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Communicative Feedback in language acquisition

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A B S T R A C T

Children start to communicate and use language in social interactions from a very young age. This allows them to experiment with their developing linguistic knowledge and receive valuable *feedback* from their – often more knowledgeable – interlocutors. While research in language acquisition has focused a great deal on children's ability to learn from the linguistic input or social cues, little work, in comparison, has investigated the nature and role of Communicative Feedback, a process that results from children and caregivers trying to coordinate mutual understanding.

In this work, we draw on insights from theories of communicative coordination to formalize a mechanism for language acquisition: We argue that children can improve their linguistic knowledge in conversation by leveraging explicit or implicit signals of communication success or failure. This new formalization provides a common framework for several lines of research in child development that have been pursued separately. Further, it points towards several gaps in the literature that, we believe, should be addressed in future research in order to achieve a more complete understanding of language acquisition within and through social interaction.

1. Introduction

Research in language acquisition has extensively documented the impressive skills children use to learn from the properties of the language they hear around them (Saffran et al., 1996) together with the properties of their visual environment (Smith & Yu, 2008). Such multimodal input is, however, not the only source of information available to children. In particular, children start to actively interact with people very early in development. This early social interaction has long been considered to play an important role in the acquisition of language (e.g., Bruner, 1985; Clark, 2016, 2018; Kuhl, 2007; Matthews, 2014; Ninio & Snow, 1988; Tomasello, 2005; Vygotsky, 1962; Yurovsky, 2018).

The current dominant line of research studying the role of social interaction focuses on children's ability to make inferences about people's communicative intents. For example, when a – more knowledgeable – adult introduces a novel word in an ambiguous context where there are many objects, children have to infer which precise object the adult meant. To make a successful pragmatic inference, children can take into account the context of language use, common ground with the interlocutor, as well as social cues provided by the latter such as gaze and pointing (Bohn & Frank, 2019; Senju & Csibra, 2008; Tomasello et al., 2005; Tsuji et al., 2020; Yurovsky & Frank, 2017).

In the current paper, we examine the role of another aspect of social interaction in language learning, involving not only pragmatic inference over what the speaker has said or done, but also the explicit negotiation of shared understanding with the interlocutor. Indeed, children start communicating long before their linguistic skills are mature (Bates et al., 1975; Clark, 2016; Halliday, 1975; Ninio & Snow, 1988). Such early attempts at communication succeed at times, but they can also fail because children make phonological, syntactic, semantic, and pragmatic mistakes that impede the transmission of their true intents. In the context of these early conversations, children receive *feedback* from their interlocutors, signaling successful or unsuccessful communication which they can use to fine-tune their linguistic knowledge (see an illustration in Fig. 1).

We call this mechanism **Communicative Feedback** (hereafter CF) for two reasons. First, to emphasize its link to general communicative principals in conversations – more studied in the adult literature – whereby interlocutors coordinate to understand each other (Clark, 1996; Pickering & Garrod, 2021). Second, to differentiate it from another form of feedback – more studied in the developmental literature – often under the name of *corrective* feedback, describing responses from caregivers that provide a correction for potential mistakes in children's utterances.

Corrective feedback has long been debated in the language acquisition literature, especially regarding the question of the learnability of grammar from negative evidence in addition to positive evidence (e.g., Gold, 1967). Some researchers questioned its availability or usefulness (e.g., Braine, 1971; Brown & Hanlon, 1970; Marcus, 1993) while others have provided evidence to the contrary, especially when corrective feedback takes the *indirect* form of recast/reformulation of the child's

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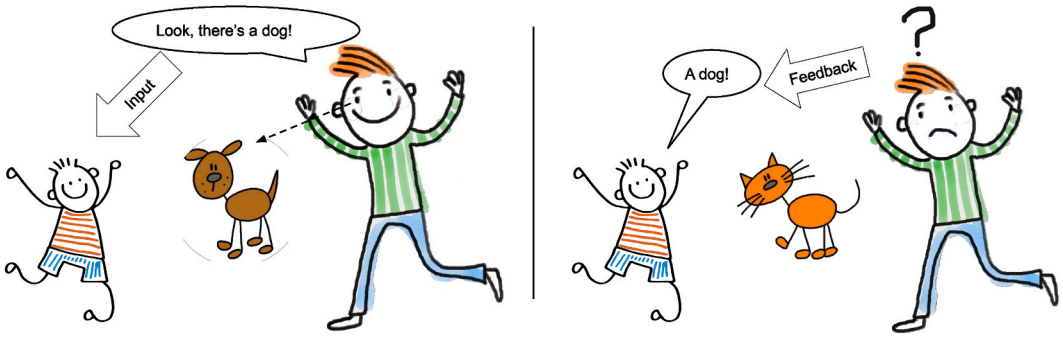

Fig. 1. Learning from input and learning from feedback. The child may learn from the linguistic input by listening to what is said and making pragmatic inference about what is meant (Left side: The child learns from the parent's utterances as well as the parent's eye gaze about the meaning of the word "dog"). The child can also learn from positive or negative feedback provided by interlocutors on their own communicative attempts (Right side: The child receives negative feedback (signals of non-understanding, in this case a puzzled face) for using the word "dog" when trying to talk about a cat).

erroneous utterance in a more conventional fashion (e.g., Chouinard & Clark, 2003; Farrar, 1992; Hiller & Fernandez, 2016; Nelson, Carskaddon, & Bonvillian, 1973; Saxton, 2000; Strapp, 1999).

