



Repositorio Institucional de la Universidad Autónoma de Madrid

<https://repositorio.uam.es>

Esta es la **versión de autor** del artículo publicado en:
This is an **author produced version** of a paper published in:

Gesture 12.1 (2012): 16–39

DOI: <http://dx.doi.org/10.1075/gest.12.1.02mur>

Copyright: © John Benjamins Publishing Company

El acceso a la versión del editor puede requerir la suscripción del recurso
Access to the published version may require subscription

Running head: GESTURAL-VOCAL COORDINATION AND EARLY LEXICAL
DEVELOPMENT

Gestural-vocal coordination: Longitudinal changes and predictive value on early lexical
development

Eva Murillo and Mercedes Belinchón

Universidad Autónoma de Madrid

Author Note

Eva Murillo, Departamento de Psicología Evolutiva y de la Educación, Universidad
Autónoma de Madrid; Mercedes Belinchón, Departamento de Psicología Básica,
Universidad Autónoma de Madrid.

Correspondence concerning this article should be addressed to Eva Murillo,
Departamento de Psicología Evolutiva y de la Educación, Universidad Autónoma de
Madrid, Campus de Cantoblanco, 28049 Madrid.

E-mail: eva.murillo@uam.es

Abstract

The aim of this study was to examine longitudinally gestural and vocal coordination in multimodal communicative patterns during the period of transition to first words, and its role in early lexical development. Eleven monolingual Spanish children were observed from 9 to 12 and 15 months of age in a semi-structured play situation. We obtained three main findings: (1) the use of multimodal patterns of communication increases significantly with age during the period studied; (2) the rate of use of those multimodal patterns at 12 months predicts lexical development at 15 months; and (3) the use of pointing gesture at 12 months, especially when it is accompanied of vocalization and social use of gaze, is the best predictor of lexical outcome at 15 months. Our findings support the idea that gestures, gazes and vocalizations are part of an integrated and developing system that children use flexibly to communicate from early on. The coordination of these three types of elements, especially when pointing gesture is involved, has a predictive value on early lexical development and appears as a key for progress in language development.

Keywords: communicative development, gestures, vocalizations, multimodal communication, first words.

Gestural-vocal coordination and its role in early lexical development

Before saying their first words, young children develop various communication skills that can be seen in their use of both vocal sounds and gestures. Understanding how these skills change during the first year of life seems to be crucial to explain the development of human language. Nevertheless, studies addressed specifically to how they become coordinated, and how they relate to later linguistic abilities, has been scarce, especially before the onset of first words. In this work we focus on the relation between vocal and gestural modalities in this period, suggesting that the coordination of gestures and vocalizations that still don't constitute a word can facilitate the access to the first phonetically stable referential forms.

On the one hand, a clear continuity has been observed between prelinguistic vocalizations and first words in both phonological and metaphonological aspects (Hsu, Fogel & Cooper, 2000; Oller, 1980; Stoel-Gammon & Cooper, 1984; Vihman, Ferguson & Elbert, 1986), and the process by which prelinguistic vocalizations take the form of conventional words is slow and gradual (Karousou, 2003; Keren-Portnoy, Majorano & Vihman, 2009; Vihman, Macken, Miller, Simmons & Miller, 1985). Children produce different types of vocalizations as early as two weeks of life (Keller & Schölmerich, 1987), and an overall increase in the amount of vocalizations occurs during the first year (Camp, Burgess, Morgan & Zerbe, 1987). Vocalizations are used in social and interactive contexts from early on, and they vary in frequency and quality depending on social interactions (Bloom, Russell & Wasenberg, 1987; D'Odorico & Franco, 1991; Goldstein & Schwade, 2008; Masataka, 1993a). The use and variations of infant's

vocalizations have communicative effects on adults, who react differently to them since the first months of life (i.e. Keller & Schölmerich, 1987).

On the other hand, since the classic work of Bates, Benigni, Bretherton, Camaioni and Volterra (1979), several studies have shown that children soon become experts in using a wide range of gestures to communicate, and that the gestures children produce have some predictive value on later lexical and syntactic outcomes (see Table 1).

[INSERT TABLE 1 HERE]

Both components, vocal and motor, seem to be linked since the first months of life (Iverson & Thelen, 2000). Fogel and Hannan (1985) observed the co-occurrence of index finger extension and vocalizations before the first 15 weeks. Masataka (1995) found the association of index finger extension with syllabic vocalizations in three-month-old babies. In addition, other studies have shown the association of canonical babbling and rhythmic manual movements between 6 and 9 months (Ejiri, 1998; Ejiri & Masataka, 2001), or suggest a mutual facilitation effect between motor and vocal development (Iverson & Fagan 2004; Iverson, Hall, Nickel, & Wozniak, 2007). Several motor and gestural milestones coemerge with language development milestones in early development (Bates & Dick, 2002).

Many studies aimed at elucidating the role of gestures in the early stages of language development report of a high frequency of vocal accompaniment of gestures used by children in this period. Near 70% of gestures displayed around the second year of life are already produced with vocalizations (Dobrich & Scarborough, 1984; Franco & Butterworth, 1996; Leung & Rheingold, 1981; Liszkowski & Tomasello, 2011; Pine,

Lufkin, Kirk & Messer, 2007; Rodrigo, González, de Vega, Muñeton-Ayala & Rodríguez, 2004; Rowe, 2000; Zinober & Martlew, 1985). In a naturalistic setting, 85% of pointing gestures were produced with vocalizations (Cochet & Vauclair, 2010a). This vocal accompaniment of pointing seems to be more frequent when the infants point with the index finger versus other forms of pointing like whole-hand point (Liszkowski & Tomasello, 2011), when they are observed in naturalistic settings versus experimental ones (Cochet & Vauclair, 2010a; Cochet & Vauclair, 2010b) and when the pointing gestures have a declarative function versus an imperative one (Cochet & Vauclair, 2010b).

Results from Capirci, Iverson, Pizzuto and Volterra (1996) show that combinations “gesture + word” were more frequent than combinations “gesture + gesture” or “word + word” between 16 and 20 months of age. Other studies reported that particular combinations of gestures and vocal elements predict specific outcomes of language. Thus, Morford and Goldin-Meadow (1992) found that children produced “gesture-gesture combinations” and “gesture-word combinations” before they combined words. Focusing on the period of transitions between single words and two-word combinations, Iverson and Goldin-Meadow (2005) observed that those children who first produced “gesture + word combinations” conveying two different meanings (the so-called, “supplementary combinations”) were also the first ones to produce two-word combinations. Correlations between the age of onset of “supplementary gesture + word combinations” and the onset of two-word combinations have also been found by Goldin-Meadow (1998), Iverson, Capirci, Volterra and Goldin-Meadow (2008), and Özçaliskan and Goldin-Meadow (2005a). Results confirming that the “gesture + word”

combinations at 16 months correlated to overall vocal production at 18 months were obtained by Capirci et al.(1996).

Goldin-Meadow, Goodrich, Sauer and Iverson (2007) examined the answers of mothers to their children's communicative gestures. They found that the mothers "put in words" or "translate" the communicative gestures of their children, and that these translations relate to words appearing in the early children vocabularies. Moreover, when mothers observed "gesture + speech combinations", the mean length utterance (MLU) of their answers was higher than when the child used gesture or speech alone. That means that gesture + speech coordination has an effect on partners which differs from that produced by the use of each element alone. Considering this, the question that arises is whether the same effect will be found when the vocalizations are not still "speech", that is, are not yet formal elements of language. If this is the case, the coordination of gestures and vocalizations can elicit social responses that help the children in learning to give "word form" to their vocalizations, that is, to use the first phonetically stable forms.

By contrast, Kishimoto, Shizawa, Yasuda, Hinobayashi and Minami (2007), found that specifically pointing gesture of infants elicit comments from adults, but there are no differences depending on the vocal accompaniment of the gesture.

