OVERVIEW
- Overview of infant speech perception abilities over first year of life.
  - tuning into native speech sounds
  - segmenting speech
- Relationship between phonological development and early word learning.
  - minimal pairs
  - native sounds
  - phonotactics
- Implications atypical development.
  - ASD research

AUDITORY DEVELOPMENT
- For infants who are typically developing, the auditory system first experiences sound in the womb at 20 weeks.
- From birth to 4 months, there is limited auditory responsiveness, however the startle response (eyes blink or widen) to loud noise is common.
- Infants differentiate mother’s voice from others and prefer to listen to mother’s voice, shortly after delivery (DeCasper & Fifer, 1980).
AUDITORY DEVELOPMENT

- As an infant approaches four months of age she may turn her head in the direction of sound however the response is variable.
- Localizing the source of sounds promotes spatial awareness.
- By the end of the fourth month the infant consistently demonstrates head turning in response to sound.

AUDITORY DEVELOPMENT

- The infant progressively gains motor control in the neck and becomes strong enough to turn laterally and directly in response to sound by approximately 7 months of age.
  - However, the turn may not be directed to exact location of source of sound if it is below the infant’s eyes.
- Localization of sound at eye level or below occurs between 7 and 9 months and is quick and defined with head turns.
- Sounds originating from any plane, above or below baby provoke a direct and briskly defined response of localization by the end of 13 months of age (Northern & Downs, 2002).

AUDITORY DEVELOPMENT

- By the end of the first year of life, babies can associate the sequence of sounds with specific events or experiences and make connections between sounds and people.
- Babies intentionally produce sounds to communicate.
- Auditory processing is growing in complexity as memories of experiences involving sounds, events, and significant people become more sophisticated (Pollack, Goldberg, & Caleffo-Schenck, 1997).
DEVELOPMENTAL SPEECH PERCEPTION:

- At birth infants can discriminate all possible speech sounds
  - adults discriminate only the sounds of their native language
- Reorganization from universal speech perception to language specific perception occurs between 6 months and 1 year of age

HABITUATION EXPERIMENTS (Eimas et al., 1971)

- Pacifier connected to pressure sensitive meter.
- Each time infant sucks, she receives a speech stimulus (e.g., CV).
- When infants habituate, they suck less often.
- Switch from old sound to new sound and see if sucking rate changes.

EXPERIMENT CONDITIONS

- Habituation Phase: repeat stimulus whenever infant sucks until habituation
- Test Phase: Switch to new stimulus
  - Category Change: different stimulus, from different adult phoneme category, e.g., 20 ms to 40 ms VOT
  - Acoustic Change: different stimulus, from same adult phoneme category, e.g., 20 ms to 0 ms VOT
  - Control Condition: no change in stimulus
- Measure sucking rate at test phase
ENGLISH VOT PERCEPTION

GENERAL INFANT ABILITIES

- Discriminate a wide range of speech contrasts (voicing, place, manner, etc.)
- Discriminate Non-Native speech contrasts
e. g., Japanese babies discriminate r-l
e. g., Canadian babies discriminate d-D
- When does perception narrow to native language sound categories?

WHEN DOES CHANGE OCCUR?

Hindi and Salish contrasts tested on English kids

Janet Werker
U. of British Columbia
INTERIM SUMMARY

- Over the first 12-months, infants narrow their perception of speech sounds to those that occur in their native language.

- However, it is important to remember that the goal of the infant is not necessarily to figure out sound categories, but to learn the words of their native language.
  - segment the speech stream
  - associate words and concepts

STRESS AS A SINGLE CUE FOR WORD SEGMENTATION

WORD SEGMENTATION

- There are spaces between written words in many writing systems.

- Spoken language is continuous.

- Most "spaces" come from voiceless stop consonants, not from silence between words.
SILENCE ≠ WORD BOUNDARY

- Silences in the acoustic signal can be within a word and don’t necessarily align with word or segment boundaries.

BY 8 MONTHS, BABIES ARE LITTLE STATISTICIANS.
- Sensitivity to frequency of co-occurring syllables (Saffran et al., 1996).
- Transitional probability
  - The chance that B will occur given that A has occurred
  - E.g. "Pretty Baby"
    - TP for “baby” is a lot higher than TP for “tyba” (pretty baby)
- If infants can track this kind of statistical information, can they track other kinds of distributional information?