Communicative Feedback, however, provides signals about *communicative* success (positive signals) or failure (negative signals). Therefore, unlike corrective feedback and more like adult communicative coordination, CF focuses on understanding the child's communicative *intent* rather than correcting the form, meaning, or use of the child's language. Correction/reformulation may occur, but only after the interlocutor has successfully understood the child's intended meaning. CF only signals whether or not the listener (here, the more knowledgeable interlocutor) understood the communicative intent of the speaker (i.e., child).

Our main proposition is that many aspects of language can be acquired as a *side product* of the child trying to achieve shared understanding in conversation with a more knowledgeable interlocutor (e.g., a caregiver or an older sibling): Positive CF confirms their language use whereas negative CF urges them to revise the way they express their intent in future exchange.

1.1. Contributions

The general idea of communication/conversation as a matrix for language acquisition is not new. We can find it proposed in the work of many developmental scientists (e.g., Bates, 1979; Clark, 2016, 2018; Golinkoff, 1986; Halliday, 1975; Ochs & Schieffelin, 1984; Yurovsky, 2018). The novelty of the current work is twofold. First, we focus specifically on the role of CF and formalize it by making a systematic link with theories of communicative coordination that have been developed largely with adults (Clark, 1996; Pickering & Garrod, 2021). Second, we briefly review lines of experimental research in language acquisition that have been using measures that closely relate to the concept of CF in child-adult conversation and argue that this research can benefit from being unified under the theoretical framework that we propose.

The broad impact of this work is to bridge across two fields that have evolved largely separately (i.e., communicative coordination and language acquisition), providing a unifying framework for different lines of experimental research in the language acquisition literature. This theoretical effort is crucial not only to make sense of what appears to be disparate research goals, methods, and findings, but also to help locate gaps in the scientific literature and open up new promising areas for future research.

2. Communicative Feedback

For communication to succeed in a conversation, interlocutors coordinate to achieve and maintain *common ground*, a process also known as communicative grounding (Clark, 1996; Lewis, 1969; Stalnaker, 1978). Intuitively speaking, this process characterizes conversation as a collaboration between (at least) two interlocutors trying to understand each other. To reach and maintain the state of mutual understanding, listeners send signals of understanding (e.g., acknowledgements), non-understanding (e.g. clarification requests), and mis-understanding (e.g., responding in a non-contingent fashion). The speakers use these signals either to move forward or to revise the expression of their intended meaning (Clark & Schaefer, 1989; Pickering & Garrod, 2021).

Using this framework, we define Communicative Feedback as the signals sent by the listener to indicate communicative success or failure depending on whether or not the listener thinks they understood the intended meaning behind the speaker's linguistic utterance. Such signals have also been referred to as "closures" (Clark, 1996; Clark & Schaefer, 1989) or "commentaries" (Pickering & Garrod, 2021).

In both cases (i.e., success and failure), CF can be either implicit or explicit: A listener can either "*say* that he[/she] understands […], or *demonstrate* that he[/she] understands" (Clark & Schaefer, 1989, p. 267).

Explicit positive signals of understanding are **acknowledgements**, also called "positive commentaries" in Pickering and Garrod (2021). These signals include short non-intrusive backchannel responses ("assertions of understanding" in Clark (1996); e.g., "uh-huh", "yeah", head nod, smile), as well as paraphrases or verbatim repetitions ("exemplifications of understanding" in Clark (1996)).[1] With these responses the listener asserts that they have understood the utterance of the speaker.

On the other hand, in the case of communicative failure, the listener can respond with a **clarification request** ("negative commentaries" in Pickering and Garrod (2021)) such as "Huh?", "Which one?", or a confused face. These are explicit signals of non-understanding.

Implicit signals of understanding are sent when the listener provides a response that is **contingent** on the speaker's utterance, as judged from the perspective of the speaker (e.g., responding "I'm at home." to the question "Where are you?"). If the listener responds in a **non-contingent** manner (e.g., responding "I'm fine." to the question "Where are you?"), they provide an implicit signal of communication failure to the speaker. The speaker can detect this misunderstanding if the response is non-contingent from their perspective. A similar concept has been

[1] See also Norrick (1987) and Tannen (1989) for the coordinative function of repetitions in conversation.

described by H. H. Clark (1996, p. 228) under the name of *displays of understanding*, which can be exemplified, as we did above, by the fact that an answer displays (in part) whether a question was understood correctly or incorrectly.

The proposed classification of CF signals is summarized in Fig. 2 and will help us sort/unify various experimental studies reviewed in the following sections.

3. CF for language learning

While language acquisition can be understood in broader terms, here we focus specifically on the process of learning to *understand* and *use* language in communication. Acquiring language requires the child both to learn how to infer a speaker's intended meaning from an utterance (when listening) and to learn how to produce a linguistic utterance that best conveys their intended meaning (when speaking).

CF-based mechanisms take as a starting point children's productions. Nevertheless, the learning that results form this mechanism is general to both comprehension and production. In fact, by producing linguistic utterances in the context of a conversation, children can be understood as putting their general linguistic knowledge to test, allowing them to receive feedback on it – whether implicitly or explicitly – from their more knowledgeable interlocutors (e.g., caregivers or older peers).

This view of language use as a driving force for language learning contrasts with traditional theories on language acquisition where major linguistic components, i.e., form, meaning, and use (Bloom & Lahey, 1978) are experimentally compartmentalized and studied as if children learn them in a sequential and independent fashion. That is, children are sometimes understood as learning the *form* (e.g., the phonology of the word "water") based largely on the analysis of the linguistic input. Then, they would learn the *meaning* (i.e., that the form "water" maps on to the concept WATER) based mostly on multimodal association and categorization but also on pragmatic inference in social interaction. Finally, they learn how to *use* language in context to communicate their intent (e.g., the child uttering "Water!" to *request* WATER).