If these vocalizations-gestures combinations have an effect on interactions similar to that found by Goldin-Meadow et al., (2007) for gesture + word combinations, we can expect a predictive relationship between this vocal and gestural coordination and subsequent lexical development. On the opposite, if the vocal and gestural coordination has no different effect on adult's interaction, we can expect a predictive relationship

between specific gestures, like pointing, and lexical development irrespective of their vocal accompaniment.

The arguments put forward to explain why the coordinate use of gestures and words by children can facilitate language learning are also applicable, from our view, to those vocalizations that still do not constitute a word. There is considerable agreement among researchers in considering the existence of five stages of vocal development, from the first vocalizations to the first words (phonation, primitive articulation, expansion, canonical and integrative) (Oller & Lynch, 1992). Infants are able to produce well formed syllables from the canonical stage, and the two last stages of this classification (from around 8 months to 18 months) include vocalizations that overlap and coexist with first words. Moreover, sometimes it is difficult to establish a clear limit between vocalization and the first phonetically stable forms such as protowords or words. To determine what is considered a word entails to develop methodological criteria (quite conservative in our study) to set the limits between words and vocalization that are not phonetically stable forms.

These vocalizations admittedly appear along with gestures in many spontaneous communicative acts of young children. However, most of the empirical studies linking gestural and vocal production with later linguistic achievements have not really considered them, either because they did not specify whether the gestures they analyzed were (or not) accompanied by vocalizations (i.e. Butterworth & Morrisette, 1996), or because the authors only considered those vocal productions that constitute a word or, at least, a protoword (i.e., Blake, Osborne, Cabral & Gluck, 2003; Blake, Vitale, Osborne & Olshansky et al. 2005; Iverson, Capirci, Volterra & Goldin- Meadow, 2008; Özçaliskan

& Goldin-Meadow, 2005a; Rowe, Özçalışkan & Goldin-Meadow, 2008; Rowe & Goldin-Meadow, 2009). Gestures that were coded in these studies as “gesture only” may actually be gestures with vocalizations which do not still constitute a word or a protoword.

The early coordination of vocal sounds and gestures by young children is a robust phenomenon not unnoticed to researchers. Many of them mention the high frequency of “non-sense speech” accompanying gestures, even if this type of vocalizations is not specifically addressed in their studies. (i.e. Guidetti, 2005; Iverson & Thelen, 2000; Özçalışkan & Goldin-Meadow, 2009). Bates et al. (1979) labeled those vocal forms as “vocal gestures” and described their use as clear, consistent and systematic in certain communicative exchanges. These authors proposed a gradual change from “word-like sounds” with performative functions to “semi-referential words” linked to specific contexts. Rome-Flanders and Cronk (1995) considered these vocalizations as “non lexical referential forms”, and included the gestural accompaniment in their definition. They found that particular forms of these vocalizations, such as the “prelexical comments” at 12 months, predict language development measures at both 18 and 24 months.

From our perspective, the study of early use of gestures accompanied of non lexical (or pre-lexical) vocalizations deserves attention in itself, as well as for its potential predictive value on the first stages of language development. Moreover, the multimodal character of early communication has been recently emphasized and the need of a broader perspective in the study of language development that encompasses the analysis of verbal and non verbal aspects of communication has been stressed (i.e. Guidetti & Colletta, 2010).

Given that multimodal behavior coordination is present from early in life, (see Iverson, 2010 for a review) it is possible to hypothesize that the communicative power of the interactions in the preverbal period actually rely not on gesture by itself, but on the coordination of different communicative resources (gesture, vocalization and gaze use). However, this aspect, as far as we know, has not being directly addressed in Spanish children.

In order to test this hypothesis, in this study we analyze the relationship between gesture and vocalization combinations and early lexical development in the period of transition to first words. We expect to see both a progressive and significant increase of multimodal communicative behaviors from 9 to 15 months of age, that is, an increasing rate of communicative behaviors that include gesture, vocalization and social use of gaze along this period. A transition from unimodal forms of communication to behaviors that include initially two, and later three elements, is expected from 9 to 15 months.

We hypothesize that this increase in multimodality will be predictive of subsequent lexical development. In this sense, considering the predictive value of gestures in lexical development, we can expect during the early stages of the period studied a predictive relationship of gesture use and lexical development. As different communicative elements become integrated in multimodal patterns, the coordination of elements (gesture, gaze and vocalization) at 12 months will be the best predictor of early lexical development.

Additionally, we examine the role of specific communicative elements in early lexical development. The importance of pointing as predictor of later linguistic skills

has been frequently stressed in the literature (see Table 1 above). A meta-analysis conducted by Colonnaesi, Stams, Koster and Noom (2010) has shown that the association between pointing and language development is present as early as 11 months of life. This relationship becomes stronger with age, and when the pointing gesture is declarative or is considered in general, but not when it is imperative.

If we consider the multimodal character of infant communication, we can expect that the predictive value of the pointing gesture is not strictly due to the gesture, but to its coordination with other communicative elements such as vocalizations and/or social gaze. Our hypothesis, therefore, is that the use of pointing with vocalization and social gaze at 12 months will be a good predictor of early lexical development, better than the use of other frequent gestures as reaching, or than the use of pointing without vocalizations.

Method

Participants

Eleven Spanish children (6 girls, 5 boys) were videotaped every three months from 9 to 15 months of age. Eligible families were contacted by means of day care facilities and personal contacts. Informed consent was obtained from parents upon enrollment. All infant participants were from full-term, uncomplicated pregnancies with normal deliveries. Parents reported typical developmental histories and normal acquisition of motor developmental milestones. They all came from biparental monolingual Spanish-speaking homes. All but one were first-born, and all attended

nursery school when data collection started. After the last recording session, every child received a present, and a copy of the video recording was provided to parents.

Materials and Procedure

The children were observed in their habitual context, six of them in their home and five in an isolated room in their nursery school. They were observed at 9, 12 and 15 months of age during a semi-structured play situation conducted by an experimenter (E.M.). Observation sessions were programmed within two weeks of each infant's birthday. Mean of age was 9 months and 3 days for the first recording session (min.=8; 17, max.= 9; 15, S.D.= 8), 12 months for the second session (min.=11; 17, max.=12; 15; S.D.= 8) and 15 months and 2 days for the last session (min.=14; 15, max.= 15; 15; S.D.= 8).

A digital camcorder and a lapel microphone were used to videotape the sessions. The microphone was placed in children's lapel in a way that they couldn't see it to avoid distraction and recording problems.

The primary caregivers (mother or father) were present during the sessions, and they were encouraged to normally respond to communicative attempts from the child but they were not asked to elicit or provoke communicative behaviors from the child. During the observation session, the infant sat on a child-chair. Primary caregiver was placed next to the child in the right side, and the experimenter was in front of the child.

The experimenter showed a set of toys one at a time and let the child play with them if he was interested. The toy set included balloons, bubbles, a picture book, a

symbolic play set with plates, glasses and spoons, a spinning top, toy cars, and a wind-up toy. The set was constant across all the observations sessions. The order of toy's presentation was not previously established, but all the toys were presented to all the children in each observation session.

The experimenter interacted with the child and responded to his communicative attempts. We tried to obtain a sample of children's spontaneous communication, so we let them lead the interaction and the experimenter followed the children initiative. We coded as "*answer*" the communicative behaviors from the children that followed a direct question or request from the adult. We did so in order to know to what extent the communicative behaviors were directly prompted by the adult intervention.

The estimated duration of each session was 20 minutes, although it was adapted to the attention and motivational state of the child. Mean duration of recording sessions was 17 minutes for the 9 months session (min. = 11'14''; max. = 31'31''; S.D.= 5'44''), 16 minutes for the 12 months session (min. = 9'45''; max. = 24' 51''; S.D. = 4'29'') and 17 minutes for the 15 months session (min. = 10'15''; max. = 39'; S.D.=8' 28''). A total of 563 minutes of video were analyzed.

