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# *Mixed Signals: Combining Linguistic and Affective Functions of Eyebrows in Questions in Sign Language of the Netherlands*

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## **Key words**

*emotion*

*facial expressions*

*intonation*

*prosody*

*sign language*

## **Abstract**

The eyebrows are used as conversational signals in face-to-face spoken interaction (Ekman, 1979). In Sign Language of the Netherlands (NGT), the eyebrows are typically furrowed in content questions, and raised in polar questions (Coerts, 1992). On the other hand, these eyebrow positions are also associated with anger and surprise, respectively, in general human communication (Ekman, 1993). This overlap in the functional load of the eyebrow positions results in a potential conflict for NGT signers when combining these functions simultaneously. In order to investigate the effect of the simultaneous realization of both functions on the eyebrow position we elicited instances of both question types with neutral affect and with various affective states. The data were coded using the Facial Action Coding System (FACS: Ekman, Friesen, & Hager, 2002) for type of brow movement as well as for intensity. FACS allows for the coding of muscle groups, which are termed Action Units (AUs) and which produce facial appearance changes. The results show that linguistic and affective functions of eyebrows may influence each other in NGT. That is, in surprised polar questions and angry content question a phonetic enhancement takes place of raising and furrowing, respectively. In the items with contrasting eyebrow movements, the grammatical and affective AUs are either blended (occur simultaneously) or they are realized sequentially. Interestingly, the absence of eyebrow raising (marked by AU 1+2) in angry polar questions, and the presence of eyebrow furrowing (realized by AU 4) in surprised content questions suggests that in general AU 4 may be phonetically stronger than AU 1 and AU 2, independent of its linguistic or affective function.

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## 1 Introduction

Signed languages are the natural languages of the visual-gestural modality. They are perceived visually and produced not only by the hands, but also by the upper body, head, and face.<sup>1</sup> Besides differences in the modality of production and perception, to a large extent signed languages parallel spoken languages in their grammatical structures, their acquisition, and their processing (see for example the papers in Meier, Cormier, & Quinto-Pozos, 2002). At the phonological level, signed languages show suprasegmental patterns similar to the prosodic organization of spoken languages (Nespor & Sandler, 1999; Sandler, 1999; Wilbur, 2000). The prosodic hierarchy of Nespor and Vogel (1986; Ladd, 1997) has been argued to surface in the structure of signed languages as well (Nespor & Sandler, 1999). Although prosodic phonetic cues in signed language can be found in both the manual and the nonmanual domain, facial expressions in particular seem to parallel spoken language intonation, in that they spread across signs. These facial expressions are systematically associated with linguistic meaning in signed languages (Sandler & Lillo-Martin, 2006). However, as in spoken communication (Keltner, Ekman, Gonzaga, & Beer, 2003), the face also conveys paralinguistic meanings such as affect in communication among signers (Campbell, Woll, Benson, & Wallace, 1999; McCullough, Emmorey, & Sereno, 2005). Hence, the face can carry both linguistic and paralinguistic information in signed languages. This fact resembles the multiple functions of prosody in spoken language where intonation expresses paralinguistic information as well as grammatical functions (Ladd, 1997; Scherer, 1986; Scherer & Johnstone, 2003; van Bezooijen, 1984). The role of prosody in signed language and prosody in spoken language thus lead to similar types of linguistic questions: how can linguistic and paralinguistic functions be distinguished based on formal and functional properties, and do they interact? The present study addresses the latter question in investigating the use of eyebrows in Sign Language of the Netherlands (Nederlandse Gebarentaal, NGT).<sup>2</sup>

Eyebrow positions serve various grammatical functions in NGT (Coerts, 1992). They are furrowed in content questions and raised in polar questions. In fact, this particular use of the eyebrows is found in other signed languages as well (Baker-Shenk, 1983, for American Sign Language (ASL); Bergman, 1984, for Swedish Sign Language (SSL); Kyle & Woll, 1985, for British Sign Language (BSL)). Eyebrow position is not the only marker of these different sentence types in NGT; there are various cues to indicate a question. In most content questions there will also be a manual *wh*-sign, and in questions in general the use of eye gaze appears to be an important cue (looking at the interlocutor or a referent created in the discourse). Moreover, in polar questions the head is often tilted. However, most of these features have not been systematically investigated for NGT.

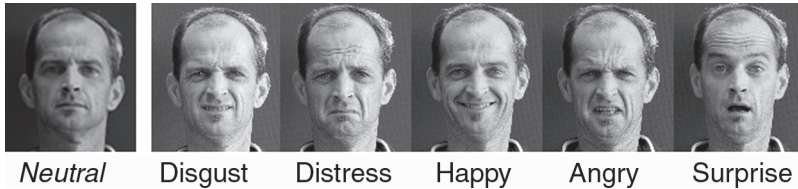
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<sup>1</sup> In the sign language literature, manual articulators are distinguished from nonmanual articulators. The nonmanual articulators of signed communication include facial expressions, body movements, head orientation, and eyegaze.

<sup>2</sup> For an overview of literature on Sign Language of the Netherlands see Crasborn (2001).

**Figure 1**

Five out of seven basic emotions and their facial expressions compared to a neutral facial expression



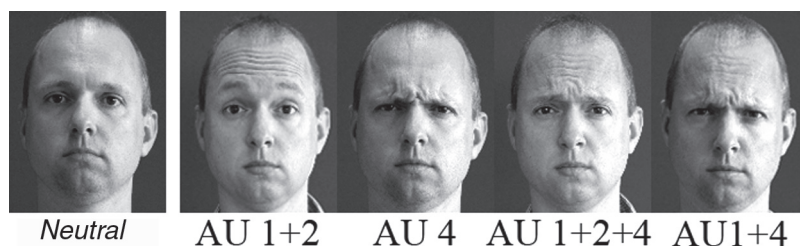
In addition to their linguistic functions in NGT, facial expressions, including eyebrow movements, are also important in expressing emotions in general human communication (Darwin, 1872; Ekman, 1979, 1993; Izard, 1977; Russell & Fernández-Dols, 1997). In fact, there is a widespread universality hypothesis in the psychological literature, claiming there is a basic subset of emotions that can be found in every culture (Frijda, 1986). What is more, these so-called basic emotions are universally expressed in similar ways, and thus cross-culturally identifiable (Ekman, 1973, 1993; Izard, 1994). This idea of universal facial expressions goes back to work of Charles Darwin who collected large-scale comparative surveys from missionaries on the perception of emotional facial expressions of dispersed human societies (Darwin, 1872).<sup>3</sup> Figure 1 illustrates the facial expressions of five of the seven basic emotions as suggested by Ekman (1973, 1993). The eyebrows play an important role in these facial expressions. Relevant for the current study are the expressions of surprise and anger. In the expression of surprise eyebrows are raised, and in the expression of anger they are furrowed. These facial expressions are also used in affective signing in ASL (Baker-Shenk, 1986; Reilly, McIntire, & Seago, 1992). Based on the extensive literature on universal facial expressions, we assumed for this study that NGT signers would use the same facial expressions as well; the concrete independent evidence we have for this is the realization of NGT lexical items for basic emotional states such as angry ('boos') and surprised ('verbaasd') in the online reference lexicon of NGT (Nederlands Gebarententrum, 2002), which are indeed accompanied by the predicted facial expressions. In other words, signers use universal facial expressions to indicate affect in NGT.