However, more recent theories on language acquisition do highlight synergies when learning form and meaning (e.g., Abend et al., 2017; Babineau et al., 2022; Christophe et al., 2008; Dupoux, 2018; Feldman et al., 2013; Fourtassi et al., 2020; Landau & Gleitman, 1985; Räsänen & Rasilo, 2015), as well as when leveraging information about how language is used in context to learn various linguistic structures (Bohn & Frank, 2019; Clark, 2016, 2018; Tomasello, 2005). Most relevant to our proposal are the studies showing that children do not wait to have mastered the form and meaning before they start using language to communicate with people around them (Bates et al., 1975; Halliday, 1975; Snow et al., 1996). In fact, the CF-based mechanisms assume that the feedback children receive on their early – correct or incorrect – language use allows them to refine their linguistic knowledge, a priori, at every level.

We illustrate the general idea of CF-based mechanisms in Fig. 3, using word learning as an example. In brief, the CF-based mechanisms can be characterized as instances of social reinforcement. Signals of communicative success lead to positive reinforcement, thus comforting the child in their word choice. In contrast, signals of communicative failures lead to negative reinforcement, thus prompting the child to revise their knowledge and, in future exchange, use different words to try and better convey the intended meaning.

A crucial property of the CF-based mechanisms is that they do not require the interlocutor to explicitly teach or correct linguistic knowledge. Learning takes place as a *side product* of the child and interlocutor trying to understand each other. In fact, the mechanisms do not even require the interlocutor to interact with the child differently than they would do with any mature speaker of the language: Upon hearing the child's utterance, the interlocutor – as in a typical conversation between adults – produces positive CF or negative CF, depending on whether or not they have understood the message as intended by the child.

If the interlocutor thinks they understood the child's intended meaning, they can acknowledge the receipt and/or move forward with the interaction in a contingent fashion. This is, as described above, a positive signal to the child, confirming – and thereby strengthening – the child's linguistic use in such a context. If the interlocutor did not understand or misunderstood the message, they may ask for clarification or respond in a non-contingent fashion (from the child's point of view): Both are negative signals to the child, inviting knowledge revision.

It follows that the CF-based mechanism is an indirect way to learn language. The learner *uses* language in context and continuously updates their knowledge based on the feedback received. Such error-driven learning mechanisms have been proposed to play a major role in human learning more generally (Clark, 2015; Friston, 2009) and are increasingly being applied to language acquisition (Babineau et al., 2022; Cox et al., 2020).

A question one could raise is the following: Why propose to study an indirect mechanism of language learning when previous research has focused on more direct mechanisms such as corrective feedback?

There are three main reasons. First, corrective feedback can only operate when the child produces relatively minor mistakes which do not impede the understanding of their intended meaning. Indeed, only if the interlocutor first understands the child's communicative intent can they then correct the mistake with a more conventional language use (e.g., via reformulation). In contrast, CF-based mechanisms are more general and can be useful even in early stages of development when children are barely intelligible (this will become clearer in the following section).

Second, while instances of corrective feedback have been observed in many naturalistic studies of child-caregiver interactions (e.g., Chouinard & Clark, 2003; Hiller & Fernandez, 2016; Saxton, 2000; Strapp, 1999), it is unclear the extent to which this parenting style is constant across cultures. In fact, there is evidence that caregivers in some cultures talk only rarely directly to their young children or do not specifically adapt their language when talking to children (Casillas et al., 2020; Cristia et al., 2019; Ochs & Schieffelin, 1984; Shneidman & Goldin-Meadow, 2012). In contrast, CF-based mechanisms are not specific to child-caregiver interactions. They rely on fundamental properties of human communication (Clark, 1996; Pickering & Garrod, 2021), making them much more likely to be universal across cultures. There is indeed accumulating evidence that feedback signals of the sort described above are present in a diversity of languages and cultures (although not always studied in the context interaction with children), such as for acknowledgements (Cutrone, 2005; Liesenfeld & Dingemanse, 2022; Maynard, 1990), communicative repair (Dingemanse et al., 2015; Ochs & Schieffelin, 1984; Schegloff, 2006), and time-contingent responses (Bornstein et al., 1992; Richman et al., 1992).

Finally, the feedback-based learning mechanism has the advantage that the learner can play an active role in shaping the learning process by engaging in curiosity-driven learning. That is, a child can choose to selectively initiate, shape and/or put more attention on topics with high amount of uncertainty in order to receive optimally informative responses depending on their current state in the learning process (Foushee et al., 2022; Gelderloos et al., 2020; Kidd et al., 2012; Moulin-Frier, Nguyen, & Oudeyer, 2014; Twomey & Westermann, 2018).

4. Empirical evidence for CF-based mechanisms

We looked in the development literature for experimental evidence supporting CF-based mechanisms in language learning. In the following, we provide an overview of major studies in each type of CF, in light of the classification made in Fig. 2.

4.1. Acknowledgements

Within this category, we consider all responses that explicitly confirm understanding from the listener's side. These form an explicit positive CF signal to the speaker (in our case: the child).

