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Young Children Create Iconic Gestures to Inform Others

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Much is known about young children's use of deictic gestures such as pointing. Much less is known about their use of other types of communicative gestures, especially iconic or symbolic gestures. In particular, it is unknown whether children can create iconic gestures on the spot to inform others. Study 1 provided 27-month-olds with the opportunity to inform a novice how to perform a task. The majority of children created appropriate iconic gestures, and they did so significantly more than in a control condition in which the need to inform someone was removed. In Study 2, some of the 21-month-olds tested also created novel iconic gestures but to a lesser extent. Results are discussed in relation to children's symbolic, linguistic, and social–cognitive development.

Keywords: iconic gestures, social–cognitive development, intentional communication, communicative development, gesture–speech integration

When adults talk, they commonly gesture. These spontaneous hand movements often include iconic gestures that depict, in their form and manner of execution, an aspect of the meaning that the speaker is communicating (McNeill, 1992). Adults create such iconic gestures on the spot, as they are speaking. Such gesturing may help speakers to express their thoughts (e.g., Kita, 2000; Krauss 1998), and it makes the speaker's meaning more accessible for the listener (see, e.g., Goldin-Meadow, 1999; Hostetter, 2011, and Kendon, 1994, for reviews). Gesture and speech are so closely integrated, both temporally and semantically, that they are thought to form a single unified system, with both modalities co-operating and helping to convey the communicative message (e.g., Clark, 1996; Goldin-Meadow, 2003; Kendon, 2004; McNeill, 1992). In fact, recent experimental research has clearly demonstrated the communicative function and semantic integration of iconic gestures (e.g., Holler, Shovelton, & Beattie, 2009; Kelly, Creigh, & Bartolotti, 2009; Özyurek, 2010). Using the hands to depict things for others iconically is an important communicative activity that is believed to be used universally among speakers from all cultural and linguistic backgrounds (Kita, 2009).

Despite the fact that iconic gesturing is fundamental to human communication, little is known about its ontogenetic development. As Guidetti and Nicoladis (2008) highlighted in their review of early gesture development, "there is a curious lack of the predominant kind of gesture used by adults: spontaneous, nonconventional gestures that seem to be created on the spot to convey meaning" (pp. 109–110). In fact, as far as we know there is no research that has investigated this directly—testing specifically whether and at what age young children can create novel iconic gestures. There are, however, a number of related findings that help to shed some light on children's early skill with iconic gestures, looking at both comprehension and production.

In comprehension, a general finding is that the iconicity of gestures does not seem to be transparent for young children. This point is shown by research comparing children's responses to iconic versus-arbitrary gestures and signs. Young children raised by signing parents are exposed to both arbitrary and iconic signs, but they show no preference for acquiring the iconic ones (e.g., Folven & Bonvillian, 1991; Orlansky & Bonvillian, 1984), suggesting that iconicity does not facilitate their recognition and retention of new signs—in contrast to older children's and adults' learning patterns (e.g., Lieberth & Gamble, 1991; Newport & Meier, 1985). Similarly, in experiments, hearing children before 2 to 3 years of age do not seem to appreciate the iconicity of gestures or signs (e.g., Marentette & Nicoladis, 2011; Namy, 2008; Namy, Campbell, & Tomasello, 2004; Shore, Bates, Bretherton, Beeghley, & O'Connell, 1990; Tolar, Lederberg, Gokhale, & Tomasello, 2008; Tomasello, Striano, & Rochat, 1999).

In production, infants start to communicate using gestures several months before they say their first words (e.g., Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979; Bates, Camaioni, & Vol-

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terra, 1975), and once they start talking, they combine gestures with their first words (e.g., Capirci, Iverson, Pizzuto, & Volterra, 1996; Goldin-Meadow & Butcher, 2003; Iverson, Capirci, & Caselli, 1994; Iverson & Goldin-Meadow, 2005). During this early period, from around 10 to 24 months of age, infants produce two types of gestures: deictic gestures (e.g., pointing) that draw the addressee's attention to some entity or event in the environment and non-deictic gestures that carry some semantic content based on a fairly consistent relation between gesture form and meaning across contexts. These non-deictic gestures may be arbitrary in form (e.g., nodding or shaking the head), or they may include an iconic element (e.g., flapping the arms to convey "flying"; see Acredolo & Goodwyn, 1988).

Despite a wealth of research on infants' use of gesture (see, e.g., Bates & Dick, 2002, and Volterra, Caselli, Capirci, & Pizzuto, 2005, for reviews), not much is known about infants' ability to construct iconic gestures. This is because iconic gestures are often subsumed in a class of non-deictic gestures without distinguishing within this class between iconic and non-iconic gestures (e.g.,Capirci, Contaldo, Caselli, & Volterra, 2005; Capirci et al., 1996; Iverson et al., 1994; Pizzutto & Capobianco, 2005). Even those studies in which these gestures are distinguished do not typically consider their origin or emergence (see Acredolo & Goodwyn, 1988, for an exception). When infants use iconic gestures, they may be creating them themselves, on the spot, the way older children and adults do (see McNeill, 1986, 1992), or they may simply be copying their caregiver's gestures. Note that, in the latter case, the gesture's iconicity would simply be a byproduct of the adult's use of iconicity (Namy, Acredolo, & Goodwyn, 2000; Tomasello, 2008).

There is little direct research on this, but the available evidence suggests that infants acquire their iconic gestures from their parents. That is, parents use iconic gestures when interacting with their young children (Iverson, Capirci, Longobardi, & Caselli, 1999; Özçalişkan & Goldin-Meadow, 2011), and infants readily learn the iconic gestures that they are taught (see Goodwyn & Acredolo, 1993, and Goodwyn, Acredolo, & Brown, 2000, for research on "baby signs"). Correlations have been found between parents' use of iconic gestures and their children's own gesture use, both when individual differences across parents (Namy et al., 2000; Namy, Vallas, & Knight-Schwarz, 2008) and when cross-cultural differences (Iverson, Capirci, Volterra, & Goldin-Meadow, 2008) were examined. The role of gesture input has also been confirmed by parental reports: Infants' iconic gestures could often be traced back to their parents' use of such gestures, either in the context of ritualized games or everyday routines (Aredolo & Goodwyn, 1988; see also Caselli's, 1990, case study).

