


The Predictive Value of Non-Referential Beat Gestures: Early Use in Parent–Child Interactions Predicts Narrative Abilities at 5 Years of Age

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A longitudinal study with 45 children (Hispanic, 13%; non-Hispanic, 87%) investigated whether the early production of non-referential beat and flip gestures, as opposed to referential iconic gestures, in parent–child naturalistic interactions from 14 to 58 months old predicts narrative abilities at age 5. Results revealed that only non-referential beats significantly ($p < .01$) predicted later narrative productions. The pragmatic functions of the children’s speech that accompany these gestures were also analyzed in a representative sample of 18 parent-child dyads, revealing that beats were typically associated with biased assertions or questions. These findings show that the early use of beats predicts narrative abilities later in development, and suggest that this relation is likely due to the pragmatic–structuring function that beats reflect in early discourse.

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Children’s early gesturing not only precedes but also predicts simple linguistic milestones (e.g., Iversen & Goldin-Meadow, 2005). Given the fact that oral language skills play a role in subsequent successful school literacy (Demir, Levine, & Goldin-Meadow, 2012; Naremore, Densmore, & Harman, 1995), it becomes important to ask whether the early production of gestures also predicts more complex language skills, such as narrative skills, at later stages of development.

Two previous longitudinal studies have demonstrated that the production of referential gestures, which depict properties of a referent, produced in narrative discourses predicts later narrative abilities (Demir, Levine, & Goldin-Meadow, 2015; Vilà-Giménez, Demir-Lira, & Prieto, 2020). Demir et al. (2015) examined the predictive value of referential iconic character-viewpoint (CVPT) gestures. In these cases, the gesturer takes on the role of the character, using one or more parts of their own body to directly represent the character’s corresponding

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body parts (e.g., repeatedly bowing forward to illustrate a bird pecking from the bird's point of view). Results found that children who employed CVPT gestures in narratives at age 5 produced better goal-structured narratives at later ages, compared to children who did not produce CVPT gestures, suggesting that these gestures show that the child has the capacity to take a first-person perspective on events. Vilà-Giménez et al. (2020) also looked at children's use of referential iconic gestures in narrative speech and their relation to later narratives, and found that referential iconic gestures produced in children's narrative retellings at ages 5–6 also predicted the children's narrative structure scores 2 years later, whereas non-referential beat gestures had no such predictive value. To our knowledge, however, no previous investigation has examined the role of non-referential gestures, in comparison to other gesture types, produced in children's early spontaneous speech in predicting later narrative abilities. Non-referential gestures are devoid of semantic content, but have been argued to contribute discourse-pragmatic meaning to communication (Ferré, 2011; Kendon, 2004, 2017; McNeill, 1992; Prieto, Cravotta, Kushch, Rohrer, & Vilà-Giménez, 2018; Rohrer et al., 2020; Shattuck-Hufnagel, Ren, Mathew, Yuen, & Demuth, 2016; see also Vilà-Giménez & Prieto, 2021, for a systematic review of the cognitive and linguistic effects of non-referential beat gestures in children's language development).

Here we focus on the early use of two types of non-referential gestures, beat gestures and flip gestures, produced by preschool children (14–58 months old) in naturalistic parent-child interactions, and explore their value for predicting children's later narrative performance at 60 months (age 5). To extend this analysis and assess the types of pragmatic discourse functions that these gestures are associated with in child naturalistic discourse, we examined the pragmatic function of the utterances children produced along with their non-referential beat, non-referential flip, and referential iconic gestures. Given that non-referential gestures are rarely studied before 5 years of age, the results of this study (together with its focus on the pragmatic-structuring functions of these gestures) can provide enlightening data on multimodal development.

Referential Gestures in Language Development

During the early stages of communicative development, children use gestures before they speak.

At around 10 months of age, children produce their first referential gestures, called *deictic* (or pointing) gestures, to indicate an object, event, or location before they have words to do so (Bates, 1976; Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979; Esteve-Gibert & Prieto, 2014; McNeill, 1992). The specific lexical items that label the objects the child pointed at then turn up in their verbal vocabulary approximately 3 months later (Iverson & Goldin-Meadow, 2005). By the end of the first year of life, children have usually begun to produce words, but their use of gestures continues, often simultaneously with speech (e.g., Butcher & Goldin-Meadow, 2000; Esteve-Gibert & Prieto, 2014; Volterra & Iverson, 1995). At some point, gesture and speech combinations begin to refer to separate entities—such as pointing at a ball while saying “mommy” or “play”—and these combinations have been shown to predict the onset of children's first two-word utterances (e.g., “mommy ball” or “play ball,” Bavin, 2014; Goldin-Meadow & Butcher, 2003; Iverson & Goldin-Meadow, 2005; Özçalışkan & Goldin-Meadow, 2005).

A second type of referential gesture—also produced as early as 10 months of age—is the *iconic* gesture (Bates, 1976; Bates et al., 1979). According to McNeill's (1992) classification of gestures, iconic gestures bear a close relationship to the semantic content of the segments of speech they accompany, as they depict properties of an object, action, or scene. Thus, their meaning is given by the form of the gesture in context, such as when a child talking about shooting a bow and arrow simulated pulling the arrow back instead of using words to describe the action. The production of iconic gestures had been shown to follow rather than precede the verbal description of actions, with a lag of some 6 months between the earliest use of verbs and performance of the corresponding iconic gestures (Özçalışkan, Gentner, & Goldin-Meadow, 2014). However, the same research also found that, once children start to produce verbs, iconic gestures increase in frequency and help children to expand their communicative repertoires by allowing them to convey action meanings for which words are not yet available. Moreover, iconic gestures produced at around 5 years of age have been shown to predict and enhance children's subsequent narrative abilities (Demir, Fisher, Goldin-Meadow, & Levine, 2014; Demir et al., 2015; Parrill, Lavanty, Bennett, Klcó, & Demir, 2018; Stites & Özçalışkan, 2017; Vilà-Giménez et al., 2020).

*Non-Referential Beat Gestures in Language
Development: Evidence That They Convey Pragmatic
Meanings*

Later in development, at around 2 years of age (Levy & McNeill, 2013; Nicoladis, Mayberry, & Genesee, 1999), children begin to produce non-referential *beat* gestures. These are typically quick up and down rhythmic movements of the hand or fingers referred to as “beat” gestures because they characteristically coincide with prosodic prominences in discourse (e.g., discourse entities that receive prosodic prominence in the form of pitch accentuation; McNeill, 1992). These gestures are non-referential in that they have no semantic meaning, but are used instead to signal the temporal locus of important information (McNeill, 1992, 2005) and have also been argued to serve pragmatic and structuring functions (Graziano, 2014a, 2014b; Prieto et al., 2018; Rohrer et al., 2020; Shattuck-Hufnagel & Prieto, 2019; Shattuck-Hufnagel & Ren, 2018; Shattuck-Hufnagel et al., 2016; see Vilà-Giménez & Prieto, 2021, for a review). In the words of Kendon (2017), “the kinesic action appears to make distinct different segments or components of the discourse, providing emphasis, contrast, parenthesis, and the like, or where it marks up the discourse in relation to aspects of its structure such as theme-rheme or topical focus” (p. 168).

Evidence shows that adults use non-referential beat gestures to mark information structure, rhythm, and discourse structure (Dimitrova, Chu, Wang, Özyürek, & Hagoort, 2016; Im & Baumann, 2020; Rohrer et al., 2020; Shattuck-Hufnagel et al., 2016). This discourse marking function (e.g., to introduce new characters, summarize the action, etc.) was first noted by McNeill (1992), and confirmed by Im and Baumann (2020) and Ferré (2014). Im and Baumann (2020) showed that non-referential gestures, in conjunction with prosodic prominence (i.e., pitch accents), encoded information status in speech by highlighting new (i.e., new and unused) or accessible (i.e., bridging) referents, rather than given referents or words that had no referential status. Ferré (2014) also analyzed information status marking through gestures and prosody and found that non-referential beat gestures co-occurred with prosodic focus marking much more than other gesture types. Furthermore, investigations using event-related potentials or functional resonance imaging in adults have provided evidence that beat gestures can facilitate syntactic and semantic processing (Biau & Soto-Faraco, 2013; Holle et al., 2012; Wang & Chu, 2013).

