

Accepted version of Vilà-Giménez I, Prieto P. Encouraging kids to beat: Children's beat gesture production boosts their narrative performance. Developmental science. 2020 Mar 28:e12967. DOI: 10.1111/desc.12967

Title Page

Title: Encouraging kids to beat: Children's beat gesture production boosts their narrative performance

Short running title: Encouraging children to produce beat gestures

Authors names and affiliations:

*Ingrid Vilà-Giménez*¹, *Pilar Prieto*^{2,1}

¹Department of Translation and Language Sciences, Universitat Pompeu Fabra, Barcelona, Catalonia, Spain

²Institució Catalana de Recerca i Estudis Avançats (ICREA), Barcelona, Catalonia, Spain

ingrid.vila@upf.edu, pilar.prieto@upf.edu

Corresponding author:

Ingrid Vilà-Giménez

ingrid.vila@upf.edu

Roc Boronat, 138. 08018 Barcelona (Catalonia, Spain)

Conflict of Interest Statement:

No potential conflict of interest was reported by the authors.

Data Availability Statement:

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Acknowledgments:

We would like to express our gratitude to the *Col·legi Dr. Masmitjà* and *Escola Montjuïc* in Girona for helping us recruit participants for the present study, as well as to the participating children themselves and their families. Special thanks go to Dr. Joan Borràs-Comes for helping with the statistical analyses, Dr. Alfonso Igualada for helping with the experimental design, Judith Llanes-Coromina for helping with data collection,

and to Eva Castillo and Núria de Rocafiguera, the two independent raters for the coding reliability of the study. Many thanks also to Clara Nogué and Anna Reixach, the storytellers featured in our stimulus recordings. We are indebted to Prof. Susan Goldin-Meadow, Dr. Özlem Ece Demir-Lira and the members of the Goldin-Meadow Lab at University of Chicago (where this work was presented in Spring 2017), as well as Dr. Daniel Casasanto and Ché Lucero at Cornell University, for helpful and inspiring comments. We are likewise grateful to the audiences at the conferences in which this study was presented, to Drs. Gemma Boleda, Josep Quer and Enric Vallduví of the UR-Ling group at Universitat Pompeu Fabra, and to the Prosodic Studies Group at Universitat Pompeu Fabra for their feedback. We are also grateful to Drs. Núria Esteve-Gibert, Emma Rodero and Melina Aparici for their useful comments throughout the project. Many thanks also go to the anonymous reviewers and the editor whose comments helped to improve the manuscript. This study was approved by the ethics committee of the Universitat Pompeu Fabra and benefited from funding awarded by the Spanish Ministry of Science, Innovation and Universities (MCIU), Agencia Estatal de Investigación (AEI), and Fondo Europeo de Desarrollo Regional (FEDER) (PGC2018-097007-B-100 “Multimodal Language Learning (MLL): Prosodic and Gestural Integration in Pragmatic and Phonological Development”) and by the Generalitat de Catalunya (2017 SGR_971) to the Prosodic Studies Group. The first author also acknowledges an FI grant from the Generalitat de Catalunya (ref. 2019FI_B2_00125).

Title: Encouraging kids to beat: Children's beat gesture production boosts their narrative performance

Research Highlights:

- Encouraging children to produce beat gestures in a brief narrative training session helped them to produce better narrative discourse performance.
- Children's narrative structure scores improved after the children were encouraged to produce beat gestures in a brief narrative training task.
- Children's fluency scores improved after the children were encouraged to produce beat gestures in a brief narrative training task.

Abstract

Gesture is an integral part of language development. While recent evidence shows that observing a speaker who is simultaneously producing beat gestures helps preschoolers remember and understand information and also improves the production of oral narratives, little is known about the potential value of encouraging children to produce beat gestures –as opposed to merely observing them. In this between-subjects pretest-posttest training study we examine whether encouraging children to produce beats can boost their narrative performance. A total of 47 5- to 6-year-old children were divided into two groups and exposed to a training session in which a total of six stories were presented under one of two experimental conditions: 1) the children merely observed video-recordings of a storyteller who used beat gestures and were then asked to retell the narratives; or 2) the children observed the same video-recordings and then retold the narratives but were encouraged to simultaneously use their hands in the same way the storytellers did. Pretests and posttests consisting of children's narrations of short animated cartoons were analyzed for narrative structure and fluency. A comparison of scores showed that children in the group that had been encouraged to use beat gestures in the training phase performed better in both narrative structure and fluency than the group of children who were simply asked to retell the story without gesture instruction. These findings suggest that linguistically relevant body movements serve to boost language development and that embodied storytelling can be of help in narrative training.

Keywords: beat gestures; narrative discourse performance; between-subjects training study; narrative structure; fluency; embodied storytelling

Introduction

Narratives constitute a solid measure of children's more complex language skills in both typical (Demir, Levine, & Goldin-Meadow, 2015a; Stites & Özçalışkan, 2017) and atypical language development (e.g., Demir, Fisher, Goldin-Meadow, & Levine, 2014; Demir, Levine, & Goldin-Meadow, 2010; Demir, Rowe, Heller, Goldin-Meadow, & Levine, 2015b; Duinmeijer, de Jong, & Scheper, 2012). Several studies have also shown that narrative ability is a strong predictor of later school literacy success (e.g., see Demir, Levine, & Goldin-Meadow, 2012, for a review; Naremore, Densmore, & Harman, 1995). As Demir et al. (2012) claim, narrative skill is "an oral language skill that is argued to provide the missing link between oral language and later reading comprehension" (p. 6) and "oral language skills that develop during early ages and provide the foundation for later reading comprehension include vocabulary, syntax, narrative and academic language use" (p. 5).

Research has shown that the development of gesture and speech go hand in hand in the context of narrative development (see Colletta et al., 2015). While the period from age 3 to 6 constitutes "a particularly relevant age range to observe children's burgeoning narrative abilities in gesture and speech" (Stites & Özçalışkan, 2017, p. 1021), it is only around age 5 or 6 that children begin to produce 'true narratives' containing a central theme, characters and a logically and/or temporally ordered plot line (Applebee, 1978). For instance, Mathew, Yuen and Demuth (2017) found that 6-year-old children start producing a variety of gestures including stroke-defined beats for discourse functions in both storytelling and exposition tasks. This is confirmed by results in Colletta, Pellenq and Guidetti (2010) showing that beats in discourse emerge between 6 and 10 years old (see also Blake, Myszczyzyn, Jokel, & Bebiroglu, 2008; McNeill, 1992). Other research has shown that starting at age 9 children can produce spontaneous narratives with accompanying co-speech gestures in an adult-like fashion to represent the narrated events or symbolize the objects, places or persons which the speaker refers to, as well as to mark discourse cohesion, express the pragmatic functions and emotional states that help the framing and discourse connotation of the utterance (Colletta, 2009). Finally, several studies have reported strong developmental links between the use of representational gestures by children and the quality of their narratives (Demir et al., 2014; Demir et al. 2015a; Stites & Özçalışkan, 2017), suggesting that children's use of gestures to accompany narratives

becomes more elaborate as those narratives become more complex. For example, Demir et al. (2015a) found evidence that 5-year-old children who expressed character viewpoint (CVPT) in their narratives by means of gestures were more likely to show better structure in the verbal narratives they produced when older. Additionally, recent evidence has shown that training children to produce such CVPT gestures also boosts their narrative structure scores immediately after training (Parrill, Lavanty, Bennett, Klco, & Demir, 2018).

At the same time, there is broad evidence that gesturing has beneficial effects on various cognitive and linguistic domains (see Kita, Alibali, & Chu, 2017, for a review). For instance, gesture production was found by Goldin-Meadow, Nusbaum, Kelly and Wagner (2001) to have positive effects on memory recall in general. Furthermore, there is also evidence that both observing and producing iconic gestures facilitated participant's memory recall. A study by Cook, Yip and Goldin-Meadow (2010) reported positive effects of producing iconic gestures (vs. no gesture) on adult's memory representation of present events. Similar results were found by Aussems & Kita (2019) in children, showing that observing iconic gestures (vs. interactive gestures and no gesture) facilitated their recognition memory of action events. Gesturing also seems to help people generate problem-solving strategies in mathematics (Broaders, Cook, Mitchell, & Goldin-Meadow, 2007; Cook, Mitchell, & Goldin-Meadow, 2008; Goldin-Meadow, Cook, & Mitchell, 2009; Novack, Congdon, Hemani-Lopez, & Goldin-Meadow, 2014) and execute other thinking tasks (Alibali & Kita, 2010; Alibali, Spencer, Knox, & Kita, 2011). In terms of development, encouraging children to gesture while attempting to solve math problems has been shown to provide them with new and correct problem-solving strategies –expressed only through gesture– of which they had been previously unaware (Broaders et al., 2007). Further, Kirk and Lewis (2017) demonstrated that when 8- to 11-year-old children spontaneously produced gestures, or were prompted to do so, they came up with more creative novel uses for everyday items, suggesting that the gestures helped them to create ideas more fluently.