But what about truly creative iconic gestures? Hardly anything is known about young children's ability to create such gestures on the spot. One reason for this is a prominent age gap in the gesture literature. Research on infant communication has focused on the integration of first gestures and words, without looking much beyond the two-word stage. Research on speech-accompanying gestures, on the other hand, has focused on adults and school-age children, with a few studies documenting the use of iconic gestures in preschoolers from around age 4 to 5 years (e.g., Kidd & Holler, 2009; McNeill, 1992; So, Demir, & Goldin-Meadow, 2010). Not much is known, however, about the early development of iconic gesture use in 2- to 3-year-olds. Only a few studies have looked at this younger age range (e.g., Nicoladis, Mayberry, & Genesee, 1999; Özçalişkan, Genter, & Goldin-Meadow, 2013; Özçalişkan & Goldin-Meadow, 2011; Stefanini, Bello, Caselli, Iverson, & Volterra, 2009), and again it is difficult to know whether children were simply copying their parents' (or others') iconic gestures or whether they created them on the spot. For instance, in a longitudinal observation study, children showed an increase in their use of iconic gestures from age 26 months on (Özçalişkan & Goldin-Meadow, 2011), with little overlap between child and parent in the iconic gestures that they produced during the observation sessions (children were recorded for 90 min once every 4 months from age 14 months to 34 months). While these observations are in line with the idea that children might create iconic gestures spontaneously, it is also possible that they re-enacted gestures acquired from their parents (not during the sessions themselves but sometime previously).

Thus, it is unclear whether the creative use of iconic gesture develops only later in childhood, based perhaps on the development of more proficient language skills (see Mayberry & Nicoladis, 2000), or whether 2-year-old children are already capable of this, given the right circumstances. As Capirci and Volterra (2008) pointed out, "the transition through which children's gestures become organized into the adult speech–gesture system has not been fully described, and . . . little is known about the development of gesture especially between the ages of 2 and 3" (p. 33). This age, however, is of particular interest, as it is at around 2–3 years that children show remarkable developments in their symbolic capacity—as shown, for instance, in their ability to treat pictures and other artefacts as representations (e.g., DeLoache, 2004) and in their understanding of pretend play (e.g., Harris & Kavanaugh, 1993; Rakoczy, Tomasello, & Striano, 2004).

In the current study, we aimed to address this age gap by investigating 2-year-olds' ability to create iconic gestures. Thus, we set up situations to elicit iconic gestures that the child would have to create on the spot. Unlike most previous work, we did not focus on children depicting objects, but rather on children depicting the actions that another person would need to perform to attain some goal. Arguably, acting out the actions another person should perform is more natural than referring to an object by depicting an associated action or depicting its perceptual form (Tomasello, 2008; see also Stefanini et al., 2009, and Marenette & Nicoladis, 2011). In order to ensure the need for children to communicate and use gestures, children first learned how to solve a novel problem (such as opening an unfamiliar apparatus) themselves, and then they encountered a novice who was struggling with the same problem and turned to them for help. (A child puppet was used to present a plausible novice.)

To explore children's communicative use of iconic gestures, we also looked at their accompanying speech. Research on adult communication has shown that adults employ verbal deictic markers in order to highlight the communicative relevance of their iconic gestures (e.g., Holler & Wilkins, 2011; Streeck, 1993, 2002). For example, a speaker might say "Do it like this!" followed by an iconic gesture that depicts the action that the listener needs to perform. Thus, we examined whether children's iconic gestures were also accompanied by such verbal deictic markers.

Study 1

In Study 1, we looked at young 2-year-olds, aged 27 months. At this age precisely, children demonstrate a robust and flexible

understanding of intentionally "acting as if" (as shown by research on pretend play, e.g., Rakoczy & Tomasello, 2006, and Harris & Kavanaugh, 1993). Furthermore, children this age and younger are motivated to help others (e.g., Warneken & Tomasello, 2006) and to get their communicative message across (Grosse, Behne, Carpenter, & Tomasello, 2009). Against this background, we predicted that children this age would be able to create iconic gestures to inform others. We did not have any a priori predictions concerning whether children this age would already use verbal markers (such as "like this") to highlight their iconic gestures.

Method

Participants. Participants were 36 children, aged 27 months, who were randomly assigned to one of two conditions (see below). Twenty-four children (12 girls) participated in the communicative condition (mean age = 27 months, 16 days; range: from 27 months, 2 days, to 27 months, 26 days). Twelve children (five girls) participated in the control condition (mean age = 27 months, 21 days; range: from 27 months, 8 days, to 28 months, 0 days). An additional two children (one in each condition) were tested but not included in the final sample because they lost interest in participating in the games during the test session. Children were recruited in a medium-sized city in Germany, from a list of parents who had expressed interest in participating in child development studies. Parents were informed about the aim and the procedure of the study and gave informed consent.

Design. We presented children with two between-subject conditions. In the communicative condition, children encountered the puppet struggling to operate apparatuses that they themselves knew how to operate and were given a chance to instruct the puppet using iconic gestures. In the control condition, children experienced the same general procedure, and the same apparatuses were presented, but no one needed help operating them. This control assessed whether children would simply produce a corresponding hand or arm movement whenever their attention was drawn to a particular apparatus, as one might expect if children's gestures were not communicative but simply reflected their recognition of how an object is used (see Shore et al., 1990, for a description of the recognitory, "I know what to do with this", gestures that infants start to produce around their first birthday).

Each child participated in five tasks: four iconic-gesture tasks and one pointing task. In the iconic-gesture tasks, the puppet's mistaken attempts were designed so that correcting her required the use of iconic gestures (or verbal descriptions linguistically too complex for young 2-year-olds). In contrast, in the pointing task, children were put in a situation in which pointing would suffice. This task was included to assess more generally children's use of gestures in this context and their willingness to interact with and help the puppet.

To assess children's language level, we asked the parents to fill out a standardized language development checklist for German-speaking 2-year-olds called ELFRA 2 (Grimm & Doil, 2000). This checklist is based on the MacArthur Communicative Development Inventories (CDIs; Fenson et al., 1993) and assesses productive vocabulary, syntax, and morphology.