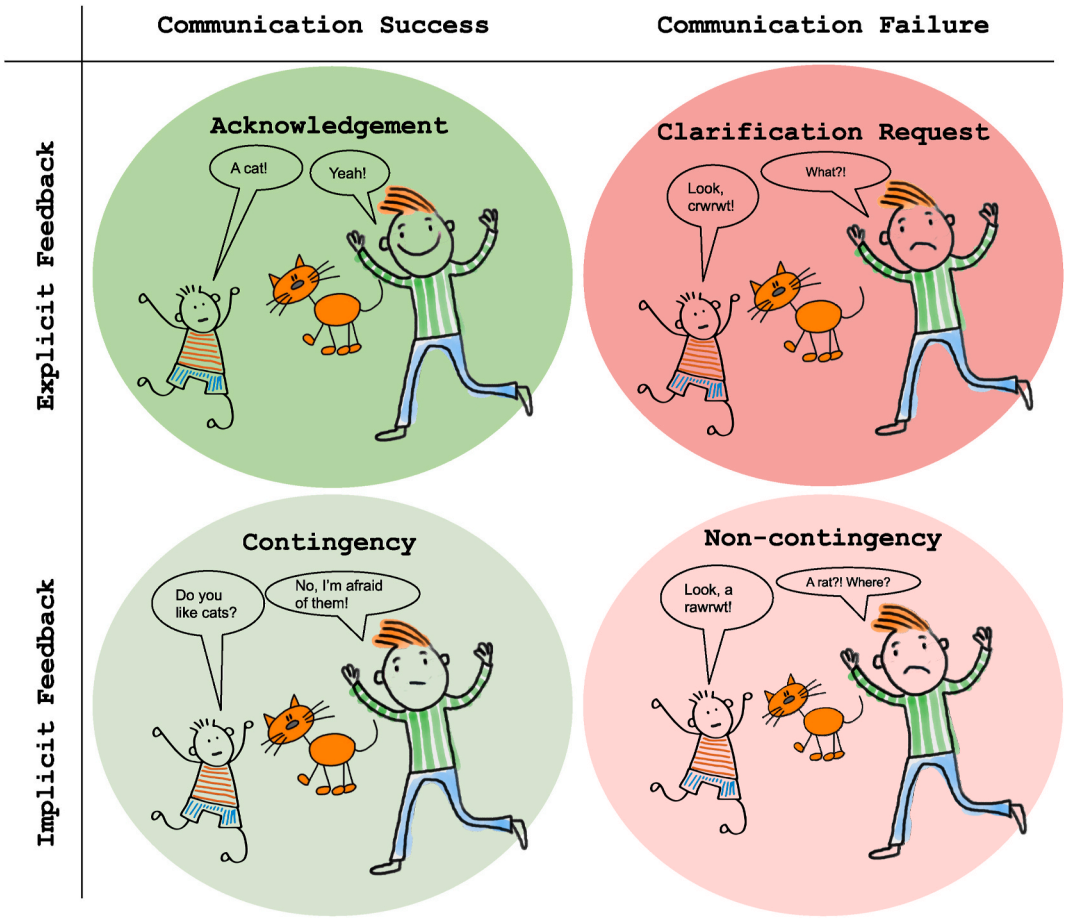

Fig. 2. Function and nature of Communicative Feedback signals. We illustrate each signal type with an example. Acknowledgement: The interlocutor acknowledges their understanding by smiling and uttering "Yeah". Clarification request: The interlocutor verbalizes their problem in understanding the child by responding with an open clarification request "What?". Contingency: The interlocutor responds with a relevant answer to the question, thereby providing an implicit signal to the child that they have understood the utterance. Non-contingency: The interlocutor misunderstands the child, responds non-contingently (from the perspective of the child), thereby providing implicit feedback signalling communication failure.

Acknowledgements include backchannels, as well as certain kinds of repetitions. Backchannels are short non-intrusive vocalizations that signal attention, understanding, or agreement from the listener (Bangerter & Clark, 2003; Schegloff, 1982; Yngve, 1970).[2] They can be verbal (e.g., "yeah", "right", "uh-huh") or non-verbal (e.g., smiling, nodding). Regarding repetitions, certain exact repetitions as well as paraphrases can function as acknowledgement, i.e. to communicate the receipt of information (Clark, 1996; Demetras et al., 1986; Huang, 2011).

While there is research on children's ability to produce and interpret backchannel signals in the context of child-caregiver interaction (Bodur et al., 2022; Dittmann, 1972; Hess & Johnston, 1988), we found very few studies investigating the potential effect of received backchannels on children's language learning. We can mention the work by Peterson et al. (1999) who conducted an intervention study with preschool children, investigating the effect of caregivers' backchannel responses on children's narration (among other narrative-eliciting behaviors such as asking more open-ended and context-eliciting questions). They found that children in the intervention group showed more improvement in vocabulary and narrative skills both immediately after the intervention and in a follow-up testing one year after the intervention. In another work, Newport, Gleitman, and Gleitman (1977) included a "Note on Reinforcement" (p. 172), suggesting that backchannels "may constitute confirmatory evidence for a child trying to build some hypotheses about how to speak English effectively", because they indicate understanding of what the child said. They based this claim on their finding that the rate of caregivers' use of interjections (which include backchannels) was positively correlated with growth of children's productive vocabulary as well as their use of verb inflections and auxiliaries.

Regarding the role of repetitions, Demetras et al. (1986) found that in naturalistic child-caregiver conversations, exact repetitions are much more frequently used in response to well-formed (semantically, syntactically and phonologically appropriate) than to ill-formed child utterances, thereby providing a useful positive feedback signal.

4.2. *Clarification requests*

Clarification requests (also referred to as other-initiated repairs) are used by listeners to signal difficulty or lack of understanding (Purver, 2004; Schegloff et al., 1977). They form an explicit negative CF, signaling to the speaker that their intended meaning has not been communicated successfully. Importantly, this negative CF signal can be used by language learners not only to revise their message in the upcoming conversational turn, but also to take into account the communicative failure to improve their linguistic knowledge for future interactions. Clarification requests can also be verbal (e.g., "what?",

[2] Schegloff (1982) argues that backchannels such as "uh-huh" ("continuers") are not strictly signalling understanding in all cases, but sometimes just an invitation for the speaker to continue (as the listener is passing on the opportunity to initiate a repair). We consider this still as a positive (but probably weaker) feedback signal to the speaker.

