The Emergence of Tongue/Jaw Movements' Dissociation: A Cue for Articulatory Control Development

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Spontaneous mandibular movements would already be present during fœtal life. According to Vries *et al.* (1985) they would appear as from the 11th week of prenatal development, leading to the speculation that mandible would play an important part in orofacial movements.

At babbling stage, vocal productions are supposedly the result of mandible oscillation patterns (MacNeilage 1998), which could be the only active articulator. In other words, babbling productions may be physiologically constrained and based on simple oscillatory mechanisms that dominate the production system. The « Frame/Content » theory of MacNeilage assumes the dominance of mandibular activity at this stage and a limited implication of the tongue. Thus, a systematic intra syllabic correlation between consonants and vowels exists, resulting in several co-occurrence patterns. Initial position of the tongue would be maintained during several mandibular cycles. Experimental studies (Davis & MacNeilage 1995), for which babies' productions were transcribed from acoustical and video recordings, have confirmed the fact that bilabial consonants, such as [b], are primarily associated with [a], which can be produced with a quasi neutral tongue position, associated with jaw lowering, while coronal consonants, such as [d], mostly occur with front vowels like [e], and velar consonants mainly appear with back vowels like [u].

Thus, the language development process would imply the dissociation of tongue/jaw displacements with age. Green *et al.* (2000, 2002) posit that speech production maturation would result from an initial mandibular frame dominance, followed by a progressive differentiation of movement of the other articulators, and they have shown that the developmental pattern of lip movements would be integrated into a preceding and steady mandibular pattern, between 1 and 2 years.

To test this hypothesis, simultaneous acoustical and kinematic recordings were carried out on 15 subjects, between 8 months and 12 months of age. Jaw and the head movements were captured using Optotrak, and, since F2 is a good indicator of tongue position in the anterior-posterior dimension (Fant 1960), the second formant was measured.

During the segmentation protocol, simple jaw movements and simple tongue movements were extracted from babbling sequences. Each simple mandible movement corresponded to a raising or lowering mandibular gesture, and finding every simple lingual movement corresponded to detecting every change in tongue direction (*i.e.* in the anterior / posterior dimension), within this simple temporal mandibular interval. We expected to find less variation in tongue movement at an early stage of babbling, compared with the end of this period. In order to account for such a phenomenon, we calculated, for each association of simple movements obtained, the difference in Hertz between F2, at movement onset, and F2 at movement offset. The distance (mm), covered by the jaw in the same temporal interval was also measured. Further, we determined the ratio of these two variables (Delta F2/Delta jaw). The interpretation of such a parameter was the following:

The higher the ratio, the more important the tongue movement would be, relative to the jaw. Inversely, the lower the ratio, the more predominant jaw movement would be. The ratio's average was calculated for each subject, and the correlation between this ratio and age was established, in order to report on the progression of independence of tongue movement between 8 and 12 months.

Results seem to confirm our assumption and show the evolution of the independence of tongue and jaw trajectories. Lingual movements in the anterior-posterior dimension will be superimposed to the mandible's vertical displacements, with age.