Materials and procedure. Before the start of the test session, the two experimenters (E1 and E2) played with the child to get acquainted. During this play, E2 introduced and animated the puppet. The puppet was a girl puppet (height = 45 cm) whose mouth and hands could be moved. Her glove hands, each with five moveable fingers, allowed for natural hand movements.

Children were tested in a quiet room in the lab. Their parents were present throughout the session but sat in a far corner of the room and were busy filling out the language questionnaire. The session started with a warm-up phase to set up the games' turn-taking structure and to introduce the puppet's general ignorance and need for assistance.

There were two warm-up games. For the first, E1, the child, and the puppet (animated by E2) took turns putting marbles into a "jingle machine" (an apparatus with a xylophone inside to generate the sound). When none were left, E1 presented a "marble dispenser" that needed to be turned or spun around to retrieve a marble from its small opening. E1 demonstrated how to retrieve a marble and then let the child have a go—helping the child, if necessary. Next the puppet tried to retrieve a marble but struggled because she tried to reach into the small opening of the dispenser instead of turning it around. If children did not help spontaneously, the puppet asked them, "How does this work?" For the second game, E1 and the child drew with color pencils. The puppet joined in and tried to draw, holding the pencil the wrong way round. If children did not assist or correct her spontaneously, again she asked them for help. (Children helped the puppet, e.g., by retrieving the marble for her or by turning the pencil the right way round). Afterward, the puppet, who had become tired, excused herself, said good night, and went to her side of the room to sleep (i.e., she lay down, her back turned to the child, and her eyes covered by E2, while E2 also closed her eyes, lowered her head, and made sleep sounds to emphasize that the puppet did not witness what happened next).

During the following test phase, E1 and the child sat at a small table, separated from the puppet's side of the room by a long transparent barrier (≈ 75 cm high). There were four different apparatuses to elicit iconic gestures and one to elicit pointing gestures (see Figure 1). For each task (with the puppet always still asleep), E1 presented the respective apparatus and demonstrated twice how to operate it before the child got a turn. When demonstrating, E1 used clear, marked movements on the apparatus and occasionally accompanied them with sound effects to mark her action, but she did not use any verbal deictic markers (such as "Like this!" or "Do this!") or any gestures. Once the child managed to operate the apparatus, E1 and the child alternated, taking two more turns each, to ensure that the child was very familiar with the actions needed. Then E1 placed the apparatus on the puppet's side of the room, orienting it so that the child could clearly see but not reach it.

In the communicative condition, the puppet woke up at this stage, and E1 asked her whether she wanted to have a go (e.g., "Do you want to get some marbles out, too?"). The puppet answered affirmatively and started to act on the apparatus, using an incorrect action (either using the wrong type of action in the iconic-gesture tasks, e.g., twisting instead of pushing, or acting on the wrong part of the apparatus in the pointing task). There were two trials per task. For the first trial, the puppet's sequence of action was as follows: She first performed two incorrect attempts and turned to the child with a questioning "Hmm?" Then she made another incorrect attempt and turned to the child, this time addressing her by name in a friendly questioning manner (e.g., "Anna?"). Finally she attempted it once again and asked the child, "How does this work?" To ensure a natural communicative interaction with the

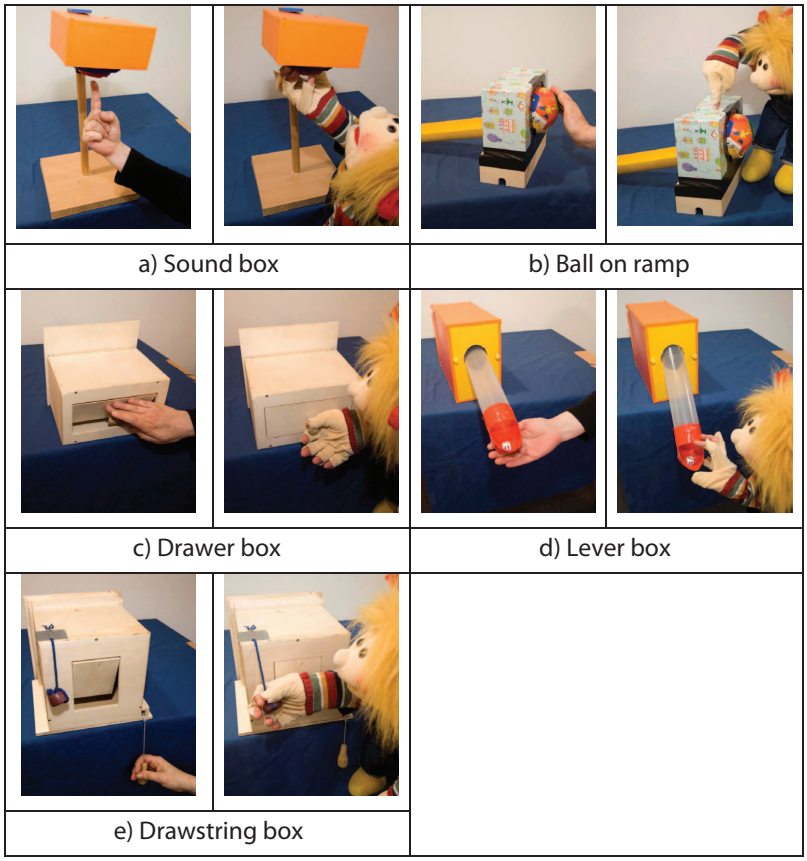


Figure 1. Apparatuses used in Study 1. Panels (a)–(d) show the four different apparatuses used to elicit iconic gestures, and Panel (e) shows the apparatus for the pointing task. For each apparatus, the photograph on the left depicts how to correctly open the box, and the photograph on the right shows how the puppet attempted to open it incorrectly. See the online article for the color version of this figure.

child, the puppet always responded to and acknowledged the child's responses. If the child produced a verbal or gestural response that was uninformative or not specific enough (e.g., the child simply pointed in an iconic-gesture task), the puppet responded to it in a positive manner and if possible acted on the suggestion, but without going beyond the information given, and naturally continued in her sequence of responses (incorporating the suggestion where possible). If the child provided the required information, the puppet acted on this, operated the apparatus successfully, and the first trial ended. If the child did not provide the required information, the first trial ended after the child's response (if any) to the puppet's final question.