Data analysis

Coding

All communicative attempts from the child, addressed to the experimenter or to their primary caregivers, were registered and coded according the definitions and criteria included in the Appendix. We considered as communicative those behaviors that were triadic, that is, that were referred to some external entity, and that included gesture, vocalization and/or look directed to the adult. We didn't consider behaviors without a

clear referent and no sign of being directed to an adult (orientation towards the adult or gaze use).

A vocalization was defined following the definition by Bloom et al. (1987), used in subsequent studies about vocalizations in infants (Masataka, 1993a; Masataka, 1993b; Masataka, 1995; Hsu, et al 2000; Hsu y Fogel, 2001). We considered a vocalization as *a discrete, continuously voiced sound occurring within a single respiration. Non-verbal sounds (sneezes, coughs, hiccoughs, etc.), cries and other vegetative sounds are excluded. We consider as two different vocalizations if there is an audible inspiration or a second of silence.*

We considered as a gesture any motor action that is not reduced to an instrumental action with the object, conveys a meaning that is interpreted by the adult and it is stable, which means it has a structure along time and interactive contexts. For coding gestures we based on previous definitions included in the Appendix.

With regard to gaze, we coded where the children was looking at when displaying a communicative behavior, in order to determine if there was a social use of gaze (gaze to the adult or gaze alternation).

Reliability

To test interrater reliability, two trained observers coded samples of 6 observation sessions (18% of the total recordings) including different children at different ages. The observers coded the type of gesture and vocalization and the social vs. non social use of gaze following the criteria included in the Appendix. Agreement between coders was 92% for gesture ($k = .90$, $N = 155$), with a percentage of agreement of 97% for pointing

(N=38), 89% for reaching (N=54), 100% for showing (N=6), 100% for giving (N=15), 100% for conventional gestures (N=5), 88% for symbolic gestures (N=8), 97% for gestures in the category “others” (N=18), and 73% for gestures with less than 5 observations in the sample (N=11). For gaze use, the agreement was 86% ($k = .77$, $N=240$), with 89% of agreement for social use of gaze (N=169) and 79% for non social use of gaze (N=71). In the case of the type of vocalizations, the agreement between coders was 98% ($k = .89$, $N=339$), with 98% of agreement for babbling (N=309) and 96% for words and protowords (N=30). There was no instance of imitation in the sample.

The observers coded as “answer” the communicative behaviors developed by the children that were an immediate answer to a question (for example “*what’s that?*”) or request from the adult (“*what do you want ?*”). Agreement of “Answer” was 75% (N=20).

Results

A total of 2437 communicative behaviors were coded. A mean rate of 4.32 communicative behaviors per minute was observed, which means that children displayed an average of a communicative behavior each 14 seconds.

As Table 2 shows, pointing and reaching were the gestures with highest frequency along the period studied. Concerning vocalizations, the most frequent form of vocal behavior was always babbling, constituting the 98% of vocal behavior at 9 months, 93% at 12 months and 82% at 15 months. Words and protowords increased its frequency along the period, rising from 0.7% at 9 months, to 5.4% at 12 months and 15.8% at 15 months.

Only 83 (3.4%) communicative behaviors were an answer, so that most of the communicative interactions were initiated by the children.

[INSERT TABLE 2]

1) Changes in complexity and modality of communicative behaviors with age

Changes in the structure of communicative behaviors were observed. There was a decreasing tendency of communicative behaviors with only one element, in benefit of communicative patterns that involved the combination of two (gesture + gaze, vocalization + gaze or gesture + vocalization) and three elements (gesture + vocalization + gaze) (see Figure 1).

[INSERT FIGURE 1 HERE]

A two-way repeated measures ANOVA was carried out to test both the effect of age (9m, 12m, 15m) and of number of elements used to communicate (one, two, three). As dependent variable we took the rate of communicative behavior (frequency per minute). Results yielded a significant main effect of elements combination [$F(2, 20) = 35.043$; $p < .001$; $\eta^2 = .778$]. With regard to the main effect of age, no significant results were found, appearing only a marginal probability [$F(2, 20) = 2.925$; $p = .077$; $\eta^2 = .226$]. However, we found a significant effect of interaction between age and elements combination [$F(4, 40) = 6.329$; $p < .001$; $\eta^2 = .388$]. At 9 months, Bonferroni corrected pairwise comparisons showed significant differences between the rate of behaviors composed of one and two elements ($p < .01$), as well as between those composed of one and three elements ($p < .001$). Differences between those composed by two and three elements were also significant ($p < .001$). At 12 months, significant differences were still found between behaviors composed of one and three elements ($p < .001$), and between

those composed of two and three elements ($p < .001$). However, differences in the rate of behaviors composed of one and two elements were no more significant ($p = 1$). Finally, at 15 months, we only found significant differences between the rate of behaviors composed of two and three elements ($p < .005$).

In order to address the changes with age in communicative modalities (elements alone or combined) a two-way repeated measures ANOVA was carried out, with factors being age (9m, 12m, 15m) and communicative modality (gesture only, vocalization only, gaze only, gesture + gaze, gesture + vocalization, vocalization + gaze, gesture + vocalization + gaze). As dependent variable, we took again the rate of communicative behavior.

There was no significant main effect of age, appearing only a marginal probability [$F(2, 20) = 2.925$; $p = .077$; $\eta^2 = .226$]. Results showed a significant effect of modality (sphericity was not verified, so Greenhouse-Geisser correction was applied) [$F(2.565, 25.651) = 7.699$, $p < .005$; $\eta^2 = .435$]. Bonferroni pairwise comparisons showed significant differences between *gesture only* rate and *vocalizations only* rate (.339 vs. 1.09; $p < .005$), as between *gesture only* rate and *vocalization+gaze* rate (.339 vs. 0.719; $p < .05$).

Results showed no significant effect of the interaction between age and modality (Greenhouse-Geisser correction was applied) [$F(3.572, 35.721) = 2.058$; $p = .114$].

2) *Relationships between communicative patterns and early lexical development*

In order to test the predictive relationship between the coordinated use of different communicative modalities and early lexical development, we calculated the rate per minute of words + protowords (i.e. referential forms phonetically stables) they used at

15 months, and we took this measure as the index of their early lexical development. A great variability was observed in the children of our sample in this measure (min. = 0; max = 1.88, S.D. = .68).

In order to assess the association between variables, Pearson's correlations were calculated between communicative modalities at 9 and 12 months and the lexical development at 15 months. The assumption of normality of variables was tested through the Kolmogorov-Smirnov test.

[INSERT TABLE 3 HERE]

As it is shown in Table 3, the communicative elements that show higher associations at 9 months with lexical development at 15 months were gesture only and gesture + gaze. At 12 months, the correlation between gesture only and words + protowords at 15 months was not significant anymore. At this age, all the combinations of two elements (gesture + gaze, gesture + vocalization, vocalization + gaze) showed a positive and significant correlation with the use of words and protowords at 15 months. More so, the coordinated use of three elements at 12 months (gesture + vocalization + gaze) was the one that reached the strongest positive association with the rate of words + protowords at 15 months.

Finally, to explore the relationship between communicative elements coordination at 12 months and lexical uses at 15 months, we ran a simple regression analysis. As depicted in Figure 2, we found a positive ($R^2=.90$; $R^2_{\text{adjusted}}=.89$) and significant relationship between rates of gesture + vocalization + gaze (GVG) combinations at 12 months and lexical uses at 15 months [$\beta = 1.27$, $t(9)=9.10$; $p<.001$]. The assumptions of the simple linear regression model were tested through a normality

test, together with visual inspection of the scatterplots, on the residuals of the estimations, and the correlation analysis of absolute errors and predicted values.

As Table 3 shows, the coordination of communicative elements (gesture, vocalization and gaze) at 12 months clearly predicts early lexical development at 15 months. However, at the first year, the isolated use of the different communicative elements did not predict the rate of words and protowords at 15 months.