Paul Ekman and his colleagues developed the Facial Action Coding System (FACS) that allows coding of all visually distinguishable facial expressions (Ekman, Friesen, & Hager, 2002). FACS groups muscle activity into so-called Action Units (AUs) that bundle uniquely identifiable facial movements; the articulatory basis of

<sup>3</sup> Interestingly, Darwin hypothesized that the existence of universal emotional facial expressions could be explained from an evolutionary perspective. For example, raised eyebrows would signal a request for more information because of its adaptive value: it enlarges one's visual field. While this kind of adaptive explanation seems plausible for surprise, and even the raised eyebrows in signed polar questions, it evidently does not provide an explanation for the use of furrowed eyebrows in signed content questions. It thus seems that this kind of functional explanation may not hold for conventional linguistic functions.

**Figure 2**

Five eyebrow positions relevant to this study



these can thus be the activity of one or multiple muscles. Three AUs are relevant in the production of eyebrow movements: AU 1, the Inner Brow Raiser; AU 2, the Outer Brow Raiser; and AU 4, the Brow Lowerer. They may be used individually or simultaneously in varying combinations. These combinations of AU are described in FACS separately, because the appearance changes they bring about are different from the sum of changes that each AU independently brings about. Although logically possible, a combination of AU 2 and 4 is rarely found (Ekman et al., 2002), nor is it present in our data. Including a neutral brow position, there are thus a total of seven eyebrow positions described by FACS. The five relevant to this study are shown in Figure 2.

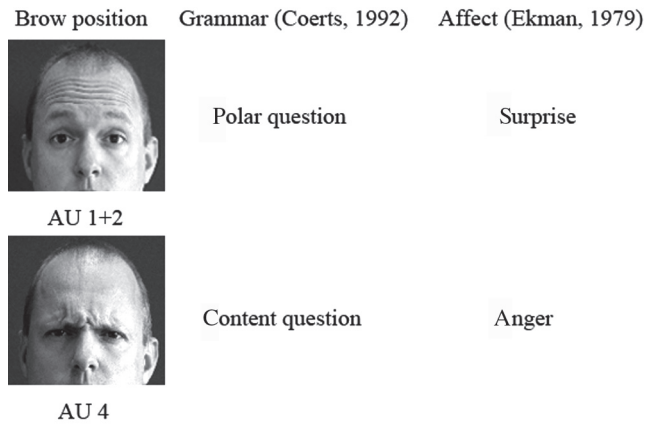
The main advantage of using FACS is that it is anatomically based, which allows for culturally neutral comparison. However, it is also extremely time-consuming to learn and use. For this reason, it was not used to describe eyebrow movements in NGT in the work of Coerts (1992). Instead, Coerts (1992) used categories such as “up” and “down” from the Edinburgh Non-manual Coding System.<sup>4</sup> We thus had to interpret these coding categories in terms of AUs in order to compare her findings to our results. “Down” in Coerts’ work was interpreted as AU 4, and “up” as AU 1+2.

These same eyebrow positions are employed for the expression of emotion. AU 4 is associated with anger, and a configuration of AU 1+2 is associated with the expression of surprise (Ekman, 1973, 1979). Figure 3 depicts a schematic overview of the use of both the linguistic and affective functions of eyebrows. In the left column the AUs and the resulting eyebrow position are shown. The middle and right rows indicate which linguistic and affective function is associated with each eyebrow position. The fact that both linguistic and affective functions are associated to the same eyebrow positions results in a potential phonetic conflict for NGT signers. For example, in an angrily signed polar question, is the eyebrow position formed by AU 1+2 only, thus linguistically marking the question, or by AU 4, thus expressing anger, or perhaps by AU 1+2+4, as a simultaneous expression of both functions?

<sup>4</sup> The Edinburgh non-manual coding system (ENCS) was developed by Colville, Denmark, Mason, Denmark, & Brennan (1984) in order to code for actions in signed communication that are not produced by the hands.

**Figure 3**

Identical brow positions serve linguistic and affective functions in NGT



Although the same muscles (AUs) are used in affective and linguistic use of eyebrows, it has been argued that they are distinct in their formal properties such as scope, onset, and apex (Corina, Bellugi, & Reilly, 1999; Wilbur, 2003). First of all, while linguistic facial signals are hypothesized to align with phrasal boundaries within the signed sentence, affective facial signals may spread over longer periods of conversation and not line up strictly with phrasal boundaries. The rationale behind this is that because of their linguistic function, linguistic nonmanuals are generated by prosodic linguistic domains; therefore they should align relatively closely with linguistic units such as signed phrases. In contrast, AUs that express affective meaning would not be expected to align with linguistic units, as the expression of emotional states (whether real or acted) is not considered to be part of the linguistic meaning. Thus, their scope is not determined by linguistic boundaries, even though they might occasionally align in time. Second, the onsets and offsets of affective expressions are thought to be more gradual compared to the abrupt appearance changes in a linguistic facial expression (Baker-Shenk, 1983). A further hypothesized difference in form is that with linguistic nonmanuals the intensity of the facial expression rises suddenly to its peak and stays constant before again going down abruptly. Affective facial expressions on the other hand would have less constant apexes, and their intensity varies over time (Liddell, 1980). The only study we know of that actually tests these hypotheses for any signed language is Baker-Shenk (1983). In fact, some of these hypothesized differences in form between the linguistic and affective use of facial expressions are not supported by her findings for ASL. For example, the nonmanual linguistic signal in her data was generally at apex level before the initiation of the first manual sign in the sentence (Baker-Shenk, 1983, p.267). We found the same phenomenon in the data collected for the present study: in many items the linguistic facial expression was already in place before the first manual sign started. Recent research on Israeli Sign Language (ISL) shows that other formal cues such as the number of facial muscles (AUs) involved in a facial expression may more reliably distinguish between affective and linguistic

facial expressions (Dachkovsky, 2005). We suggest that there is also a semiotic reason to distinguish both communicative uses of the eyebrows. That is, when brow movements are used paralinguistically, form and meaning can relate in a gradient way. For example, someone can express surprise to varying degrees by accordingly raising or lowering the intensity of AU 1+2. In contrast, the marking of questions by AU 1+2 is interpreted categorically: something is either a question, or not. How to distinguish linguistic and paralinguistic intonation remains an important issue in (sign) linguistic research (Gussenhoven, 2004).

