

Mixed Signals

*Combining Affective and Linguistic functions
of Eyebrows
in Sign Language of the Netherlands*

Connie de Vos

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Department of Linguistics
Radboud University Nijmegen

Supervisors:
Dr. O. Crasborn
Dr. E. van der Kooij

Second reader:
Dr. Helen de Hoop

Table of Contents

Acknowledgements	iv
Tables and Figures	v
Glossing Conventions	viii
Abbreviations of Sign Languages	ix
Samenvatting	x
Summary	xi
1 Introduction	1
1.1 Sign Linguistics	1
1.2 Nederlandse Gebarentaal	2
1.3 Prosody	3
1.4 Combining affective and linguistic functions of eye brows	4
1.5 Thesis outline	5
2 Affective and linguistic functions of eyebrows	6
2.1 Affective facial expressions	6
2.1.1 Basic emotions and universal facial expressions	6
2.1.2 Facial Action Coding System	7
2.1.3 Position of eyebrows in a neutral face, anger, surprise, and distress	8
2.1.4 Differences in form between affective and linguistic facial expressions	8
2.2 Linguistic non-manuals in Nederlandse Gebarentaal	9
2.2.1 The form of non-manuals	9
2.2.1.1 Body position and orientation	10
2.2.1.2 Eye gaze, and head position and orientation	10
2.2.2 The linguistic functions of non-manuals	10
2.2.2.1 Lexical mouthings	10
2.2.2.2 Morphological mouthings	11
2.2.2.3 Syntactical non-manuals	11
2.2.2.4 Pragmatic non-manuals	12
2.3 Linguistic functions of eyebrows	14
2.3.1 Linguistic functions of eyebrows in ASL	14
2.3.2 Linguistic functions of eyebrows in NGT	14
2.4 Combining linguistic and affective functions of eyebrows	15
2.4.1 Surprise and distress in ASL question signals	16
2.4.2 Affective prosody in ASL motherese	16
2.4.3 Combining affective and grammatical functions of eyebrows	16
2.4.3.1 Non-manual layering	17
2.4.3.2 Hypotheses	18

3 Methodology	19
3.1 Research question	19
3.2 Elicitation study	19
3.2.1 Participants	20
3.2.2 Materials	20
3.2.3 Set-up	21
3.2.4 Procedure	21
3.3 Data annotation	22
3.3.1 ELAN annotation software	22
3.3.2 Learning FACS	23
3.3.3 Scoring Procedure	24
3.3.4 Using FACS	24
3.3.4.1 Coded data	24
3.3.4.2 Action Units and their combinations	24
3.3.4.3 Intensity levels	24
3.3.4.4 Facial Events	25
3.4 Reliability of coding	27
3.5 Predictions	27
3.5.1 Simple sentences: affective or linguistic functions of eyebrows	28
3.5.1.1 Simple sentences: only grammatical usage of eyebrows	28
3.5.1.2 Simple sentences: only affective usage of eyebrows	28
3.5.2 Complex sentences: combining affective and linguistic functions of eyebrows	29
3.5.2.1 Predictions by the Affect > Grammar hypothesis	30
3.5.2.2 Predictions by the Grammar > Affect hypothesis	30
3.5.2.3 Predictions by the Phonetic Sum hypothesis	31
3.6 Validity	32
3.6.1 Materials	32
3.6.2 Procedure	32
3.6.3 Results and conclusion	32
4 Results and Analysis	33
4.1 General impression of the data	35
4.2 Neutral sentences	36
4.2.1 Neutral declarative sentences	36
4.2.2 Neutral topic sentences	39
4.2.3 Neutral yes-no questions	41
4.2.4 Neutral wh-questions	43
4.2.4.1 Neutral wh-questions with the wh-sign sentence-final	43
4.2.4.2 Neutral wh-questions with the wh-sign sentence-initial	45
4.2.5 Generalisations neutral sentence types	47
4.3 Affective yes-no questions	48
4.3.1 Angry yes-no questions	49

4.3.2 Surprised yes-no questions	50
4.3.3 Distressed yes-no questions	52
4.3.4 Conclusion: yes-no questions	53
4.4 Affective wh-questions	54
4.4.1 Angry wh-questions	54
4.4.2 Surprised wh-questions	57
4.4.3 Distressed wh-questions	60
4.4.4 Conclusion: affective wh-questions	62
4.5 Analysis complex sentences	63
	66
5 Conclusions	
5.1 Phonetic weight	66
5.1.1 The form of eyebrow positions in NGT sentence types	66
5.1.2 Affect displays influence question signals in NGT	67
5.1.3 Research question	68
5.2 Sign language prosodic research	68
5.2.1 Methodological issues	68
5.2.2 Non-manual layering	69
5.2.3 Layering a modality effect?	69
5.2.4 Future research	70
References	72
Appendix A Elicitation materials	76
Appendix B Questionnaire (language) backgrounds	81
Appendix C Action Units	84

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Tables and Figures

Tables

Table 1 Non-manual markers of prototypical ASL questions	14
Table 2 Non-manual markers of sentence types in NGT	15
Table 3 Language backgrounds of participants 1, 2, and 3	20
Table 4 Data categories that were and were not analysed using FACS	24
Table 5 Simple sentences that require eyebrow for just one purpose are in the shaded areas	29
Table 6 Predictions made by the Affect > Grammar hypothesis concerning the Action Units in different NGT sentence types	30
Table 7 Predictions made by the Grammar > Affect hypothesis concerning the Action Units in different NGT sentence types	31
Table 8 Predictions made by the Phonetic Sum hypothesis concerning the Action Units in different NGT sentence types	31
Table 9 Mismatches between Participant 1's judgements and Respondent 1 and 2's signed utterances are spread across sentence types and emotions	33
Table 10 Action Units used in neutral declarative sentences	37
Table 11 Action Units used in neutral topic sentences	39
Table 12 Action Units used in neutral yes-no questions	42
Table 13 Action Units used in neutral wh- questions with wh-sign sentence-final	43
Table 14 Action Units used in neutral wh-questions with sentence-initial wh-sign	45
Table 15 Predictions by different hypotheses on angry yes-no questions	49
Table 16 Action Units used in angry yes-no questions	49
Table 17 Predictions by different hypotheses on surprised yes-no questions	50
Table 18 Action Units used in surprised yes-no questions	50
Table 19 Predictions by different hypotheses on distressed yes-no questions	52
Table 20 Action Units used in distressed yes-no questions	53
Table 21 The yes-no questions with additional affective meaning show evidence for the	54

Affect > Grammar hypothesis and for the Phonetic Sum hypothesis	
Table 22 Predictions by different hypotheses on angry wh-questions with wh-sign sentence-final	55
Table 23 Action Units used in angry wh-questions with wh-sign sentence-final	55
Table 24 Action Units used in angry wh-questions with wh-sign sentence-initial	56
Table 25 Predictions by different hypotheses on surprised wh- questions	57
Table 26 Action Units used in surprised wh-questions with wh-sign sentence-final	58
Table 27 Action Units used in surprised wh-questions with wh-sign sentence-initial	58
Table 28 Predictions by different hypotheses on distressed wh- questions	60
Table 29 Action Units used in distressed wh-questions with wh-sign sentence-final	60
Table 30 Action Units used in distressed wh-questions with wh-sign sentence-initial	61
Table 31 Wh-questions with additional affective meaning, whether the wh-sign is sentence-final or sentence-initial, provide evidence for the Phonetic Sum hypothesis	63
Table 32 All three hypotheses are partly supported	64
Table 33 New predictions for the complex declarative sentences and complex topic sentences	65
Table 34 Findings concerning neutral sentence types in NGT	67

Figures

Fig. 1 Basic emotions that are associated with universally recognisable facial expressions	7
Fig. 2 Action Units are associated with (groups of) muscles	7
Fig. 3 Action Units 1, 2, and 4 and their combinations	8
Fig. 4 Emotional states that were used in this study are associated with certain brow positions	8
Fig. 5 Apex structure of linguistic facial expressions are smoother than the apex of an affective facial expression	9
Fig. 6 AU that are associated with certain emotional facial expression, are also important for NGT grammar	17
Fig. 7 Presentation of stimuli materials	22
Fig. 8 ELAN annotation software	23
Fig. 9 Intensity scores do not cover equal intervals of scale of evidence (Picture taken	25

from FACS (2002a) p.8)	
Fig. 10 Background event (FACS 2002 p.363)	26
Fig. 11 AU 1 is part of new facial event (FACS 2002 p.364)	26
Fig. 12 A decrease or increase of the intensity level of a background event may be considered a new event if the intensity level increases or decreases with one point or more	27
Fig. 13a Neutral yes-no question	35
Fig. 13b Surprised yes-no question	35
Fig. 13c Distressed yes-no question	35
Fig. 13d Angry yes-no question	35
Fig. 14 Action Units used in wh-questions with the wh-sign sentence-final versus sentence-initial (i) by Respondent 1 and 2	46
Fig. 15 Intensity levels of AU 1+2 in neutral yes-no questions by Respondent 1 and 2	51
Fig. 16 Intensity levels of AU 1+2 in surprised yes-no questions by Respondent 1 and 2	52
Fig. 17 Intensity levels of AU 4 in neutral wh-questions by Respondent 1 and 2	56
Fig. 18 Intensity levels for AU 4 in angry wh-questions by Respondent 1 and 2	57
Fig. 19 Intensity levels of AU 4 in neutral wh-questions by Respondent 1 and 2	61
Fig. 20 Intensity levels of AU 4 in distressed wh-questions by Respondent 1 and 2	62

Glossing Conventions

The manual part of a signed sentence is glossed using capitalised English words which correspond to the same concept as the sign. The nonmanual adverb is glossed by a line that denotes the alignment of the signal with the manual part of the linguistic signal ending in the term for this linguistic function. The duration in terms of alignment with the nonmanual signals are shown by the alignment with the glosses. The line ends in an abbreviation that is associated with a linguistic function. Please see the abbreviations below.

abbreviation	function
t	topic
neg	nonmanual negation
q / pol-q	yes-no question / polar question
wh /cont-q	wh-question / content question
th	adverb 'th'
/zuster/	mouthings related to the spoken language associated with the sign language are between slashes.
'surprised'	affective facial expressions are denoted by the word for the emotion between single quotes.

Abbreviations of Sign Languages

ASL	American Sign Language
BSL	British Sign Language
DSL	Danish Sign Language
NGT	Nederlandse gebarentaal (Sign Language of the Netherlands)
DGS	Deutsche Gebärden Sprache (Sign Language of Germany)
SSL	Swedish Sign Language
DSGS	Deutschscheizerischen Gebärdensprache
IPSL	Indo-Pakistani Sign Language

Samenvatting

In gebarentalen wordt niet alleen gecommuniceerd met de handen; ook de houding van het lichaam, het hoofd en gezichtsuitdrukkingen zijn belangrijk. Gezichtsuitdrukkingen vervullen grammaticale functies in het markeren van topics in zinnen met een topic-comment structuur, in ja/nee-vragen, en in wh-vragen. Bovendien worden gezichtsuitdrukkingen gebruikt voor het uitdrukken van affect. Doordat het gezicht verschillende functies vervult, zouden deze functies met elkaar in conflict kunnen komen. In deze scriptie wordt de combinatie van deze functies bij wenkbrauwen onderzocht in Nederlandse Gebarentaal (NGT).

Er zijn drie hypothesen gesteld. Ten eerste, dat affectuele markeringen de grammaticale domineren. Ten tweede, dat grammatica belangrijker is dan affect. En ten derde, dat er een Fonetische Som zou ontstaan waarbij beide functies tegelijkertijd worden uitgedrukt.

Er is een productiestudie gedaan waarbij zinnen zijn geëliciteerd door twee gebaarders. Er zijn vijf NGT zinstypes gebruikt: declaratieve zinnen, topic zinnen, ja/nee-vragen, wh-vragen met het vraaggebaar zinsfinaal en wh-vragen met het vraaggebaar zinsinitieel. Deze zinnen zijn gecombineerd met vier affectieve functies: neutraal, boos, verbaasd, en bezorgd. De wenkbrauwbewegingen zijn vervolgens geanalyseerd met het Facial Action Coding System (Ekman et al., 2002a).

In de geëliciteerde zinnen hebben de wenkbrauwen ofwel een grammaticale functie, dan wel een affectieve functie, of ze combineerden beide. Een van de mogelijkheden was dat een fonetische optelsom zou ontstaan dat beide functies tegelijkertijd laat zien. Opvallend is dat in deze fonetische optelsom het fonetische gewicht van AU 4 (Brow Lowerer ‘wenkbrauwverlager’) een belangrijke rol lijkt te spelen. De resultaten laten zien dat het uitdrukken van affect het niet-manuele signaal van vragen in NGT kan veranderen.

Summary

Sign Language of the Netherlands (NGT) is a visual-gestural language in which linguistic information is conveyed through manual as well as non-manual channels; not only the hands, but also body position, head position and facial expression are important for the language structure. Facial expressions serve grammatical functions in the marking of topics, yes/no questions, and wh-questions (Coerts, 1992). Furthermore, facial expression is used non-linguistically in the expression of affect (Ekman, 1979). Consequently, at the phonetic level obligatory marking of grammar using facial expression may conflict with the expression of affect. In this study, I investigated the interplay of linguistic and affective functions of brow movements in NGT.

Three hypotheses were tested in this thesis. The first is that the affective markers of eyebrows would dominate over the linguistic markers. The second hypothesis predicts that the grammatical markers dominate over the affective brow movements. A third possibility is that a Phonetic Sum would occur in which both functions are combined simultaneously.

I elicited sentences combining grammatical and affective functions of eyebrows using a randomised design. Five sentence types were included: declarative sentences, topic sentences, yes-no questions, wh-questions with the wh-sign sentence-final and wh-questions with the wh-sign sentence-initial. These sentences were combined with neutral, surprised, angry, and distressed affect. The brow movements were analysed using the Facial Action Coding System (Ekman, Friesen, & Hager, 2002a).

In these sentences, the eyebrows serve a linguistic function, an affective function, or both. One of the possibilities in the latter cases was that a Phonetic Sum would occur that combines both functions simultaneously. Surprisingly, it was found that a Phonetic Sum occurs in which the phonetic weight of Action Unit 4 appears to play an important role. The results show that affect displays may alter question signals in NGT.

1. Introduction

In this thesis, I look at the combination of linguistic and affective functions of the eyebrows in the signed language that is used by members of the deaf community in the Netherlands: Nederlandse Gebarentaal (NGT). In NGT, the eyebrows serve grammatical functions that are elaborately described in literature (Coerts, 1992). In addition, the eyebrows' affective functions are used in affective facial expressions Ekman (1979). Notably, the brow positions for these functions partly overlap. This may thus result in a conflict for NGT signers to express both functions simultaneously.

In this introductory chapter, I first discuss the place of sign language research in the field of linguistics. Secondly, I give a description of NGT; the signed language I investigate in this thesis and which is used by the Deaf¹ community in the Netherlands. Thirdly, I describe the field of prosodic research in spoken and signed languages. In section 1.4, I formulate the research aims of the present study. Finally, I give an outline of the structure of this thesis.

1.1 Sign linguistics

All communities in the world use one or more languages. Although the languages differ greatly, linguists hypothesise that the diversity of language structures is constrained. It is mainly the rate and age at which children acquire language that has caused linguists to think that at least some of these constraints are innate. Linguists are thus interested in the rules that constrain languages, and deduce from this the aspects of the human language capacity that may be innate.

Until recently, linguistic research focused on spoken languages. Most linguistic theory has thus been based on languages from the oral-auditive modality. Signed languages have evolved spontaneously in Deaf communities² all over the world. Just as spoken languages, they are considered natural in the sense that they are not artificially made, but spontaneously come into existence when Deaf communities are formed. As such, sign languages form a unique opportunity for linguists to test and possibly adjust their theories on possible human languages.

The realisation that signed languages are true languages is one of the great discoveries of the last 30 years of linguistic research (Meier, Cormier, & Quinto-Pozos, 2002). Research has shown that there are strong similarities between signed and spoken languages in their structures, acquisition, and processing (see for example the papers in Meier, Cormier, and Quinto-Pozos (2002)). Linguists attribute similarities between signed and spoken languages to general properties of the human language capacity or human cognition. In contrast, dissimilarities may be caused by the fact that signed

¹ 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 the same culture et cetera. In contrast, when deaf is spelled in regular script it refers to the audiological state: persons who cannot hear (Lane, 1984; Reagan, 1995).

² In fact, there are some known hearing communities in which signed languages have evolved. For example, by Plain Indians in North America (where tribes of different languages met in commerce and war) and by Trappist monks (who have made a vow of silence) (Bloomfield, 1933; Farnell, 1995; Meier, 2005).

languages are in the visual-gestural modality and spoken languages in the oral-auditive modality. These modality effects are caused by the differing physical properties of the articulators (i.e. hands, body, and face instead of mouth) and perceptual systems (visual instead of auditive) of signed versus spoken languages (Meier, 2002).

One of the modality effects on language is the tendency for signed language to code linguistic information simultaneously, while spoken languages code more information sequentially (Wilbur, 2003). This tendency is presumably caused by the fact that a signer has several independent articulators at his disposal. While signing, not only the hands are used; also body position, eye gaze, and facial expression too are required for communication. In contrast, a speaker has only one output channel: the mouth. Wilbur (2000) calls the simultaneous use of articulators in signed conversation 'layering'.

Wilbur has suggested that in signed languages this so-called layering may also take place within one articulator (Wilbur, 2000, 2003). According to her, various functions of an articulator may be expressed simultaneously. In this study I focus on the combination of affective and linguistic functions of one particular articulator: the eyebrows. The following research question is posed: how can affective and linguistic functions of eyebrows be combined in an NGT sentence?

1.2 Nederlandse Gebarentaal

In this thesis I investigate Sign Language of the Netherlands, which is also known as Nederlandse Gebarentaal (NGT). The Deaf community in the Netherlands consists of approximately 16,000 people, which is 0,1% of the Dutch population (Crasborn, 2001). It is defined by the preferred mode of communication of its members, not their audiological status; it also includes some hearing children of Deaf adults³. The NGT, just as American Sign Language, has probably been in use for at least a century and was influenced by Old French Sign language. NGT has three main dialects: one in the north, one in the west and one in the south (Crasborn, 2001). In this thesis, only signers from the western dialect participated.

