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# Quantifying Categorical and Conceptual Convergence in Child-Adult Dialogue

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## Abstract

Using corpus-based methods inspired by recurrence quantification analysis, we investigate the patterns that shape coordination in dialogue, in particular during the process of language acquisition. We show that the turn-by-turn temporal development of conversation is a key factor influencing when and how interlocutors match each other's linguistic representations. Although there is continuity between child-adult and adult-adult dialogue with respect to alignment of semantic representations, our results show important differences regarding syntactic alignment in adjacent turns, with adults showing less cross-speaker syntactic matches than expected by chance.

**Keywords:** Child language; Dialogue interaction; Corpus analysis; Recurrence analysis; Distributional semantics.

## Introduction

As any other type of joint action, conversation requires coordination in real time. Interlocutors need to understand and adequately react to each other's contributions while taking turns in speaking and they need to offer online feedback to their partners on the success (or lack thereof) of the communicative process (H. Clark, 1996). This often gives rise to interlocutors matching each other's patterns of language use (Brennan & Clark, 1996; Pickering & Garrod, 2004). In this study we aim to further our understanding of the patterns that shape coordination in dialogue, in particular during the process of language acquisition, by using corpus-based methods to quantify the level of convergence between interlocutors.

It has often been noted that adults modify their language when they talk to young children. Snow (1995) hypothesised that child-directed speech is not only adapted to the child's overall level of development, but it is locally fine-tuned to and contingent on the child's linguistic behaviour during the course of a dialogue. In our quantitative study, we address the following 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?

Kunert, Fernández, and Zuidema (2011) found strong correlations between the complexity of the child's and the adult's speech in a range of measures including lexical, syntactic, and phonological features. The correlations remained significant after controlling for the child's age, thus suggesting that local adaptation mechanisms are at play. However, their analysis was not able to pinpoint in what way the local dynamics of

a dialogue gives rise to the observed effects. Veneziano and Parisse (2010) have shed some light on this issue by showing that contingent adult-child correspondences in verbal forms influence the way in which children acquiring French learn to produce verbs. Dale and Spivey (2005, 2006) have proposed the use of techniques from recurrence quantification analysis to investigate lexical and syntactic alignment between children and their caregivers, and have shown that sequences of word classes occurring in temporal proximity within a dialogue are more strongly coordinated.

The work presented in this paper contributes to this line of research. We propose a refined model for applying recurrence analysis to dialogue data based on turns as the main temporal unit (rather than on sequences of word classes as done by Dale and Spivey (2005, 2006)). This methodology is introduced in the next section. We then present our main analysis conducted on naturally occurring child-adult dialogues from the CHILDES database (MacWhinney, 2000). We investigate categorical coordination (at lexical and syntactic levels) and also develop a method to quantify conceptual coordination. This is followed up by a second experiment on adult-adult dialogue data from the Switchboard corpus (Godfrey, Holliman, & McDaniel, 1992), which allows us to test the extent to which our findings are specific to child-adult interaction or are a general feature of conversational joint action.

## Turn-Based Cross-Recurrence

We construct cross-recurrence plots taking dialogue turns as the basic units of analysis (in contrast to Dale and Spivey (2005, 2006)). We consider a turn to be a stretch of speech by one speaker, which may include more than one utterance. Thus, by definition, a two-party dialogue between interlocutors A and B consists of a series of alternating turns  $\dots a, b, a, b \dots$ . From this, we extract one turn sequence per speaker ( $a_1, a_2, \dots, a_n$  and  $b_1, b_2, \dots, b_n$ ), which we time-index in order to retain the structure of the dialogue.<sup>1</sup> A cross-recurrence plot is an  $n \times n$  grid where the  $x$  and  $y$  axes correspond to each of the two interlocutors' turn sequences. Each cell represents a pair of turns  $(i, j)$ , where  $i$  is the  $i$ th turn by the participant in the  $x$ -axis and  $j$  is the  $j$ th turn by the participant in the  $y$ -axis. In the case of child-adult dialogue, we always place the adult turn sequence along the  $x$ -axis of the grid. To this two-dimensional grid, we add a third dimension:

<sup>1</sup>For the sake of simplicity, if the same speaker starts and ends the dialogue, we discard the last turn in order to end up with turn sequences of the same length for each of the two interlocutors.

a value between 0 and 1 indicating the extent to which the pair of turns in each point are similar (i.e., converge) given a particular linguistic measure  $m$ .<sup>2</sup>

The software used to generate cross-recurrence plots and to calculate similarity scores out of corpus data has been developed for the purpose of the present experiments. It is implemented in Python and it includes a GUI component written in Java to visually explore the plots. In the visualisation, the convergence scores are represented with shades of grey. White indicates there is no convergence while black indicates convergence is maximal. Figure 1 shows a sample plot.

## Recurrence Measures

The simplest information we can extract from a recurrence plot is the *global* recurrence rate. This measure captures the average amount of cross-participant recurrence found in a conversation, ignoring the temporal structure of the dialogue. It is computed by summing up all the recurrence values in the plot and then dividing by the total number of points. In addition, a recurrence plot allows us to quantify the degree to which convergence is tied to the temporal contingency of the turns contributed by the two dialogue participants. Points corresponding to pairs of turns  $(i, j)$  with the same time index  $i = j$  (i.e., points in the *diagonal line of incidence*) are always immediately adjacent in the dialogue. As we move away from the diagonal, the recurrence points correspond to pairs of turns that are further apart in the dialogue.<sup>3</sup> We are interested in quantifying the level of recurrence found close to the diagonal. For this we consider the average amount of cross-participant recurrence in points found up to distance  $d$  from the diagonal line of incidence. If, for instance,  $d = 3$ , we consider all points within a region of up to distance 3 above and below the diagonal. Let  $D$  be the set of points in the diagonal region determined by  $d$ . The *local* recurrence rate  $RR_d$  with  $d < n$  is computed as follows:

$$RR_d = \frac{\sum_{i \leq n} \sum_{j \in [i-d, i+d]} m(i, j)}{|D|}$$

Finally, a recurrence plot also allows us to investigate whether the observed recurrence has a directionality. For instance, if the adult adapts to the child more than the child does to the adult, we would expect to find more recurrence in pairs of turns where the child’s turn temporally precedes the caregiver’s turn. And *vice versa* if it is mostly the child’s speech that resembles earlier speech by the adult. The information encoded in the plot can easily be exploited to capture these notions. Since the child’s turns are always located on the  $y$ -axis of the plot, the subset of recurrence points in  $D$  where  $j > i$  (located in the upper half of the plot, above the diagonal line of incidence) correspond to pairs of turns where the child speaks after the adult, while the opposite is the case for the

<sup>2</sup>We follow Angus, Smith, and Wiles (2012) in using real values rather than Boolean ones as done by Dale and Spivey (2006).

<sup>3</sup>Note that either points  $(i, i - 1)$  or  $(i, i + 1)$  will also correspond to adjacent turns when the child or the adult, respectively, have uttered the first turn in the dialogue.

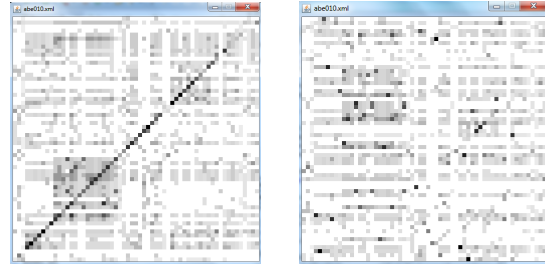


Figure 1: Cross-recurrence plot from a dialogue in the Abe corpus (age 2;5.26) showing recurrence of lexeme unigrams. Original dialogue (left) and its shuffled version (right).

subset of points in  $D$  where  $i > j$  (located in the lower half of the plot, below the diagonal). We can thus derive two additional measures,  $RR_d^+$  and  $RR_d^-$ , by restricting the computation of  $RR_d$  to points  $(i, j)$  with  $j > i$  and  $i > j$ , respectively.