STRESS SEGMENTATION: ENGLISH

- Stress is the prominence of syllables
  - English: conVICT (V) versus CONvict (N)

Predominant stress pattern in English is Strong-Weak (Sw). TROCHAIC
- Stress makes syllables in English:
  - longer
  - louder
  - higher in pitch
PARTICIPANTS

- 8-month old infants
- 32 English monolinguals
- Sequential looking preference procedure

METHOD

- Familiarization Phase

  English

  biFAsenaZIshaviGEbimeFAvishaGEnaseZIime
  - While enjoying a field of tulips

- Test Phase – 2 groups

  Trochaic GROUP
  Initial Stress (SWW)
  Medial Stress (WSW)
  Novel Sequences

  Iambic GROUP
  Final Stress (WWS)
  Medial Stress (WSW)
  Novel Sequences

  (meshabi, shamevi, viname)
METHOD

- No stress in test items
- Random order
- Attention getter, then checkerboard

PREFERENCE RESULTS ENGLISH

<table>
<thead>
<tr>
<th>Trochaic Group</th>
<th>Iambic Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWW</td>
<td>WSW</td>
</tr>
<tr>
<td>p=.016</td>
<td>p&gt;.051</td>
</tr>
<tr>
<td>WWS</td>
<td>WSW</td>
</tr>
<tr>
<td>p=.007</td>
<td>p&gt;.051</td>
</tr>
</tbody>
</table>

DISCUSSION

- English infants appear to make use of stress and favour trochaic units in their segmentation.
  - They pull out all words that align with a trochaic (Sw) pattern
    - initial
    - medial
- Does attention to stress continue on into word learning?
LEARNING NEWS WORDS

- Social information is necessary, but not sufficient to ensure word learning in 12-month-olds (Hollich, Hirsh-Pasek, & Golinkoff, 2000).
  - If the object is not interesting to the infant, then no learning occurs.
- 10-month-old infants will inappropriately map a word to an interesting object, even if speaker’s intent for labeling is directed at a boring object (Prudent, Hirsh-Pasek, Golinkoff, & Hennon, 2006).

LEARNING WORDS

- The results of these studies suggest that word learning is tenuous at these younger ages and that appropriate attention is required to facilitate the mapping between a novel word and object.

- What information might infants attend to at the early stages of word learning?

MINIMAL STRESS

- Can infants young learn two new word-object associations when the words only differ in the stress pattern?

STRESS AND WORD LEARNING

DISCUSSION

- Words differing only in lexical stress are distinguished by infants as young as 12-months.

- They look longer at a mismatch in a newly learned pairing when the word with the incorrect stress pattern is accompanied by the incorrect object.

- Thus stress information helps to disambiguate between similar items.

However, it could be that infants are only storing the stressed syllables...

RESULTS

<table>
<thead>
<tr>
<th>Test Trial Type</th>
<th>Mean Looking Time (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same</td>
<td>6.83</td>
</tr>
<tr>
<td>Object Switch</td>
<td>8.38</td>
</tr>
<tr>
<td>Syllable Switch</td>
<td>10.38</td>
</tr>
</tbody>
</table>

CONCLUSIONS

- 12-months old can learn two new word-object pairings without contextual support.
- 12-month-olds can learn two new words that differ only in the stress pattern!
- Infants are storing the whole word, not just the stressed syllable.
- Representation of the sequence encodes segmental AND stress information.
WHAT OTHER KNOWLEDGE DO INFANTS HAVE ABOUT THE APPROPRIATE FORM OF LABELS?
MacKenzie, Graham, & Curtin (in press)
MacKenzie, Curtin, & Graham (under review)

DO INFANTS HAVE EXPECTATIONS ABOUT SOUND COMBINATIONS AS OBJECT LABELS?

In a interactive naming task:
- Infants will accept a variety of forms as names for objects including:
  - Words
  - Gestures
  - Pictograms
  - Tones
  (E.g., Woodward & Horne, 1999; Namy, 2000; Namy & Waxman, 2001; Namy & Campbell, 2003; Graham & Kilbreath, 2007)

- Developmental change in this openness

DO INFANTS HAVE EXPECTATIONS ABOUT SOUND COMBINATIONS AS OBJECT LABELS?

Categorization and Individuation tasks:
- Infants as young as 3-4 months treat words and tones differently
  (e.g., Ferry, Hengos, & Waxman, in press; Fulkerson & Waxman, 2007, Xu, 2002)
DO INFANTS HAVE EXPECTATIONS ABOUT SOUND COMBINATIONS AS OBJECT LABELS?

So

- In rich naming contexts, infants are symbolically open
- In other tasks, infants distinguish between words and other sounds to guide their categorization behaviour.

But:

- Possibility: The rich, intentional cues provided in interactive tasks may mask infants’ preferences for particular word forms when labeling objects.

