in adolescence or adulthood
- Some children show <u>no</u> apparent delays in acquisition

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



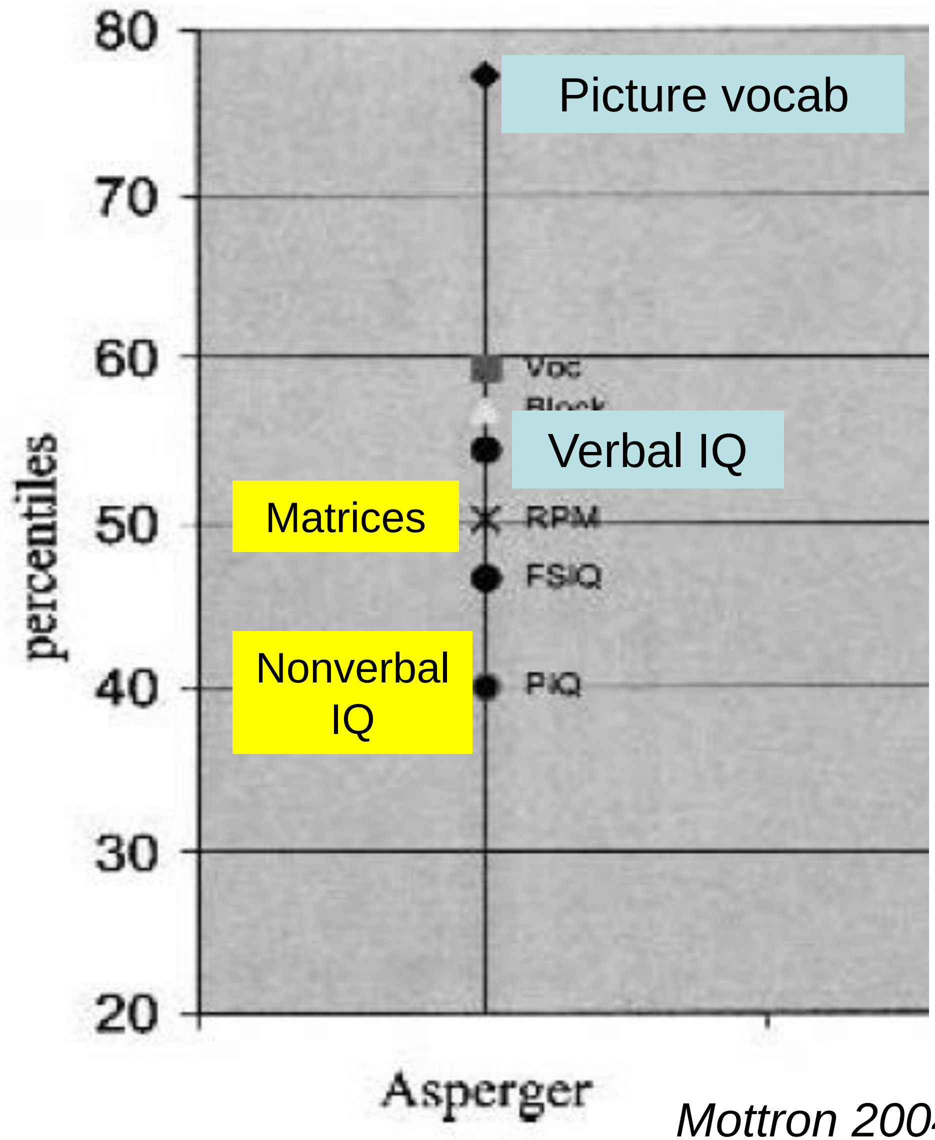
Kjelgaard & Tager-Flusberg (2001)

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



Mottron 2004

Common, casual, matching strategies are inadequate

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

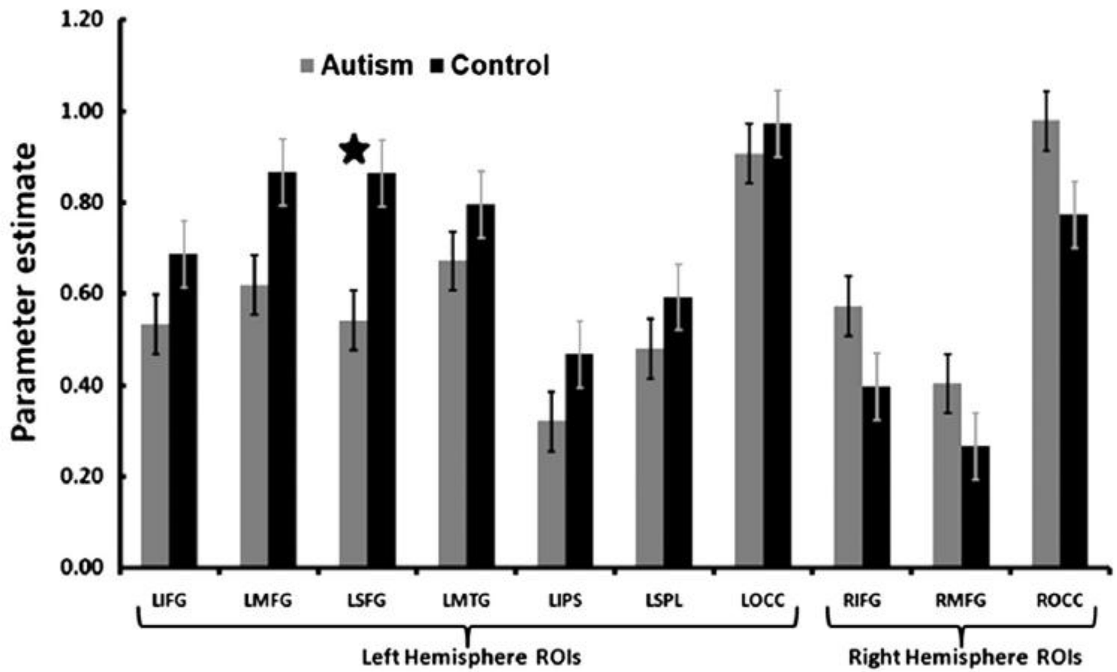


Fig. 4. Parameter estimates. Graph displaying the parameter estimates (beta-weights) from 10 ROIs. This graph displays the significant increase in beta-weights for the control group in the LSFG. It also displays the trend toward greater levels of activation in all left hemisphere regions for controls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

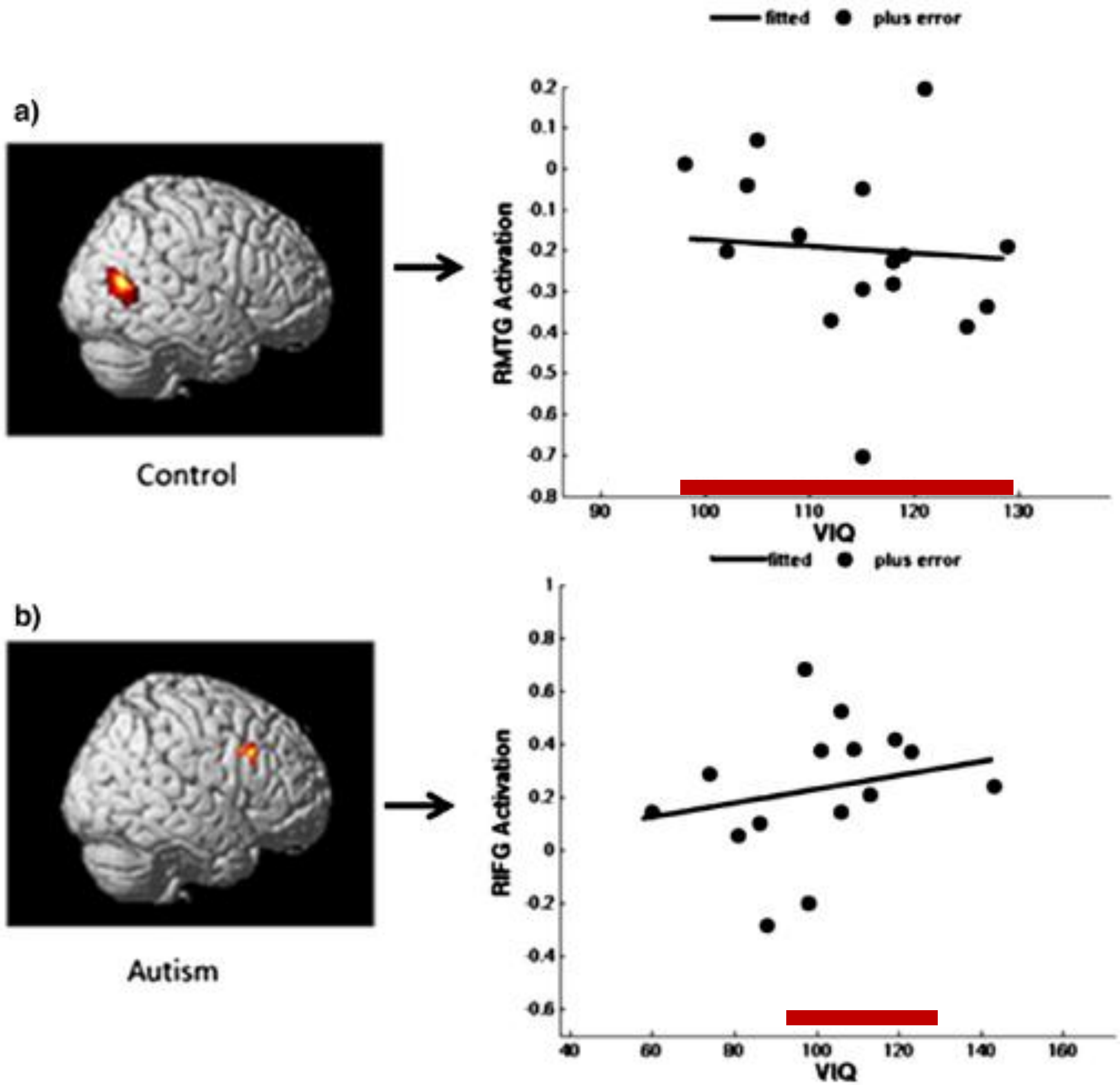


Fig. 3. Correlation between language skills and activation. Figure displaying the activation in core right hemisphere language regions in the within-group regression of activation with VIQ score. A) Displays the negative correlation between VIQ score and activation within the right posterior language 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:

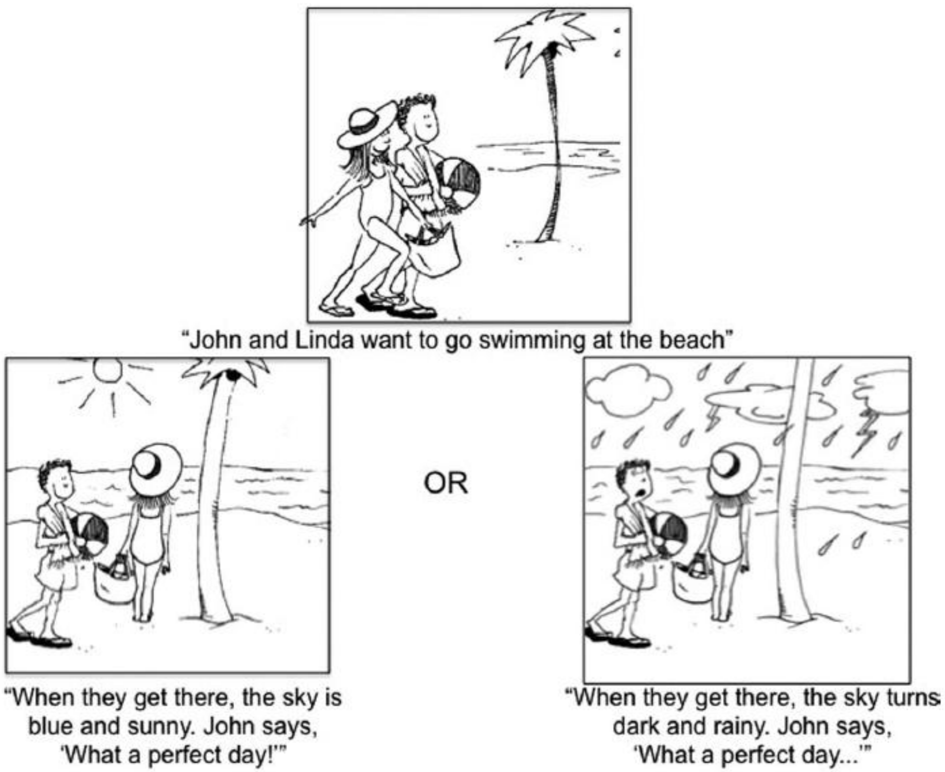
- lower mean (60% vs. 83%)
- greater range
- participants with standard scores outside the normal range