Until the 1980s, sign language was regarded as a threat to the integration of Deaf into the wider hearing community; as a consequence education was provided in spoken Dutch only. Since then, the attitude of educators has much changed; bilingual (Dutch and NGT) and even monolingual NGT schools have been set up in the 1990s. This transition in Deaf education was initiated by linguists (Crasborn, 2001). Linguistic research has shown the importance of natural first language acquisition for cognitive development and second language acquisition. By 'natural first language acquisition, linguists mean the spontaneous process by which children acquire language when they receive input from adults in their environment, not formal instruction. Deaf children can only acquire a language naturally when it is used in the visual-gestural modality, that is, a signed language. Detailed descriptions of the language may aid the training of sign language teachers, and thus parents of deaf children, and sign language interpreters. This study aims to provide such a description on the use of eyebrows for linguistic and affective purposes.

³ Hearing children of Deaf adults are referred to by the acronym CODA.

1.3 Prosody

In spoken language, prosody refers to the intonation, pitch, loudness, rhythmical aspects, and stress while speaking. These prosodic cues may provide linguistic information. For example, in Dutch I can say ‘Mama komt ook.’ with falling intonation, this means ‘My mother is coming as well’. In contrast, if I say ‘Mama komt ook?’ with a rising intonation pattern, the utterance gets the meaning of a question. This syntactic function of prosody is found in many spoken languages of the world. Notably, prosody is one of the ways in which speakers may express layered information.

Prosodic cues may also express so-called paralinguistic information. Paralinguistic information involves the speaker’s attitude towards himself, towards this interlocutor, and towards the message conveyed in the utterance (Chen, 2005). For example, by hearing someone’s voice, I can tell whether or not the speaker is sure of his statement, whether the message is to be taken seriously, and whether the speaker is happy or sad. In this study, I investigate how this latter paralinguistic function of prosody (affect display) is combined with linguistic functions of prosody in NGT.

In signed languages, prosodic cues are either expressed manually, or through non-manual channels such as the face and body. In the hands, prosodic cues include acceleration, velocity, sign duration, and the size of signs (Reilly, McIntire, & Seago, 1992; Wilbur, 2000). Non-manual prosodic cues include changes in head and body position, eye gaze, and facial expressions. Importantly, both the manual and non-manual channels of a signed language can provide linguistic and paralinguistic information (Reilly et al., 1992).

NGT, similar to Dutch, distinguishes a yes-no question from a declarative sentence by a prosodic cue. In Dutch, changing the intonation pattern is one of the ways to form a question. In NGT, a yes-no question is distinguished from a declarative sentence by raised eyebrows (Coerts, 1992). See examples 1 and 2 below. In example 1, a declarative sentence is expressed. In example 2, the same signs are used in the same order, but the eyebrows are raised, the head tilted, and the eye gaze is directed towards the interlocutor. The line above the signs ending in ‘q’ denotes the spread of the non-manual prosodic cues, i.e. over the full length of the sentence. All these non-manual prosodic cues make the same utterance into a yes-no question. In contrast to Dutch, which also allows word order to form questions, non-manual prosodic cues are the only means of distinguishing a declarative sentence from a yes-no question in NGT.

1. WOMAN BAG FORGET
‘The woman forgot the purse.’
_____q
2. WOMAN BAG FORGET
‘Did the woman forget the purse?’
(Ros, personal communication)

Facial expressions thus serve linguistic functions in NGT. In fact, this linguistic use of the face is widespread in NGT and serves lexical, morphological, syntactical, and pragmatic functions (Coerts, 1992). In addition, in many, if not all, signed languages

the face is used for these linguistic purposes. However, facial expressions are also important in expressing affect in human communication in general. For example, anger is expressed, and universally recognised, by frowned eyebrows (Ekman, 1979). This affective use of facial expression is considered paralinguistic and is also used during signing.

Notably, research on American Sign Language has shown that the overlap between linguistic and affective functions of the face makes acquiring linguistic facial expressions for adult learners of American Sign Language difficult (McIntire & Reilly, 1988). I assume that the same problem arises with adult learners of NGT. Most adult second language learners of NGT are either interpreters or parents of a Deaf child. Hence, it is relevant to interpreter training as well as sign language teacher training that the linguistic and paralinguistic functions of the face are studied in depth. Detailed instruction on the use of facial expressions may raise awareness in learners and aid the acquisition process. In this thesis, I focus on the combination of linguistic and paralinguistic functions in one facial articulator: the eyebrows.

1.4 Combining affective and linguistic functions of eyebrows

In NGT the eyebrows are used for linguistic and for paralinguistic purposes. Notably, these linguistic and affective functions may require opposite brow positions. Recall that in NGT, yes-no questions require raised eyebrows; and frowned eyebrows universally express anger. Hence, the overlap in functions of the same articulator results in a potential conflict for signers when expressing both functions simultaneously. If a NGT signer is asking a yes-no question when angry, are the brows up or down? Research by Ekman, Friessen, and Hager (2002a; 2002b) has shown that the muscles used for various eyebrow positions may be active simultaneously, resulting in various visually distinguishable brow positions. Hence, a third option arises: linguistic and affective function of eyebrows may be combined simultaneously. The present study therefore aims to answer the following research question:

How can affective and linguistic functions of eyebrows be combined in an NGT sentence?

In this thesis, three hypotheses are tested on how linguistic and affective functions are combined by signers of NGT. First of all, the expression of affect may replace linguistic marking by the eyebrows; only the affective facial expression is present. In this case, the angry yes-no question would be signed with an angry facial expression. Other non-manual cues that form a yes-no question (e.g. a head tilt) could still be present. I will refer to this first possibility as affect ‘dominates’ grammar (Affect > Grammar) hypothesis.

The second possibility is that the grammatical functions of eyebrows block the expression of affect. In this case, linguistic marking is visible and affect may be apparent from other prosodic cues. The eyebrows would be raised in an angry yes-no question. Other articulators, manual or non-manual, may still express affect. For example, it has been reported for American Sign Language (ASL) that sign duration is

shorter in angry signed sentences (Reilly et al., 1992). I will refer to this hypothesis as the Grammar > Affect hypothesis.

Lastly, the Phonetic Sum hypothesis predicts that affective and linguistic functions of eyebrows may be combined in one sentence, either sequentially or simultaneously. In the latter case, muscles used to raise the eyebrows and muscles that pull the eyebrows down and together (i.e. a frown) are used simultaneously.

In order to test these hypotheses I did a production study in which NGT sentence types were elicited with different affective cues. The data were analysed using the Facial Action Coding System (Ekman, Friesen, & Hager, 2002a).

1.5 Thesis outline

In chapter 2, *Combining Affective and Linguistic Functions of Eyebrows in NGT*, I provide the theoretical background of this thesis. In chapter 3, *Methodology*, I describe the research design and annotations in detail. In chapter 4, *Results and Analysis*, I analyse the results of the elicitation experiment in relation to the hypotheses. In chapter 5, *Conclusions*, I make general conclusions as well as suggestions for further research.

2 Affective and linguistic functions of eyebrows

As mentioned in the introduction, in a visual-gestural language like NGT, not only the hands are used. Non-manual signals are important as well. Already in the early days of sign linguistics, Stokoe noticed the use of the face in ASL and stated that non-manuals “need much more investigation, for it is the key to syntactic structure” (Stokoe, 1960). What is more, nowadays non-manuals are found to play a role at all levels of linguistic structure in signed languages and are crucial to the understanding of these languages (Baker-Shenk, 1983; Brita Bergman, 1984; Coerts, 1992; Liddell, 1980). However, as I all know, facial expressions are also important for the expression of affect in general human interaction, deaf and hearing.

In this chapter I start by describing research that has been done by psychologists on affective facial expressions and how they differ from linguistic facial expressions that are used in signed languages. Secondly, I give an overview of the various forms that linguistic non-manuals may take, and the linguistic functions they carry in NGT. Then, I zoom in on the syntactic functions of eyebrows in ASL and NGT. In section 2.4, I start by discussing two studies on ASL that looked into the combination of both the affective and syntactic functions more deeply. I then discuss three hypotheses on how both the affective and syntactic functions of eyebrows are combined in NGT. Finally, the research methodology and design that have been used in this study are described, as well as the predictions each hypothesis makes on the collected data. I will go into this in more detail in the methodological chapter.

2.1 Affective facial expressions

Among others, Paul Ekman claims that certain emotions are not only universal to all humans, but also associated with universally recognisable facial expressions (Ekman, 1992a, 1992b, 1994, 1999a, 1999c). This idea is not new; more than a century ago, Charles Darwin already reports on a study investigating the universality of facial expressions (Darwin, 1872).

First, I describe what makes certain emotions *basic* and show how they are linked to specific universal facial expressions. Secondly, I describe the Facial Action Coding System that was developed by Ekman, Friessen, and Hager to describe facial appearance changes, and that is used in this study too (Ekman et al., 2002a). Finally, I zoom in on the specific claims Ekman et al. make on the position of the eyebrows in the expression of the emotions used in this study.

2.1.1 Basic emotions and universal facial expressions

There is a widespread assumption in theories of emotion that there is a small set of so-called basic emotions (Ortony & Turner, 1990). The idea is that basic emotions have evolved physically and have thus been retained in all humans, while other, non-basic, emotions will vary (more) between cultures. According to Ekman these basic emotions include happiness, surprise, fear, anger, disgust and sadness (Ekman, 1992a, 1999a). Because basic emotions are thought to be innate, psychologists, among others, have been trying to find universal neurophysiological or anatomical substrates, for example facial expressions. Large cross-cultural studies have shown that each of these

basic emotions is associated with a facial expression that is universally recognisable. See figure 1 below, which displays facial expressions correlated with basic emotions. Research from sign linguists has shown that signers make use of these universally recognisable facial expressions to express emotional states during signing (Baker-Shenk, 1986; Jauch, 1994).



Fig. 1 Basic emotions that are associated with universally recognisable facial expressions

2.1.2 Facial Action Coding System

As you may know intuitively, the face has numerous possible expressions, which may involve the lower face, the upper face, or both. Changes in the lower faces consist of alteration of the mouth, wrinkling of the nose, and movement of the cheeks. Upper face changes involve widening or tightening of the eyes as well as brow movement (Ekman et al., 2002a). Ekman et al. (2002a) developed the Facial Action Coding System (FACS) to describe all possible visibly distinguishable facial expressions. Because it is a comprehensive system, it allows researchers from various fields of research to use it. Baker-Shenk too used it for describing non-manuals in ASL (1983, 1986). Baker-Shenk (1983) shows that FACS can be useful for sign linguists. In this study, too, FACS is used.

FACS groups muscles into so-called Action Units that, when combined, produce perceivable appearance changes in the face. In the left picture of figure 2 below you see the facial muscles that produce appearance changes in the eyes and brows. In the right column you see the corresponding Action Units (AU). Although all Action Units have a name, they are also associated with a number, which is useful for coding.

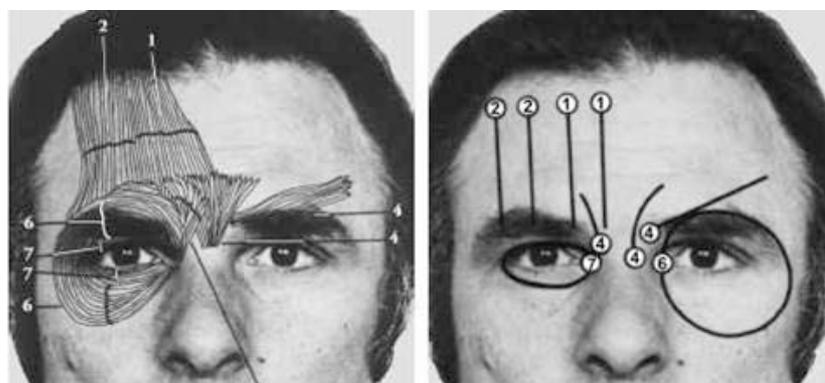


Fig. 2 Action Units are associated with (groups of) muscles

According to FACS, all eyebrow movements can be described by (a combination of) three Action Units: Inner Brow Raiser, Outer Brow Raiser, and Brow Lowerer. As

you can see by the schematic lines and numbers in the right picture of figure 2 above, AU 4 (Brow Lowerer) includes three different muscles; two that run from the forehead down to the foot of the nose, and one runs from the forehead towards the inner corner of the brow. Both AU 1 (Inner Brow Raise) and 2 (Outer Brow Raise) consist of two muscles that vertically run across the forehead. All muscles and AU are depicted only once in figure 2, although all of them have a symmetrical counterpart in the other half of the face. These Action Units 1, 2, and 4 may be combined in any logical combination and result in various brow positions. See figure 3 below. A combination of AU 2+4 is not included in the picture below. However, it is a direct sum of the appearance change due to AU 2 and AU 4.



Fig. 3 Action Units 1, 2, and 4 and their combinations

2.1.3 Position of eyebrows in a neutral face, anger, surprise, and distress

For eyebrow positions, Ekman makes predictions as to what they look like when certain basic emotions are expressed. In the present study, I focus on four affective states: neutral affect, anger, surprise, and distress. The facial expression that accompanies anger includes frowned eyebrows, that is, AU 4 is used. With ‘surprise’ the eyebrows are raised using AU 1 and 2 simultaneously (Ekman, 1979). Ekman reports on the combining of AU 4 (combined with a slight AU 1) in general human interaction as displaying distress (Ekman, 1979). See figure 4 below and compare the eyebrow positions to the neutral example of the same face on the left. A good way to do that is by taking the eyes as a reference point and compare the relative distance between the eyes and eyebrows in the pictures of figure 4.

<i>Brow position</i>				
<i>&</i>				
<i>Action Units</i>	-	4	1 + 2	1 + 4
<i>Emotion</i>	<i>neutral</i>	<i>anger</i>	<i>surprise</i>	<i>distress</i>

Fig. 4 Emotional states that were used in this study are associated with certain brow positions

2.1.4 Differences in form between affective and linguistic facial expressions

Although the same muscles (Action Units) are used in affective and linguistic non-manual signals, there are some differences between them in form. Affective facial signals, in contrast with linguistic facial expression during signing, do not align with

constituents. The idea is that because of their linguistic function, linguistic non-manuals are tied to linguistic domains; therefore they should align with linguistic units, e.g. signs. In contrast, Action Units that are used for an additional affective meaning do not need to align with linguistic units. In addition, the onset and offset of affective facial expressions are thought to be gradual compared to the abrupt appearance changes in a linguistic facial expression (Wilbur, 2000, 2003). Another difference in form is that with linguistic non-manuals the intensity level of the Action Unit rises suddenly to its peak and stays smooth (this maximum level is called the apex) before again going down abruptly. Affective facial expressions on the other hand have less smooth apexes. These differences in apex structure are schematically represented in figure 5 below.

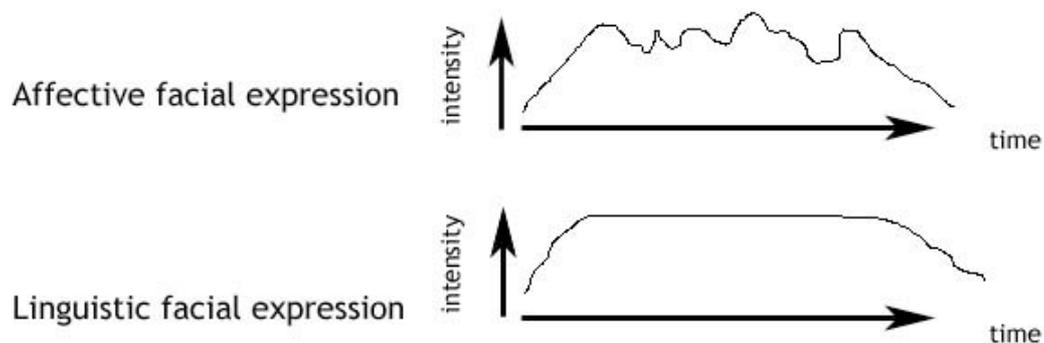


Fig. 5 Apex structure of linguistic facial expressions are smoother than the apex of an affective facial expression

In fact, these supposed differences in form between the linguistic and affective use of facial expression are not supported by the findings of Baker-Shenk (1983). Baker-Shenk (1983, p.244-245) raises the question ‘just how separate [...] the components of this linguistic system [are] from the behaviours associated with the expression of affect.’

2.2 Linguistic non-manuals in NGT

Besides facial expressions, linguistic non-manual signals in NGT include body position, head position, and eye gaze. In the first section I discuss the forms that non-manual signals may take. In section 2.2.2, I give an overview of the linguistic functions non-manuals may carry.

2.2.1 The form of non-manuals

Spoken languages are normally thought of as unichannelled and having one articulatory channel through which linguistic information is conveyed (i.e. the mouth). In contrast, signed languages are considered multi-channelled in the sense that a signer can simultaneously express information using not only the hands, but also other articulators such as body and face. These non-manual signals include all visible information that the signer expresses during signing other than the information coded in the manual articulators. Signers will use their body position and orientation, head position and orientation, eye gaze, and facial expressions for linguistic purposes.

2.2.1.1 *Body position and orientation*

A signer may lean forwards or backwards, or shift the body along an imaginary vertical axis when taking the role of a referent other than the signer himself (Coerts, 1992). This mechanism of role-taking is referred to as *role play*. In the typical case of role play, a signer changes his eye gaze away from the interlocutor, changes his facial expression, and moves his body towards the location where the referent earlier has been established in discourse. Also, the signer will adopt one or more physical characteristics of the referent. The use role-play is most frequent in spontaneous conversations and narratives. Body positions may also serve different functions, e.g. for NGT it was found that body leans also serve pragmatic functions (Kooij, Crasborn, & Emmerik, to appear). Interestingly, the various functions of body leans may enhance or conflict with each other.

2.2.1.2 *Eye gaze, and head position and orientation*

During signing, head and eye positions change constantly; they move up or down, away from or towards the interlocutor, from left to right and vice versa. Most certainly, when signers look at their interlocutors they do not look at each other's hands constantly, nor do they look deeply into each other's eyes. The movements that are made by the head and eyes are important in establishing discourse as well as referent-tracking, by directing eye gaze towards points in sign space in which referents have been previously established (Coerts, 1992). A forward or backward head tilt is also used in question signals (Coerts, 1992).

2.2.2 **The linguistic functions of non-manuals**

Non-manual signals may be distinguished on the basis of their form or articulator, but it is also possible to group them based on the linguistic functions they serve. According to Coerts (1992), facial expressions in the lower face serve mostly phonological, lexical and morphological functions, while at the syntactical level upper face features are an important part of the non-manual linguistic signal in NGT. In this section, I give an overview of the functions of non-manual markings in NGT at the lexical, morphological, syntactical, and pragmatic level.