[INSERT FIGURE 2]

3) *On the predictive value of specific communicative patterns*

A last question we explored is that referred to whether certain types of gestures have a special role in early language development, as previous literature suggested (Bates et al. 1979; Camaioni, Castelli, Longobardi & Volterra, 1991; Butterworth & Morisette, 1996). Specifically, we focused on the relationship between the use of pointing at 9 and 12 months and the word + protoword rate at 15 months, compared with the same relationship for reaching. Given that GVG coordination was the best predictor of later lexical development, in this analysis we included only pointing and reaching accompanied by social gaze.

[INSERT TABLE 4 HERE]

As shown in Table 4, a significant positive Pearson's correlation was obtained between pointing and reaching rates at 9 months and word + protoword rate at 15 months when the gestures were used alone. At 12 months, we still observe this positive relation between pointing only and words + protowords at 15 months, but not for reaching gestures. Otherwise, at 12 months, we found a significant and strong relation

between the rate of pointing with vocalization and the rate of words + protowords at 15 months, but not between reaching with vocalization and rate of words + protowords at 15 months.

We tested the assumption of normality of the variables using Kolmogorov-Smirnov test. Results showed that normality can be assumed for all the tested variables except for pointing+ vocalization at 9 months. We repeated the correlation analyses using Tau of Kendall and we obtained the same results showing no significant correlation between this variable and words + protowords rate at 15 months ($\tau=.157$; $p=.547$).

In order to explore the relationship between the rate of pointing with vocalization at 12 months and the rate of words + protowords at 15 months, we conducted a simple regression analysis with the rate of words + protowords at 15 months used as dependent variable and the rate of pointing + vocalization at 12 months as a predictor one. A significant relation between variables [$\beta = 2,16$, $t(9)= 6.32$, $p<.001$] was obtained, with a high degree of linear relation between variables ($R^2=.816$; $R^2_{\text{adjusted}}=.796$), as depicted in Figure 3. The assumptions of the simple linear regression model were tested through a normality test, together with visual inspection of the scatterplots, on the residuals of the estimations, and the correlation analysis of absolute errors and predicted values.

[INSERT HERE FIGURE 3]

Our results, thus, suggested that already at 9 months pointing predicts subsequent lexical development, and at 12 months is the best predictor of early lexical development, especially when it's accompanied by vocalizations and social use of gaze.

Discussion

The aim of the present study was to investigate longitudinally the coordination of different communicative elements as gestures, vocalizations and gaze, and their predictive value in the development of early lexical forms. Our results show that the association between vocal and motor components described by several other authors in the first months of life (Fogel & Hannan, 1985; Ejiri, 1998; Ejiri & Masataka, 2001; Iverson & Fagan 2004; Iverson et al., 2007) appears to be clearly established in children aged one year. The link between vocal and communicative motor elements seems to remain constant along development, being the changes in the number and modality of elements associated in each time the clearest indicator of prelinguistic intentional communicative development between 9 and 15 months of age. Behaviors that involve the combination of two or three different elements (gesture, vocalization and/or gaze) are progressively the most used resources for the child to communicate, as opposed to behaviors that involve only one of these elements.

Regarding the predictive value of communicative elements on early lexical development, our results reveal the dynamic character of communicative development. At 9 months, we found that communicative behaviors including gesture alone or gesture combined with social gaze appeared as significantly related to later lexical rate. At this age, children rarely accompany their gestures and vocalizations with social gaze, what

can be regarded as an initial level of understanding of others as intentional agents. Only three months later (12 months), the rate of gesture alone is no longer related to subsequent lexical development but the communicative behaviors that include at least two elements appeared as significant and positively correlated to lexical rate at 15 months. Specifically, the most complex communicative behaviors at 12 months (that involved the coordination of gestures, vocalizations and social use of gaze) appeared as the best predictors of lexical development at 15 months. A more mature understanding of the other as intentional agent seems to have developed at this age, which has probably been facilitated by the reactions of adults to the previous (more simple) communicative behaviors of the child.

The developmental sequence that emerges from our results, therefore, points to a gradual specialization from unimodal forms of communication, less demanding in cognitive, social and semiotic terms, to multimodal patterns involving the coordination of specific gestures and vocalizations. Most likely, these increasingly multimodal behaviors have a greater and differential communicative impact on partners, enabling opportunities of social responses and interactions that contribute to the facilitation of pre-lexical and adult lexical forms.

Children seem to use a variety of communicative gestures at 9 months, but at this age, the vocal component is fundamentally babbling. Whereas the use of gestures is correlated with later lexical development from 9 months, vocalizations doesn't appear correlated with lexical development until 12 months, when they are immersed as part of multimodal communicative behaviors. This data can support the hypothesis of the primary role of gestures in intentional communication development.

Otherwise, our results show that the path to the multimodality subtly varies depending on the specific types of gestures involved. Thus, reaching only at 9 months was related to lexical development at 15 months but this is not the case for reaching only at 12 months. On the contrary, pointing gesture keeps a lineal and consistent link with later lexical rate, especially when it is accompanied by vocalizations.

Several authors have stressed the distinctions between pointing and reaching, considering pointing with the index finger primarily associated with declarative function and reaching (also called imperative pointing) mainly associated with imperative function (Franco & Butterworth, 1996). However in our study the function of gestures were not taken into account.

This distinction assumes the existence of different socio-cognitive origins for both communicative gestures. Whereas reaching gestures require an understanding of others as causal agents, declarative pointing relies on an understanding of others as psychological agents (Liszkowski & Tomasello, 2011). These differences are reflected in the developmental sequence of emergence, and in the relation between production of declarative pointing and understanding of others' intentions, not found for reaching or imperative pointing (Camaioni, Perucchini, Bellagamba & Colonnaesi, 2004). Our results show an initial relationship between reaching and subsequent lexical development, what can be seen as an initial understanding of others as causal agents necessary for the development of communicative intention.

Different explanatory hypotheses have been proposed to explain why combining gestures and speech positively influences language development. On one side, it is possible that the child has implicit knowledge that he is not yet able to express

linguistically. This knowledge can first be expressed through gestures, becoming later explicit and verbally expressed. Thus, “gesture + word combinations” could provide the structure or “skeleton” on which two words combinations are established (Özçalışkan & Goldin-Meadow, 2009). On the other side, gestures may lighten the task’s cognitive load inasmuch as they allow the speaker to convey information that he knows but still he cannot verbalize (Goldin-Meadow, Nusbaum, Kelly & Wagner, 2001). Finally, a more social perspective could be adopted, based on the fact that combinations “gesture + speech” of children have some impact on partners, eliciting actions by them that encourage language development. Goldin-Meadow et al. (2007) examined the answers of mothers to their children’s communicative gestures. They found that the mothers “put in words” or “translate” the communicative gestures of their children, and that these translations relate to words appearing in the early children vocabularies. Moreover, when mothers observed “gesture + speech combinations”, the mean length utterance (MLU) of their answers was higher than when the child used gesture or speech alone. That means that gesture + speech coordination has an effect on partners which differs from that produced by the use of each element alone. Although we didn’t measured the adult’s behaviors in our study, we can hypothesize that gesture + vocalizations combinations can have the same effect on partners than gesture + speech coordination, which means that gesture + vocalization coordination can elicit more verbal responses from adults. These responses can facilitate the gradual assimilation of vocalizations to verbal forms that is a facilitator effect in early phonetically stable referential forms.

The study of Kishimoto et al. (2007) found no differences in the rate of verbal response from adults to infant’s pointing when the gesture were accompanied by vocalization or not, but they didn’t take into account the quality of the verbal response

from the adult. In this sense it would be interesting to analyze and compare the formal characteristics of verbal behavior that accompanies the communicative gestures of children and those of adults' responses in order to clarify this question.