Baker-Shenk (1983, 1986) shows that the AUs related to ASL content questions and polar questions can be influenced by the display of affect in dialogues. Among other things, she found rhetorical questions, normally marked by AU 1+2, in which a configuration of AU 1+4 occurred. In the expression of affect, this configuration of AU 1+4 is normally associated with the expression of distress (Ekman, 1979). Accordingly, Baker-Shenk (1986) attributed the use of AU 1+4 in these questions to the expression of distress. She also found that the intensity levels of AU 1+2 are higher in polar questions that express surprise than in the neutral cases. She concludes that affective facial expressions may thus either enhance the intensity level of facial expressions, or change the facial components that are used (Baker-Shenk, 1983, p.265, 1986). The expression of affect thus results in a combination of AUs or in different intensity levels. An alternative explanation for the AU 1+4 found in the rhetorical questions is that it shows the display of distress only. In parallel, the intensity level of AU 1+2 in the surprised polar question may have been caused by surprise alone. That is, due to the gradient nature of the expression of affect, these instances may have been displaying only affect, but at a higher intensity level.

We thus hypothesized that the expression of affect may *override* the linguistic signal. We will refer to this as the “Affect over Grammar” hypothesis. The possibility that the affective signal may be more important in sign than the linguistic facial expression was shown for ASL motherese, in which mothers refrain from using AU 4 in content question until children are ready to identify its linguistic function (Reilly & Bellugi, 1996). We tested the Affect over Grammar hypothesis for NGT questions systematically by comparing question sentences with the same lexical semantics, but different affective load. We elicited various question types combined with various affect displays from NGT signers and coded them using FACS (Ekman et al., 2002).

## 2 Methodology

### 2.1

#### Participants

Two native Deaf<sup>5</sup> signers agreed to participate in this study. They were selected by a Deaf colleague whom we asked to look for expressive native signers in order to ensure

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<sup>5</sup> Deaf with capital “D” refers to the cultural notion of being deaf, i.e., using a signed language as preferred mode of communication and being part of the Deaf community in the sense of going to Deaf clubs, having signing friends, etc. In contrast, when deaf is spelled with lowercase “d” it refers to the audiological state: persons who cannot hear (Lane, 1984; Reagan, 1995).



that they would not be shy in acting out emotions. He did not explicitly mention our interest on eyebrows or facial expressions but told participants the study concerned the way emotions are expressed in NGT. Both men are born, raised, and still living in the same area around Amsterdam, the same area our confederate signer was born and raised in. All three of them are friends and have known each other for most of their lives.

All participants are born into Deaf families where they acquired NGT as their native language. The confederate signer, and Participants 1 and 2 were aged 38, 38, and 36 at the time of recordings. The confederate signer works as a research assistant in NGT research and as a sign language teacher. Participants 1 and 2 are vocational workers without special linguistic training. They all went to the same Deaf school in Amsterdam, receiving mostly oral education. All three are members of the Deaf community: they have Deaf friends, go to Deaf meetings and visit Deaf sport clubs. The participants thus form a homogenous group and they use the same variant of NGT.

## 2.2

### Materials

The NGT stimulus items were based on translations of Dutch sentences that aimed at eliciting NGT polar questions, content questions, topic sentences, and declaratives. The sentences do not contain complex semantics. The confederate signer translated 40 written Dutch sentences into NGT. They were evenly distributed across four sentence types: polar questions, content questions, topic sentences, and declarative sentences. The latter two types of sentences are not further discussed here. The 10 content questions were translated from written Dutch into 20 signed sentences; 10 had the wh-sign at the beginning of the sentence and 10 were signed with the wh-sign at the end of the sentence.<sup>6</sup> This resulted in a total of 50 signed sentences.

We asked our confederate signer to sign the stimulus sentences in a neutral manner, without any specific affect. The signer then reviewed the video recording and judged the neutrality of his signed sentences. A few sentences had to be filmed again, because they contained some affective expression according to the signer's own judgment. The recordings resulted in signed utterances containing on average 3.7 signs in sequence, with a standard deviation of 1.0 sign. Appendix 1 presents the 30 stimulus questions that are analyzed in the present study.

## 2.3

### Data elicitation

We filmed the signers with two mini-DV video cameras (PAL). One of the cameras covered the whole signing space (i.e., from head to hips); the other one was used to make a close-up recording of the face. The signer viewed the videotaped sentences, and was instructed to repeat it with a specific expression of affect that was presented

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<sup>6</sup> The purpose of recording two sets of wh-questions varying in the position of the wh-sign lies in a separate line of research and is not relevant in this context. For the current investigations we treated both variants of the wh-questions on a par as they both display the same grammatical use of AUs.



afterwards in text in the video window. The stimulus set contained sentences and affect instructions in random order, yet was manipulated to prevent identical sentences or identical affects occurring in sequence. The participant was facing another signer who was standing behind the camera. This allowed for a somewhat interactional setting which was kept constant during the experiment and across participants. The semantically neutral sentences (see Appendix 1) ensured that shared knowledge about a topic or presuppositions on the familiarity of a topic would not interfere with the facial expression of the signer. The goal was to let the emotional intent solely stem from the instruction to combine a certain facial expression with as neutral sentence content as possible.

## 2.4

### Data annotation

The recordings were annotated using the ELAN annotation software, which allows the user to add time-aligned text annotations to video and audio files.<sup>7</sup> In this computer program, annotations are made on different tiers related to a timeline, and the user can add tiers at will. For a better view the videos can be enlarged. The video can be watched at any speed, and also frame by frame; there are 25 video frames per second in the PAL video recordings we used.

Because it is a phonetically-based coding system that is independent of the actual function that facial actions may serve, FACS was used for coding the data. Ekman (1979), for example, used it to describe brow movements during speech as conversational signals. Moreover, it was proven useful for descriptions of facial behaviors in ASL (Baker-Shenk, 1983, 1986).

The first author studied the FACS manual for AUs 1, 2, and 4 and did self-assessments tests until she had reached FACS proficiency for those particular AUs. She annotated the appearance changes caused by AU 1, 2, and 4 in the “brows” tier. While annotating, only the signer’s face was visible. This was done because the manual signs and body movements might otherwise influence the annotator’s expectations on the AU that would be used. Each item was examined at least twice; first at 30% speed to scan the location of any facial events, and then the video was inspected frame by frame to select the time segment for each distinct eyebrow position. We annotated only those parts of the video recording that contained the relevant items; this amounted to approximately 24 minutes of annotated video in total. The annotation of the data using FACS took approximately 120 hours (the transcription ratio was thus 1:300).

