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## Multimodal representational gestures in the transition to multi-word productions

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### **Abstract**

The aim of this study is to analyze the use of representational gestures from a multimodal point of view in the transition from one-word to multi-word constructions.

Twenty-one Spanish-speaking children were observed longitudinally from 18 to 30 months of age. We analyzed the production of deictic and representational gestures and its coordination with different verbal elements. We also compared how different types of representational gestures (conventional and symbolic) evolve. Moreover we explored the relationship between gestural multimodal and unimodal productions and independent measures of language development. Results showed that gesture production remains stable in the period studied. Whereas deictic gestures are frequent and mostly multimodal from the beginning, representational gestures are rare and mainly unimodal. However, between 24 and 30 months of age this pattern reverse, with more representational gestures than deictics, and more multimodal representational gestures than unimodal. In addition, the frequency of multimodal representational gestures at specific ages seems to be positively related to independent measures of vocabulary and morphosyntax development. By contrast, the production of unimodal representational gestures appears negatively related to these measures. Our results suggest that multimodal representational gestures could have a facilitating role in the process of learning to combine meanings for communicative goals.

*Key words:* multimodal communication, representational gestures, conventional gestures, symbolic gestures, iconicity, language development, gestures

**Multimodal representational gestures in the transition to multi-word productions**

Language is a multimodal process that develops in a multimodal context (Perniss, 2018). The coordination of different sensorial resources is present from the very early stages of language development, as a key characteristic of human interaction. The coordination of motor and vocal elements develops from the very early social interactions (Iverson, 2010) until the gesture-speech synchrony seen in adult speakers (Kendon, 1980; 2004; McNeill, 1992; 2005).

Since the pioneering works on early infant communication (e.g. Bates et al., 1979), there has been a considerable amount of research focused on the role of gesture and vocal coordination during language development. Deictic gestures, and specifically pointing gestures, have been widely studied as precursors of early lexical development, and its role on language acquisition appears to be out of question (see for example, the metaanalysis conducted by Colonna, et al., 2010). However, the evidence about the role of representational gestures on language development and its coordination with verbal elements in this process is much scarcer. The aim of this study is to analyze the role of representational gestures during the transition from one-word to multi-word productions from a multimodal point of view, compared to deictic gestures in this period.

There is a fairly broad consensus in the definition of deictic gestures. Deictics are gestures aimed at directing other's person attention towards an object or event. This type of gestures isolate a referent from its general context. The exact meaning of the gesture depends on the context, i.e., deictics have no meaning by themselves, and have to be interpreted in relation to the speech they are produced with, or in relation to the context in which they are produced. Pointing, reaching, giving or showing are examples of deictic gestures (Bates et al., 1975; Capirci et al., 1996; Iverson et al., 1994).

By contrast, in the case of representational gestures, we can find several different denominations and classifications. As Iverson et al. (1994) defined them, representational gestures denote a precise referent and their semantic content remains stable across contexts. The meaning of the representational gestures is not context-dependent as in the case of deictic gestures, but it results from an agreement between communicative partners (Pizzuto et al., 2005). Goodwyn and Acredolo (1998) refer to this type of gestures as “symbolic gestures” to emphasize the comparison to “symbolic words”. This type of gestures are characterized by its relationship with their referent: they carry their meaning in their form. We can find two broad categories of gestures that have a stable form and a relatively context-independent meaning. On the one side, there are gestures that follow standards of form and that are established in the context of specific cultures or communities. The thumb-up gesture to express “ok”, hand waving to say “goodbye” or shrug to express uncertainty, are examples of this type of gestures. These gestures have been called “emblems” by Ekman and Friesen (1969), “symbolic gestures” by Efron (1941) or “quotable gestures” by Kendon (1992). To emphasize the idea that the form and meaning of these gestures are established by conventions in the different communities, Mc Neill (1998) chose to call them “conventional gestures”, and several authors have adopted this denomination (e.g. Iverson et al., 1999; or Rowe et al., 2008).

On the other side, we find iconically motivated gestures. The form of the gesture depicts some characteristic or attribute of the referent. Gestures such as flapping the hands to refer to a bird, or pretending to drink without a real cup, are examples of this type of gestures, that have been called: “enactive gestures” (Zinober & Martlew, 1985), “characterizing gestures” (Goldin-Meadow & Morford, 1990), “symbolic gestures” (Bates et al., 1979, 1980; Fasolo & D’Odorico, 2012), “representational gestures”

(Rowe et al., 2008; Batista et al., 2019) or “iconic gestures” (Özçalışkan & Goldin-Meadow, 2001; Wermelinger et al., 2020).

