

# Eyebrow raising and communication in Map Task dialogues

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## ABSTRACT

There is some evidence suggesting that eyebrow movements may have linguistic functions in communication, but research in this area has been scarce. This study tested the hypothesis that eyebrow raises (BRs) are unequally distributed across different types of conversational move, which may indicate they have linguistic communicative functions. Multiple regression analysis of six task-oriented dialogues between native speakers of British English showed that the variance in the distribution of BRs across moves was mainly explained by the duration of the move. Longer moves had more BRs and longer total brow raising. However, move type could also account for a significant part of the variance in the distribution of BRs. Instructions had significantly more BRs and longer total brow raising than other types of moves. There was also some speaker variation. Future analyses will look at the distribution of BRs across higher levels of dialogue structure. It is hoped that this research will eventually provide useful information for more efficient engineering of multimodal communication systems.

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## 1 INTRODUCTION

The study of facial movements has attracted the interest of researchers from many different fields. One aspect that has received special attention is the expression of emotion on the face. But the face also encodes more properly linguistic messages. The oral articulatory movements of speech production are concentrated on the lower part of the face and have been studied, for instance, in visual speech recognition and audiovisual speech perception. However, research on upper-face movements in connection with speech is still scarce. Gesture studies in communication have mainly concentrated on the movements we perform with our arms and hands as we speak (e.g. McNeill 2000). But some researchers have also emphasised the need to study faces in a similar way. One of the limitations to do this kind of research on facial movements has been the methodological difficulty of such studies. The current research is an attempt to investigate eyebrow raising in connection with speech from a communicative perspective.

There is some evidence for the linguistic functions of upper-face gestures. One area in which this has been investigated is the study of signed languages, where it is widely accepted that some of these non-manual markers are used to fulfil prosodic functions (Wilbur 1994; Corina 1989). Facial displays have been found to mark the introduction of a topic, and of certain clauses or questions. Obviously, the use of these displays with linguistic functions in signed languages is more systematised than it could be in the speech of hearing people. But it is

nevertheless important to note how upper face movements can substitute for the auditory suprasegmental cues that signers do not have. Evidence for linguistic functions of non-articulatory facial gestures has also been found in spoken language. Ekman (1979) pointed out how two of the brow actions described in the Facial Action Coding System (Ekman and Friesen, 1978) seem to have important linguistic roles, such as: giving emphasis to words and phrases, marking punctuation, and signalling questions. In a more detailed study, Chovil (1991/92) observed and described syntactic and semantic linguistic functions of facial displays in spontaneous dialogues. Of the syntactic displays the most common were eyebrow movements that served as emphasisers and question markers. Looking at eyebrow movements in particular, Cave *et al.* (1996) compared the curves of rapid rising-falling eyebrow movements with the fundamental frequency curves of the accompanying speech. They found that eyebrow movements and fundamental frequency changes were not automatically linked, suggesting that they were not the result of muscular synergy, but rather a consequence of linguistic and communicational choices. Other studies have shown that the eyebrow raises of a Dutch computerised talking head may have a significant effect on the perception of focus in the accompanying synthetic speech (Krahmer *et al.*, 2002a,b). As these researchers have pointed out, it would be useful to study this phenomenon in natural speech and real faces.

In short, there have been some studies suggesting the linguistic functions of eyebrow movements but there is not enough knowledge about the way in which these gestures are combined with speech. This lack of information becomes a limitation in the design of multimodal communication systems. This paper presents a preliminary study of the relationship between different types of conversational move and the distribution of eyebrow raises. The hypothesis was that eyebrow raises are unequally distributed across different types of conversational move, suggesting that they have communicative functions. The aim of the project is to provide some information about audiovisual speech production that could be used as a guideline for more efficient engineering of multimodal communication systems.

## **2 METHOD**

### **2.1 Materials**

#### **2.1.1 Corpus**

Four female native speakers of British English, university students in their early twenties, were videorecorded performing a collaborative task, namely the Map Task (Anderson *et al.* 1991). In the Map Task, two participants, the Instruction Giver and the Instruction Follower, sit opposite each other with slightly different versions of a simple map. The Giver's map has a route and a set of landmarks, whereas the Follower's has only landmarks. Their task is to reproduce the route on the Follower's map. Since their sets of landmarks are not quite identical and they cannot see each other's map they have to negotiate in order to reach the Finish Point. There were a total of eight dialogues in which four different maps were used. Each participant served as a Giver for the same map to two different Followers and as Follower for two different maps. The current analysis only includes three of the speakers in the role of Giver participating in six dialogues. All of them were videorecorded with a frontal view of their head and shoulders.

