Development and Mechanisms of Language Impairment in ASD: Parallels with other Language Disorders

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Overview

1. Autism spectrum disorder; language
2. Studying high risk infants in first year of life
3. Early concerns and language milestones
4. Mechanisms:
   – Neural underpinnings of domain general functioning
   – Neural underpinnings of speech perception and language;
   – Maternal contributions
5. Comparison to studies of early mechanisms in SLI
6. Conclusions
1. Autism Spectrum Disorder
Autism Spectrum Disorder: DSM 5

1. Impairments in **social communication**
2. Repetitive behaviors and restricted interests

Communication impairments include:
- Failure in back-and-forth conversation
- Deficits in nonverbal communicative behaviors
- Difficulties adjusting behavior to suit various social contexts

In addition need to specify whether ASD occurs with or without accompanying **language impairment**
Language in autism

- Minimally Verbal: 30%
- No Language Impairment: 25%
- Language Impaired: 45%
Developmental profiles

- Over 90% delayed language milestones
- About 20% language regression – loss of words, phrases in second year of life (unique to ASD)
- About 25% accelerated language growth in preschool years – catch up to peers (enrolled in EI)
- Most significant influence of early intervention: promotes language acquisition

Comprehensive behavioral programs (e.g., ABA; ESDM)
Target interventions (e.g., joint attention)
Early intervention: Language outcomes

**ESDM: Two year outcomes**
Dawson et al. 2010

**Joint attention**
Kasari et al. 2008
2. Studying High Risk Infants
Studying early developmental trajectories

• Surge in interest during past decade in studying infants at risk for neurodevelopmental disorders – most extensive now for ASD

• 20+ groups from around the world, forming the Baby Sibling Research Consortium

• Compare infant with older sibling with ASD to low risk control

• (And for us, an attempt to have group with an older sibling with SLI....)
Recurrence rate: 18.7% overall

Ozonoff et al., 2011 - BSRC
ASD demographic risk factors

1. Males > females
2. Family history/genetics
3. (Parental age)
General findings from infant sibling studies

- ASD manifests as change in developmental trajectories (Ozonoff et al., 2010)
- Behavioral onset of ASD in the second year of life – declines in social engagement (eye contact, social smiles)
- Slowed cognitive development
- Delays in language and gesture at 12 months
Our Infant Sibling Project

- Collaboration between Boston University and Children’s Hospital Boston – Charles Nelson
- Time points: 3, 6, 9, 12, 18, 24, and 36 months
- Include wide range of behavioral and observational measures; complement with home video diaries (6-18 months)
- Eye-tracking measures – face and language
- Brain measures – measures of brain function
  - Electrophysiology (EEG; ERP) – face & language
  - Near Infra-Red Spectroscopy (fNIRS)
3. Early Concerns and Language Milestones
Concerns at 6 months

- Language
- Social Com
- RBB

Bars indicate concerns levels for ASD, HRA-, LRC.
Concerns at 9 months

- Language
- Social Com
- RBB

Graph showing concerns for ASD, HRA-, and LRC.
Concerns at 12 months
Infant 12 month gesture use

Gesture Token

Gesture Type

LRC

HRA

ASD

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Early vocalizations @ 12 months

![Bar chart showing vocalizations by group at 12 months]

- **LRC**: Blue bar
- **ASD+**: Pink bar
- **HRA-**: Red bar

**Total Vocalizations**:
- **LRC**: ~90
- **ASD+**: ~50
- **HRA-**: ~110

**Legend**
- LRC: Language Receptive Communication
- ASD+: Autism Spectrum Disorder +
- HRA-: High Risk for Autism -
Growth curves: Mullen language scores

Mullen Expressive Language - cohort raw scores

Mullen Receptive Language - cohort raw scores

Confidence bands of mean expressive language score

Confidence bands of mean receptive language score
4. Mechanisms
Gamma frequency

- Associated with cognition – attention, working memory, learning
- Involved in integrating information in different brain networks, which is required for complex skills
Development of EEG – spectral power

• Baseline/resting state EEG
• Collected at least 2 minutes over frontal regions 6-24 months
Group differences in frontal gamma power

![Graph showing log power (µV^2) versus age of infant (months) with lines for LRC and HRA groups.](image-url)
Speech perception

1. Perceptual narrowing at 9-12 months ---related to attending to the linguistic environment, in social contexts

Do infants later diagnosed with ASD fail to show perceptual narrowing?

