Hand/Mouth Cooperation in Pointing-Naming Tasks

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INTRODUCTION

Manual gestures are omnipresent in spoken communication. A variety of gestures can accompany speech and they have been classified in different ways (*e.g.* McNeill, 2000; Kendon, 2004). Among these gestures, the pointing gesture holds a specific role as it is associated with a specific function of language: deixis. The connexion between speech and pointing is crucial in speech and language development (see, *e.g.*, Abry *et al.*, 2004; Pizzutto *et al.*, 2005; Goldin-Meadow, 2007;).

Levelt *et al.* (1985) first developed an experimental paradigm to study finger/voice coordination in deictic tasks (paradigm used and extended in Feyereisen, 1997). They compared the characteristics of the vocal production (voice onset) and of the gestural production in three production conditions: speech alone, gesture alone and speech + gesture. They found that finger/voice coordination mainly consisted in an adaptation of the voice onset to the pointing gesture which was very weakly affected by the simultaneous production of speech. These results were confirmed by Feyereisen (1997).

The aim of this paper is to present a working framework around the study of hand/mouth coordination in spoken communication using experimental investigations inspired from Levelt *et al.* (1985). Two recent studies on hand/mouth coordination in pointing-naming tasks will be presented as well as the paradigm of two undergoing experiments in the line of these studies. The preliminary results of these two latter experiments will be presented in this conference as well.

JAW/FINGER COORDINATION AND STRESS POSITION

This study (Rochet-Capellan *et al.*, in press) aimed at analyzing jaw/finger coordination in a pointing-naming task (PN) in which the stress position was varied across the two-syllables of a CVCV non-word (/pápa/ *vs.* /papá/). Twenty native Brazilian Portuguese speakers were tested. The task was to point and name a target at a go-signal. The position of the target was varied (near *vs.* far). In a second experiment running on the same subjects, the effect of the variation of the consonantal context of the target name was studied (*e.g.* /pata/ *vs.* /tapa/; see Rochet-Capellan *et al.*, 2007). An IRED tracking system (Optotrak) was used to capture jaw and finger motion.

When stress was on the first syllable, it appeared that the pointing apex was synchronized with the maximum jaw displacement of the corresponding syllable. When stress was on the second syllable, the pointing apex occurred half way between the two jaw apices and the return of the pointing gesture was synchronized with the maximum jaw displacement corresponding to the stressed syllable (second syllable). This coordination pattern was observed for both target positions (near *vs.* far) and for /papa/-/tata/ as well as /pata/-/tapa/ bisyllables. It resulted from two types of adaptations:

1. An online adaptation of the jaw to the pointing gesture: the jaw movement started earlier when the target was far rather than near (about 10 ms) and also when stress was on the second syllable rather than the first syllable (about 100 ms).
2. An offline finger adaptation: the variation of stress position did not influence the pointing gesture from initiation to apex, however the duration for which the finger pointed at the target (pointing plateau) was longer.

The main conclusion was that the two systems (hand and mouth) cooperate to achieve one goal: include the stressed part of discourse in the part of the gesture that shows. This study shows that there seems to be a tight hand/jaw coordination which serves communication purposes. It also confirms that the investigation of articulatory motion rather than only acoustic features such as voice onset could be more informative for understanding the processes of speech-hand coordination in communication.

INFLUENCE OF THE NUMBER OF SYLLABLES ON THE POINTING GESTURE

The task (pointing-naming) and the set-up used for the study described above were then used to investigate the effect of the variation of the number of syllables of the target name on jaw/finger coordination in pointing. The phonetic material used was simple: 1, 2 or 3 syllable (CV) words involving clear jaw motion, easily trackable using the optotrak apparatus. The study involved 10 native speakers of Brazilian (pilot study) and 15 native speakers of French. For the French group, kinematics of the pointing gesture in the pointing-naming (PN) task were also compared to the kinematics of the pointing gesture in a pointing-only (P) task. First detailed analyses of the kinematics of the pointing gesture (Rochet-Capellan *et al.*, 2008), show that the increase in the number of syllables slightly delays the timing of the pointing gesture towards the target. Surprisingly, the duration of the pointing stroke also tends to be shorter for 1- and 2- syllable words in the PN task compared to the P task. For both language groups, the main adaptation of the pointing gesture to speech is offline: it consists in the adaptation of the finger-target alignment duration which gradually increases with the number of syllables of the target name. These first results are strongly coherent with our previous data. They also suggest that speech could affect the pointing stroke, from initiation to apex. The question is now to understand if this effect is an interaction effect or the product of a tight collaboration of the hand and mouth systems. The changes observed for the pointing gesture in the PN task compared to the P task tend to show that speech could calibrate the pointing gesture (cf. shorter duration of both the pointing stroke and the pointing plateau in the PN task compare to the P task).

FURTHER QUESTIONS AND UNDERGOING STUDIES

The studies described above suggest that the hand and mouth systems tend to cooperate to achieve one common communicative goal. It seems that it is not only one system adapting to the other but the two systems really cooperating. This suggests that the coordination between hand and mouth in communication would not be “purely motor” but rather calibrated by the communicative situation. Of course, this has to be further studied especially in more ecological communicative situations (naturally inducing co-speech gestures) involving the production of more “complex” speech (utterances consisting of more than one word, discourse…).

This is the direction towards which we are heading in our current studies (Roustan & Dohen, 2008). We would like to address the questions of the dependency of hand/mouth coordination on the type of gesture produced and on its communicative function as well as its dependency on the structure of speech compared to the gesture (mapping of what the gesture shows and what speech shows). We designed an experimental paradigm aiming at comparing three gestures: pointing (communicative deictic gesture), beat gesture (communicative non-deictic) and button pressing (control gesture: non-communicative, non-deictic). The task was a correction task in which the speakers uttered a simple subject-verb-object (SVO) sentence. Correction on one of the constituents (S or O) was induced by an audio prompt depending on an audio prompt. The speakers were thus indirectly asked to produce prosodic focus on one of the constituents of the sentence. Two conditions were compared: speech only and gesture + speech. In the gesture + speech condition, the speakers were asked to produce a gesture of a given type (pointing, beat or control) at the same time as they spoke (no further indication was given on how and when the speakers should produce the gesture). Hand and mouth (jaw + lips) motion were captured using an Optotrak. Furthermore, two experiments were designed. In the first one, the element focused in speech exactly corresponded to the image the speakers were asked to point at (*e.g.,* focus on ‘Sarah’ and pointing at a picture of Sarah). In the second one, the element focused in speech corresponded to part of the image the speakers pointed at (*e.g.,* focus on ‘red’ and pointing at an image of a red ballon). The preliminary results of this study are described in Roustan & Dohen (2008).

The next step will be to compare coordination of hand and mouth in communicative interaction to examine whether coordination can be calibrated by communicative efficiency for example.

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