In this study, we use the "representational" label for the gestures that have a stable form and reference. Within the representational category, we use the original denomination of Bates et al. (1979) for symbolic gestures (gestures that depict some characteristic or attribute of the referent), and the denomination of Mc Neill (1998) for conventional ones (gestures with a standard of form established in a cultural context). Children start to produce deictic gestures by the end of the first year of life. Initially, they are produced without vocal accompaniment, but promptly they begin to be coordinated with vocalizations (Cochet & Vauclair, 2010; Iverson & Goldin-Meadow, 2005; Leung & Rheingold, 1981; Murillo & Belinchon, 2012; 2013; Rowe et al., 2008). In fact, deictic gestures are not only coordinated but also synchronized with the vocalizations before the vocal elements constitute a word yet. Esteve-Gibert and Prieto (2014) found that Catalan-speaking children temporally coordinated gestures with vocalizations already in the period of transition to first words. Similar results were found by Romero, Etxebarria, de Pablo and Romero (2017) studying Basque-speaking children and by Murillo et al. (2018) for Spanish-speaking children. More importantly, the coordination of gestures and vocalizations at the early stages of language development has a predictive value on subsequent linguistic achievements. The frequency of pointing production with vocalizations at 12 months of age can strongly predict lexical development three months later (Murillo & Belinchón, 2012; Wu & Gros-Louis, 2014). Infants who integrate pointing and speech by 12 months, have better vocabulary abilities at 18 months of age (Igualada, Bosch & Prieto, 2015). Moreover, the synchrony between gestural and vocal elements is related to subsequent language development (Murillo et al., 2018).

The influence of gesture-speech combination is not restricted to lexical development but it is also present in the early stages of grammar development. The age at which children produce their first pointing+word combinations, allows predicting the onset age for determiner + noun constructions (Cartmill et al., 2014). The coordination of deictic gestures with the first words has a predictive value on the production of two-word utterances. The onset age of deictic gestures and word combinations in which each element conveys a different meaning (complementary combinations), predicts the onset age of the first two-word combinations (Butcher & Goldin-Meadow, 2000; Capirci et al. 1996; Capobianco et al., 2017; Goldin-Meadow & Butcher, 2003; Goldin-Meadow & Morford, 1985; Iverson & Goldin-Meadow, 2005; Morford & Goldin-Meadow, 1992; Özçaliskan & Goldin-Meadow, 2005, 2009; Volterra et al. 2005). The relationship between verbal and gestural components in language acquisition process do not seem to finish here. Capobianco et al., (2017) found that the frequency of complementary gesture-speech combinations at 12 months predicts verbal complexity around 2 years of age. Children begin to produce two-word utterances only after the emergence of “supplementary” crossmodal combinations (combinations in which gesture and speech convey redundant information).

In sum, evidence suggest that children begin to coordinate deictic gestures with vocal elements from the earliest stages of language development. This coordination seems to facilitate lexical and early grammar development. Deictic gestures are, therefore, mainly multimodal, at least during the first stages of language development.

Considering that representational gestures appear in the children's repertoire slightly after the deictic ones, it is worth asking whether their evolution regarding the coordination with verbal elements follows a similar pattern.

Fist words are usually coordinated with deictic gestures, whereas representational gestures are less frequent in children's first vocabularies. Around the first year, representational gestures occur mostly without vocal accompaniment (Murillo & Belinchón, 2012; 2013; Murillo et al., 2018). Although children between 12 and 24 months often combine deictic gestures with words, combinations of representational gestures with verbal elements remain low in this period (Pizzuto & Cappobianco, 2005). Pizzuto et al. (2005) report a clear prevalence of deictics over representational elements in children from 10 to 25 months. Many other studies also report a low incidence of representational gestures in children early repertoires (Iverson et al., 1994; Nicoladis et al., 1999), and some even found a decrease of representational gestures after 20 months, once the children have the verbal labels for the referents (Iverson et al., 1994). This low frequency of representational gestures may be related to the fact that in the early stages of development children do not seem to take advantage of iconicity when they have to map gestures with their referent. Some studies have suggested that it is not until 26 months of age that iconicity is an advantage when matching a gesture with its referent (Namy et al., 2004).

Despite the apparent lower frequency of representational gestures compared to deictics, they seem to be related to language development. There is a positive correlation between representational gesturing and verbal development (Acredolo & Goodwyn, 1988; Goodwyn & Acredolo, 1998).

In spite of these findings, the evidence of how representational gestures evolve after the second birthday is surprisingly scarce. Some studies have found a significant increase of symbolic gestures from 22 to 26 months of age (Özçaliskan & Goldin-Meadow, 2011), but little is known about how they coordinate with verbal elements and its role on language development. It seems that the strong link between verbal elements and deictic



gestures is not found for representational gestures at the early stages of language development (Pizzuto et al., 2005). However, the evidence about how representational gestures evolve from a multimodal point of view is still scarce. In order to explore this issue, we analyzed the gestural and verbal productions of children from 18 to 30 months of age. Although symbolic gestures seem to be less multimodal than deictics, they may follow a similar pattern to that of deictic gestures, with an initial period of mainly unimodal production and a general tendency to progressively coordinate more and more with verbal elements. If this were the case, we would expect to find an increase in the frequency of representation gestures and specifically multimodal productions throughout the period studied.

The combination of a representational gesture and a verbal element involves the coordination of two components that have their own meaning, what is semiotically more complex than combining a deictic gesture with a word. Considering this, we will expect to find a bidirectional relationship between language development and representational multimodal gestures. Children with larger vocabularies at an early age will produce more multimodal representational gestures in subsequent observations. On the other hand, the production of multimodal representational gestures can contribute to lexical and syntax development, facilitating the learning about how to combine elements to convey a meaning, and fostering the use of multimodal representational gestures. Although some authors emphasize the need for a distinction and a separate analysis of the different types of representational gestures (i.e. symbolic vs. conventional) (e.g. Guidetti, 2002), this comparison has not always been conducted. In our view, symbolic and conventional gestures share specific features that differentiate them from deictic gestures, but they have also particular defining characteristics that make worth to analyze them also separately.