In general, previous investigations have tended to focus on representational gestures (also called iconic and metaphoric gestures, i.e., those representing referential properties of objects and concepts; see McNeill, 1992) and this is also true of research on the relationship between gesturing and narrative skills (Demir et al., 2014; Demir et al. 2015a; Stites & Özçalışkan, 2017). By contrast, so far relatively little attention has

been devoted to another type of gesture, namely beat gestures, which are defined as rhythmic non-referential hand movements –usually of the fingers or hand– that are *typically* associated with prosodic prominence in speech (McNeill, 1992; Prieto, Cravotta, Kushch, Rohrer, & Vilà-Giménez, 2018) and can be coordinated to other articulator movements, such as head nods and eyebrow raises (Krahmer & Swerts, 2007). Beat gestures could also be associated with sequences of prosodic prominence, having complex phasing structures (Shattuck-Hufnagel, Ren, Mathew, Yuen, & Demuth, 2016). Although the majority of the studies have defined beat gestures as essentially non-meaningful, some studies have argued that beat gestures can in fact highlight linguistically relevant information. For example, McNeill (1992, p. 15) claimed that beats have discourse structure marking functions, as they “mark information that does not advance the plot line but provides the structure within which the plot line unfolds.” It is worth noting that the author relates the semiotic value of a beat to discourse-pragmatic content as a whole (e.g., to introduce new characters or themes, or summarize the action, etc.) rather than specific events in a narrative. Along the same lines, Kendon (2018) states that manual gestures can contribute to a variety of important pragmatic and discourse meanings in general and identifies four pragmatic functions in particular, namely operational functions (function as an operator in relation to the speaker’s spoken meaning; e.g., head or hand actions that add negation), modal functions (indicate how the listener should interpret the utterance; e.g., the speaker’s epistemic stance), performative functions (show the type of the speech act; e.g., a question, a refusal, etc.) and parsing functions, the latter referring to the role of the speaker’s hand in marking discourse structure. As such, Kendon (2004, p. 158) associated beat gestures with the abovementioned larger class of pragmatic gestures that are “related to features of an utterance’s meaning that are not a part of its referential meaning or propositional content.” Indeed, various studies have shown beat gestures performing a range of pragmatic and discourse functions (see Prieto et al., 2018; Shattuck-Hufnagel & Prieto, 2019; and Shattuck-Hufnagel et al., 2016, for a review). To our knowledge, however, only three studies have specifically focused on the effects of observing beat gestures on narrative development. Though one of these three, Macoun and Sweller (2016), found that observing beat gestures showed no benefit for narrative recall and comprehension in children, the other two studies reported positive effects. Llanes-Coromina, Vilà-Giménez, Kushch, Borràs-Comes and Prieto (2018) found that children’s narrative comprehension improved when they watched stories in

which beat gestures were aligned with prosodic prominences, and Vilà-Giménez, Igualada and Prieto (2019) showed that, when asked to retell a narrative, 5- and 6-year olds achieved higher narrative structure scores if the person telling them the narrative to be recalled had accompanied their performance with beat gestures.

While the abovementioned studies have assessed the effects of observing beat gestures on children's narrative development, in this study we ask whether encouraging children to accompany their own storytelling with beat gestures (instead of just observing them while someone else is doing the storytelling) can boost their narrative skills. Given the body of evidence noted above, our underlying assumption is that it will.

The current study

The current study investigates whether 5- to 6-year-old children who are encouraged to perform beat gestures while retelling narratives will then produce higher quality narratives than a control group who merely observe the beat gestures but are not encouraged to produce them. This particular age range was chosen because, as we have noted above, it is in this period that children start to produce 'true narratives'. At age 5 children's narratives begin to get more structurally complex (Shapiro & Hudson, 1991) and show an understanding that characters perform actions to achieve particular goals (Trabasso, Stein, Rodkin, Munger, & Baughn, 1992; e.g., Berman, 1988). Furthermore, it is also around age 6 that children spontaneously start to produce beat gestures with a functional meaning while they are recounting a narrative (Mathew et al., 2017; McNeill, 1992).

For the purposes of the present study, narrative quality will be assessed in terms of narrative structure and fluency. First, we hypothesize that promoting the production of beats will boost structure scores, given the evidence that beat gestures play an important role as highlighters of linguistic functions such as focus marking and discourse structure marking (Dimitrova, Chu, Wang, Özyürek, & Hagoort, 2016; Shattuck-Hufnagel et al., 2016). For instance, Dimitrova et al.'s (2016) ERP study demonstrated the interaction between beats (i.e., nonverbal emphatic cues) and focus, showing that beats are integrated with the information structure of a message during multimodal speech comprehension and they have the role of enhancing the listener's attention. Moreover, in line with previous studies demonstrating that iconic gestures

could serve as meaningful social cues in enhancing memory representation of events (e.g., Aussems & Kita, 2019; Cook et al., 2010, among others), we also predict that beat gestures can equally help children to focus on critical parts of a story and thus parse it better (specifically, focused constituents and discourse markers). This hypothesis is supported by Austin and Sweller's (2014) study, which reported positive effects of both observing beat gestures and iconic gestures on the recall of spatial directions in 3- to 4-year-old children in a discourse pragmatic context. Moreover, So, Chen-Hui and Wei-Shan (2012) showed that seeing a list of single verbs accompanied by beat gestures (vs. iconic gestures and no gestures) helped adults recall the information better. Along the same lines, Igualada, Esteve-Gibert and Prieto (2017) and Llanes-Coromina et al. (2018) found that beat gestures also significantly improved recall in 3- to 5-year-old children. All in all, our hypothesis is that children who observe and are encouraged to produce meaningful discourse-pragmatic beat gestures in a narrative training task should produce better structured stories at posttest. Second, we expect the same positive effects on narrative fluency scores, as previous literature has highlighted the positive effects of producing beat gestures on lexical access in adults (Lucero, Zaharchuk, & Casasanto, 2014), as well as on oral fluency (Rauscher, Krauss, & Chen, 1996) and L2 pronunciation (e.g., Gluhareva & Prieto, 2017; Llanes-Coromina, Prieto, & Rohrer, 2018). Our hypothesis is that the rhythmic properties of beat gestures and their tight synchrony with prominent prosodic positions in speech (Shattuck-Hufnagel & Ren, 2018; McNeill, 1992; see also Esteve-Gibert & Prieto, 2013) can enhance oral speech fluency. All in all, given this evidence, it is therefore reasonable to assume that narrative structure and fluency scores will be significantly improved if children are encouraged to use beat gestures during narrative performance.

Methods

The experiment consisted of a between-subjects study with a pretest and an immediate posttest design. Child participants were assigned to one of two groups, the experimental group receiving a short training session in which they were encouraged to accompany their retelling of a narrative with beat gestures (henceforth the *beat encouraging* condition), and the control group being exposed to the same storytelling activity but not being encouraged to gesture in their retelling performance (the *beat non-encouraging*

condition). Pretest and posttest narrative structure and fluency scores of the two groups were then compared to determine the effect of the beat gesture encouraging.

Participants

Fifty-three children (23 boys and 30 girls) from the Girona area of Catalonia participated in this study. The majority of the participants ($n = 49$) were drawn from two schools (*Col·legi Dr. Masmitjà* and *Escola Montjuïc*); the four remaining children were recruited individually. Data from six of the original participants had to be excluded from analysis either because of technical recording problems ($n = 4$) or because they did not want to collaborate in the experimental task ($n = 2$). Thus, the dataset analyzed in this study came from the remaining 47 participants (mean age = 5.92, $SD = 0.54$). The sample size was determined post-hoc using G*Power version 3.1 (Faul, Erdfelder, Buchner, & Lang, 2009) and showed a sample size of 45 participants with a small- to medium-sized effect ($\alpha = .05$, power = 0.42 for narrative structure; $\alpha = .05$, power = 0.56 for narrative fluency). Before the experiment, parents gave their consent to having their children participate in the experiment and be video-recorded. [Note 1] Parents also filled out a family language questionnaire (Bosch & Sebastián-Gallés, 2001) which revealed on the one hand that all the participants were typically developing children with no prior history of communication disorders in themselves or within their families, and on the other that, even though all children were functional Catalan-Spanish bilinguals, these children were exposed to Catalan on a daily basis 88.74% of the time ($SD = 10.68$) as this is also the main language of instruction in the school.

