Quantifying Convergence in Child-Adult Dialogue

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Keywords

- natural language
- semantics and pragmatics (language as a communication device)
- linguistic interaction $\rightsquigarrow$ 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

$\rightsquigarrow$ 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 $\rightsquigarrow$ *alignment, adaptation, convergence, ...*

- exactly how this works and what causes it are open questions

Child-Adult Dialogue

How does coordination show up in child-adult dialogue?
$\rightsquigarrow$ 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

Raquel Fernández & Robert Grimm (2014) Quantifying Categorical and Conceptual Convergence in Child-Adult Dialogue, in *Proceedings of the 36th Annual Conference of the Cognitive Science Society (CogSci 2014)*.

(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)

Dale & Spivey (2006) Unraveling the Dyad: Using Recurrence Analysis to Explore Patterns of Syntactic Coordination Between Children and Caregivers in Conversation, *Language Learning*, 56(3): 391–430.

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

Fusaroli, Konvalinka, Wallot (2014) Analyzing Social Interactions: The Promises and Challenges of Using Cross Recurrence Quantification Analysis, in *Springer Proceedings in Mathematics & Statistics*.

Method: Turn-based Cross-Recurrence Plots

Two-party dialogue transcript:

A_1: which one do you want first
B_1: that one
A_2: you like this one
B_2: yeah, give me
⋮
A_n: ...
B_n: ...

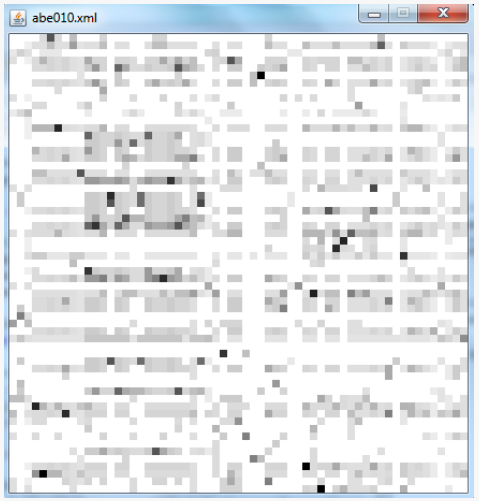
$\Longrightarrow$

One turn sequence per speaker:

$a_1, a_2, \ldots, a_n$
$b_1, b_2, \ldots, b_n$

$\Downarrow$

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



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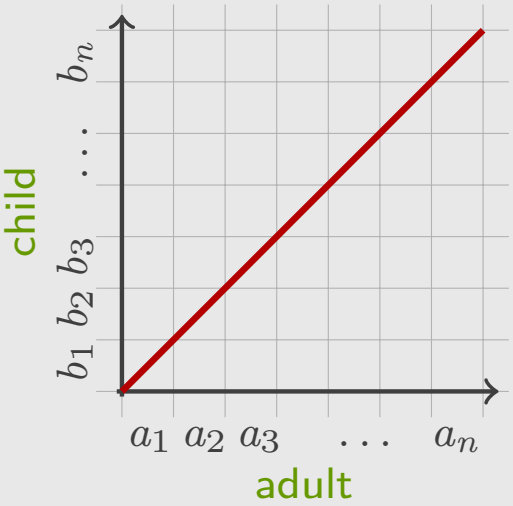


We add a third dimension: a real value $[0, 1]$ indicating the degree of convergence between turns (i, j) given some linguistic measure m. Visualised as shades of grey.

