Quantifying Convergence in Child-Adult Dialogue

Raquel Fernández

Institute for Logic, Language & Computation
University of Amsterdam
Keywords

- natural language
- semantics and pragmatics (language as a communication device)
- linguistic interaction $\leadsto$ dialogue
- empirical evidence behind theoretical claims
- use of actual (naturally occurring) linguistic data
- use of computational methods to explore semantic/pragmatic phenomena
Dialogue Interaction

Dialogue is a multi-agent phenomenon, a type of joint action

→ it requires coordination in real time

• content coordination: understand and adequately react

• coordination of the communicative process:
  – turn-taking: who talks when
  – feedback: need to let your interlocutor know whether communication is successful

This often gives rise to interlocutors matching each other’s patterns of language use → alignment, adaptation, convergence, . . .

→ exactly how this works and what causes it are open questions
How does coordination show up in child-adult dialogue?

- asymmetry with respect to linguistic abilities

- Adults modify their language when they talk to young children.
  - child-directed speech (CDS) has distinct features at many levels of linguistic processing

- This is typically seen as a (dynamic) adaptation process of the adult to the child. Two possible interpretations:
  - global process driven by the child’s overall level of development
  - micro-level process: reaction to local dialogue cues rather than to global characteristics of the child.
Research Questions

(1) To what extent is convergence in child-adult dialogue influenced by local, turn-by-turn dialogue mechanisms?

(2) If local mechanisms are at play, is convergence amongst child and adult speakers bidirectional?

(3) Does the level of convergence change with development?

(4) Does child-adult dialogue differ from adult-adult dialogue with regard to convergence patterns?
CHILDES Database
A database of transcribed actual dialogues between children and their care-givers over extended periods of time (often a few years).
Freely available at http://childes.psy.cmu.edu

CHI: Daddy, let’s have a bath.
DAD: we will do. we’ve got to wait for mummy to finish washing up first.
CHI: you you have a bath.
DAD: what’s that? show daddy. show daddy.
CHI: it’s something break. it’s something break.
DAD: something’s it’s something break?
CHI: yes.
DAD: it’s something. no.
DAD: what we say is it’s something that broke or that has broken.
CHI: been broken.
DAD: let’s have a look. here it is. you know what it is?
CHI: yes.
DAD: it’s the top off a pen.
CHI: a pen?
DAD: yes.
DAD: but I think we’ve lost the pen so that needs to go in the bin now.
DAD: can you throw it in the bin?
CHI: this pen. it goes on this pen.
DAD: no, sweetheart. no. it doesn’t go on that pen.
Method

We use recurrence quantification analysis (RQA)
   – technique for the analysis of complex dynamical systems
   – a dialogue can also be seen as a dynamical system where patterns of language use recur over time.
   – first used for dialogue by Dale & Spivey (2006)


We are interested in characterising coordination between interlocutors
   ↔ focus on cross-recurrence: co-occurrence of elements in the speech of both dialogue participants at particular points in time.

**Method: Turn-based Cross-Recurrence Plots**

Two-party dialogue transcript:

A₁: which one do you want first  
B₁: that one  
A₂: you like this one  
B₂: yeah, give me  
...  
Aₙ: ...  
Bₙ: ...

One turn sequence per speaker:

\[ a₁, a₂, \ldots, aₙ \]  
\[ b₁, b₂, \ldots, bₙ \]

2-dimensional cross-recurrence plot: each cell corresponds to a pair of turns \((i, j)\)

We add a third dimension: a real value \([0, 1]\) indicating the degree of convergence between turns \((i, j)\) given some linguistic measure \(m\). Visualised as shades of grey.
Measures of Linguistic Convergence

Categorical convergence: identity matches in turn pairs \((i, j)\)
- Lexical: shared lexeme unigrams / bigrams, e.g., \(<cat, noun>\).
- Syntactic: shared part-of-speech bigrams / trigrams, e.g., \(<_, adj> <_, noun>\) factoring out lexical recurrence.

Conceptual convergence: similarity, e.g., \(<dog, noun> \approx <bark, verb>\)
- vector-based distributional semantic model: we use a large corpus to generate a vector for each word representing its distributional meaning
- we compute one vector per turn by adding up the lexical vectors
- we use the cosine of a turn pair \((i, j)\) as the convergence score
Recurrence Measures

- $RR_n$ global recurrence rate: average recurrence over all turn pairs
- $RR_d$ local recurrence rate: recurrence in (semi-)adjacent turns, separated by at most distance $d < n$ (diagonal line of incidence)
- $RR^+_d$ child converges with adult: upper part of the diagonal
- $RR^-_d$ adult converges with child: lower part of the diagonal
Analysis 1: Child-Adult Dialogue

