

Temporal alignment of prosody and gesture in Catalan-babbling infants

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In recent years, several studies have worked on the relation between gesture and speech in communicative acts, showing that both are tightly related (McNeill, 1992; Kita, 2000; Loehr, 2004). McNeill (1992) proposes a growth point, i.e. a minimal unit of an imaginery-language dialectic, a package that has both linguistic categorical and imagistic components. He gives five main reasons for the growth point: (1) gestures occur with speech in 90% of the cases, (2) gesture and speech are semantically and pragmatically co-expressive, (3) gesture and speech are phonologically synchronous, (4) gesture and speech develop together in children, and (5) also they break together in aphasia. Right after birth, children do not gesture in a communicative way. It is not until 0;8-0;10, coinciding with the development of intentionality, that children gesture to influence the mental state of others, producing deictic gestures such as pointing, giving, showing, or requesting. At around 1;0, children start reproducing actions associated with specific objects, called object-actions. From 1;4 to 1;8, children mostly produce pointing gestures and they start producing iconic gestures, which increase a lot between 3;0 and 5;0. And it is not until children are 5 years of age that they produce metaphoric gestures and beats (Bates, Camaioni & Volterra, 1975; Iverson & Goldin-Meadow 2005; Sansavini, Guarini & Stefanini, 2010; Tomasello, Carpenter & Liszkowsky, 2007). Some research in the field has focused on the temporal synchronization between gesture and intonation in adult communication (Bolinger, 1986; Kendon, 1980; Loehr, 1994). Whereas in adult communication most gestures were found to occur during speech, previous work suggests that it is not until the end of the one-word period that children primarily use gestures in combination with speech for communicative purposes, and that gesture and speech are temporally synchronized, i.e. that gestural strokes occur during or after the stressed syllable of the word they produce (Butcher & Goldin-Meadow, 2000). Yet, no studies have focused on the relation between prosody and gesture at the babbling period or on the precise temporal alignment between intonation peaks and gestural strokes at this period.

This study investigates the communicative acts where gesture and speech occur together at the babbling stage. To do this, two analyses were run: first, a pilot study with adults; second, an analysis of a corpus of four Catalan-learning children. In the adult analysis, 5 Catalan-speaking adults produced 240 occurrences of pointing gestures accompanied by speech. Results show that these speakers synchronized the stroke of the pointing gesture with the pitch accent in 98% of the cases, and that the pitch peak tended to align at the beginning of the stroke. In the children's analysis, all communicative acts produced when children were 0;11, 1;1, 1;3, 1;5, and 1;7 were classified as 'gesture-only', 'speech-only', or 'gesture-speech combinations'. Then, position of the pitch peak, position of the gestural stroke, type of speech act, and gesture type of deictic 'gesture-speech combinations' were analyzed. All meaningful words produced by children during the 30-minute recording session were also annotated to determine the lexical developmental points. Results showed that at 0;11, 'gesture-speech combinations' represent only 43,26% of the cases of the communicative acts containing gesture, whereas at age 1;1 they are already 54,8%, and this tendency is more evident in the late babbling and one-word stage (*see* figure 1). Chi-squared tests of independence were carried out in order to investigate whether these proportions differed significantly from each other across ages. Results showed that the proportion of gesture-only acts and gesture-speech combinations were statistically significant at 0;11 ($\chi^2(1, N=594)=10.774, p=.001$), 1;3 ($\chi^2(1, N=304)=17.053, p=.001$), 1;7 ($\chi^2(1, N=191)=31.642, p<.001$), almost significant at 1;1 ($\chi^2(1,$

$N=310$)=2.903, $p=.088$), and non-significant at 1;5 ($\chi^2(1, N=281)=0.801, p=.371$). Across ages, the statistical analyses revealed that the change in tendencies observed between 0;11 and 1;1 was statistically significant: ($\chi^2(1, N=477)=81.361, p<.001$) for gesture-only acts and ($\chi^2(1, N=427)=17.726, p<.001$) for gesture-speech combinations. The analysis of the alignment showed that in the late babbling stage most children produced pitch peaks while performing the stroke of the gesture (*see* figure 2), thus aligning adequately. A closer analysis showed that at the beginning of the babbling stage, the pitch peak tends to align at the end of the stroke, moving to the beginning of the stroke at the late babbling stage (*see* figure 3). In conclusion, gesture-speech combinations are more often produced than gesture-only acts already at the late babbling stage, and adequate alignment was shown to emerge in the late babbling and early one-word period (earlier than predicted in Butcher & Goldin-Meadow, 2000). Specifically, as the child turns into the one-word period, the f_0 peak is progressively aligned at the beginning of the stroke (as in the adult data). Thus, we claim that at the end of the babbling stage, temporal alignment between gesture and prosody starts being adult-like.

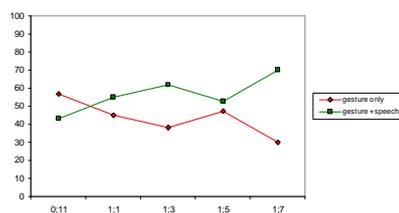


Figure 1. Longitudinal evolution of 'gesture-only' and 'gesture- speech combinations' communicative acts.

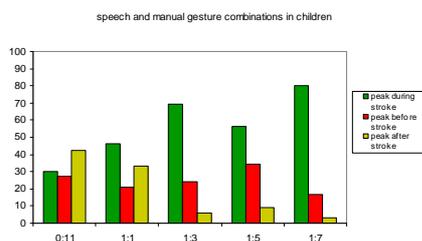


Figure 2. Evolution of the position of the pitch peak compared to the stroke.

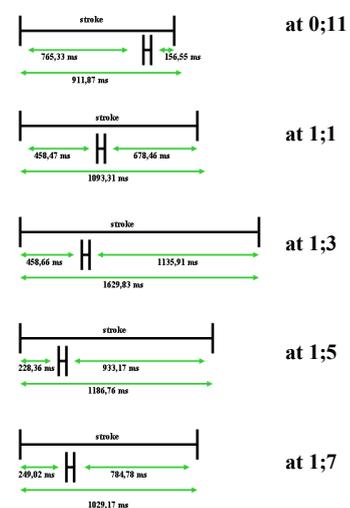


Figure 3. Longitudinal evolution of the alignment of the pitch peak and the stroke.

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