The second trial then followed. If the puppet had been successful, the second trial started with her saying, "Oh, I'll do that again," but then hesitating, showing that she had forgotten how to do it (indicated by her puzzled "Hmm?"). If she had not been successful, the second trial started with her saying, "Oh, I'll try again." In both cases, the puppet then started the same sequence as described for the first trial. After the second trial, the puppet went back to sleep, and children got the apparatus another time, in order to test (especially for cases in which they had not gestured) whether they still knew how to operate it. (For details of the appropriate actions and the puppet's mistakes on each task, see the Appendix).

In the control condition, the procedure was exactly the same up to the point when the apparatus was placed on the puppet's side of the room. The crucial difference then was that in the control condition, the puppet did not wake up but remained asleep throughout. Instead E1 drew the child's attention to the apparatus, following a schedule that paralleled the puppet's sequence of actions during the first trial: As the puppet had acted on the apparatus and addressed the child up to three times in the communicative condition, E1 also drew attention to the apparatus three times. Specifically, when placing the apparatus on the puppet's side of the room, E1 drew attention to it the first time by saying, "I'll put the [name of apparatus] here for [name of puppet]." Then, a few seconds later, she acted on the apparatus again, saying, "Ah, I'll place it like this," while touching and moving it about slightly, as if to adjust its position. Finally, E1 touched the apparatus again, saying, "Ah, the [name of apparatus]," and then (after a pause) "Hm, [the puppet] is still asleep, so I'll put it away." Children were then given the apparatus to test whether they still knew how to operate it.

There was no second trial in the control condition, as this would have made the procedure too long and tedious. For any comparisons between conditions, we only included children's responses in the first trial of each task for the communicative condition, to make the response phases in the two conditions directly comparable. (Note that in 96% of cases in which children produced iconic

gestures in the communicative condition, they did so already on their first trial; see the Results section.)

Coding and reliability. Sessions were videotaped, and children's verbal and gestural responses were transcribed and coded from tape. Children's gestural responses to the puppet were coded as (a) appropriate iconic gestures, (b) pointing, (c) other gestural responses, or (d) no gestures. If children produced more than one type of response in a given trial, we used a hierarchical coding approach, so that each child was given one score for each trial and task (for details and definitions, see Table 1 and the Appendix). For the control condition, we also coded whether E1 had been successful in drawing children's attention to the apparatus. Thus, for each of the three phases of the response period, the coder assessed whether the child had looked toward the apparatus.

For each condition, the coding was performed by a research assistant who had not been present at the test sessions, was unaware of the hypotheses, and was instructed to judge children's responses solely on the basis of the given coding criteria and told that her judgment may or may not coincide with the puppet's response. To assess interrater reliability, for each condition a second coder coded and scored 25% of the data independently from videotapes (i.e., six randomly chosen children from the communicative condition and three from the control condition). In the communicative condition, interrater reliability for gesture scores was excellent both for children's first trials ($n = 30$, Cohen's $\kappa = .90$) and their second trials ($n = 30$, Cohen's $\kappa = .85$). In the control condition, 100% agreement was observed for the rating of both gestural responses and attentiveness.

When children produced appropriate gestures, we also coded their accompanying verbal responses as (a) related speech (e.g., "Like this" for iconic-gesture tasks or "No, there" for the pointing task), (b) unrelated speech, (c) unclear speech, or (d) no speech (just sound effects or nothing said at all). To assess interrater reliability, a second coder scored the transcripts of children's accompanying speech independently. There was 100% agreement on the categorization of children's verbal responses.

As two children (one in each condition) declined to participate in one of their iconic-gesture tasks, children's gesture scores were calculated as proportions of tasks in which they participated. All p values reported are based on exact calculations and are two tailed.

Results

Comparisons between conditions. Preliminary analyses, based on the parental language questionnaire, showed that children in the communicative condition and the control condition did not differ significantly in any of their language scores—productive vocabulary: $t(34) = 0.39$, $p = .698$; morphology: $t(34) = -0.481$, $p = .633$; and syntax: $t(34) = -1.71$, $p = .097$.

For the main analyses, we compared children's use of appropriate gestures in the two conditions (looking at first trial data only in the communicative condition as explained above). On the iconic-gesture tasks, children produced significantly more appropriate iconic gestures in the communicative condition than in the control condition (in which they never produced these gestures; Mann-Whitney U test on the proportion of iconic-gesture tasks with an appropriate gesture, $U = 60.0$, $n_1 = 12$, $n_2 = 24$, $p < .01$, $r = .54$). Likewise on the pointing task, children produced significantly more pointing gestures in the communicative condition than in the control condition, in which they never pointed (Fisher's exact test, $n = 36$, $p < .001$).

Looking at individual performances, 83% of children in the communicative condition (i.e., 21 of 24 children) used appropriate communicative gestures (iconic gestures and/or pointing) on at least one occasion when addressing the puppet (again looking at first trial responses for each task only), but no child did this in the control condition (Fisher's exact test, $n = 36$, $p < .001$). Note that the absence of gesture responses in the control condition was not due to children taking no notice of the apparatus: Children in the control condition all attended to the apparatus on each of their five tasks.

Table 1
Coding Categories for Children's Gestural Responses

Score	Description of the child's response
1. Appropriate iconic gesture	The child produced an appropriate iconic gesture which indicated how to operate the respective apparatus. (See the Appendix for the description of appropriate gestures for each of the four iconic-gesture tasks.)
2. Pointing	The child pointed during the response phase (but did not produce any "appropriate iconic gesture").
3. Other gestural responses	The child produced gestures other than "appropriate iconic gestures" or "pointing." Such gestures could include ambiguous gestures that contained some element of the corresponding appropriate iconic gestures but were too vague or unclear to be counted. It could also include gestures that resembled the description of an "appropriate iconic gesture" of **another** task. (If the latter occurred, it was marked for further analyses.)[a]
4. No gestures	The child did not produce any gestures during the response phase.