Measures of Linguistic Convergence

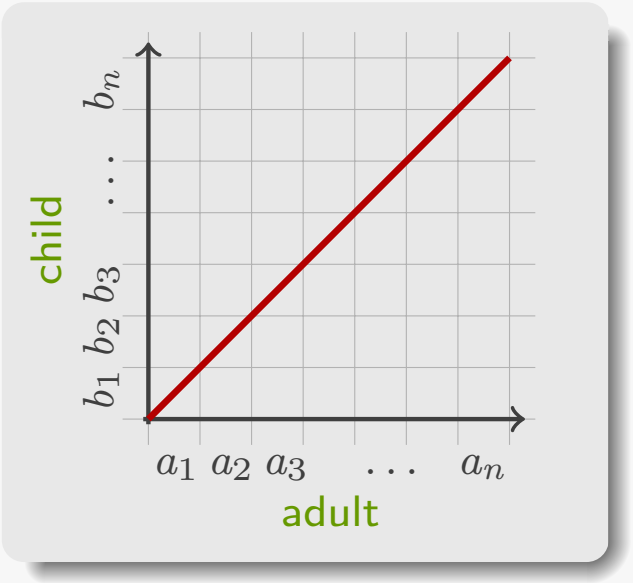
Categorical convergence: identity matches in turn pairs (i, j)

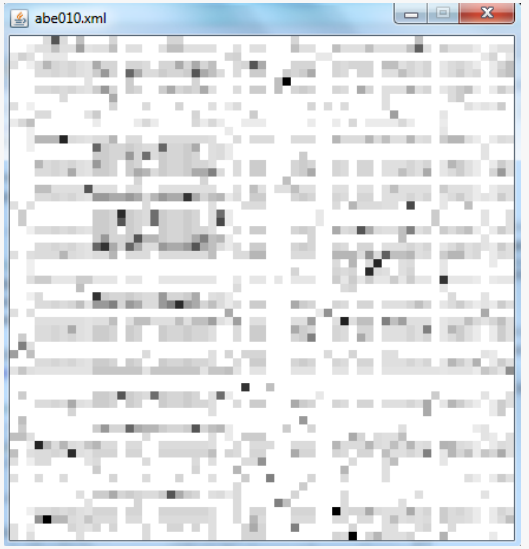
- Lexical: shared lexeme unigrams / bigrams, e.g., $\langle cat, noun \rangle$.
- Syntactic: shared part-of-speech bigrams / trigrams, e.g., $\langle \_, adj \rangle \langle \_, noun \rangle$ factoring out lexical recurrence.

Conceptual convergence: similarity, e.g., $\langle dog, noun \rangle \approx \langle bark, verb \rangle$

- 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

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

- 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.

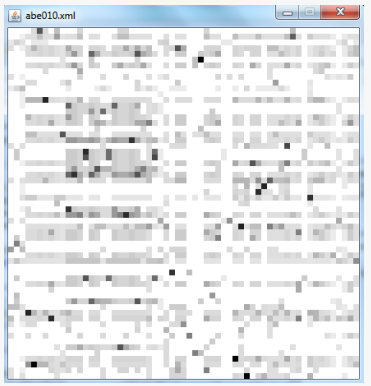
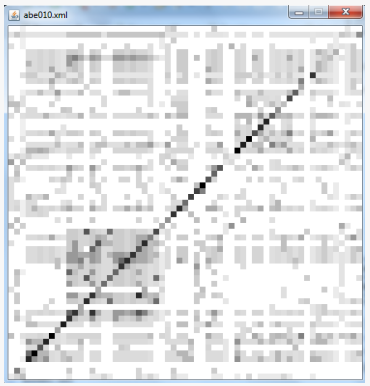
Addressing the Research Questions: Results