## Control Dialogues

In order to investigate the extent to which the turn-by-turn structure of a dialogue influences the degree of cross-participant recurrence, we need a control condition that accounts for the amount of recurrence that would be expected by chance regardless of the temporal structure of the conversation. We follow a strategy similar to that used in previous studies (Dale & Spivey, 2006; Howes, Healey, & Purver, 2010): For each original dialogue, we create a *shuffled* control dialogue where we keep the turns by one speaker unchanged and randomly shuffle the turns by the other speaker (see Figure 1). By definition, the global recurrence rate (equivalent to  $RR_n$ ) will be the same regardless of dialogue type (original vs. shuffled). The shuffled control dialogues, however, offer a baseline for the level of local recurrence rate  $RR_d$  (with  $d < n$ ) that could be expected by chance.

## Analysis 1: Child-Adult Dialogue

### Methods

Like Chouinard and Clark (2003) and Dale and Spivey (2005, 2006), our data was drawn from the following three English corpora in the CHILDES Database (MacWhinney, 2000): Abe from the Kuczaj corpus, Sarah from the Brown corpus, and Naomi from the Sachs corpus. We selected all dialogue transcripts from each of these three corpora where the child utterances had a minimum mean length of 2 words. Table 1 gives an overview of the data used in the analysis.

We created a shuffled control dialogue for each transcript in the corpora and generated cross-recurrence plots for all dialogues. Each point  $(i, j)$  in a plot corresponds to a pair of turns, one by the caregiver and one by the child. Since the caregiver’s turns are always situated along the  $x$ -axis of the plot,  $i$  stands for the temporal index for the caregiver’s turn while  $j$  stands for that of the child.<sup>4</sup>

<sup>4</sup>Adults other than the child’s mother may sporadically take part in a dialogue. When this is the case, we consider all adult turns as contributed by one (general) caregiver participant.

Table 1: Dialogues used in Analysis 1.

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)

**Measures of Categorical Convergence.** We investigated the following two categorical aspects:

*Lexical convergence.* To quantify lexical convergence we use two measures: the number of shared lexeme unigrams and the number of shared lexeme bigrams. We consider a lexeme to be a pair consisting of a stem and a part-of-speech tag, e.g.  $\langle \text{cat}, \text{noun} \rangle$ . A lexeme bigram is thus a sequence of two such lexemes, e.g.  $\langle \text{grey}, \text{adj} \rangle \langle \text{cat}, \text{noun} \rangle$ . For a pair of turns  $(i, j)$ , we compute the number of lexemes (or lexeme bigrams) which appear in both turns and normalise it by the number of lexemes (or lexeme bigrams) in the longer turn. Lexical convergence is maximal (value 1) only when the two turns contain exactly the same lexemes.

*Syntactic convergence.* We capture syntactic convergence with two measures that consider sequences of part-of-speech (POS) classes: the number of shared POS bigrams and the number of shared POS trigrams. In order to disentangle syntactic from lexical coordination, we only take into account POS sequences where the lexical stems are not identical across turns. For instance, if the sequence  $\langle \_ , \text{adj} \rangle \langle \_ , \text{noun} \rangle$  is found in both turns  $(i, j)$ , this will increment the POS bigram measure only if the stems in the bigram are not the same in  $i$  and  $j$ . This contrasts with the approach by Dale and Spivey (2005, 2006) where lexical recurrence is not factored out from syntactic recurrence.

**Measures of Conceptual Convergence.** The measures of convergence we have defined above are restricted to categorical overlap, i.e. identity matches at the lexical and syntactic levels of linguistic representation. We are also interested in applying more subtle measures that allow us to quantify the degree of conceptual similarity between related but possibly different expressions. For instance, an utterance containing the verb “bark” is likely to be more semantically related to an utterance with the noun “dog” than to an utterance with the noun “telephone.” To develop a measure of conceptual convergence that captures such abstract relationships, we exploit powerful natural language processing techniques.