(5 below 25% vs. 0)

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

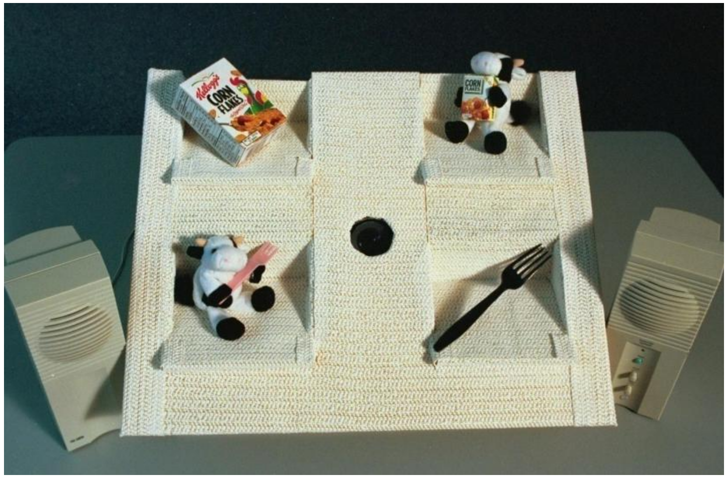
Intact interpretation of ironic remarks in teens

(Colich et al., 2010)



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”

Goal: to manipulate some set of social cognitive abilities

Controlling: 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

III. A few studies on pragmatics in autism

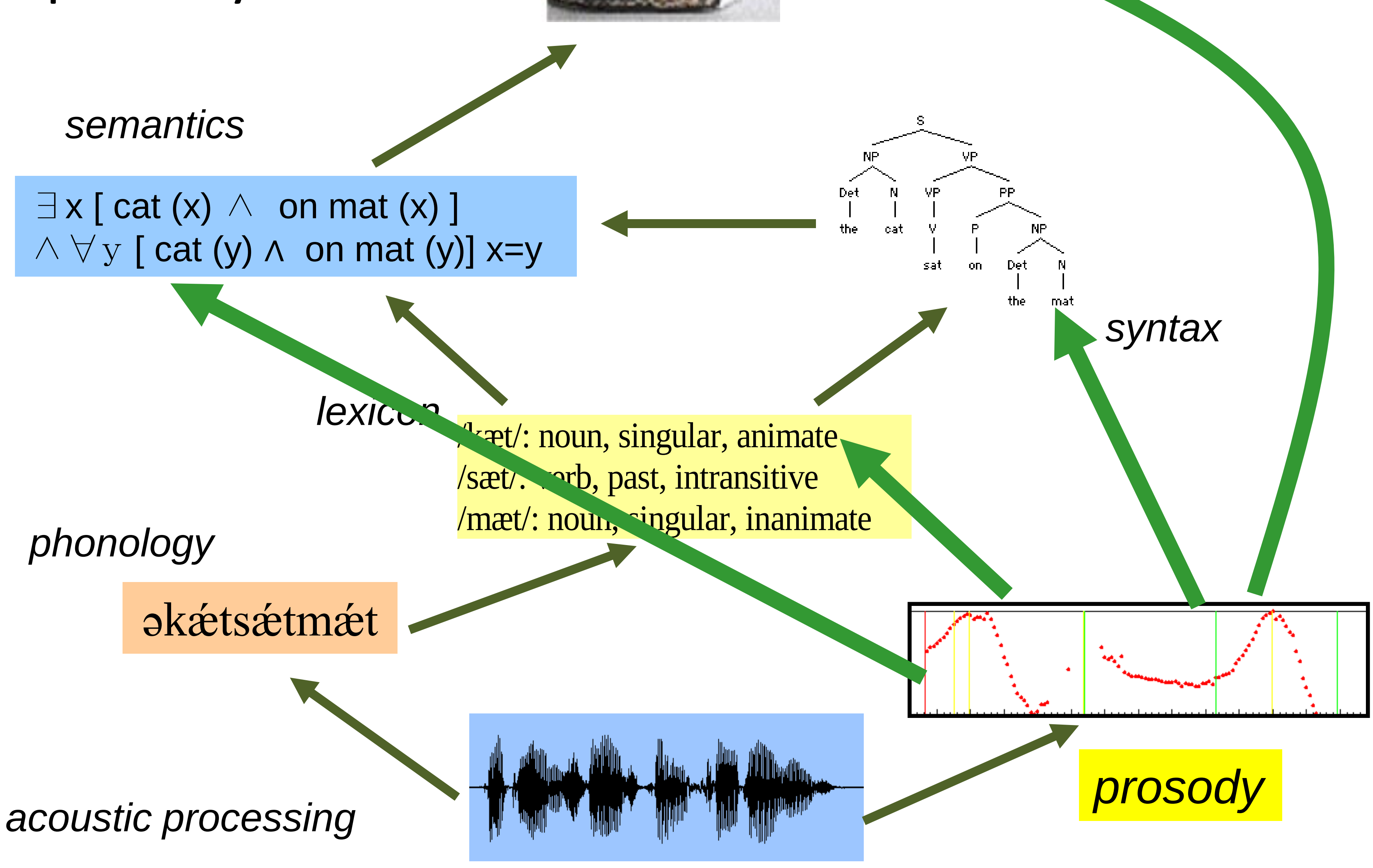
A. Prosodic processing in ASD

Pragmatic and non-pragmatic functions

Working hypothesis

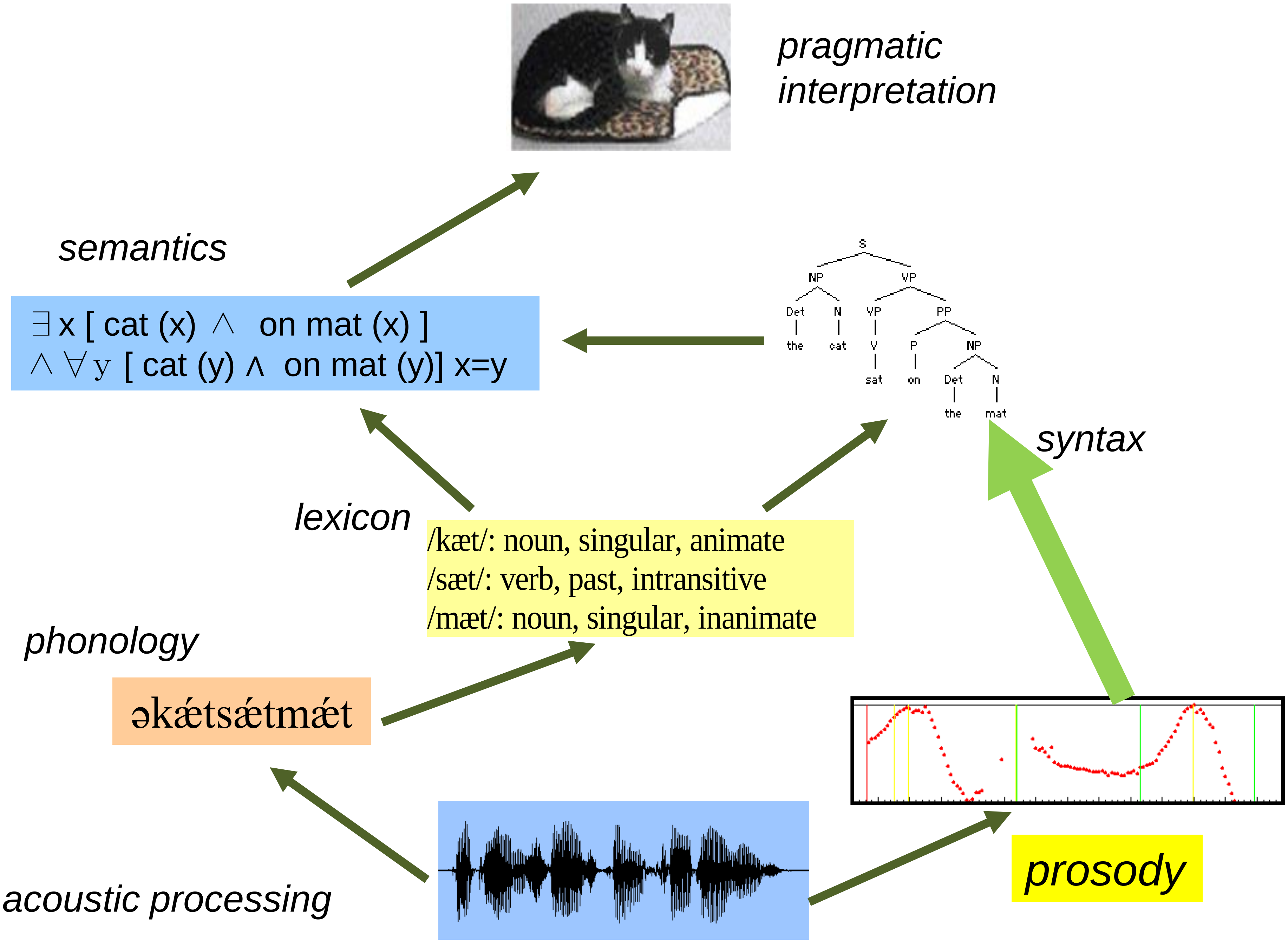
- There is no global prosodic impairment in highly verbal autism
  - Depends which level of representation prosody is constraining

What does prosody do?



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
∃ x [cat (x) ∧ on mat (x)]
∧ ∀ y [cat (y) ∧ on mat (y)] x=y
S
NP
VP
Det
N
VP
PP
the
cat
V
P
NP
sat
on
Det
N
the
mat
syntax
lexicon
/kæt/: noun, singular, animate
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/mæt/: noun, singular, inanimate
phonology
əkǽtsǽtmǽt
prosody
acoustic processing

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

Diehl, Paul & Snedeker (submitted)

Paradigm

(Snedeker & Yuan, 2008)

- Instrument Prosody

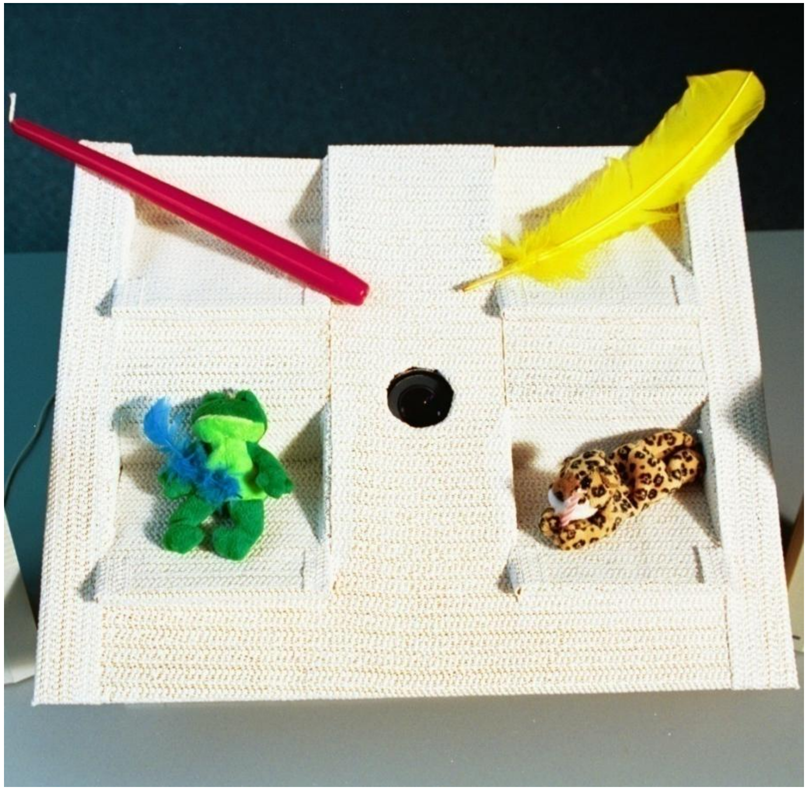
  You can feel the frawwg….
  ….with the feather