Therefore, our specific research questions are as follows:

- a) How does representational gestures evolve in the transition period from one-word productions to word combination compared to deictic gestures?
- b) Are representational gestures combined with verbal elements in the same way as deictic gestures are? How these gestures evolve from a multimodal point of view? Which verbal elements are coordinated with representational gestures and how these combinations evolve with age?
- c) Are there differences between the types of representational gestures, i.e. symbolic and conventional gestures, regarding their frequency and their coordination with speech?
- d) Is there a relationship between multimodal representational gestures production and language development?

To address these questions, we observed longitudinally the spontaneous communicative behavior of 21 children during spontaneous interaction with their mother or father in a play situation from 18 to 30 months of age.

## **Method**

### **Participants**

We followed longitudinally twenty-one children (10 girls, 11 boys) from 18 to 30 months of age. The children were observed in a spontaneous play situation with their mother or father when they were 18, 21, 24 and 30 month-old (the mean age of the children at each session can be seen in Table 1). Two children could not complete the 30 months session, so at this age the sample was reduced to 19 children.

[INSERT TABLE 1 HERE]

All the participants came from monolingual Spanish-speaking homes, except one girl who came from a Catalan-Spanish environment. We administered the Spanish version of the Battelle Developmental Screening test (de la Cruz y González, 1996) to all the participants before every observation session. They all were typically developing and their acquisition of motor milestones was within the normal range. We asked the parents to fulfill the Spanish version of the MacArthur Communicative Development Inventory (MCDI) (López-Ornat, et al., 2005) at each observation session.

Parents agreed to participate voluntarily and provided the informed consent. The University Research Ethics Committee approved all the study procedures.

## **Materials and Procedure**

The observation sessions were scheduled within the week of infant's birthday. When it was not possible, due to illness of the child or problems of the parents to arrange the appointment, we extended the criterion by a week.

We conducted the sessions in a familiar environment for the children: their homes or an isolated room of their day care center. We asked the mother or father to play with the child as they usually do. We provided a set of toys including blocks, cars, plates, glasses and spoons, animals, picture books, and we indicated that they could also use any other toy present in the room if they wanted to. The sessions were video-recorded for further analysis. The researcher stayed next to the camera and did not participate in the situation, responding only if the child explicitly addressed her. The camera was fixed on a tripod at a distance of approximately one and a half meters from the dyad to be observed. Session estimated duration was 15 minutes, although it was adapted to children's attentional state. Mean session duration can be seen in Table 2.

[INSERT TABLE 2 HERE]

## Coding and analysis

Two independent observers coded all the communicative behaviors produced by children using ELAN Software (Lausberg & Sloetjes, 2009). We considered as communicative those children's behaviors referring to an external entity (e.g. triadic) and that included a gesture or a vocalization directed at the adult (with orientation towards the adult or gaze use). For gesture analysis we used a coding system employed in previous works (*Blinded for review*, 2012; 2013;2018). The gestures produced, i.e. any motor action addressed to convey a meaning to other, were coded as follows:

- *Point*: index finger visible extended with some extension of the arm.
- *Reach*: the arm is extended with hand open and finger straight.
- *Show*: the child holds up the object, but it remains in child's possession.
- *Give*: infant hands object to adult and object change hands.
- *Symbolic*: gestures that represent objects, actions or events.
- *Conventional*: gestures produced as social routines such as say hello or bye, clapping hands, etc.
- *Other*: any gesture observed not included in the previous categories or not clearly observable.

More details about gestures classification and pictures with examples can be found in (*blinded for review*, 2018).

Gestures aimed to direct other's attention towards some entity or relevant event in the environment were considered deictic gestures: pointing, reaching, showing and giving gestures were included in this category.

Gestures representing an object or action or reflecting a social convention were considered representational gestures: symbolic and conventional gestures were included in this category.

Regarding the analysis of the vocal productions, we coded all the vocal sounds produced by children except vegetative sounds, cries and laughs. We considered as two different vocalizations when there was at least a second of silence or a conversational turn between them. We classified children vocalizations as follows:

- *Babbling*: the utterance is not similar to any word of the language. It has no sound-meaning regularity and no formal relationship with the referent alluded.
- *Word*: the utterance is clearly identifiable as a word and has a referential sense. We included in this category the onomatopoeic sounds, because they have a stable phonetic structure and a clear relationship with the referent.
- *Combination*: the utterance includes at least two different words. The inclusion in this category requires at least two-word combination. Utterances containing the same word produced twice, were not included in this category, but in the category “word”.
- *Other*: any vocal sound that results unclear or that cannot be included in the previous categories.

We calculated the temporal overlap between gestures and vocalizations by means of ELAN 5.7 software (Lausberg & Sloetjes, 2009), and considered a communicative behavior as multimodal when there was temporal overlap between a gesture and a vocal element. When there was no temporal coincidence between them, the gesture or the vocalizations were considered as unimodal communicative behaviors.

### **Reliability**

A third independent observer coded 5% of the observations sessions including different children at different ages. Agreement for gesture categories was 91% ( $k=.88$ ) and for vocalizations was 86% ( $k=.76$ ).

