Cross-situational learning of sign-like gestures from infancy to adulthood: an exploration of behavioral, pupil and ERP data

Candidate: Arianna Colombani

Supervisors: Prof Outi Tuomainen, Prof Mridula Sharma, Prof Natalie Boll-Avetisyan, Dr Amanda Saksida

University of Potsdam, Macquarie University

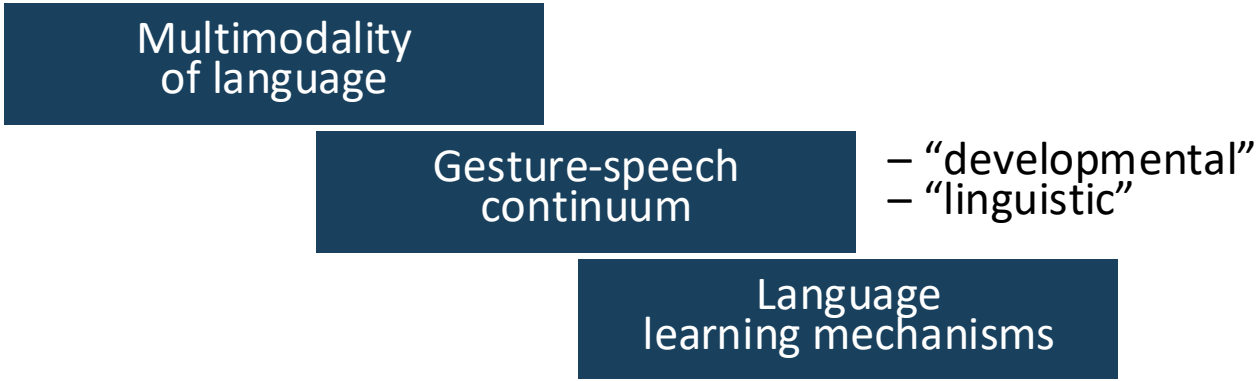
IDEALAB Summer School
September 16–20, 2024
University of Potsdam

Presentation

- Background
- Research questions
- Research project overview
- Experiment 2
- Experiment 3