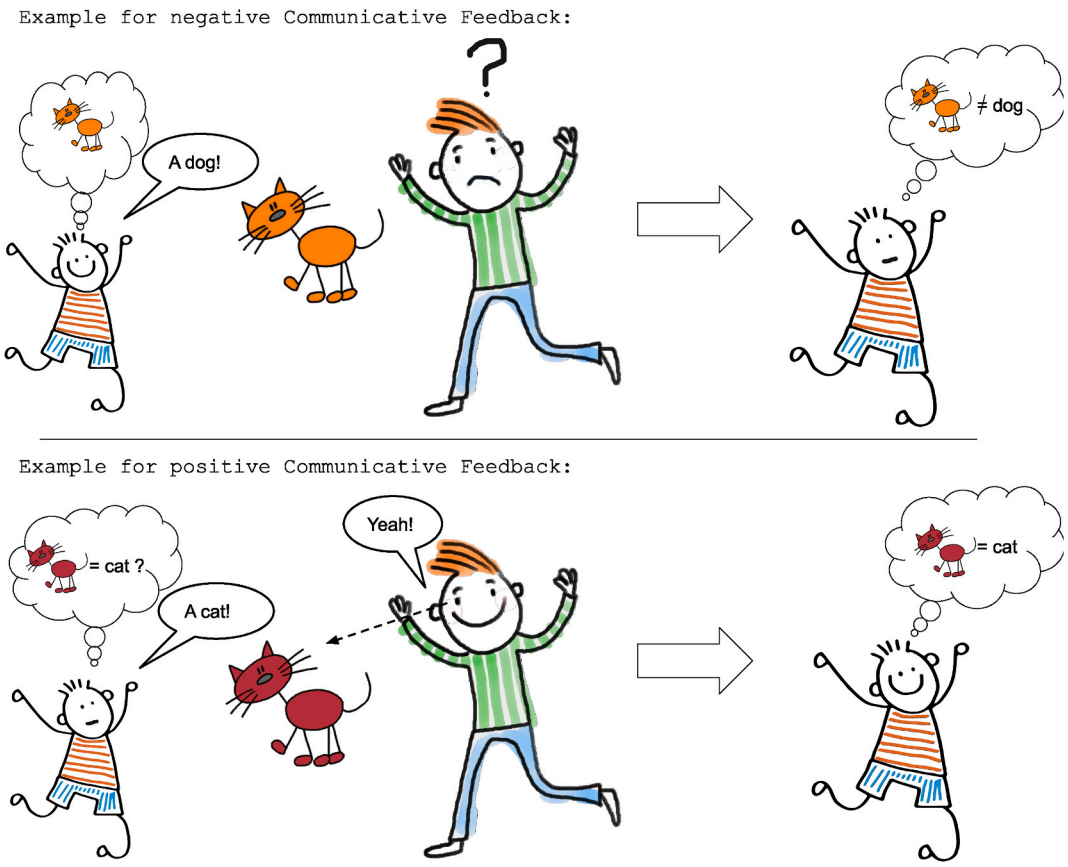

Fig. 3. We illustrate the CF-based mechanism with an example of word learning. The first illustration (top) shows a child that overgeneralizes the word "dog" to both cat and dog. Upon encountering a cat, they might say "A dog!" to draw the caregiver's attention to the cat. The caregiver would most probably react with a puzzled face, or ask for clarification, thereby providing rather negative CF to the child. Through this short interaction, the child can revise their knowledge about the meaning of "dog".
Later on (illustration at the bottom), the child might have learned about the word "cat" but might not be totally sure about its meaning. When encountering a new animal that looks like a cat, they might say "A cat!" The caregiver would most likely attend to the cat and respond contingently, thereby sending positive CF to the child, and strengthening the child's knowledge about the word cat.

"which one?") or non-verbal (e.g., frowning). We consider both open and restricted clarification requests as part of the CF-based mechanism, as they both signal a lack of understanding.[3]

In a naturalistic study of four mother-child dyads, Demetras et al. (1986) found that mothers use clarification requests more often in response to ill-formed child utterances (semantically, syntactically or phonologically inappropriate) than to well-formed ones. They conclude that clarification requests therefore form a useful negative feedback signal.[4]

Regarding children's sensitivity to clarification requests, it has been shown that even preverbal infants attempt to repair conversations if interlocutors show signs of non-understanding (Golinkoff, 1986). Studying children in their early stages of language use, Gallagher (1977) found that caregivers' clarification requests are understood by 2-to-3 year-olds and they follow up on these requests by revising or repeating their utterances. In the case of revision, which was more frequent, children either expanded on the original utterance or adapted the pronunciation. Saxton et al. (2005) studied the effect of clarification requests on grammatical errors with 2- and 4-years old children using an intervention paradigm. They found that children were more likely to correct grammatical errors (than to introduce an error) when prompted with clarification requests.

In addition to these experimental studies, Nikolaus, Prévot, and Fourtassi (2022) performed a large-scale corpus study of child-caregiver conversations and found that (1) caregivers use clarification requests more often in response to unintelligible utterances than to intelligible ones and (2) children improve their intelligibility when prompted with a clarification request.

Several other studies explored the ways that children perceive and react to clarification requests at different stages of development (e.g., Anselmi et al., 1986; Bosco et al., 2006; Brinton et al., 1986; Carmiol et al., 2018; Clark & de Marneffe, 2012; Corrin, 2010; Forrester & Cherington, 2009; Gallagher, 1981; Lustigman & Clark, 2019; Wilcox & Webster, 1980). We refer readers to Clark (2020) for a more comprehensive overview on the role of clarification requests for language acquisition.