The first author coded the stimulus items, the yes/no questions, and both kinds of content questions in FACS. She coded for each of the seven possible brow positions. AU 1 and AU 2 did not occur independently in the data set, nor did a combination of AU 2+4. Asymmetrical occurrences of brow positions were not coded for.

FACS allows for coding of intensity of an AU at five levels. The A level refers to a trace of the action; B to slight evidence; C to marked or pronounced; D to severe

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<sup>7</sup> ELAN is open-source software that is freely available for academic use from <http://www.lat-mpi.eu/tools/elan>. For more information on ELAN see Brugman & Russell (2004), Crasborn & Sloetjes (2008), and Wittenburg, Brugman, Russell, Klassmann, & Sloetjes (2006).

or extreme; and E to maximum evidence. Whereas Baker-Shenk (1983, 1986) used a three-level system in her study of ASL, we used all five intensity levels, A–E to code for the intensity of each AU. Intensity level E in FACS 2002 is equal to intensity level “z” in FACS 1978 used by Baker-Shenk (1983).

## 2.5

### Reliability

In order to test the reliability of the annotation codes, we randomly selected 25 elicited items for each participant’s recordings and coded them a second time. The items used for this check amount to approximately 15% of the total number of coded items. We did not have access to a second coder for this reliability check, since FACS coding proficiency takes a lot of time and effort to acquire. The annotator followed the same procedure as described above, but made the original “brows” tier invisible during annotation so that initial annotations would not interfere. Reliability for the type of facial event (e.g., 1+4, 1+2+4) was 92% for both participants’ items. Coerts (1992) reports an intracoder reliability of 83% in the eyebrows using the ENCS transcription system (Colville et al., 1984). Considering that FACS is a more fine-grained coding system, the intracoder agreement in this study is comparatively high. Baker-Shenk (1983) reports on intercoder agreement level on classification of AUs of 80% using FACS (Ekman & Friesen, 1978). In those cases where the type of facial event was coded correctly, the reliability for intensity level was 60%. The Investigators’ Guide reports on reliability of intensity of 55% (Ekman et al., 2002). It may thus be the case that the criteria FACS puts forward to distinguish the five intensity levels are not sufficient to get a higher reliability.

## 2.6

### Validity

Although the participants found the imitation task of the elicitation experiment easy to do, the data from this elicitation study are not instances of spontaneous natural language. In contrast to Baker-Shenk’s (1986) study we chose an experimental set-up because it allowed us to be sure which emotion was actually intended. However, using elicited language data always raises questions of validity. That is, were the elicited sentences really successfully expressing this affective load? In order to get an assessment of the validity of the data, a perception study was done. From the recordings of Participants 1 and 2, we selected 40 sentences that were recorded during the elicitation task, evenly distributed over sentence types and emotional states. The sample included eight yes/no questions, eight content questions with the wh-sign in sentence-final position, eight content questions with the wh-sign sentence-initially, and eight declarative sentences. For each sentence type we included two sentences from each of the neutral, surprised, angry, and concerned realizations.

Three different deaf signers viewed the whole-body recording of these sentences and were asked to mark on a form one of four emotional states: neutral, anger, surprise, and concerned. They were given the option of writing down a different emotional state. Signers were given the option of viewing the sentence once or twice more, if they were not immediately sure about their judgment. In 27.5% of the sentences all three participants identified the intended emotion; in 14% of the sentences, two of the participants

correctly identified the intended emotion; in 6%, only one participant identified the intended emotion. This resulted in an overall correct response of 38.75%. This is far above chance level, which would be at 20% for this task. Notably, participants chose to make use of the fifth category for “other emotion” in 7% of the responses, showing that they were highly motivated in doing this task as accurately as possible.

### 3 Results and analysis

Our study aimed at investigating how NGT signers combine the expression of anger and surprise with the linguistic use of eyebrows in content questions and polar questions. In general, we found more variation in nonmanual marking in NGT questions than previous studies have reported (Coerts, 1992). This may to a certain extent be due to the more fine-grained coding system used at present. Overall, our data do not support the Affect over Grammar Hypothesis. Instead, we will argue on the basis of the data that, in general, AU 4, independent of its linguistic or affective status, is phonetically stronger than AU 1+2. In the next sections we discuss the results and our analysis in more detail.

#### 3.1

##### General results

All occurrences of AUs are presented per item and per respondent in Appendix B. In Table 1, the results are summarized. The percentages of occurrences are given across items and for both signers. The elicited emotions are presented in rows and the two question types are in the columns. In the headers, the AUs are listed that are correlated with the various categories according to the literature: AU 1+2 for the marking of polar questions and surprise, and AU 4 for marking of content questions and anger. For neutral affect, no additional use of eyebrow movements were expected. The boldface AU 4 refers to a relatively high intensity level.

First of all, it appears that the neutral sentences were not all marked by the expected AUs. We found that polar questions are marked by the expected AU 1+2 in two-thirds of the cases, but that AU 1+2+4 was used in as much as one-third of the cases. Likewise, the neutral content questions did not all display the expected AU 4, but were produced with AU 1+2 in 36% of the cases. Also, combinations of AU 1+2 and 4 occurring simultaneously and/or sequentially were frequently found. These sequential and/or simultaneous combinations within a single sentence include occurrences of AU 1+2 and AU 4, as well as occurrences of AU 1+2+4, in sequence with AU 1+4, AU 4 and/or AU 1+2. See Appendix B for details per item.

While the observed neutral realizations of grammatical markers of sentence type did not all conform to the expectation, we did find a significant difference in the pattern of AUs that were used for the neutral versus the surprised and the angry realizations, both for polar questions and content questions. Comparing the use of the three patterns AU 1+2, AU 1+2+4, and AU 4, a chi-square test showed a significant difference in the use of the patterns between angry and neutral polar questions (Fisher's exact test = 12.808,  $p < .001$  for Participant 1, Fisher's exact test = 12.808,  $p < .001$  for Participant 2). Neutral polar questions are predominantly articulated with AU 1+2, while angry content questions are predominantly articulated with AU 4. Comparing these same

**Table 1**

Results: AUs used in response items, combined for both participants

	<i>Polar questions</i> <i>AU 1+2 Coerts (1992)</i>	<i>Content questions</i> <i>AU 4 Coerts (1992)</i>
Neutral <i>No additional brow movements</i>	AU 1+2 (67%) AU 1+2+4 (33%)	AU 1+2 (36%) AU 4 (23%) Sequential and/or simultaneous combinations of AU 1+2+4 (26%) Neutral brow position (15%)
Anger <i>AU 4</i> <i>(Ekman, 1979)</i>	<b>AU 4 (78%)</b> Sequential and/or simultaneous combination of AU 1+2+4 (22%)	<b>AU 4 (72%)</b> Sequential and/or simultaneous combinations of AU 1+2+4 (23%) AU 1+2 (3%) Neutral brow position (2%)
Surprise <i>AU 1+2</i> <i>(Ekman, 1979)</i>	AU 1+2 (58%) Sequential and/or simultaneous combination of AU 1+2+4 (25%) AU 1+2+4 (17%)	Sequential and/or simultaneous combination of AU 1+2+4 (68%) AU 4 (16%) AU 1+2 (16%)

three patterns for content questions, there was a significant difference between angry and neutral (Fisher's exact test = 14.515,  $p < .001$  for Participant 1, Fisher's exact test = 18.623,  $p < .001$  for Participant 2). Here, neutral content questions showed use of AU 1+2 or AU 1+2+4, while angry content questions were strongly associated with AU 4 by itself.