Non-referential beat gestures appear in complex discourse when children are between 4 and 6 years of age and seem to be related to the emergence of more complex discursive skills (e.g., Graziano, 2009; Mathew, Yuen, & Demuth, 2018; McNeill, 1992; see also the longitudinal study by Florit-Pons, Vilà-Giménez, Rohrer, & Prieto, 2020). Several studies have suggested that children start using beat gestures to mark clause relations in storytelling at around 5–6 years of age (Blake, Myszczyzyn, Jokel, & Bebiroglu, 2008; Colletta et al., 2015; Colletta, Pellenq, & Guidetti, 2010; Mathew et al., 2018; McNeill, 1992). For instance, a cross-linguistic study with 5- to 10-year-old French, American, and Italian children by Colletta et al. (2015) found that, cross-linguistically, children at the older ages produced more beat gestures (i.e., discourse or cohesive gestures) to structure their speech or mark cohesion than referential gestures, but also more beat gestures than framing gestures (expressing an emotion or mental state of the narrator), performative gestures (expressing the illocutionary value of a speech act), interactive gestures (which make reference to the interlocutor) and word searching gestures. Moreover, in a narrative task performed by 6- to 10-year-old monolingual French-speaking children and adults (Colletta et al., 2010), the average number of beat gestures with a discursive function (e.g., accompanying connectors, highlighting important linguistic units, or performing anaphoric functions) and beat gestures with a framing function increased significantly with age. In fact, children use non-referential beat gestures significantly more as they get older (Colletta et al., 2010; Florit-Pons et al., 2020).

*Non-Referential Flip Gestures: Evidence That They
Convey Epistemic Meanings*

Besides the beat gesture, which involves an up and down movement of the hand or finger, there is a second common non-referential gesture called a wrist *flip* gesture, in which the downward-facing palm is flipped to face upwards, often accompanied by a shrug of the shoulders (Ferré, 2011). Cooperider, Abner, and Goldin-Meadow (2018) distinguished different types of palm-up gestures according to form and meaning, and proposed that the basic flip gesture form is used for two distinct gesture functions: (a) the *palm-up epistemic* gesture, which frequently co-occurs with a shoulder shrug, is used to express a lack of knowledge, ability, or concern; (b) the *palm-up presentational* gesture metaphorically is used to present information or

request a response from the interlocutor. Although flip gestures have been classified as culturally established conventionalized emblem gestures for expressing ignorance (e.g., Ferré, 2011; Johnson et al., 1975; see McNeill, 1992, for a definition of conventional gesture forms), they can also be used to express epistemic states aside from ignorance, such as indicating a shared knowledge, obviousness, or extreme certainty. Furthermore, flip gestures may take a range of meanings about the speaker's affective state, such as disinterest, non-responsibility, or excitement. Moreover, flip gestures (again often accompanied by a shoulder shrug) can convey a modal function of uncertainty (Kendon, 2004), as if adding a question-tag to the utterance (Ferré, 2011).

Children start producing flip gestures before they produce beat gestures, but flips have a long trajectory during which the conveyed meaning is expanded. A few observational studies have documented that flips conveying ignorance are first used at 15 months of age. For instance, Acredolo and Goodwyn (1985) observed one child from 12 to 17 months and found that she began to use flip gestures (and shoulder shrugs) to signal ignorance at 15 months. Similarly, Bartz (2017) analyzed sixty-four 14- to 42-month-old children included in a longitudinal study of early language development (Goldin-Meadow et al., 2014) and found that one-fifth of the children produced a flip to signal ignorance at 22 months, and half of the children produced a flip to convey ignorance by 42 months of age (see Harris, Bartz, & Rowe, 2017, for a review of the emergence and prevalence of flip gestures conveying ignorance). Moreover, two studies by Graziano (2014a, 2014b) analyzed palm-up gesture performance from the *Open Hand Supine* family (following Kendon, 2004) in older Italian-speaking children's narratives. Findings revealed that the flip gesture with a backward and lateral movement of the hand—often accompanied by a shoulder shrug—(i.e., *Palm with a Lateral Movement* gesture) was used to mark the end of the narrative discourse or in association with phrases such as “I don't know” or “I don't remember”. Older children also used these gestures to convey various other pragmatic meanings of the utterance, such as obviousness or unwillingness.

Effects of Referential and Non-Referential Gestures in Complex Narrative Discourses

A growing area of research interest has to do with the value of gesture use by young children to predict changes in complexity of the discourse,

particularly with regard to their production of linguistically complex narratives. The emergence of children's narratives in speech appears in the transitional period between ages 3 to 6 (Stites & Özçalışkan, 2017). During the preschool years, children start telling simple narratives, with a basic goal and character components of a story (Applebee, 1980; Berman & Slobin, 1994; Stradler & Ward, 2005). However, between ages 5 and 6, children begin to tell well-structured stories containing all the features that comprise narrative structure (Bamberg, 1987; Berman & Slobin, 1994; O'Neill & Holmes, 2002). As we have noted, language and gesture develop together during the school-age years. For example, the same developmental changes found in spoken narratives can be found in the gestures that accompany those narratives (Alamillo, Colletta, & Guidetti, 2013; Colletta et al., 2015). The use of gestures related to narrative organization—including beat gestures—increases as children's narratives become more complex in terms of length and amount of detail. Children are able to accompany their narratives with representational gestures (i.e., referential gestures such as iconic and metaphoric gestures) at around 4 or 5 years of age (McNeill, 1992). Moreover, by age 9, children can accompany their narratives with gestures that function like adult gestures to represent the events narrated, to mark discourse cohesion, to convey the pragmatic framing of the utterance that help discourse connotation, and so on (Colletta, 2009).

Across studies, there is evidence that referential iconic gestures not only co-occur with narratives, but also precede and predict the development of narrative abilities (Demir et al., 2015; Stites & Özçalışkan, 2017; Vilà-Giménez et al., 2020) and enhance that development (e.g., Demir et al., 2014; Parrill et al., 2018). Stites and Özçalışkan (2017) found that, before children introduce story referents in speech using noun phrases and pronouns at 6 years of age, they rely on iconic gesture plus speech combinations at age 5 to introduce new characters into the story by using CVPT gestures. Interestingly, an earlier study by Demir et al. (2014) found that observing a storyteller produce story-relevant gestures during a narrative task helped both 5-year-old children with early brain injury and typically developing children produce better-structured narrative retellings than observing the teller produce the story in speech alone. Similarly, Parrill et al. (2018) found that training children to produce CVPT gestures during storytelling had significant positive effects on their narrative structure scores immediately after training.

With regard to non-referential gestures, some recent research has focused on the role that beat gestures may play in bolstering children's narrative performance. For instance, two studies showed that asking 5- to 6-year-old children to observe non-referential beat gestures (Vilà-Giménez, Igualada, & Prieto, 2019) and to produce non-referential beat gestures (Vilà-Giménez & Prieto, 2020) in a brief narrative training task boosted their posttest narrative performance. Moreover, Llanes-Coromina, Vilà-Giménez, Kushch, Borràs-Comes, and Prieto (2018) also found that children who were asked to watch stories accompanied by beat gestures could remember the story information better than children who did not observe beat gestures (see Austin & Sweller, 2014; Igualada, Esteve-Gibert, & Prieto, 2017; Llanes-Coromina et al., 2018, for comparable effect on recall in 3- to 5-year-olds). However, to date, the predictive value of early non-referential gestures in later narrative complexity has yet to be explored, and it is this gap in the research which this study intends to address.

The Current Study

The research presented here is twofold in purpose. First, it investigates whether the early production of non-referential beat gestures, non-referential flip gestures, and referential iconic gestures produced in naturalistic interactions predicts later narrative production (in particular, narrative structure) at 5 years of age. The predictive analysis was run on a longitudinal database that includes 45 parent-child dyads visited in their home every 4 months between 14 and 58 months of age. At 60 months (i.e., 5 years old), the same children participated in a narrative task (data from Demir et al., 2014).