Background

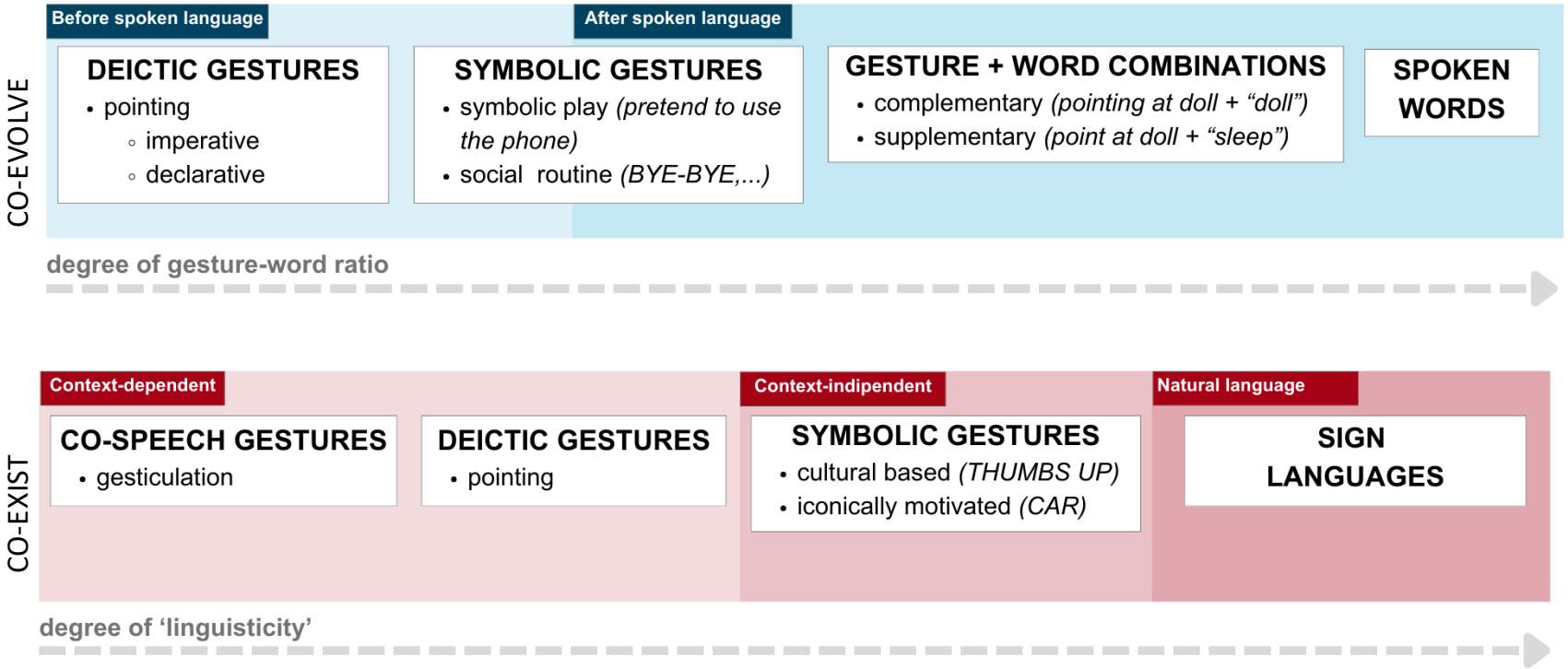
Background



- Gestures and words share a common neural system
- They develop on a gesture-speech continuum
- Language is learned through innate ability of detecting regularities

(Xu et al., 2009; Fabbri-Destro et al., 2015; Bates et al., 1979; Capirci & Volterra, 2008; Yu & Smith, 2007)

Gesture-speech continuum



(Adapted from Kendon, 1988; Bates et al. 1979)

Signs vs. gestures

VEASYT Tour Guida accessebile
YouTube link

Link to
Video 2

Link to
Video 3

Signs vs. gestures

SIGN LANGUAGE SIGNS

- language system
- related to one another to understand the complex meaning
- usually not produced with speech

CONTEXT-INDIPENDENT GESTURES

- rely on vocal language
- part of communication
- iconic and/or cultural-based
- associated with spoken words and speech

Signs vs. gestures

SIGN LANGUAGE SIGNS

- language system
- related to one another to understand the complex meaning
- usually not produced with speech

SIGN-LIKE GESTURES

- arbitrary
- standardized
- non-iconic
- non-cultural based
- in isolation
- with speech

CONTEXT-INDIPENDENT GESTURES

- not part of a language system
- part of communication
- iconic and/or cultural-based
- associated with spoken words and speech

Sign languages vs. exact signing

American Sign Language

e.g., My house look-like what?

Signing Exact English

e.g., What does my house look-like?

- signs + speech
- English syntax
- **each word → one sign**

VISUAL SUPPORT

(ASL vs. PSE vs. SEE - House Description – YouTube link)

Sign languages vs. baby signing

Link to video

e.g. You ate the YOUGURT!

Link to video

e.g., MILK – SLEEP

- signs + speech
- **Target word = one sign**

VISUAL SALIENCE

(Videos courtesy of Baby Signs Italia©)

Research objective

BABY SIGNING BIMODAL METHOD

- Scarce psycholinguistic evidence
- Sign language literature cannot fully explain sign-like gestures, due to key differences

⇩

Preliminary investigation of the mechanisms underlying gesture + speech communication.

Research project

Research questions

Exp.1 Exp.2

- Is it possible to map familiar spoken words on **novel sign-like gestures**?
- Is this possible to do this mapping rapidly through **statistical learning**?
- Is this ability stable **across development**?

- Is it possible to **build semantic categories** of novel sign-like gestures?
- In case of category violation, do sign-like gestures **elicit (electro)physiological responses similar to spoken words**?

Exp.3

- Are **sign-like gestures preferred** over other types of stimuli (e.g. drawings)?