## Results

In order to analyze the evolution of representational gestures compared to deictic gestures in the transition period from one-word productions to word combination, we conducted a repeated measures ANOVA. The dependent variable was the rate per minute of gestures production, and the type of gesture (deictic vs. representational) and the age (18, 21, 24 and 30 months) were the factors. Figure 1 shows the production of representational and deictic gestures from 18 to 30 months of age.

[INSERT FIGURE 1 HERE]

We did not find a main effect of age in gesture production ( $F(3,54) = .76; p=.52$ ), the rate of gesture production remains stable during the period studied. By contrast, we found an interaction effect between age and type of gesture ( $F(3,54) = 6.70; p=.001; \eta^2=.27; 1-\beta=.96$ ). When children were 18 months-old, they produced more frequently deictic gestures than representational ones (1.48 vs. 0.72;  $p=.005$ ). We found the same pattern at 21 months, with more deictic than representational gestures (1.36 vs. 0.99;  $p=.043$ ). However, these differences disappeared when children were 24 months-old (1.17 vs. 0.94:  $p=.50$ ), and by 30 months of age, the pattern was reversed: we found significantly more representational gestures than deictics (1.59 vs. 1.06;  $p=.036$ ).

To explore how deictic and representational gestures evolve in this period from a multimodal point of view, we conducted two repeated measures analyses, comparing the rate of production of each type of gesture (deictic or representational) depending on whether they were produced in coordination with vocal elements (multimodal) or in isolation (unimodal) at each age (see Figure 2).

In the case of deictic gestures, we found a main effect of multimodality, ( $F(1,18)=34.07; p<.001; \eta^2=.65; 1-\beta = 1$ ) showing a higher rate of multimodal than unimodal

gestures (.90 vs .35). There was no main effect of age nor the interaction between age and multimodality.

[INSERT FIGURE 2 HERE]

When regarding representational gestures, we found an interaction effect between age and multimodality ( $F(3,54) = 4.11$ ;  $p = .011$ ;  $\eta^2 = .18$ ;  $1-\beta = .82$ ). There were no differences in the rate of representational gestures when they were produced in isolation, i.e. when they were unimodal. By contrast, when the representational gestures are multimodal, the rate of production is higher at 30 months of age than at 18 months (1.07 vs. .30;  $p = .010$ ), at 21 months (1.07 vs. .38  $p = .022$ ) and at 24 months of age (1.07 vs. .40;  $p = .017$ ). At 30 months of age children produced more multimodal representational gestures than unimodal (1.07 vs. .51;  $p = .023$ ). These results suggest that the increase in the rate per minute of representational gestures is due to a higher production of multimodal gestures.

Considering the different patterns of development of deictic and representational gestures from a multimodal point of view, we explored which verbal elements were combined with every type of gesture and how this coordination evolved with age.

We conducted a repeated measures ANOVA taking the rate per minute of deictic gesture production as the dependent variable and the age (18, 21, 24 and 30 months) and the type of vocal element (babbling, word, combination) as factors (see Figure 3). There was no main effect of age ( $F(3,54) = .070$ ;  $p = .97$ ). We found a main effect of vocalization type ( $F(2,36) = 9.29$ ;  $p = .001$ ;  $\eta^2 = .34$ ;  $1-\beta = .96$ ) and an interaction effect of age and type of vocal element ( $F(6,108) = 9.50$ ;  $p < .001$ ;  $\eta^2 = .34$ ;  $1-\beta = 1$ ). Results show that at 18 months of age there is more babbling than word combination (.41 vs. 0.89;  $p = .026$ ). At 21 months there are more words than babbling (.49 vs. .25;  $p = .022$ ) and than word combinations (.49 vs. .13;  $p < .001$ ). By 24 months of age, the difference between babbling

and words remains (.51 vs. .31;  $p=.002$ ), but there are no differences in the rate of production of words and word combinations (.51 vs. .31;  $p=.74$ ). When children are 30 month-old, isolated words are more frequent than babbling (.26 vs. .011;  $p<.001$ ), but in turn, word combinations are more frequent than single-word utterances (.59 vs. .26;  $p=.008$ ) and babbling (.59 vs. .011;  $p<.001$ ).

In sum, these results show that, when children use deictics, the vocalizations that are not yet a word tend to decrease with age. By 21 months, the gesture-speech combinations are produced mostly with isolated words and from 24 months on the use of multi-word constructions begins to generalize.

[INSERT FIGURE 3 HERE]

We conducted the same analysis for representational gestures. We found an interaction effect between age and type of vocal element<sup>1</sup> ( $F(2.51, 45.23) = 4.50$ ;  $p=.011$ ,  $\eta^2=.20$ ;  $1-\beta=.80$ ). When children were 18 month-old there were no differences in the rate of representational gestures production depending on the type of vocal element involved in the communicative behavior. Three months later, we found a higher rate of words than of babbling (.24 vs .059;  $p=.029$ ). When children were 24 months-old they produced more representational gestures with words than with babbling (.24 vs. .026;  $p=.001$ ) and than with word combinations (.24 vs. .11;  $p=.026$ ). At 30 months, we found more gesture production coordinated with words than with babbling (.59 vs. 0;  $p=.001$ ) and more coordination with multi-word utterances than with babbling (.38 vs. .0;  $p=.002$ ).