Second, in order to assess the discourse role that non-referential beat and flip gestures (vs. referential iconic gestures) might play in later children's narrative development, we used a representative sample of 18 parent-child dyads from this database to examine the pragmatic function of the speech that children produced along with beats, flips, and iconic gestures during the naturalistic interactions. Our hypothesis is that non-referential beat and flip gestures will be associated with speech that encodes a richer variety of discourse meanings than referential iconic gestures (e.g., specifically *biased* assertions or questions, see Table 2 for detailed examples). In contrast to referential iconic gestures, which involve imagistic or pictorial content, both types of non-referential gestures have been found to convey pragmatic meanings, as noted above. We further

hypothesize that non-referential beat gestures—in conjunction with prosodic prominence—will help more than non-referential flip gestures to frame structure and manage discourse, since, as we have seen, they have been shown to serve important linguistic discourse functions, such as marking discourse and information structure (Dimitrova et al., 2016; Im & Baumann, 2020; Kendon, 2004, 2017; McNeill, 1992; Prieto et al., 2018; Rohrer et al., 2020; Shattuck-Hufnagel & Prieto, 2019; Shattuck-Hufnagel et al., 2016; see Vilà-Giménez & Prieto, 2021, for a review; and others). In contrast, we think that non-referential flip gestures will primarily convey epistemic meanings in discourse such as “I don't know” (e.g., Cooperrider et al., 2018). Based on these findings, we expect that non-referential beat gestures are in a privileged position to scaffold later children's narratives. We, therefore, predict that the early use of non-referential beat gestures by very young children in parent-child interactions will forecast later narrative abilities at 5 years of age.

Our study consisted of two separate confirmatory analyses. The first sought to explore the relative value of the early use by children of three types of gestures, two of them non-referential (beat and flip gestures), the other referential (iconic gestures) for predicting the children's narrative abilities. The second analysis aimed at determining the pragmatic discourse functions that tend to be expressed by the speech accompanying each of the three types of gesture.

Analysis 1: Using Non-Referential Beat Gestures to Predict Children's Later Narrative Abilities

Method

Participants

A total of 45 typically developing children (20 females, 25 males) took part in the study. The participants and their families were part of a larger longitudinal study of language development (see Demir et al., 2014, 2015; Goldin-Meadow et al., 2014; Özçalışkan & Goldin-Meadow, 2005; Rowe & Goldin-Meadow, 2009), and the sample was representative of the greater Chicago area in terms of ethnicity (white, 75%; black, 16%; multiple or other, 9%), race (Hispanic, 13%; non-Hispanic, 87%) and income levels (\$7,500, 4.4%; \$25,000, 20%; \$42,500, 24.4%; \$62,500, 15.6%; \$87,500, 13.3%; \$100,000, 22.2%). For these 45 children and their families, mean parent education was 16.13 years,

corresponding on average to a college degree ($SD = 1.82$, range = 12 (high school)—18 (graduate school)). All children were being raised as monolingual English speakers.

Materials and Procedure

Parent-child dyads were visited in their homes every 4 months between child age 14 and 58 months. At each visit, families were instructed to go about their day as usual and recordings commonly included activities like mealtimes, book readings, and play sessions. As unobtrusively as possible, over a period of 90 min per visit, researchers videotaped the children and caregivers as they engaged in a spontaneous interaction. These data were collected as part of a larger longitudinal study of language development at the University of Chicago.

In addition, in order to gather endpoint data related to the development of their narrative skills, a second set of data from the 45 children was collected at age 5 ($M = 6$, $SD = 0.42$; see Demir et al., 2014). These data were obtained by means of a narrative task in which each child was shown two cartoons on a DVD player during a regular home visit. The German-produced cartoons (*Maus*, Westdeutscher Rundfunk Köln, <http://www.wdrma.us.de>) contained no text or verbal content and were unfamiliar to the children in the study. Each cartoon (30–73 s) featured a small mouse and his friends, and followed the same structure with causally connected events: a goal, an initiating event (the problem), multiple episodes (attempts to achieve the goal), and an outcome or resolution. Because the children were not exposed to any language content in the cartoons, in retelling what they had seen for the narrative task, they had to depend entirely on their own communicative resources (see Demir et al., 2014, for more details about the procedure and other conditions).

Transcription and Coding

Speech. Speech was transcribed verbatim, not phonetically, and then labeled by utterance type (i.e., different fragments of speech were counted as word, phrase, or complex sentence with many embedded clauses), with utterance unit boundaries determined by pauses, prosody, turn transitions, and syntax. The number of word types a child produced was also counted and used in the later methods of this study as a measure of the child's speech development (as in Rowe, Özçalışkan, & Goldin-

Meadow, 2008). For instance, if the child said "milk, milk, milk" this was counted as one type. If the child said "milk, mom, bottle," this was counted as three types.

Gesture. All video recordings of parent-child interactions were carefully scrutinized. Every parent or child co-speech gesture (i.e., all spontaneous communicative movements of the body, excluding non-communicative movements such as self-adapters, actions, and locomotion, see McNeill, 1992) was annotated on the speech transcript and coded following McNeill (1992) according to five types of gesture: *deictic*, *iconic*, *metaphoric*, *beat* and *conventional*. A sixth type, the wrist *flip* gesture, which is not included in McNeill's (1992) classification of gestures, was also coded. In this study, these gesture types were also classified into two more general groups: *referential* gestures (i.e., deictic, iconic, and metaphoric gestures) which visually illustrate some information about the referent in speech, and *non-referential* gestures (i.e., beat and flip gestures) which do not convey specific semantic information about a referent. Importantly, conventional gesture forms (i.e., conventional or emblem gestures) are not included in our analysis (but see the caveat with respect to flip gestures), as they have been defined as conventionalized signs created in accordance with the rules of a particular system and thus have a culturally defined meaning and form within a given community (McNeill, 1992). Gestures were also annotated for form (i.e., description of the manual or non-manual articulators) and gloss (i.e., presumed meaning of the gesture). The first-level coding scheme included a broad array of gesture forms, including deictic pointing and emblems like "thumbs up;" however, for purposes of the current work, we focused on non-referential beat and flip gestures. As noted above, referential iconic gestures were included to control for the possibility that any observed relationship was due to the effect of gesture *per se*, regardless of type. We thus recorded results for non-referential beat gestures, non-referential flip gestures, and referential iconic gestures.

Beat gestures. McNeill (1992) states that "beats are typically biphasic, small, low energy, rapid flicks of the fingers or hand; they lack a special gesture space, and are performed indeed wherever the hands happen to find themselves, including rest positions" (p. 80). They are typically short and quick movements of the hand in one dimension, up and down, or back and forth, and can occur alone (on a single word) or in a sequence (punctuating syllables or several words). Beat

gestures are considered to be rhythmic, non-referential (without adding semantic information to a referent in speech) gestures and are typically associated with prominent positions in natural discourse (e.g., emphasizing important information in discourse or marking the introduction of a new discourse).

Flip gestures. Sometimes referred to as palm-up gestures, flips are defined as a full or partial rotation of wrist with open palm(s) to present the flat palm, often accompanied by a shrug of the shoulders. Flips are also considered non-referential gestures, as they do not depict properties of an object referred to in speech but can contribute to interpreting pragmatic meanings in discourse, for example, by showing the speaker’s judgment or other epistemic values, such as obviousness (Ferré, 2011; see also Cooperrider et al., 2018; Graziano, 2014a, 2014b). Importantly, our definition does not consider flip gestures as conventional (i.e., emblem) gestures, although they can be used emblematically (e.g., when produced in the absence of speech; see Ferré, 2011; Johnson et al., 1975), because they are not limited to a single conventionalized meaning and their diversity of meanings is not unique to any particular cultural or linguistic community (McNeill, 1992).

Iconic gestures. Gestures that are referential and representational (visually depicting properties of a referent in speech) and bear a close formal relationship to the semantic content of the speech they accompany are considered iconic. Iconic gestures can refer either to actions or perceptual features associated with objects. An example of an iconic gesture is moving the hand upward while saying “he tried going up inside the pipe this time” to represent the act of going up (McNeill, 1992, p. 78).