*Semantic model.* A distributional semantic model is a high-dimensional vector space where words are represented as vectors that record the frequency with which they occur in different linguistic contexts in a corpus. These semantic spaces—of which LSA (Landauer & Dumais, 1997) is a well-known example—make mathematically precise the so-called *distributional hypothesis* according to which expressions with similar meanings tend to occur in similar contexts. Such models allow us to use well-defined methods to measure how similar

Table 2:  $F(1, 209)$  statistics and significance strength for the effect of dialogue type and distance on RR in the Abe corpus.

	dialogue type	$d$	$d \times$ dialogue type
Lex unigrams	731.5 ***	797.5 ***	858.2 ***
Lex bigrams	448.5 ***	354.6 ***	392.9 ***
POS bigrams	68.66 ***	95.69 ***	130.6 ***
POS trigrams	196.7 ***	208.7 ***	194.7 ***
Conceptual	1181 ***	1079 ***	1113 ***

the meanings of two expressions are, such as computing the cosine of the angle formed by their corresponding vectors.

We use the WaCuk corpus—a freely available 2-billion-word corpus of English gathered from the Web (Baroni, Bernardini, Ferraresi, & Zanchetta, 2009)—to build a semantic model from which we can extract vectors for the content stems (noun, adjective, and verb types) in our CHILDES data. For each of the three CHILDES corpora, we extract the 10,000 noun, adjective, and verb stems from the WaCuk corpus that most frequently occur in the same sentence as the target stems in the relevant CHILDES corpus. This generates large semantic spaces with 10,000-dimensional vectors. Using the DISSECT toolkit (Dinu, Pham, & Baroni, 2013), we process this space by (a) removing the 50 target stems that appear most frequently in the WaCuk corpus (since very frequent stems are less informative), (b) normalising the vectors by their length, (c) weighting their elements using Mutual Information, and (d) reducing the number of dimensions to 300 by applying singular value decomposition.<sup>5</sup> This produces manageable but powerful semantic models from which we can extract vector-based conceptual representations for our target stems in the CHILDES data.

*Conceptual convergence.* To compute the degree of conceptual convergence between a pair of turns  $(i, j)$ , we first obtain a semantic vector for each turn by adding up the vectors corresponding to the content stems present in the turn, and then calculate the cosine of the angle formed by the two turn vectors. The convergence score corresponds to the cosine value if the cosine is positive, and to 0 otherwise.

## Results

We calculated recurrence values for each point  $(i, j)$  in the dialogue plots for the categorical and conceptual convergence measures defined above.

An ANOVA with  $d$  and dialogue type as within-subjects factors reveals a reliable difference in recurrence rate between original and control dialogues, a significant main effect of the distance parameter  $d$ , and a significant interaction between  $d$  and dialogue type for all linguistic measures. This is reliably the case for the three children considered ( $p < .01$  across all measures and children). Table 2 gives a summary of results for Abe.<sup>6</sup> The graphs in Figure 2 show the average recurrence rate in actual dialogues and in shuffled control dialogues at

<sup>5</sup>See the DISSECT documentation for further technical details.

<sup>6</sup>We use the convention  $p < .001$  \*\*\*,  $p < .01$  \*\*, and  $p < .05$  \*.

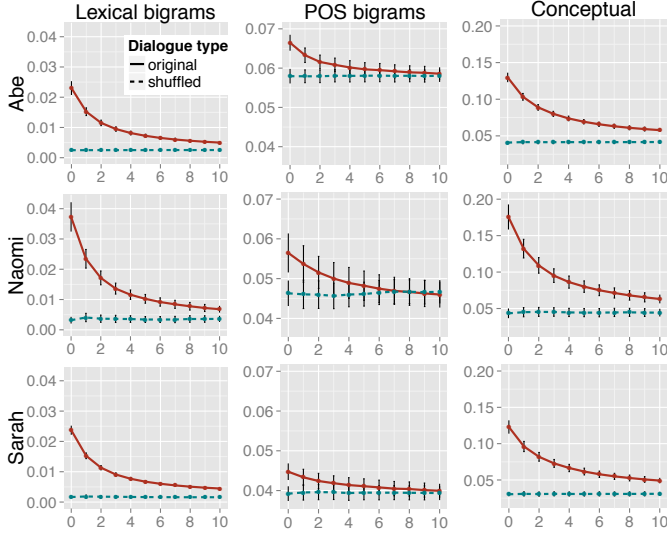


Figure 2: Average RR (y-axis) at different levels  $d$  of locality (x-axis) in original vs. control CHILDES dialogues.