### **2.2 Annotation**

The start and end points of conversational game moves were annotated on the time-line of the dialogue. Eyebrow raises were marked in a similar way. Both annotations are discussed below.

### 2.2.1 Conversational Game Moves

Move annotation, the lowest level of dialogue structure as described by Carletta *et al.* (1997), was performed for all dialogues using Xwaves and xlabel from Entropic. A conversational move is an utterance or part of an utterance in the dialogue that can be classified according to its purpose in the communicative task. The types of move known as *ready* and *clarify* in Carletta *et al.*'s coding scheme were not annotated in this study. Also, in order to get sufficient numbers of cases, move types were grouped into larger categories as follows:

<i>Carletta et al.(1997)</i>	<i>Current study</i>
Instruct	<b>Instruct</b>
Explain	<b>Explain</b>
Query-yn	<b>Query</b>
Query-w	
Check	<b>Align/Check</b>
Align	
Reply-y	<b>Reply</b>
Reply-n	
Reply-w	
Acknowledge	<b>Acknowledge</b>
Unclassifiable	<b>Unclassifiable</b>

### 2.2.2 Eyebrow movements

Rising eyebrow movements were annotated on the time-line of the dialogue using *SignStream* (MacLaughlin *et al.* 2000). These included raises with one or both eyebrows. The start point was marked where the first upward displacement was observed when advancing the movie file frame by frame. The end point was placed where the downward movement finished. Information about the extent to which the eyebrows were raised was not recorded.

### 2.3 Sample size

The data in the current analysis comes from three speakers, in the role of Giver, participating in six dialogues with a mean duration of 369 sec. There were a total of 718 moves from which *unclassifiable* moves were removed, yielding 697 moves for the analysis: 305 *Instruct*, 110 *Acknowledge*, 120 *Reply*, 68 *Explain*, 65 *Query* and 29 *Align/Check*.

### 2.4 Dependent variables

Two measures were used to assess the distribution of eyebrow raises (BRs) across the dialogue moves:

1. **number of BRs** per move, counting 1 for a complete BR inside a move, and 0.5 for a BR that started within the move but finished outside, or a BR that started before the move but finished inside it.
2. **total BR duration** per move, adding up the duration of all eyebrow raising occurring within a move.

## 3 RESULTS

Figures 1a and 1b show the results of a two-way ANOVA with *number of BRs* as the dependent variable and *move type* and *speaker* as factors. The names of move types below the bars have been abbreviated to their first one or two letters. Overall there was a significant difference in the number of BRs across the different types of move ( $F(5,679) = 22.085$ ;  $p < .001$ ). The significant pairwise differences ( $p < .05$ ) were as follows:

*Instruct* > *Acknowledge*  
*Instruct* > *Query*  
*Instruct* > *Reply*  
*Explain* > *Acknowledge*

where *Instruct* moves had significantly more BRs than *Acknowledge*, *Query* and *Reply* moves; and *Explain* moves had significantly more BRs than *Acknowledge* moves. There was also a significant interaction between *move type* and *speaker* ( $F_{(10,679)} = 2.518, p < .05$ ).

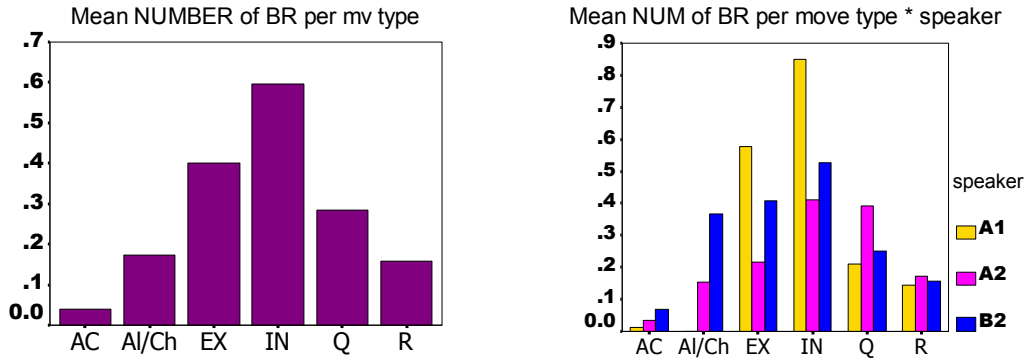


Figure 1(a) Number of BRs per move type      Figure 1(b) Number of BRs per move type and speaker