Materials

The pretest, training and posttest materials used in this experiment were the same as those used in Vilà-Giménez et al. (2019). The pretest and posttest task consisted of the children retelling what they had seen in four short (~ 41-50 s) online animated cartoons about a small mouse and his friends (Westdeutscher Rundfunk Köln, <http://www.wdrmaus.de>), with which they were previously unfamiliar (see summaries of the four cartoons in Appendix A). These materials were also used for narrative retelling tasks in Demir et al. (2014) and Alibali, Evans, Hostetter, Ryan and Mainela-Arnold (2009). The cartoon soundtracks contained only background music, not speech.

Two of these cartoons were shown in the pretest whereas the other two were shown in the posttest. However, in both pretest and posttest, the first cartoon featured one character (the mouse –see cartoon summaries A and C in Appendix A) and the second featured two (summaries B and D). The stories in the four cartoons followed the same goal-based structure, which included the following main features of a narrative: a) temporal and causal structure, b) animate protagonists, c) an initiating event, d) a goal, e) an attempt to achieve the goal, and f) an outcome or resolution (Demir et al., 2014; Demir et al., 2015a).

The training materials consisted of 12 video-recorded short narratives performed in Catalan by two adult female storytellers (6 stories \times 2 storytellers). The narratives' main characters were a set of animals that lived on a farm. The structure of the six narratives followed that of the stories featured in the animated cartoons (English translations of the six stories are provided in Appendix B). In order to simulate real-world storytelling situations, the two storytellers were asked to use child-directed speech and smile throughout the recording session as if they were speaking to a group of children. The audio-visual stimuli were created after conducting a preliminary study in which the two female preschool teachers were recorded performing a child-directed expressive reading task (see Vilà-Giménez et al., 2019, for further details). The results of this analysis showed that storytellers associated beat gestures with discourse markers and focal content words. Discourse markers (e.g., *once upon a time*, *before*, *but*, *because*, *therefore*, *otherwise*, etc.) are “sequentially dependent elements which bracket units of talk” (Schiffrin, 1987, p. 31; classification based on Portolés, 1998). Focal content words (*a duck*, *rain*, *umbrella*, etc.) are considered as words with lexical meaning, typically nouns, verbs, adjectives or adverbs, which receive semantic and prosodic prominence within discourse. Regarding the form of the gesture, the results showed that the open-palm outward gesture occurred either with discourse markers or focal content words, whereas the inward gesture only accompanied focal content words. [Note 2] Moreover, both hand movements were also associated with a head nod, a widening of the eyes, and a raising of the eyebrows. Therefore, following these findings, the audio-visual stimuli for the training phase were recorded by the two storytellers who were trained to perform the open-palm outward gesture to emphasize discourse markers and the inward hand movements to emphasize focal content words (see Figure 1). Both storytellers were monitored for to make sure that they consistently synchronized beat gestures and the corresponding target verbalizations. After recordings

were completed, the first author also checked the results to ensure that the use of gestures appeared to be natural (the videos were the same as the ones used in the beat gesture condition in Vilà-Giménez et al., 2019).



Figure 1. Still images showing one of the two storytellers performing an outward beat gesture hand movement (left panel) and an inward beat gesture hand movement (right panel) in one of the training videos.

Eight different versions of a PowerPoint presentation were prepared in which the order of the pretest and posttest cartoons, the six training stories and the two storytellers were counterbalanced. In each PPT presentation, before showing the six training stories (three performed by each storyteller), two slides introduced the farm and all the animals featured in the narratives.

Procedure

The experiment followed the same pretest-training-posttest procedure as in Vilà-Giménez et al. (2019) (see Figure 2). Each participant was randomly assigned to one of two conditions, *beat non-encouraging* ($n = 25$; mean age = 5.96, $SD = 0.57$) or *beat encouraging* ($n = 22$; mean age = 5.88, $SD = 0.51$) (see Training session below). Children were tested individually in a quiet classroom at their school and were video-recorded in all phases of the task. Each child was seated wearing headphones while watching the video presentations in the pretest, training and posttest parts; after watching each video, the child removed the headphones and stood in front of the experimenter to retell the story. The whole session lasted approximately 30 minutes.

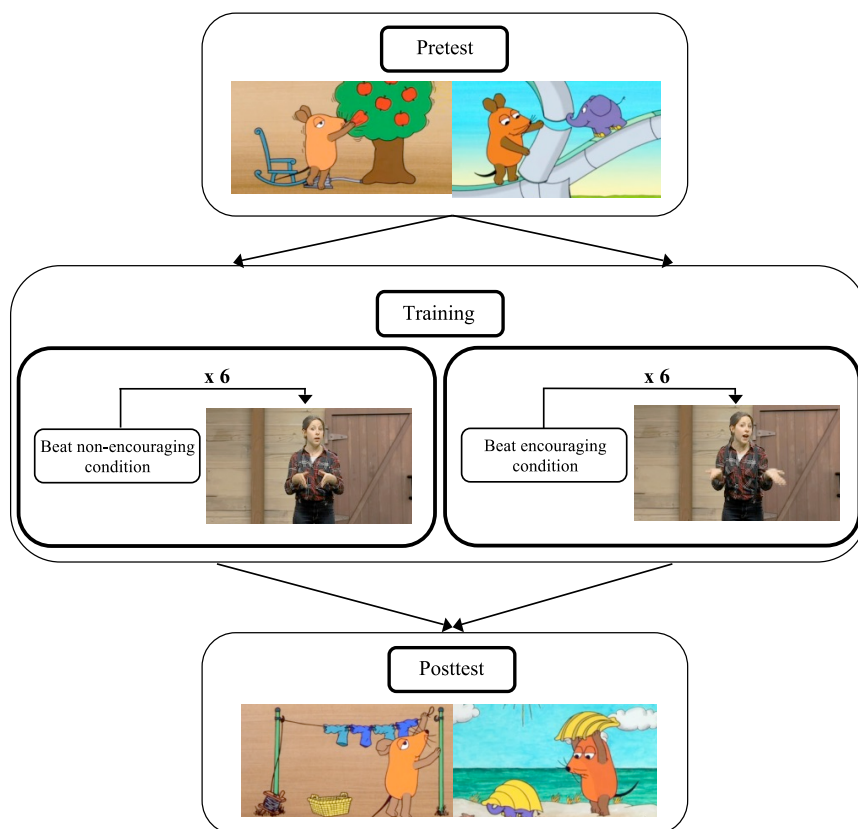


Figure 2. Experimental procedure.

Pretest and Posttest. The pretest and posttest phases consisted of a narrative retelling task. The child first watched a cartoon (containing only one character; see Cartoons A and C in Appendix A) using a laptop equipped with headphones and was then asked to stand up and retell what s/he had seen to the experimenter, who, though present in the room, pretended not to have watched the video clip. To provide motivation, the narrative task was carried out like a game, as the experimenter had to guess the story that the child was telling through a variety of pictures extracted from the original video and from other videos. As the child attempted to retell the story, the experimenter provided positive feedback in the form of comments like “I like the way you told the story very much, so I can easily guess which picture it is!” If the narrative was not immediately forthcoming, the experimenter said “Can you tell me the story?” and if the child seemed to be losing focus, the experimenter prompted her/him by means of comments like “Anything else?” The story finished when the child stopped or had nothing more to say. This procedure was then repeated using a different cartoon, this time containing two characters (see Cartoons B and D in Appendix A). The two

cartoons shown in the pretest were different from the two shown in the posttest. The prompting procedure for pretest and posttest were identical across conditions.