[a] The coding category "gesture that would be appropriate for **another** iconic gesture task" was included to ensure that we would not categorize general unspecific hand movements that might occur throughout the session as "appropriate iconic gesture" on one task while simply ignoring the same hand movements when they occurred during another tasks. It turned out that on the few occasions that this was coded, it seemed to be a carry-over effect from one task to the next (rather than general nonspecific hand movements produced throughout), as this was only ever observed *after* the appropriate gesture had been produced on a preceding task (never before the relevant task) and once the child also seemed to correct himself (see Study 2).

Children's use of gestures in the communicative condition. In the communicative condition, children used appropriate iconic gestures on average on 35% of their iconic-gesture tasks (either in one or in both trials of a task; see below). There was no significant difference between boys and girls regarding their use of iconic gestures (Mann-Whitney *U* test on the proportion of iconic-gesture tasks with an appropriate gesture, $U = 66.0$, $n_1 = 12$, $n_2 = 12$, $p = .755$, $r = .07$). Looking at individual patterns, the majority of children ($n = 14$ or 58%) used an appropriate iconic gesture on at least one of their iconic-gesture tasks. The remaining children either produced just points or other gestures ($n = 7$), or they did not gesture at all on the iconic-gesture tasks ($n = 3$).

On the pointing task, most children ($n = 17$ or 71%) produced pointing gestures to instruct the puppet, and one child gave a fully informative verbal instruction (i.e., "You need to pull the other one") without pointing. Again no difference between boys and girls was observed (Fisher's exact test, $n = 24$, $p = 1.000$).

Comparing the two types of tasks, we found that children performed significantly better when the task required them to point than when they needed to produce an iconic gesture (Wilcoxon test on the proportion of tasks with an appropriate gesture: $z = 3.01$, $n = 24$, $p < .01$, $r = .61$). As the pointing task came after the four iconic-gesture tasks, we analyzed to what extent the difference between the two types of tasks could be accounted for by order effects. As expected given this order of tasks, we found a significant effect when comparing children's performance on Tasks 1–5 (Cochran test, $n = 23$ [as one child missed one iconic gesture task], $df = 4$, Cochran's $Q = 14.71$, $p < .01$). However, there was no difference when looking at children's performance on the first four tasks (Cochran test, $n = 23$, $df = 3$, Cochran's $Q = 1.88$, $p = .734$), and children's performance on Task 5 was significantly different from each of the four preceding tasks (McNemar's tests, all ps $< .05$). Thus, the findings reflect the exact pattern that one would expect if children's performance was driven by the type of task, rather than by a general improvement across trials.

Iconic gesturing. The iconic gestures that children employed specifically depicted the action that the puppet needed to perform: Looking at data from both trials, children in total produced 56 iconic gestures that were appropriate to the task at hand, compared with just one instance in which a child produced a single gesture that was not appropriate to the task, but depicted an action that the puppet would have had to perform on one of the three other iconic-gesture task (i.e., there were 98% task-specific gestures vs. 2% "other-task" gestures). Thus, despite the fact that the baseline probability for other-task gestures was three times higher than for task-specific ones, children produced significantly more task-specific gestures than other-task gestures (Wilcoxon test, $z = 3.31$, $n = 24$, $p < .001$, $r = .68$).

If children produced appropriate iconic gestures, they mostly did so in both trials of a task (in 75% of cases). In 22% of cases, children produced a clear iconic gesture on their first trial only. In the latter cases, on their second trial, children sometimes produced a more "ambiguous gesture" that resembled their previous response but was not quite as distinct or incorporated only some of its features. (In two cases, such "ambiguous gestures" were seen from the first trial on: for the sound box, two children pressed with their index finger on a nearby substrate, thus re-enacting the required action, but using a downward movement).

Gesture use and accompanying speech. Children's iconic gestures were generally accompanied by related speech (see Figure 2). Note that such speech had not been modeled by E1 when she had operated the apparatus herself. Looking at what children said, we found that in 45% of cases children's accompanying speech included the German demonstrative term *so* used deictically (in English, *like this*). For example, children said, "Nein, so" ("No, like this"), "So hochheben" ("Lift it like this"), "So geht das" ("This is how it's done"), or just "So!" ("Like this!"), as they produced the iconic gestures. In the other cases, children's iconic gestures were accompanied by spatial demonstratives, directional and action terms, and/or simple negations, for example, "No, there. Up!" or "Press there." (An iconic gesture without accompanying speech was only observed once when, on Trial 2, a child repeated the gesture that she had already used, accompanied by speech, a moment earlier on Trial 1). On the pointing task, children's pointing gestures were always accompanied by related speech (e.g., "No, pull there" or simply "There!").

Relation between gesture use and language development. There was no relation between children's use of iconic gestures and any of the three language scores of the parental questionnaire (Spearman's correlations between the proportion of tasks with iconic gestures and the respective language scores; $n = 24$ for each; vocabulary: $r_s = .02$, $p = .944$; morphology: $r_s = .16$, $p = .449$; and syntax: $r_s = .11$, $p = .606$).

Discussion

These findings suggest that, given the right circumstances, 2-year-old children are able to use spontaneous, nonconventional gestures that seem to be created on the spot to convey meaning. Specifically, when they were confronted with someone who needed help regarding how to operate an apparatus, they spontaneously produced iconic gestures that showed the other what action she needed to perform. Children's initial tendency may have been to help instrumentally by operating the apparatus directly, but as this was not physically possible, the majority of children resorted to the use of iconic gestures.

Comparing children's responses in the communicative condition and the control condition indicates that children did not simply produce a corresponding gesture whenever their attention was

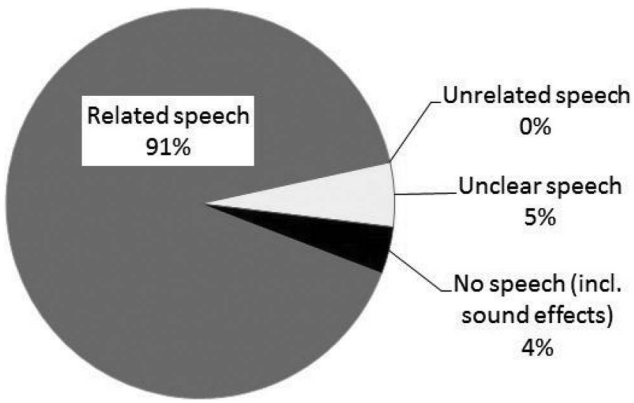


Figure 2. The type of speech accompanying 27-month-olds' iconic gestures. incl. = including.

drawn to a particular apparatus, as one might expect if children's gestures simply reflected their recognition of how an object is used (see Shore et al., 1990). Instead, the 2-year-olds produced iconic gestures when engaged in a communicative exchange with someone who was struggling to operate that apparatus. Their accompanying speech (e.g., "Like this!") made the communicative intent underlying their iconic gestures quite explicit—highlighting that these gestures were meant to inform. Thus, soon after their second birthday, young children are able to produce iconic gestures that are constructed spontaneously and intended to communicate.