- Modifier Prosody

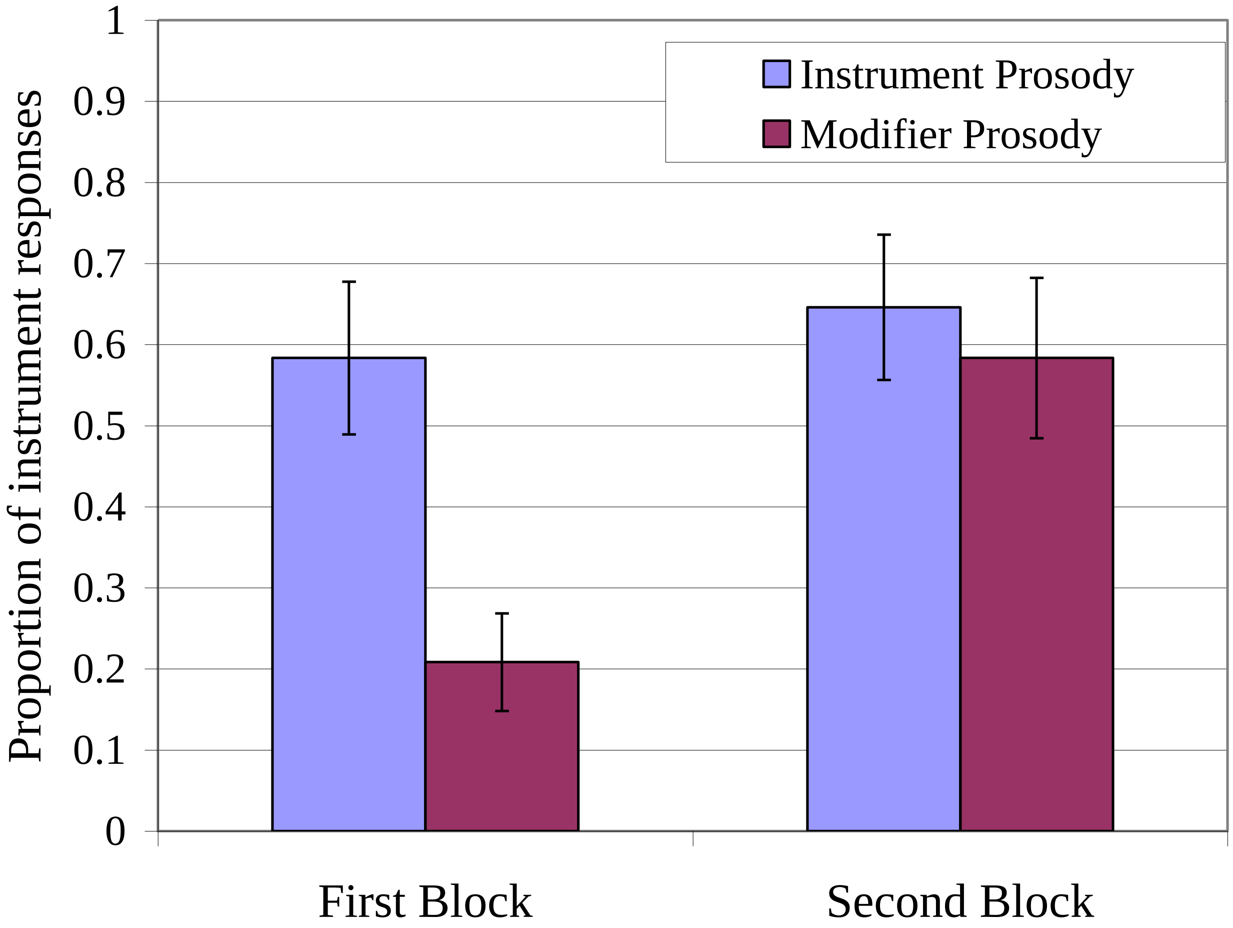
  You can feeeel….

  ….the frog-with-the-feather

- Blocked Design



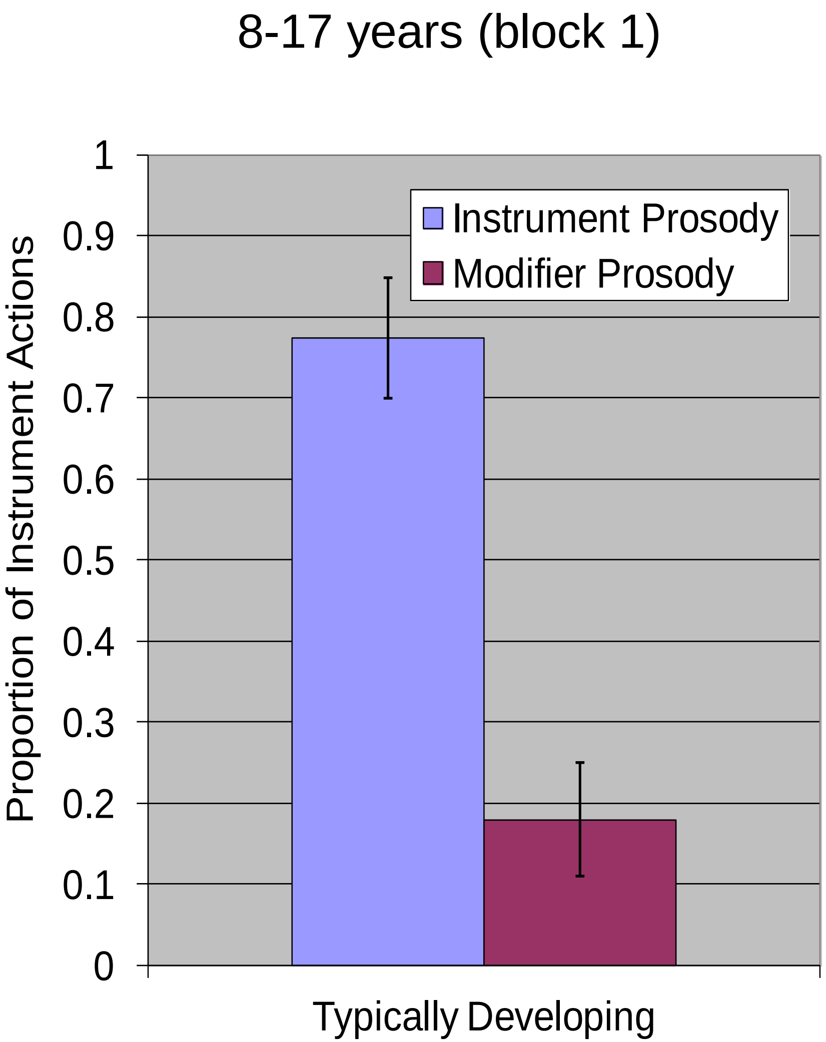
Preschoolers use prosody …but only for the first block of trials



Snedeker & Yuan, 2008

Prosody affects syntactic analysis (actions)

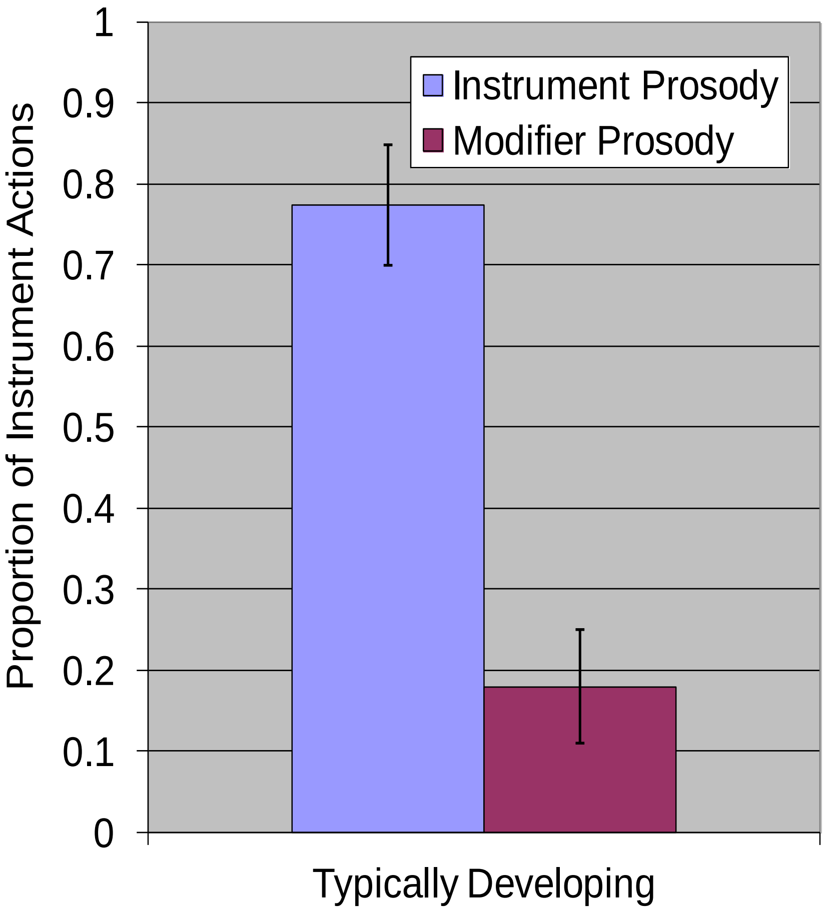
Typically-developing Children



Prosody affects syntactic analysis (actions)

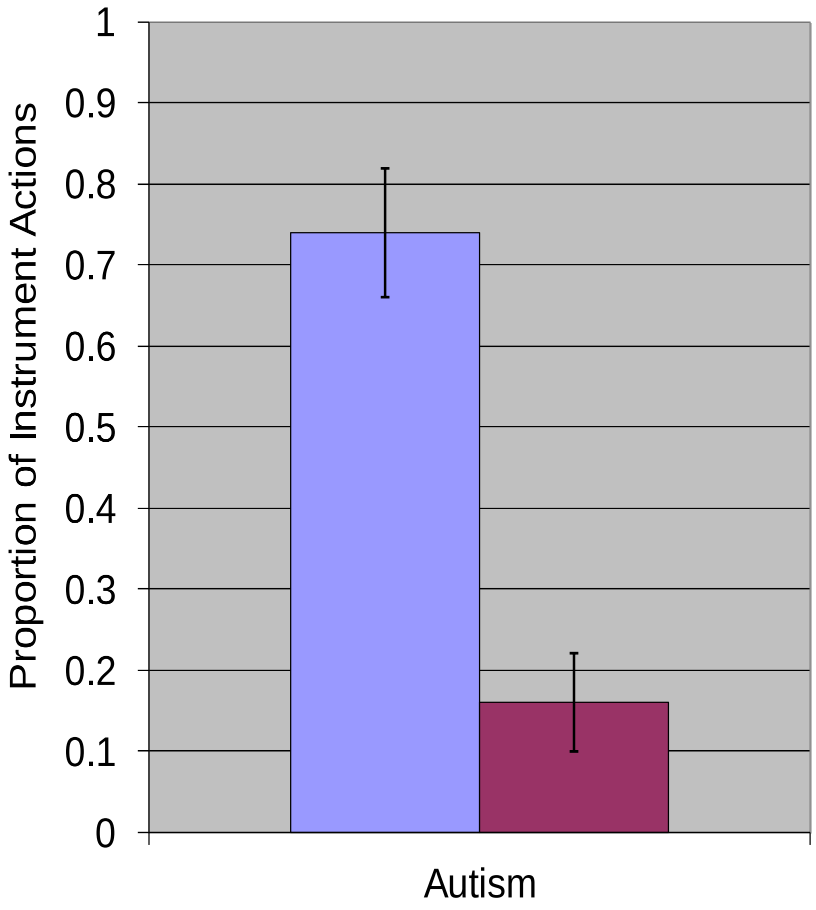
Typically-developing Children

8-17 years (block 1)