Most of the angry polar questions (78%) and angry content questions (72%) were signed with AU 4. For the angry content questions, the intensity level of all AUs was raised in comparison to the neutral content questions. An analysis of variance with signer and emotion as fixed effects showed this to be a significant effect for emotion,  $F(1, 67) = 30.907, p < .001$ , with additionally a significant effect for respondent,  $F(1, 67) = 8.736, p < .01$ , as well as for the interaction of respondent and emotion,  $F(1, 67) = 8.405, p < .01$ ; Participant 2 was found to be most pronounced in his use of AU 4 for anger. Similarly, as we predicted, the intensity levels of AU 1+2 appeared to be raised in surprised polar questions in comparison to the neutral items, but this effect was not significant,  $F(1, 67) = .687, p < .5$ . In Table 1, the significantly raised intensity level is marked in bold.

In the following sections we discuss how these results invalidate the Affect over Grammar Hypothesis.

### 3.2

#### **A possible influence of stimulus items?**

Appendix A presents all stimulus items and the AUs used in these by the confederate signer. There one can observe that not all stimulus items had brow positions consistent with the predicted pattern for neutral questions: AU 1+2 for polar questions, AU 4 for content questions. One might therefore wonder whether variation in brow positions in the response items by Participants 1 and 2 may have been due to variation in the stimulus set. However, only in two out of nine neutral polar questions (items 1 and 3) the AU used in the stimulus item corresponded with the AU used by both respondents. Hence, the AUs used in the response item could not predict the use of brow position for either of the participants. In the neutral content questions there was no exact overlap in the AUs used between the two respondent items and those in the stimulus set. What is more, there was no overlap between the uses of AUs within the ten different respondent items either. Hence, the “deviant” patterns in the stimulus items did not seem to rigidly bias the use of AUs by Participants 1 and 2.

### 3.3

#### **Brow movements for neutral questions: Free variation and semantics**

We identified two eyebrow positions marking neutral polar questions in our data, namely AU 1+2 and AU 1+2+4. We did not find polar questions with neutral eyebrow positions; the responses to the one stimulus item in which AU 4 was used was excluded from further analysis (item 6 in Table B1). Based on Coerts' (1992) study of NGT we expected for neutral polar questions to find a brow raise using AU 1+2. The occurrence of AU 1+2+4 was not predicted as Coerts (p.201) reports on only a single occurrence of brows “up, inner corner down,” which we interpreted to be the equivalent of AU 1+2+4. However, Coerts (1992) used a simpler coding system (ENCS: Colville et al., 1984), which normally distinguishes between just three brow positions: neutral, down, and up. It may be the case that ENCS creates a bias to include occurrences of AU 1+2+4 either in the down or up category. Whether Coerts used a systematic categorization with respect to AU 1+2+4, or “up, inner corner down” is not clear. Since Coerts (1992) did not control for the display of affect, we cannot exclude this as another explanation for the differences we find with our results either. It may thus also be the case that a higher percentage of AU 1+2 was present in her data, not for marking polar questions, but displaying surprise.

The occurrence of AU 1+2+4 in neutral polar questions was not predicted by previous NGT literature, nor has it been reported by Baker-Shenk (1983, 1986) for ASL. The occurrences of AU 1+2+4 in our data set are all the more surprising because this eyebrow position is normally associated with the universal facial expression for fear (Ekman, 1979). To test whether this configuration of AU 1+2+4 is associated with fear in NGT as well, we showed these instances of polar questions marked by AU 1+2+4 to the confederate signer. He could not see that there was any additional emotion intended to be expressed by the signer. Even when we suggested that fear may be expressed, he did not confirm. His response suggests that using conventionalized facial expressions in a signed language may override universal tendencies to interpret these same expressions as an indicator of emotion. Our informant could not think of a difference in meaning between the polar questions using AU 1+2 or AU 1+2+4. Hence, it seems that AU 1+2 or AU 1+2+4 may be free phonetic variants of a category “brow raise” in NGT.

According to Coerts (1992), furrowed eyebrows prosodically mark neutral content questions in NGT. Her conclusion is only partly supported by the stimulus content questions of the present experiment. First of all, there was one item in which AU 9 (a nose wrinkle) was used while AU 4 was absent. We did not systematically annotate this AU, but this anecdotal observation may suggest that there is a relation between these AUs. Secondly, there was one item in which AU 1+2 was used (item 1 of the content questions with a sentence-final wh-sign). Moreover, in some cases AU 4 was either sequentially or simultaneously combined with AU 1+2. What is more, the neutral content questions of the two respondents show even more variation. There are in fact three frequent patterns that appear in the response items: AU 4 alone, AU 1+2 alone, or a combination of them. This spreading of various brow positions is found to be independent from the type of wh-sign and the position of the wh-sign in the sentence. There were both sequential and simultaneous combinations of AU 4 and AU 1+2 in the response items; parts of the utterance were marked by AU 1+2, others by AU 4, again others by AU 1+2+4. Coerts (1992) also describes the occurrence of brow raise during content questions in her data, and associates these with topics and conditionals at the beginning of the utterance. However, we did not see these kinds of structures in the stimulus items for the content questions. Hence, this cannot explain the variation in the nonmanual marking of content questions in our data either.

The literature on NGT suggests that the occurrence of brow raise in a content question is rare (Coerts, 1992), but recent research on other signed languages reports similar language-internal variation, for example in Japanese Sign Language (JSL) (Morgan, 2006). Variation in nonmanual marking of questions is suggested to be linked to pragmatics and signer's attitude (Baker-Shenk, 1986). For example, the expression of impatience may cause brow raise in content questions in JSL (that otherwise exhibit lowered brows) as suggested by Morgan (2006). We tested whether impatience may also be expressed in the NGT content questions by presenting our informant with the same sequence of signs with either AU 4 or AU 1+2. See examples (1) and (2) below. The capitalized words represent manual signs; the line above represents the timing of the eyebrow movements while the manual signs were produced. These sentences are the NGT translation of the JSL content questions as presented by Morgan (2006). In response to these NGT sentences, our informant suggested that while the content question with lowered brows is a felicitous information request, the version with raised brows narrows down the range of possible answers. Thus, rather than expressing impatience, the brow raise in example (2) may indicate a restricted set of referents, namely people present at the scene. Hence, for NGT using AU 1+2 content questions seems to have a semantic function, rather than a display of impatience.