Study 2

To explore the developmental trajectory of this ability, in Study 2 we tested children who were 6 months younger. Given that infants' use of baby signs is said to decline toward their second birthday (Acredolo & Goodwyn, 1988), one might expect the younger age group to produce more iconic gestures. However, since our aim was to explore whether 1½-year-olds are able to create iconic gestures on the spot (rather than to re-enact previously acquired gestures), if anything, we expected less rather than more iconic gesturing (see Özçalişkan & Goldin-Meadow, 2011).

Method

Participants. Thirty children (17 boys) between the ages of 20 and 21 months participated (mean age = 21 months, 5 days; range: from 20 months, 2 days, to 21 months, 31 days). They were recruited from the same database as the children in Study 1. Two additional children were tested but were not included in the final sample because they were not interested in the games.

Design. The design was generally the same as in Study 1. However, based on pilot findings, a few changes were made to adjust the procedure for the younger age group. The younger children all participated in the communicative condition (i.e., there was no control condition). (As piloting suggested that the younger children responded and gestured less when asked to help the puppet, our main focus was on whether they would produce appropriate gestures at all). To shorten the procedure, we had each child participate in three iconic-gesture tasks (not four) and in one pointing task. The three iconic-gesture tasks were presented as a block, with the pointing task either presented first ($n = 11$) or last ($n = 19$). Finally, each task consisted of only one trial, and the puppet's comments and questions during the response phase were more explicit. Parents were also asked to fill out a standardized language development checklist for German-speaking 1-year-olds, called ELFRA 1, which again is based on the MacArthur CDIs and assesses language production, language comprehension, gesture use, and fine motor skills (Grimm & Doil, 2000).

Materials and procedure. The set-up, the general procedure, and the first warm-up task, the marble game, were the same as in Study 1. As a second warm-up game, the 1½-year-olds played "Pound the Ball." E1 demonstrated pounding four balls with a mallet, and children either did this too or used their hands. When it was the puppet's turn, she blew heavily onto the balls instead of pounding them. The vast majority of children helped at least once during the warm-up phase, for example, by retrieving the marble for the puppet or handing her the mallet.

The procedure of the following test phase was generally the same as described above for the communicative condition. That is, each task started with E1 and the child taking turns operating the apparatus, and then the puppet woke up and had a turn. The puppet's attempts followed the same general procedure as described above for Trial 1, with a few minor changes: To give the younger children additional support in grasping what was going on and to encourage them to respond, the puppet was a little more explicit and repetitive. To start, she announced her intention to operate the apparatus, saying for example, "Now I'll roll the ball." She then performed the incorrect action twice, making sounds of effort, and turned to the child, saying something like "Huh?!" (in German, "Na sowas?!"). After that, she performed the incorrect action twice again, turned to the child, and said, "I don't know how this works." Finally, she made another two incorrect attempts and addressed the child by name, saying, "[Child's name], how does this work?" As there was no second trial, at the end, the puppet went back to sleep, and children got another chance to operate the apparatus, to ensure that they still knew how to, before the next task started. For the details of the three iconic-gesture tasks, see Table 2. The pointing task was exactly the same as in Study 1.

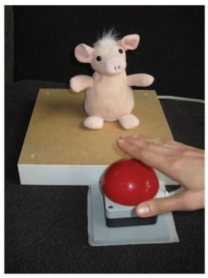
Coding and reliability. The same coding procedures and categories were used as in Study 1. The coding was again done by a research assistant who had not been present at the test sessions, was unaware of the hypotheses, and received the same instructions. To assess interrater reliability, a second person coded the responses of eight randomly chosen children (i.e., 26% of the data) independently from videotape. Interrater reliability on children's gesture scores was high ($n = 31$, Cohen's $\kappa = .87$). Two children had one missing iconic-gesture trial each, and for two further children, the camera view was obstructed during crucial phases of one of their trials. Thus, children's scores were calculated as proportions of the number of tasks that children had participated in and that could be coded from tape.

Results

Children's use of gestures. Overall, 66% of children (i.e., 20 of 30 children) used appropriate communicative gestures (iconic gestures and/or pointing) on at least one occasion when addressing the puppet. Regarding children's use of iconic gestures, on average they produced appropriate iconic gestures on 11% of their iconic-gesture tasks. There was no significant difference between girls and boys on the proportion of tasks with an appropriate iconic gesture (Mann-Whitney U test, $U = 71.5$, $n_1 = 17$, $n_2 = 13$, $p = .103$). Looking at individual performance, we found that 20% of children (i.e., six boys) produced appropriate iconic gestures on at least one iconic-gesture task. The remaining children either produced just points and other gestures ($n = 13$), or they did not produce any codable gestures at all ($n = 11$) on their iconic-gesture tasks. On the pointing task, in contrast, the majority of children ($n = 19$ or 63%) produced pointing gestures. Again there was no significant difference between girls and boys (Fisher's exact test, $n = 30$, $p = .132$).

Comparing the two types of tasks, we found that children performed better when they needed to point than when they needed to produce iconic gestures (Wilcoxon test on the proportion of tasks with an appropriate gesture: $z = 3.992$, $n = 30$, $p < .001$, $r = .63$). The order of tasks (pointing task first or last) had no effect on children's performance, either for the iconic-gesture tasks ($U = 99.0$, $n_1 = 16$, $n_2 = 14$, $p = .608$) or for the pointing task (Fisher's exact test, $n = 30$, $p = .466$).