Training session. The training session took place between the pretest and the posttest phases and the materials used were embedded in the same PowerPoint presentation between the pretest and posttest materials. Training consisted of two tasks, watching a video clip of a person telling story, and then retelling the story to the researcher, this procedure being followed for six separate video clips. The same six videos were used for both experimental conditions, although the order of stories and storyteller varied from one participant to the next. In each of the videos a storyteller told a story while using beat gestures to emphasize discourse markers and focal content words. Prior to viewing, each child in the two conditions was instructed to pay close attention to how the storyteller was going to move her hands (e.g., “Look at the farmer [the storyteller] and watch how she moves her hands when she’s telling you the story”). After viewing, however, the child was given different instructions depending on the experimental group to which s/he had been assigned. While children assigned to the control *beat non-encouraging* condition were merely asked to retell the story they had just heard without receiving any gesture instructions, children assigned to the experimental *beat encouraging* condition were asked to retell the story while producing hand movements like those they had seen the storyteller use, with instructions along the lines of “Did you notice that the farmer [the storyteller] moved her hands a lot as she told the story? So now tell me the story just like the farmer did, moving your hands a lot the entire time. “Do you remember how she did it? Do you remember when she said, ‘Once upon a time, there was a duck...’?” While giving these instructions, the experimenter modeled the beat gestures as used by the storyteller, performing an outward beat gesture hand movement while saying discourse markers like “once upon a time” and an inward beat gesture hand movement for key content words like “duck.” In this way the experimenter stressed the fact that the storyteller had been moving her hands during the entire narrative. The child then either simply retold the story (if they were in the control group) or retold it with beat gestures (if they were in the experimental group) (see Figure 3). If the child did not respond immediately to the instructions, the same neutral prompts used in the pretest and posttest parts were provided (e.g., “Can you tell me the story?” or “Anything else?”). The story went on until the child stopped or had nothing else to add.

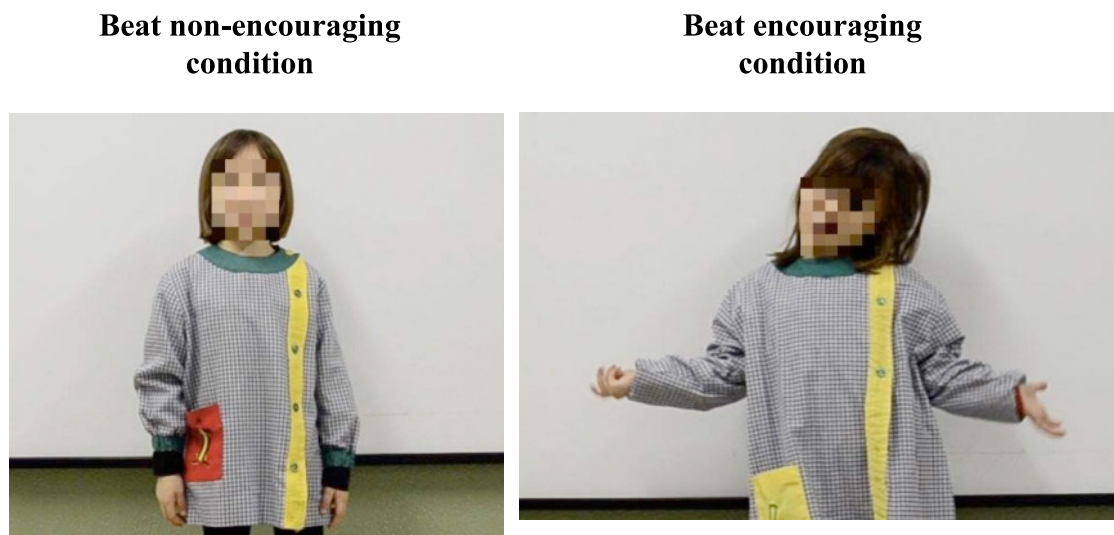


Figure 3. Still images of children performing posttest narratives after being exposed to the beat non-encouraging condition (left panel) and the beat encouraging condition (right panel).

In order to check that children correctly understood the training instructions and performed the gestures as in the model narrative, the first author of the study conducted an initial inspection of all the six short narratives produced by the children in the *beat encouraging* condition during the training sessions in which she verified the children's gestural behavior during the narrative training sessions across conditions. All the children understood the training instructions and followed them properly by imitating the beat gestures performed in the narrative in at least in some parts of their retelling task. Therefore, none of the participants were excluded from the dataset due to a lack of understanding of the training instructions. After the first author systematically counted all kind of gestures in the training narratives in the two conditions, an independent-samples t-test was then conducted to compare the number of gestures produced during the training session in both the *beat encouraging* and the *beat non-encouraging* conditions. As expected, there was a significant difference in the mean number of gestures produced per group in the *beat encouraging* condition ($n = 581$; $M = 26.41$, $SD = 10.52$) and the *beat non-encouraging* condition ($n = 55$; $M = 2.2$, $SD = 7.13$); $t(45)=9.33$, $p < .001$). These results show that the experimental condition was successful in boosting the number of gestures produced by the children during training.

Coding

Children's pretest and posttest narratives (47 children \times 4 stories (2 pretest + 2 posttest) = 188 stories) from the full audio-video recordings were analyzed and scored by the first author (a native speaker of Catalan) for narrative structure and narrative fluency. She was blind to the experimental conditions. All children's scores were averaged for both pretest and posttest.

Narrative structure. For the overall narrative structure scores of the pretest and posttest narratives, we used the same narrative assessment-coding scheme as in Vilà-Giménez et al. (2019), which was adapted from Demir et al. (2014) and Demir et al. (2015a). Four main features were considered when analyzing the structure of each story, yielding a score between 0 and 6: a) the presence of an animate protagonist, b) its temporal structure, c) its causal structure, and d) the presence of a goal-directed action (i.e., an action including an initiating event, the goal, the attempt to achieve the goal and the outcome of that attempt). Specifically, the instructions for coding narrative structure from 0 to 6 were as follows.

- (0) A **narrative with no structure**. No protagonist. It does not even contain a descriptive sequence; the story is not remembered.
- (1) A **descriptive sequence**. Protagonist but no temporal structure. This is a narrative that includes the physical and personality characteristics of an animate protagonist with no mention of a sequence of actions (i.e., no temporal structure).
- (2) An **action sequence**. Protagonist and temporal structure but no causal structure. This 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.
- (3) A **reactive sequence**. Protagonist, temporal and causal structure, but no goal. This contains actions that are temporally and causally organized but omits either the protagonist's goal or the attempt to achieve that goal, or omits both. The outcome is always mentioned here.
- (4) An **incomplete goal-based narrative**. This includes temporal and causal structure, a goal statement and/or description of an attempt to achieve the goal, but no information about the outcome.
- (5) A **goal-based narrative**. This includes not only temporal and causal structure as well as a goal statement, description of an attempt to achieve the goal and the final outcome.

(6) A **complete goal-based narrative**. This contains not only temporal and causal structure but also all the main features noted above. Moreover, the story is fleshed out with details including the initiating event.

A maximum score of 6 thus corresponded to a complex *complete goal-based narrative* which contained all four narrative features. (For a more detailed rubric and example for scoring child-produced retelling narratives, see Vilà-Giménez et al., 2019).

Fluency. To rate the children's oral fluency, we followed the lead of many other studies (O'Brien, 2014; and see Isaacs & Trofimovich, 2011; Kennedy & Trofimovich, 2008, for examples) and had a native listener listen to the children's productions and then assign a holistic perceived fluency score using a seven-point Likert scale, with 1 = extremely disfluent and 7 = extremely fluent. Perceived fluency, according to Segalowitz (2016) refers to the "subjective judgments of L2 speakers' oral fluency" based on their perceptions of how fluent the speaker is (p. 86).

Inter-rater reliability

Inter-rater reliability for narrative structure and fluency coding was established by checking the agreement between three raters (one of them the first author of the study), on a random subset of 20% of the data (44 cases). The three raters were blind to the two conditions of the study. Before conducting the reliability test, the two coders were trained in a one-hour session in which they had to analyze and blindly rate the narrative structure and fluency of a set of random audio-visual narratives. At the beginning of the session they were provided with an explanation of each of the scores of narrative structure and the fluency. Then, they were asked to rate a total of 10 stories and to compare the results with the first author of the study.

Cronbach's alpha coefficients, as measures of inter-rater reliability, were calculated. As for the narrative structure, overall agreement between the two coders and the author of the study indicated a high level of internal consistency (Cronbach's $\alpha = .815$). For the fluency scores, overall agreement between the two coders and the author of the study was satisfactory (Cronbach's $\alpha = .781$).