Table 3:  $t$  statistics and significance level for  $RR_2^+$  vs.  $RR_2^-$  for Abe (df=209), Naomi (df=61), and Sarah (df=106).

	Abe	Naomi	Sarah
Lex unigrams	-3.37 ***	-4.26 ***	-11.90 ***
Lex bigrams	-2.46 ***	-4.31 ***	-10.15 ***
POS bigrams	-2.26 *	-2.49 *	-3.66 ***
POS trigrams	-4.10 ***	-3.23 **	-6.66 ***
Conceptual	-5.32 ***	-2.46 *	-8.82 ***

different levels of locality, from  $d = 0$  (only adjacent turns are considered) to  $d = 10$ , for three linguistic measures.

To investigate whether there are differences in the recurrence rate contributed by the adult vs. the child, we compare  $RR_d^+$  and  $RR_d^-$ , i.e., the amount of recurrence found in pairs of turns where the child speaks after the adult and the recurrence in pairs of turns where the adult’s contribution comes after the child’s in the original dialogues. We focus on  $d = 2$ , i.e., on those pairs of turns in the plot which are at most 2 turns apart in the original dialogues (where most of the convergence is found as illustrated in Figure 2). We find a very homogeneous pattern of results:  $RR_2^-$ , the recurrence found when the adult’s turn succeeds the child’s, is significantly higher than  $RR_2^+$  across children for all linguistic measures. The results of a paired  $t$ -test per linguistic measure and corpora are summarised in Table 3.<sup>7</sup>

Finally, we investigate whether there are developmental changes in recurrence rate, focussing again on  $d = 2$ . We test for correlations between the child’s age and  $RR_2^+ / RR_2^-$ . In this case, we find individual differences amongst children: The level of recurrence decreases overall for Abe and with respect to the semantic measures for Naomi, while in the case of Sarah it increases, especially for the syntactic measures. The correlation results are summarised Table 4.

<sup>7</sup>Here the significance level indicates the confidence with which we can reject  $H_0$ , according to which  $RR_2^+ = RR_2^-$ .

## Discussion

Our results show that coordination in child-adult interaction is directly shaped by the turn-by-turn structure of the dialogue: There is significantly more recurrence the closer the turns are in the temporal development of the conversation. This corroborates and extends previous results by Dale and Spivey (2005, 2006). In our turn-based model, syntactic recurrence appears to be a very local phenomenon: As we move away from strict adjacency, the recurrence rate quickly becomes not significantly different from chance level. This type of convergence could be due to syntactic priming mechanisms (see e.g., Gerard, Keller, and Palpanas (2010)). The semantic measures (lexical and conceptual) are less local: Although the strongest contrast between original and control dialogues is found in adjacent turns (e.g., 13% higher conceptual recurrence in original than in shuffled dialogues for Naomi at  $d = 0$ ), above-chance semantic recurrence can be observed between relatively distant turns. Thus, conceptual convergence could give us information on the dynamics and time span of conversational topics, beyond the repetition tracked by lexical recurrence.

Our data also shows that when temporal proximity is taken into account adults adapt to children more than children do to adults. This is in fact not surprising given that children have fewer linguistic resources to match the language use of their adult interlocutors. Despite of this, it is important to bear in mind that recurrence patterns are found in both directions: The child also matches patterns produced earlier by the adult, albeit with lower frequency. These types of recurrence could have different functions: The one contributed by the adult may include expansions or reformulations, while the one contributed by the child may signal uptake (Chouinard & Clark, 2003; E. V. Clark & Bernicot, 2008).

Concerning developmental change, Dale and Spivey (2005) found a reduction of syntactic recurrence. Although we do observe a significant decline in recurrence rate for some children and linguistic measures with increasing age, this does not fully happen across the board in our analysis. We believe the mixed results concern individual differences between the children: for instance, at age 5 Sarah’s MLU (in words) is only around 3.8, while Abe’s almost reaches 9.

## Analysis 2: Adult-Adult Dialogue

To investigate the extent to which our findings are specific to child-adult interaction, we carried out a follow-up experiment on adult-adult dialogue. Given the mixed developmental trends we have observed across children and the limited age range covered by our CHILDES data, this second study should also offer insight as to what the adult target stage is meant to be.