For the initial first-level coding, each type of gesture was assigned a gloss or meaning from a drop-down list according to its gesture form and context. For example, after identifying a flip form, the meaning was chosen from the following list: *all gone, all done, don’t know, question, exclamation, of course, whatever*. This list was not intended to be exhaustive of all flip meanings, but was sufficient to describe all of the flips observed in this corpus. Beat gestures were always glossed as *emphasis*. Iconic gestures were coded with an open-ended description of form and glossed according to the corresponding referent in speech.

Narrative structure. Scored narratives from the cartoon-based narrative task at 5 years of age were obtained from Demir et al.’s (2014) study. The score was based on the narrative structure using a rating

adapted from Stein and colleagues (Stein, 1988; Stein & Albro, 1997; Trabasso, Stein, Rodkin, Munger, & Baughn, 1992), as shown in Table 1 below.

Inter-rater reliability. Transcription reliability was established by having 20% of videos double-coded by an expert coder. Because of the extended longitudinal nature of this developmental data set (following children beginning in the second year of life and continuing into young adulthood), the initial transcription and gesture coding was performed by a large team of research assistants. For the purposes of establishing reliability in the early childhood visits, two research assistants served the role of the expert coder. Reliability was assessed at two levels of coding, the first involving the speech transcription and the second involving the gesture categorization into types. The reliability process established two agreement scores, comparing the double-coded transcripts for utterance boundaries and words produced. Transcribers were first trained on the system and had to reach 95% agreement with expert coders for both utterance and word scores before moving past the training stage. From there, 30% of transcripts were randomly selected for reliability, where an expert coder coded

Table 1
Narrative Structure Scores Used for the Child’s Narrative Production Assessment in Demir et al.’s (2014) Study

Score of 0	A scoreless narrative is a string of sentences that do not contain a descriptive sequence and have no structure
Score of 1	A descriptive sequence is a narrative that includes the physical and personality characteristics of an animate protagonist with no mention of a sequence of actions
Score of 2	An action sequence is a narrative with actions described in a temporal order (actions follow one another in time) but in which the actions are not causally organized
Score of 3	A reactive sequence contains actions that are causally organized but does not include the protagonist’s goal, the intention of the protagonist to act to achieve a specific end
Score of 4	An incomplete goal-based narrative contains a goal statement and/or an attempt but no outcome following the goal
Score of 5	A complete goal-based narrative with one episode includes not only temporal and causal structure but also a goal of the protagonist, an attempt to achieve the goal, and an outcome of these attempts
Score of 6	A complete goal-based narrative with multiple episodes includes multiple goal-attempt-outcome sequences

a 20-min segment of video and calculated agreement using the same system. Reliability was then achieved when coders agreed on 90% of transcription decisions. If either was below the 90% threshold, the original transcriber reviewed his or her own work and revised it as needed. As for gesture categorization into types, gesture coders had to reach a 90% agreement level for gesture presence and form to move past training and thus before they could begin coding. The additional pragmatic annotation in our descriptive analysis was performed at the utterance level; that is, codes were assigned per utterance (rather than per word, gesture, turn, etc.) with utterance boundaries determined by the initial transcription.

Data analysis

Three Generalized Linear Mixed Models (GLMMs; West, Welch, & Galecki, 2007) were run using R Studio software with children's narrative productions at 60 months of age as the dependent variable. A first GLMM analysis was run to test whether the mean overall number of non-referential beat gestures, non-referential flip gestures, and referential iconic gestures produced in the total developmental window (from 14 to 58 months) predicted the structure of children's later narrative productions. The average numbers of non-referential beat and flip gestures and referential iconic gestures produced by the 45 children were set as fixed factors. Forty parent-child dyads out of the 45 completed all 12 sessions. The five remaining families each missed one session and completed 11, leaving data on the quantity and forms of child-produced gestures for 535 sessions. In a second GLMM analysis, we replicated the model but controlled for children's early speech, which was set as a fixed effect. Finally, in order to examine if predictive relations would hold when an earlier time developmental window is considered, a third GLMM was conducted to analyze whether the average number of non-referential beat gestures, non-referential flip gestures, and referential iconic gestures, produced between 14 and 42 months still predicted later narrative productions. In all three analyses, the random structure that provided the best fit according to the AIC (Akaike Information Criterion) included a random intercept for subject (and all subjects included parent education measures). In general, the average month of onset was 39 months for beat gestures, 28 months for flip gestures, and 24 months for iconic gestures.

Results

Results of the first GLMM analysis were calculated to predict narrative abilities (measured in terms of structural wellformedness) at 5 years of age based on the number of beats, flips, and iconic gestures produced by children during their parent-child naturalistic interactions between 14 and 58 months. On average, children produced 1.19 beat gestures per session ($SD = 1.74$, range = 0–10.23), 1.86 flips per session ($SD = 1.87$, range = 0.15–9.15), and 3.58 iconic gestures per session ($SD = 2.73$, range = 0.31–11.46; see Table A1 in Appendix A). Results showed that the average number of non-referential beat gestures produced between 14 and 58 months significantly predicted narrative skills ($\beta = 0.299$, $SE = .111$, $z = 2.689$, $p < .01$). However, the average number of non-referential flips ($\beta = -0.163$, $SE = .109$, $z = -1.489$, $p = .137$) and the average number of referential iconic gestures ($\beta = 0.029$, $SE = .077$, $z = 0.381$, $p = .703$) did not significantly predict later narrative scores. Children's narrative abilities at age 5 improved by 0.299 for each beat gesture produced. This model explained 88.4% of the variance in children's narrative outcomes ($R^2 = .884$). See Table B1 in Appendix B for a summary of the results.

In the second GLMM statistical analysis, we added the mean overall number of word types as a measure of children's early language in the model. We picked word type, which has been used as a measure of vocabulary diversity, rather than other measures of speech for two reasons. First, in our data set, average number of word types was significantly correlated with later narrative measure ($r = .33$, $p = .02$), but number of utterances, a measure of amount, was not ($r = .24$, $p > .10$). Second, the number of utterances was highly correlated with gesture measures, creating a possibility of collinearity (correlations reaching up to .5), compared to word types (correlations between .3 and .4). The results of this analysis, in which we controlled for children's early language, showed that the overall mean number of non-referential beat gestures ($\beta = 0.235$, $SE = .111$, $z = 2.106$, $p = .035$) produced in the relevant period emerged as a significant predictor of later outcomes but non-referential flips ($\beta = -0.186$, $SE = .105$, $z = -1.763$, $p = .078$) or referential iconic gestures ($\beta = -0.021$, $SE = .078$, $z = -0.274$, $p = .784$) did not. This model explained 95.7% of the variability in children's narrative discourses ($R^2 = .957$). See Table B2 in Appendix B for a summary of the results.

In order to check whether the same patterns of prediction arise using an earlier time window potentially up to 4 years and to avoid the possible age overlap between 46–58 and 60 months of age when children produce their narratives, we ran a third GLMM analysis. This analysis was carried out to predict narrative abilities at 5 years of age based on the number of beats, flips, and iconic gestures produced by the children during their parent–child naturalistic interactions between 14 and 42 months. On average, the children produced .42 beat gestures per session ($SD = 0.38$, range = 0–1.50), 1.69 flips per session ($SD = 2.11$, range = 0–10.88), and 3.83 iconic gestures per session ($SD = 3.46$, range = 0.25–15.63; see Table A2 in Appendix A). The results showed that the average number of non-referential beat gestures produced between 14 and 42 months still significantly predicted narrative skills ($\beta = 1.386$, $SE = .583$, $z = 2.377$, $p = .017$). However, the average number of non-referential flip gestures ($\beta = -0.136$, $SE = .112$, $z = -1.212$, $p = .225$) and the average number of referential iconic gestures ($\beta = 0.009$, $SE = .067$, $z = 0.137$, $p = .891$) did not significantly predict later narrative scores. Children's narrative abilities at age 5 improved by 1.386 for each beat gesture produced. This model explains 80.1% of the variance in children's narrative outcomes ($R^2 = .801$). See Table B3 in Appendix B for a summary of the results.