2.2.2.1 *Lexical mouthings*

Two types of non-manual signals operating at the lexical level have traditionally been distinguished in literature; both involve movements of the mouth. Both types are articulated simultaneously with a sign and may spread across signs. The first group of phonological non-manuals, *word pictures* are derived from (parts of) spoken Dutch words. The signer makes the mouth movement of the spoken Dutch word with or without using voice. Some of these non-manual signals are used during signing even when exclusively Deaf are around. The major function of this type of word pictures is that they are used contrastively at the phonological level. The signs BROTHER and SISTER for example have identical manual parts, but are disambiguated by the word pictures similar to the Dutch words /broer/ 'brother' or /zuster/ 'sister'.

Besides word pictures, NGT also uses other mouth movements for phonological purposes in so-called *mouth gestures*. These mouth movements are produced simultaneously with a sign but are *not* related to spoken Dutch. When these signs are

produced in absence of the mouth gesture, the meaning of the sign becomes vague. Coerts describes the minimal pair between FINALLY-UNDERSTAND and TIRED in NGT (Coerts, 1986). While the manual part of these signs stays the same, the non-manual components are different. In case of FINALLY-UNDERSTAND /fa/ or /van/ is uttered, with TIRED a facial expression is used that mimics tiredness.

Similar contrasting non-manual components have been reported for American Sign Language (Bellugi & Fischer, 1973), Norwegian Sign Language (Schroeder, 1985; Vogt-Svendsen, 1983), Swedish Sign Language (Brita Bergman, 1984), and British Sign Language (Brennan, 1984).

2.2.2.2 *Morphological mouthings*

At the morphological level Coerts (1992) distinguishes two types of non-manual markings: again word pictures, but also *non-manual adverbs*. Word pictures which can be used without an accompanying sign or simultaneously with a sign that does not match its meaning are considered to be morphemes. An example of the morphological function of a word picture is that an NGT signer may sign I FEEL and at the same time utter ‘but’ /maar/. In this case two different concepts are expressed simultaneously and results in the meaning ‘but I feel’. In NGT word pictures are also used to mark tense and number with certain verbs. For example, the sign TO FLY can be accompanied by the word picture /gevlogen/ which is the perfect participle in spoken Dutch of the verb for ‘to fly’, consequently, the NGT sign TO FLY is marked for perfect tense. This latter use of word pictures seems to be quite unusual compared to other signed languages (Coerts, 1992).

Non-manual adverbs are simultaneously produced with and thus modify the meanings of verbs, adjectives, and other adverbs. Schermer reports on an adverb similar to the ASL non-manual ‘th’ (Schermer, 1990), which expresses the additional meaning of ‘lack of control’, ‘inattention’ or ‘unawareness’. With this non-manual adverb the head is tilted and the tongue is protruded through the lips, and must be pushed out. In example 3 below I give a glossed NGT sentence in which this non-manual adverb is used. Non-manual adverbs have also been reported for ASL (Liddell, 1980) and SSL (B. Bergman, 1983).

3. th
 LOPEN
 ‘I walked carelessly.’

Non-manual adverbs have been reported for ASL (Baker & Cokely, 1980; Liddell, 1980), BSL (Lawson, 1983), and SSL (B. Bergman, 1983) and presumably other signed languages as well.

2.2.2.3 *Syntactical non-manuals*

In NGT and other signed languages sentence types are distinguished by using facial expression in combination with other non-manuals such as movements of head and shoulders (Coerts, 1992). For American Sign Language, Swedish Sign Language, NGT and perhaps other western sign languages these non-manual signals look very similar (Brita Bergman, 1984; Coerts, 1992). Asian sign languages such as Nihon Suwa

(Japanese Sign Language) and Chinese Sign Language only partly follow that pattern (Fischer, 2005). Non-manuals that serve grammatical functions in NGT are investigated and reported in Coerts' 1992 dissertation. In this section I discuss only the sentence types that are relevant to this study. These sentence types include declarative sentences, yes-no questions, wh-questions, and sentences with a topic-comment structure.

The prototypical polar question (yes-no question) in NGT is formed by *raising the eyebrows and tilting the head forward* (Coerts, 1992). In a declarative sentence the head and eyebrow position are neutral (Coerts, 1992). There are no other grammatical mechanisms such as word order to distinguish a declarative sentence from a yes-no interrogative in NGT. See the examples from NGT below that form a minimal pair; example 4 is a declarative sentence and example 5 is a polar question. Again as with non-manual adverbs the continuous line above the glosses for the signs represents the duration of the non-manual signal. Similar markers of the difference between a yes-no question and a declarative sentence have been reported for ASL (Liddell, 1980), BSL (Deuchar, 1984), SSL (Brita Bergman, 1984), and DSGS (Steiner, 2000).

4. VROUW TAS VERGETEN
 'The woman forgot the purse.'
 _____ q
5. VROUW TAS VERGETEN
 'Did the woman forget the purse?'

In addition to this non-manual prosodic cue, the last sign in a question is often held longer than usual in its final position (Zeshan, 2004). This so-called final lengthening is considered a manual prosodic cue and well known from spoken language research.

Wh-questions are normally⁴ formed by using a wh-sign, e.g. WHAT, WHERE, WHO and additional non-manual marking. The non-manual signal during a wh-question requires *furrowed eyebrows and chin up* (Coerts, 1992). Note that this is quite different from the marking used in yes-no interrogatives. Similar marking of a wh-question has been reported for ASL (Baker-Shenk, 1983), SSL (Brita Bergman, 1984), and BSL (Kyle & Woll, 1985).

In examples 4 and 5 below I give two examples of wh-question in NGT. In NGT wh-questions, the wh-sign may remain *in situ* (sentence-final position) as in the example above, or it is moved to sentence-initial position (van Gijn, 2004). A third possibility is that the wh-sign is copied to sentence-initial position. No difference in meaning is associated with any of these three types of wh-questions. By contrast, depending on the position of the wh-sign sentence, and sentence structure, the domain of the wh-marking differs (van Gijn, 2004). According to Pfau this is due to the fact that wh-features have to be checked (Pfau, 2005). In example 6, the wh-sign stays *in situ*,

⁴ Notably, wh-questions in NGT can also be formed without a wh-sign, but with wh-marking. Consider example i.

- i. wh
 MY SUITCASE
 'Where is my suitcase'
 (Coerts, 1992)

sentence-final, and the wh-marking is required from the beginning of the sentence until the end. In example 7, the wh-sign is sentence-initial, the wh-marking is exclusively used on the wh-sign.

6. $\frac{\text{wh}}{\text{INDEX}_2 \text{ DRINK WHAT}}$
 ‘What do you drink?’
7. $\frac{\text{wh}}{\text{WHAT INDEX}_1 \text{ LIKE twhat INDEX}_1}$
 ‘What do I like?’
 (van Gijn, 2004)

In the data that were elicited in the present study, the differences in scope of wh-marking was not found: in all wh-questions the wh-markers spread across the sentence. In addition, non-manual marking of a wh-question involved AU 1+2 instead of AU 4 in many cases. I discuss this fact more elaborately in section 4.2.4 of the Results and Analysis chapter.

Coerts (1992) describes sentences that contain a topicalised element. Topicalisation is a grammatical mechanism for (re)introducing referents in discourse. The so-called topic, which is the referent (re)introduced by the signer, is moved to sentence-initial position and requires *raised eyebrows* in NGT, additionally there is *a pause* between the topic and the rest of the sentence, i.e. the comment. These sentences have a so-called topic-comment structure. See example 8 below in which AIRPLANE is topicalised. Similar markers of topics have been reported for ASL (Liddell, 1980), SSL (Brita Bergman, 1984), and DSL (Engberg-Pedersen, 1990).

8. $\frac{\text{t}}{\text{AIRPLANE}} \text{ -----} \frac{\text{neg}}{\text{COME NOT}}$
 ‘As for the airplane, it did not arrive.’⁵
 (Coerts, 1992)

2.2.2.4 Pragmatic non-manuals

Linguistic non-manual signals have also been identified at the pragmatic level (Engberg-Pedersen, 1990; Kooij et al., to appear). Kooij et al. report on the use of body leans for expressing mood in NGT. For example, ‘doubt’ is expressed by a lean forward combined with a lowered head position. Similarly, for ASL, Wilbur and Patschke (1998) report on the pragmatic use of body leans to indicate the fundamental opposition between ‘affirmation’ and ‘negation/denial’ of the truth of proposition (Wilbur & Patschke, 1998). Engberg-Pedersen (1990) found that in DSL squinted eyes are used with referential expressions to check the interlocuter’s understanding of the reference. This pragmatic use of non-manuals has to do with referent accessibility in discourse.

⁵ In example 6 below, also a non-manual negation is glossed; see Coerts (1992) for more information on non-manual negation.

2.3 Linguistic functions of eyebrows

The present study focuses on the various functions which the eyebrows may express. In this section I discuss more elaborately the research methodology and conclusions of two dissertations which have focused on the syntactic functions of non-manuals in a signed language. Baker-Shenk studied non-manuals in American Sign Language and found that eyebrows, as well as other non-manual signals, are used to distinguish between different sentence types in ASL (Baker-Shenk, 1983). Coerts (1992) has done a study with similar results on NGT.

2.3.1 Linguistic functions of eyebrows in American Sign Language

Baker-Shenk (1983) reports on the non-manual components in American Sign Language. She filmed two deaf men and two deaf women in natural conversation. Both dyads were close friends who had not seen each other for a few months. These conversations were recorded simultaneously using six video cameras, filming the participants from different angles, which allowed her to do a detailed analysis of their non-manual behaviour. From these recordings she selected 65 questions and 40 statements. The questions included yes-no questions, wh-questions, and rhetorical questions. She coded all movements of the face, eye gaze, head, body, and hands and arms separately; not only for type but also in relation to the time segments in the video. In total, the data that were analysed in detail are approximately three minutes in length.

For the coding of the face Baker-Shenk (1983) used FACS. In the 1978 version of FACS, which was used by Baker-Shenk, the intensity of AU is distinguished at three intensity levels, that is x, y or z-level (maximum level). In the face, Baker-Shenk coded a total of 6 AU and their combinations. I discuss only AU 1, 2, and 4 here, because these are used for eyebrows and thus relevant to the study.

For yes-no questions Baker-Shenk reports raised eyebrows (AU 1+2), raised upper eye lid, a forward head tilt, and a forward body shift. For wh-questions she reports frowned eyebrows (AU 4) combined with a backward head tilt, and an optional headshake. Rhetorical wh-questions (e.g. 'Why did I do it? I don't know.') are marked by raised eyebrows (AU 1+2) and a sideward head tilt. In all three types of questions continued eye gaze at the addressee is required additionally (marked as + eye gaze). See the table 1 below for an overview of non-manual markings in these three ASL sentence types. However, in approximately 30% of the yes-no questions, and in 33% of the rhetorical questions these generalisations do not hold.

Table 1 Non-manual markers of prototypical ASL questions (Baker-Shenk, 1983)

Sentence type	Non-manual signals
Yes-no questions	AU 1+2+ raised upper eyelid + head forward + torso forward + '+' eye gaze
Wh-questions	AU 4 + head tilt + (headshake) + '+' eye gaze
Rhetorical questions	AU 1+2 + head side tilt + '+' eye gaze

2.3.2 Linguistic functions of eyebrows in NGT

Coerts (1992) reports on sentence types in NGT that are distinguished by non-manual signals. See section 2.2.2.3 for an elaborate discussion. Coerts elicited data from 16 signers using four tasks. In task 1 people were asked to tell a story of their own choice to another participant. In task 2, an informant was asked to retell a picture story. In task 3 Coerts used picture cards; one person was supposed to find out what kind of object was depicted on the card by asking questions to the addressee. In task 4 the signer was asked to retell a short story from a cartoon book.

In all four tasks two participants were sitting opposite to each other. In task 1, 2, and 4 the dyads were filmed with one camera recording the upper body; the other camera zoomed in on the face. In task 3 a second camera was zoomed in on the face of the addressee. From these four tasks Coerts elicited 95 yes-no questions, 34 wh-questions and 64 topic sentences. She analyzed her data using the Edinburgh Non-manual Coding System (Colville, Denmark, Mason, Denmark, & Brennan, 1984), which originates from the Sign Notation System (Stokoe, 1978). Coerts distinguishes three positions for eyebrows: neutral, up, and down.

Prototypical yes-no questions in NGT have raised eyebrows and the head is tilted forward. In wh-questions the brows are down and the chin goes up. In so-called topic sentences the eyebrows are up on the topicalised element. See table 2 below for a summary of non-manual markers that co-occur with a selection of NGT sentence types.

Table 2 Non-manual markers of sentence types in NGT (Coerts, 1992)

Sentence type	Non-manual signals
Yes-no questions	Eyebrows up, head forward
Wh-questions	Eyebrows down chin up
Topic sentences	Eyebrows up on topicalised element

In Coerts' study too, the generalisations concerning the non-manual signals co-occurring with certain sentence types hold only in a certain amount of the time. In 40% of the yes-no interrogatives the eyebrows were not 'up'. Moreover, in 18% of the wh-question the eyebrows were either neutral, or up, instead of down. For topic sentences too, Coerts reports that in approximately 9% of sentences the eyebrows either go down or stay in neutral position (Coerts, 1992). Besides raised eyebrows, one of the characteristic features of a topic is lengthening of the topicalised sign. Coerts (1992) identified topics by detecting the lengthening of a sign based on Liddell's findings on duration of initial signs (Liddell, 1980).

2.4 Combining linguistic and affective functions of eyebrows

Both the study by Baker-Shenk (1983) and the study by Coerts (1992) tells us that eyebrow positions as markers of sentence types in ASL and NGT are not used in all cases. What is more, opposite eyebrow positions, i.e. 'up' versus 'down', were sometimes used. A possible reason for this variation is the expression of affect. In this section I firstly discuss a study by Baker-Shenk (1986) that concludes that in ASL yes-no questions and rhetorical questions 'surprise' and 'distress' may affect eyebrow position. Secondly, I discuss a study by Reilly and Bellugi (1996) that addresses the potential conflict for deaf mothers in using their eyebrows for marking

of wh-questions, a signal otherwise associated with ‘anger’ (Reilly & Bellugi, 1996). In section 3, I discuss the overlap between the linguistic and affective functions of eyebrows in NGT and describe the design that was used to investigate the combination of affective and linguistic functions of eyebrows in NGT. Finally, I formulate three possible hypotheses on how linguistic and affective functions of eyebrows in NGT may be combined.

2.4.1 Surprise and distress in ASL question signals

Baker-Shenk (1983) formulates generalisations concerning the use of non-manuals in ASL sentence types. However, she also reports on variation in the use of certain Action Units in these data. Baker-Shenk (1986) aims to investigate what causes this variation.

In one out of thirteen wh-questions, AU 1 occurs. Baker-Shenk hypothesises that it is part of topic marking (AU 1+2), but cannot explain the absence of AU 2 (Baker-Shenk, 1983). In approximately one third of the cases, yes-no questions did not include a raised upper eyelid (AU 5 Lid raiser, see Appendix C). Baker-Shenk (1986) hypothesises that these were infelicitous questions, that is, questions in which the signer was asking for information that he already possessed. However, there were also yes-no questions that were infelicitous but still had the raised upper eyelid (AU 5) which results in widening of the eye aperture. Baker-Shenk claims that if the signer is expressing ‘surprise’, AU 5 always appears. Also, the intensity of AU 1+2 (raised eyebrows) increased until the highest possibly level (z) in ‘surprised’ cases. In the rhetorical questions as well, one third of the utterances did not follow the generalisations Baker-Shenk (1983) formulated: 1+4 brow configuration appeared instead of 1+2. In these cases the signer was either ‘distressed’ or describing a situation which would normally evoke distress. Baker-Shenk (1986) concludes that the display of affect may alter the form of the linguistic signal in ASL.

2.4.2 Affective prosody in ASL motherese

Another study in which the linguistic and affective functions of eyebrows in ASL were investigated is described in a paper by Reilly & Bellugi (1996). They investigated mother-child interaction from deaf mothers signing ASL to their deaf toddlers, and analysed eyebrow positions in maternal wh-questions using the Facial Action Coding System (Ekman et al., 2002a). Recall that the eyebrow position (furrowed) that is used for expressing wh-questions in American Sign Language is associated with the expression of anger. Hence, wh-questions in motherese form a natural context to address the potential conflict of grammatical and affective functions of eyebrows. Reilly and Bellugi found that in more than 90% of the wh-questions that were signed to toddlers younger than 2 years old, deaf mothers did not use the standard furrowed eyebrows. In most cases they would use a neutral face, and sometimes raised brows. In contrast, toddlers older than 2 years old were asked wh-questions that did have the required wh-marking. Reilly and Bellugi (1996) observed that this timing coincides with the child’s first wh-signs. Hence, Reilly and Bellugi (1996) conclude that parents sign ‘ungrammatically’ until the child is able to distinguish between affective and grammatical marking.

In figure 6 AU 1+2, 4, and 1+4 and the brow positions are shown, as well as their affective and syntactic functions in NGT. Note that the brow position that is associated with an angry face (AU 4, brow lowerer) is the same as the linguistic marking of a wh-question in NGT. Similarly, the brow position in surprise, raised eyebrows, makes use of the same AU (1+2) as used to mark a yes-no question, and topics, in many signed languages. In declarative sentences, the eyebrow position is neutral.

Recall from section 2.1.4 that although the same brow positions serve linguistic and affective functions, their alignment with constituents, onsets and offsets, and apex structures are distinct. I hypothesise, following Wilbur (2000), that it is these differences in form that permits linguistic and affective functions of eyebrows to be produced simultaneously. The present study aims to answer the question how these two functions of eyebrows are combined in NGT. Specifically, I investigate which functions are expressed by the eyebrows within a sentence.

2.4.3.2 Hypotheses

The present study tests three hypotheses concerning the combination of the grammatical and affective functions of eyebrows in NGT. Affective functions of eyebrow positions may overrule grammatical ones. This *'affect over grammar'*-hypothesis claims that when affective and linguistic functions require different eyebrow positions, only the position for the affective meaning will be expressed. The second hypothesis tested here is that grammar prevails over affect in all cases and the generalisations of the syntactical non-manuals hold. This hypothesis that I call *'grammar over affect'* still allows for affect to be expressed through other channels than the eyebrows, presumably through prosodic cues in the hands, or Action Units that do not involve brows. The third hypothesis, which I named *'phonetic sum' hypothesis*, predicts that affective and grammatical functions are combined simultaneously and a 'phonetic sum' is created. The Action Units related to the affective position of the eyebrows and the Action Units related to the linguistic position of the eyebrows appear simultaneously.