(1)

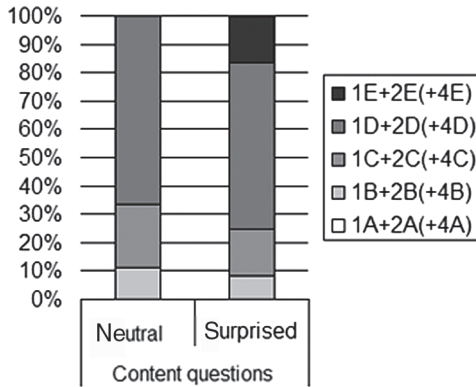
	AU4
-----	
WHO	LECTURE
	‘Who is presenting?’

(2)

	AU1+2
-----	
WHO	LECTURE
	‘Who of you is presenting?’

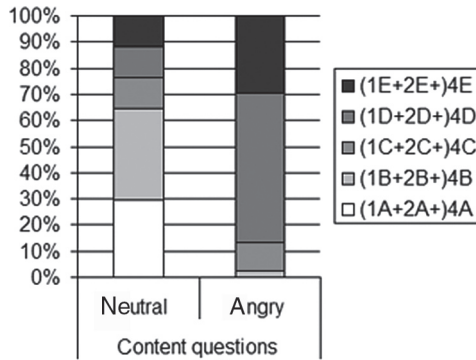
**Figure 4**

Intensity levels of AU 1+2 in neutral and surprised polar questions



**Figure 5**

Intensity levels of AU 4 in neutral and angry content questions



More empirical research is needed to determine when these different markers of content questions occur and what the range of semantic properties is that they can express.

### 3.4

#### Higher intensity levels in surprised polar questions and angry content questions

In the surprised polar questions and angry content questions, an effect of phonetic enhancement was found. That is, when the same AUs were used for affective as well as for linguistic functions, intensity levels of the affective items were raised compared to the neutral items. In the stimulus items, all polar questions involved a brow raise. This is illustrated in Figure 4. Note that the categories included intensity levels of instances of AU 1+2+4 as well as AU 1+2. Baker-Shenk (1983) found the same effect of the expression of surprise in ASL polar questions. That is, AU 1+2 were at the highest intensity level in polar questions that also expressed surprise.



Similar to phonetic enhancement of AU 1+2 in the surprised polar questions, intensity levels of AU 4 in the angry condition are enhanced compared to the neutral content questions. Figure 5 presents the distribution of intensity levels of AU 4 in neutral and angry content questions. These frequencies are based on the highest intensity level of AU 4 in the sentence.

The raised intensity levels in surprised polar questions and angry content questions suggest that the phonetic cue of the linguistic function is enhanced by the affective use of the same cue. This is similar to the phenomenon of phonetic enhancement found in the interaction of tone and intonation in tone languages (Gussenhoven, 2004). There is, however, an alternative explanation of our findings. Affective facial expressions are gradient in nature—one can be angry to varying degrees, and this can be reflected in facial expression. There likely is no “default level” of each emotional state in a given human being, let alone that there is a universal default “intensity” of a corresponding facial expression. The participants in this experiment may thus have expressed surprise and anger at high intensities, leading to higher intensities of their facial expressions at the cost of any linguistic marking. This would then support the Affect over Grammar Hypothesis. We could test this hypothesis with a perception experiment. For instance, we could ask a native signer to rate the intensity of the emotion. If these ratings correlate with the intensity levels of the relevant AUs in surprised polar questions (AU 1+2) and angry content questions (AU 4), then there is reason to assume that the raised intensity levels reflect emotion at various levels, without necessarily being the result of expressing two functions at the same time (a combination of linguistic marking of questions *and* emotion). If that would indeed be the case, the Affect over Grammar Hypothesis would be supported. However, as we shall discuss below, the Affect over Grammar Hypothesis in its purest form cannot be maintained, based on the use of AUs in other sentence types.

### 3.5

#### **The Affect over Grammar Hypothesis**

The Affect over Grammar Hypothesis predicts that the affective signal always overrides the linguistic signal. The raised intensity levels in surprised polar questions as well as the angry content questions do not lead us to dismiss this hypothesis. However, the results from different sentence groups show that the Affect over Grammar Hypothesis in its present form cannot be maintained. First of all, in 22% of the respondent items the linguistic use of AU 1+2 in the polar questions was not overridden by the affective use of AU 4 to express anger. More strikingly, in 84% of the surprised content questions the linguistic use of AU 4 does not disappear at the expense of the affective use of AU 1+2 to express surprise. Rather, we find AU 1+2 to be *combined* with AU 4 in sequential and simultaneous configurations in 68% of the sentences. Looking closely at the occurrences of AU 1+2+4 in these surprised content questions, a pattern arises that is rarely found in the other sentence types. AU 4 is used at a lower intensity level than AU 1+2 in these configurations. The linguistic signal of the eyebrows is thus influenced by the affective signal, but not completely dominated by it. In conclusion, the many configurations of AU 1+2+4 in surprised content questions, and sequential occurrences of AU 4 and AU 1+2 are counter-evidence for the Affect over Grammar Hypothesis. In contrast to the angry polar questions, in which the linguistic use of

AU 1+2 disappears at the expense of the affective use of AU 4 in 78% of the cases, the linguistic use of AU 4 to mark content questions is not overruled by the expression of surprise by AU 1+2. From these facts we conclude that it is not the affective versus linguistic status of the brow position that determines its dominance. In the next section we suggest an alternative explanation of the findings.

### 3.6

#### **An alternative explanation: The phonetic strength of AU 4**

If it had been the case that affect displays override the linguistic signal put forward by the eyebrows, one would have predicted the tendency of AU 1+2 to disappear in the angry polar questions. However, such an analysis is inconsistent with the fact that in the surprised content questions AU 4 is present in 84% of the items. We conclude that AU 4 is stronger than AUs 1 and 2, irrespective of its origin in the linguistic specification of the utterance or the affective expression of the signer. In other words, it is a kind of “phonetic strength” or “phonetic weight” rather than the function that determines the states of the eyebrows in signers. At present we do not know what actually might be the background of this difference, but we can see two possible directions of research to further investigate this phenomenon.

If it is true that AU 4 is indeed stronger than AU 1+2 for some articulatory reason, it is predicted that for signers of other signed languages too, this will play a role in their use of eyebrow movements. The little evidence we have stems from research by Baker-Shenk (1986) on ASL and supports this hypothesis. When ASL signers combine AU 1+2 for rhetorical questions with AU 1+4 for the expression of distress, it is only AU 1+4 that remains. Research from other fields of research, for example on the properties of facial musculature, may help test the hypothesis put forward in the present study. Alternatively, it may be the case that the strength of AU 4 is a property of the phonetic implementation module that is specific to the above languages. Cross-linguistic research will be necessary to investigate these alternatives, in addition to phonetic research on the articulation of eyebrow muscles.