It seems, therefore, that the initial rate of multimodal combinations involving representational gestures is quite low. Around 21 months, this type of gesture is mostly combined with isolated words, and progressively multi-words utterances begin to be incorporated to representational gestural production. However, the multi-word



utterances are never the most frequent verbal element as it was the case when regarding deictic gestures.

Considering the differences between deictic and representational gestures from a multimodal point of view, we explored the differences between the two specific types of representational gestures: symbolic and conventional.

Although both types of gestures tend to increase with age in the period studied, the pattern followed by both gestures is clearly different. As for the symbolic gestures, we found an age effect ( $F(3,54) = 3.29$ ;  $p = .027$ ;  $\eta^2 = .15$ ;  $1-\beta = .72$ ). Children produced more symbolic gestures when they were 30 month-old than when they were 18 month-old (.56 vs. .22;  $p = .028$ ). There was no multimodality effect ( $F(1, 18) = .001$ ;  $p = .97$ ).

However, we did find an interaction effect between age and multimodality<sup>1</sup> ( $F(3, 54) = 6.65$ ;  $p = .005$ ;  $\eta^2 = .27$ ;  $1-\beta = .85$ ). There were no differences in the rate of symbolic gestures production when the gestures were unimodal. By contrast, when the gestures were multimodal, the rate per minute of symbolic gestures was higher at 30 months than at 18 (.86 vs. .17;  $p = .004$ ), than at 21 (.86 vs. .18;  $p = .001$ ) and that at 24 months of age (.86 vs. .23;  $p = .011$ ). These results mean that symbolic gestures increase with age only when they are produced with verbal elements. As can be seen in Figure 4, the increase is especially marked at 30 months.

[INSERT FIGURE 4 HERE]

Conventional gestures behave differently. Although the general tendency is to increase with age, the differences found did not reach statistical significance  $F(3, 54) = 2.58$ ;  $p = .062$ . Nor is there a main effect of multimodality ( $F(1, 18) = .377$ ;  $p = .54$ ), nor of the interaction ( $F(3, 54) = 1.28$ ;  $p = .29$ ).

Our last research question was related to the relationship between the evolution of representational gestures and language development. To explore this issue, we

conducted several non-parametric correlations between the rate of representational gestures (global, multimodal and unimodal) and CDI vocabulary and morphosyntax raw scores. Although these results must be interpreted with caution due to the sample size, we found some interesting trends that may be relevant to understand the role of this type of gestures in language development. We were able to obtain all the CDIs at 18 and 21 months, but we lost data from 4 participants at 24 months and from 3 participants at 30 months: we obtained only 17 and 18 CDIs respectively.

We found a positive and significant correlation between the global rate of representational gestures produced at 18 months and the vocabulary ( $\rho=.49$ ;  $p=.045$ ) and morphosyntax ( $\rho=.529$ ;  $p=.029$ ) CDI raw scores at 24 months. We also found this positive relationship with vocabulary score at 30 months ( $\rho=.676$ ;  $p=.002$ ).

This relationship between gestures production and language development varies depending on whether the gestures are unimodal or multimodal. When representational gestures are multimodal, the rate of production at 18 months correlates positively with CDI vocabulary score at 24 months ( $\rho=.54$ ,  $p=.025$ ) and at 30 months of age ( $\rho=.49$ ,  $p=.03$ ). There is also a positive relationship of representational multimodal production and CDI vocabulary score both at 18 months ( $\rho=.39$ ,  $p=.078$ ), and between multimodal representational gestures production at 21 months and CDI vocabulary score at the same age ( $\rho=.37$ ,  $p=.097$ ), but in this two cases this relationship did not reach statistical significance.

We only found a positive relationship when gestures were unimodal between the rate of production at 18 months and the CDI vocabulary score at 30 months of age ( $\rho=.058$ ,  $p=.01$ ).

At 21 months of age, multimodal rate of representational gestures production is positively related with CDI vocabulary ( $\rho=.54$ ,  $p=.010$ ) and morphosyntax ( $\rho=.050$ ,

$p=.029$ ) scores at 18 months, as well as CDI vocabulary score at 21 months ( $\rho=.49$ ,  $p=.022$ ). The relationship between the production of multimodal representational gestures at 21 months and morphosyntax CDI score at the same age, although positive, was only marginally significant ( $\rho=.041$ ,  $p=.06$ ).

By contrast, the rate of unimodal representational gestures at 21 months is negatively related to CDI vocabulary ( $\rho = -.47$ ,  $p=.030$ ) and morphosyntax ( $\rho = -.60$ ,  $p=.007$ ) scores at 18 months. There is also a negative relationship between the frequency of unimodal representational gestures at 21 months and the CDI vocabulary ( $\rho = -.40$ ,  $p = .067$ ) score at 21 months, although this relationship is only marginally significant.

Summing up, our results show that representational gestures increase with age in the period studied, especially from 24 to 30 months of age. This increment is due to a higher production of multimodal representational gestures, mainly symbolic gestures. Representational gestures begin to be frequently coordinated with words from 21 months on. By 24 months, they are also combined with multi-word utterances and the frequency of these combinations raises when children are 30 months of age. The production of multimodal representational gestures seems to be positively related to lexical and morphological measures of language development at specific age moments, whereas unimodal representational gestures do not show this positive relationship.