Our longitudinal study has provided an interesting set of data showing both the increasing multimodality of communicative behaviors in children between 9 and 15 months old, and its value as a predictor of the early lexical development.

Both from previous literature and our results, we can outline a developmental sequence in the coordination of vocal and gestural components in early stages of language development. Around 9 months we find gestures without vocalizations that start to be coordinated with social gaze. At 12 months, gestures, specially pointing, and prelexical vocalizations coordination can facilitate the development of the first lexical forms. Then, the coordination of the first lexical forms (words and protowords) with gestures in multimodal communicative patterns results predictive of later specific linguistic achievements (Goldin-Meadow, 1998; Iverson, et al., 2008; Iverson & Goldin-Meadow, 2005; Özçaliskan & Goldin-Meadow, 2005b). For example, when gesture and word convey complementary meanings, the answer obtained from the caregiver seems to facilitate the development of two-word combinations (Goldin-Meadow et al., 2007).

Coordination of multiple communicative elements remains as a robust feature of infant behavior after 15 months. The link between vocal and gestural elements continues along language learning as in adult communication (Kendon, 1980, 1993; Kita, 2000, Kita & Özyürek, 2003; McNeill, 2000; de Ruiter, 2007).

This trajectory shows the dynamic character of the vocal and gestural relationship and its role in language development. Besides, our results have some implications regarding the question of language origins. Faced with the dichotomy between vocal and gestural origins of language (Corballis, 2009), multimodality must be taken into account considering that it is present from early stages of communicative development. As Masataka (2008) suggests, language development implies complex processes involving gestural and vocal skills, so that formulating the question of language origins dichotomously may result irrelevant. Language must be considered as a dynamic and multimodal process.

References

- Acredolo, Linda P., & Susan Goodwyn (1988). Symbolic gesturing in normal infants. *Child Development*, 59 (2), 450-466.
- Bates, Elisabeth, Laura Benigni, Inge Bretherton, Luigia Camaioni, & Virginia Volterra (1979). *The emergence of symbols: Cognition and communication in infancy*. New York: Academic Press.
- Bates, Elisabeth, & Frederic Dick (2002). Language, gestures and the developing brain. *Developmental Psychobiology*, 40, 293-310.
- Blake, Joanna, Sheilah McConnell, Gayle Horton & Nancy Benson (1992). The gestural repertoire and its evolution over the second year. *Early Development & Parenting*, 1(3), 127-136.
- Blake, Joanna, Paula O'Rourke, & Grace Borzellino (1994). Form and function in the development of pointing and reaching gestures. *Infant Behavior & Development*, 17(2), 195-203.
- Blake, Joanna, Patricia Osborne, Marlene Cabral, & Pamela Gluck, (2003). The development of communicative gestures in japanese infants. *First Language*, 23(1), 3-20.
- Blake, Joanna, Grace Vitale, Patricia Osborne, & Esther Olshansky (2005). A cross-cultural comparison of communicative gestures in human infants during the transition to language. *Gesture. Special Issue: Gestural Communication in Nonhuman and Human Primates*, 5(1-2), 201-217.

- Bloom, Kathleen, Ann Russell, & Karen Wassenberg (1987). Turn taking affects the quality of infant vocalizations. *Journal of Child Language*, 14(2), 211-227.
- Butterworth, George, & Paul Morissette (1996). Onset of pointing and the acquisition of language in infancy. *Journal of Reproductive and Infant Psychology*, 14(3), 219-231.
- Camaioni, Luigia, Maria C. Castelli, Emiddia Longobardi, & Virginia Volterra (1991). A parent report instrument for early language assessment. *First Language*, 11(33), 345-359.
- Camaioni, Luigia, Paola Perucchini, Francesca Bellagamba, & Cristina Colonnese (2004). *Infancy*, 5 (3) 291-308.
- Camp, Bonnie W., David Burgess, Linda J. Morgan, & Gary Zerbe (1987). A longitudinal study of infant vocalization in the first year. *Journal of Pediatric Psychology*, 12(3), 321-331.
- Capirci, Olga, Jana M. Iverson, Elena Pizzuto, & Virginia Volterra (1996). Gestures and words during the transition to two-word speech. *Journal of Child Language*, 23(3), 645-673.
- Carpenter, Malinda, Katherine Nagell, & Michael Tomasello (1998). Social cognition, joint attention, and communicative competence from 9 to 15 months of age. *Monographs of the Society for Research in Child Development*, 63(4), 1-174.
- Cochet, Hélène & Jacques Vauclair (2010a). Features of spontaneous pointing gestures in toddlers. *Gesture*, 10(1), 86-107.

Cochet, Hélène & Jacques Vauclair (2010b). Pointing gestures produced by toddlers from 15 to 30 months: different functions, hand shapes and laterality patterns. *Infant behavior and development*, 33, 431-441.

Colonnesi, Cristina, Geert Jan J.M Stams, Irene Koster, & Marc J.Noom (2010). The relation between pointing and language development: A meta-analysis. *Developmental Review*, 30 (4), 352-366.

Corballis, Michael, C. (2009). Language as gesture. *Human Movement Science*, 28 (5), 556-565.

de Ruiter, Jan Peter (2007). Postcards from the mind: The relationship between speech, imagistic gesture, and thought. *Gesture*, 7(1), 21-38.

Dobrich, Wanda & Hollis S. Scarborough (1984). Form and function in early communication: Language and pointing gestures. *Journal of Experimental Child Psychology*, 38(3), 475-490.

D'Odorico, Laura & Fabia Franco (1991). Selective production of vocalization types in different communication contexts. *Journal of Child Language*, 18(3), 475- 499.

Ejiri, Keiko (1998). Relationship between rhythmic behavior and canonical babbling in infant vocal development. *Phonetica*, 55(4), 226 - 237.

Ejiri, Keiko, & Nobuo Masataka (2001). Co-occurrence of preverbal vocal behavior and motor action in early infancy. *Developmental Science*, 4(1), 40-48.

- Fogel, Alan & Thomas E. Hannan (1985). Manual actions of nine- to fifteen-week-old human infants during face-to-face interaction with their mothers. *Child Development*, 56(5), 1271-1279.
- Franco, Fabia & George Butterworth (1996). Pointing and social awareness: Declaring and requesting in the second year. *Journal of Child Language*, 23(2), 307-336.
- Goldin-Meadow, Susan (1998). *The development of gesture and speech as an integrated system*. San Francisco, CA, US: Jossey-Bass.
- Goldin-Meadow, Susan, Whitney Goodrich, Eve Sauer, & Jana M. Iverson (2007). Young children use their hands to tell their mothers what to say. *Developmental Science*, 10(6), 778-785.
- Goldin-Meadow, Susan, Howard C. Nusbaum, Spencer D. Kelly, & Susan Wagner (2001). Explaining math: Gesturing lightens the load. *Psychological Science*, 12, 516-522.
- Goldstein, Michael H. & Jennifer A. Schwade (2008). Social feedback to infants' babbling facilitates rapid phonological learning. *Psychological Science*, 19(5), 515-523.
- Guidetti, Michèle (2005). Yes or no? how young French children combine gestures and speech to agree and refuse. *Journal of Child Language*, 32(4), 911-924.
- Guidetti, Michèle & Jean Marc Colletta (2010). Gesture and multimodal development. *Gesture*, 10 (2-3), 123-128.