(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

schuffled   original

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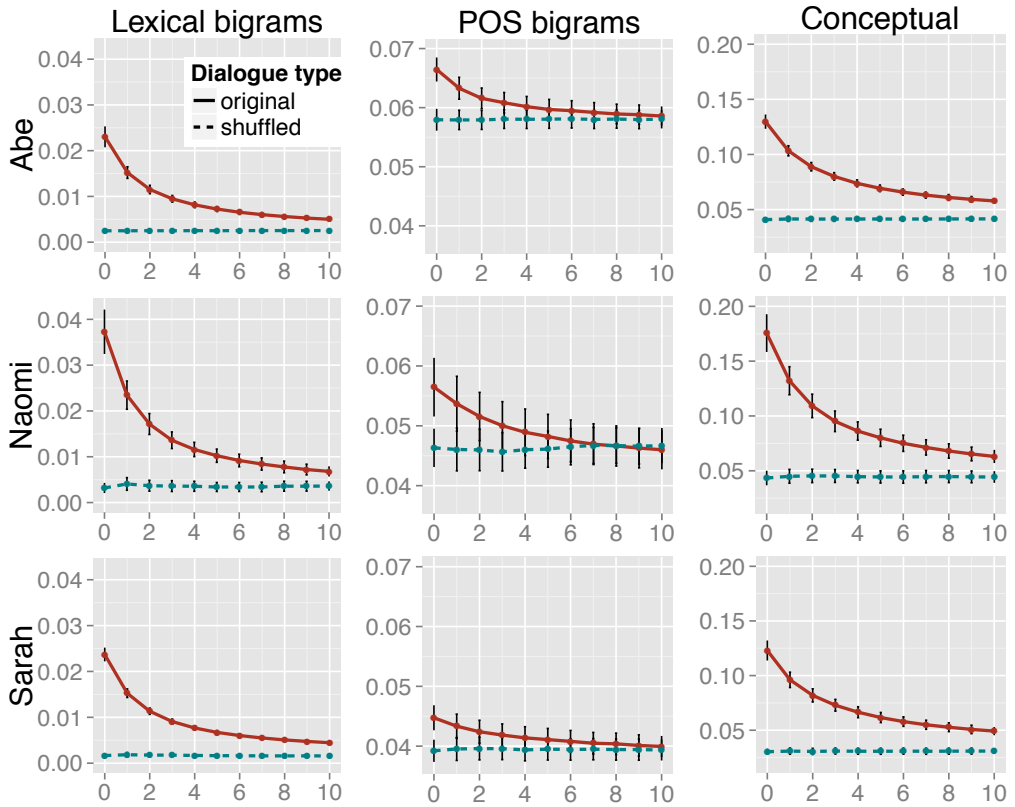


We find a reliable effect of dialogue type (original vs. shuffled) and distance (x-axis) on RR (y-axis) for all measures and corpora.

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?

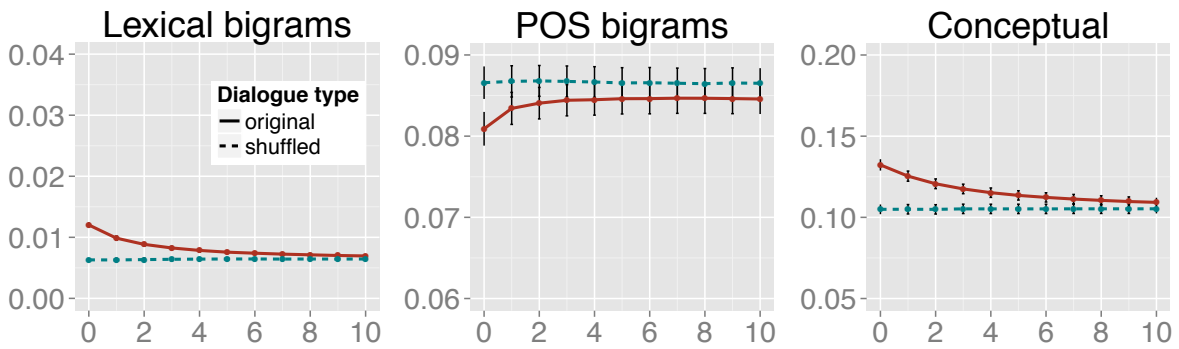
- Switchboard corpus: 1,155 dialogues by different interlocutors.
- We ignore backchannels (*"uh huh"*) since they are not considered proper turns (19% of all utterances).
- Same methodology as in Analysis 1:
  - Two CRPs for each dialogue: original vs. shuffled condition.
  - Categorical and conceptual 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.  /
```

Results

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