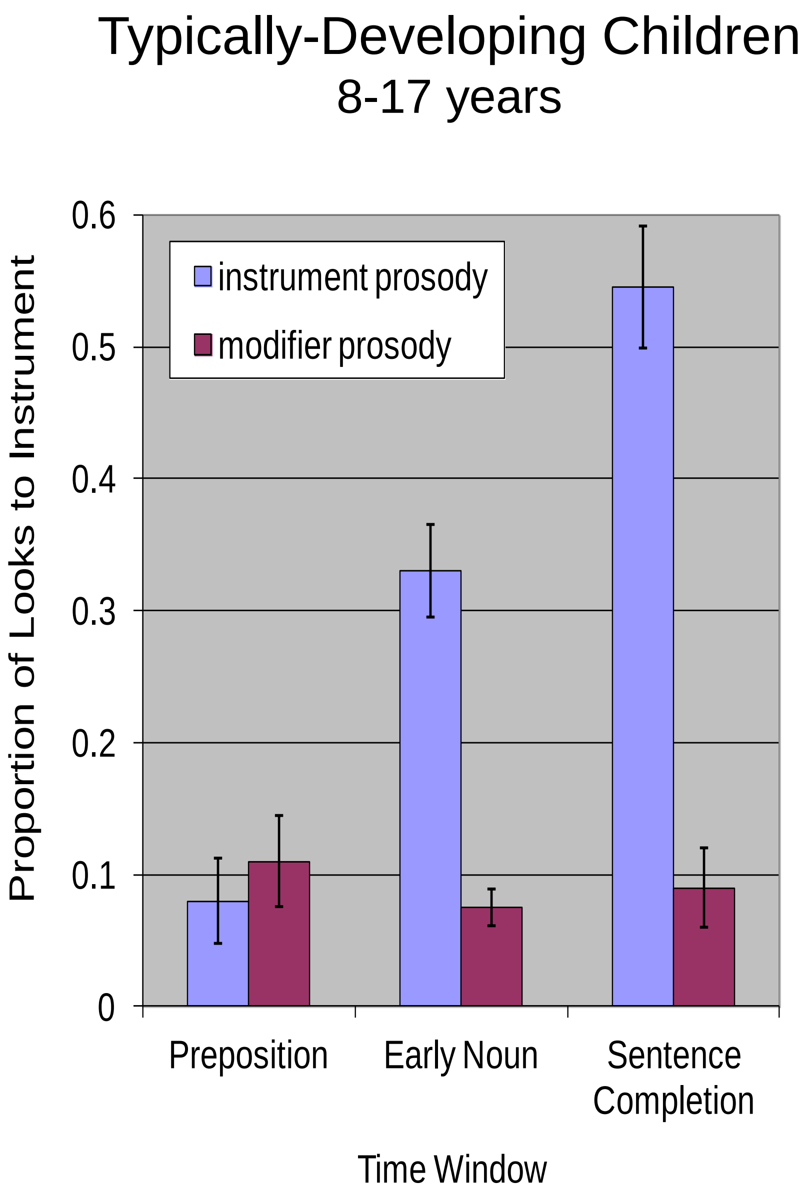


Children with Autism

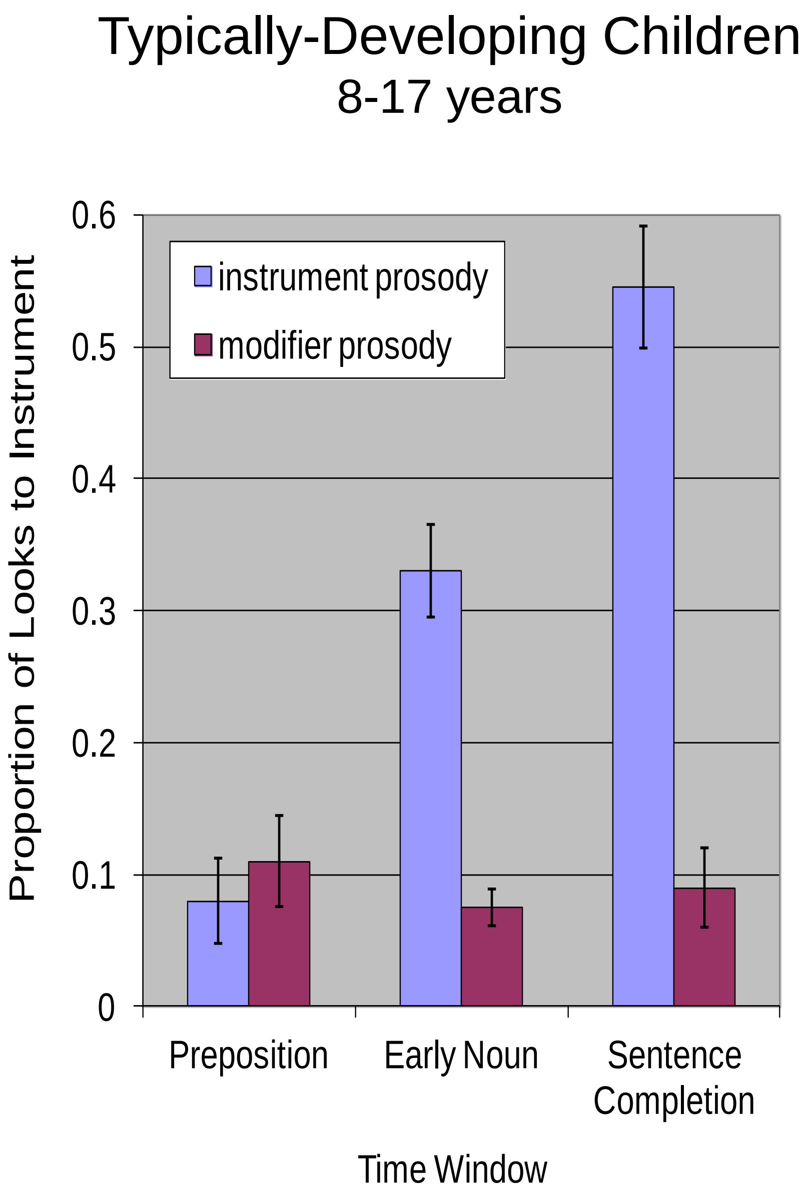
8-17 years (block 1)