Analysis 2: Describing the Pragmatic Discourse Functions Expressed by the Speech That Accompanies Non-Referential Beat, Non-Referential Flip, and Referential Iconic Gestures

Method

In order to assess which pragmatic discourse functions of speech were associated with each gesture type in the children's spontaneous speech interactions, a further pragmatic descriptive analysis was conducted of the speech produced in the course of naturalistic interactions with caregivers by a smaller sample of 18 children, 12 of whom were part of the larger sample whose data were examined in the first analysis.

Participants

Due to the intensive nature of coding for the second aim of the study, annotation was performed on a subsample of 18 children (8 females, 10 males) from the same longitudinal project used in Analysis 1. The pragmatic annotation builds on speech and

gesture coding from previous research that was conducted with only these 18 families (see Cartmill, Hunsicker, & Goldin-Meadow, 2014). This group of dyads was originally selected in the previous study based on the average mean length of utterance (MLU) for the first five observation sessions (at 14, 18, 22, 26, and 30 months). It included six children with the highest MLUs in the larger sample (mean 2.04 ± 0.10 ; 3 girls and 3 boys), six with the lowest MLUs (mean 1.22 ± 0.06 ; 2 girls and 4 boys), and six with the median MLUs (mean 1.52 ± 0.06 ; 3 girls and 3 boys). The subsample was representative of the entire sample with respect to the children's MLU and was also diverse in terms of gender, ethnicity (Hispanic, 6%; non-Hispanic, 94%), race (white, 67%; black, 22%; multiple or other, 11%) and socioeconomic status income (\$7,500, 5.6%; \$25,000, 16.7%; \$42,500, 11.1%; \$62,500, 22.2%; \$87,500, 27.8%; \$100,000, 16.7%). For these families, the mean parent education was 15.5 years ($SD = 2.25$), not significantly different from the group of 45 families ($p = .25$). Six of the children in this subsample were not part of the larger sample of Analysis 1 because they did not have later narrative scores.

Pragmatic Coding of Speech

All the 18 children's target utterances accompanied by beats, flips or iconic gestures were analyzed by the first author, following a pragmatic coding scheme adapted from Ninio, Snow, Pan, and Rollins (1994) and based on Krifka's (2015) commitment space semantics framework. Four main pragmatic functions were coded as follows (see Table 2 for examples). An utterance was annotated as "unclear" if its pragmatic function could not be determined from the context (2.78% of the utterances fell into this category).

1. *Unbiased assertions*. This category includes unmarked or unbiased assertions (see Krifka's commitment analysis of speech acts, 2015), with a declarative or explanation illocutionary force and with no markers of modality. By asserting a proposition, the speaker makes a public commitment to the truth of that proposition (Brandom, 1983). These assertions may take the form of declaratives, explanations, and information responses.
2. *Biased assertions or questions*. This category is based on the idea that speech acts are a part of semantics, allowing semantic operators to scope over them (Krifka, 2015). Thus, these

Table 2
Examples of Children's Target Utterances Conveying Different Pragmatic Functions

Unbiased assertions	Declarative	"I'm going to get it straight down." (iconic)	
	Explanation	"at the end of the day, we went home" (beat—beat)	
	Information response	"if you still don't, you have to go back this way" (iconic)	
Biased assertions or questions	Epistemic uncertainty	Confirming question. "Mom, you know what I should do?" (beat)	
		Information-seeking question. "why that cover his eyes?" (iconic)	
		Expressing ignorance. "I don't know" (flip)	
	Epistemic agreement	Expressing absence. "all gone" (flip)	
		Acknowledgment	know there is five" (beat)
		Affirmation. "yes I did" (flip)	
Negation	Affirmation with agreement. "you got to practice every time a day. (beat—beat—beat)"		
	Correction. "no, her puzzles." (beat—point)		
	Contradiction. "yes she do!" (beat—beat—beat)		
	Negation. "no" (iconic)		
Requesting speech act	Negation with disagreement. "I hate egg salad" (beat)		
	Requesting question. "wait for games." (beat)		
Expressive speech act	Request. "say whee!" (iconic)		
	Exclamation. "we're at school" (flip)		
	Marking. "the end." (flip)		

assertions or questions express the degree of commitment to the truth of the proposition. We coded three different subcategories: epistemic uncertainty, epistemic agreement, and negation.

3. *Requesting speech act.* All requests and commands, including both interrogative and imperative structure, were included in this category.
4. *Expressive speech act.* All expressive and emotional utterances and markings (e.g., exclamations, thanking, greetings, etc.) were included in this category.

Inter-rater reliability. Coding of speech pragmatic functions was carried out by the first author of this study. Coding reliability of these annotations was established by having a second coder (the second author of the study) code 20% of the children's data. Before conducting the reliability test, the two coders tested the coding scheme on a set of six randomly selected parent-child interaction sessions and compared their annotations. Inter-rater agreement for speech pragmatic function was high: $\kappa = .846$ (85%), $p < .001$. Disagreements in coding were resolved by coder consensus.

Data Analysis

A frequency analysis using R Studio software was run with the 18 parent-child dyads to examine

the pragmatic functions of the speech children produced along with each type of gesture (see Figures 1A–1C; see also Appendix C for frequency tables). All the 18 parent-child dyads from the representative subsample completed all 12 sessions, except one family who missed one session, leaving data for 215 sessions. As the objective was to analyze the pragmatic function of the associated speech, we did not include gestures produced in the absence of speech (79 flip gestures and 119 iconic gestures). Moreover, taking the absolute numbers of non-referential beat gestures and referential iconic gestures produced on either unbiased or biased pragmatic functions of speech, we ran a GLMM with number of gestures as the dependent variable (Poisson distribution, log link). Gesture Type (beat, iconic), Pragmatic Function of Speech (unbiased, biased), and their interaction were set as fixed factors. The random structure that provided the best fit according to the AIC included a random slope for the gesture by subject, plus a random intercept for the session. Pairwise comparisons were extracted, with a Bonferroni correction applied when necessary.

Results

The results from the pragmatic analysis of speech produced with flip gestures ($n = 335$) can be found in Figure 1A (Table C1 in Appendix C). The

majority of flips (40.7%) accompanied utterances that were *biased assertions or questions* (epistemic uncertainty, epistemic agreement, and negation); 36.7% accompanied utterances that were *unbiased pragmatic functions*; 9.3% accompanied utterances that were *requesting speech acts*; and 7.8% accompanied utterances that were *expressive speech acts*.

Results from the pragmatic analysis of speech produced with beat gestures ($n = 222$) are presented in Figure 1B (Table C2 in Appendix C). The majority of beats (69.8% of beats) accompanied sentences that were *unbiased assertions* (declarative, explanation, and information response); 19% accompanied sentences that were *biased assertions or questions*; 8.6% accompanied *requesting speech acts*; and 1.8% accompanied sentences that were *expressive speech acts*.

Results from the pragmatic analysis of speech produced with iconic gestures ($n = 553$) are presented in Figure 1C (Table C3 in Appendix C). The majority of iconic gestures (74.5%) accompanied sentences that were *unbiased assertions*; 12.1% of iconics accompanied sentences that were *biased assertions or questions*; 10.8% accompanied sentences that were *requesting speech acts*; and 1.4% accompanied *expressive speech acts*.

Overall, results from the pragmatic analysis of speech produced with flip gestures indicate that flips (40.7%), compared to beats (19%), and iconic gestures (12.1%), were associated with *biased assertions or questions*, suggesting that they serve a clear pragmatic epistemic meaning in discourse (e.g., "I don't know it" or "but move what?" were utterances accompanied by a flip).

In contrast to flips, beats, and iconics tended to accompany *unbiased assertions* (e.g., 69.8% of beats; 74.5% of iconics). Interestingly, flips that co-occurred with *unbiased assertions* (36.7%) were mostly used to convey some kind of exclamation meaning (e.g., explanation, "It was an accident") or some discourse epistemicity in the utterance (e.g., declarative, "she wants to be free," or information response, "Umm, I can't decide it"), functions that are often associated with this type of palm-up gesture (Cooperrider et al., 2018). The fact that non-referential flips seem to be associated with assertions or questions that involve markers of modality, specifically of epistemic stance, more than non-referential beat gestures helps to distinguish these two types of gestures. For instance, flips were produced primarily in conjunction with assertions expressing ignorance and absence, such as "I don't know" or "all gone;" in contrast, none of the beat gestures in the database co-occurred with these types of assertions.