CONTRASTING DIFFERENT TYPES OF LINGUISTIC SOUNDS

12-month-olds tested on:

- CVC English Words:
- Vowel-based Communicative Sounds:
- Consonant-based Communicative Sounds:
- Consonantal Sounds:

MacKenzie, Graham, & Curtin, in press
*Developmental Science*

HABITUATION

<table>
<thead>
<tr>
<th>Vowel Comm. sounds</th>
<th>ooh</th>
<th>ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consonant Comm. sounds</td>
<td>memm</td>
<td>sash</td>
</tr>
<tr>
<td>CVC words</td>
<td>tep</td>
<td>wug</td>
</tr>
<tr>
<td>Consonantal sounds</td>
<td>/l/</td>
<td>/ʒ/</td>
</tr>
</tbody>
</table>

Test

<table>
<thead>
<tr>
<th></th>
<th>tep</th>
<th>tep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same Trial</td>
<td>Familiar object-sound pairing</td>
<td></td>
</tr>
<tr>
<td>Switch Trial</td>
<td>Object-sound pairing violated</td>
<td></td>
</tr>
</tbody>
</table>
PROCEDURE
Tested 12-month-old infants (n = 16 per group)

RESULTS

CONCLUSIONS
- Infants will privilege CVC words over other linguistic sounds in a Switch Task
- By 12-months, infants have knowledge about the nature of an appropriate sound form for an object label.
RESEARCH QUESTION

• Is this preference for CVC words driven by the infants’ knowledge of their native language?

• Will this preference for words in the Switch task extend to words from different languages?

• CVCV Japanese words?
  - Phonetically different from English

• CCVC Czech words?
  - Violate English phonotactics

MacKenzie, Curtin, & Graham (under review)

STIMULI

<table>
<thead>
<tr>
<th>Word Type</th>
<th>Language</th>
<th>English</th>
<th>Japanese</th>
<th>Czech</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVCV</td>
<td>English</td>
<td>mido</td>
<td>sika</td>
<td>svet</td>
</tr>
<tr>
<td></td>
<td>Japanese</td>
<td>panu</td>
<td>hasi</td>
<td>plok</td>
</tr>
<tr>
<td>CCVC</td>
<td>English</td>
<td>snet</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Czech</td>
<td>plok</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Tested 12-month-old infants (n =15 per group)

RESULTS
FINDINGS

- 12-month-olds will map both English & Japanese words to objects in an associative learning task
  - Infants are somewhat flexible in types of words they will accept as labels for objects.
  - Flexibility limited to words that do not violate the phonotactics of their native language.

In absence of any cues that might shift their expectations:
- Can see 12-month-olds’ knowledge of their sound system
- This is reflected in their unwillingness to map ill-formed labels to an object

HOW MIGHT THIS PREFERENCE DEVELOP?

- Infants are attending to speech over other types of auditory stimuli from early on.
- May come to recognize that words, and, specifically, those sounds whose phonological forms are characteristic of content words, are unique from other parts of speech.
- In absence of evidence to the contrary, apply these expectations in sound-object mapping tasks
SUMMARY OF TYPICAL DEVELOPMENT

- By 12-months, infants have a solid foundation in the sound system of their native language.
  - know sound categories
  - segment words from speech stream
  - map words to objects
  - reject possible labels that violate legal sound combinations (phonotactics)

- BUT, still display some flexibility
  - useful since we are often in situations where we need to accommodate for accents

- Can our knowledge of infant speech processing help us to understand later language and atypical development?

ATTENTION TO SOCIAL COMMUNICATION: AN INFANT SIBLINGS PROJECT

Team:
- Suzanne Curtin, PI
- Shirley Leew, Co-PI
- Tavis Campbell, Collaborator
- Peter Faris, Collaborator
- Athena Vouloumanos, Collaborator
- Lonnie Zwaigenbaum, Collaborator
- Danielle Droucker, RA (Ph.D. student)
- Jennifer Ference, RA (M.Sc. student)
- Melanie Khu (co-ordinator)

ATYPICAL DEVELOPMENT

AUTISM SPECTRUM DISORDER (ASD)

- DSM IV-TR classifies ASD as a Pervasive Developmental Disorder (PDD) with symptoms ranging from mild to severe
- Characterized by
  - Impairments in development of reciprocal social and communication skills
  - Abnormal language development
  - Restricted repertoire of behaviours and interests
- Signs usually present by three years of age
**GOAL**

- Characterize relationships amongst two major factors related to attention biases in infants at elevated risk for ASD:
  - speech biases and joint attention (JA).
- Attending to relevant properties of the speech signal and to relevant aspects of meaning through JA is important for language acquisition (Dominey & Dodane, 2004).