Research structure

Exp.1		Exp.2		Exp.3	
	*Sign-like gestures + familiar words* **Cross-situational learning** **EEG**		*Sign-like gestures + familiar words* **Cross-situational learning** **Pupillometry**		*Sign-like gestures vs. Pictograms* **Cross-situational learning** **Pupillometry**
	Children (8–11 y.o.) Adults (18–35 y.o.)		Toddlers (1–3 y.o.)		Infants (12–14 m.o)
	• Paper submitted		• Working on pre-registration		• Under definition

Research paradigm

Cross-situational statistical learning (Yu & Smith, 2007)

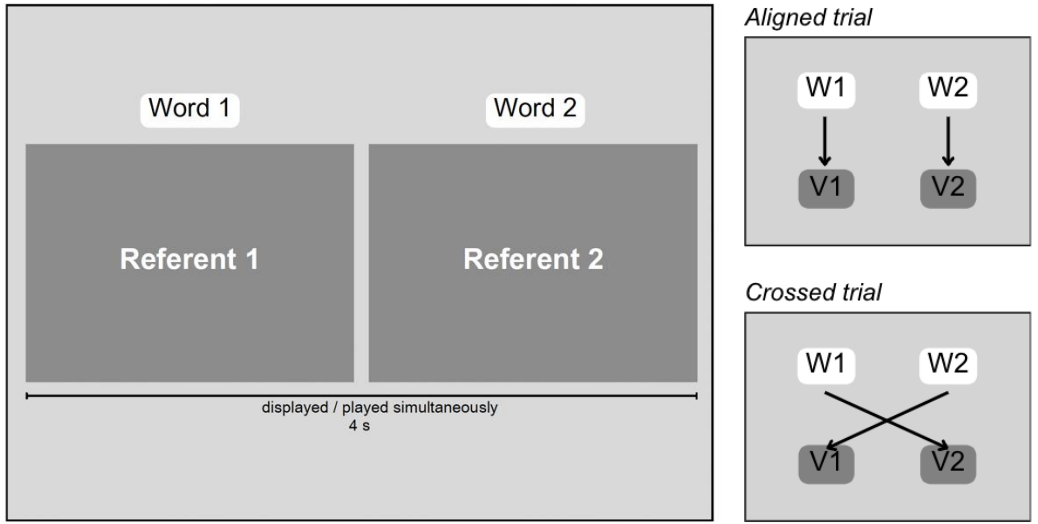
- ambiguous learning trials
- multiple referents and labels
- no explicit indication of word-referent correspondences
- recreates a naturalistic learning environment

↓

ability to identify the correct association by **implicitly detecting co-occurrences** across the trials

↓

LEARNING



Experiment 1 and 2

Exp. 1 findings

- Despite the ambiguous learning context
- Naive to gestural communication languages (i.e., sign languages / baby signing,)
- No instruction on the task
- No associative cues

⇩

Sign-like gesture can:

- be **learned through statistical learning**
- be **rapidly associated with a meaning**
- elicit **brain responses (N400) similar to spoken words**

⇩

Sign-like gestures and words can be an **ecologic language input**, as sign-like gestures are perceived as possible **linguistic, meaningful referents.**

⇩

Test this hypothesis on a younger age group (Exp.2)