4.3. Contingency (or lack thereof)

We use the term contingency in a broad sense as any felicitous

[3] The specificity of the feedback signal varies with the kind of clarification request. For open clarification requests ("What?"), the speaker only gets a binary feedback: The message has not been understood. Restricted clarification requests (e.g., Child: "I went to xxx." Adult: "You went where?") offer more specific feedback (arguably more valuable) on the part of the utterance that has not been understood. Restricted offers (Child: "I falled", Adult: "You fell?") offer the most specific feedback, as they additionally provide a possible repair. In that way, they are very close to corrective feedback, however we still include them within the framework of CF because they are part of general conversational management, and not specific to correcting children's mistakes.

[4] However, see Marcus (1993) for an important critique of these results.

response (verbal or non-verbal) from the listener that is coherent/compatible with the speaker's utterance (e.g., responding on-topic to a statement or answering with "yes!" to a yes-no question). A contingent response is an *implicit* CF that shows the listener has understood the speaker's intended meaning.

Non-contingency, by opposition, is defined as any response that is incoherent with the speaker's utterance (e.g., an off-topic response or answering with "yes!" to a greeting), implicitly indicating to the speaker that the listener did not understand their communicative intent. It has been shown that from an early age, children are aware of breakdowns in social coordination more generally (Bourvis et al., 2018; Markova & Legerstee, 2006; Tronick et al., 1978), and try to re-establish communication, e.g., by using self-initiated repairs when the caregiver's response does not seem to match their expectations (Forrester, 2008; Morgenstern et al., 2013).

Contingency is a notoriously challenging concept to operationalize (from the researcher's third point of view) because it requires inferring the child's communicative intent and judging whether the interlocutor's response is compatible with this intent. Both are non-trivial tasks. That being said, researchers have used various measures to approximate contingency in the context of children's early conversations.

4.3.1. Temporal contingency

Temporal contingency has been mainly used in studies with pre-verbal infants, especially regarding the development of their vocalizations into speech-like sounds. It describes responses that *follow* a child's communicative attempt within a short temporal delay, usually one to two seconds (Bloom et al., 1987; Goldstein et al., 2003; Warlaumont et al., 2014).[5] The idea is that if a speaker receives a response (as opposed to silence or a delayed response), this provides positive reinforcing feedback.

Using controlled experimental paradigms, researchers have found that infants' proportion of speech-like (syllabic) sounds over vocalic sounds increased if caregivers responded time-contingently, as compared to when they responded at random timepoints (Bloom, 1988; Bloom et al., 1987; Goldstein et al., 2003).

Similar effects have been reproduced in more naturalistic settings. For example, Warlaumont et al. (2014) analyzed home recordings from child-caregiver conversations and found that (1) caregivers are more time-contingent on child speech-related vocalization (e.g., babbling) than on non-speech-related vocalization (e.g., laugh or cry) and (2) children were more likely to continue with a speech-related utterances if they received a time-contingent response than if the caregiver was unresponsive. Using similar methodology, Nikolaus et al. (2022) explored the effect of time-contingent responses on children's intelligibility and found that (1) caregivers provide more time-contingent responses to intelligible utterances and (2) children produce more intelligible utterances if their caregivers are responsive.

Finally, Lopez et al. (2020) found that sequences made of child canonical babbling, followed by caregiver time-contingent response, followed by repeated child canonical babbling were predictive of productive vocabulary later in the child's development.

Note that for studies that have focused on the role of social feedback in helping children transition from early vocalization (e.g., crying) to speech-related sounds (i.e., babbling), it is not straightforward to equate Communicative Feedback, as we defined it above, with the caregiver's temporal contingency because the child's production may lack communicative intent and the caregiver's reaction is unlikely to be driven by an effort to "understand." Indeed, babbling is still unintelligible speech; it does not make the communicative intent, if there is any, clearer than mere vocalic sounds. It is, therefore, likely that this early form of social reinforcement is driven by a desire for emotional connection/attachment (Ainsworth & Bowlby, 1991; Bowlby, 1969) – without necessarily being about mutual understanding.

That said, we still consider this line of research to be related to our proposal. We believe this early form of "emotional connection"-based reinforcement represents a precursor, if not a basis, for later communication-based reinforcement when children start being able to talk about their intents in an (at least partly) intelligible fashion.

4.3.2. Content contingency

As soon as children's vocalizations start to be intelligible, we can go beyond time-contingency and use measures of contingency that also take into account the *content* of utterances.

Hoff-Ginsberg (1987) put forward the notion of topic-continuing replies to describe responses that refer to an entity or event that was referred to in the child's prior utterance. Caregiver's topic-continuing response behavior was found to elicit higher child responsiveness and to be predictive of children's vocabulary knowledge at later stages (Hoff, 2003; Hoff-Ginsberg, 1987).

The effect of negative feedback in the form of non-contingent responses to young infant's communicative attempts has been studied using controlled conversational paradigms (Grosse et al., 2010; Shwe & Markman, 1997). In these studies, the researchers showed that infants revise and repair their requests for objects in the case of misunderstanding, i.e. if their interlocutor did *not* understand their request correctly (e.g., if they responded "Oh, you want the paper?! Here you are!" to a child's request for a ball).

The research that aims at measuring lexical and semantic alignment in child-caregiver conversations can also be seen as capturing some aspects of contingency. In particular, many have investigated the extent to which caregivers re-use some of children words (or semantically related words) in their follow-up utterances (Fernandez & Grimm, 2014; Misiek et al., 2020; Yurovsky et al., 2016) and some have found this behavior to predict later development in linguistic skills (Denby & Yurovsky, 2019; Fusaroli et al., 2021).