Statistical analyses

Two GLMM analyses (West, Welch, & Galecki, 2007) were run using SPSS Statistics 23.0 (SPSS Inc., Chicago IL) with overall narrative structure scores and overall fluency scores as dependent variables. In both GLMMs, Training Condition (two levels: beat non-encouraging and beat encouraging) and Test (two levels: pretest and posttest), and the interaction Condition \times Test were set as fixed factors. Subject and Item (i.e., the four stories used in the pretest and posttest) were set as random factors. Bonferroni pairwise comparison post hoc tests were carried out to detect significant main effects and interactions in each of the analyses. Furthermore, in the GLMM analysis of the fluency scores, Duration was included as a random factor, following the assumption that the duration in time of the narrative (e.g., how long a child speaks) correlates with her/his fluency. Finally, descriptive statistics (range, mean, SD) for both narrative structure and fluency scores in the pretest and posttest parts and in both conditions are provided in Appendix C.

Results

Narrative structure scores

The results of the GLMM analysis indicated a main effect of Test ($F(1, 184) = 25.194$, $p < .001$), showing better narrative structure scores in the posttest ($\beta = .834$, $SE = .166$, $p < .001$) than in the pretest for all subjects. Regarding effect size, the β regression coefficient indicates that a child has a .834 probability of achieving a higher posttest than pretest narrative structure score. A significant interaction between Condition and Test was also found ($F(1, 184) = 6.167$, $p = .014$), indicating that narrative structure scores differed depending on the experimental group and whether the narrative was pretest or posttest. Further post hoc analyses showed that the two experimental groups differed significantly in posttest narrative structure scores, with children in the *beat encouraging* group ($\beta = .697$, $SE = .265$, $p = .009$) producing better narrative structures than children in the *beat non-encouraging* condition. The β scores indicate that a child in the experimental group is .697 more likely to achieve a high narrative structure score than a child in the control group. Importantly, pretest scores between the two groups did not differ significantly ($\beta = .129$, $SE = .265$, $p = .628$), nor did pretest and posttest scores for the *beat non-encouraging* group ($\beta = .421$, $SE = .230$, $p = .069$). However,

significant differences were found between pretest and posttest scores in the *beat encouraging* condition, with better scores in the posttest ($\beta = 1.246$, $SE = .240$, $p < .001$) than in the pretest. In other words, a child in the experimental group is 1.246 more likely to achieve a higher posttest narrative structure score relative to pretest than a child in the control group. Therefore, children performed better in their posttest narratives when they were encouraged to gesture than when they were not (see Figure 4).

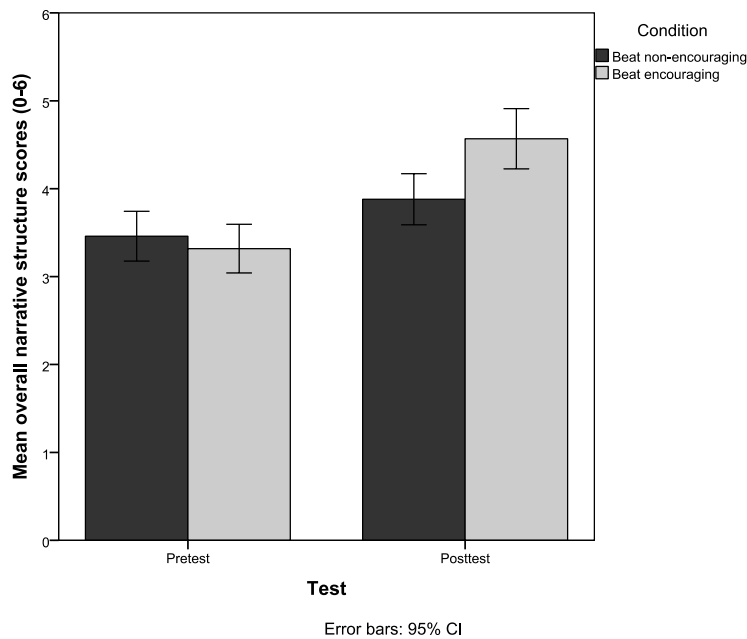


Figure 4. Mean overall narrative structure scores from 0 to 6, broken down by training condition (beat non-encouraging vs. beat encouraging) and test (pretest vs. posttest). Error bars represent 95% confidence intervals of the means.

Fluency scores

The results of the GLMM analysis showed a main effect of Test ($F(1, 184) = 18.277$, $p < .001$), with better fluency scores in the posttest ($\beta = .803$, $SE = .188$, $p < .001$) than in the pretest. The probability of a child’s posttest narrative having a higher narrative fluency score relative to pretest is about .803. A significant interaction between Condition and Test was also found ($F(1, 184) = 4.649$, $p = .032$). Again, pretest scores were not significantly different across groups ($\beta = .214$, $SE = .468$, $p = .647$), and

neither were posttest scores ($\beta = .596, SE = .533, p = .265$). However, whereas pretest and posttest scores for the *beat non-encouraging* condition did not significantly differ ($\beta = .398, SE = .249, p = .112$), significant differences were found between pretest and posttest scores for the *beat encouraging* condition, with better fluency scores in the posttest ($\beta = 1.208, SE = .281, p < .001$) than in the pretest. In other words, children in the experimental condition are 1.208 more likely to obtain better posttest than pretest narrative fluency scores than children in the control group. Therefore, children performed the posttest narratives more fluently when they were encouraged to gesture during the training session than when they were not (see Figure 5).

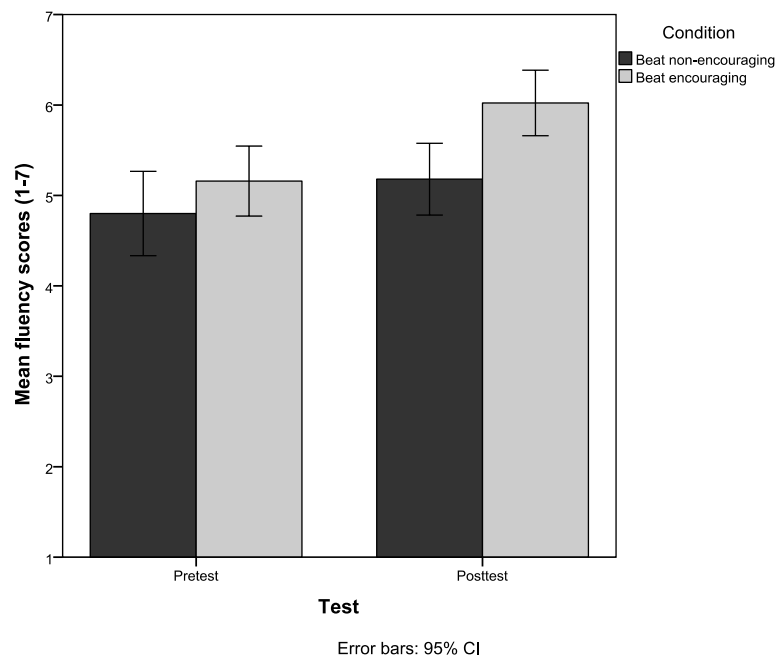


Figure 5. Mean overall fluency scores from 1 to 7, broken down by training condition (beat non-encouraging vs. beat encouraging) and test (pretest vs. posttest). Error bars represent 95% confidence intervals of the means.

Discussion and Conclusions

The current study was aimed at extending our understanding of the potential benefits of promoting the use of beat gestures in improving children's narrative performance. To our knowledge, this is the first study that investigates whether encouraging children to accompany their retelling of stories with beat gestures might lead to higher quality narratives as measured in terms of narrative structure and fluency. Our hypothesis was that it would, and our results seem to have confirmed this. A comparison of pretest and posttest scores for both narrative structure and narrative fluency showed that children in the experimental group, who were encouraged to produce gestures used during training, achieved higher scores than children in the control group, who had received no such instructions, suggesting that beat gestures act as meaningful highlighters of linguistic functions in speech (e.g., information focus, discourse structure, rhythm).

These findings complement recent research showing that merely observing beat gestures as they are told a story also improves children's subsequent retelling (Vilà-Giménez et al., 2019). However, the present study goes further in that it investigates the effect of not merely observing beat gestures but also producing them.

Our findings also go beyond the previous demonstration of the positive impact of seeing beat gestures in recall tasks (Austin & Sweller, 2014; So et al., 2012; Igualada et al., 2017; Llanes-Coromina et al., 2018). We argue that gestures that do not reflect representational (i.e., iconic or metaphoric) meaning, but important pragmatic and linguistic functions in discourse can boost children's narrative performance. There is previous research showing that observing iconic gestures facilitates children's memory of both nonlinguistic information (e.g., Aussems & Kita, 2019) and linguistic information (e.g., So et al., 2012). Further similar results were found in producing iconic gestures to encode aspects of events (e.g., Cook et al., 2010). Along these lines, the results of the training experiment demonstrate that, as iconic gestures do, encouraging children to produce beat gestures in the training phase influences how they produce their subsequent posttest narratives, as they can be provided with visual structure that enhances the parsing and processing of narrative events in speech.