In relation to the results of Analysis 1, which showed the value of using non-referential beat gestures, but not referential iconic gestures, to predict later narratives, it is worth looking at the differences between the speech produced with beat gestures and speech produced with iconic gestures. Beat gestures were 6.9% more likely than iconic gestures to be associated with *biased assertions or questions*, showing a slight tendency for a higher frequency of beat gestures serving these biased pragmatic functions. More specifically, beat gestures were associated with biased pragmatic meanings including epistemic uncertainty, in questions ("like—like a blanket?" and "what if it is really old?"); epistemic agreement, in assertions or acknowledgments ("I know there is five" or "you got to practice every time a day"); and expressions of negation or rejection, in corrections of information ("no, her puzzles") or contradictions ("yes she do!"), negations ("no"), and negations with disagreement ("I hate egg salad").

Regarding the absolute numbers of non-referential beat gestures and referential iconic gestures accompanying sentences that had either unbiased or biased pragmatic functions, results from the GLMM model indicated a main effect of Gesture Type ($\chi^2(2) = 36.961$, $p < .001$), showing higher rates of iconic gestures than beat gestures ($d = 0.96$, $p < .001$), and a main effect of Pragmatic Function of Speech ($\chi^2(1) = 128.564$, $p < .001$), showing a larger number of gestures accompanying sentences that were unbiased assertions than sentences that were biased assertions or questions ($d = 1.01$, $p < .001$). A significant interaction between Gesture Type and Pragmatic Function of Speech was also found ($\chi^2(2) = 118.460$, $p < .001$), indicating that number of gestures differed depending on gesture type and pragmatic function of speech. Further post hoc analyses showed that Gesture Type differed significantly in both unbiased and biased levels, showing a higher proportion of iconic gestures accompanying sentences that were both unbiased ($d = 1.21$, $p < .001$) and biased ($d = 0.70$, $p = .024$) assertions or questions. Regarding Cohen's d effect size, this difference was higher in unbiased ($d = 1.21$) than in biased ($d = 0.70$) functions. Moreover, Pragmatic Function of Speech also differed significantly in both beat and iconic gesture levels, with both beat and iconic gestures performed more often with sentences that were unbiased than were biased (beat gestures: $d = 1.31$, $p < .001$; iconic gestures: $d = 1.82$, $p < .001$). Crucially, the d scores indicated that this difference was stronger for iconic gestures ($d = 1.82$) than for beat gestures ($d = 1.31$).

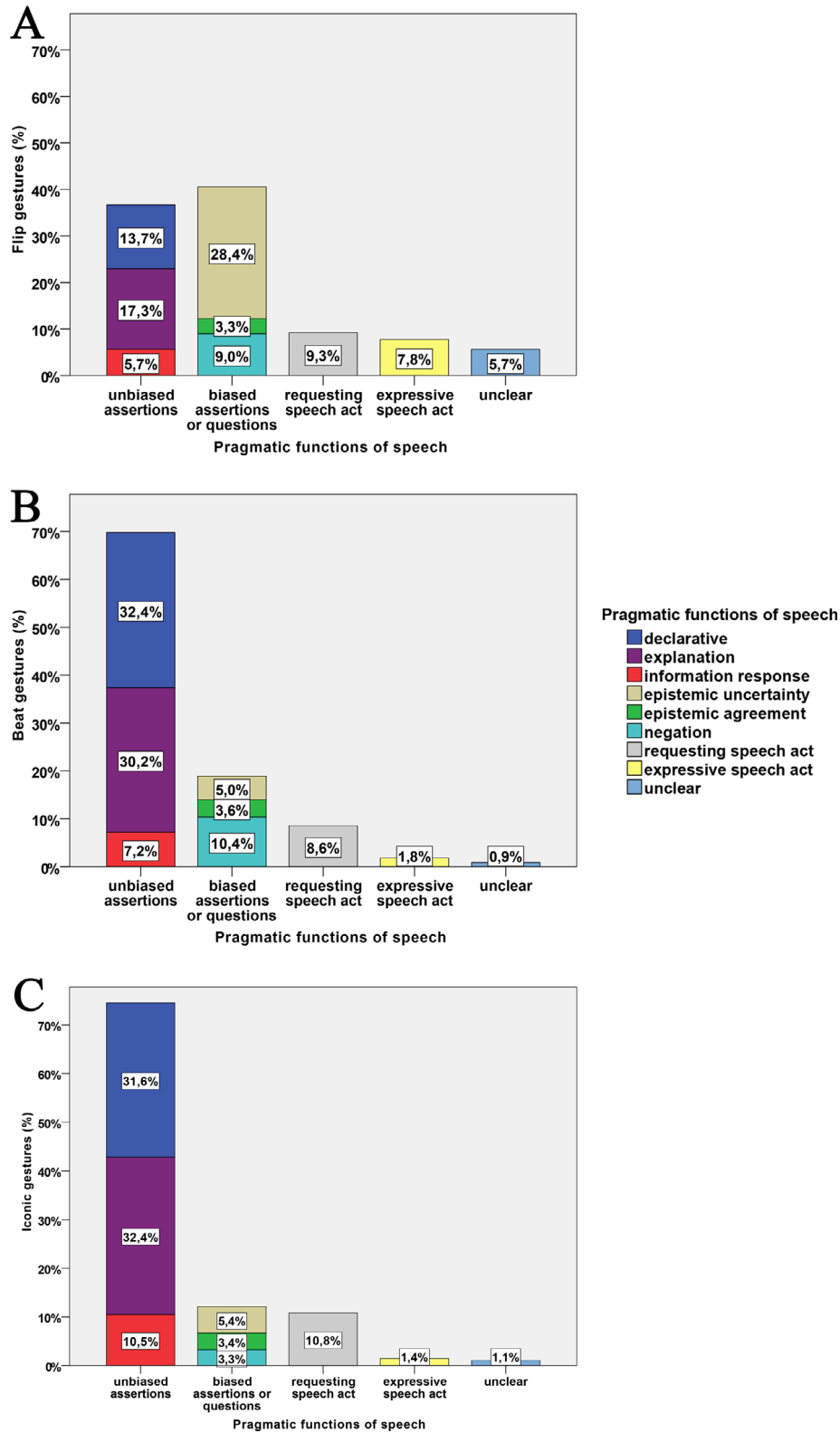


Figure 1. Percentage of flip (A), beat (B) and iconic (C) gestures associated with the different speech pragmatic functions: (1) unbiased assertions, which includes declarative, explanation and information response; (2) biased assertions or questions, which includes epistemic uncertainty, epistemic agreement and negation; (3) requesting speech act; (4) expressive speech act; and (5) unclear.

Thus, our overall results show that, even though both beat and iconic gesture rates are higher in sentences with unbiased pragmatic functions, iconic gestures have a slight tendency to appear more often than beat gestures in sentences with unbiased functions. See Table B4 in Appendix B for a summary of the results.

Discussion and Conclusions

The main objective of this study was to determine whether the early production of non-referential gestures in the form of beat and flip gestures and referential iconic gestures by children in naturalistic interactions with caregivers between 14 and 58 months old would predict their later narrative production skills at 60 months of age. Findings clearly showed that children's production of non-referential beat gestures in the developmental window of 14 and 58 months, but not non-referential flips or referential iconic gestures, significantly predicted the structure of their later narratives. The field of child language development has focused almost exclusively on the role of referential gestures (e.g., pointing gestures and iconic gestures) in predicting later language abilities. Our study is thus the first to determine whether non-referential gestures, such as beat and flip gestures, produced in early spontaneous and naturalistic discourses predict narrative abilities. To our knowledge, this is the first study to explore the early pragmatic role that beat gestures might play in scaffolding children's later narrative discourse.