## Discussion

Our results showed that frequency of gestures production remains stable in the transition from one word use to multi-word constructions. These results challenge the idea of the verbal replacement of gestures once children are able to combine verbal elements. However, when considering the types of gestures, we observed some

interesting changes with age. Our data reflected the prominence of deictics over representational gestures reported in previous studies (Pizzuto et al. 2005), but this pattern reversed after 24 months. By 30 months of age, we found significantly more representational gestures than deictics. Contrary to the idea of the decline in the use of representational gestures with the increase in vocabulary, i.e. once they have the verbal label for the referent (Iverson et al. 1994), the children in our sample increased their use of this type of gestures especially between 24 and 30 months of age. These findings are consistent with the “iconic spurt” reported by Özçalışkan and Goldin-Meadow (2011). The growing understanding of the relationship between a representational gesture and its referent would be related to this increase in symbolic gesture use. These results support the idea of the verbal and gestural components evolving together as parts of a single communicative system.

Regarding the coordination of gestures and verbal elements, we found markedly different patterns when comparing deictic and representational gestures. Deictics are mainly multimodal from the beginning of the period studied, and the frequency of multimodal deictic gestures remains stable at least until 30 months of age. By contrast, representational multimodal and unimodal gestures are equally frequent from 18 to 24 months. However, at 30 months of age there is a pronounced increase in multimodal representational gestures, becoming clearly more frequent than unimodal productions.

The “representational spurt” observed at 30 months is due to the increase of multimodal productions. This evolution of representational gestures in relation to multimodality parallels that of deictic gestures in previous stages of communicative development (Murillo & Belinchón, 2012). As deictics, representational gestures are initially rare and mostly unimodal. Later on, they begin to be more and more combined

with verbal elements until they become more frequent in multimodal patterns than in unimodal ones.

The evolution of the type of verbal elements combined with deictics and representational gestures show some differences in timing. Whereas deictic gestures are frequently combined with vocal elements from the beginning of the period studied, the coordination with verbal elements of representational gestures is scarce at 18 months.

By 21 months, deictics are mostly combined with single-word utterances and three months later multi-word productions are as frequent as single word utterances. By 30 months of age, multi-word productions are the most common verbal element coordinated with deictic gestures.

Representational gestures did not show the initial combination with early vocalizations seen for the deictic gestures at 18 months. As deictics, they are mostly combined with isolated words at 21 months, but representational gestures need more time than deictics to be frequently combined with multi-word utterances. Whereas in the case of deictics, multi-word productions begin to be often combined with gestures from 24 months on, and by 30 months, they are more frequent than single-word productions, representational gestures are combined more frequently with single words at 24 months.

Although the production of multi-word utterances increases considerably at 30 months, they do not become more frequent than isolated words even at this age when combined with representational gestures.

Considering the semiotic characteristics of representational gestures, the coordination with verbal constructions is much more demanding than in the case of deictic gestures. It could be that representational gestures are not combined with verbal elements until the verbal construction (single word use, two-word combination) is well established in children's communicative repertoire. Our results show how, at the same developmental

moment, children combine multi-word productions with deictics, but they scarcely use these verbal constructions with representational gestures. This idea is consistent with recent findings showing that in the case of verbs and gestures depicting actions, the former precede the latter. However, once children understand how verbs work, there is an increase in iconic gesture production (Özçalışkan et al., 2014).

Symbolic and conventional gestures evolve differently through the period studied. The frequency of conventional gestures remains low from 18 to 30 months, regardless they are produced in unimodal or in multimodal patterns. By contrast, symbolic gestures increase during the period studied specifically when they are multimodal, and especially from 24 to 30 months of age. These differences between conventional and symbolic gestures may be due to the differences in the characteristics of each type of gesture. Whereas conventional gestures have a stable form predefined by a social agreement, symbolic gestures are more flexible and allow conveying a wider range of meanings (objects, actions, qualities, etc). The relationship between the form of the gesture and the referent is quite arbitrary in the case of conventional gestures, whereas symbolic gestures keep some iconic relationship with their referent. The ability to take advantage of iconicity to understand gestures observed shortly after the second birthday (Namy et al., 2004) can also be exploited when producing gestures to convey meanings. The comprehension of the relationship between symbolic gestures and its referent allows children to create their own symbolic gestures to communicate with others. Behne et al. (2014) showed that children by 27 months of age were able to generate new symbolic gestures to cooperate with others. When children produced these gestures, they were generally accompanied by related speech. By contrast, children of 20-21 months of age were less able to employ such novel symbolic gestures. Moreover, symbolic gestures comprehension by age three seems to be predictive for later grammar skills (Lüke et al.,

2020). Considering all this, it is not surprising that children begin to use symbolic gestures as building blocks of their linguistic constructions when starting to master the early rules of grammar.

If children were able to take advantage of representational gestures for learning how to combine meaningful elements in a creative way for communicating with others, one would expect a bidirectional relationship between multimodal representations gestures and language learning.

Although our results in this regard must be interpreted with caution, they seem to point in this direction. We observed a positive relationship between early representational gestures production and subsequent lexical and morphosyntactic development six months later. Importantly, we observed critical differences between multimodal and unimodal gestures. Multimodal representational gestures are positively related to independent measures of language development, especially at 18 and 21 months of age. By contrast, unimodal representational gestures productions by 21 months seems to be negatively related to language development. It may be that when the language level is low, representational gestures are used as a compensatory element rather than a complementary one. This would partially explain why there are more representational gestures without verbal elements when children have lower CDI scores. A thorough qualitative analysis of the function of the gesture, and how children are using it, would be necessary to shed light at this respect.