The results of the present study also expand on previous developmental work on the relationship between gestures and narrative abilities. While previous research has shown that representational gestures serve as forerunners of narrative development

(Demir et al., 2014; Demir et al. 2015a; Stites & Özçalışkan, 2017), the present study suggests that beat gestures may have a similar effect. Up until recently, beat gestures had not been studied extensively in this context (see Vilà-Giménez et al., 2019, for a review). In part, this may be because beat gestures have been traditionally seen as purely rhythmic and non-meaningful (non-referential) gestures. Nonetheless, there is growing evidence that these gestures are pragmatically meaningful (Kendon, 2004, 2018; McNeill, 1992; Prieto et al., 2018; Shattuck-Hufnagel & Prieto, 2019; Shattuck-Hufnagel et al., 2016) and, in our view, the rhythmic and discourse-pragmatic cues beats have provided to children in the *beat encouraging* condition, with the visual scaffolding that highlights focal content words and discourse markers, may have actually helped boost their posttest narrative performance. The results of the present study thus add further force to the claim that beat gestures aid the language planning and learning processes underlying oral narrative discourse.

That said, it is clear that more research is needed to examine in greater depth how beat gesture training (together with other types of gesture training) might affect cognitive and language development. There are various issues that merit further investigation. First, further analyses of the temporal alignment between beat gestures and speech in the narratives produced by children may also extend on previous work by Mathew et al. (2017) and analyze the relevance of producing fine-grained adult's gesture-speech alignment patterns for the child's narrative success. Second, it would be of value to control the specific role of beat gestures in comparison to other types of gestures, such as representational gestures, which have already been shown to boost narrative abilities (e.g., Demir et al., 2014), or with conditions that include both representational gestures and beat gestures. Following up on previous studies describing the pragmatic and discourse functions of beat gestures (e.g., Prieto et al., 2018; Shattuck-Hufnagel & Prieto, 2019; Shattuck-Hufnagel et al., 2016) as well as their benefits on narrative performance (Vilà-Giménez et al., 2019) and speech production (Lucero et al., 2014), the present study aimed at assessing the specific role of beat gestures on their own. However, we believe that in order to contribute to the child's (or any speaker's) narrative success, the child does not need to be producing beat gestures exclusively, and using other types of gestures (just as referential gestures) would just strengthen the positive effects of gestures on narrative development. Thus, further research could examine the training value of different types of gestures in children's posttest narrative performance. We would expect that children (or any speaker) being

encouraged to produce other types of gestures (i.e., representational gestures), and not only specifically non-referential beat gestures, could benefit from gains in narrative performance. Moreover, while the present study demonstrated immediate short-term effects of a brief gesture-based training session on children's narrative performance, future research could focus more on the potential long-term effects of this sort of intervention. In other words, it would be of interest to explore whether any positive effects are sustained over time. Another question for future studies is whether beat gesture use by children has any predictive value with regard to their future narrative abilities. It may be that the onset of use of natural beat gestures by children is predictive of the superior narrative skills at different points in development. Finally, another future direction could examine how exactly the children's stories change in children who undertook the beat encouraging condition. In this sense, it could be that beats helped them with adding in a goal and perhaps with temporal sequencing.

In general terms, the results of this study are consistent with recent research showing the benefits of enacting or producing co-speech gestures while learning. Following the Gesture-for-Conceptualization Hypothesis (Kita et al., 2017, p. 258), we understand that gesture “activates, manipulates, packages and explores spatio-motoric representations for the purposes of speaking and thinking.” Gestural representation is thus shaped by on-line interactions with the speech formulation process, as speech and gesture production are intimately related and their relationship underlies the cognitive processes involved. The results of this study thus have implications for embodied cognition paradigms, whereby gestural perception and production processes are integrated with speech and strongly underlie cognitive and language processing, specifically narrative development (see Kiefer & Trumpp, 2012; Wellsby & Pexman, 2014, for a review). We believe that the positive impact of storytelling incorporating bodily movement, specifically the use of beat gestures, relies on the cognitive processes involved during both the observation and performance of narratives. The ultimate value of this research, however, may lie in the potential applicability of these findings to education, because they suggest that active intervention in the form of gestural training –a technique easily adapted to the classroom context– may actually enhance the cognitive development of children. Given the evidence for links between early narrative skills and later literacy and scholastic success, anything that can boost early childhood narrative performance –as the use of beat gestures seem to do– deserves serious attention.

Notes

1. This study obtained ethics approval from the Ethics Committee at the Universitat Pompeu Fabra (Internal Committee for the Ethical Review of Projects, CIREP-UPF) as part of gaining approval for funding from the Spanish Ministry of Science, Innovation and Universities (MCIU), Agencia Estatal de Investigación (AEI), and Fondo Europeo de Desarrollo Regional (FEDER) for Project PGC2018-097007-B-100 “Multimodal Language Learning (MLL): Prosodic and Gestural Integration in Pragmatic and Phonological Development.”
2. Following the MIT *Gesture Studies Coding Manual*. Retrieved from <http://web.mit.edu/pelire/www/manual/> (Shattuck-Hufnagel et al., 2016).

References

- ALIBALI, M. W., EVANS, J. L., HOSTETTER, A. B., RYAN, K., & MAINELA-ARNOLD, E. (2009). Gesture-speech integration in narrative: Are children less redundant than adults? *Gesture*, *9*, 290–311. doi: 10.1075/gest.9.3.02ali
- ALIBALI, M. W., & KITA, S. (2010). Gesture highlights perceptually present information for speakers. *Gesture*, *10*, 3–28. doi: 10.1075/gest.10.1.02ali
- ALIBALI, M. W., SPENCER, R. C., KNOX, L., & KITA, S. (2011). Spontaneous gestures influence strategy choices in problem solving. *Psychological Science*, *22*, 1138–1144. doi: 10.1177/0956797611417722
- APPLEBEE, A. (1978). *The child's concept of story*. Chicago, IL: Chicago Press.
- AUSSEMS, S., & KITA, S. (2019). Seeing Iconic Gestures While Encoding Events Facilitates Children's Memory of These Events. *Child Development*, 8–15. doi: 10.1111/cdev.12988
- AUSTIN, E. E., & SWELLER, N. (2014). Presentation and production: The role of gesture in spatial communication. *Journal of Experimental Child Psychology*, *122*, 92–103. doi: 10.1016/j.jecp.2013.12.008
- BERMAN, R.A. (1988). On the ability to relate events in narrative. *Discourse Processes*, *11*, 469–497. doi: 10.1080/01638538809544714
- BLAKE, J., MYSZCZYNSZYN, D., JOKEL, A., & BEBIROGLU, N. (2008). Gestures accompanying speech in specifically language-impaired children and their timing with speech. *First Language*, *28*, 237–253. doi: 10.1177/0142723707087583
- BOSCH, L., & SEBASTIÁN-GALLÉS, N. (2001). Evidence of Early Language Discrimination Abilities in Infants from Bilingual Environments. *Infancy*, *2*, 29–49. doi: 10.1207/S15327078IN0201_3
- BROADERS, S. C., COOK, S. W., MITCHELL, Z., & GOLDIN-MEADOW, S. (2007). Making children gesture brings out implicit knowledge and leads to learning. *Journal of Experimental Psychology: General*, *136*, 539–550. doi: 10.1037/0096-3445.136.4.539
- COLLETTA, J. M. (2009). Comparative analysis of children's narratives at different ages: a multimodal approach. *Gesture*, *9*, 61–97. doi: 10.1075/gest.9.1.03col
- COLLETTA, J. M., GUIDETTI, M., CAPIRCI, O., CRISTILLI, C., DEMIR, O. E., KUNENE-NICOLAS, R. N., & LEVINE, S. (2015). Effects of age and language on co-speech