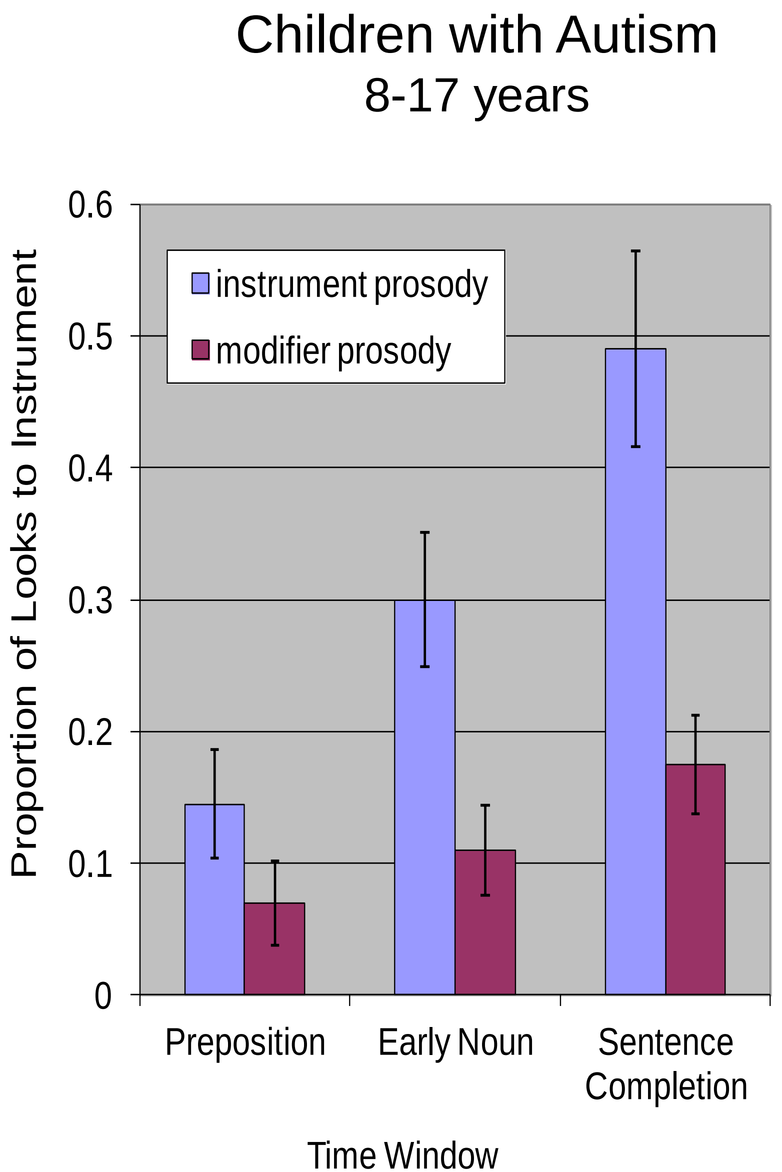


Eye movements demonstrate rapid use of prosody

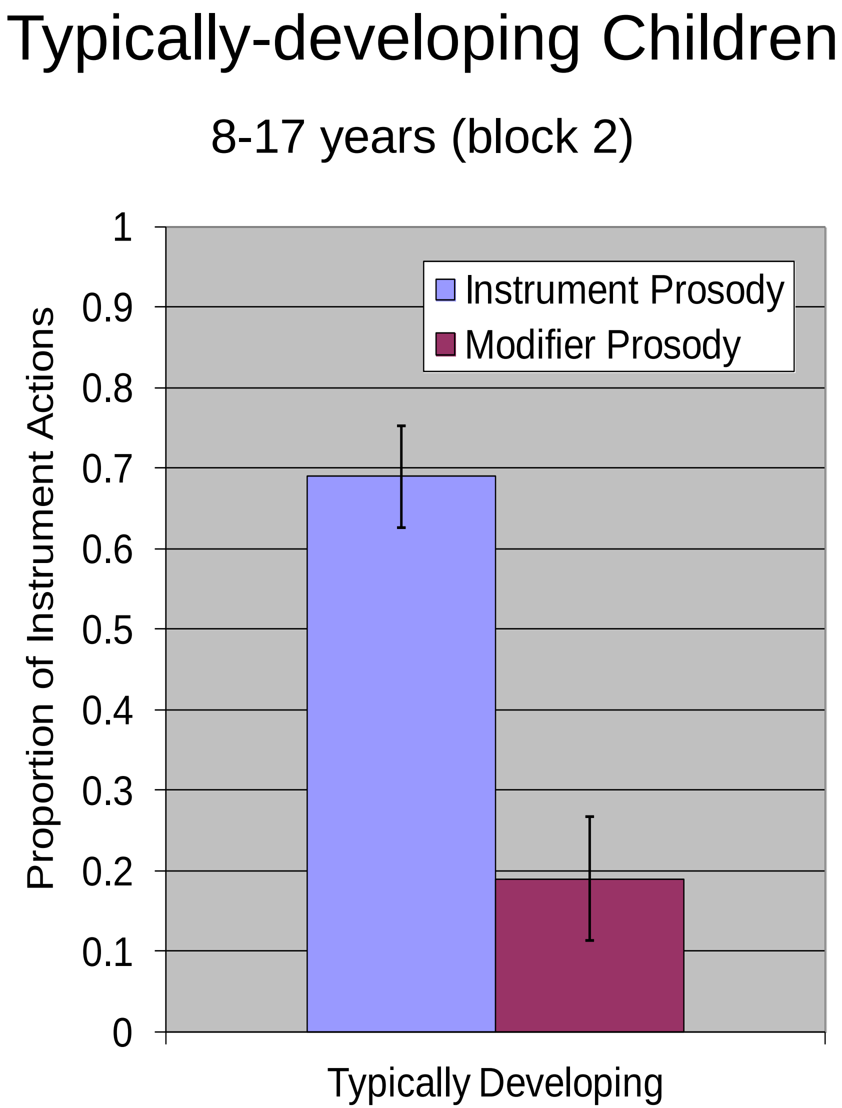


Eye movements demonstrate rapid use of prosody





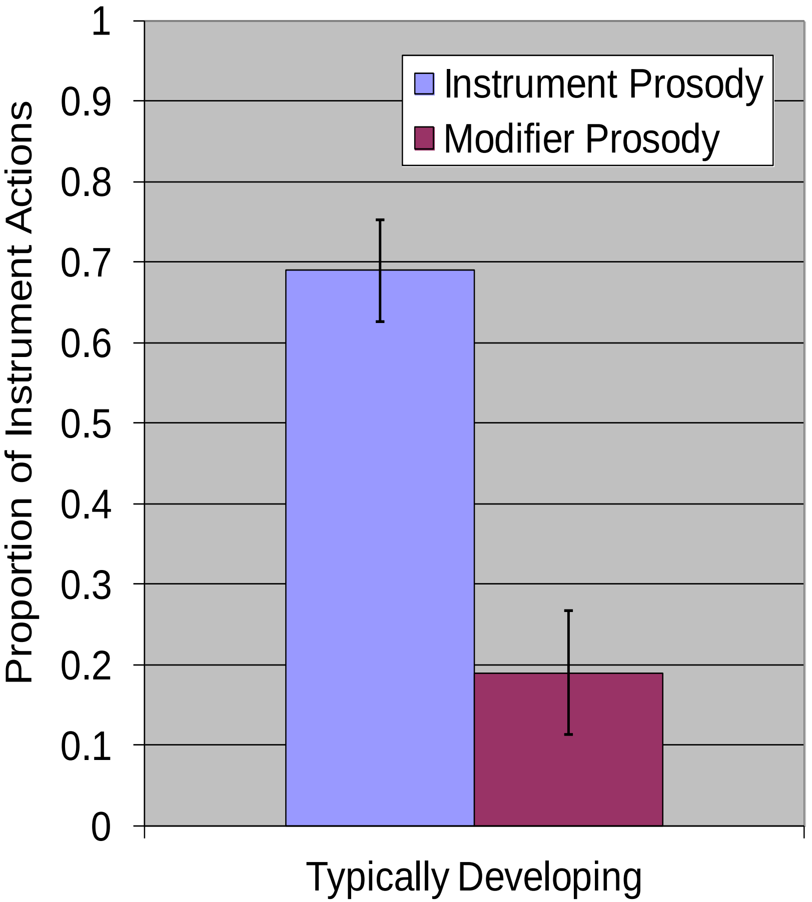
Typically-developing children do not perseverate



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

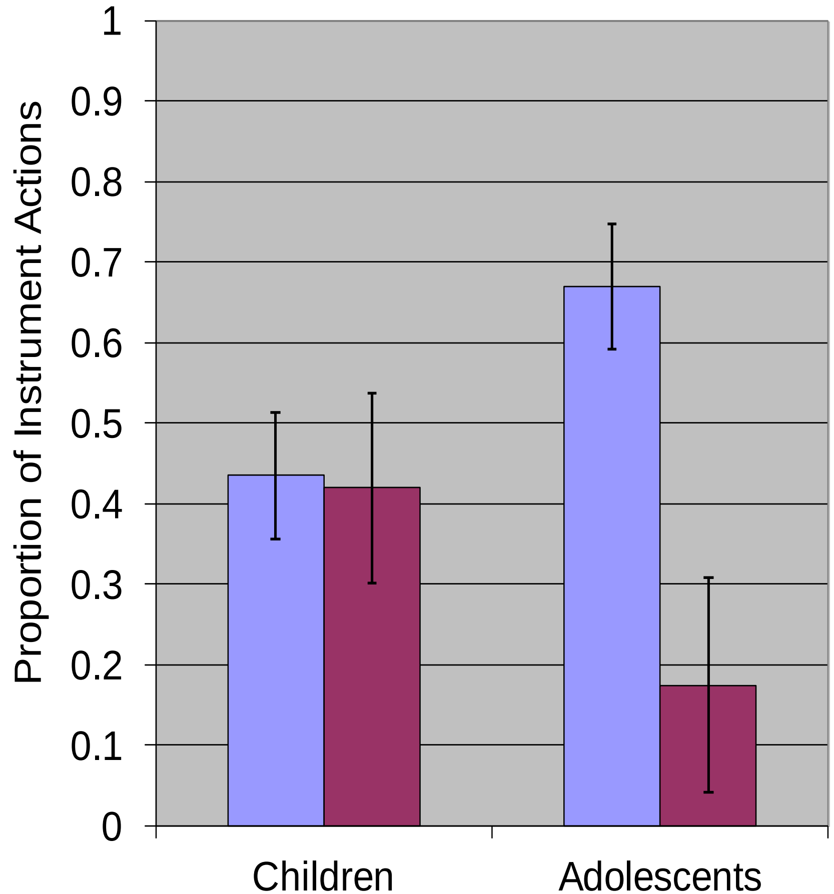
Typically-developing Children

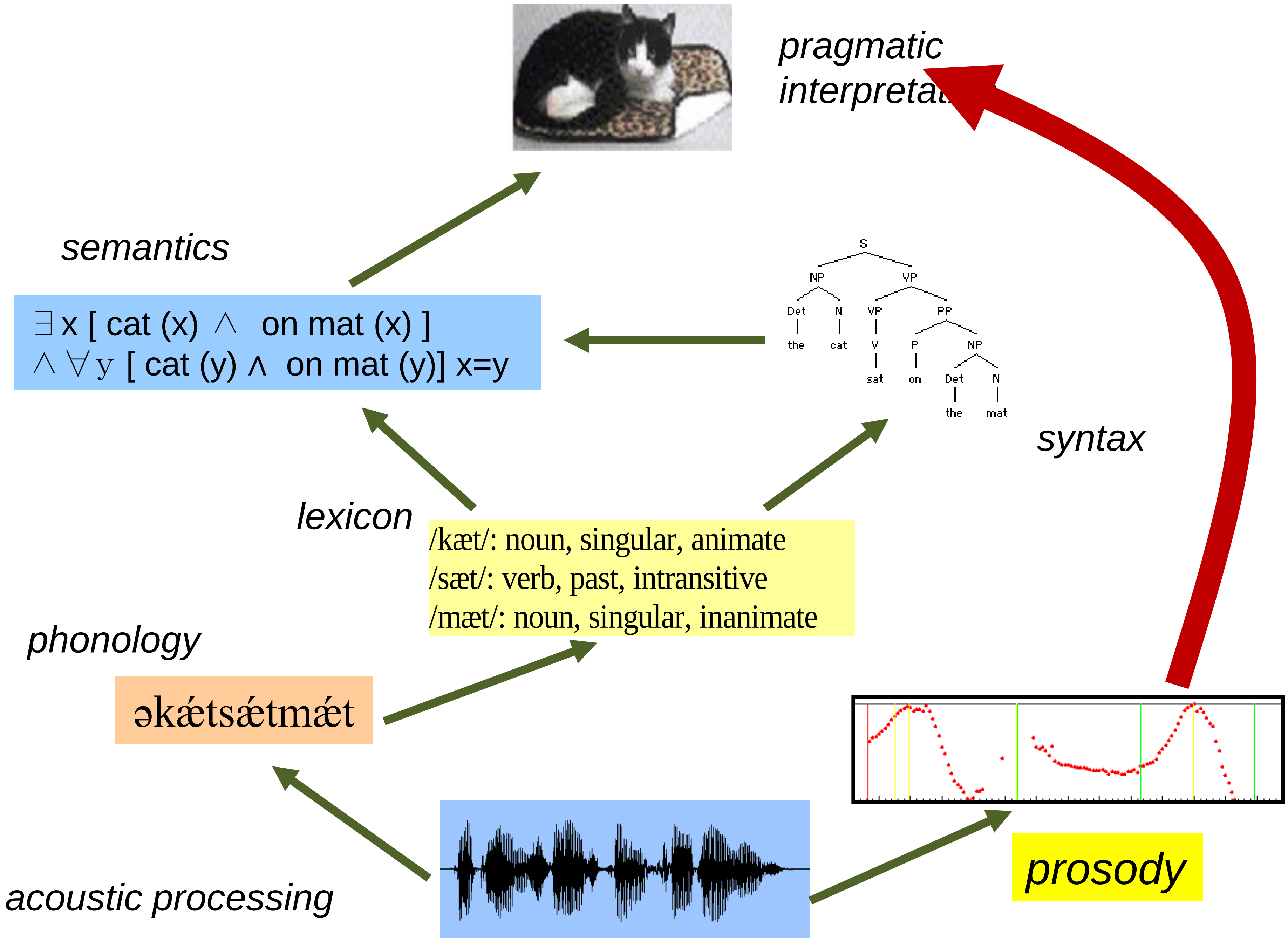
8-17 years (block 2)



Children with Autism

8-17 years (block 2)





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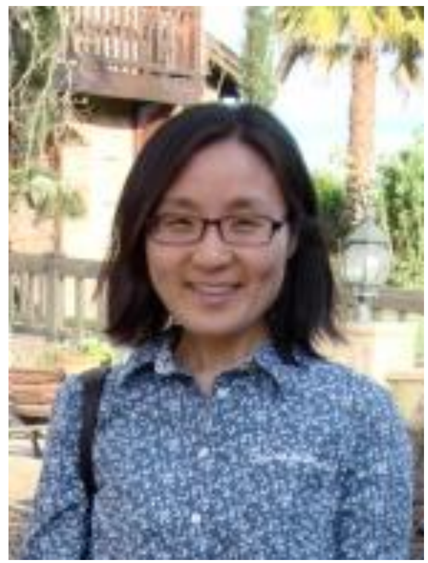
acoustic processing
prosody

How do children with autism interpret pitch accents?

Tracy Brookhyser



Eun Kyung Lee

Becky Nappa

SFARI SIMONS FOUNDATION AUTISM RESEARCH INITIATIVE

A: How was your parents' visit?

B: OK.

My dad bought a BB gun for Oscar.

What should A say next?

A: How was your parents' visit?

B: OK.

My dad bought a BB gun for *Oscar*.

But he's only six!

Was his brother jealous?

A: How was your parents’ visit?

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 parents’ visit?

B: OK.

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

How is <u>he</u> doing?