Our study has some important limitations derived from the small size of the sample. We did not analyze the relationship between the information conveyed by gestural and verbal means. However, our study may contribute to trace the developmental path of gesture-speech system, from the early motor-action coordination to the synchrony between gestures and speech observed in adult language. Specifically, these

developmental patterns could be useful for early language development surveillance and atypical developing detection. All in all, our results support the idea of gesture and speech as parts of the developing linguistic system.



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**Table 1**

*Mean age (months; days) and standard deviation of the participants at each observation session.*

	Mean (SD)	Min-max	N
18 months	18;6 (0;10)	17;6- 18;14	21
21 months	21;6(0;10)	20;18-22;4	21
24 months	24;9 ( 0;16)	23;12-25;24	21
30 months	30;11 (0;14)	29;19-31;12	19

**Table 2***Duration of the observation session at each age*

	Mean (SD)	Min-max	N
18 months	14'47'' (2'23'')	7' 51''- 19'11''	21
21 months	15'38'' (3'21'')	5' 58''- 25'18''	21
24 months	14'51'' (2'50'')	6' 0''- 19' 39''	21
30 months	15'01'' (2'27'')	10'0''- 19'44''	19



**Figure 1**

*Rate per minute of representational and deictic gestures by age.*

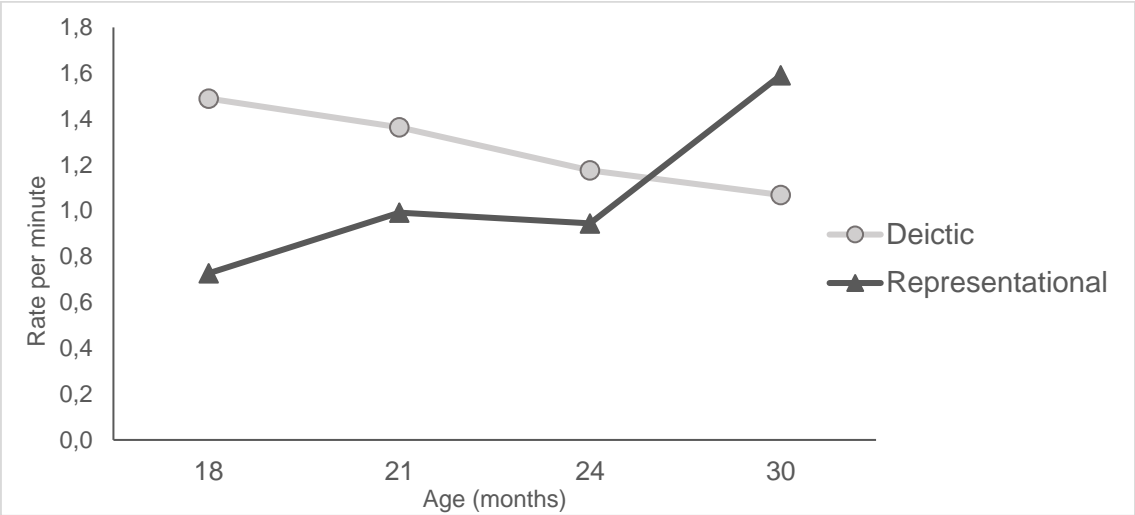


Figure 2

Multimodal and unimodal deictic and representational gestures by age. Rate per minute