Table 2
Description of the Correct Actions, the Puppet's Mistakes, and the Appropriate Gestures for the Iconic-Gesture Tasks in Study 2

Apparatus	Correct action	Attempt by puppet	Gesture
1. Sound box (same as in Study 1; see Fig. 1a)	Pressing upwards with index finger from below	Holding onto the ring at the bottom of the box and trying to twist it around	Hand with extended index finger pressing upwards
2. Ball on ramp (similar to Study 1; see Fig. 1b)	Sideways movement with a flat, sideways-facing hand (with thumb on top) to push the ball down the ramp[a]	Pressing downwards with her index finger onto the top of the arch above the ball	Sideways hitting movement with a flat, sideways-facing hand
3. Dancing pig (new task, see photo) 	Pushing down on the big red button with a flat hand, palm facing downwards	Trying to twist the red button	Downward hand movement with a flat hand, palm facing downwards

Note. The pointing task was the same as in Study 1. See the online article for the color version of this table.
[a] As piloting showed that the younger age group had difficulty imitating punching the ball with the fist, Experimenter 1 demonstrated the action using a flat hand position herself.

Iconic gesturing. Regarding the specificity of children's iconic gestures, the 1½-year-olds produced appropriate iconic gestures (i.e., gestures that resembled the action the puppet needed to perform on that specific apparatus) on nine trials in total. This compares to two trials in which children performed a gesture that resembled an action that would be appropriate for another iconic-gesture task (i.e., there were 82% task-specific gestures vs. 18% other-task gestures). (Note that in one of these two cases the child corrected himself and produced the appropriate iconic gesture immediately afterward.) Thus, despite the fact that the baseline probability for other-task gestures was twice as high as for task-specific gestures, children tended to produce more task-specific gestures (Wilcoxon test, $z = 1.93$, $n = 30$, $p = .094$).

Gesture use and accompanying speech. The 1½-year-olds also produced accompanying speech when gesturing (with eight of their nine iconic gestures), but there was a qualitative difference compared with the older children such that the younger children never used the term *so* (in English, *like this*). Of the six children who produced iconic gestures on at least one task, four produced these gestures ($n = 6$) accompanied by related speech (e.g., using local deictic terms such as "There!" and "Down there!" or adverbs of manner, i.e., "Hard[er]"), while the other two used no speech or unclear speech when gesturing. In the pointing task, for about a third of the children who pointed (seven of 19 children), the gesture was accompanied by related speech (i.e., "There!").

Relation between gesture use and language development. There was no relation between children's use of iconic gestures and any of the four language scores (Spearman's correlations between the proportion of tasks with iconic gestures and the respective questionnaire scores; $n = 24$ for each, as no questionnaire data were available for six children: language production, $r_s = .32$, $p = .126$; language comprehension, $r_s = .27$, $p = .206$; gesture use $r_s = -.050$, $p = .815$; and fine motor skills $r_s = .068$, $p = .752$).

Age comparison. A significant age difference was found when looking at the number of children who created an appropriate iconic gesture on at least one occasion: Significantly more 27-month-olds than 21-month-olds did so (Fisher's exact test, $n = 54$, $p = .005$). (The same age difference was observed when looking at the proportion of iconic-gesture tasks with an appropriate gesture, Mann-Whitney U test, $U = 223.0$, $n_1 = 30$, $n_2 = 24$, $p = .005$.) In contrast, no such age difference was observed on the pointing task (Fisher's exact test, $n = 54$, $p = .722$; see also Table 3 for a comparison of children's performance across each of the tasks).

Regarding the specificity of children's iconic gestures, there was no significant difference between the two age groups when looking

Table 3
Children's Use of Appropriate Gestures Across Age Groups and Tasks

Task	27-month-olds	21-month-olds
Iconic gesture tasks		
Sound box	42%	7%
Ball on ramp	29%	13%
Drawer box	29%	—
Lever box	35%	—
Dancing pig	—	10%
Pointing task		
Drawstring box	71%	63%

Note. The percentage of children who used an appropriate gesture is shown. Only the first-trial data for the 27-month-olds from the communicative condition was used, so that the two age groups are directly comparable.

at the number of children who produced only task-specific gestures (vs. those whose gesture use included other-task gestures; Fisher's exact test including all children who produced any iconic gestures, $n = 21$, $p = .247$). In other words, carry-over effects from previous tasks were rare but occurred in both age groups.

Discussion

These findings suggest that some 1½-year-old children (age 20–21 months) are able to create iconic gestures on the spot. However, when comparing their responses to those of the 2-year-olds, limitations in their gesture use become apparent. For the 1½-year-olds, the number of children who produced iconic gestures was significantly lower than for the 2-year-olds. In addition, we observed a qualitative age difference regarding children's gesture–speech integration: The 1½-year-olds did not use verbal markers in the same way as the older children (i.e., they did not use the German term *so* [English, *like this*] with their iconic gestures). Thus, while a few of the 1½-year-olds produced appropriate iconic gestures, this phenomenon was much less frequent and robust than for the 2-year-olds. The developmental pattern found here contrasts with the one reported for infants' use of baby signs, which declines over the second year (Acredolo & Goodwyn, 1988). This contrast is in line with the idea that infants acquire iconic baby signs in interaction with their caregivers (just as they acquire arbitrary conventional gestures), without necessarily noticing the iconic resemblance between gesture and referent (see Namy, 2008).

General Discussion

These findings show that young 2-year-olds (and perhaps some 1½-year-olds) are able to create iconic gestures spontaneously. The novelty of the situation—and the gestures it required—meant that children could not simply re-enact highly routinized gestures but instead they had to create iconic gestures on the spot. At both ages, children were more successful when pointing gestures were sufficient to guide the recipient's actions. However, by 2 years of age, the majority of children also produced appropriate iconic gestures to instruct their interlocutor on how to perform the action in question.

There are two reasons to conclude that children's iconic gestures were intended to communicate. The first is the timing and context of their gestures: the 2-year-olds produced iconic gestures indicating how to perform an action when someone needed help to execute this action (and not when their own attention was drawn to the apparatus on other occasions). The second is the way their gestures were integrated with their speech: Children's iconic gestures were nearly always framed by speech, and this speech generally included verbal deictic markers. The most common thing children said as they were producing the iconic gestures was the German *so* (in English: *like this*). This is exactly what adults do when they want to highlight the communicative importance of their gestures (e.g., Holler & Wilkin, 2011; Streeck, 1993). In fact, Streeck (2002) observed that when German-speaking adults use descriptive iconic gestures, they nearly always say "so." Thus, the communicative intent behind children's gestures becomes quite explicit when looking at their speech–gesture integration.