- **Data**: three English corpora from the CHILDES Database

<table>
<thead>
<tr>
<th>corpus</th>
<th>age range</th>
<th># dialogues</th>
<th>av. # turns/dialogue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abe</td>
<td>2;5 – 5;0</td>
<td>210</td>
<td>191 (sd=74)</td>
</tr>
<tr>
<td>Sarah</td>
<td>2;6 – 5;1</td>
<td>107</td>
<td>340 (sd=84)</td>
</tr>
<tr>
<td>Naomi</td>
<td>1;11 – 4;9</td>
<td>62</td>
<td>152 (sd=100)</td>
</tr>
</tbody>
</table>

- **Generate CRP** for each dialogue:
  - compute values for each turn pair \((i, j)\) in each CRP, for each of the linguistic convergence measures: lexical, syntactic, conceptual

- **Use the recurrence measures** to address the research questions.
Addressing the Research Questions: Results

(1) To what extent is convergence in child-adult dialogue influenced by local, turn-by-turn dialogue mechanisms?

We need a control condition to account for chance cross-recurrence:

• for each original dialogue, we create a shuffled control dialogue: we keep the turns by one speaker unchanged and randomly shuffle the turns by the other speaker

• the global recurrence rate is the same in original vs. shuffled conditions

• the shuffled control dialogues offer a baseline for the level of local recurrence that could be expected by chance.

CRP from Abe corpus (age 2;5.26), lexical convergence
(1) To what extent is convergence in child-adult dialogue influenced by local, turn-by-turn dialogue mechanisms?

We find a reliable effect of dialogue type (original vs. shuffled) and distance (x-axis) on RR (y-axis) for all measures and corpora.
Addressing the Research Questions: Results

(2) Is convergence amongst child and adult speakers bidirectional?
- $RR_d^+$ (child adapts) vs. $RR_d^-$ (adult adapts) with $d = 2$.
- The recurrence found when the adult’s turn succeeds the child’s is significantly higher across children for all linguistic measures.
- The child also recurs, but with lower frequency.

(3) Does the level of convergence change with development?
- Test for correlations between the child’s age and $RR_2^+$ / $RR_2^-$
- Individual differences: decrease for Abe, increase for Sarah, mixed for Naomi.

(4) Does child-adult dialogue differ from adult-adult dialogue with regard to convergence patterns?
Analysis 2: Adult-Adult Dialogue

It is generally accepted that local coordination takes place in adult dialogue, but how do the patterns differ from child-adult dialogue?

- **Switchboard corpus**: 1,155 dialogues by different interlocutors.

- We ignore backchannels ("uh huh") since they are not considered proper turns (19% of all utterances).

- Same methodology as in Analysis 1:
  - Two CRPs for each dialogue: original vs. shuffled condition.
  - Categorical and conceptual recurrence values for each turn pair \((i, j)\) in each CRP.
  - Different distance values (\(d\) parameter)
A transcript fragment from the Switchboard corpus:

B.52 utt1: Yeah, /
B.52 utt2: [it’s,+ it’s] fun getting together with immediate family. /
B.52 utt3: A lot of my cousins are real close /
B.52 utt4: {C and} we always get together during holidays and weddings and stuff like that, /
A.53 utt1: {F Uh, } those are the ones that are in Texas? /
B.54 utt1: # {F Uh, } no, # /
A.55 utt1: # {C Or } you # go to Indiana on that? /
B.56 utt1: the ones in Indiana, /
B.56 utt2: uh-huh. /
A.57 utt1: Uh-huh, /
A.57 utt2: where in Indiana? /
B.58 utt1: Lafayette. /
A.59 utt1: Lafayette, I don’t know where, /
A.59 utt2: I used to live in Indianapolis. /
B.60 utt1: Yeah, /
B.60 utt2: it’s a little north of Indianapolis, about an hour. /
As in child-adult dialogue, there is a significant effect of dialogue type (original vs. shuffled) and distance ($x$-axis).

- Semantic lexical/conceptual measures, same trend: above-chance convergence in close-by turns.
- Syntactic measure: significant effect in the opposite direction – less convergence than expected by chance in adjacent turns.
Summing Up

Coordination in child-adult dialogue is strongly influenced by local, turn-by-turn convergence rather than global adaptation.

- Both the child and the adult converge with each other, but the adult adapts significantly more to the child.
- Convergence rates tend to decrease with development (but results not conclusive).

Adult dialogue contains less recurrence than child-adult dialogue, but there is a reliable effect of locality.

- This effect is negative in the case of syntax $\rightsquigarrow$ syntactic divergence
- Puzzling results given previous evidence (e.g., Pickering & Ferreira 2008), but in line with recent findings (Healey et al. 2014).
Open Questions

- Role of convergence: difference across linguistic levels in adult dialogue?
  - Semantic convergence contributes to thematic coherence.
  - Advancing a conversation requires different dialogue acts with distinct syntactic patterns.

- Why is there syntactic convergence in child-adult dialogue?
  - It may be related to feedback patterns used in this setting: a way to ratify or acknowledge linguistic constructions.
  - Interesting to investigate how the transition to adult interaction patterns takes place.

- Does convergence contribute to language acquisition?

Thank you