Methods

Participants

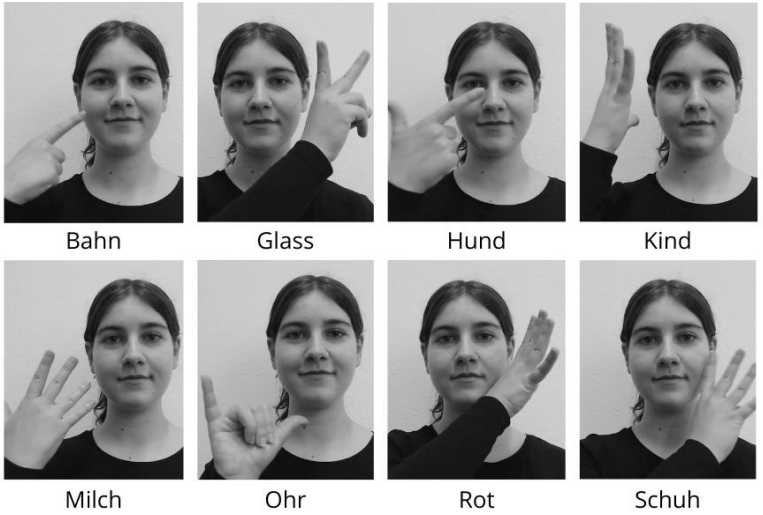
- Toddlers (3–4 y.o) N ~24

Stimuli:

- 8 spoken words (8 semantic categories) matched with 8 **sign-like gestures**

Measures:

- Pupil dilation:
  difference in pupil size (mm) between congruent versus incongruent trials
  - more pupil dilation = surprise, novelty, cognitive effort
  - semantic mismatch



Static depiction of the 8 sign-like gestures and matched target words

(Karatekin, 2007; Kuipers & Thierry, 2011)

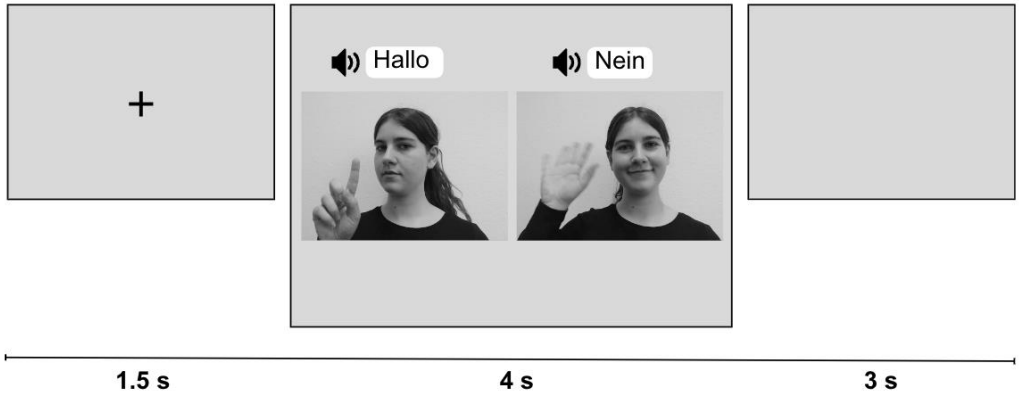
Paradigm

1a. Training phase with familiar stimuli ➡

1. **Familiarization phase**
   cross-situational learning of word-sign-like gestures pairs
   Trial n = 48

2. Recognition task
   check learning of gesture forms
   (pupil dilation)

3. Categorization task
   check semantic learning
   (pupil dilation)



Static depiction of the training phase

(Mangardich and Sabbagh, 2022)

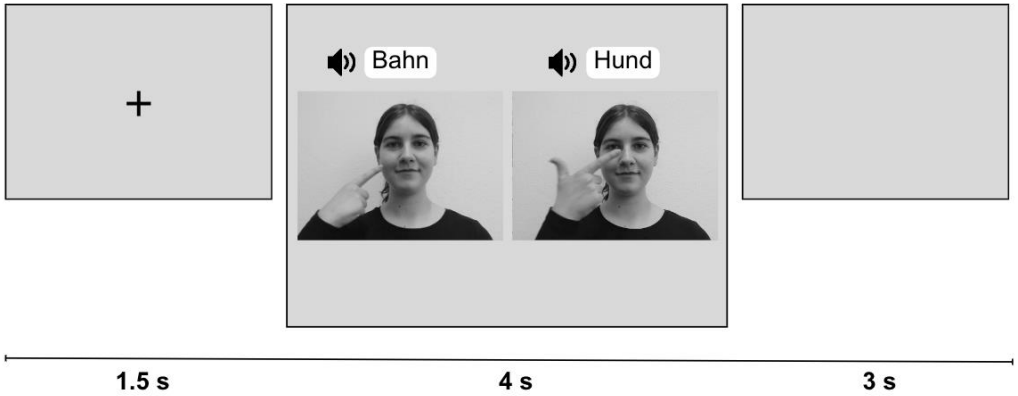
Paradigm

1a. Training phase with familiar stimuli

1. **Familiarization phase** ➜
   cross-situational learning of word-sign-like gestures pairs
   Trial n = 48