4.3.3. Action contingency

Linguistic utterances do not only elicit verbal responses (e.g., a yes-no question eliciting a verbal answer), it can also elicit action (e.g., a request to hand over the ball). In the example of a request, the listener might just provide the speaker with the requested object as a response. As this is a form of successful communication, it provides positive CF. If a request is not met with the right action, this constitutes negative CF.

Whitehurst and Valdez-Menchaca (1988) studied the acquisition of foreign-language words for toys in 2–3 years old children. They found that children performed better in production and comprehension tests if they were (selectively) reinforced when making a correct production of the word by handing the corresponding toy to the child (and allowing them to play with it).

5. Directions for future work

In the light of our theoretical framework where we propose an explicit link between conversational coordination and language acquisition, the above literature review reveals several research gaps and points towards many directions for promising future work.

5.1. On the role of acknowledgements

Amongst all kinds of signals that can be provided by the listener

[5] This contrasts with a closely related line of research on caregiver *responsiveness* which has studied responses that match the child's focus of interest rather than responses that provide feedback on the child's production (Akhtar et al., 1991; Carpenter et al., 1998; Donnellan et al., 2020; Gros-Louis et al., 2014; Masek et al., 2021; McGillion et al., 2013; Tamis-LeMonda et al., 2001; Wu & Gros-Louis, 2014).We consider that these measures of contingency are therefore dealing with contingent *input* rather than contingent *feedback*. (Distinctions between feedback and "input at the right time" have been discussed in previous work (K. Bloom, 1984; Goldstein & Schwade, 2008; Poulson, 1983).

(Fig. 2), "Acknowledgement" stood out as the feedback mechanism that has received the least attention regarding its potential role in fine-tuning children's linguistic knowledge. One issue with existing studies is that they explored the role of acknowledgements only within a set of other communicative devices (e.g., as part of a set of interjections, narrative-eliciting behaviors, or repetitions in general). More controlled studies are required to test the specific role of acknowledgements.

5.2. Towards automated measures of contingency

As we mentioned in our review, it is not easy to judge contingency from a third point of view as this requires inferring the speaker's communicative intent and interpreting the listener's response.

Ideally, the endeavor to improve measures of content-contingency should be pursued within a computational agenda that aims at automatizing them as well. This is important to avoid subjective biases in human annotation, facilitate cross-lab and large-scale comparison, leading to more cumulative science on this question.

An automatic measure should, at a minimum, be able to evaluate the similarity of pairs of utterances while also capturing their complementarity at the speech act level as in the case of adjacency pairs (Nikolaus, Maes, Auguste, Prevot, & Fourtassi, 2021; Schegloff & Sacks, 1973).

To achieve this goal, the child developmental community would benefit from ongoing effort in natural language processing methods on the evaluation of coherence in dialog systems (Cervone et al., 2018; Cervone & Riccardi, 2020; Dziri et al., 2019; Higashinaka et al., 2014).

One shortcoming of automatic measures is that they usually overemphasize internal discourse coherence (e.g., the extent that two turns are semantically or "logically" related) rather than subtle context-dependent pragmatics. However, in conversations, meaning is usually constructed in a highly incremental and inter-subjective fashion (e.g., Fusaroli et al., 2014), and thus, a deep understanding of the discourse as whole as well as the interlocutors' common ground is required to judge the contingency of a turn. That said, we suspect most of child-caregiver interactions in early childhood would still be reasonably captured by rather simple measures of contingency. As children's conversations become longer and more sophisticated, more advanced methods for measuring contingency and their role as Communicative Feedback will have to be developed.

5.3. CF in later stages of language acquisition?

Most of the studies we reviewed have investigated the role of CF in the pre-verbal stage or for children producing their first words. It is unclear how CF would play out in later stages of language development and more future work is required to address this question.

On the one hand, we speculate that as children become more competent speakers, the role of CF would diminish for the learning of some aspects of *form* such as syntax and morphology. If the child makes mistakes that do *not* impede understanding (e.g., "go-ed" instead of "went"), CF may not provide a useful learning signal as children can still receive explicit or implicit signals of communicative success (see also Brown & Hanlon, 1970; Marcus, 1993, regarding the role of corrective feedback). CF is more useful regarding mistakes that are big enough to risk impeding the transmission of the child's communicative intents (e.g., "I bit dog" instead of "Dog bit me"). Such big mistakes naturally occur more in the earlier stages.

On the other hand, CF should continue to play a role regarding the acquisition of *meaning* throughout the learning process; errors in meaning often impede successful communication (e.g., when the child requests "ball" but they mean DOLL). In addition to meaning, we believe CF would continue help children refine their mastery of language *use*: A communicative intent can be phrased in various ways, and very often, the choice of the correct phrasing depends on the context. In other words, even when the form and (literal) meaning of the utterance is sound, its use in a specific context could still be correct or incorrect (e.g., using a verb in present tense when talking about the past), leading to signals of communicative success or failure from the listener that the child can pick up on.

5.4. Cross- and within-cultural variability

One motivation behind our focus on CF as a mechanism for language learning is that it relies on what is generally assumed to be principles of human communication. It is, therefore, more likely to be universal than mechanisms that require parents to adopt explicit teaching strategies towards children (e.g., corrections).

While, as we mentioned earlier, there is evidence that Communicative Feedback is used across many cultures in adult-adult conversations, there is surprisingly very few studies capitalizing on this potential to understand how CF plays out in the context of children's first interactions and to investigate how it influences language development across cultures, including in non-WEIRD[6] ones (Henrich et al., 2010). For example, the role of CF for children in conversation with interlocutors other than their caregivers, such as with older siblings, could play a more important role in cultures with relatively less frequent adults' child-directed speech (Casillas et al., 2020; Ochs & Schieffelin, 1984; Shneidman & Goldin-Meadow, 2012).