The results of our study add several new insights to research on children's production of non-referential beat gestures and their role in the development of language. The findings of our predictive analysis confirm that the production of beat gestures in the window between 14 and 58 months of age can be indicative of better narrative abilities later on in development, specifically at 60 months of age, approximately when children start acquiring these gestures within narrative discourse (Colletta et al., 2010, 2015; Florit-Pons et al., 2020; Mathew et al., 2018; McNeill, 1992; and others). Importantly, results obtained in a follow-up analysis found that non-referential beat gestures produced between 14 and 42 months of ages still predict children's later narrative productions at 60 months. Our results thus extend and complement previous findings showing that referential gestures, such as iconic gestures and deictic gestures, significantly affect speaker's language development and learning (see

Goldin-Meadow & Alibali, 2013, for a review; e.g., Goldin-Meadow, Nusbaum, Kelly, & Wagner, 2001; Novack, Congdon, Hemani-Lopez, & Goldin-Meadow, 2014). Our predictive analysis clearly shows that non-referential beat gestures can also have strong relations to a later stage of language development, and specifically, to predict narrative performance at a later age. This result is consistent with findings related to the predictive effects of multimodal gesture-speech integration patterns at 12 months. Igalada, Bosch, and Prieto (2015) showed that using simultaneous pointing-speech combinations at 12 months to indicate the same referent when drawing attention to the referent predicts later expressive vocabulary and morphosyntactic measures at 18 months. Moreover, these results are consistent with findings reported for the role of training with non-referential beat gestures in improving 5- to 6-year-old children's short-term narrative performance through a brief narrative training task (Vilà-Giménez et al., 2019; Vilà-Giménez & Prieto, 2020). However, a recent longitudinal study conducted by Vilà-Giménez et al. (2020) examined the effects of gestures produced by older children than in the present study in narrative speech and yielded contradictory results. The authors found that non-referential beat gestures produced in narrative discourses at age 5–6 did not predict children's narrative productions (in terms of narrative structure) 2 years later, but referential iconic gestures did. The non-effect of non-referential beat gestures in Vilà-Giménez et al.'s study (2020) could be due to the fact that children at 5–6 years are still acquiring these discourse-pragmatic functions of non-referential beat gestures in complex narrative discourses and also to the greater number of referential iconic gestures produced in narrative corpora, which could also include different viewpoints in narrative (in line with Demir et al., 2015). It would be interesting to further investigate the predictive effects of non-referential beat gestures for even later stages of narrative production, when the use of such gestures has become more firmly incorporated into children's performance of complex discourses (see Florit-Pons et al., 2020).

To our knowledge, this is also the first study to explore the early pragmatic role that non-referential beat gestures play in scaffolding children's later narrative discourse, compared with other non-referential and referential gestures. Our initial hypothesis that non-referential beat gestures would have greater predictive value than flip gestures was confirmed. Controlling for beat gestures, non-

referential flip gestures, and referential iconic gestures were not found to be significant predictors of children's narrative abilities at age 5. According to our pragmatic analysis, children tend to associate flip gestures ($n = 335$) with accompanying verbal acknowledgments of ignorance (e.g., "I don't know"; see Harris et al., 2017, for a review). In contrast, beat gestures ($n = 222$) in this study did not occur in the same proportion as flip gestures in this specific epistemic pragmatic context. In other words, in contrast to non-referential beat gestures (19%), non-referential flip gestures (40.7%) tended to accompany biased assertions or questions which had some kind of epistemic value in discourse. Therefore, one possible explanation for the lack of predictive value of flip gestures would be that children tend to rely more on beat gestures' structuring and focusing functions rather than on flips' common pragmatic function of marking ignorance. Moreover, as beat gestures tend to appear later than flip gestures in children's discourse, it might be the case that the former is more closely connected to complex linguistic skills (Nicoladis et al., 1999).

On the other hand, given their high frequency in our data set ($n = 553$), one might expect iconic gestures to be strong predictors of narrative abilities, though we found no evidence of this. Nevertheless, it is important to mention that previous predictive studies have examined the role of referential iconic gestures performed exclusively in children's narrative discourses and not in early spontaneous interactions (Demir et al., 2015; Vilà-Giménez et al., 2020). For instance, the study by Demir et al. (2015) examined the role of specific iconic CVPT gestures but not iconic gestures, in general, depicting properties of a referent. Results found that children who expressed CVPT by means of gestures while narrating produced more fully structured narratives at later ages than children who did not produce these gestures, which suggests that CVPT gestures reflect a child's ability to adopt a character's first-person perspective on events. Although the authors reported no evidence for a causal role, capturing a character's perspective in gesture could boost a child's focus on the character's goals, thus making the child more aware of the narrative structure (see also Parrill et al., 2018). In other words, it may be the role the iconic gesture plays in discourse, rather than the fact that it is an iconic gesture *per se*, that is important in its ability to predict subsequent narrative skills (see also Vilà-Giménez et al., 2020). This could be a line for future investigation. The positive effects of CVPT gestures could also have

implications for embodied cognition paradigms in learning, since it is conceivable that this specific type of iconic gesture allows the speaker to embody the narrative situation in a more complete way (see Wellsby & Pexman, 2014, for a review).

In order to assess what properties of non-referential beat gestures could help in predicting later narratives, a second analysis was carried out to identify the pragmatic functions of the speech that accompanied beats, flips, and iconic gestures produced by children. The findings of this pragmatic analysis are also important in light of other research suggesting that non-referential beat gestures serve a pragmatic function in children's spontaneous speech and act as important linguistic cues in discourse (Kendon, 2004, 2017; McNeill, 1992; Prieto et al., 2018; Shattuck-Hufnagel & Prieto, 2019; Shattuck-Hufnagel et al., 2016; see also Vilà-Giménez & Prieto, 2021, for a review). Beat gestures highlight important structural properties of language such as information structure, discourse structure, and rhythm (Dimitrova et al., 2016; Im & Baumann, 2020; Rohrer et al., 2020; Shattuck-Hufnagel et al., 2016) and also trigger attentional effects that activate language-related areas instead of just simulating the visual-perception areas of the brain (Biau & Soto-Faraco, 2013; Holle et al., 2012; Wang & Chu, 2013). Specifically, the results of this analysis suggested that non-referential beat gestures are associated with sentences encoding a range of pragmatic and discourse meanings. Although the majority of the beats that the children produced during their parent-child interactions accompanied sentences that were unbiased assertions, such as declaratives, explanations, or information responses, a relatively large proportion of them (19%, in comparison to iconic gestures 12.1%) also accompanied sentences that were biased assertions or questions. Beat gestures are thus meaningful cues that not only mark certain aspects of the structure of the discourse (i.e., they serve a parsing function), but also show the illocutionary act that a speaker is engaged in (they serve a performative function) and indicate how a specific part of the spoken discourse should be interpreted (they have modal biased functions; Kendon, 2017). Crucially, non-referential beat gestures may reflect the child's understanding of pragmatic structure in discourse, and this early understanding sets the child up to learn later narrative skills. However, our study does not tell us whether producing beat gestures simply *reflects* a child's skill in framing discourse or highlighting aspects of prosodic focus (e.g., emphasis), or plays a *causal* role in facilitating narrative

development. If the latter, the pragmatic and discursive properties of beat gestures may play a beneficial role in narrative development.

Moreover, although recent research has shown that both referential and non-referential gestures can behave similarly in terms of temporal (i.e., prosodic) alignment (Florit-Pons et al., 2020), in this study, beat gestures always emphasize speech by visibly "punctuating" prosodic prominence. Importantly, preliminary results found in Rohrer et al. (2020) have shown how 5- to 9-year-old children mark information structure (i.e., discourse entities) in a non-referential manner using non-referential beat gestures. Iconic gestures, in contrast, are entirely representational, acting as visual representations of a particular referent, rather than calling attention to the prosodic focus or structure of speech. We suggest that this fundamental difference in referential and discourse-pragmatic functions between the two types of gestures is also important in explaining the results of our predictive analysis. In other words, when children produce non-referential beat gestures, they are highlighting information structure in discourse; when they produce iconic gestures, they are highlighting a particular referential or lexical meaning. Since the challenge of producing early narratives is not just holding many referents in mind, but also creating a cohesive discourse structure, non-referential beat gestures may reflect a distinct type of discourse knowledge, that is probably less present in semantically specific referential iconic gestures.