2. Recognition task
   check learning of gesture forms
   (pupil dilation)

3. Categorization task
   check semantic learning
   (pupil dilation)



Static depiction of the familiarization phase

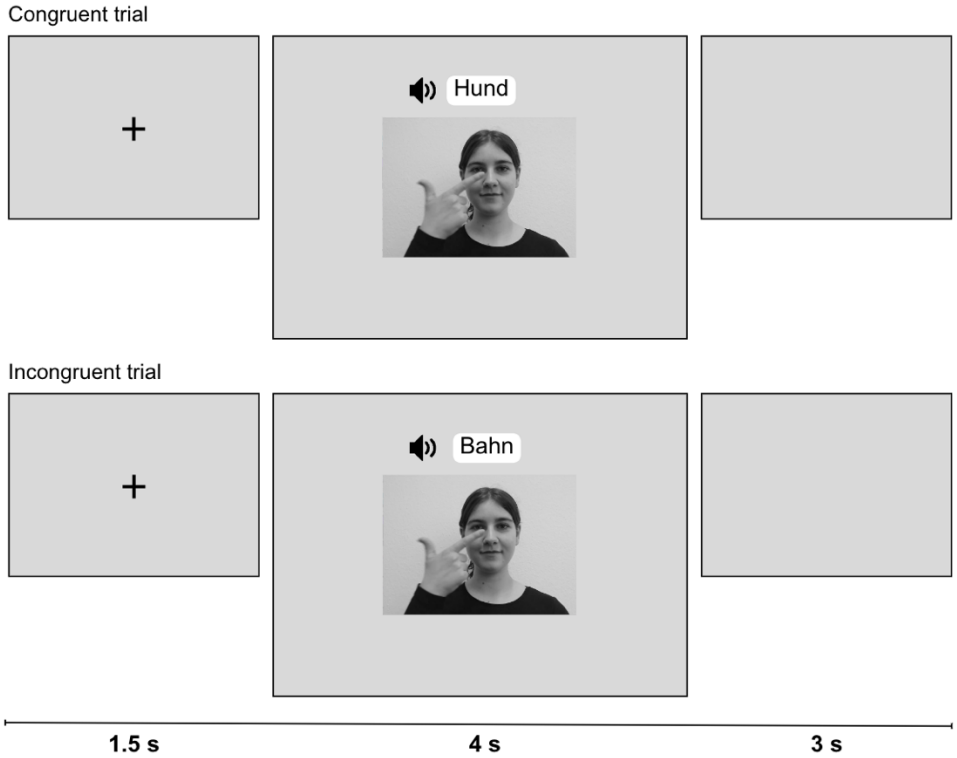
Paradigm

1a. Training phase with familiar stimuli

1. Familiarization phase
   cross-situational learning of
   word-sign-like gestures pairs
   Trial n = 48

2. Recognition task ➡
   check learning of gesture forms
   (pupil dilation)

3. Categorization task
   check semantic learning
   (pupil dilation)



Static depiction of the recognition task

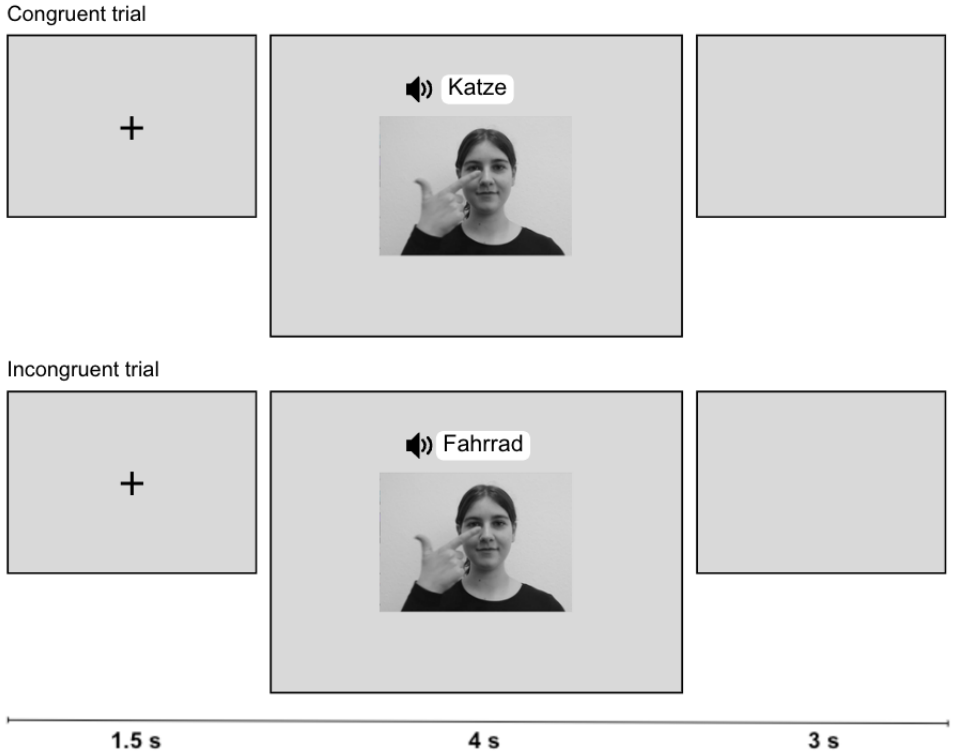
Paradigm

1a. Training phase with familiar stimuli

1. Familiarization phase
   cross-situational learning of
   word-sign-like gestures pairs
   Trial n = 48

2. Recognition task
   check learning of gesture forms
   (pupil dilation)

3. Categorization task ➡
   check semantic learning
   (pupil dilation)



Static depiction of the categorization task

Hypothesis

Experiment 2:

- Toddlers can map spoken words onto sign-like gestures
- Toddlers can build semantic categories of sign-like gestures

↓

Sign-like gestures are acceptable referents also for toddlers.

The gesture + words input can be an **ecologic language input** even at younger stages of development.

↓

Test this hypothesis on a younger age group (Exp.3)

Experiment 3

Research questions

- Is it possible to associate novel **sign-like gestures** with familiar spoken words?