3 Methodology

In this methodological chapter I describe the research methodology used in the present study. After starting with the specific research question in section 1, I discuss the elicitation experiment that was conducted in order to test these hypotheses, in section 2. In section 3, I describe the data annotation. In section 4, the reliability of coding is discussed. In Section 5, the predictions on the occurrence of AU by the Affect > Grammar, Grammar > Affect, and Phonetic Sum hypotheses are formulated. Finally, in section 6, I discuss a small perception study that was used to test the validity of the data.

3.1 Research question

The present study aims to answer the following research question:

How can affective and linguistic functions of eyebrows be combined in an NGT sentence?

In order to test this research question, I elicited sentences which required either linguistic use of eyebrows or affective use of eyebrows, and sentences that require both. Ultimately, answering this research question will give us insight into how NGT signers combine affective and linguistic facial expressions and into the interplay between language and affective signals in human communication in general.

3.2 Elicitation study

In the elicitation study, two deaf native signers were filmed, who were asked to sign sentences in different affective ways. I will first discuss the social and language backgrounds of the participants. Secondly, I elaborate on how I selected the materials that were used. In section 3.2.3, the set-up of cameras and participants is described. Finally, I describe the design and procedure of this elicitation study.

3.2.1 Participants

We asked a Deaf colleague to look for expressive fluent signers. He informed signers in his social environment on the aim of this study (i.e. how are emotions expressed in NGT?) and asked them to participate in this experiment. Two native deaf signers agreed to participate in this study. They are both born, raised, and still living in the same area around Amsterdam. My deaf colleague (Participant 1 from now on) was born and raised in the same area as the other two. All three of them have known each other for most of their lives and are friends.

All participants are Deaf born into a Deaf family. They acquired NGT as a native language. Participant 1, 2, and 3 were aged 38, 38, and 36 at the time of recordings. Participant 1 works as a research assistant in NGT research and as a sign language teacher. Participants 2 and 3 are vocational workers; one is a mechanic and the other works in a warehouse. This sociolinguistic status may be an explanation for possible variation in the data. As children they went to the same Deaf school in Amsterdam, two receiving monolingual Dutch (oral) education and the other receiving bilingual

education in Dutch and NGT. All three are members of the Deaf community in the sense that they have Deaf friends, go to Deaf meetings and visit Deaf sport clubs. The participants form a homogenous group in the sense that they use the same dialect of NGT, and are all men in their mid-thirties. In the table 3 below, the language background of each participant is summarised. The questionnaire used to describe the social and languages backgrounds of the participants in this study is based on the questionnaire for the ECHO project⁶, which you will find in Appendix B.

Table 3 Language backgrounds of participants 1, 2, and 3

	Participant 1 (Stimuli)	Participant 2 (Response 1)	Participant 3 (Response 2)
Age of acquiring NGT	from birth	from birth	from birth
Primary education	monolingual Dutch (oral education)	bilingual, NGT and Dutch	monolingual Dutch (oral education)
Dialect	Western dialect of NGT	Western dialect of NGT	Western dialect of NGT
Work	research assistant	vocational	vocational

3.2.2 Materials

Participant 1 translated forty written Dutch sentences to NGT. The forty written Dutch sentences were evenly distributed across four sentence types; yes-no questions, wh-questions, topic sentences, and declarative sentences. The ten wh-questions were translated from written Dutch into twenty signed sentences; ten had the wh-sign at the front of the sentence and ten were signed with the wh-sign at the end of the sentence. This was done for two reasons. First of all, I wanted to test the domain of wh-marking in both types of wh-questions in NGT, i.e. only on the wh-sign or over the entire sentence as described by Pfau (2005). Secondly, my informant (Participant 1) did not seem to have a preference for either type of construction. The issue of domain of wh-marking has been discussed in section 2.2.3 of the previous chapter. This resulted in a total of fifty signed sentences.

We used written Dutch sentences that had 4.7 on average words in them. I did not include any negation because Coerts (1992) reports that in negation eyebrows are down in 28.6% of the cases, and up in 57.1% of the cases. Thus, if elements of negation were included, this could have influenced the brow movement in the data as well. The written Dutch sentences that aimed at eliciting topic sentences in NGT were distinguished from declarative sentences by placing a comma between the first constituent (always one of the arguments) and the rest of the sentence.

Six out of ten declarative sentences begin with an adverbial element of time. In NGT time-adverbials are sentence-initial, and require similar prosodic marking as topics, namely raised eyebrows. I was not aware of this at the time of the recordings. The

⁶ The address of the website of the ECHO project is <http://www.let.ru.nl/sign-lang/echo/index.html>.

choice for these declarative sentences has influenced the data, a fact which will be discussed more elaborately in section 2 of the Results and Analysis chapter. All but one yes-no question had a 3rd person singular subject. I avoided 1st person in questions in general because in a pilot study it turned out that first person does not combine well with ‘surprise’, and may have resulted in rhetorical questions in the NGT translations.

The wh-questions contained the following wh-signs: WHAT (three sentences), WHO (three sentences), HOW (one sentence), WHY (two sentences), and WHERE (one sentence). The WHAT-questions questioned direct objects (sentences 3 and 5), the WHO-questions questioned subjects, two questioned the subject of an intransitive verb (sentences 7 and 4), and one questioned the subject of a transitive verb (sentence 10). The written Dutch sentences used for the initial translations are in Appendix B. We asked Participant 1 to sign the sentences neutrally, and after recording I let him review his signed sentences. A few sentences had to be filmed again, because in their translation they had additional affective meaning. The recordings resulted in signed sentences that on average lasted for 3188 ms with a standard deviation of 771 mms, containing on average 3,7 signs in sequence, with a standard deviation of 1,0 sign.

3.2.3 Set-up

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 hip); the other one was used to make a close-up recording of the face. The cameras were positioned behind each other, with one camera at the same level of the face of the Participant and the other directly above that. The Participant was sitting on a desk chair without arm rests. The instructor, Participant 1, was standing behind the cameras so it would feel natural for the Participant to sign in that direction. A laptop was placed on a table next to the participant, on which the stimuli were presented. One of the researchers sat next to the Participant to control the mouse, going from one item to another. Participant 2’s natural hair colour is blond; to make sure that his eyebrows would be visible on the video recordings, a brown line was drawn on his eyebrow using an eye pencil.

3.2.4 Procedure

For the elicitation of the data, I used the fifty previously recorded NGT sentences and presented them to the participants with an ‘affective assignment’ added. I asked them to repeat the sentences in an angry manner, for example. Each sentence was presented four times, with different affective cues: neutral, angry, surprised, and distressed. An asterisk preceded the signed sentence for the purpose of getting visual attention before each sentence. The affective assignments were given by presenting the written Dutch word for the emotion for 5 seconds after the signed sentence had been presented. A flow chart depicting the presentation of stimuli is shown in figure 7. One instance of a signed sentence combined with an affective assignment is called an item.

The items were presented in randomised order. When the Participant requested it, I repeated the item. I did not start the next item until the Participant was ready, but normally a 5-10 second micro break was used. After a hundred items, there was an obligatory fifteen minutes coffee break. Participants were told they could pause

whenever they wanted to. Total recording times did not exceed 1 hour. Before analysis, the recordings were synchronised and comprised into MPEG-1.

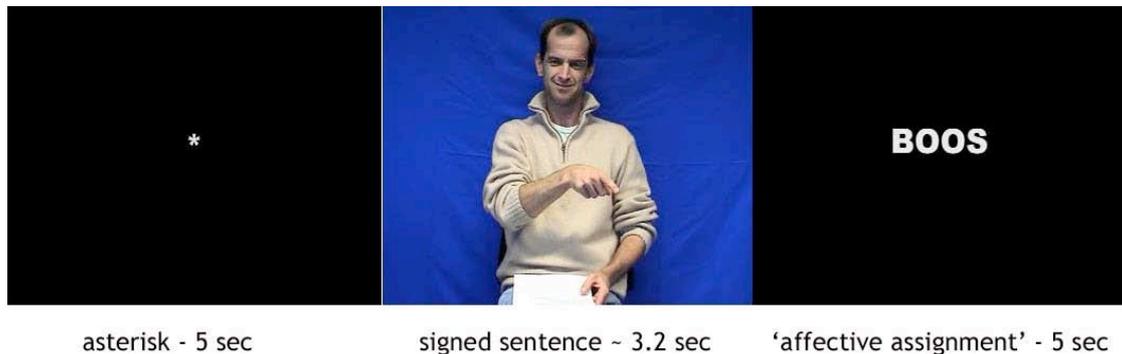


Fig. 7 Presentation of stimuli materials

3.3 Data annotation

In this section, I describe in detail how the data were annotated. First of all, I describe the program that was used for data annotation (ELAN), and how it was used. Secondly, I describe the scoring procedure. Thirdly, I discuss the exact way in which FACS codes were used.

3.3.1 ELAN annotation software

The recordings were annotated using ELAN annotation software. This is a computer program that allows one to annotate videos in time. Up to four video files can be played simultaneously, linked to a timeline. Annotations are made on different tiers of the timeline, to which the user can add tiers at will. The videos can be detached from the main program at any time to be enlarged, consequently giving the coder a better view. The video can be watched at any speed, and even frame by frame; one frame accounts for 40 milliseconds in PAL video recordings.

Figure 8 gives an impression of the program as it was used in this study. In figure 8, the video is shown in the left upper corner. In the middle of the picture the timeline is shown. This timeline divides the video file from the annotations part of ELAN. Annotations are made in the tiers, which are in the lower half of the picture. The tier names are shown in the left column (item, reliability, brows, and comments). The red vertical line across the tiers is the cursor. The shaded area is currently selected. The program is freely available at www.mpi.nl/tools/.

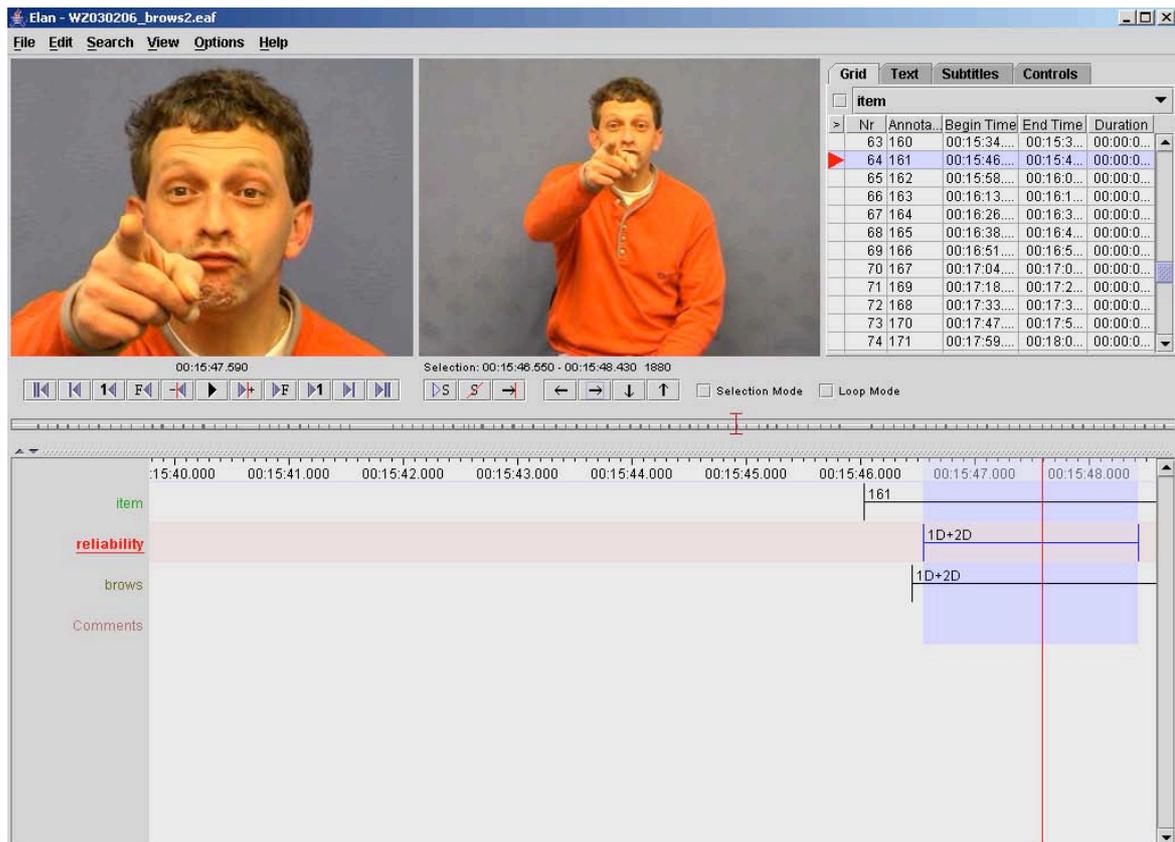


Fig. 8 ELAN annotation software

I annotated the recordings using the following tiers: ‘item number’, ‘comments’, ‘brows’, and ‘reliability’. In the ‘item’ tier I annotated all the numbers of the two hundred items. The key for sentence types and emotions was in an Excel file. The item numbers combined with this key allowed me to search for certain items by item number. The ‘brows’ tier was used for annotating AU. In the ‘reliability’ tier I annotated some items for the second time. The reliability coding is discussed more elaborately in section 4. The ‘comments’ tier was used for various annotation purposes.

3.3.2 Learning FACS

The Facial Action Coding System is learnt by studying a manual, which for each AU describes the facial appearance changes that are caused by the muscular activity of the muscles that belong to that AU. Facial appearance changes that may occur include parts of the face that have moved, wrinkles that have appeared or disappeared, and alterations in the shape of facial parts. Compare the shape of the eyebrows with different AU combinations in figure 3; AU 2, for example, produces an arched shape of the eyebrows; in contrast, AU 4 flattens the eyebrows. Also, see how wrinkles on the forehead differ between for example AU 1+2 and AU 1+4.

After an introduction to the Action Units, subtle differences in appearance changes of these AU are learnt. Subsequently, some combinations of AU are learnt in which one AU may interfere with the detection of another. In the FACS manual, various example pictures and videos illustrate each AU. However, the most important element of learning to code facial expressions is learning how to do each AU yourself.

3.3.3 Scoring procedure

I annotated the appearance changes (AU 1, 2, and 4) in the ‘brows’ tier. I disconnected the MPEG file in which the signs were shown, so that only the signer’s face was visible while annotating. I did this because the signs may have influenced my expectations on the AU that would be used. For each item, I watched it at least 2 times; firstly at 30 percent speed to scan the sentence and the location of any facial events, secondly, I watched it frame by frame and selected the segment for each distinct eyebrow position. I annotated only the parts of the video recording that contained the relevant items; this amounted to approximately 24 minutes of video in total. The initial annotation of the data using FACS took me approximately 120 hours (the transcription ratio was thus 1:300), spread over four weeks.

3.3.4 Using FACS

Firstly, I describe which data were coded in what way. Secondly, I describe the Action Units that were annotated. Thirdly, I describe the intensity scale that was used to annotate the data. Finally, I describe the guidelines that were used to separate AU and their alignment into facial events.

3.3.4.1 Coded data

In order to test predictions 1.1-3.2, I used FACS (Ekman et al., 2002a) to code the neutral items, all the yes-no questions, and both kinds of wh-questions. I did not code the topic sentences and declarative sentences that had additional affective meaning using FACS. The main reason for this has to do with time consumption. Although previously planned, during annotating I realised that it was not feasible to annotate all sentences within this MA project. Table 4 below contains a schematic overview of the parts of the elicited data I did and did not annotate using FACS.

Table 4 Data categories that were and were not analysed using FACS

	neutral	anger	surprise	distress
yes-no questions	FACS	FACS	FACS	FACS
wh-questions	FACS	FACS	FACS	FACS
wh-questions (i)	FACS	FACS	FACS	FACS
topic sentences	FACS	-	-	-
declaratives	FACS	-	-	-

3.3.4.2 Action Units and their combinations

I did not only annotate three Action Units when they occurred by themselves: AU 4, AU 1 and AU 2 but also the combinations 1+2, 1+4, and 1+2+4. 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. A combination of AU 2+4 results in a brow position that is a direct sum of AU 2 and AU 4. Thus, if a coder can code AU 2 and can code AU 4, he is also able to code a combination of AU 2+4. I did not find any occurrence of AU 2+4 in the data. This is not surprising, because it is not predicted for the sentences that were elicited in this

study. Furthermore, it is not linked to any specific emotional facial expression (Ekman, 1979), its occurrence is infrequent, nor has it been reported in literature on NGT to have a linguistic function. I did not code for asymmetrical occurrences of brow positions.

3.3.4.3 Intensity levels

In contrast with Baker-Shenk (1983, 1986), I used five instead of three intensity levels to code for the amount of evidence for each AU; level A-E (Ekman et al., 2002a). The A level refers to a trace of the action; B, slight evidence; C marked or pronounced; D severe or extreme, and E, maximum evidence. See figure 9 below in which the scale is depicted. Note that the A-B-C-D-E scale is not a scoring scale that has equal intervals; C and D cover a larger range of appearance changes. Furthermore, most of the AU movements fall into intensity levels C and D. Intensity level E in FACS 2002 is the equal to intensity level ‘z’ in FACS 1978 used by Baker-Shenk (1983).

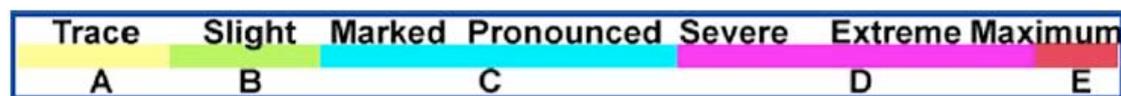


Fig. 9 Intensity scores do not cover equal intervals of scale of evidence (Picture taken from FACS (2002a) p.8)

3.3.3.4 Facial Events

According to Ekman et al. (2002a), ‘observable facial activity is not continuous but episodic, typically manifest as a set of discrete events’ (p.359). Therefore, FACS (Ekman et al., 2002a) provides a system to identify such discrete events as Facial Events. The advantage to describe facial activity in terms of Facial Events mainly lies in the fact that it is less time-consuming. The main reason for this is that it does not require the observer to code the beginning, apex, and end of each AU separately. Also, in some cases coding separately does not make much sense because the meaningfulness of the appearance of some AU lies in its combination with other AU. Ekman et al. (2002a) show this by elaborating on the occurrence of AU 1. The occurrence of AU 1 does not have meaning on its own instead it is interesting whether it occurs in a combination with 2, or 2+4.