Future work should include more complex analyses of the different types of gestures that are produced by children, examining not only their functions, forms, and synchrony with speech, but also the different pragmatic contexts in which they are performed. One possible limitation of this study concerns the lack of gesture-speech alignment analyses. The pragmatic analysis was performed at the utterance level and no information was available on the specific parts of speech associated with the gestures the children produced. Importantly, further analyses are needed to determine whether there are temporal differences in the alignment of speech that accompanies non-referential beat and flip gestures versus referential iconic gestures. First, this type of analysis would allow us to evaluate whether children temporally align co-speech gestures, and specifically non-referential gestures, in an adult-like fashion in discourse. Along these lines, it would be of interest to extend the findings obtained by Mathew et al.'s (2018) study, in order to analyze whether beat gestures are associated with

prominent positions in speech. Second, future research on gesture-speech alignment could also use this supplementary data to examine the association between non-referential beat and flip gestures and referential iconic gestures and specific content in speech. For example, it would be interesting to see whether beat gestures accompany lexical (i.e., focal content words) or functional words (i.e., discourse markers). All these further steps would nicely extend and complement the present findings.

In summary, our findings have important implications for our understanding of the role of non-referential beat gestures in the development of young children's narrative abilities. This study adds to the body of literature showing the relevant discourse-pragmatic role that beat gestures may play from early stages in language development. By having this meaningful role in language, children's non-referential beat gestures may reflect the child's understanding of information and discursive structure. These early productions can act as a harbinger of things to come in children's later narrative development.

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Appendix A

Descriptive Statistics for Non-referential Beat and Flip Gestures and Referential Iconic Gestures

Table A1

Descriptive Statistics for Non-Referential Beat and Flip Gestures and Referential Iconic Gestures Produced in the Total Developmental Window From 14 to 58 Months of Age

	N	Range	Min.	Max.	M	SD
Descriptive statistics						
Non-referential beat gestures	45	10.23	0	10.23	1.19	1.74
Non-referential flip gestures	45	9	0.15	9.15	1.86	1.87
Referential iconic gestures	45	11.15	0.31	11.46	3.58	2.73
Valid N (listwise)	45					

Table A2

Descriptive Statistics for Non-Referential Beat and Flip Gestures and Referential Iconic Gestures Produced in the Total Developmental Window From 14 to 42 Months of Age

	N	Range	Min.	Max.	M	SD
Descriptive statistics						
Non-referential beat gestures	45	1.50	0	1.50	0.42	0.38
Non-referential flip gestures	45	10.88	0	10.88	1.69	2.11
Referential iconic gestures	45	15.38	0.25	15.63	3.83	3.46
Valid N (listwise)	45					

Appendix B

Summary of the Generalized Linear Mixed Models (GLMMs) Results for Analysis 1 and Analysis 2

Table B1

GLMM Output for the Analysis of the Predictive Value of Non-Referential Beat and Flip Gestures and Referential Iconic Gestures From 14 to 58 Months of Age

Predictors	Estimates	SE	CI	z value	p
Narrative structure scores					
(Intercept)	3.465	.338	2.803, 4.128	10.247	< .001
Non-referential beat gestures	0.299	.111	0.081, 0.518	2.689	.007
Non-referential flip gestures	-0.163	.109	-0.377, 0.052	-1.489	.137
Referential iconic gestures	0.029	.077	-0.122, 0.180	0.381	.703
Observations	45				

Note. R formula: `maus_ca ~ beat + flip + iconic + (1|id/parent_ed)`.

Table B2

GLMM Output for the Analysis of the Predictive Value of Non-Referential Beat and Flip Gestures and Referential Iconic Gestures From 14 to 58 Months of Age, Controlling for Average Number of Word Types

Predictors	Estimates	SE	CI	z value	p
Narrative structure scores					
(Intercept)	2.049	.774	0.532, 3.565	2.647	.008
Non-referential beat gestures	0.235	.111	0.016, 0.453	2.106	.035
Non-referential flip gestures	-0.186	.105	-0.392, 0.021	-1.763	.078
Referential iconic gestures	-0.021	.078	-0.174, 0.131	-0.274	.784
Average no. of word types	0.008	.004	0.000, 0.015	2.016	.044
Observations	45				

Note. R formula: `maus_ca ~ beat + flip + iconic + wordtypes_average + (1|id/parent_ed)`.

Table B3

GLMM Output for the Analysis of the Predictive Value of Non-Referential Beat and Flip Gestures and Referential Iconic Gestures From 14 to 42 Months of Age

Predictors	Estimates	SE	CI	z value	p
Narrative structure scores					
(Intercept)	3.250	.350	2.564, 3.935	9.286	< .001
Non-referential beat gestures	1.386	.583	0.243, 2.529	2.377	.017
Non-referential flip gestures	-0.136	.112	-0.356, 0.084	-1.212	.225
Referential iconic gestures	0.009	.067	-0.122, 0.140	0.137	.891
Observations	45				

Note. R formula: `maus_ca ~ beat + flip + iconic + (1|id/parent_ed)`.

Table B4

GLMM Output for the Analysis of the Absolute Numbers of Non-Referential Beat and Referential Iconic Gestures Performed on Either Unbiased or Biased Pragmatic Functions of Speech

Term	χ^2	df	p	Levels	Contrast	Cohen's d	Sig	Levels	Contrast	Cohen's d	Sig
GLMM results											
Gesture Type	36.961	2	.000		Flip * > Beat	-.48	.078				
					Iconic > beat	-.96	.000				
					Iconic * > Flip	-.47	.095				
Pragmatic Function of Speech	128.654	1	.000					Unbiased > biased	-1.01	.000	
Gesture type: pragmatic function of speech	118.460	2	.000	Biased	Flip > beat	-1.18	.000				
					Iconic > beat	-.70	.024				
					Flip = iconic	.48	.160				
				Unbiased	Beat = flip	.22	.963				
					Iconic > beat	-1.21	.000				
					Iconic > flip	-1.43					
				Beat	Unbiased > biased	-1.31	.000				
				Flip	Biased = unbiased	.10	.420				
				Iconic	Unbiased > biased	-1.82	.000				

Note. R formula: `glmmTMB::glmmTMB(n ~ gesture * bias + (1 + gesture|subject) + (1|session), family = poisson(link = log), data = df)`.

Appendix C

Pragmatic Functions of Speech Associated With Non-Referential Beat and Flip Gestures and Referential Iconic Gestures

Table C1

Pragmatic Functions of Speech Related to the Children's Flip Gesture Production

	Frequency	Percent	Valid percent	Cumulative percent
Pragmatic functions of speech associated with flip gestures				
Unbiased assertions	123	36.7	36.7	90.7
Biased assertions or questions	136	40.7	40.7	46.3
Requesting speech act	31	9.3	9.3	100.0
Expressive speech act	26	7.8	7.8	54.0
Unclear	19	5.7	5.7	5.7
Total	335	100.0	100.0	

Table C2

Pragmatic Functions of Speech Related to the Children's Beat Gesture Production

	Frequency	Percent	Valid percent	Cumulative percent
Pragmatic functions of speech associated with beat gestures				
Unbiased assertions	155	69.8	69.8	91.4
Biased assertions or questions	42	18.9	18.9	19.8
Requesting speech act	19	8.6	8.6	100.0
Expressive speech act	4	1.8	1.8	21.6
Unclear	2	0.9	0.9	0.9
Total	222	100.0	100.0	

Table C3

Pragmatic Functions of Speech Related to the Children's Iconic Gesture Production

	Frequency	Percent	Valid percent	Cumulative percent
Pragmatic functions of speech associated with iconic gestures				
Unbiased assertions	412	74.5	74.5	89.2
Biased assertions or questions	67	12.1	12.1	13.2
Requesting speech act	60	10.8	10.8	100.0
Expressive speech act	8	1.4	1.4	14.6
Unclear	6	1.1	1.1	1.1
Total	553	100.0	100.0	