## Methods

We use the Switchboard corpus (Godfrey et al., 1992), a collection of 1,155 transcribed telephone conversations, each by a different pair of adult interlocutors. The corpus is distributed with dialogue act annotations (Jurafsky, Shriberg, &

Table 4: Pearson’s  $r$  and significance strength for effect of age on  $RR_2^+$  (child recurs w. adult) and  $RR_2^-$  (adult recurs w. child).

$RR_2^+$	Abe	Naomi	Sarah
Lex unigrams	-0.27 ***	-0.47 ***	-0.36 ***
Lex bigrams	-0.25 ***	-0.44 ***	-0.01
POS bigrams	-0.16 *	0.10	0.47 ***
POS trigrams	-0.08	0.04	0.46 ***
Conceptual	-0.29 ***	-0.47 ***	-0.08

$RR_2^-$	Abe	Naomi	Sarah
Lex unigrams	-0.64 ***	-0.36 **	-0.28 *
Lex bigrams	-0.57 ***	-0.26 *	0.38 ***
POS bigrams	-0.35 ***	-0.09	0.38 ***
POS trigrams	-0.37 ***	-0.02	0.38 ***
Conceptual	-0.54 ***	-0.30 *	-0.07

Table 5:  $F(1, 1154)$  statistics and significance strength for the effect of dialogue type and distance on RR in Switchboard.

	dialogue type	$d$	$d \times$ dialogue type
Lex unigrams	665.6 ***	411.6 ***	495.7 ***
Lex bigrams	741.5 ***	605.9 ***	671.5 ***
POS bigrams	157.7 ***	20.55 ***	35.37 ***
POS trigrams	2.21	13.42 ***	9.43 **
Conceptual	1077 ***	640.6 ***	793 ***

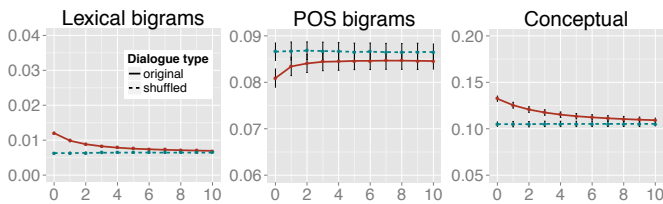


Figure 3: Average RR (y-axis) at different levels  $d$  of locality (x-axis) in original vs. control Switchboard dialogues.

Biasca, 1997). Since we consider turns our basic unit of analysis, we ignore any contributions tagged as backchannels—utterances such as “uh huh” that do not function as turns *per se* nor as attempts to take the turn, but rather as signals of understanding that are often given in overlap with the other speaker’s turn (H. Clark, 1996).<sup>8</sup> Ignoring backchannels, the Switchboard dialogues contain 60 turns on average ( $sd=30$ ).<sup>9</sup>

We follow the same methodology as in our previous analysis: We create a shuffled control dialogue for each transcript, generate turn-based cross-recurrence plots for all dialogues, and calculate recurrence scores for the categorical and conceptual convergence measures we have defined above.

## Results

For the semantic measures (categorical and conceptual), the pattern of results obtained in the adult data is similar to the one observed in child-adult interaction: We find a reliable difference in recurrence rate between the original and the control dialogues, a main effect of distance  $d$ , and an interaction between  $d$  and dialogue type. Interestingly, the results are different for the syntactic measures (POS bi- and trigrams). Regarding shared POS bigrams, there is a significant effect of locality and dialogue type, but we find *less* (rather than

<sup>8</sup>Backchannels are particularly frequent in the Switchboard corpus (19% of all utterances), possibly as a side effect of the telephone medium, which prevents feedback via eye gaze or head nods.

<sup>9</sup>We use Christopher Potts’ corpus reader (<http://compprag.christopherpotts.net/swda.html>) to extract turns from the corpus.

more) convergence in the original dialogues that would be expected by chance, especially in pairs of adjacent turns ( $d = 0$ ). For POS trigrams, there is an effect of distance but no significant difference between dialogue types (original vs. shuffled). Table 5 summarises the results of the ANOVA and Figure 3 shows graphs for three linguistic measures (the adult counterparts of the graphs in Figure 2 for the CHILDES data).