2. Studies of children and adults with ASD (and their relatives) show atypical brain asymmetry – non left lateralized for language

Do infants at risk or later diagnosed show atypical lateralization to speech?
Perceptual narrowing study

- Based on Pat Kuhl’s research paradigm
- Double oddball procedure:
  - /da/ - 80% of time standard
  - /ɖa/ - 10% of time non-native contrast
  - /ta/ - 10% of time native contrast

Expect at 6 months infants differentiate standard and non-native contrast; by 12 months should not
6 and 9 months - larger/faster peaks to both deviants relative to standard

12 months - larger/faster peaks to only native deviant relative to standard

NO interaction with group at any age!
Late slow wave – sensitive to lateralization/asymmetry

Low risk:
Right more negative than left at 9 and 12 months

High risk:
No difference at any age
Lateralization of LSW @ 12 months by outcome

Amplitude (µV)

LRC-Typ  HRA-Typ  HRA-Atyp  ASD

Left
Right
Enhanced P150 amplitude to standard /da/ @ 9 months in HRA

a) Amplitude of response to standards
Frontal ROIs

b) Amplitude of response to the deviant
Frontal ROIs

P150 Amplitude (uV)

S1 S2 S3 S1 S2 S3

Dev Dev

HRA

CARE Center for Autism Research Excellence

BOSTON UNIVERSITY
Correlation between amplitude of P150 Response @ 9 months and expressive language @ 18 months
Brain connectivity in ASD

Anatomical connectivity: fewer long range connections (inter-regional) in children and adults with ASD

Functional connectivity is reduced in ASD, compared to controls - intra- and inter-hemispheric connectivity

How early do connectivity differences emerge?

Are they specific to ASD outcome infants?
Functional connectivity in infants

- Measured connectivity during speech task
- Metric of functional connectivity was \textit{event-related coherence in gamma}:
  - Measure of similarity between signals in different regions of the brain, which reflects strength of functional connection between two regions: frontal and parietal
Linear coherence at 6 and 12 months
12 month data for ASD outcomes

[Bar graph showing linear coherence with labels LRC-, HRA-, HRA+]
Connectivity analysis using fNIRS

• Auditory processing paradigm: ABB vs. ABC syllables
• Infants listened to 28 blocks of artificial “words” with syllables in either an ABB or ABC pattern (e.g., penana vs. baloti)
• Infants at high-risk (HRA) and low-risk comparison (LRC) infants were tested at 3-, 6-, 9-, and 12-months
Near-Infrared Spectroscopy (fNIRS)

Same concept as pulse oximetry, but measure O$_2$Hb and DeoxyHb separately.

(courtesy of Aslin Lab, University of Rochester)

(Strangman et al. 2002)
Regions of interest
Findings

Differences in regional connectivity between low and high risk infants

Correlation matrices:
Global connectivity differences between LRC and HRA
Home-based video diaries

• Between 6 and 18 months mothers recorded home videos on a monthly basis
• Recorded interaction with their infant in a series of vignettes (play with novel toys, book reading, toy drop event, social games)
• The videos complement data collected in the lab – naturalistic mother-child interactions
Maternal responses to infants’ vocalizations @ 9 Months
Maternal communication @ 12 months during toy drop

![Graph showing relative proportion of each maternal prompt type for LRC, HRA, and ASD groups.]

- Request
- Question
- Comment
- Gesture
- Gesture+Vocal
Maternal gesture at 12 months

[Box plot diagram showing maternal gesture tokens by diagnostic group (LRC, HRA-, ASD+).]
Summary

- Differences in the first year of life in frontal gamma power – related to risk, not outcome
- Atypical neural response cortical organization and reduced neural connectivity in neural systems underlying speech/language – extreme differences found in ASD outcome infants
- No differences in maternal linguistic or gestural behavior
5. Comparisons to SLI
SLI: Risk factors and early signs

1. Males > females
2. Family history
3. Parental concerns
4. Delays in early gesture use and language milestones
5. Slowed growth in language during preschool years
SLI: Neural/cognitive mechanisms

1. Lower resting frontal gamma 16-36 months (Benasich et al., 2008)
2. Higher rapid auditory processing threshold to tones at 7 months (Benasich & Tallal, 2002)
3. Atypical lateralization of response to tone pairs 6-12 months (Choudhury & Benasich 2011)
4. Delayed mismatch response to changes in syllable length at 2 months (Friedrich et al., 2004)
5. Delayed mismatch response to changes in word stress 4-5 months (Weber et al., 2005)
6. Reduced mismatch response to tones at 6 months (Benasich et al., 2006)
6. Conclusions
Gaps and future research

- Many parallels between risk factors and mechanisms for language impairment in ASD and SLI
- Studies of brain development employ different paradigms and measures
- Longitudinal studies highlight developmental trajectories, which may differ across disorders
- Studies of risk may contribute to development and implementation of targeted early or preventive interventions
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