- gesture production: an investigation of French, American, and Italian children's narratives. *Journal of Child Language*, *42*, 122–145. doi: 10.1017/S0305000913000585
- COLLETTA, J. M., PELLENO, C., & GUIDETTI, M. (2010). Age-related changes in co-speech gesture and narrative: evidence from French children and adults. *Speech Communication*, *52*, 565–576. doi: 10.1016/j.specom.2010.02.009
- COOK, S. W., MITCHELL, Z., & GOLDIN-MEADOW, S. (2008). Gesturing makes learning last. *Cognition*, *106*, 1047–1058. doi: 10.1016/j.cognition.2007.04.010
- COOK, S. W., YIP, T., & GOLDIN-MEADOW, S. (2010). Gesturing makes memories that last. *Journal of Memory and Language*, *63*, 465–475. doi: 10.1016/j.jml.2010.07.002
- DEMIR, Ö. E., FISHER, J. A., GOLDIN-MEADOW, S., & LEVINE, S. C. (2014). Narrative processing in typically developing children and children with early unilateral brain injury: Seeing gesture matters. *Developmental Psychology*, *50*, 815–828. doi: 10.1037/a0034322
- DEMIR, Ö. E., LEVINE, S. C., & GOLDIN-MEADOW, S. (2010). Narrative skill in children with early unilateral brain injury: a possible limit to functional plasticity. *Developmental Science*, *13*, 636–647. doi:10.1111/j.1467-7687.2009.00920.x
- DEMIR, Ö. E., LEVINE, S. C., & GOLDIN-MEADOW, S. (2012). Getting on track early for school success: The STEP assessment system to support effective instruction (PreK-3rd). Creating an assessment of literacy skills for three and four year olds. *Foundation for Child Development*. Retrieved from <http://fcd-us.org/sites/default/files/Lit%20Tech%20Report.pdf>
- DEMIR, Ö. E., LEVINE, S. C., & GOLDIN-MEADOW, S. (2015a). A tale of two hands: children's early gesture use in narrative production predicts later narrative structure in speech. *Journal of Child Language*, *42*, 662–681. doi: 10.1017/S0305000914000415
- DEMIR, Ö. E., ROWE, M. L., HELLER, G., GOLDIN-MEADOW, S. & LEVINE, S. C. (2015b). Vocabulary, syntax, and narrative development in typically developing children and children with early unilateral brain injury: early parental talk about the “there-and-then” matters. *Developmental Psychology*, *51*, 161–175. doi: 10.1037/a0038476
- DIMITROVA, D., CHU, M., WANG, L., ÖZYÜREK, A., & HAGOORT, P. (2016). Beat that word: how listeners integrate beat gesture and focus in multimodal speech

- discourse. *Journal of Cognitive Neuroscience*, 28, 1255–1269. doi:10.1162/jocn_a_00963
- DUINMEIJER, I., DE JONG, J., & SCHEPER, A. (2012). Narrative abilities, memory and attention in children with a specific language impairment. *International Journal of Language & Communication Disorders*, 47, 542–555. doi: 10.1111/j.1460-6984.2012.00164.x
- ESTEVE-GIBERT, N., & PRIETO, P. (2013). Prosodic Structure Shapes the Temporal Realization of Intonation and Manual Gesture Movements. *Journal of Speech, Language, and Hearing Research*, 56, 850–864. doi: 10.1044/1092-4388(2012/12-0049)
- FAUL, F., ERDFELDER, E., BUCHNER, A., & LANG, A. G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, 41, 1149–1160. doi: 10.3758/BRM.41.4.1149
- GLUHAREVA, D., & PRIETO, P. (2017). Training with rhythmic beat gestures benefits L2 pronunciation in discourse-demanding situations. *Language Teaching Research*, 21, 609–631. doi: 10.1177/1362168816651463
- GOLDIN-MEADOW, S., COOK, S. W., & MITCHELL, Z. (2009). Gesturing gives children new ideas about math. *Psychological Science*, 20, 267–272. doi: 10.1111/j.1467-9280.2009.02297.x
- GOLDIN-MEADOW, S., NUSBAUM, H., KELLY, S. D., & WAGNER, S. (2001). Explaining math: Gesture lightens the load. *Psychological Science*, 12, 516–522. doi: 10.1111/1467-9280.00395
- IGUALADA, A., ESTEVE-GIBERT, N., & PRIETO, P. (2017). Beat gestures improve word recall in 3- to 5-year-old children. *Journal of Experimental Child Psychology*, 156, 99–112. doi: 10.1016/j.jecp.2016.11.017
- ISAACS, T., & TROFIMOVICH, P. (2011). Phonological memory, attention control, and musical ability: Effects of individual differences on rater judgments of second language speech. *Applied Psycholinguistics*, 32, 113–140. doi: 10.1017/S0142716410000317
- KENDON, A. (2004). *Gesture: Visible Action as Utterance*. Cambridge: Cambridge University Press.
- KENDON, A. (2018). Pragmatic functions of gestures. Some observations on the history of their study and their nature. *Gesture*, 16, 157–175. doi: 10.1075/gest.16.2.01ken

- KENNEDY, S., & TROFIMOVICH, P. (2008). Intelligibility, comprehensibility and accentedness of L2 speech: The role of listener experience and semantic context. *Canadian Modern Language Review*, 64, 459–489. doi: 10.3138/cmlr.64.3.459
- KIEFER, M., & TRUMPP, N. M. (2012). Embodiment theory and education: The foundations of cognition in perception and action. *Trends in Neuroscience and Education*, 1, 15–20. doi: 10.1016/j.tine.2012.07.002
- KIRK, E., & LEWIS, C. (2017). Gesture Facilitates Children’s Creative Thinking. *Psychological Science*, 28, 225–232. doi: 10.1177/0956797616679183
- KITA, S., ALIBALI, M. W., & CHU, M. (2017). How do gestures influence thinking and speaking? The gesture-for-conceptualization hypothesis. *Psychological Review*, 124, 245–266. doi: 10.1037/rev0000059
- KRAHMER, E., & SWERTS, M. (2007). The effects of visual beats on prosodic prominence: Acoustic analyses, auditory perception and visual perception. *Journal of Memory and Language*, 57(3), 396–414. doi: 10.1016/j.jml.2007.06.005
- LUCERO, C., ZAHARCHUK, H., & CASASANTO, D. (2014). Beat gestures facilitate speech production. *Proceedings of the 36th Annual Conference of the Cognitive Science Society*, pp. 898–903.
- LLANES-COROMINA, J., PRIETO, P., & ROHRER, P. (2018). Brief training with rhythmic beat gestures helps L2 pronunciation in a reading aloud task. *Proceedings from the 9th International Conference on Speech Prosody*. Poznań, Poland.
- LLANES-COROMINA, J., VILÀ-GIMÉNEZ, I., KUSHCH, O., BORRÀS-COMES, J., & PRIETO, P. (2018). Beat gestures help preschoolers recall and comprehend discourse information. *Journal of Experimental Child Psychology*, 172, 168–188. doi: 10.1016/j.jecp.2018.02.004
- MACOUN, A., & SWELLER, N. (2016). Listening and watching: The effects of observing gesture on preschoolers’ narrative comprehension. *Cognitive Development*, 40, 68–81. doi: 10.1016/j.cogdev.2016.08.005
- MATHEW, M., YUEN, I., & DEMUTH, K. (2017). Talking to the beat: Six-year-olds’ use of stroke-defined non-referential gestures. *First Language*, 38(2), 1–18. doi: 10.1177/0142723717734949
- MCNEILL. (1992). *Hand and Mind: What Gestures Reveal about Thought*. Chicago: University of Chicago Press.

