ABSTRACT
Our research deals with the relationship between voice and gesture during speech in an interview situation. In this study, we focus on rapid eyebrow movements during questioning. Eyebrow movements were recorded using a motion analysis system (ELITE) enabling computer reconstruction of the trajectories of small infrared retroreflective markers attached to the subject's skin. This kinematic data and the speech signal were analyzed on a Sparc SUN station. A classification based on all 150 question-answer pairs revealed recurrent rapid eyebrow movements. This kinesic marker was mainly located on answers, and appears to function as a speaking-turn onset signal which probably helps the speaker plan his/her verbal message. We also found this marker on questions (particularly during requests for confirmation), where eyebrow movements appear to emphasize the utterance's melodic curves and thus have a specific pragmatic function.

INTRODUCTION
The objective of the present study was to analyze eyebrow movements during questioning, in a corpus composed of interviews. Questioning is considered to be an interaction unit made up of two consecutive speech acts: (1) the question, where the speaker tries to obtain lacking information (request for information or RI) or confirmation of a presumption (request for confirmation or RC), and (2) the listener's answer, which is semantically, pragmatically, and prosodically related to the question [1], [2].

THEROREICAL BACKGROUND
It was assumed that eyebrow movements act as interrogative markers. According to Ekman and Friesen [3], eyebrow movements of the rise+hold type that are not associated with any face movement are treated as questioning facial emblems. They are frequently produced by the listener, while the speaker is talking, to silently express some question or doubt about the statement being made.

This marking function has also been demonstrated in the case of blind children who have never had any visual information [4], [5], and in sign language where eyebrow movements are part of interrogative structure marking in addition to other facial cues and signs [6], [7]. In the case of RIs, the eyebrows are raised during so called yes-no questions and lowered during wh-questions. It is also possible for signers to produce RC's by reversing the eyebrow configuration in yes-no questions. This deviating marking is used when the signer thinks he/she already knows the answer but would like the addressee to confirm.

Cosnier [8] contends that eyebrow movement is related to the different question types. It is regularly used in interactive questions (involved in the co-management of information), but it seems to be optional in informational questions, whose purpose is to obtain information about a referent that is external to the interaction.

Since Condon [9], we have known that a speaker's gestural system is coordinated from the inside. This "autosynchrony" hypothesis is also applied to intonation, insofar as a high pitch is often associated with a rise of the eyebrows, shoulders, hands, and arms [10],[11].

In prior experimental studies, we examined the relationship in speech production between rapid upward-downward eyebrow movements and variations in the fundamental frequency (F0) of the voice, especially in rhythmic prominence production [12] and in the interaction regulation process [13], [14].
EXPERIMENTAL PROCEDURE

The corpus consisted of seven dialogues between an interviewer and an interviewee, each lasting approximately five minutes. For each subject, vocal and gestural activity was recorded. We limited the present study to rapid upward-downward eyebrow movements located on question-answer pairs. Only those movements where both eyebrows moved simultaneously were retained for analysis. The eyebrow movements produced by the interviewees were analyzed using a motion analysis system (ELITE) enabling computer reconstruction of trajectories of small infrared retroflexive markers attached to the subject's skin [15]. The eyebrow movements produced by the interviewers were identified on videotape. The entire output data set was verified a posteriori by viewing the video documents.

HYPOTHESIS

Our hypothesis concerns the existence of a link between vocal and gestural activity during questioning. More precisely, eyebrow movement, as an interrogative marker, should contribute to the management of the interaction.

RESULTS

Eyebrows distribution

For the 150 question-answer pairs, eyebrow movements were present in 67% of the cases (27% were produced on questions and 40% on answers). They occurred much more often on RC's than on RI's (65% vs. 35%). This tendency was found on both the question and answers parts of the pairs (Figure 1).