- Hsu, Hui-Chin, & Alan Fogel, (2001). Infant vocal development in a dynamic mother–infant communication system. *Infancy*, 2(1), 87-109.
- Hsu, Hui-Chin, Alan Fogel, & Rebecca B. Cooper, (2000). Infant vocal development during the first 6 months: Speech quality and melodic complexity. *Infant and Child Development*, 9, 1-16.
- Iverson, Jana M. (2010). Developing language in a developing body: The relationship between motor development and language development. *Journal of Child Language*, 37(2), 229-261.
- Iverson, Jana M., Olga Capirci, Virginia Volterra, & Susan Goldin-Meadow (2008). Learning to talk in a gesture-rich world: Early communication in Italian vs. American children. *First Language*, 28(2), 164-181.
- Iverson, Jana M., & Mary K. Fagan (2004). Infant vocal-motor coordination: Precursor to the gesture-speech system?. *Child Development*, 75(4), 1053-1066.
- Iverson, Jana M., & Susan Goldin-Meadow (2005). Gesture paves the way for language development. *Psychological Science*, 16(5), 367-371.
- Iverson, Jana M., Amanda J. Hall, Lindsay Nickel, & Robert H. Wozniak, (2007). The relationship between reduplicated babble onset and laterality biases in infant rhythmic arm movements. *Brain and Language*, 101(3), 198-207.
- Iverson, Jana M., & Thelen, Esther (2000). *Hand, mouth and brain: The dynamic emergence of speech and gesture*. Charlottesville, VA: Imprint Academic.

- Karousou, Alexandra (2003). *Análisis de las vocalizaciones tempranas: su patrón evolutivo y su función determinante en la emergencia de la palabra.* (Doctoral Thesis, Universidad Complutense, Madrid).
- Keller, Heidi & Axel Schölmerich, (1987). Infant vocalizations and parental reactions during the first 4 months of life. *Developmental Psychology*, 23(1), 62-67.
- Kendon, Adam (1980). Gesticulation and speech: Two aspects of the process of utterance. In M. Ritchie Key (Ed.), *The relationship between verbal and nonverbal communication* . (pp. 207-227). Mouton: The Hague.
- Kendon, Adam (1993). Human gesture. In Kathleen R. Gibson, & Tim Ingold (Eds.), *Tools, language and cognition in human evolution*. (pp. 43-62). New York, NY, US: Cambridge University Press.
- Keren-Portnoy, Tamar, Marinella Majorano, & Marilyn M. Vihman, (2009). From phonetics to phonology: The emergence of first words in Italian. *Journal of Child Language*, 36(2), 235-267.
- Kishimoto, Takeshi, Yasuhiro Shizawa, Jun Yasuda, Toshihiko Hinobayashi, & Tetsuhiro Minami (2007). Do pointing gestures by infants provoke comments from adults? *Infant Behavior & Development*, 30(4), 562-567.
- Kita, Sotaro (2000). How representational gestures help speaking. In David McNeill (Ed.), *Language and gesture*. (pp.162-185). Cambridge: Cambridge University Press.

- Kita, Sotaro & Asli Özyürek (2003). What does cross-linguistic variation in semantic coordination of speech and gesture reveal?: Evidence for an interface representation of spatial thinking and speaking. *Journal of Memory and Language*, 48(1), 16-32.
- Laakso, Marja L., Anna M. Poikkeus, J. Katajamaki, & Paula Lyytinen (1999). Early intentional communication as a predictor of language development in toddlers. *First Language*, 19, 207-231.
- Leung, Eleanor H., & Harriet L. Rheingold (1981). Development of pointing as a social gesture. *Developmental Psychology*, 17(2), 215-220.
- Liszkowski, Ulf, & Michael Tomasello (2011). Individual differences in social, cognitive, and morphological aspects of infant pointing. *Cognitive Development*, 26(1), 16-29.
- Masataka, Nobuo (1993a). Effects of contingent and noncontingent maternal stimulation on the vocal behaviour of three- to four-month-old Japanese infants. *Journal of Child Language*, 20(2), 303-312.
- Masataka, Nobuo (1993b). Relation between pitch contour of prelinguistic vocalizations and communicative functions in Japanese infants. *Infant Behavior & Development*, 16(3), 397-401.
- Masataka, Nobuo (1995). The relation between index-finger extension and the acoustic quality of cooing in three-month-old infants. *Journal of Child Language*, 22(2), 247-257.

- Masataka, Nobuo (2008). The gestural theory of and the vocal theory of language origins are not incompatible with one another. In Nobuo Masataka (Ed.), *The origins of language: Unraveling evolutionary forces* (pp. 1-10). Heidelberg: Springer.
- McNeill, David (2000). *Language and gesture*. Cambridge: Cambridge University Press.
- Morford, Marolyn, & Susan Goldin-Meadow (1992). Comprehension and production of gesture in combination with speech in one-word speakers. *Journal of Child Language*, 19(3), 559-580.
- Oller, D. Kimbrough (1980). The emergence of sounds of speech in infancy. In James S. Kavanagh, & Charles A. Ferguson (Eds.), *Child phonology, 1: Production*. (pp.93-112). New York: Academic Press.
- Oller, D. Kimbrough & Michael P. Lynch, (1992). Infant vocalizations and innovations in infraphonology: Toward a broader theory of development and disorders. In Charles A. Ferguson, Lise Menn & Carol Stoel-Gammon (Eds.), *Phonological development: Models research and implications*. (pp.509-536). Timonium: York.
- Özçaliskan, Şeyda, & Susan Goldin-Meadow (2005a). Gesture is at the cutting edge of early language development. *Cognition*, 96(3), B101-B113.
- Özçaliskan, Şeyda, & Susan Goldin-Meadow (2005b). Do parents lead their children by the hand?. *Journal of Child Language*, 32(3), 481-505.

- Özçalışkan, Şeyda, & Susan Goldin-Meadow (2009). When gesture-speech combinations do and do not index linguistic change. *Language and Cognitive Processes*, 24(2), 190-217.
- Pine, Karen J., Nicola Lufkin, Elizabeth Kirk, & David Messer (2007). A microgenetic analysis of the relationship between speech and gesture in children: Evidence for semantic and temporal asynchrony. *Language and Cognitive Processes*, 22(2), 234-246.
- Rodrigo, María J., Angela González, Manuel de Vega, M., Mercedes Muñetón-Ayala, & Guacimara Rodríguez (2004). From gestural to verbal deixis: A longitudinal study with Spanish infants and toddlers. *First Language*, 24(1), 71-90.
- Rome-Flanders, Tibie, & Carolyn Cronk, (1995). A longitudinal study of infant vocalizations during mother-infant games. *Journal of Child Language*, 22 (2), 259-274.
- Rowe, Meredith L. (2000). Pointing and talk by low-income mothers and their 14-month-old children. *First Language*, 20(60), 305-330.
- Rowe, Meredith L., & Susan Goldin-Meadow (2009). Early gesture *selectively* predicts later language learning. *Developmental Science*, 12(1), 182-187.
- Rowe, Meredith L., Şeyda Özçalışkan & Susan Goldin-Meadow (2006). The added value of gesture in predicting vocabulary growth. *Proceedings of the Annual Boston University Conference on Language Development*, 30(2), 501-512.

Rowe, Meredith L., Şeyda Özçalışkan & Susan Goldin-Meadow (2008). Learning words by hand: Gesture's role in predicting vocabulary development. *First Language*, 28(2), 182-199.

Stoel-Gammon, Carol, & Judith A. Cooper (1984). Patterns of early lexical and phonological development. *Journal of Child Language*, 11(2), 247-271.

Vihman, Marilyn M., Charles A. Ferguson, & Mary Elbert (1986). Phonological development from babbling to speech: Common tendencies and individual differences. *Applied Psycholinguistics*, 7(1), 3-40.

Vihman, Marilyn M., Marlys A. Macken, Ruth Miller, Hazel Simmons, & Jim Miller (1985). From babbling to speech: A re-assessment of the continuity issue. *Language*, 61, 397- 445.

Zinober, Brenda & Margaret Martlew (1985). Developmental changes in four types of gesture in relation to acts and vocalizations from 10 to 21 months. *British Journal of Developmental Psychology. Special Issue: Infancy*, 3(3), 293-306.