In the adult gesture literature, the relation between gesture and speech has been described as a continuum (called *Kendon's continuum*, see McNeill, 2006), comprising gestures that accompany speech (gesticulation), gestures framed by speech, and gestures replacing speech (e.g., pantomime). In case of the speech-framed gestures, the speaker's utterance marks a slot needing to be filled by a gesture, with the obligatory gesture contributing to the speaker's intended meaning. The way children in the present study integrated their speech and gesture fits this description precisely. Thus, regarding young children's use of iconic gestures, they already show signs of the adult speech–gesture system by 2 years of age.

This finding raises two interesting questions. The first concerns the relation between young children's comprehension and production of iconic gestures. At first glance, comparing our findings to those of comprehension studies seems to suggest that comprehension lags behind production. However, a careful look at studies on early comprehension of iconic gestures reveals mixed findings. So, instead of suggesting a décalage between production and comprehension, we propose that the discrepancy can be explained by looking at the mode of representations employed. For adults' iconic gestures, a general distinction has been made between action-based iconic gestures (also called *enactments*; e.g., moving one's arms up and down like a flying bird) and size/shape-based iconic gestures (also called *modeling* or *depiction*; e.g., tracing the outline of a triangle) (e.g., Kendon, 2004; McNeill, 1992; Streeck, 2008). Children in the present study created action-based gestures, and these are also the most frequent type of iconic gestures that have been documented in natural observations (Özçalişkan & Goldin-Meadow, 2011) and picture-naming tasks (Stefanini et al., 2009). Similarly, regarding comprehension, studies that have demonstrated an early comprehension of iconic gestures generally used action-based gestures (e.g., Namy, 2008). In fact, children have been shown to comprehend action-based signs at an earlier age than size/shape-based ones (Tolar et al., 2008).

The second question concerns how children's gesture use interacts with their language development. Looking at the literature, the relation between gesture use and language development seems to be a complex one. On the one hand, gestures may be used to compensate for delays in language development. For example, in the context of a picture-naming task, children with Down syndrome used more iconic gestures than their typically developing peers (Stefanini, Caselli, & Volterra, 2007; see also Thal & Tobias, 1992). On the other hand, findings with bilingual children suggest that some types of gesture use presuppose certain linguistic competence. That is, young bilinguals initially only produced speech-accompanying iconic gestures in their more proficient language (Mayberry & Nicoladis, 2000). In the present study, no relation was found between children's use of iconic gestures and their individual language development within each age group. In general, though, our tasks were specifically set up so that their linguistic requirements would be high for all children this age (in order to elicit iconic gestures in the first place). So, in that sense, children were generally using iconic gestures to bridge gaps in their linguistic repertoire.

The development with age that we found matches the observation that children's use of iconic gesture actually increases after their second birthday (Özçalişkan & Goldin-Meadow, 2011), and it supports the idea that young children's understanding of iconicity develops throughout early childhood (Namy, 2008; Tolar et al., 2008). An interesting question for future research is how children's recognition and use of iconic resemblance in their gestural communication relates to their symbolic development more generally—including their understanding of pretense (see Tomasello, 2008). For example, the

developmental trajectory we observed in the current studies closely mirrors the age pattern that is found when looking at children's first grasp of the intentional structure of pretense acts (Rakoczy & Tomasello, 2006). (Specifically, children this age recognize pretense acts as intentionally acting "as if" and distinguish them from superficially similar forms of unintentional "as-if" behaviors, such as trying to perform an action.) This fits nicely, given that children's grasp of pretense acts and their creative use of iconic gestures both require some understanding of what it means to intentionally act "as if."[1] Thus, while iconic gesturing and pretense acts may take place in different contexts and have different aims, they both share the same underlying action structure. Further research is needed to explore whether it is children's developing understanding of such action structures that drives these developmental trajectories.

To conclude, the findings of the present study show that, at least by 2 years of age, young children are able to create communicative iconic gestures on the spot. The way children used these gestures—in combination with speech—marks their transition to an adult gesture–speech system, in which iconic gestures and speech are closely integrated and jointly contribute to the expression of the intended communicative meaning.

[1] In both cases—be it pretending to perform an action or using iconic gestures to indicate how to perform an action—the original instrumental action (e.g., twisting the lid of a jar) is removed from its instrumental context (opening the jar) and is intentionally performed in a noninstrumental "as-if" fashion (e.g., performing an empty-handed twisting movement above the jar). In pretense, children first show such understanding in their re-enactments and creative extensions of pretend acts (Rakoczy & Tomasello, 2006), and by 3 years of age, they start to reason about this in more verbal scenarios (e.g., Sobel, 2007).

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(*Appendix follows*)

Appendix

Description of the Correct Actions, the Puppet's Mistakes, and the Appropriate Gestures for Each of the Five Tasks in Study 1

Apparatus	Correct action	Attempt by puppet	Gesture
Iconic gesture tasks			
1. Sound box	Pressing upwards with index finger from below	Holding onto the ring at the bottom of the box and trying to twist it around	Hand with extended index finger pressing upwards (into the air or against a substrate, e.g., the child's other hand)
2. Ball on ramp	Sideways movement of fist through arch to push ball down ramp	Pressing downwards with her index finger onto the top of the arch above the ball	Sideways hitting movement, ideally with hand in fist[a]
3. Drawer box	Pushing inwards with flat hand	Pulling on knob of drawer	Sideways or forward pushing movement with flat hand, open palm
4. Lever box	Pushing pipe upwards with flat hand placed underneath the end of the pipe	Trying to twist the end of the pipe	Upward movement of the hand with palm facing upwards
Pointing task			
5. Drawstring box	Pulling on the correct string	Pulling on the wrong string	Pointing to the correct string

[a] As children often did not form a fist when punching the ball themselves, we also considered this hand movement as an appropriate gesture if children's hand was not in a fist.

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