These results confirm the presence of eyebrow movements during questioning between speakers. However, considering the large number of eyebrow movements on answers, their importance in the kinesic marking of questions is relative. Moreover, they show that pragmatic factors affect the occurrence of eyebrow activity. Our observations reveal a real difference between RC's and RI's, eyebrow movements being more frequent on RC's.

When producing an RC, the speaker tries to obtain (negotiate) the confirmation of a presumption. The relational dimension in this type of question plays a key role, which is in line with Cosnier's [8] ideas on interactive questions.

Temporal organisation

To relate the occurrence of eyebrow movements to the vocal production, the following two intervals were measured: the time between the onset of the vocal signal and the eyebrow movement, and the time between the eyebrow movement and the end of the vocal signal (Figure 2).

For the answers, the eyebrow-movement/end-of-vocalization interval averaged 2033 ms and the beginning-of-vocalization/eyebrow-movement interval averaged 400 ms. These averages take into account the data for a speaker whose interactive strategy was the opposite of the others. This speaker's data contributed to weakening the overall tendency exhibited by the majority of the subjects. The interval data as a whole showed that eyebrow movements occurred closer to the beginning of a vocal production than to the end. This effect was statistically significant (p=.0008). In addition, note that in 50% of the cases, eyebrow movement impulses were produced before the beginning of the speaker's verbal production.

For the questions, no significant tendencies were observed. This confirms the findings of previous studies on eyebrow movements as signals of the onset of a speaking turn [14]. Nevertheless, eyebrow movements during questioning introduce an interaction dynamic since, in this case, they mark a turn-taking change between two speakers.

Grant's studies [16] in human ethology have demonstrated different types of nonverbal behaviours during interviews. In particularly, he
showed that eyebrow raising is associated with "contact" sequences introduced by speakers. In illocutionary theory, speech acts are assumed to be in F(P) form, i.e., an illocutionary force, F, applied to a propositional content, P. An eyebrow movement is understood here to be the first element of the response, i.e., the acknowledgement of the illocutionary force of the question. It acts as a prime for the speaker's vocalization, which constitutes the second element of the response (reply to the propositional content). The time lapse between these two elements, associated with pauses or hesitations, would be a surface-level reflection of an underlying verbal-message planning mechanism.

**Pitch**

For the speaker's vocal production, the F0 contours were classified into six categories (Figure 3): rising-falling (RF), falling-rising (FR), plateau (P), rising (R), falling (F), and rising-falling-rising (RFR).

![Figure 3: F0 contours associated with eyebrow movements.](image)

We essentially found eyebrow movements on accented patterns. RF intonation contours, which were similar in shape to the eyebrow movement curves, were found for 45% of the movements. This confirms the link between gesture and voice, which does not appear to be specific to questioning. It seems instead to be a muscular synergy effect in disguise; the speaker facilitates message production by coordinating muscular tension.

In an earlier study [17] on RC's in French, we isolated the regular occurrence of a final melodic pattern with a circumflex-like shape. This shape was also observed in our corpus on RC's. Simultaneous analysis of the F0 and eyebrow activity curves of very expressive subjects pointed out occurrences where there was total synchronization between rising and falling eyebrow patterns and F0. This reinforcement of the melodic curve by gesture supports the conclusion that a final circumflex-shaped pattern could have an iconic value, achievable as much by voice as by gesture.

**CONCLUSION**

Considering eyebrow movement as a kinesic marker of interrogation seems unwarranted. Though its use in questions appears to be linked "upstream" to pragmatic and melodic factors, this link is not systematic. On the other hand, its use is clearly more regular in replies, where it serves as a turn-taking signal. However, our results should be considered with caution, for three reasons: (1) only one specific category of eyebrow movements was studied, (2) due to technical constraints only the interviewees were fit with the experimental device, which considerably reduced the number of curves where questions could be analyzed, and (3) the fact that the conversers' roles were predetermined may have led the interviewee to "erase" part of the kinesic information from his/her message.

**REFERENCES**