What did your <u>mom</u> 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 ___

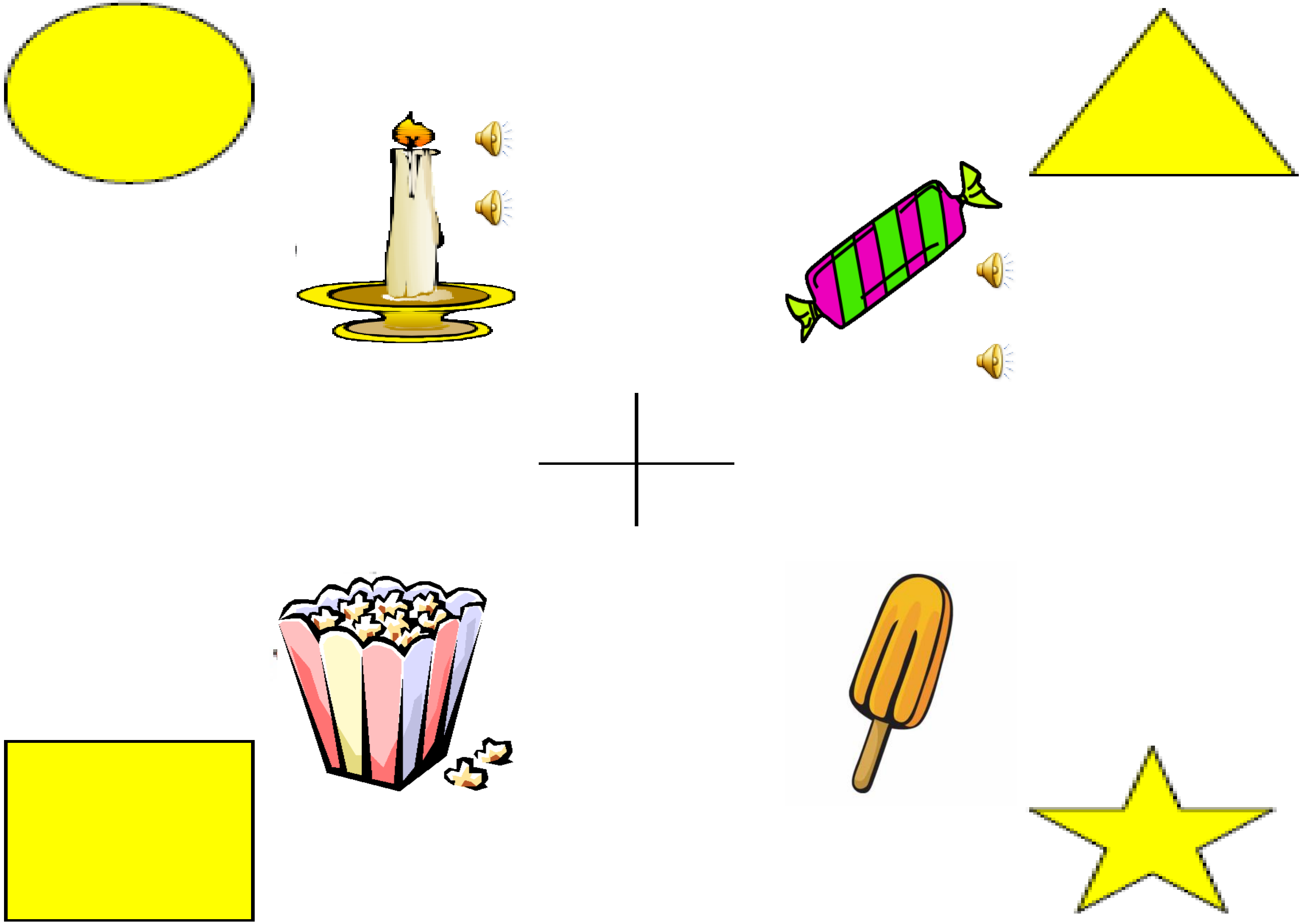
- Hypothesis 2: accent provides contrast set (Rooth, 1992)
  - Accent marks a variable
  - Replace variable with alternate values
  - To get set of alternatives under consideration

Study 2: prosody & discourse structure

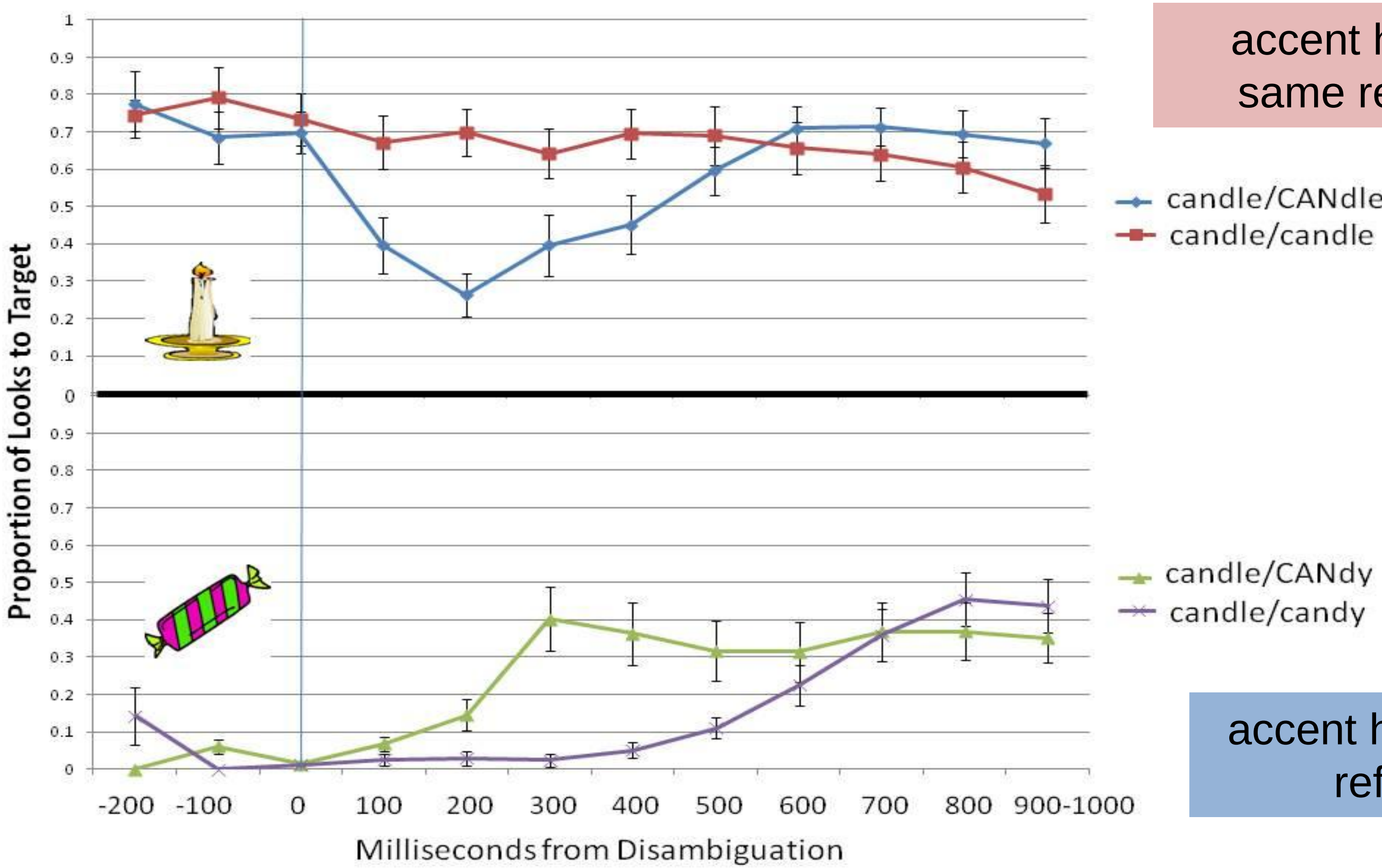
- Two functions of pitch accents (stress)
  - Cue to novelty (Dahan et al., 2002)
  - Cue to contrast set (Ito & Speer, 2008)
- 24 children with autism (5 – 10 yrs)
  - ADOS confirmed diagnoses
  - TROG (syntax) scores above 80
  - Full scale and verbal IQ above 80 (KBIT)
- 24 typically developing controls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

Nappa & Snedeker (in prep)

“Put the candle on the square. Now…”



Typical kids use prosodic stress as cue to novelty

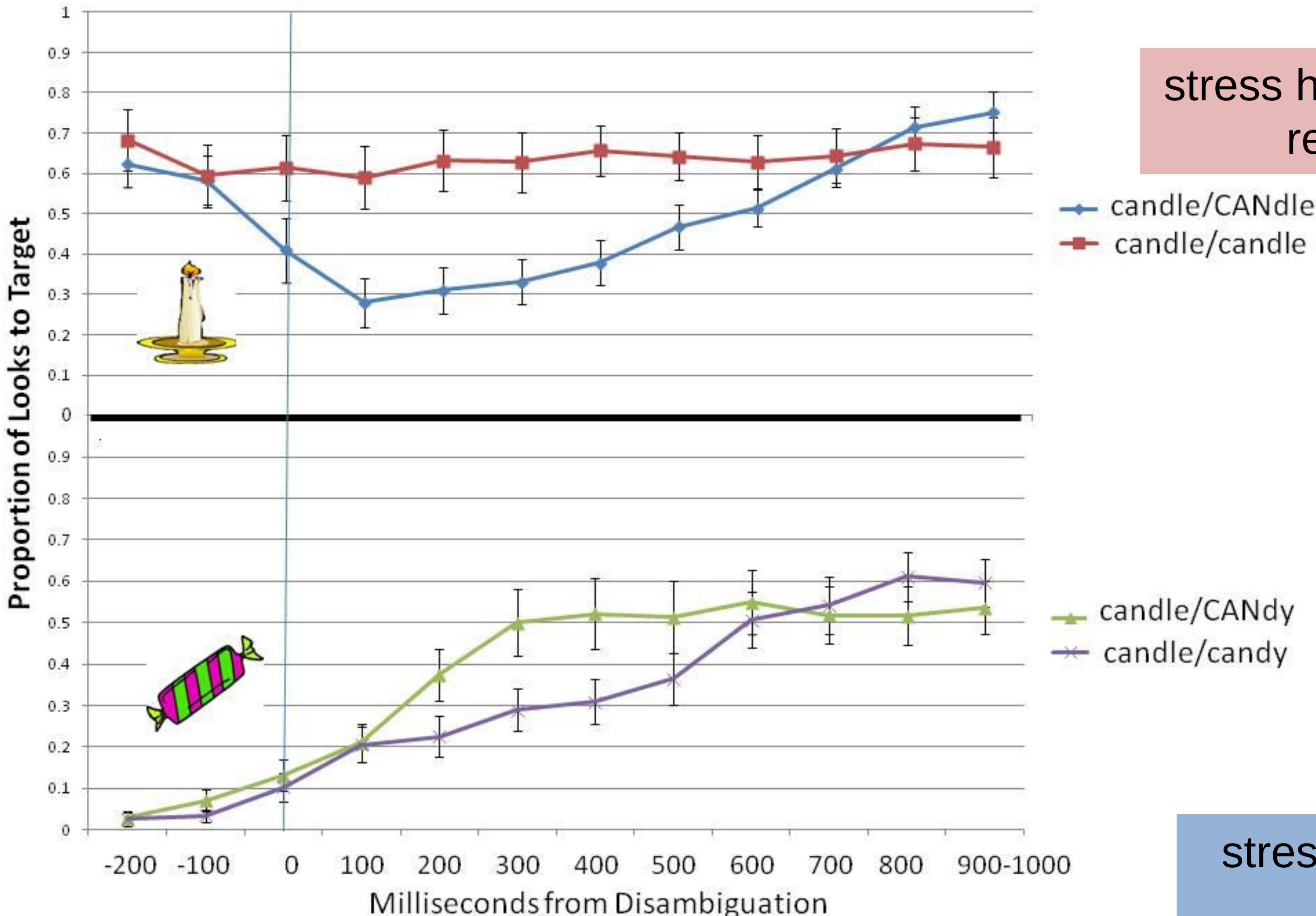


accent hinders same referent

accent helps novel referent

Nappa & Snedeker (in prep); see also Arnold (2008)