How are these facial events identified? Facial events normally emerge from a neutral face, reach an apex, and then relax into a neutral face again. However, a combination of AU may also merge into another event without a return to the ‘neutral’ baseline. What is more, this second configuration may involve one or more AU from the first facial event. There are a few rules to distinguish a facial event from background events.

When an AU or a combination of them stays on the face for long periods of time at the same intensity level, it is considered a background event. In this case, only the AU that appear additionally at a certain time are coded. By contrast, if the AU increases in intensity when additional AU become involved, it is considered part of a new Facial Event. See the examples below in figure 10 and 11, where ‘<’ stands for increasing intensity level, ‘>’ decreasing intensity level, a ‘|’ for apex level, ‘.’ means that the AU started some time before, or ended after this example. In the first example, in figure 10, AU 1 is considered a background event and thus is not included in the FACS code

4+5+7. Note that Action Units that belong to the same facial expression are always coded in numerical order, not order of occurrence. In the latter case the annotation would have been 4+7+5 instead of 4+5+7. In the second example, the AU is considered part of a new facial event because it increases in intensity level together with the other AU; this is reflected in the coding 1+2+4. For the purposes of this study background events that started 2 seconds before the start of a sentence were excluded from analysis.

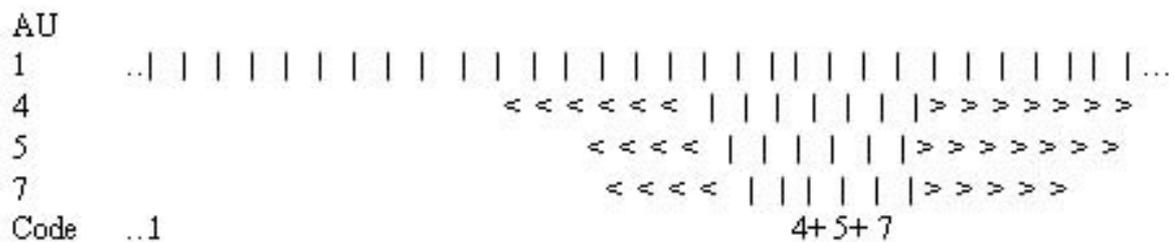


Fig. 10 Background event (FACS 2002 p.363)

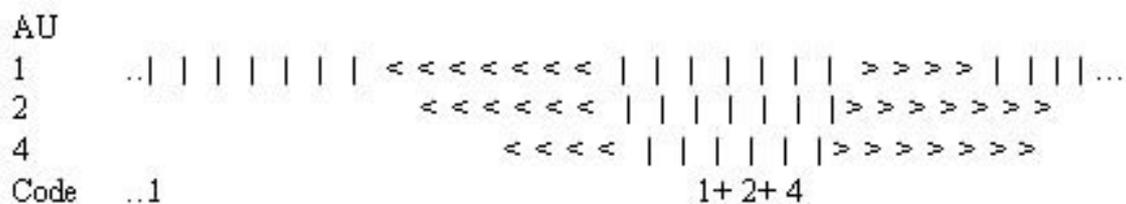


Fig. 11 AU 1 is part of new facial event (FACS 2002 p.364)

When a background event increases or decreases this is only coded when the event is rapid and discrete. Definitions for ‘rapid and discrete’ are not formulated by Ekman et al. (2002a). The second criterion that Ekman et al. (2002a) suggest for increments and decrements of a background event to be considered as new events is that they should have an increase or decrease of intensity level that is two points or more within the A-B-C-D-E scale used. For the purpose of this study, I formulated a lower standard; i.e. a one-point difference is enough to be considered a new facial event. The reason for this is it that Ekman et al.’s criterion may be too coarse for the subtle differences that are predicted by the Phonetic Sum hypothesis. For example, in a surprised topic sentence the intensity level of AU 1+2 is predicted to be higher on the topic part, than on the comment part of the sentence. Figure 12 below illustrates a possible outcome in which the intensity level of AU 1+2 decreases from D to C level. If Ekman et al.’s criteria had been used, AU 1+2 would not have been coded as a new Facial Event. Hence, this example would not be considered evidence for the Phonetic Sum hypothesis.

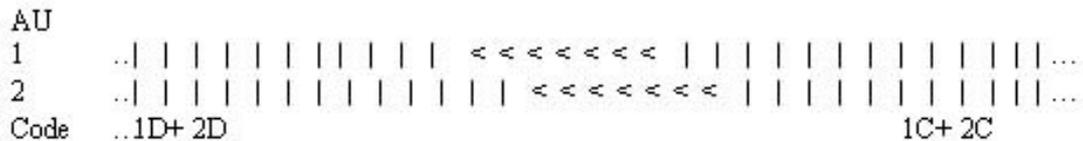


Fig. 12 A decrease or increase of the intensity level of a background event may be considered a new event if the intensity level increases or decreases with one point or more

3.4 Reliability of coding

I randomly selected 25 items and coded them for a second time for each participant's recordings. These items amount to approximately 15% of the total number of coded items. I followed the same procedure as described above, but made the original 'brows' tier invisible during annotating. Reliability for type of facial event (e.g. 1+4, 1+2+4) was 92% for both participants' items. Coerts (1992) reports on intracoder reliability of 83% in the eyebrows using ENCS (Colville et al., 1984). Baker-Shenk (1983) reports on intercoder agreement level on classification of AUs of 80% using FACS (Ekman & Friesen, 1978). Hence, the intracoder agreement in this study is comparatively high.

In those cases where the facial event was coded correctly, the reliability for intensity level was 60%. The Investigators' Guide reports on reliability of intensity of 55% (Ekman, Friesen, & Hager, 2002b). I did not check the reliability of length of facial event, but all of the initial and repeated annotations of facial events overlapped for the most parts.

When the second coding deviated from the original coding concerning intensity levels, this difference was never larger than one point deviation of the scale used. Moreover, most of these mismatches were coded lower the second time of coding; in 60% of the cases intensity scores were lower the second time of coding, in 40% I assigned a higher score. Six out of seven instances that were scored higher involved the single occurrence of AU 4. For the items that were scored lower, two thirds also involved AU 4. Therefore, I studied the section on intensity scoring for AU 4 again and scored the items that did not match the initial coding a third time.

The third time I coded AU 4, I used the same method. However, this time I did not coded using ELAN. For these third annotations reliability of type of facial event was 100%. 65% of the intensity scores matched the original annotations, 35% matched the second annotations. Hence, by restudying the manual, reliability with the initial annotations increased, but agreements with the second annotations decreased. Therefore, in cases of disagreement, the original judgements were used for analysis.

3.5 Predictions

In this section predictions for the results of the elicitation study are formulated. In section 3.5.1, I summarise the predictions for eyebrow position in sentences that either use the eyebrows for linguistic purposes, or for the expression of affect. These include the sentences with neutral affect and the declarative sentences. I will refer to these sentences as simple sentences because they require the eyebrows for just one purpose. In section 3.5.2, I discuss the predictions made by the Affect > Grammar,

Grammar > Affect, and Phonetic Sum hypotheses on the outcome sentences that combine affective and linguistic functions of eyebrows in NGT. Because they require the eyebrows for two purposes in one sentence, I will refer to these as complex sentences.

3.5.1 Simple sentences: affective or linguistic functions of eyebrows

Simple sentences require the eyebrows either for linguistic purposes or for affective purposes. In section 5.1.1, I discuss predictions for the sentences that only require the eyebrows for linguistic purposes. This group of sentences includes all the sentences that were signed in an affectively neutral way. In section 5.1.2, I discuss predictions for the sentences that require the eyebrows for affective purposes only. This group of sentences consists of the declarative sentences that have additional affective meaning.

3.5.1.1 Simple sentences: only grammatical usage of eyebrows

For the 'neutral' sentences, predictions are based on the generalisations for yes-no questions and topic sentences and for the wh-questions on Coerts (1992). The prediction for neutral declarative sentences is based on Koenen et al. (1993) and Coerts (1992). See section 2.2.2.3 of the previous chapter for an elaborate discussion of these sentence types. I list the predictions as 1.1-1.4b below.

Prediction 1.1

In neutral NGT declarative sentences, the eyebrows are in neutral position.

Prediction 1.2

In neutral NGT topic sentences, AU 1+2 are used only during the topicalised element; in the rest of the sentence the eyebrows are in neutral position.

Prediction 1.3

In neutral NGT yes-no questions, AU 1+2 are used over the full length of the sentence.

Prediction 1.4a

In neutral NGT wh-questions with the wh-sign sentence-final, AU 4 is used over the full length of the sentence.

Prediction 1.4b

In neutral NGT wh-questions with the wh-sign sentence-initial, AU 4 is used only during the wh-sign; in the rest of the sentence the eyebrows are in neutral position.

3.5.1.2 Simple sentences: only affective usage of eyebrows

Predictions on the Action Units used to express different emotions during signing are based on studies by Ekman (1979) and by Baker-Shenk (1986). For elaborate

discussion the expression of affect see sections 1.3 and 4.1 of the previous chapter. I list these predictions as 2.1-3 below.

Prediction 2.1

In angry declarative sentences in NGT AU 4 is used.

Prediction 2.2

In surprised, declarative sentences In NGT AU 1+2 are used.

Prediction 2.3

In distressed, declarative sentences In NGT AU 1+4 are used.

Predictions for the simple sentences are summarised in table 5 below in the shaded cells. Predictions for the complex sentences are indicated by a question mark in the table because the different hypotheses (Grammar>Affect, Affect>Grammar and the Phonetic Sum hypothesis) make different predictions, which I discuss in the next section. The sentences that contain a wh-sign that was sentence-initial are indicated by (i), the others have the wh-sign sentence-final. There is a comma between the predictions for the first part and the second part of both the sentence-initial wh-sentences and the topic sentences to indicate sequential predictions in one sentence. Neutral eyebrow position is shown by a hyphen.

Table 5 Simple sentences that require eyebrow for just one purpose are in the shaded areas

	neutral	anger	surprise	distress
yes-no questions	AU 1+2	?	?	?
wh-questions	AU 4	?	?	?
wh-questions (i)	AU 4, -	?	?	?
topic sentences	AU 1+2, -	?	?	?
declaratives	-	AU 4	AU 1+2	AU 1+4

3.5.2 Complex sentences: combining affective and linguistic functions of eyebrows

In this section I discuss three different hypotheses that make different predictions about the sentences that combine affective and linguistic functions of eyebrows; the complex sentences. In table 5 these types of sentences were denoted by question marks. However, before giving a detailed description of the predictions of each hypothesis, I discuss some cases in which predictions on the complex sentences do not differ per hypothesis. These cases include sentence parts that do not require linguistic marking, i.e. the second parts of wh-questions with a sentence-initial wh-sign, and the second (comment) parts of topic sentences. The fact that the comment parts of a topic sentence can be marked affectively has also been reported by Van Gijn (2004, p.14). These cases follow predictions 2.1-3 on the expression of affect in declarative sentences. In section 2.2.1, I discuss predictions made by the Affect > Grammar hypothesis. In section 2.2.2, I discuss predictions made by Grammar >

Affect. Finally, I discuss the predictions of the Phonetic Sum hypothesis in section 2.2.3.

3.5.2.1 Predictions by the *Affect > Grammar* hypothesis

This hypothesis, stating that affect prevails over grammar (*Affect > Grammar*), predicts that in case a signer wants to simultaneously express affect and grammar using his eyebrows, only the Action Units belonging to the emotional facial expression are used and that the eyebrow positions required for linguistic purposes are not shown. What is more, the same affective facial expression is used over the full length of the sentence. This hypothesis predicts that in all angry sentences AU 4 is present, in all surprised sentences AU 1+2 are present, and in all distressed sentences AU 1+4 are present. Hence, this hypothesis groups ‘angry’, ‘surprised’, and ‘distressed’ sentences together in the sense that the predictions they make on the AU that will be used are the same. The predictions per sentence type are presented in the table 6 below. Prediction 3.1a summarises the predictions by the *Affect > Grammar* hypothesis.

Prediction 3.1a

In case the affective and linguistic functions of the eyebrows require different Action Units, only the Action Units that express affective meaning are used.

Table 6 Predictions made by the Affect > Grammar hypothesis concerning the Action Units in different NGT sentence types

	neutral	anger	surprise	distress
yes-no questions	AU 1+2	AU 4	AU 1+2	AU 1+4
wh-questions	AU 4	AU 4	AU 1+2	AU 1+4
wh-questions (i)	AU 4, -	AU 4	AU 1+2	AU 1+4
topic sentences	AU 1+2, -	AU 4	AU 1+2	AU 1+4
declaratives		AU 4	AU 1+2	AU 1+4

3.5.2.2 Predictions by the *Grammar > Affect* hypothesis

The *Grammar > Affect* hypothesis predicts that in all cases where the eyebrows are required for grammatical marking of the sentence, they will not be used for the expression of affect; this is prediction 3.1b. These cases include declarative sentences, but also for the ‘comment’ parts of sentences that have a topic-comment structure, and the second part of wh-question which have a sentence-initial wh-sign which does not require wh-marking. For example, the *Grammar > Affect* hypothesis predicts that in an ‘angry’ topic sentence the signer firstly displays raised eyebrows on the topic (AU 1+2), and on the rest of the sentence lower his eyebrows (AU 4) to express anger. In contrast, in a yes-no question which require AU 1+2 over the full length of the sentence, AU 4 will not be present. See table 7 below for an overview of these predictions. Prediction 3.1b summarises the predictions by the *Affect > Grammar* hypothesis.

Prediction 3.1b

In case the affective and linguistic functions of the eyebrows require different Action Units, only the Action Units that have linguistic functions are used.

Table 7 Predictions made by the Grammar > Affect hypothesis concerning the Action Units in different NGT sentence types

	neutral	anger	surprise	distress
yes-no questions	AU 1+2	AU 1+2	AU 1+2	AU 1+2
wh-questions	AU 4	AU 4	AU 4	AU 4
wh-questions (i)	AU 4, -	AU 4	AU 4, 1+2	AU 4, 1+4
topic sentences	AU 1+2, -	AU 1+2, 4	AU 1+2	AU 1+2, 1+4
declaratives		AU 4	AU 1+2	AU 1+4

3.5.2.3 Predictions by the Phonetic Sum hypothesis

The Phonetic Sum hypothesis predicts that in sentences where the eyebrows are required for grammatical purposes and at the same time the signer expresses affect, this results in a combination of Action Units. In case identical AU are used for two purposes this results in higher intensity levels. Prediction 3.1c states that in case different Action Units are required they are combined simultaneously, e.g. an angry yes-no question results in the combining of AU 1+2+4. Prediction 3.2 states that in case the same Action Units are required, the intensity level increases, e.g. an angry wh-question results in an AU 4 that is more intense than a neutral wh-question. See table 8 below for the predictions made by the Phonetic Sum hypothesis per group of sentences. The cases in which a raised intensity level for an AU is predicted are given in bold in the table. Again the predictions are that in declaratives, in comment parts of topic sentences, and in the second part of wh-questions with the wh-sign sentence-initial, only the AU that expresses affect will be visible because the eyebrows are not required for linguistic functions. The Phonetic Sum hypothesis is the only hypothesis that makes predictions about the intensity levels of Action Units.

Prediction 3.1c

In case the affective and linguistic functions of the eyebrows require *different* Action Units, this leads to a simultaneous use of these Action Units.

Prediction 3.2

In case the affective and linguistic functions of the eyebrows require *the same* Action Units, this results in higher intensity levels of these Action Units.

Table 8 Predictions made by the Phonetic Sum hypothesis concerning the Action Units in different NGT sentence types

	neutral	anger	surprise	distress
yes-no questions	AU 1+2	AU 1+2+4	AU 1+2	AU 1+2+4
Wh-questions	AU 4	AU 4	AU 1+2+4	AU 1+4
Wh-questions	AU 4, -	AU 4, 4	AU 1+2+4,	AU 1+4, 1+4

(i)			1+2	
topic sentences	AU 1+2, -	AU 1+2+4, 4	AU 1+2, 1+2	AU 1+2+4, 1+4
declaratives		AU 4	AU 1+2	AU 1+4

3.6 Validity

Although I did not elicit semantically odd sentences, the elicitation study was not a case of natural language use. In order to get an assessment of the validity of the data, I did a small perception study. Participant 1 was asked to review a selected portion of the recordings and determine the emotion that was expressed. In this section I first describe the materials I used. Secondly, I describe the procedure of this perception study. Finally, I discuss the results of this perception study and conclude that the sentences that were elicited in the main experiment are valid.

3.6.1 Materials

From the recordings of Participant 2 and 3, I selected forty sentences that were recorded during the elicitation task, evenly distributed over sentence types and emotional states. The sample included eight yes-no questions, eight wh-questions with the wh-sign in sentence-final position, eight wh-questions with the wh-sign sentence-initially, and eight declarative sentences. For each sentence type I included two neutral utterances, two surprised utterances, two angry versions, and two distressed ones. I used the same items for each participant, but did not include a sentence more than once. For the yes-no questions I took neutral versions of sentences 1 and 2 from both participants, surprised versions of sentences 3 and 4, angry versions of sentences 5 and 6, and distressed sentences of items 7 and 8. The same method was used for the other sentence types.

3.6.2 Procedure

Participant 1 was asked to view the selected sentences from both participants at recorded speed using ELAN. The signs and the face were visible. The sentences had already been recorded in random order. For each sentence he was asked to choose between four emotional states: neutral, anger, surprise, and distress.

3.6.3 Results and conclusion

On average, Participant 1 judged 80% of the sentences as the signers intended; six mismatches occurred in his judgments of Participant 2 and ten mismatches occurred in judging Participant 3. Considering that chance scores are at 25% when choosing from four options, I am confident to say that these sentences were indeed efficient in expressing the targeted affective state. However, this does not tell us whether the eyebrows are in fact used as a cue to perceive affect during signing.