- NAREMORE, R., DENSMORE, A. E., & HARMAN, D. (1995). *Language intervention with school age children: conversation, narrative and text*. San Diego, CA: Singular Publishing Group.
- NOVACK, M. A., CONGDON, E. L., HEMANI-LOPEZ, N., & GOLDIN-MEADOW, S. (2014). From action to abstraction: Using the hands to learn math. *Psychological Science*, 25, 903–910. doi: 10.1177/0956797613518351
- O'BRIEN, M. G. (2014). L2 Learners' Assessments of Accentedness, Fluency, and Comprehensibility of Native and Nonnative German Speech. *Language Learning*, 64, 715–748. doi: 10.1111/lang.12082
- PARRILL, F., LAVANTY, B., BENNETT, A., KLCO, A., & DEMIR, Ö. E. (2018). The relationship between character viewpoint gesture and narrative structure in children. *Language and Cognition*, 10(3) 1–27. doi: 10.1017/langcog.2018.9
- PORTOLÉS, J. (1998). *Marcadores del discurso* [Discourse markers]. Barcelona, Spain: Ariel.
- PRIETO, P., CRAVOTTA, A., KUSHCH, O., ROHRER, P., & VILÀ-GIMÉNEZ, I. (2018). Deconstructing beat gestures: a labelling proposal. *Proceedings from the 9th International Conference on Speech Prosody*. Poznań, Poland.
- RAUSCHER, F. H., KRAUSS, R. M., & CHEN, Y. (1996). Gesture, speech, and lexical access: The role of lexical movements in speech production. *Psychological Science*, 7, 226–231. doi: 10.1111/j.1467-9280.1996.tb00364.x
- SCHIFFRIN, D. (1987). *Discourse markers (studies in interactional sociolinguistics 5)*. United Kingdom: Cambridge University Press.
- SEGALOWITZ, N. (2016). Second language fluency and its underlying cognitive and social determinants. *International Review of Applied Linguistics in Language Teaching*, 54(2), 79–95. doi: 10.1515/iral-2016-9991
- SHAPIRO, L., & HUDSON, J. (1991). Tell me a make-believe story: coherence and cohesion in young children's picture-elicited narratives. *Developmental Psychology*, 27, 960–974. doi: 10.1037/0012-1649.27.6.960
- SHATTUCK-HUFNAGEL, S., & PRIETO, P. (2019). Dimensionalizing co-speech gestures. *Proceedings from the International Congress of Phonetic Sciences*. Melbourne, Australia.
- SHATTUCK-HUFNAGEL, S., & REN, A. (2018). The Prosodic Characteristics of Non-referential Co-speech Gestures in a Sample of Academic-Lecture-Style Speech. *Frontiers in Psychology*, 9(1514). doi: 10.3389/fpsyg.2018.01514

- SHATTUCK-HUFNAGEL, S., REN, A., MATHEW, M., YUEN, I., & DEMUTH, K. (2016). Non-referential gestures in adult and child speech: Are they prosodic? *Proceedings from the 8th International Conference on Speech Prosody* (pp. 836–839). Boston, USA.
- SO, W. C., CHEN-HUI, C. S., & WEI-SHAN, J. L. (2012). Mnemonic effect of iconic gesture and beat gesture in adults and children: Is meaning in gesture important for memory recall? *Language and Cognitive Processes*, *27*, 665–681. doi: 10.1080/01690965.2011.573220
- STITES, L. J., & ÖZÇALIŞKAN, Ş. (2017). Who Did What to Whom? Children Track Story Referents First in Gesture. *Journal of Psycholinguistic Research*, *46*, 1019–1032. doi: 10.1007/s10936-017-9476-0
- TRABASSO, T., STEIN, N. L., RODKIN, P. C., MUNGER, M. P., & BAUGHN, C. R. (1992). Knowledge of goals and plans in the on-line narration of events. *Cognitive Development*, *7*, 133–170. doi: 10.1016/0885-2014(92)90009-G
- VILÀ-GIMÉNEZ, I., IGUALADA, A., & PRIETO, P. (2019). Observing Storytellers Who Use Rhythmic Beat Gestures Improves Children's Narrative Discourse Performance. *Developmental Psychology*, *55*(2), 250–262. doi: 10.1037/dev0000604
- WELLSBY, M., & PEXMAN, P. M. (2014). Developing embodied cognition: insights from children's concepts and language processing. *Frontiers in Psychology*, *5*(506), 1–10. doi: 10.3389/fpsyg.2014.00506
- WEST, B., WELCH, K. B., & GALECKI, A. T. (2007). *Linear mixed models: A practical guide using statistical software*. New York: Chapman & Hall/CRC.

Figure Legends

Figure 1. Still images showing one of the two storytellers performing an outward beat gesture hand movement (left panel) and an inward beat gesture hand movement (right panel) in one of the training videos.

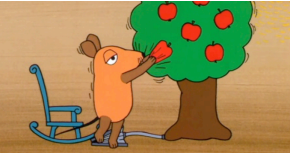



Figure 2. Experimental procedure.

Figure 3. Still images of children performing posttest narratives after being exposed to the beat non-encouraging condition (left panel) and the beat encouraging condition (right panel).

Figure 4. Mean overall narrative structure scores from 0 to 6, broken down by training condition (beat non-encouraging vs. beat encouraging) and test (pretest vs. posttest). Error bars represent 95% confidence intervals of the means.

Figure 5. Mean overall fluency scores from 1 to 7, broken down by training condition (beat non-encouraging vs. beat encouraging) and test (pretest vs. posttest). Error bars represent 95% confidence intervals of the means.

Appendix A: Pretest and posttest cartoon-based narratives

	<p>CARTOON A</p> <p>Initiating event: After the mouse has inflated the inflatable apple tree, he sniffs an apple.</p> <p>Goal: The mouse wants to take an apple from the tree.</p> <p>Attempt: The mouse picks an apple from the tree.</p> <p>Outcome: The tree deflates automatically so the mouse can not eat the apple.</p>
	<p>CARTOON B</p> <p>Initiating event: The mouse and elephant find a sculpture but the elephant accidentally knocks it over with his trunk.</p> <p>Goal: The mouse and elephant want to repair the sculpture.</p> <p>Attempt: The mouse and elephant turn the sculpture into a slide.</p> <p>Outcome: The mouse and elephant slide down the slide.</p>
	<p>CARTOON C</p> <p>Initiating event: The wind keeps blowing the socks off the clothesline.</p> <p>Goal: The mouse wants to hang up the socks (so they won't get blown off the line).</p> <p>Attempt: The mouse unties the clothesline, passes it through the socks, and reties it.</p> <p>Outcome: When the wind blows again, the socks no longer blow off the line.</p>
	<p>CARTOON D</p> <p>Initiating event: The mouse and elephant are walking on the beach and find a large clamshell. The mouse tries unsuccessfully to open the clamshell.</p> <p>Goal: The mouse wants to open up the clamshell.</p> <p>Attempt: The mouse tries unsuccessfully to open the clamshell with his foot so the elephant helps him with his trunk.</p> <p>Outcome: The mouse and elephant each use one half of the clamshell as a hat.</p>

Appendix B: English translation of the six narratives used in the training phase

<u>First story</u>	Once upon a time , a duck was walking to school. Suddenly , it started to rain , and the duck didn't have an umbrella . In the end , he came up with a solution : he put his hood on his head to protect himself from the rain.
<u>Second story</u>	Once upon a time , a rabbit went for walk in the mountains. Suddenly , some cows started to walk towards him and he was scared. In the end , he found a solution : he stood still behind a tree until the cows left.
<u>Third story</u>	Once upon a time , there was a horse that was hungry. Suddenly , he realized that there were no biscuits in the cupboard, because he had eaten them all. In the end , he thought of a solution : he made biscuits in the oven .
<u>Fourth story</u>	Once upon a time , there was a hen that was sleepy. Suddenly , she fell asleep on the sofa , but her alarm clock woke her up. She had forgotten that the following day was her birthday and that she was planning to buy candles to celebrate it. In the end , she found a solution : she bought some enormous candles and was therefore able to celebrate her birthday.
<u>Fifth story</u>	Once upon a time , a pig was playing football in the park. Suddenly , he realized that it was late and he had to go back home , because otherwise his mother would get angry. In the end , he thought of a solution : he took a shortcut to get home. That way , he managed to not arrive late and his mother did not get angry.
<u>Sixth story</u>	Once upon a time , a cat was staying at his grandparents' house in summer. Suddenly , he remembered that he had to do his homework , because otherwise his grandparents wouldn't wait for him to go to the beach. In the end , he came up with a solution : he did the homework before his grandparents arrived, and that way he was able to go to the beach .

Appendix C: Descriptive statistics for narrative structure and fluency scores

Descriptive statistics for narrative structure and fluency scores in the pretest part of the beat non-encouraging condition

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Narrative structure scores	50	5	0	5	3.46	.994
Fluency scores	50	6	1	7	4.80	1.641
Valid N (listwise)	50					

Descriptive statistics for narrative structure and fluency scores in the pretest part of the beat encouraging condition

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Narrative structure scores	44	3	2	5	3.32	.909
Fluency scores	44	5	2	7	5.16	1.275
Valid N (listwise)	44					

Descriptive statistics for narrative structure and fluency scores in the posttest part of the beat non-encouraging condition

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Narrative structure scores	50	3	3	6	3.88	1.023
Fluency scores	50	5	2	7	5.18	1.395
Valid N (listwise)	50					

Descriptive statistics for narrative structure and fluency scores in the posttest part of the beat encouraging condition

Descriptive Statistics

	<i>N</i>	Range	Minimum	Maximum	Mean	Std. Deviation
Narrative structure scores	44	3	3	6	4.57	1.129
Fluency scores	44	6	1	7	6.02	1.191
Valid <i>N</i> (listwise)	44					