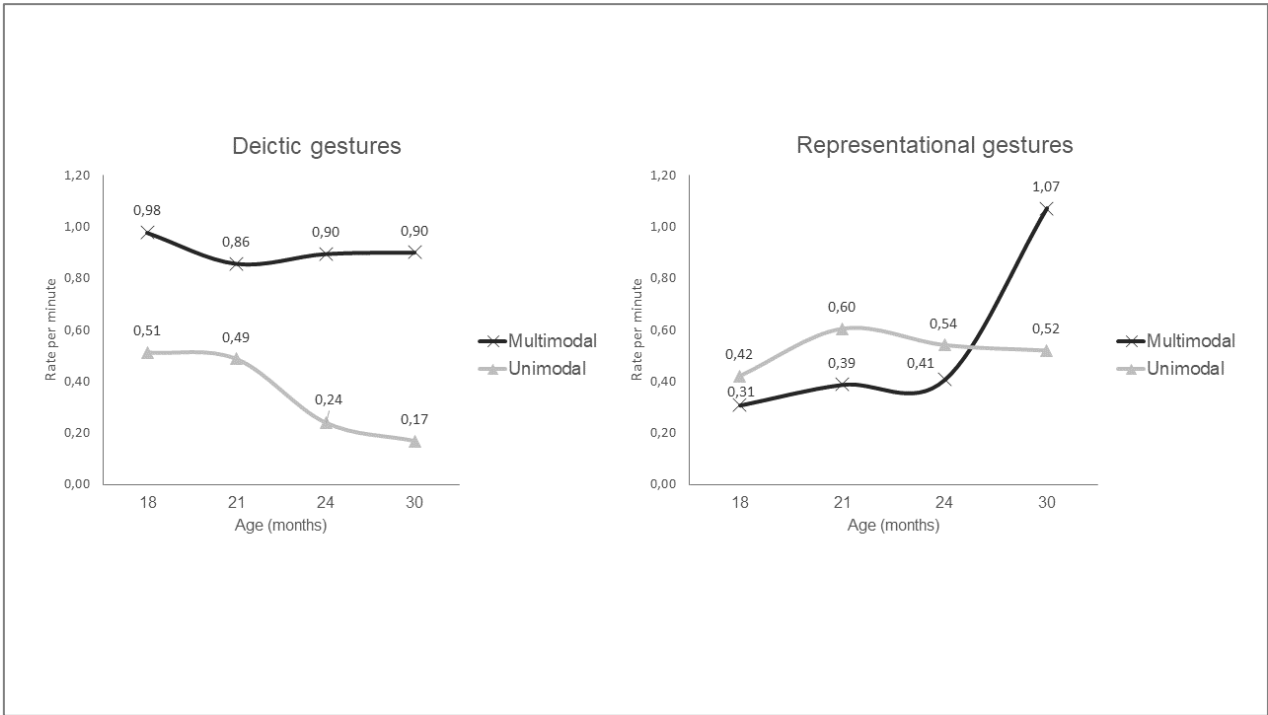
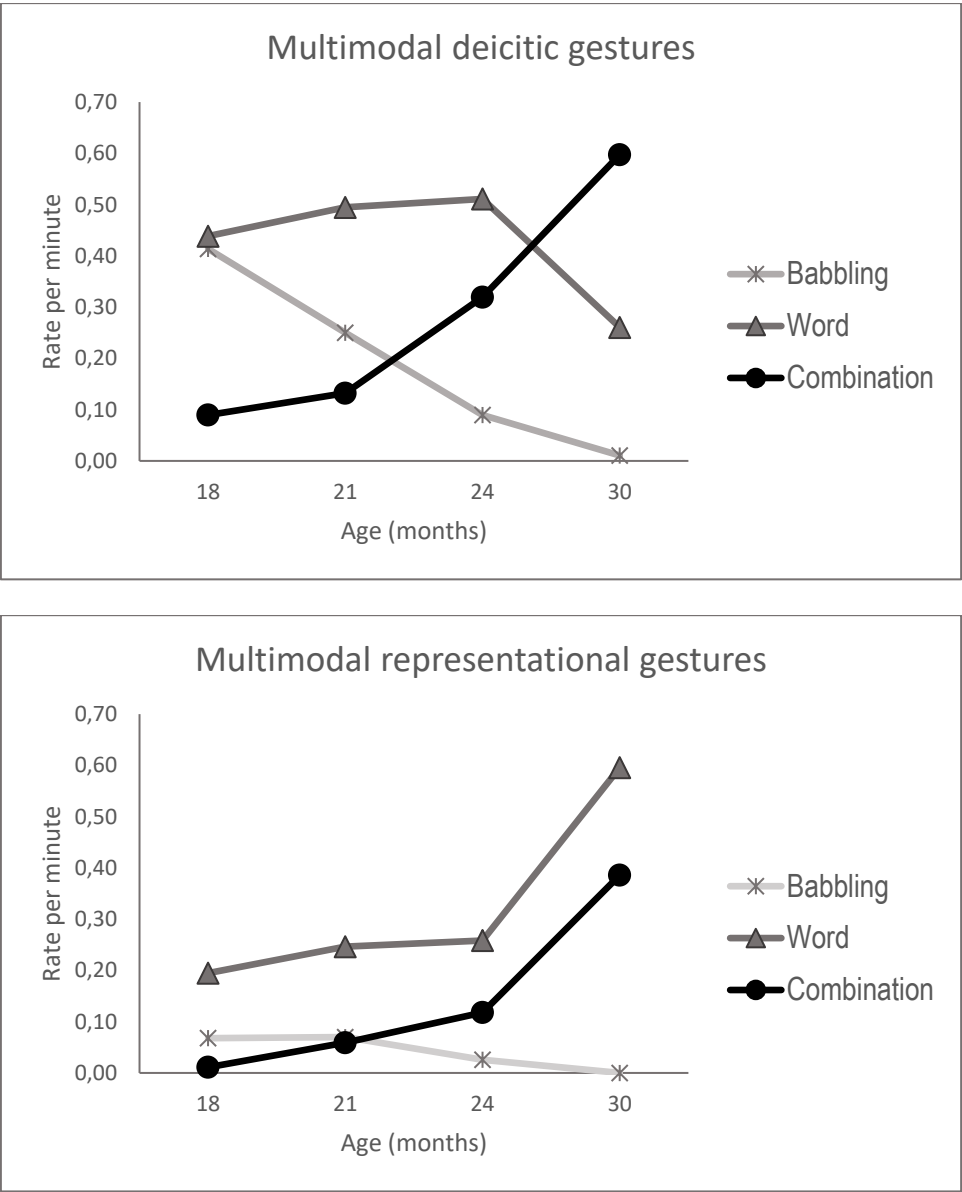


Figure 3

Type of vocalization in multimodal deictic and representational gestures by age.



**Figure 4**

*Rate per minute of multimodal and unimodal symbolic and conventional gestures by age.*