## Discussion

The results of our second analysis allow us to conclude that the turn-by-turn local level of dialogue interaction has a significant impact on patterns of recurrence beyond the case of child-adult dialogue. This is by no means a new observation for adult dialogue, for which local coordination is well attested and a key aspect of dialogue theories (see e.g., H. Clark (1996); Pickering and Garrod (2004)). There is however a caveat regarding the kind of impact we observe: While in both child-adult dialogue and adult-adult dialogue semantic convergence is significantly higher the closer the turns are in the temporal dialogue sequence, in adult dialogue there is less syntactic recurrence in adjacent turns that would be expected by chance, given the baseline provided by the shuffled control dialogues.

These results are puzzling, not only in contrast to the child-adult results from our previous analysis but also, and perhaps especially, given the relatively large amount of experiments that have offered evidence of syntactic alignment across adult interlocutors (see Pickering and Ferreira (2008) for a review). In a recent corpus-based study, however, Howes et al. (2010) have suggested that “the ubiquity of syntactic priming may have been overstated.” They point out that often experiments on syntactic convergence fail to account for the degree of alignment that would be expected by chance. Howes et al. examined the dative alternation construction—a commonly studied syntactic construction in alignment experiments—in a corpus of 127 dialogues amongst two adult participants. They used a methodology to create control dialogue similar to the one we have employed here and found that there was not reliably more syntactic matching that would occur by chance. Our results are in line with these findings and are in fact stronger since we found a reliable effect of syntactic *divergence* in immediately adjacent turns.

The reasons behind this are unclear, but we suspect they may be related to a difference in feedback patterns and feedback functions between children and adults. In child-adult dialogue, recurrence appears to be used as a feedback mechanism for acknowledging, reformulating, or ratifying—not

only meanings but also linguistic forms. In adult-adult dialogue, form and structure are much less of an issue and, thus, although syntactic convergence may occur due to priming effects, it is not typically used as a feedback mechanism beyond lexical overlap. Instead, to provide evidence of understanding, adult dialogue participants will tend to offer an appropriate next contribution (such as an answer to a question, which is likely to show semantic recurrence but will display a markedly different syntactic pattern), or to issue an acknowledgement with no apparent recurrence. This latter point becomes more evident if backchannels are considered turns (rather than being ignored as in our analysis): In such case, the divergence is much more pronounced and reliably affects both syntactic and lexical recurrence rates.

### Conclusions

Our analyses confirm that the local, turn-by-turn temporal development of dialogue is a key factor in explaining the coordination patterns that characterise linguistic interaction between young children and adults, which corroborates fine-tuning accounts of child-adult dialogue (Snow, 1995). This is in line with the local coordination that characterises adult conversational joint action. However, our results regarding syntactic convergence show that, while locality matters for both children and adults, the convergence patterns themselves may be different in these two kinds of dialogue: Child-adult dialogue exhibits significant cross-speaker syntactic recurrence at temporally close turns, while adult-adult dialogue shows less cross-speaker syntactic matches in adjacent turns than expected by chance. This contrasts with previous results on adult conversation (Pickering & Ferreira, 2008) and thus calls for a deeper investigation of syntactic alignment patterns in adult dialogue interaction.

We point up that any comparisons between our results in analysis 1 and analysis 2 should be taken with caution given the different dialogue settings in each of the two corpora used: physical co-presence in CHILDES vs. telephone mediation in Switchboard. Barring any confounding effects due to these difference (which we believe are unlikely given our manipulation of backchannels), overall we observe lower levels of recurrence for all linguistic measures in the adult-adult data than in the child-adult dialogues, relative to what is expected to occur by chance independently in each case. There must therefore be a decline in recurrence with developmental change, even though the longitudinal data available in the CHILDES corpora did not allow us to confirm this for all children. Further analysis is needed to understand in detail how this change takes place, as well as to quantitatively investigate the extent to which local convergence may contribute to boost learning during language acquisition.

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