Table 1

Variables of gesture use predicting later language measures

Variable	at age	Predicts	at age	References
Communicative pointing (Relative frequency)	9 – 13 months	Language comprehension level (interview) Number of words comprehended (interview) Nonreferential words (interview and observation) Number and frequency of referential words (interview and observation)	9-13 months	Bates et al. 1979
Pointing (Frequency informed by parent through questionnaire)	12 months	Vocabulary size (Vocabulary checklist)	20 months	Camaioni, Castelli, Longobardi & Volterra, 1991
Referential gestures (Frequency informed by parent through questionnaire)	12 months	Vocabulary size (Vocabulary checklist)	20 months	Camaioni, et al., 1991
Pointing (age of onset)		Total number of animal sounds comprehended (McArthur Communicative Developmental inventory, CDI)	14 months	Butterworth & Morisette, 1996
Number of different gestures (tokens)	14 months	Peabody Picture Vocabulary Test score	42 months	Rowe, Özçaliskan & Goldin-Meadow, 2008
Number of meanings conveyed by gestures (types)	14 months	Peabody Picture Vocabulary Test score	42 months	Rowe et al., 2008
Number of gestures produced (observation)	14 months	Peabody Picture Vocabulary Test score	30 months	Rowe, Özçaliskan & Goldin-Meadow, 2006
Actions and gestures (index derived from CDI)	14 months	Verbal comprehension (Reynell Developmental Language Scales)	18 months	Laakso, M., Poikkeus, A., Katajamaki, J., & Lyytinen, P., 1999
Actions and gestures (index derived from CDI)	14 months	Expressive language (index derived from vocabulary production and maximum sentence length from the CDI, and Bayley expressive score)	24 months	Laakso, et al., 1999
“Comment” gestures (relative frequency)	15 months	Peabody Picture Vocabulary Test score	37 months	Blake, Vitale, Osborne & Olshansky, 2005; Blake, Osborne, Cabral & Gluck, 2003
“Object Exchange” gestures (relative frequency)	15 months	Productive vocabulary size (CDI)	15 months	Blake, et al., 2005
Gesture vocabulary (number of different meanings conveyed by gesture. Observation)	18 months	Peabody Picture Vocabulary Test score	42 months	Rowe & Goldin-Meadow, 2009

GESTURAL-VOCAL COORDINATION AND EARLY LEXICAL DEVELOPMENT

Table 2

Rate per minute of gesture and vocalization types used at each age

	Age					
	9 months		12 months		15 months	
Type of Gesture	Mean	S.D.	Mean	S.D.	Mean	S.D.
Pointing	.19	.29	.60	.62	.52	.47
Reaching	.44	.28	.67	.37	.73	.55
Give	.03	.07	.23	.23	.52	.40
Conventional	.09	.12	.10	.12	.23	.31
Symbolic	-	-	.16	.02	.18	.27
Showing	.04	.07	.08	.14	.02	.03
Prepoint	.09	.10	.13	.32	.004	.01
Shaking	.20	.50	.01	.02	.014	.03
Ritualized requests	-	-	-	-	.03	.10
Enactive	.03	.09	.03	.06	.06	.10
Action imitation	.004	.015	-	-	.01	.03
Protest/rejection	.04	.06	.09	.10	.07	.12
Other	.08	.01	.21	.38	.15	.15
Type of Vocalization						
Babbling	2.26	1.2	3.24	1.36	3.10	1.87
Words + protowords	.014	.03	.19	.30	.52	.68
Imitation	.01	.03	.05	.08	.04	.06

Table 3

Pearson's correlation of multimodal combinations at 9 and 12 months and words +
protowords rate at 15 months.

Multimodal combinations	At 9 months	At 12 months
Gesture only	.678(*)	.602
Vocalization only	-.334	-.199
Gaze only	.212	.428
Gesture + gaze	.667(*)	.605(*)
Gesture + vocalization	.176	.801(**)
Vocalization + gaze	-.003	.773(**)
Gesture + vocalization + gaze	.173	.945(**)

* p<.05 . **p<.01

Table 4

Pearson's correlations between communicative behaviors rate at 9 and 12 months and words + protowords rate at 15 months.

Modality	At 9 months	At 12 months
Pointing only	.678(*)	.652(*)
Pointing + vocalization	.351	.903(**)
Reaching only	.679(*)	-.235
Reaching + vocalization	-.238	.035

* p<..05 **p<..01.

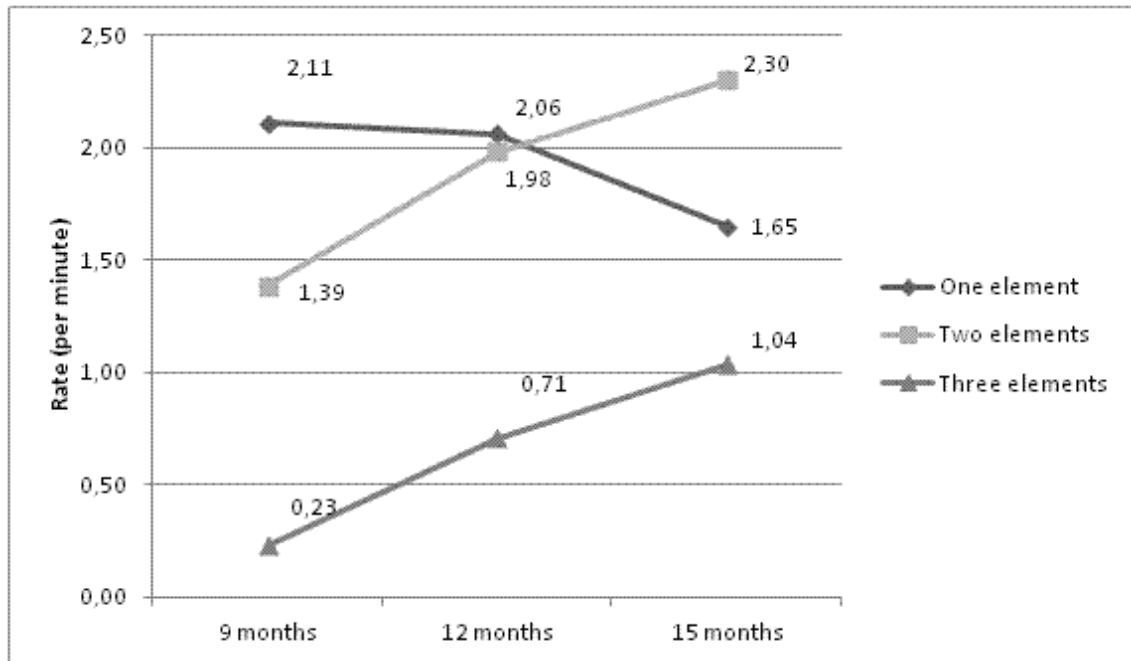


Figure 1. Rate of communicative behavior composed by one, two or three elements at every age.