Initially, apart from the neutral items for which only one mismatch occurred, the misidentifications of emotions seemed to occur evenly spread across sentence types and emotions. However, ten out of sixteen mismatches involved instances in which the signers used an atypical AU to express an emotion; these atypical AU explained Participant 1's judgement and were thus excluded for Further analysis.

In seven instances, Participant 1 judged a sentence as distressed while another emotion was intended by the signer. These items included an angry declarative question (item 65), an angry topic sentence (item 67) and a surprise wh-question with the wh-sign sentence-initial by Participant 2; and, a surprised yes-no question (item 2), a surprised declarative sentence (item 26), an angry yes-no question (item 70), and an angry wh-question (item 164) by Participant 3. In all seven cases AU 4 (associated with either anger or distress) was present over the full length of the sentence. Because Participant 1's interpretation could be explained by the occurrence of AU 4, I did not include these mismatches for Further analysis in this section. Participant 1 judged one surprised wh-question by Participant 3 as neutral (item 20). In this item too AU 4 was present over the full length of the sentence, without any occurrence of AU 1+2. I excluded this item because this sentence only showed evidence for linguistic marking by the eyebrows, and not the marking of surprise by AU 1+2. In item 66, by Participant 3, a distressed wh-question, only AU 1+2 were present. The presence of these AUs was interpreted by Participant 1 as displaying surprise. Hence, this item was excluded as well.

In total, six of the initially sixteen mismatches were included for Further analysis. See table 9 below for an overview of the types of mismatches between Participant 1's judgements and the intentions of participants 2 and 3. Notably, distressed sentences were judged as surprised in four cases. In three out of four cases this involved sentences in which AU 1+2, which are associated with surprise, were used for linguistic purposes; that is, in the yes-no questions and topic sentences. Hence, Participant 1 interpreted the use of AU 1+2 as being affective instead of linguistic. One surprised topic sentence is judged as being neutral. In a surprised yes-no question, AU 1+2 are required for both a linguistic and an affective purpose. In this instance, Participant interpreted the use of AU 1+2 as being only linguistic. One wh-question that has a sentence-initial wh-sign was judged as surprised while neutral affect was intended. This may be related to the fact that in this item, Participant 3 widened his eye aperture (AU 5) which is associated with surprise when combined with AU 1+2.

Table 9 Mismatches between Participant 1's judgements and Respondent 1 and 2's signed utterances are spread across sentence types and emotions

	neutral	anger	surprise	distress
yes-no questions				surprised
wh-questions				
wh-questions (i)	surprised			
topic sentences				surprised,
			neutral	surprised
Declaratives				<i>surprised</i>

In just one case, namely a distressed declarative which was judged as surprised, it is unclear what cues caused this mismatch. In table 9 above it is denoted by italic script. The remaining types of mismatches support the idea that eyebrow movements are important cues for the perceiver in judging the signer's affective state.

4 Results and analysis

In this chapter the results of the elicitation study are presented and analysed in relation to the hypotheses that were formulated in the methodological chapter. I start off with giving a general impression of the data. Secondly, I describe the neutral sentences of the study. The descriptions of the neutral sentences resulted in new generalisations that were used to compare the sentences with and without additional affective meaning.

4.1 General impression of the present data

I annotated all the neutral sentences, and the yes-no questions and wh-questions with additional affective meaning using FACS (Ekman et al. 2002a). In section 3.3.3.4 of the previous chapter the notion of Facial Events has been discussed. Recall that Facial Events are discrete appearance changes in the face, in this case brow movements. In the present data, the annotated sentences contained on average 1.4 Facial Events, with a standard deviation of 0.8. On average, a Facial Event lasted 1 second and 644 milliseconds with a standard deviation of 1 second and 118 milliseconds⁷. According to Hager and Ekman (1995), Facial Events rarely last more than five seconds or less than 250 milliseconds. The Facial Events in the present data are thus not particularly longer or shorter than the typical Facial Event.

Baker-Shenk conducted one of the few studies that used FACS to describe facial behaviours in a signed language (ASL). However, Baker-Shenk (1983; 1986) used an earlier version of FACS (Ekman & Friesen, 1978) in which the notion of Facial Events had not yet been incorporated. Therefore, Baker-Shenk does not report on the length of brow movements in her data and I cannot compare Facial Events in my data to her description of facial behaviour in ASL.

Ekman (1979; 2002a) has claimed that AU 1, AU 2, AU 2+4 are rare brow movements. The present data support this idea; AU 2 and AU 2+4 were not observed and AU 1 only once. In fact, AU 1+2 almost always occur as a couple. Another observation is that distress is almost never expressed by using AU 1+4, rather AU 4 is used.

In general, the imitation task of the elicitation experiment was easy to do for the participants. Especially in items with additional affective meaning, they did not only change their facial expressions, but adjusted manual prosodic cues as well. This is illustrated in figures 13a-d below in which the sign COME-WITH is shown. In figure 13a it is signed neutrally, in 13b it is signed in a surprised way, in figure 13c it is signed in a distressed way, and in figure 13d it is signed angrily. In 13c (distress), the chin is down in comparison to the other examples. In 13d (anger) the sign is made bigger by extending the elbow in comparison to 13a. This type of enlargement is called proximalisation (Crasborn, 2001) In contrast, the surprised and distressed version of this sign is smaller, that is, signed more closely to the body. This type of signing is called distalised (Crasborn, 2001) In general, angry items were enlarged and signed

⁷ Note that the PAL video recordings that were used had a time resolution of 25Hz or 40 milliseconds per frame.

jerkier, and shorter. The fact that angry sentences are shorter has also been reported by Reilly et al. (1992) for ASL. In surprised items signers tilted their bodies backwards in comparison to the neutral items. In comparison, in angry items, signers leaned forward and extended their signing space forward. In distressed items both participants signed smaller and slower in comparison to the neutral items.



Fig. 13a Neutral yes-no question



Fig. 13b Surprised yes-no question



Fig. 13c Distressed yes-no question



Fig. 13d Angry yes-no question

The manual phonetic cues for angry sentences and distressed sentences in comparison to the neutral sentences are similar to the manual phonetic cues in different registers by NGT signers. Crasborn (2001) reports on the proximalisation of signs by NGT signers when ‘shouting’ and distalisation when ‘whispering’. (cf. Crasborn, 2001) The angry sentences in the collected data have similar manual phonetic cues as has been reported by Crasborn (2001) on shouted signs; the distressed items have similar manual phonetic cues as has been reported for whispering.

I aimed at eliciting ten items per sentence type from two participants. This amounts to twenty sentences per sentence type (ten per participant) but in a few cases an item was missed during the elicitation task without being noticed. Although I asked both participants to repeat signed sentences, they signed very few items in the same way. Not only did the brow movement and alignment of the non-manual signal differ; in some cases a pointing sign was added or left out. In a few cases an item was therefore left for further analysis. I report one of these for each sentence type separately.

4.2 Neutral sentences

In this section I discuss the different sentence types that were elicited with neutral affect in relation to the predictions and the stimuli materials. I start off with summarising the predictions for the neutral sentence types. The actual data led me to revise some of the details of the predictions. The new generalisations on the neutral sentences can be found in section 4.2.5.

It is predicted that in declarative sentences, the brow position will be neutral throughout the sentence (Coerts, 1992). In topic sentences, the eyebrows are up on the topic, but in neutral position on the comment part of the sentence (Coerts, 1992). In yes-no questions the eyebrows are up throughout the sentence (Coerts, 1992). In wh-questions the eyebrows are frowned. When the wh-sign is sentence final, frowned eyebrows (AU 4) will be present over the full length of the sentence. When the wh-sign is sentence-initial, the eyebrows are frowned exclusively on the wh-sign and the eyebrows are in neutral position over the rest of the sentence (Pfau, 2005). I repeat predictions 1.1-4 below for convenience.

Prediction 1.1

In neutral NGT declarative sentences, the eyebrows are in neutral position.

Prediction 1.2

In neutral NGT topic sentences, AU 1+2 are used only during the topicalised element; the eyebrows are in neutral position in the rest of the sentence.

Prediction 1.3

In neutral NGT yes-no questions, AU 1+2 are used over the full length of the sentence.

Prediction 1.4a

In neutral NGT wh-questions with the wh-sign in sentence-final position, AU 4 is used over the full length of the sentence.

Prediction 1.4b

In neutral NGT wh-questions with the wh-sign in sentence-initial position, AU 4 is used only during the wh-sign; in the rest of the sentence the eyebrows are in neutral position.

4.2.1 Neutral declarative sentences

In total thirty neutral declarative sentences were recorded, including the ten stimulus sentences that were signed by Participant 1. In table 10 below the results are presented. In the first column the numbers of the items are presented. In the second column the Action Units (AU) that were used in the stimuli are presented. In the third column, the AU by Participant 2 (Response 1). In the fourth column the AU by Participant 3 (Response 2). A comma distinguishes two Facial Events. When no brow movements were present during the sentence, this is shown by a hyphen in the table.

The AUs that are not predicted by Prediction 1.1 are in italic script. For neutral declarative sentences, no brow movement was predicted and thus all occurrences of brow movement are in italic script. The glosses of the stimuli are in Appendix A.

Table 10 Action Units used in neutral declarative sentences

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

Four out of ten items of the stimuli follow the pattern of Prediction 1.1 (items 3, 4, 7, and 10). That is, throughout the sentence the eyebrows are in neutral position. In the remaining stimuli items, the eyebrows are in various positions. In the next paragraph I try to account for this remaining six of stimuli items that do not follow prediction 1.1. In items 1, 2, and 5 of the stimuli AU 1+2+4 are used. Items 1 and 2 both begin with an INDEX⁸ without a previously introduced referent. Both sentences have an affirmative headshake at the beginning while the use of AU 1+2+4 spreads throughout the sentence. The headshake at the beginning seems to be a check with the interlocutor, who is behind the camera, whether he is familiar with the referent. Throughout the sentence AU 1+2+4 is used. It is unclear to me whether this configuration may be considered a brow raise as discussed by Wilbur (1999) and Wilbur and Patschke (1998) because they do not distinguish between AU 1+2 and AU 1+2+4. Wilbur and Patschke (1999; 1998) argue that one of the functions of brow raise in ASL is to hold the referent accessible. Possibly, the brow raise of AU 1+2+4 in these NGT data may thus be analysed in this way.

In item 5, the use of AU 1+2+4 starts at the sign DEAF. According to Ekman, AU 1+2+4 is associated with fear. Hence, the use of AU 1+2+4 in this item may express this affective meaning. Although a configuration of 1+2+4 is found more often on the sign DEAF in the present data, in this example it is not imitated by Respondent 1 and 2. Thus, the use of AU 1+2+4 is not likely to be a facial expression that is lexically associated with this sign. An alternative and more likely explanation for the brow raise in this item is that contrast is expressed (van der Kooij, p.c.). This analysis would also explain why the Respondents do not copy the same brow raise.

In items 6, 8, and 9 of the stimuli materials, AU 4 is used. In item 6, AU 4 is used in combination with eye gaze towards the wrist when signing TIME. Both Respondents

⁸ An INDEX is a pointing sign using the index finger. It may be spatially marked for person (e.g. 1st person, 2nd person, or 3rd person). This is shown in the gloss by a number in subscript, e.g. INDEX₂ 'you'.

1 and 2 only use eye gaze towards their wrists during this same sign. I thus hypothesise that the fact that eye gaze is directed at the wrist is related to the fact that the sign TIME is located at the wrist. In item 8, AU 4 is used during the whole sentence. It is unclear to me why this is so. However, the intensity level of this AU 4 is low and it does not seem to have influenced Respondent 1 and 2; they both signed the sentence with the eyebrows in neutral position. In item 9, AU 4 is only used during the sign UTRECHT (a place name) which is made on the forehead. This place of articulation may have caused the signer to use AU 4 as a reflex to protect his eyes. Recall that a facial event rarely lasts shorter than 250 ms (Hager & Ekman, 1995). Notably, the Facial Event in this stimulus item has a duration of only 200 ms, which supports the idea that AU 4 is not used consciously here. I hypothesise that the use of AU 4 in this item may be a phonetic effect, i.e. AU 4 is used because of this place of articulation at the forehead near the eyes. The fact that Respondent 1 also uses AU 4 during the sign UTRECHT supports this idea. However, Respondent 2 does not. More instances of the same place of articulation are needed to determine whether it truly is a phonetic effect.

In six out of twenty elicited declarative sentences eyebrows are in neutral position as predicted. These cases without brow movements included sentences 7 and 8 of Respondent 1 and sentences 1, 3, 8, and 9 of Respondent 2. Although the stimuli support Prediction 1.1 most of the Response items do not.

In sentences 1, 3, 5, and 10 by Respondent 1 and sentence 5, 6, 7, 10 by Respondent 2, AU 1+2 were present over the full length of the sentence. This type of non-manual marking is normally associated with yes-no questions, but not declarative sentences (Coerts, 1992). However, these items do not get the interpretation of a question.

In sentences 4 and 9 by Respondent 1 and sentence 4 by Respondent 2, AU 1+2 were followed by a neutral eyebrow position. These sentences both involved a sentence-initial adverbial constituent of time. According to Coerts (1992), sentence-initial adverbial constituents of time or place are left-dislocated and receive topic marking. I hypothesise that these items do in fact have such a topic-comment structure as described by Coerts. Notably, items 3 and 10 also involve a sentence-initial element of time but did not get raised eyebrows on the topic. I did not annotate other characteristics of topics (such as lengthening of signs) so I don't know whether these two items have a topic-comment structure.

Item 2 was signed by Respondent 1 and 2 with the same non-manual marking: AU 4 over the full length of the sentence. This is due to the sign FAST which has a non-manual component that includes a facial expression using AU 4. This non-manual component spreads throughout the sentence and may be analysed as an intensifier (Kooij, p.c.). A similar form and function is found in other sentence types in the present data. However, more research is needed to determine the status of this non-manual marking.

Overall, the stimuli did not support Predictions 1.1, nor do the Response items. Most of the variation in the present data can be accounted for by other linguistic and affective functions of the eyebrows. I argue that in neutral declarative sentences in NGT, the eyebrows are in fact 'linguistically underspecified' which means that the eyebrows are available for other linguistic and affective functions. In the absence of

such other functions, the eyebrows will stay in neutral position. Future research is needed to determine the functions that eyebrows may express during declaratives.

4.2.2 Neutral topic sentences

In NGT topic sentences, the eyebrows are predicted to be up on the topic and in neutral position during the comment part of the sentence. In practice, only one of the stimuli items (no. 6) follows this pattern. In fact, in the stimuli items, several topics were found to be marked with frowned eyebrows and/or squinted eyes (nos. 1, 2, 5, 7 and 8); this type of marking may be pragmatically motivated. In future, it is wise to transcribe the stimuli items before running the elicitation experiment and thus exclude any atypical forms. This way, any influences that are not controlled for (e.g. affect, pragmatics) can be precluded. Although the stimuli items show atypical topic marking, the response items look very much like topic sentences as described by Coerts (1992). In table 11 below I present the AU used in the recorded neutral topic sentences. The cases that do not follow prediction 1.2 are in italic script. The glosses of the stimuli are in Appendix A.

Table 11 Action Units used in neutral topic sentences

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

Only one of the stimuli items (item 6) supports prediction 1.2. In this case, the eyebrows are raised on the topic and in neutral position during the comment part of the sentence. In the other stimulus items two patterns for topic marking arise; one pattern uses squinted eyes, eye gaze and AU 4, the other just squinted eyes and eye gaze.

Items 3, 4, 9 and 10 of the stimuli the eyebrows are in neutral position throughout the sentence. All of these stimuli items have an INDEX after the first constituent. The eyes are squinted (AU 7 Lid Tightner, see Appendix C) at the INDEX and eye gaze is directed towards the location in signing space where the index finger is directed to. According to Kooij (p.c.) the INDEX in these cases may thus be a locative predicate. In the second pattern again the topic is marked by squinted eyes and eye gaze but in combination with AU 4 during the first constituent and the following INDEX. This is the case in items 2, 5, 7, and 8. The use of AU 1+2+4 in item 1 may be explained by

the sign DEAF similar to item 5 of the declarative sentences. Thus, again contrast, i.e. deaf, not hearing, may be expressed.

In the stimuli items AU 1+2 is not used on the first constituent. Instead, Participant 1 uses AU 7 and eye gaze, in some cases combined with AU 4. This type marking is illustrated in the example below. It remains unclear when AU 4 is or is not used. The question arises whether the stimuli items have a true topic-comment structure, because they do not have a typical brow raise on the supposed topic. I did not annotate other prosodic cues that are characteristic of topics such as lengthening of signs (cf. Coerts, 1992) so this question remains to be answered. Notably, the stimuli items were successful in eliciting typical brow movements on topics in the response items.

AU 4 + 7 +eye gaze

11. MAN INDEX₃ BAG FORGET

‘As for the man, he forgot his bag.’

Participant 1, topic sentence 2

The Response items show a different picture than the stimuli: in sixteen of the elicited neutral topic sentences AU 1+2 are present. Half of them follow the pattern described by Prediction 1.2. These items include sentence 2, 3, 4, 5, 7, and 8 by Respondent 1 and sentences 5 and 7 by Respondent 2. In the other half AU 1+2 continued or were repeated at a different intensity level after the topicalised element; this was true for sentences 1 and 10 of Respondent 1, and for sentences 1, 3, 5, 8, and 9 of Respondent 2. This latter pattern cannot be explained by the stimuli because they looked quite different.

In sentence 8, the topic marker AU 1+2 was followed by AU 1+4. Van Gijn (2004) reports on the possibility of the expression of affect on the comment part of a sentence with topic-comment structure. I suggest that in this case distress was expressed. Similarly, in item 8 from the stimuli materials, some kind of positive affect as described by Ekman (1979) may have been expressed.

In sentence 9 by Respondent 2, the eyebrows are neutral on the first sign and then go up on the comment part of the sentence. This is the reverse pattern of Prediction 1.2. I have asked Participant 1 to look at this sentence and tell me whether there was something wrong with this sentence; he judged the item as ungrammatical. Therefore, this item was eliminated from analysis. This item was the last item before the coffee break and the signer may thus have been tired. I suggest that in future breaks during an experiment should be made after a shorter period of time than 30 minutes.

