Pragmatic and Prosodic Processing in Autism

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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
2. Most disorders are not “natural kinds”
3. Developmental profiles change over time
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

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
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 yndrome as natural kind

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 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?
Things to keep in mind

1. A developmental disorder is rarely isolated to a single module or function
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3. Developmental profiles change over time
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

Percentage of correct judgements

<table>
<thead>
<tr>
<th></th>
<th>Photo</th>
<th>Belief</th>
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<tbody>
<tr>
<td>4-year-olds</td>
<td></td>
<td></td>
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<tr>
<td>Autistic children</td>
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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
Most children with autism have an intellectual disability

![Distribution of Full Scale IQ](image)

- University Convenience Sample
- Normal Distribution
- ASD (UK)

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

- Pragmatics & Prosody
- Syntax & Phonology
- Word Learning
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 LSPG. 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.
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)

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?

semantics

∃x [ cat (x) ∧ on mat (x) ] ∧ ∀y [ cat (y) ∧ on mat (y) ] x=y

syntax

lexicon

phonology

acoustic processing

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
The image contains a diagram illustrating the relationships between various linguistic components. Here is a breakdown of the diagram:

**Semantics**

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

**Lexicon**

- `/kæt/`: noun, singular, animate
- `/sæt/`: verb, past, intransitive
- `/mæt/`: noun, singular, inanimate

**Phonology**

- `/kætsætmæt`

**Syntax**

A tree diagram showing the structure of a sentence with the following components:

- **NP**: Noun Phrase
- **VP**: Verb Phrase
- **PP**: Prepositional Phrase
- **Det**: Determiner
- **N**: Noun
- **V**: Verb
- **P**: Preposition

**Prosody**

Graphic representation of acoustic signals.
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, Friedberg, Paul & Snedeker (2015)
Paradigm
(Snedeker & Yuan, 2008)

• Instrument Prosody

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

• Modifier Prosody

You can feeel....
.....the frog-with-the-feather

• Blocked Design
Preschoolers use prosody but only for the first block of trials

Snedeker & Yuan, 2008
Study 1: prosody and syntax

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Diehl, Friedberg, Paul & Snedeker (2015)
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

- Proportion of Looks to Instrument
- Time Window

Bar chart showing the proportion of looks to instrument for different time windows:
- Preposition
- Early Noun
- Sentence Completion

Legend:
- instrument prosody
- modifier prosody
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
The image contains a diagram illustrating the relationship between various linguistic components. At the top, there is a note indicating "pragmatic interpretation." Below, the diagram is divided into sections labeled "semantics," "syntax," "lexicon," "phonology," and "acoustic processing." Each section contains relevant information:

- **Semantics:**
  - The formula: $\exists x \ [ \text{cat}(x) \land \text{on mat}(x) \land \forall y \ [ \text{cat}(y) \land \text{on mat}(y)] \ x=y$

- **Syntax:**
  - A tree diagram representing grammatical structure.

- **Lexicon:**
  - Words and their definitions:
    - /kæt/: noun, singular, animate
    - /sæt/: verb, past, intransitive
    - /mæt/: noun, singular, inanimate

- **Phonology:**
  - The pronunciation: әkәtsәtмәт

- **Acoustic Processing:**
  - A waveform graph representing sound patterns.

Additionally, there are symbols and mathematical expressions used in the diagram, such as existential quantifiers and logical conjunctions, which contribute to the overall representation of linguistic processes.
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

Nappa & Snedeker (in prep)
“Put the candle on the square. Now...”
Typical kids use prosodic stress as cue to novelty

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

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 ___

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

Huang & Snedeker, 2011
Divergent Findings in Visual World Paradigm

Delayed Upper Bound for “Some”

Instant Upper Bound for “Some”

Huang & Snedeker (2009)

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)

Underlined studies manipulated encoding
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”)

Auditory input
“some of”

Lexical Access
“some”

Semantic analysis
SOME (possibly all)

Pragmatic analysis
SOME-AND-NOT-ALL

Bottom-up analysis
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)
Pragmatic analysis

Top-down analysis

Visual input
SUBSET

SOME-AND-NOT-ALL
Lexical access

Semantic Analysis

Pragmatic analysis
SOME-AND-NOT-ALL

Visual input
SUBSET

Top-down analysis

Lexical access
“some”
Lexical access

"some"

Semantic Analysis

SOME

Pragmatic analysis

SOME-AND-NOT-ALL

Visual input

SUBSET

Auditory input

"some of"

"some"
Top-down analysis

Lexical access "some"

Pragmatic analysis

Semantic Analysis

SOME-AND-NOT-ALL

Visual input SUBSET

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
Lexical Access

Semantic analysis
SOME (possibly all)

Lexical Access
“some”

Pragmatic analysis
SOME-AND-NOT-ALL

Visual input
SUBSET

Pragmatic analysis
SOME-AND-NOT-ALL

Semantic Analysis
SOME

Lexical access
“some”

Bottom-up analysis
Top-down analysis

Dual encoding

Single encoding
My take on SOA for scalar implicature

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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).

![Graph showing logical responses (%)](image)

**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)

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

Noemi Hahn
Same online processing profile

Typically Developing

Some

Highly Verbal ASD

Hahn, Huang & Snedeker, in prep
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.

![Bar chart showing proportion correct for adults and toddlers in two conditions: Some vs. All and Some vs. None.]

- **Adults:** 92%
- **Toddlers:** 48%

“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!

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