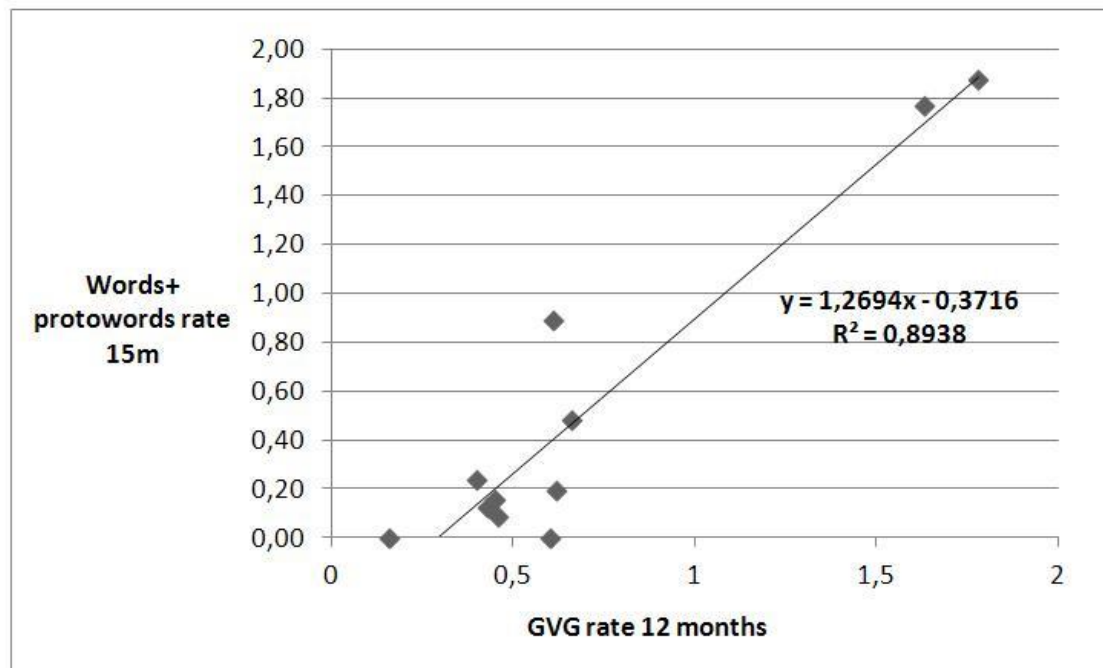


Figure 2. Relation between GVG rate at 12 months and *words+ protowords* rate at 15 months

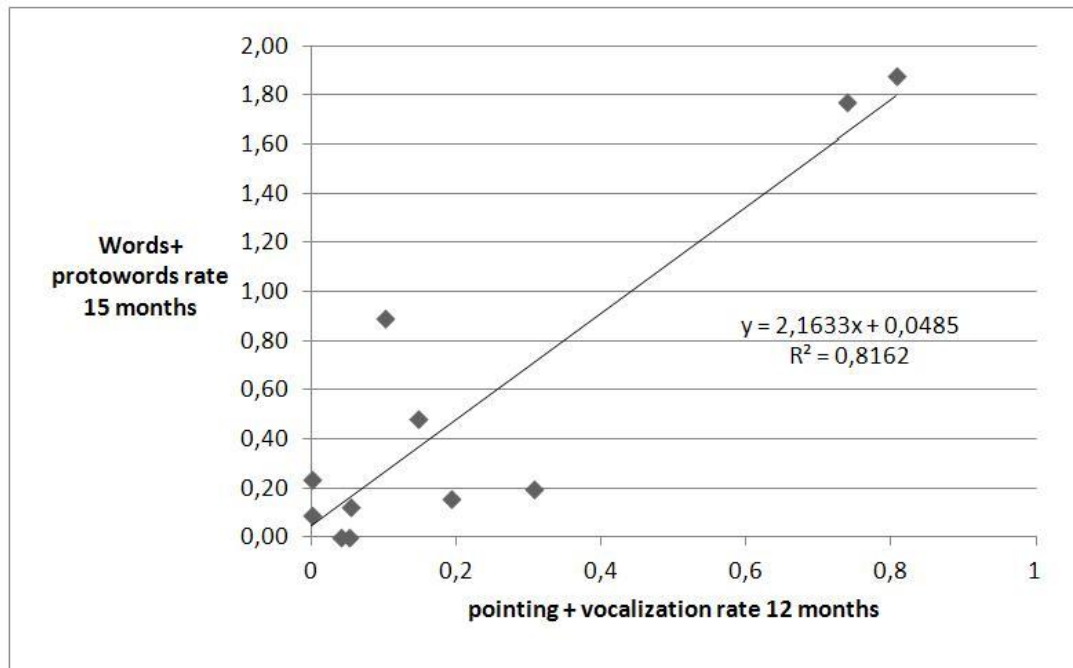


Figure 3. Linear relation between *pointing* + *vocalizations* at 12 months and *words* + *protowords* rate at 15 months.

Appendix

Vocalization coding

Vocalizations were classified according to the following categories:

- *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.
- *Protoword*: the utterance has a stable phonetic structure and a clear relationship with the referent, but it does not constitute a word in the adult language. Onomatopoeic sounds were included in this category.
- *Word*: the utterance is clearly identifiable as a word and has a referential sense. Is not necessary to be completely well articulated, but at least 80% of the sounds must be similar to the sounds of the word in the adult language.
- *Imitation*: the utterance can be included in any of the previous categories, but it is produce after listening to the adult model (within the two subsequent seconds).

Gesture coding

For coding gestures, we took a broad perspective based in several previous studies about gestural development. The categories were defined as follows:

- *Prepoint*: adapted from Blake, O'Rourke and Borzellino (1994): index finger extended, others fingers lightly or tightly curled, arm not extended.
- *Point*: as defined by Leung and Rheingold (1981): extension of the arm and index finger

- *Reach*: as defined by Blake, McConnell, Horton and Benson (1992): arm is extended, palm usually down, hand open and fingers straight. Affect is usually neutral when used in this way.
- *Show*: as defined by Blake et al. (1992) holds up object to another, usually with elbow bent. There is movement of baby's arms, but object remains in baby's possession and resistance is met if another tries to take it.
- *Give*: adapted from Blake et al., (2005): Infant hands object to adult. There is movement of arms, and object changes hands.
- *Shaking*: limb flapping, often vigorous.
- *Ritualized requests*: as defined by Bates et al. (1979): arm extended, palm up.
- *Symbolic*: Adapted from Acredolo and Goodwyn (1988) gestures that symbolically represent objects, events, desires and conditions.
- *Enactive*: child develops part of an instrumental action to describe or communicate about the whole action.
- *Action imitation*: the child imitates part of an action previously developed by an adult.
- *Protest/rejection*: child pushes away an object or turns head or body away from another's approaching or offering object.
- *Conventional*: say hello or bye with the hands, clapping, etc.
- *Other*: any gesture observed not included in the previous categories.

Gaze coding

The use of gaze in every communicative behavior was coded as follows:

- *Object*: the child looks to the object while vocalizing or gesturing. There's no look to the adult within the three seconds following the communicative behavior.
- *Person*: the child looks to the adult while vocalizing or gesturing. There is not change of attention focus within the three seconds following the communicative behavior, the child can look to the object after looking to the adult, but he doesn't look to the adult again.
- *Alternate*: the child looks to the object, then to the adult and he looks again to the object or vice versa. Following the criterion of Carpenter, Nagell and Tomasello, (1998) this gaze alternation is no longer than three seconds.
- *Other*: the child looks elsewhere during communicative behavior or is not possible to establish where he is looking in this moment.

We considered categories *person* and *alternate* as reflecting a *social use of gaze*, while *object* and *other* categories were considered as reflecting *other uses of gaze*.

Multimodal combinations

Beside previous categories, we coded if the different communicative elements (gesture, vocalization, gaze) were used alone or otherwise they were included in the same communicative attempt. We established the following categories concerning the coordinated use of the different communicative resources:

- *Gesture only*: gesture is produced without vocalization neither look to the adult.
- *Vocalization only*: Vocalization is produced without gesture neither look to the adult.
- *Gaze only*: child alternates gaze between object and adult in a period no longer of three seconds.

GESTURAL-VOCAL COORDINATION AND EARLY LEXICAL DEVELOPMENT

- *Gesture + gaze*: gesture is produce with gaze to the adult. There's no vocalization in the second prior neither subsequent to gesture production.
- *Vocalization + gaze*: Vocalization is produce with gaze to the adult. There's no gesture in the second prior neither subsequent to vocalization production.
- *Gesture + vocalization*: there's an overlap of at least one second between gesture and vocal sound production, or one element is produce within the previous or subsequent second of the other element production. There is no look to the adult during the communicative attempt.
- *Gesture + Vocalization + Gaze*: there's an overlap of at least one second between gesture and vocal sound production, or one element is produce within the previous or subsequent second of the other element production. In any moment of the communicative attempt, or in the previous or subsequent second, gaze is addressed to the adult.