- Is this possible to do this association rapidly through **statistical learning**?
- Is this ability stable **across development**?

- Is it possible to **build semantic categories** of novel sign-like gestures?
- In case of category violation, do sign-like gestures **elicit (electro)physiological responses similar to spoken words**?

Exp.3

- Are **sign-like gestures preferred** over other types of stimuli (e.g. drawings)?

Methods

Participants:

- Infants (10–12 m.o)

Stimuli:

- 8 words matched with 8 sign-like gestures and 8 pictograms

Measures:

- Pupil dilation

Exp.3

Static depiction of the 8 sign-like gestures (above) and 8 pictograms (below) and matched target words

(www.spreadthesigns.com; www.arasaac.org)

Hypothesis

Experiment 3:

- Infants can map spoken words onto sign-like gestures
- Equally / preference or sign-like gestures over pictograms

↓

Sign-like gestures are acceptable referents for infants.

↓

The gesture + words input can be an ecologic language input at preverbal stages of development, **equally viable (or even preferred)** as other type of visual stimuli

Summary

Using…
- Cross-situational learning
- Sign-like gestures

We aim to understand…
- the viability of sign-like gestures as referents for lexical labels during bimodal communication (gestures + speech)
- developmental differences in this mechanism from infancy to adulthood.

To ultimately…
- support the validity of bimodal communication (gestures + speech)

Thank you

arianna.colombani@uni-potsdam.de

Project structure and timeline