Kids with ASD do too

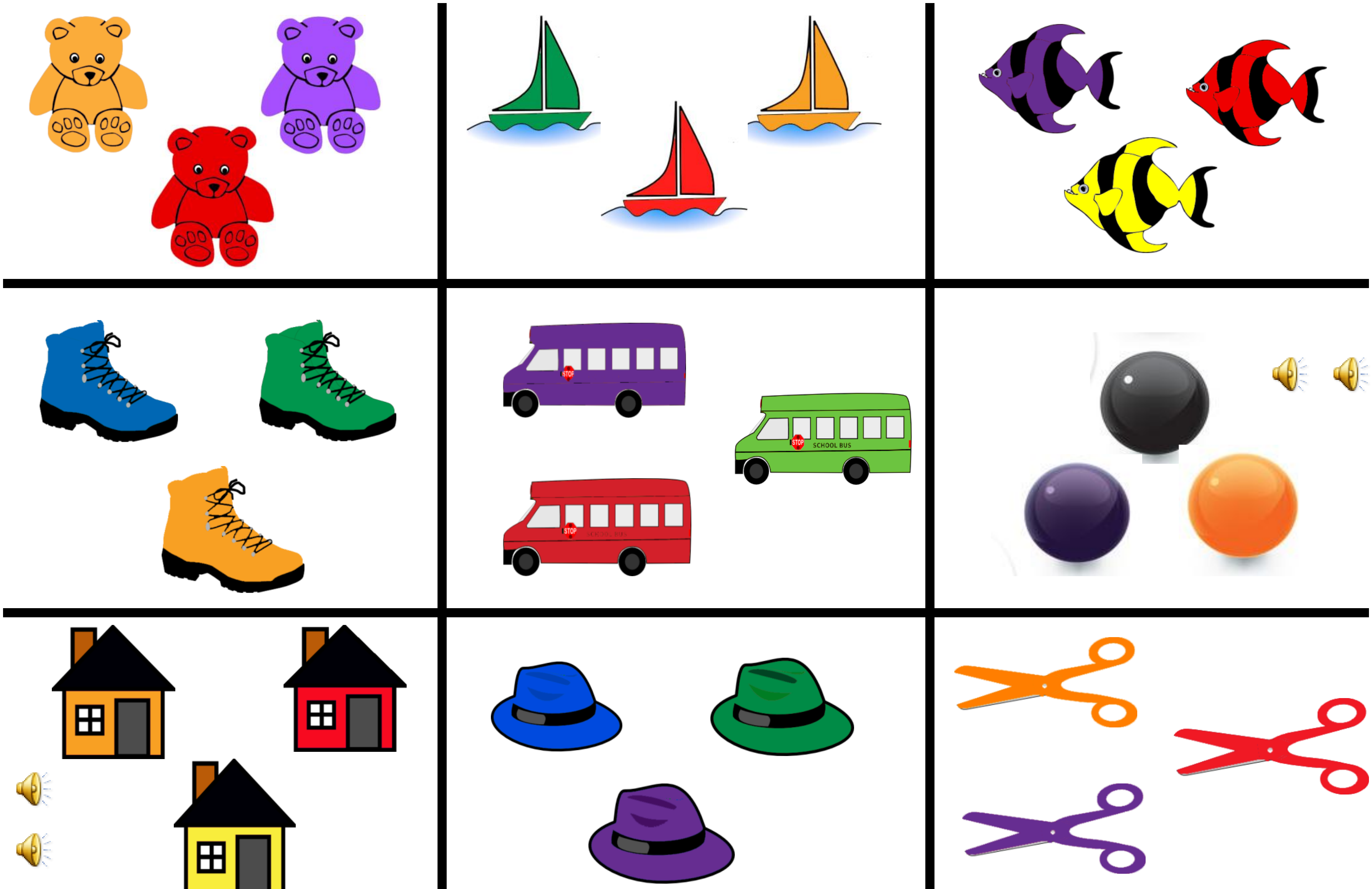


stress hinders same referent

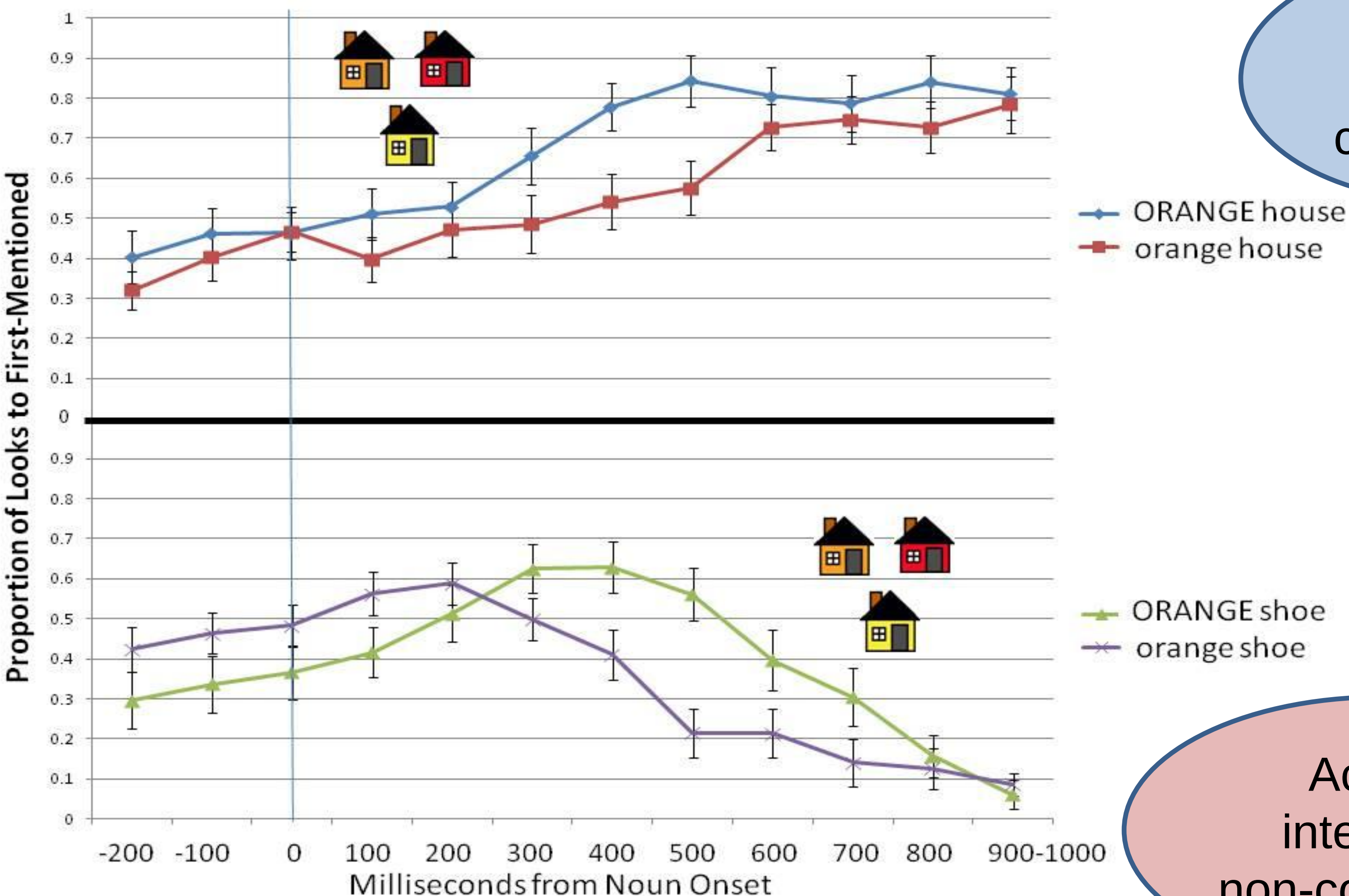
stress helps novel referent

Nappa & Snedeker (in prep)

“Click on the yellow house. Now…”



Typical kids use accent to identify contrast

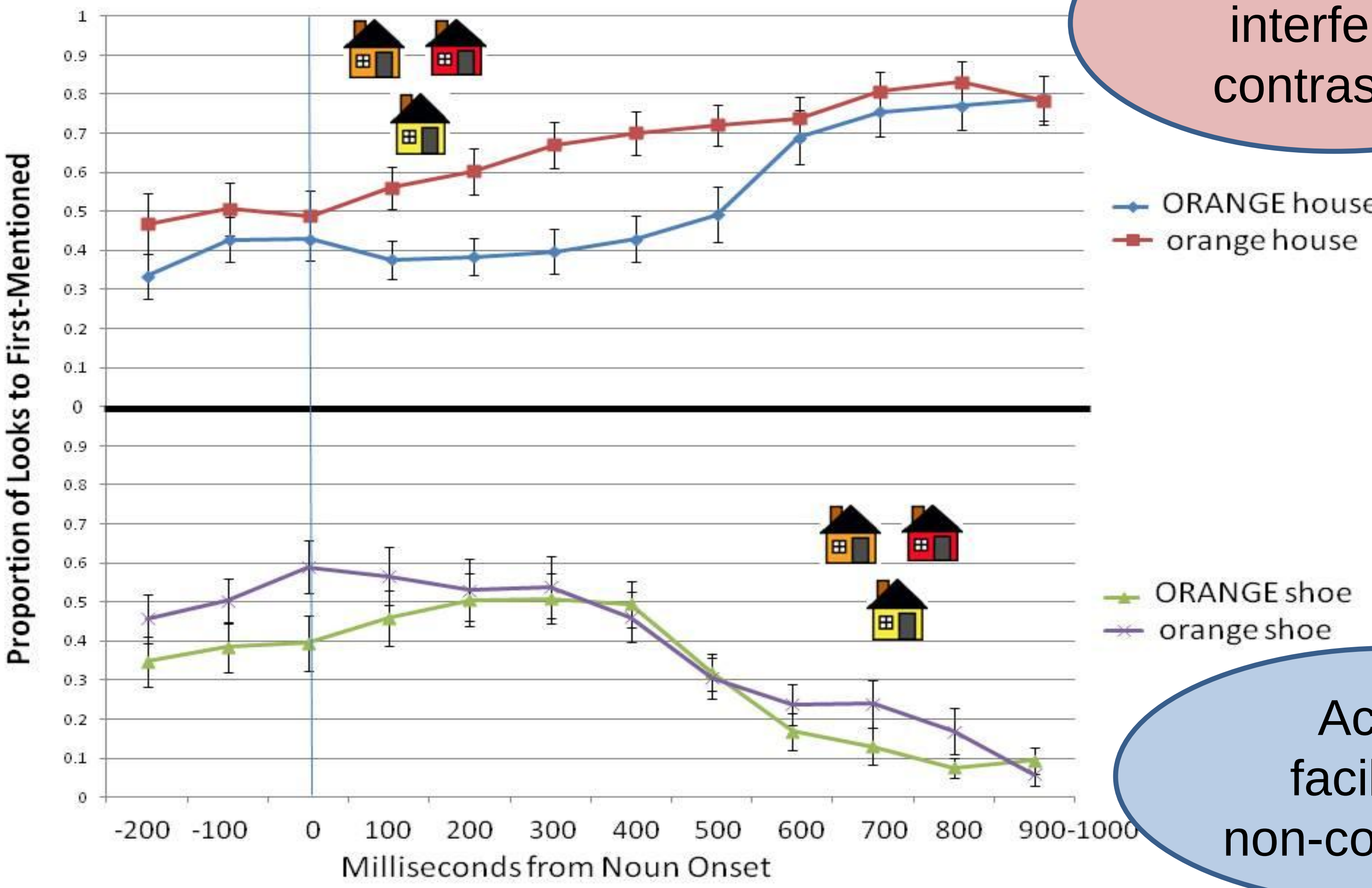


Accent facilitates contrastive

Accent interferes non-contrastive

Nappa & Snedeker (in prep); see also Ito et al. (2011)

Kids with ASD have the opposite response!



Accent interferes contrastive

Accent facilitates non-contrastive

Nappa & Snedeker (in prep)

- 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

In sum

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. Thus SI breaks down with language skills
    - Consistent with a distinction btw grammatical/social inferences or explicatures/implicatures?

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).