## 4 Conclusions

This article offers a first exploration of how the different roles of the eyebrows in NGT may interact. In particular, it shows that the display of affect can influence the linguistic use of eyebrows in NGT questions. What is more, the extent to which brow movements are influenced differs per sentence type and per emotion. The influence of the affective signal on the linguistic use of eyebrows does not influence the grammaticality of the sentence (cf. Reilly & Bellugi, 1996, for ASL). The data show that neither linguistic use, nor affective use of the brow movement is dominant, and the Affect over Grammar Hypothesis cannot be maintained. Rather, the results comply with the idea of relative “phonetic strength” of the various muscle groups (AUs). Hence, phonetics rather than the linguistic or paralinguistic function of eyebrow movement appears to be a dominant factor in NGT.

We showed that the effects of affective load might alter the position of the eyebrows corresponding to the linguistic function, highlighting the fact that paralinguistic functions of nonmanual articulators are not to be overlooked when investigating signed

language prosody, even though they have received very little attention in the study of signed languages. This overall result presumably extends to other lines of research concerning nonverbal communication, co-speech gesture, and visual prosody in face-to-face communication by speakers. That is, in looking at visual-gestural aspects of spoken languages both linguistic and paralinguistic functionalities need to be considered.

This present study raises several new questions. First of all, what is the nature of the “phonetic strength” of the AU 4 that was identified in this study: is it a matter of universal properties of eyebrow articulation or of language-specific phonetic implementation? Secondly, do other nonmanual articulators that are used for linguistic purposes in NGT and in other signed languages show the same complex interaction with their potential paralinguistic functions? And if so, are there articulatory actions that are stronger than others, irrespective of their function? In the present study, we combined affective and linguistic functions of eyebrow positions, but it would be interesting to study conflicting linguistic uses as well. For example, head position is used for many (grammatical) purposes in NGT (e.g., Coerts, 1992; van der Kooij, Crasborn, & Emmerik, 2006; see also Wilbur, 2000, for ASL), and these can potentially conflict.

Another line of investigation concerns the set of articulators that, next to the eyebrows, provide clues for the expression of affect in NGT. The data that were collected for this study can be exploited for the investigation of other (prosodic) cues for affective meaning as well. For example, are there manual prosodic cues associated to the expression of emotions? If so, it would be interesting to see how these prosodic cues interact with the functions of the eyebrows. For example, when an angry yes/no question is signed with AU 4, do other articulators take over the explicit marking of the question? And if so, how do they do it? The same type of pay-off may also be the case in spoken interaction. For example, to what extent are for example eyebrow movements used for linguistic purposes, supporting or supplementing information in the spoken utterance? We already know of the use of eyebrows as conversational signals accenting constituents from work by Ekman (1979). Krahmer and Swerts (2004) demonstrate the importance of eyebrow movements in the perception of focus in Italian and Dutch. Moreover, Joutiteau (2004) argued for the multi-channeledness of syntax in signed and spoken languages based on evidence showing the use of eyebrows by speakers of Atlantic French in sentence-initial position when a subject is missing. This type of research, showing the importance of visual cues in spoken language, possibly provides a bridge across the long-assumed gap between signed and spoken communication. As language emerged in face-to-face communication, vocalizations must have always co-occurred with visual cues. The present study shows that in the visual-gestural domain one needs to take into account both linguistic and paralinguistic communicative signals.

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**Appendix A: Transcription of the stimulus items (confederate signer)**

Yes/no questions

1. 1+2  
COME-ALONG  
“Are you coming along?”
2. 1+2+4  
INDEX<sub>2</sub> BROTHER DEAF INDEX<sub>2</sub>  
“Is your brother deaf?”
3. 1+2+4  
INDEX<sub>2</sub> CAR BREAK INDEX<sub>2</sub>  
“Is your car broken?”
4. 1+2+4  
INDEX<sub>3b</sub> DRIVE INDEX<sub>3b</sub>  
“Is he driving?”
5. 1+2+4  
INDEX<sub>2</sub> HUNGRY INDEX<sub>2</sub>  
“Are you hungry?”
6. 4  
INDEX<sub>2</sub> TIRED INDEX<sub>2</sub>  
“Are you tired?”
7. 1+2  
INDEX<sub>2</sub> HAPPY INDEX<sub>2</sub>  
“Are you happy?”
8. 1+2+4  
INDEX<sub>2</sub> BIKE <sub>2</sub>COME<sub>1</sub>  
“Did you come by bike?”
9. 1+2+4  
INDEX<sub>2</sub> WALK HERE  
“Did you walk over here?”
10. 1+2+4  
INDEX<sub>2</sub> DEAF INDEX<sub>2</sub>  
“Are you deaf?”

**Wh-questions (wh-sign sentence-final)**

PU is the gloss used for the palm-up gesture, which function as a general question sign. AU 9 is a so-called “nose wrinkle.”

1. 1+2  
TOGETHER GO-TO WHERE  
“Where are the two of us going to?”
2. 4 1+2+4  
INDEX<sub>2</sub> DRIVE WHY  
“Why are you driving?”

(Continued)



**Appendix A:** (Continued)

3.  $\frac{4}{\text{INDEX}_2 \text{ DO WHAT PU}}$   
“What are you doing?”
4.  $\frac{4 \quad 1+2+4}{\text{PRESENTING WHO PU}}$   
“Who is presenting?”
5.  $\frac{4}{\text{INDEX}_2 \text{ WANT WHAT PU}}$   
“What do you want?”
6.  $\frac{9}{\text{MAN}_{3a} \text{ SAY } 1 \text{ ON}_2 \text{ WHAT PU}}$   
“What did that man say to you?”
7.  $\frac{1+2+4}{\text{COME-ALONG WHO PU}}$   
“Who is coming along?”
8.  $\frac{4}{\text{INDEX}_2 \text{ DONE INDEX}_2 \text{ HOW PU}}$   
“How did you do that?”
9.  $\frac{4}{\text{INDEX}_2 \text{ DO WHY/PU}}$   
“Why did you do that?”
10.  $\frac{4 + \text{searching eye gaze}}{\text{DONE INDEX}_{2(\text{that})} \text{ WHO PU}}$   
“Who did that?”

**Wh-questions (wh-sign sentence-initial)**

1.  $\frac{4}{\text{WHERE TOGETHER GO-TO}}$   
“Where are the two of us going to?”
2.  $\frac{4}{\text{WHY DRIVE INDEX}_2}$   
“Why are you driving?”
3.  $\frac{4}{\text{INDEX}_2 \text{ WHAT DO PU}}$   
“What are you doing?”
4.  $\frac{4}{\text{WHO PRESENTING}}$   
“Who is presenting?”
5.  $\frac{4}{\text{WHAT WANT INDEX}_2}$   
“What do you want?”