The study of variability, not only across but also within cultures is crucial. Indeed, many aspects of conversational dynamics have been shown to vary depending on the conversational partners, contexts, and languages. For example, child-child conversations are on average shorter and less coherent than child-caregiver conversations (Barton & Tomasello, 1994; Dunn & Kendrick, 1982), and the use of certain CF signals varies between affiliative and task-oriented conversations (Dideriksen et al., 2020) as well as between languages even in culturally similar communities (Dideriksen et al., 2022). More research studying how CF plays out in a wider range of contexts (including with various conversational partners, such as peers) is needed to shed light on possibly universal mechanisms supporting the acquisition of language.

5.5. Communicative Feedback in models of language acquisition

Our survey shows that studies about CF rely almost exclusively on experimental or corpus-analysis tools. Nevertheless, computational modeling is an essential research approach for the study of language development. This exercise allows us to study aspects of learning that are difficult to address with experimental/corpus studies alone. In particular, computational models help us to precisely instantiate the learning mechanism of interest, control its effect by studying it separately from other mechanisms, but also investigate how it interacts with other mechanisms. Further, more recent models allow us to test whether the mechanism of interest scales up to learning from more naturalistic input and simulate its developmental properties over long time scales.

Existing modeling effort of first language acquisition has mostly focused on mechanisms that leverage statistical regularities in the input, such as cross-situational learning (e.g., Abend et al., 2017; Fazly et al., 2010; Kachergis et al., 2021; Khorrami & Räsänen, 2021; Roy & Pentland, 2002), sometimes integrating also non-verbal social cues (Yu & Ballard, 2007), and the ability for pragmatic inference in ambiguous learning situations (Frank et al., 2009).

In comparison, little has been done to model language acquisition in a context where an artificial child agent learns from Communicative Feedback. This slow progress is understandable: In order for a model to mimic the interlocutor's Communicative Feedback, it needs first to be able to "understand" what the child agent is saying, which is still an open challenge, especially in the context of spontaneous conversations involving real – as opposed to a toy – language. We believe a first step – before we can build models that simulate children's first naturalistic

[6] Western, Educated, Industrialized, Rich, and Democratic.

conversations – is to focus precisely on toy language learning in controlled environments.For example, we can study the acquisition of language in simple communication games (e.g., "Lewis signalling games"), where agents are learning to communicate as a means for coordination to solve well-defined problems/tasks (Lewis, 1969).

Recently, this approach has been used in computational models to study how language is *created* in increasingly complex interactive contexts (Galke et al., 2022; Kirby & Hurford, 2002; Lazaridou & Baroni, 2020; Lazaridou et al., 2017; Mordatch & Abbeel, 2018). In these studies, agents are usually updating their linguistic knowledge about form-meaning mappings using *Reinforcement Learning* (RL, Sutton & Barto, 2018): The speaker agent is given a positive reward if the game outcome was successful, and negative otherwise. This reward signal can be seen as an instantiation of CF in that it provides the speaker with signals about communication success (or failure) that may have caused (or impeded) the successful accomplishment of the coordination task.

While such models have studied language creation/emergence, very similar computational tools can be used, in principle, to study language *acquisition*. In fact, some studies in this same literature successfully incorporated a language transmission component (from a pre-trained "teacher" to an untrained "student") in their multi-generational emergent communication frameworks (Cogswell et al., 2020; Dagan et al., 2021; Li & Bowling, 2019; Lu et al., 2020). That said, the goals of these studies has been still the study of language emergence across generations rather than the study of language acquisition of a child in an interactive context.[7]

We believe that computational models that specifically aim at modeling CF as a mechanism of language acquisition, even in a simplified context, are much needed. Besides, we believe such models should not focus exclusively on CF. Children learn both from the statistical regularities of the input and from social interaction; a helpful model of language acquisition should ideally integrate and contrast both components (Lazaridou et al., 2020; Lowe et al., 2020; Tsuji et al., 2021). For example, Nikolaus and Fourtassi (2021) provided a computational proof of concept using reinforcement learning as instantiation of CF in the case of meaning learning. They showed that, while statistical (cross-situational) learning was crucial, CF-based learning improved performance above and beyond statistical learning across a wide range of semantic tasks including both word- and sentence-level semantics.

6. Conclusion

While the idea that children learn language (partly) in and through conversation is not new, here we made this link more systematic by drawing on insights from theories on conversational coordination. We focus specifically on the role of Communicative Feedback that a – more knowledgeable – listener (an adult caregiver or an older sibling) provides to the speaker (here the child), signaling communicative success or breakdown. The main argument is that such signals, though they may lack a teaching agenda, can be picked up on by children and used to refine their language skills, leading to more successful communication in future exchange.

Using this framework, we bridged across several lines on research in language acquisition that have been pursued largely independently but which, according to our framework, all investigate how children's learning can be improved by leveraging the explicit or implicit Communicative Feedback in a dialog. Further, our review of this literature – in the light of the big picture – has revealed several gaps that suggest themselves as priorities for future research in order to paint a more complete picture of children's language learning in an interactive context.

[7] Another line of work has studied the learning of natural language instructions, typically in game-like setups (Branavan et al., 2009; Goldwasser & Roth, 2014; Hill et al., 2019, 2020; Hill, Tieleman, et al., 2020; Misra et al., 2017; Wang et al., 2019). In these studies, models learn to *understand* linguistic instructions with a task-dependant feedback signal. However, though interactive, these models do not instantiate the CF-based mechanism since agents do not produce language: The feedback they receive is rather about the behavior/actions they perform in the task.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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