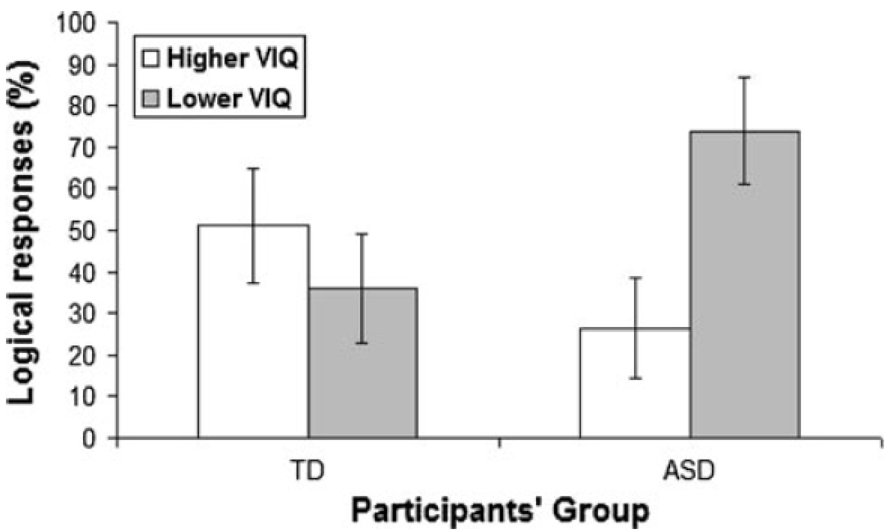


Fig. 1 Percentage of inclusive answers in the Or TT condition as a function of VIQ category (higher VIQ, lower VIQ) and group (TD, ASD)

Autism and scalar implicature

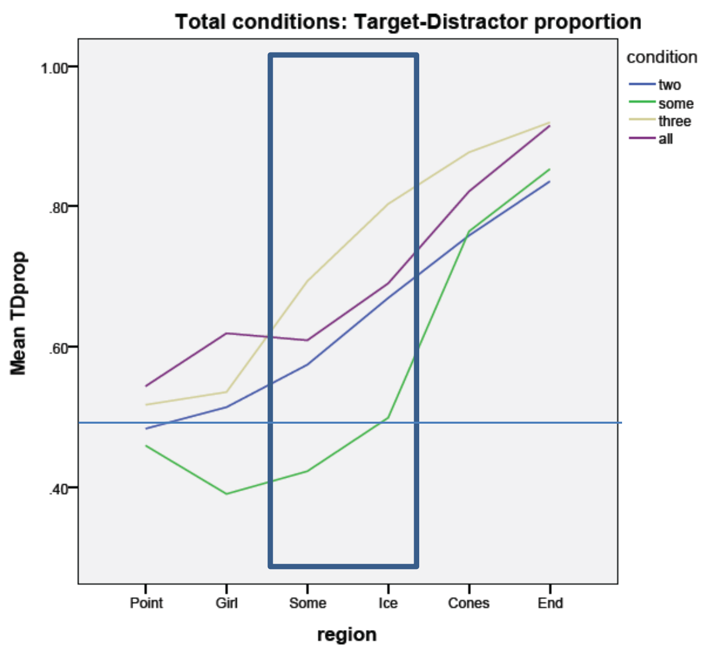
- Adults and teens with autism make SI's as often as language-matched controls (Pijnaker et al., 2008; Chevallier et al., 2010).
- Early deficit could disappear by 13
  - Ex: Deficits in Theory of Mind task only present until verbal mental age of 6-7 (Happe, 1995)
  - SI improves from 4 to 10 years
-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

Our study
(Hahn, Huang & Snedeker, in prep)

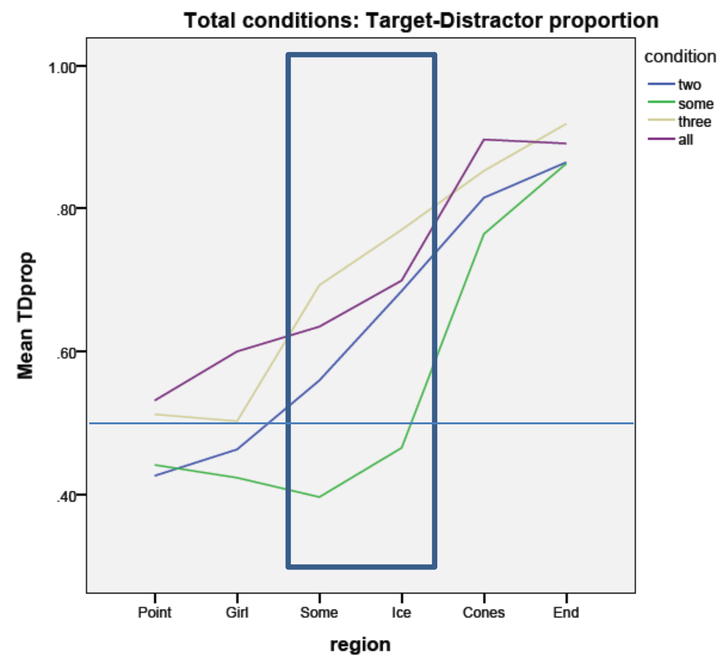
Noemi Hahn

- 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)
- 6-9 year olds children
  - 40 with High Functioning Autism
  - 40 Typically Developing
  - Matched on: age, gender, CELF syntax scores

Same online processing profile



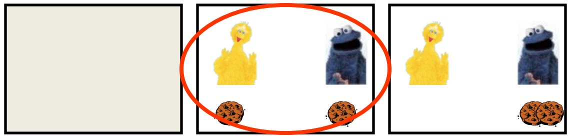
Typically Developing



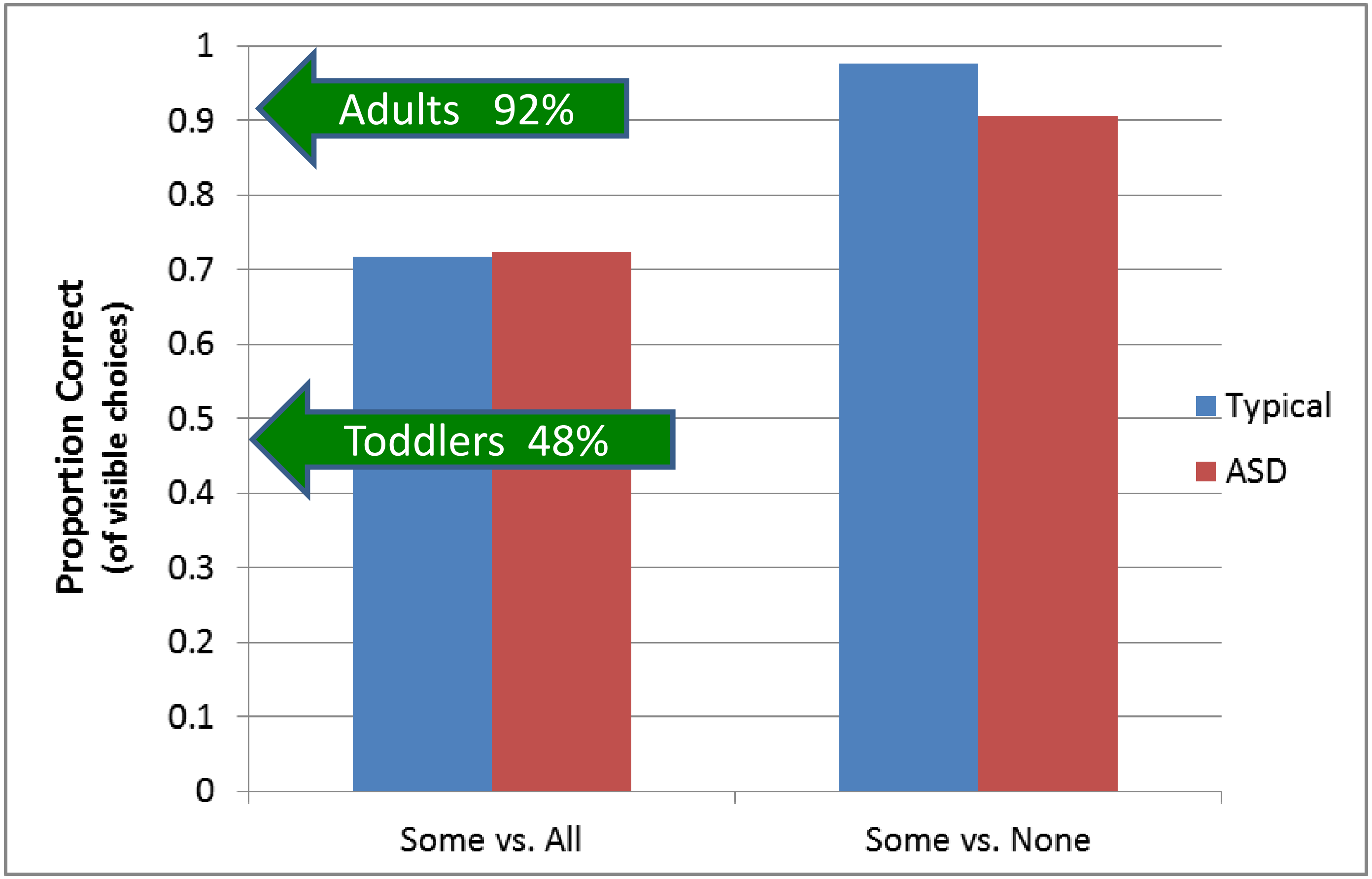
Highly Verbal ASD

Some -------

Hahn, Huang & Snedeker, in prep

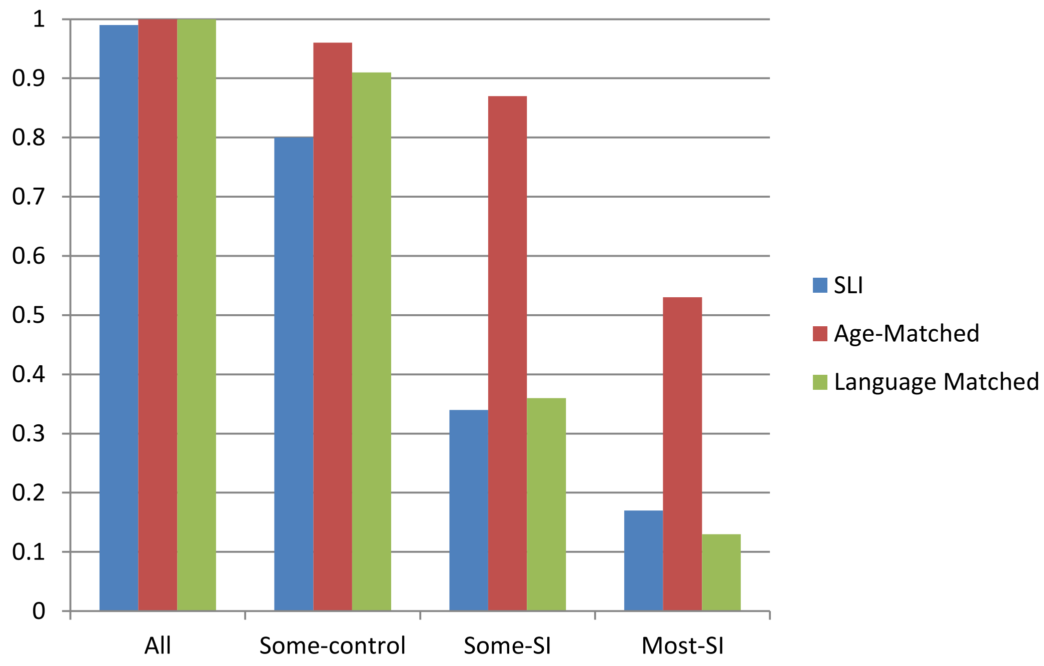


During the period where SI is developing children with ASD perform as well as controls



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 <u>communication</u> scale (not social scale)

- My suspicion:
  - In college students, communication scale may capture differences in <u>language skills</u> not social reasoning
    - NB: Noveck's correlations are with the ASQ <u>social</u> 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!

I look forward to meeting many of you again

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