In some of the Response items, I could not explain the occurrence of certain brow movements. In sentences 3 and 10 of Respondent 2, AU 4 was used in the comment part of the sentence. In sentence 10 this may be explained by the sign BLIND which is made near the eyes. A similar explanation was given for the occurrence of AU 4 with the sign UTRECHT. In the present case of AU 4 however, the brow position is hold after the sign. In sentences 4 and 6 of Respondent 2, only AU 4 was present throughout the sentence. Although again affect may be expressed as I suggested for previous items, this is not a satisfactory explanation. First of all, I instructed the Respondents to sign these sentences neutrally, in contrast to other emotions.

Secondly, the neutral topic sentences were judged correctly by Participant 1. It remains unclear why AU 4 occurs in these items. Further research is needed to explain these brow movements.

In 2 cases, sentence 6 of Respondent 1, and sentence 2 of Respondent 2, no eyebrow action was present. In the latter case, the first sign MAN is repeated six times. This may be an idiosyncratic feature of Participant 3; he signed MAN like that in all instances in the present data. Alternatively, repeating a sign may be some kind of focus marking (van der Kooij, p.c.).

I analysed nineteen of the twenty elicited topic sentences. Fifteen of them had AU 1+2 on the topicalised element, but in five items this brow raise continued over the rest of the sentence. Phonetically it is possible for a brow raise to end abruptly, however some kind of phonological spreading of the brow raise may have taken place. According to van Gijn (2004) affect may be expressed on the comment part of a sentence with topic-comment structure. Ekman (1979) claims that brow raise by using AU 1+2 may be associated with general positive affect. Thus it may be the case that the brows were raised in these sentences because the signers were expressing positive affect. This explanation for the brow raises in these sentences can easily be tested by asking a native signer to judge the affective load in these sentences.

In 10% of the elicited topic sentences, AU 4 occurred on the topic. This percentage is similar to Coerts (1992) who also found that in 7,8% of the cases brows were lowered on the topic. Coerts hypothesises that the use of AU 4 during a topicalisation is related to the accessibility of the topic in discourse. In other words, the signer is checking whether the interlocutor knows what he is talking about. Thus, according to Coerts, eyebrows down on a topic only arise under these pragmatic circumstances.

Notably, 40% of the topic sentences of the stimuli AU 4 is used combined with squinted eyes (AU 7, Lid Tightner). In addition, 40% of the stimuli the topic is marked by AU 7. According to Coerts (1992) AU 4 is related to topic inaccessibility. Recall from section 2.2.2.4 that according to Engberg-Pedersen (1990) squinted eyes are also associated with referent accessibility. When recording the stimuli no context was available. I suggest that the use of AU 4 with inaccessible topics may be related to the use of eye squint as described by Engberg-Pedersen (1990). In other words, Participant 1 may have used AU 4 and 7 to mark topics because of referent (in)accessibility. It remains unclear however, when AU 4 is or is not used.

All in all, the first part of the prediction is borne out. That is, eyebrows are up on the topic. However, the eyebrows are not in neutral position on the comment-part of the sentence. In addition, the neutral brow position is susceptible for the expression of affect and information structure. Apparently, both linguistic and affective brow movements may occur sequentially in a sentence.

4.2.3 Neutral yes-no questions

In this section I describe the neutral yes-no questions in relation to Prediction 1.3 and the stimuli materials. It was found that the stimuli and response items are homogenous in the occurrence of brow movements. That is, almost all neutral yes-no questions are marked by brow raise. However, a different form of brow raise was found besides AU 1+2: AU 1+2+4. Prediction 1.3 is thus supported by the present data, but is reformulated into Generalisation 1.3 with more detail. In table 12 below I present the

AU that were used in neutral yes-no sentences. The AUs that deviate from prediction 1.3 are in italic.

Table 12 Action Units used in neutral yes-no questions

sentence number	Stimulus	Respondent 1	Respondent 2
1	1D+2D	1B+2B	1C+2C
2	1D+2D+4D	1D+2D	1D+2D
3	1D+2D+4D	1C+2C+4C	1D+2D+4B
4	1D+2D+4D	1C+2C	1D+2D+4B
5	1E+2E+4E	1D+2D+4D	1D+2D
6	4D	1D+2D+4C	4D, 1C+4C
7	1D+2D	1D+2D+4D	1D+2D
8	1D+2D+4D	1C+2C+4B	1D+2D
9	1D+2D+4D	1D+2D	1A+2A, 1B+2B
10	1D+2D+4D	1D+2D	1D+2D

Prediction 1.3 states that in neutral NGT yes-no questions, AU 1+2 are used over the full length of the sentence. In the present data this was true for all uttered neutral yes-no questions, except for one. This exception is sentence 6 for Respondent 2, in which first AU 4 and then AU 1+4 are used. This is presumably caused by the stimulus, because this also has an AU 4 throughout the sentence. In this item the occurrence of AU 4 seems to be linked to the sign TIRE~~D~~, and the non-manual marking could either be analysed as an intensifier (van der Kooij, p.c.) or as expressing distress. Therefore, this item was left out for further analysis. This is shown in table 12 by a strike through the item.

Note that in thirteen out of twenty-seven yes-no questions, besides AU 1+2, an additional AU 4 occurs within the same facial event. This configuration of AU 1+2+4 is associated with fear (Ekman, 1979). Hence, the question arises if these yes-no questions are in fact affectively neutral, or that they have some additional fearful meaning. In chapter 3, I reported on a perception study showing that the validity of the Response items is high, i.e. the emotional state was recognised in 80% of the cases. None of the items that have AU 1+2+4 were included for this perception study. It is thus unclear whether these items would be interpreted with some kind of additional meaning. However, I think it is unlikely that all three signers were expressing fear in half the cases without an instruction to do so. I suggest that in AU 1+2+4 is a phonetic variant of brow raise.

In only one case the co-occurrence of AU 1+2+4 concerned the same item for all three participants; this is sentence 3. The fact all three signers only once used the same facial expression for an item, suggests that in this case it may have a meaning related to the semantics of the signs. A possible candidate for this non-manual marking is the sign BREAK. However, in other instances of the same sign (in topic sentence 8) different facial expressions are used.

Coerts (1992) used a transcription system that distinguishes between three eyebrow positions, i.e. brows up, down or neutral. When formulating Prediction 1.3, I interpreted brows up as AU 1+2. Similarly, Baker-Shenk (1983) describes American

Sign Language question signals of yes-no question as displaying AU 1+2. However, Coerts may have considered AU 1+2 as well as a configuration of AU 1+2+4 instances of brows up. If I interpret Coerts' generalisation concerning yes-no questions in NGT as including both 1+2 and 1+2+4 as possible markers of yes-no questions in NGT, her generalisation holds in all the yes-no questions. This percentage is comparable the reported percentage of brow raise in the yes-no interrogatives in her dissertation (Coerts, 1992, p.106), namely 88,9%.

Further research is necessary to determine whether the use of AU 1+2+4 instead of AU 1+2 carries a different meaning, or whether AU 1+2 versus AU 1+2+4 are phonetic variants for which a preference may vary per signer or region. Currently, an NGT corpus of spontaneous signing is being set up by Onno Crasborn and Inge Zwitterlood a.o. This corpus will allow researchers to include data from various regions, ages, and registers to control for such factors. Unfortunately, it is not feasible, due to time constraints, to have all the non-manual behaviour in a corpus transcribed using FACS.

4.2.4 Neutral wh-questions

In NGT, neutral wh-questions are marked by frowned eyebrows (Coerts, 1992). Furthermore, the parts of the wh-question that are marked non-manually by the eyebrows differ with the position of the wh-sign (Pfau, 2005). That is, when the wh-sign is sentence-final, the eyebrows are frowned during the whole sentence. When the wh-sign is sentence-initial, the eyebrows are frowned exclusively during the wh-sign. However, in the present data a different picture arises. Although all the stimuli items have AU 4 throughout the sentence, there are three patterns that arise from the Response items: AU 4, AU 1+2, or a combination of them. What is more, the spreading of these markers is found to be independent from the type of wh-sign and the position of the wh-sign in the sentence. More research is needed to determine when these different markers occur.

4.2.4.1 Neutral wh-questions with the wh-sign sentence-final

Prediction 1.4a states that in neutral NGT wh-questions, with the wh-sign sentence-final, AU 4 is used over the full length of the sentence. In nine out of ten stimuli items this pattern occurred. In contrast, in many of the Response items, AU 1+2 are used. In the following paragraphs I discuss possible reasons for this occurrence of AU 1+2. See table 13 below for the details of the AU that are used in the neutral wh-questions. Note that the items are not in numerical order but are grouped per wh-sign.

Table 13 Action Units used in neutral wh- questions with wh-sign sentence-final

sentence number	Wh-sign	Stimulus	Respondent 1	Respondent 2
8	HOW	4D	1D+2D, 4E, 4D	1B+2B
3	WHAT	4C	1D+2D+4D	4A
5	WHAT	4C	1C+2C	4B
6	WHAT	4C	-	4D
1	WHERE	-, 1C+2C	1C, 1C+2C, 1B+2B	1B+2B, 1D+2D

4	WHO	4C, 1D+2D+4D	4C, 4B	4A, 1D+2D
7	WHO	1D+2D+4D	1C+2C	1D+2D
10	WHO	4C, 1D+2D+4D	-	1C+2C
2	WHY	4D, 1D+2D+4D	1B+2B, 1C+2C, 1B+2B	1C+2C
9	WHY	4C	4A, 1C+2C, 1D+2D	-

In nine out of ten stimulus items, AU 4 is used throughout the sentence. This is the case in items 2-10. However, besides AU 4, AU 1+2 occur in half of the stimuli items. In three of the stimuli items, AU 4 was used initially, followed by AU 1+2+4 on the wh-sign and Palm Up⁹ sign. This is the case in items 2, 4, and 10. In item 1, AU 1+2 are used on the Palm Up sign. AU 1+2+4 spread throughout the sentence in item 7. Ekman (1979) reports on the co-occurrence of AU 1+2+4 as expressing fear. However, looking closely at these items this does not seem to be the case. It is unclear why AU 1+2+4 occurs in these cases.

Only four of the twenty elicited neutral wh-questions with the wh-sign sentence-final confirm Prediction 1.4a. This is so in sentence 4 by Respondent 1, and sentences 3, 5, and 6 by Respondent 2. In these sentences AU 4 thus appears throughout the sentence. Two additional patterns are found; AU 1+2, or a sequential combination of AU 1+2 and AU 4 may mark a wh-question.

AU 1+2 occurs exclusively in eight of the sentences. This is the case in sentences 1, 2, 5 and 7 by Respondent 1, and sentence 1, 2, 7, 8 and 10 by Respondent 2. This occurrence of AU 1+2 was not predicted. In sentence 3 by Respondent 1, a configuration of AU 1+2+4 occurs. This occurrence of 1+2+4 may have been copied from the stimulus item; in the stimulus 3 only AU 4 is used.

In some Response items AU 4 and AU 1+2 are combined sequentially in a sentence. In sentence 8, AU 4 appears on the sentence-final PU sign; in sentence 9 the reverse pattern appears and AU 4 is used on the first sign which is an INDEX. AU 1+2 are used only on the sentence-final wh-sign in sentence 4, by Respondent 2. In the stimuli items that were used to elicit these sentences different AU are used, so these do not provide an explanation. It is unclear what motivates this sequential occurrence of frowned and raised eyebrow within one wh-question. No brow movement present at all in sentence 6 and 10, by Respondent 1, and sentence 9 by Respondent 2.

In four of the response wh-questions with the wh-sign sentence-final, AU 4 is used as predicted. That is, only AU 4 is present throughout the sentence. A second pattern for these wh-questions arises in which only AU 1+2 are used, this pattern occurs in nine sentences. The third pattern is one in which AU 1+2 and AU 4 are combined in one sentence, either simultaneously (i.e. AU 1+2+4) or sequentially. This pattern is found in four wh-questions. In the remaining items no brow movement was present. Concluding, the wh-questions show a lot of variation in brow movements compared to

⁹ IAll the recorded wh-questions with the wh-sign sentence-final were signed with Palm Up in sentence final position. Nevertheless, I will refer to these sentences as wh-questions with the wh-sign sentence-final for convenience. The Palm Up sign (PU) has been analysed as a manual carrier of prosodic information (Kooij & Crasborn, 2006) and as a general question sign (Dutch 'Algemeen Vraagbaar').

the yes-no questions. I therefore hypothesised that the variation in brow movements may be explained per wh-sign.

None of the items was signed the same by all three participants. However, there are indeed some tendencies per wh-sign. Participant 1 and 3 sign the WHAT-questions (item 3, 5, and 6) by using AU 4 exclusively. The WHERE-question is signed by using AU 1 and 2 by all three participants. In seven out of nine instances of the sign WHO, the eyebrows are up (i.e. AU 1+2 or 1+2+4) on the wh-sign. Hence, there seems to be a tendency for certain wh-signs to get a different non-manual marking than the standard AU 4. I hypothesised that if the wh-markers correlate with certain wh-signs, this may also be the case for the wh-questions with the wh-sign sentence-initial. However, this was not supported by the data, as the following section will demonstrate.

4.2.4.2 Neutral wh-questions with the wh-sign sentence-initial

Prediction 1.4b states that in neutral NGT wh-questions with the wh-sign sentence-initial, AU 4 is used only on the wh-sign. None of the wh-questions I elicited showed this pattern. The stimuli form a homogenous group that have frowned eyebrows throughout the sentence. This type of wh-marking is has also been described elsewhere in the literature (Coerts, 1992). In contrast, the Response items show a lot of variation similar to the wh-questions with the wh-sign in sentence-final position. In table 14 below the results are presented.

Table 14 Action Units used in neutral wh-questions with sentence-initial wh-sign

sentenc e number	Wh-sign	Stimulus	Respondent 1	Respondent 2
8	HOW	4C	<i>ID+2D</i>	<i>IB+4B,</i> <i>IB+2B+4B</i>
3	WHAT	4C	<i>IC+2C, 4A</i>	-
5	WHAT	4C	<i>IC+2C</i>	4A
6	WHAT	4C	4C	4B
1	WHERE	4D	<i>IC+2C</i>	4B
4	WHO	4D	4D	-
7	WHO	<i>IC+2C, 4C</i>	<i>ID+2D</i>	<i>ID+2D+4B,</i> <i>IB+2B</i>
10	WHO	4B	X	<i>IA+2A</i>
2	WHY	4C	<i>ID+2D, IB+2B,</i> <i>IC+2C</i>	-
9	WHY	4D	<i>ID+2D, 4E</i>	<i>IB+2B,</i> <i>IB+2B+4B</i>

In nine out of ten stimuli AU 4 was used throughout the sentence. In contrast to the wh-questions with the wh-sign sentence-final AU 4 was used exclusively in these items. That is, it is combined only once with other AU during a sentence. Hence, the

stimuli are a homogeneous group with a single exception. This exception is item 7 of the stimuli materials, AU 4 is preceded by a brow raise (AU 1+2) on the wh-sign (WHO). In the wh-questions with the wh-sign sentence-finally, WHO was also marked by a brow raise in seven out of nine cases. Hence, the fact that WHO was used instead of any other wh-sign may have caused this brow raise.

In none of the twenty elicited sentences AU 4 was used exclusively on the wh-sign. Hence, Prediction 1.4b is not supported. In four of the twenty elicited wh-questions, AU 4 was present over the full length of the sentence. These cases included sentences 4 and 6 of Respondent 1, and sentences 1, 5, and 6 of Respondent 2. In sentence 7, AU 4 was used in combination with AU 1+2, and followed by AU 1+2. In sentence 8, AU 4 was combined with AU 1 and followed by AU 1+2+4. Respondent 2 signed both sentences. Respondent 2 did not have any eyebrow action in sentences 2, 3, and 4. Respondent 1 used only AU 1+2 in sentences 1, 2, 5, 7, and 8. Respondent 2 did this in sentences 10. For sentence 10 of Respondent 1 I do not have any data, because it was left out by accident in the process of recording.

Prediction 1.4b is not supported by the present data. Instead, the Action Units that were used in the wh-questions with a sentence-initial wh-sign are varied and the distribution of types of facial events is similar to the wh-questions with the wh-sign sentence-final. AU 4 is used throughout the sentence in 20% of the items, AU 1+2 are used exclusively in 30% of the items, and in another 20% a combination of the AU occurs. Also, the absence of brow movements and a sequence of different facial events are distributed in a similar way for both types of wh-questions. The distribution of types of facial events for both types of wh-questions is shown in the figure 14.

Neutral NGT sentences

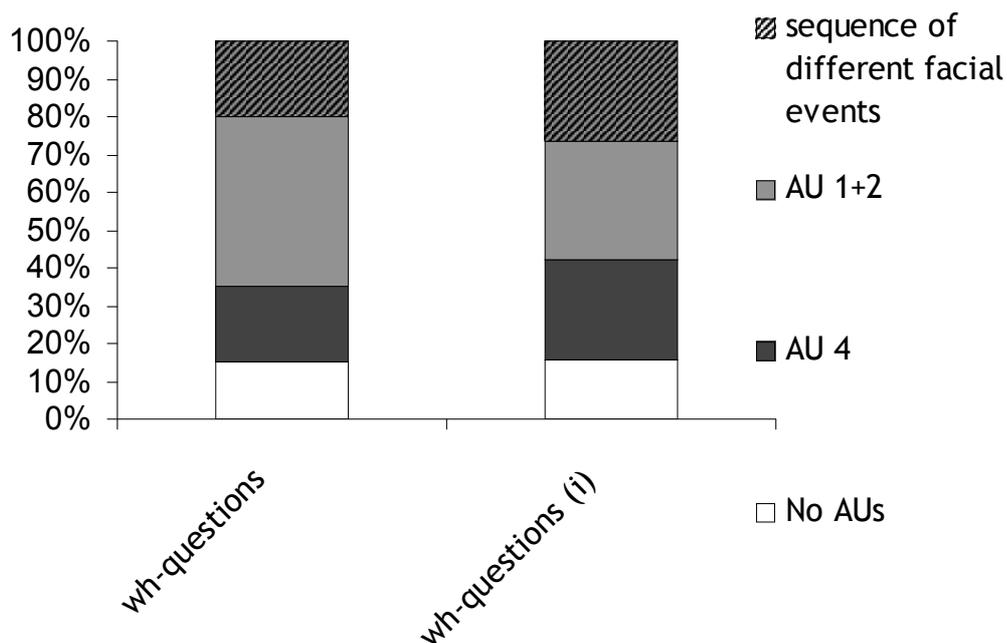


Fig. 14 Action Units used in wh-questions with the wh-sign sentence-final versus sentence-initial (i) by Respondent 1 and 2

I found varying eyebrow markers in the wh-questions; they included no marking at all, AU 4, AU 1+2, or a combination of these Action Units during a sentence. There is no difference in general between the domain of eyebrow markings in wh-questions which have a wh-sign sentence-final or sentence-initial, nor are these markers associated with certain wh-signs. Also the distribution of these markers per signer is similar, but neither AU 1+2, nor AU 4 is associated with a particular wh-sign.