**WHY ATTENTION AND LANGUAGE DEVELOPMENT?**

- It could be that one of the underlying deficits is the lack of a bias to attend to information generated by members of your species.
  - Impairment of mechanisms which bias infants to orient towards, attend to, and assign value to socially relevant stimuli (e.g., Johnson & Morton, 1991).
- This could result in a deficit in social communication skills.
  - Language disorders
  - ASD

**OUR BABYSIBS STUDY WILL...**

- Provide information about communicative development in infants who are at increased risk for ASD.
- Investigate longitudinally 2 groups of age- and sex-matched infants:
  - Later-born infant siblings of children already diagnosed with ASD (SIBS-ASD)
  - Later-born typically developing infants (SIBS-TD)
CURRENT PROJECT

- Tasks:
  - Speech preference:
    - Speech/Non-Speech
    - Infant-directed speech/adult-directed speech
  - Processing Rhythm
  - stress discrimination
  - segmentation
  - minimal stress word learning
  - Social communicative:
    - NCAST – caregiver/child interaction
    - CSBS-DP – joint attention
  - Language and cognitive development:
    - Mullen – motor and cognitive development
    - CDI – language development
  - ASD:
    - AOSI – autism observation scale

ATTENDING TO SPEECH

- The first step is to separate speech from other acoustic signals in the environment by attending to, and preferring, sounds produced by the vocal tract.
  - Preference for speech
  - Caregivers modify their speech to draw the infant's attention to relevant aspects of the speech signal (Infant-directed speech, IDS).
    - IDS is involved in the regulation of arousal and attention in infants, the learning of emotional intent, and the highlighting of linguistic structure.
  - Children with ASD do not prefer speech over non-speech, nor do they prefer infant-directed speech

CURRENT PROJECT: METHODS

- Current Enrollment:
  - Sibs-ASD: 20
  - Sibs-TD: 30

- Measures

<table>
<thead>
<tr>
<th>Age</th>
<th>Speech</th>
<th>NCAST (CCX)</th>
<th>CSBS (JA)</th>
<th>CDI (Ld)</th>
<th>Mullen (Cog)</th>
<th>AOSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
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<td>X</td>
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<td>8</td>
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<tr>
<td>12</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>18</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
METHODS:
- Behavioural & physiological
  - Looking time and heart-rate

SPEECH NON-SPEECH

PRELIMINARY RESULTS
LONGITUDINAL DATA FOR 2 INFANTS

INFANT-DIRECTED VS. ADULT-DIRECTED SPEECH

LONGITUDINAL DATA FOR 2 INFANTS
AUTISM OBSERVATION SCALE FOR INFANTS (AOSI)

- Identify and monitor early signs of autism in infants at heightened risk
- 18-item direct observational measure for infants 6-18 months
- Target behaviors include (not limited to) eye contact, atypical motor/sensory behavior, social interest, shared affect, attentional disengagement...

AOSI PRELIMINARY DATA AT 6-MONTHS

![Bar chart showing mean scores for Typical and At-Risk groups]
PRELIMINARY ASD DIAGNOSIS

- Our high-risk (HR) infant who patterned differently on our speech measures now has a preliminary diagnosis of ASD at 24-months.
- This participant also has language delays.

CONCLUSIONS

- Studies of older children diagnosed with ASD have demonstrated that they do not pattern with typically developing children on a number of these measures.
- Atypical patterning might be exhibited early in infancy.
  - This has implications for early identification and early intervention.
- Importantly, these tasks will inform us about the range of developmental trajectories exhibited in different populations.

BUT!!

- We are nowhere near being able to inform intervention or diagnosis.
- Our research hopes to find early markers, but in order to translate this knowledge into practice, we need to work with clinicians and researchers so that we can develop, test, and implement ways in which we can detect early differences.
- Basic research forms the foundation and KT at various steps will help us to inform practice.
THANKS TO:

- Co-Is:
  - Susan Graham (WL)
  - Shirley Leew (Baby-Sibs)
  - Linda Polka (Segmentation)

- Collaborators (Baby-Sibs)
  - Tavis Campbell
  - Peter Faris
  - Athena Vouloumanos
  - Lonnie Zwigenbaum

- Students
  - Shani Abada (Segmentation)
  - Danielle Droucker (Baby-Sibs)
  - Jennifer Ference (Baby-Sibs)
  - Heather MacKenzie (WL)
  - Sally Nandee (Reaper)

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  - ACCPCR

- All the Families who participated in our studies
- Volunteers
- Lab Members