(Continued)



**Appendix A:** *(Continued)*

- 
- |     |  |  |
|-----|--|--|
| 6.  | 4  |  |
|     | WHAT MAN SAY <sub>1</sub> ON <sub>2</sub>      |  |
|     | “What did that man say to you?”                |  |
| 7.  | 1+2 4  |  |
|     | WHO COME-ALONG                                 |  |
|     | “Who is coming along?”                         |  |
| 8.  | 4  |  |
|     | HOW INDEX <sub>2</sub> DONE INDEX <sub>2</sub> |  |
|     | “How did you do that?”                         |  |
| 9.  | “doen dat” 4                                   |  |
|     | WHY DO PU                                      |  |
|     | “Why did you do that?”                         |  |
| 10. | 4  |  |
|     | WHO DONE INDEX <sub>2,3b</sub>                 |  |
|     | “Who did that?”                                |  |
- 

**Appendix B: Results (Participants 1 and 2)**

A dash in the tables below marks the absence of any eyebrow AU. The absent items (empty cells) were excluded from analysis for various reasons: in some cases, sentences were produced disfluent or with an articulation error, in other cases there was a suspicion that the eyebrow position may have originated from an adverbial expression. Please see de Vos (2006) for more information on each case.

**Action Units used in yes/no questions****Table B1**

AUs used in neutral yes/no questions

<i>Sentence number</i>	<i>Participant 1</i>	<i>Participant 2</i>
1	1B+2B	1C+2C
2	1D+2D	1D+2D
3	1C+2C+4C	1D+2D+4B
4	1C+2C	1D+2D+4B
5	1D+2D+4D	1D+2D
6		
7	1D+2D+4D	1D+2D
8	1C+2C+4B	1D+2D
9	1D+2D	1A+2A, 1B+2B
10	1D+2D	1D+2D

**Table B2**

AUs used in surprised yes/no questions

<i>Sentence number</i>	<i>Participant 1</i>	<i>Participant 2</i>
1	1C+2C, 1E+2E	1D+2D+4D, 1D+2D
2	1D+2D	
3	1C+2C, 4B, 1B+2B	
4		
5	1C+2C, 4E	1C+2C+4C, 1D+2D+4D
6		
7	1E+2E	1C+4C, 1D+2D+4B
8		
9	1B+2B	1D+2D+4A
10	1D+2D, 1B+2B, 1C+2C	1D+2D

**Table B3**

AUs used in angry yes/no questions

<i>Sentence number</i>	<i>Respondent 1</i>	<i>Respondent 2</i>
1	1D+2D+4D	4D
2	4B	4B, 4D
3	4E	4D
4	4A	4D
5	4E	4D
6		
7	4C	4D
8	1B+2B, 4B	1C+2C, 1C+4C, 1B+2C
9	4A	4D
10	1D+2D+4D, 4D	4D

**Table B4**

AUs used in neutral wh-questions with sentence-final wh-sign

<i>Sentence number</i>	<i>Participant 1</i>	<i>Participant 2</i>
1	1C, 1C+2C, 1B+2B	1B+2B, 1D+2D
2	1B+2B, 1C+2C, 1B+2B	1C+2C
3	1D+2D+4D	4A
4	4C, 4B	4A, 1D+2D
5	1C+2C	4B
6	–	4D
7	1C+2C	1D+2D
8	1D+2D, 4E, 4D	1B+2B
9	4A, 1C+2C, 1D+2D	–
10	–	1C+2C

**Table B5**

AUs used in angry wh-questions with sentence-final wh-sign

<i>Sentence number</i>	<i>Participant 1</i>	<i>Participant 2</i>
1	4E, 4B	4D
2		4D
3	4E, 4C	4D
4	1C+2C, 4D, 1C+4C, 4B	4E, 4D
5	4E, 1C+2C	4D
6	4C, -, 4B	4D
7	4E	4E
8	1+2B, 4B, 4A	4D
9	4D, 1C+2C	4D, 1C+4C
10	-	4D, 4C

**Table B6**

AUs used in surprised wh-questions with sentence-final wh-sign

<i>Sentence number</i>	<i>Participant 1</i>	<i>Participant 2</i>
1	1E+2E, 4C, 1C+2C	1C+2C+4B
2	1B+2B, 1D+2D, 1B+2B, 4B	1D+2D
3	1D+2D+4B	1C+4C, 1D+2D+4D
4	1D+2D+4C	1C+2C
5	1B+2B, -, 1C+2C	1D+2D+4B
6	1D+2D	4C, 4B
7	1C+2C, 4C, 4B, 4A	1C+2C+4B, 1D+2D, 1C+2C+4A
8	4A, -	1B+2B+4B
9	1D+2D+4C, 1B+2B+4B	4D, 4C
10	1E+2E, 4C, 1C+2C	1C+4C

**Table B7**

AUs used in neutral wh-questions with sentence-initial wh-sign

<i>Sentence number</i>	<i>Participant 1</i>	<i>Participant 2</i>
1	1C+2C	4B
2	1D+2D, 1B+2B, 1C+2C	-
3	1C+2C, 4A	-
4	4D	-
5	1C+2C	4A
6	4C	4B
7	1D+2D	1D+2D+4B, 1B+2B
8	1D+2D	1B+4B, 1B+2B+4B
9	1D+2D, 4E	1B+2B, 1B+2B+4B
10		1A+2A

**Table B8**

AUs used in angry wh-questions with sentence-initial wh-sign

<i>Sentence number</i>	<i>Participant 1</i>	<i>Participant 2</i>
1	4E,4B	1C+2C
2	1C+4C, 4D, 4C	4D
3	4B, 4C, 4B	4D
4	1D+2D+4D, 4D	4E
5	4C, 4B	4D
6	4E	4D
7	4E, 1C+2C+4C	4D
8	4E	4D
9	1C+2C+4C, 1D+2D, 1C+4C	4D
10	4D	4D, 4C

**Table B9**

AUs used in surprised wh-questions with sentence-initial wh-sign

<i>Sentence number</i>	<i>Participant 1</i>	<i>Participant 2</i>
1	1D+2D, 4E	4D
2	1C+2C, 4D	1C+4B, 1C+2C+4B
3	1C+2C, 4D, 4B	1D+2D+4B
4	1D+2D, 4E, 1C+2C	1D+2D+4B, 4B
5	4C, 1D+2D	1D+2D+4A
6	4C	4A
7	1D+2D, 1B+2B	1D+2D+4C
8	1B+2B	1C+2C+4C
9	1C+2C, 4E, 4D, 4C	
10	1C+2C+4B, 4D	