Figure 2 shows the distribution of *total BR duration* per move type. There was a significant main effect of *move type* on BR duration ( $F_{(5,679)} = 24.706, p < .001$ ). The significant pairwise differences ( $p < .05$ ) were:

*Instruct* > *Acknowledge*  
*Instruct* > *Explain*  
*Instruct* > *Query*  
*Instruct* > *Reply*

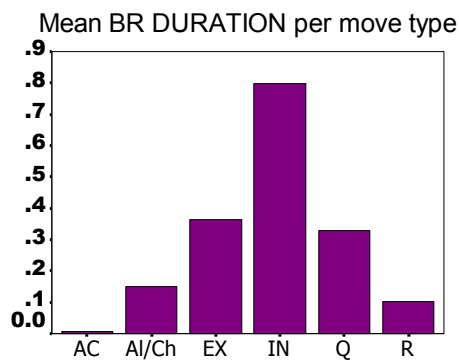


Figure 2. Total BR duration across move types

These results indicate that BRs are unequally distributed across different move types. In particular, *Instruct* moves have more and longer BR than other move types. Multiple

regression analyses, described below, were carried out to investigate further which factors other than move type might account for the distribution of BRs across moves.

Table 1 presents the results of the first multiple regression analysis with *number of BRs* per dialogue move as the dependent variable. The resulting model accounted for 23% of the variance in the number of BRs across moves. The duration of the move was the main predictor, followed by one speaker (*A1*) and the *Instruct* type of move. The standardised coefficients under Beta show the independent contribution of each predictor to  $R^2$ .

<b>R = .476 R<sup>2</sup> = .227</b>		
<b>Predictors</b>	<b>Beta</b>	<b>Sig.</b>
Move duration	.399	.000
Speaker <i>A1</i>	.109	.001
<i>Instruct</i> type	.116	.003

Table 1. Regression results for *Number of BRs*

In Table 2 we find the results of a multiple regression analysis with *total BR duration* in each move as the dependent variable. The model accounted for 28% of the variance across moves. The main predictor was again move duration, followed by *Instruct* type and Speaker *B2*.

<b>R = .533 R<sup>2</sup> = .284</b>		
<b>Predictors</b>	<b>Beta</b>	<b>Sig.</b>
Move duration	.426	.000
<i>Instruct</i> type	.139	.000
Speaker <i>B2</i>	.098	.003

Table 2. Regression results for *Total BR duration*

The main predictor for both number and duration of BR is the duration of the dialogue move. The *Instruct* move type and one of the speakers can also predict a smaller but statistically significant amount of the variation.

#### 4 DISCUSSION

This study tested the hypothesis that eyebrow raises (BRs) are unequally distributed across different types of conversational move, which in turn may suggest that they have communicative functions. The alternative hypothesis was that BRs were a random phenomenon and therefore they would occur more frequently in longer utterances. Move duration was indeed the most successful predictor of both number of BRs and total BR duration per move. That is, the longer the move the more BRs and longer brow raising activity it has. This would seem to support the null hypothesis. However, when move duration was controlled for, the *Instruct* move type also predicted a smaller but statistically significant proportion of the variance in the distribution of BRs. *Instruct* moves had more BRs and longer total brow raising than other types of move. There was also some speaker variation: one speaker produced significantly more BRs per move than the other speakers; another speaker raised her eyebrows for significantly longer periods of time than the other speakers.

These results are still preliminary. It is necessary to investigate further what may cause *Instruct* moves, and longer moves in general, to have more BRs. *Instruct* moves carry the most important information in these task-oriented dialogues. To achieve their common goal of accurately drawing the route on the follower's map, the speaker must make sure that her instructions are clear and effective. Perhaps eyebrow raises help to emphasise the most important information and are addressed in this way to the listener. Or perhaps they are a mechanic result of production processes and are not so much directed to the listener, even if the latter has learned to interpret them, but instead reflect the speaker's effort at organising her speech into a particular structure. The next analysis will investigate the distribution of BRs across higher levels of dialogue structure, namely games and transactions (Carletta *et al*, 1997). Future research will look at the alignment of BRs with gaze directed at the interlocutor and with pitch accents.

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