Coerts (1992) reports on neutral brow position in 11,8% of her wh-questions; in the wh-questions that I elicited this percentage is 15%. These percentages are similar. However, in 20% of the neutral wh-questions that I elicited only AU 4 was present; whereas, Coerts reports on a percentage of 82,4% percent. In contrast, Coerts reports on raised eyebrows in 5,9% of the wh-questions in her data. AU 1+2 are present in 38,5% of the wh-question in the present data,. However, the stimuli items show more homogeneity. In 70% of the stimuli items AU 4 is used exclusively throughout the sentence. If I include configurations of AU 1+2+4 this percentage rises to 90%. Hence, the stimuli are more similar to Coerts' data than the neutral Response items. This may have been a result of the elicitation method.

Further investigation is needed especially of those wh-questions in which AU 1+2 occur, a prosodic cue that is normally associated with yes-no questions (Coerts, 1992). For BSL it has been claimed that raised eyebrows are used when a short answer is expected, while frowned eye-brows are used when a long answer is expected (Deuchar, 1984). Thus, wh-questions that are expected to have a short answer have raised eyebrows. Similarly, yes-no questions that are expected to get long answers have frowned eyebrows. According to Coerts, these prosodic cues of eyebrows may function in NGT as well. With the present data I am unable to corroborate Deuchar's findings because I did not look at language use, thus there was no pragmatic context. However, the fact that the elicitation task made signers imitate a question may have induced a different reading for the wh-questions than was expressed in the stimuli items. Hence, the expected answer for the wh-question may have been narrowed down by the imitator and thus AU 1+2 were used. For yes-no questions this did not happen because they already are expected to get short answers. In sum, although the stimuli items are a homogenous group that show the use of AU 4 throughout the sentence, the brow movements that were used in the Response items are diverse. This diversity of brow movements may have been due to the elicitation method. For the purposes of this study, a new generalisation will be formulated in the following section.

4.2.5 Generalisations neutral sentence types

The predictions on the brow positions in neutral NGT sentence types were based on the literature on NGT (Coerts, 1992; Pfau, 2005). However, I found more variation in brow positions than is described in these works. This was partly due to the fact that earlier descriptions of NGT used a transcription system that is less detailed than the Facial Action Coding System (Ekman et al., 2002a). Coerts (1992) makes use of a transcription system (ENCS) that allows for three brow positions: up, down, and neutral. As a consequence, Coerts groups forms that are in the middle between up and

down within in either category. FACS allows for a mixed combination by AU 1+2+4. I suggest that this type of brow raise is linguistically distinct from AU 1+2. That is, in the neutral topic sentences and yes-no questions brow raises are found that involve AU 1+2 or AU 1+2+4, but this latter marker is not used in topic sentences. In other cases the variation that was found could be explained by linguistic or affective functions of eyebrows that were not controlled for in this study. However, for the wh-questions the eyebrow positions as well as the spreading of this non-manual signal deviated a lot from earlier descriptions. And, for declarative sentences, no single linguistic pattern was identified.

In this section, I give the generalisations for the neutral sentence types in NGT based on the discussions in section 4.2.1-4

Generalisation 1.1

Declarative sentences in NGT are underspecified for eyebrow position.

Generalisation 1.2 (corroborating the findings of Coerts, 1992)

In NGT topic sentences, AU 1+2 occur on the topicalised element.

Generalisation 1.3

In NGT yes-no questions either AU 1+2 or AU 1+2+4 are present over the full length of the sentence.

Generalisation 1.4

In NGT wh-questions, irrespective of the wh-sign being in sentence-final or sentence-initial position, there are two possible non-manual markers of these sentences: AU 4, or AU 1+2. These markers can be combined sequentially.

I will use these generalisations to reformulate the predictions made by the Grammar > Affect hypothesis and the Phonetic Sum hypothesis. This is done in each section separately. Evidently, the predictions by the Affect > Grammar hypothesis are not changed.

4.3 Affective Yes-no questions

In a neutral yes-no question eyebrows are raised in NGT. This brow raise may involve a configuration of Action Units 1+2 or 1+2+4. As I discussed in section 2.1.3 affect is predicted to be marked as follows: Anger – AU 4, Surprise – AU 1+2, and Distress - AU 1+4. In this section I discuss the yes-no questions that have additional affective meaning. I start off by analysing the AUs that were used and then interpret them in relation to the hypotheses. Following, I compare the distribution of AUs in yes-no questions with different affective meanings in section 4.3.4. Surprisingly, these findings lead to the conclusion that the angry and distressed items support the Affect > Grammar hypothesis, while the surprised items support the Phonetic Sum hypothesis. Comparison to the wh-question with additional affective meaning in section 4.5 will lead to the conclusion that phonetics is needed to explain these results.

4.3.1 Angry yes-no questions

In table 15 below I summarise the predictions by each hypothesis for the angry yes-no questions. The Affect > Grammar hypothesis predicts that for angry yes-no questions, only AU 4, which expresses anger, will be present. Initially, the Grammar > Affect predicts that either AU 1+2 or AU 1+2+4 linguistically mark a yes-no question. The Phonetic Sum hypothesis also predicts that a combination of AU 1+2+4 will be present over the full length of the sentence. However, the Grammar > Affect hypothesis differs from the Phonetic Sum hypothesis in the fact that the former allows for exclusive usage of AU 1+2. Although both hypotheses allow for the use of AU 1+2+4, the Phonetic Sum hypothesis allows raised intensity level of AU 4 due to the expression of anger. In addition, the Phonetic Sum hypothesis also allows for the sequential combination of AU 1+2 and AU 4, i.e. AU 1+2,4 and AU 4, 1+2, and AU 1+2+4, 4 and AU 4, 1+2+4. A raise in intensity is shown by bold script.

Table 15 Predictions by different hypotheses on angry yes-no questions

Hypothesis	Predictions	
	<i>Original</i>	<i>New</i>
Affect > Grammar	AU 4	AU 4
Grammar > Affect	AU 1+2	AU 1+2 / 1+2+4
Phonetic Sum	AU 1+2+4	AU 1+2+4 / 1+2+4 / 1+2, 4 / 4, 1+2 / 1+2+4, 4 / 4, 1+2+4

In sum, if an angry yes-no questions is marked exclusively by AU 4, it is considered support for the Affect > Grammar hypothesis. If an angry yes-no questions is marked by AU 1+2, it is considered evidence for the Grammar > Affect hypothesis. In case of a configuration of AU 1+2+4 the sentence is ambiguous between the Grammar > Affect and Phonetic Sum hypothesis unless intensity levels of AU 1+2 are raised. All other combination of AU 4 and AU 1+2 would be considered evidence of the Phonetic Sum hypothesis.

In table 16 below the results on the angry yes-no questions are presented. In fourteen out of nineteen angry yes-no questions a single AU 4 occurred over the full length of the sentence. The evidence provided by these sentences support the Affect > Grammar hypothesis. The four of the sentences were a mix of AU 1+2 and 4.

Table 16 Action Units used in angry yes-no questions

sentence number	Respondent 1	Respondent 2
1	1D+2D+4D	4D
2	4B	4B, 4D
3	4E	4D
4	4A	4D
5	4E	4D
6	1D+2D+4C , 4E	4D
7	4C	4D
8	1B+2B, 4B	1C+2C, 1C+4C, 1B+2C

9	4A	4D
10	1D+2D+4D, 4D	4D

In sentences 1, 6 and 10 AU 1+2+4 occurred, followed by AU 4 in the latter two cases. In item 8, both participants used AU 1+2 firstly. In Respondent 1 this was followed by AU 4, in Respondent 2 AU 1+4 and again AU 1+2 follow this. The cases in which AU 1+2 / AU 1+2+4 and 4 are combined sequentially are evidence for the Phonetic Sum hypothesis. Sentence 1 by Respondent 1 is ambiguous between the Grammar > Affect hypothesis and the Phonetic Sum hypothesis. However, when compared with the neutral version by this participant, it is considered evidence of the Phonetic Sum hypothesis.

4.3.2 Surprised yes-no questions

In table 17 below I present the predictions on the surprised yes-no questions by each hypothesis. Recall that for a yes-no question AU 1+2 or AU 1+2+4 are required for linguistic purposes, and for the expression of surprise AU 1+2 are required. The Affect > Grammar hypothesis thus claims that only AU 1+2 will be present. The Grammar > Affect hypothesis predicts that either AU 1+2 or AU 1+2+4 will be present at similar intensity levels as in the neutral yes-no questions. The Phonetic Sum hypothesis allows for AU 1+2 and 1+2+4 appearing sequentially. That is, AU 1+2 as expressing surprise, and AU 1+2+4 as expressing a yes-no question. In addition, the Phonetic Sum hypothesis predicts that for AU 1+2 intensity levels will be higher compared to neutral yes-no questions. Notably, the Affect > Grammar hypothesis does not allow for the occurrence of AU 1+2+4.

Table 17 Predictions by different hypotheses on surprised yes-no questions

Hypothesis	Predictions	
	<i>Original</i>	<i>New</i>
Affect > Grammar	AU 1+2	AU 1+2
Grammar > Affect	AU 1+2	AU 1+2 / 1+2+4
Phonetic Sum	AU 1+2	AU 1+2 / 1+2+4 / 1+2+4, 1+2 / 1+2, 1+2+4

In six out of twenty sentences AU 1+2 occur exclusively. This option is predicted by all three hypotheses. See table 18 for the AU used in the surprised yes-no questions. The cases that do not follow predictions by the three hypotheses are in italic.

Table 18 Action Units used in surprised yes-no questions

sentence number	Respondent 1	Respondent 2
1	1C+2C, 1E+2E	1D+2D+4D, 1D+2D
2	1D+2D	<i>4C, 1C+2C+4B</i>
3	1C+2C, <i>4B</i> , 1B+2B	<i>4B, 4D, 1D+4D</i>
4	<i>4D, 4E</i>	<i>4D</i>
5	1C+2C, <i>4E</i>	1C+2C+4C, 1D+2D+4D
6	<i>1D+2D, 1D+2D+4B</i>	<i>1D+2D+4B</i>

7	1E+2E	1C+4C, 1D+2D+4B
8	4E, 4B, 1B+2B	4D, 4C
9	1B+2B	1D+2D+4A
10	1D+2D, 1B+2B, 1C+2C	1D+2D

In four of the stimuli items there is AU 4 occurs throughout the sentence. None of the three hypotheses has predicted these occurrences. Van der Kooij (p.c) has suggested that AU 4 may function as an intensifier. I suggest that in these cases this is so. In items 4 and 8 both participants use AU 4, in both these cases AU 4 is used as an intensifier of the sign FAST. Similarly, in item 3 by Respondent 2, AU 4 is used as an intensifier on the sign BREAK. In item 2 by Respondent 2, AU 1+2+4 is used on the sign DEAF. And this configuration may thus be due to the expression of fear instead of NGT grammar. Because the occurrence of AU 1+2+4 and may influence the interpretation of the present data, I remove these items from analysis.

In item 2 by Respondent 2, AU 4 is used on the first sign BROTHER. In item 5, AU 4 is used on INDEX₂. In both cases these sign are the questioned argument and AU 4 seems to be used because of referent accessibility. In both cases, I excluded the occurrence of AU 4 from analysis.

The remaining types of brow movements in the yes-no questions very much follow the pattern as described by generalisation 1.3. That is, they either have AU 1+2 or AU 1+2+4. Because the Affect > Grammar hypothesis does not allow a configuration of AU 1+2+4 all of such instance are contra-evidence for this hypothesis. These cases include items 1, 5, 7, and 9 by Respondent 2. However, it is unclear whether the Grammar > Affect or Phonetic Sum hypothesis is supported by the present data on surprised yes-no questions. Therefore, I analysed the intensity levels of AU 1+2 in these data.

The Phonetic Sum hypothesis predicts higher intensity levels of AU 1+2 in the surprised yes-no questions compared to the neutral yes-no questions. To test this I listed the highest intensity level of AU 1+2 for each neutral and for each surprised yes-no question by Respondent 1 and 2. I included all occurrence of AU 1+2 and AU 1+2+4. In the neutral yes-no questions AU 1+2 are never at the highest intensity level (E-level). In comparison, in the surprised yes-no question this happens in 25% of the instances of AU 1+2. Moreover, in the surprised yes-no questions AU 1+2 are never used at a lower intensity level than C-level. In comparison, in the neutral yes-no questions a configuration of AU 1+2 at B-level occurs in 12,5% of the cases. In sum, in the surprise yes-no questions AU 1+2 occur at higher intensity levels. In figures 15 and 16 below this is illustrated. Hence, the Phonetic Sum hypothesis is supported by the surprised yes-no questions in the present data.

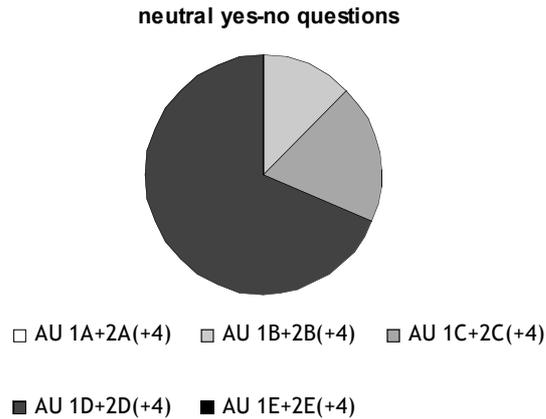


Fig. 15 Intensity levels of AU 1+2 in neutral yes-no questions by Respondent 1 and 2

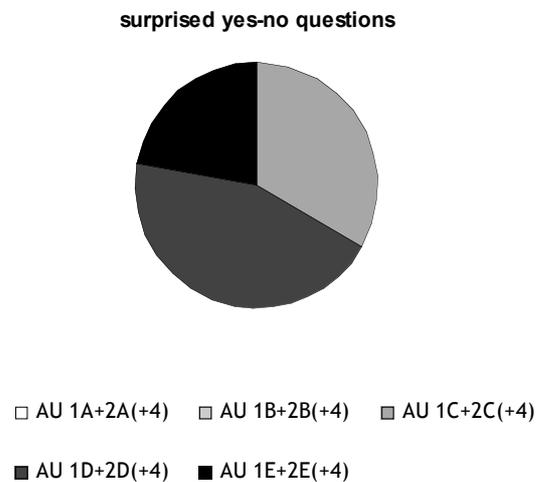


Fig. 16 Intensity levels of AU 1+2 in surprised yes-no questions by Respondent 1 and 2

4.3.3 Distressed yes-no questions

In this section I discuss the distressed yes-no questions in relation to the Affect > Grammar, Grammar > Affect, and Phonetic Sum hypothesis. I start of by reformulating the prediction for the Grammar > Affect and Phonetic Sum hypothesis based on Generalisation 1.3. Secondly, I describe the brow positions in the distressed yes-no questions by Respondent 1 and 2. Distress was almost always expressed by the occurrence of AU 4 only, although a combination of AU 4 with a slight AU 1 was predicted. A large part of the distressed yes-no questions support the Affect > Grammar hypothesis.

For distressed yes-no questions again AU 1+2 are required for linguistic purposes, for the expression of distressed affect, AU 1+4 are important (with less evidence of AU 1). The Affect > Grammar hypothesis predicts that only AU 1+4 will be used, with less evidence of AU 1. The Grammar > Affect hypothesis predicts that only AU 1+2 will be used. The Phonetic Sum hypothesis predicts a combination of AU 1+2+4 with a raise in intensity for AU 1. See table 19 below for the predictions per hypothesis.

Table 19 Predictions by different hypotheses on distressed yes-no questions

Hypothesis	Predictions
------------	-------------

	<i>Original</i>	<i>New</i>
Affect > Grammar	AU 1+4	AU 1+4
Grammar > Affect	AU 1+2	AU 1+2 / 1+2+4
Phonetic Sum	AU 1+2+4	AU 1+2+4 / 1+2+4 / 1+2, 1+4 / 1+4, 1+2 / 1+2+4, 1+4 / 1+4, 1+2+4

In sum, any sentence in which AU 1+4 occur exclusively are considered evidence for the Affect > Grammar hypothesis. A sentence in which AU 1+2 occur exclusively is considered evidence for the Grammar > Affect hypothesis. Any sequential combination of AU 1+2 or AU 1+2+4 and AU 1+4 is considered evidence for the Phonetic Sum hypothesis. A configuration of 1+2+4 is only considered evidence for the Phonetic Sum hypothesis if the intensity levels of AU 1 and/or AU 4 are raised.

In seventeen out of twenty distressed yes-no questions only AU 4 or a combination of AU 1+4 are used. These sentences all support the Affect > Grammar hypothesis. See table 20 below for details on the occurrence of AU in distressed yes-no questions by both participants.

Table 20 Action Units used in distressed yes-no questions

sentence number	Respondent 1	Respondent 2
1	4E, 1C+4D	1B+4B, 1C+4C
2	4E, 4B	1D+2D+4D
3	4E	4C
4	4B	4C
5	4E, 4C	1C+2C+4C
6	4E	1D+4D
7	1C+2C+4C, 4E	1C+4D
8	4E, 4D	1B+4B, 1C+4C
9	4E, 4D	1D+2D+4D
10	4C, 4B	4C

In sentence 7 by Respondent 1, AU 1+2+4 was followed by AU 4 expressing distress; this example is evidence for the Phonetic Sum hypothesis. In three cases, sentences 2, 5, and 9 by Respondent 2, a combination of AU 1+2+4 was used over the full length of the sentence. In all these three items, Respondent 2 used only AU 1+2 in the neutral versions. Hence the addition of AU 4 in these cases is considered evidence for the Phonetic Sum hypothesis.

4.3.4 Conclusion yes-no questions

In this section I summarise the interpretation of the present data on the yes-no questions with additional affective meaning. In the angry yes-no questions, AU 4 is used exclusively in most cases. These items provide evidence for the Affect > Grammar hypothesis. Similarly, most distressed sentences only Affect is shown, either by AU 4 or by AU 1+4. Hence, the distressed yes-no questions provide evidence for the Affect > Grammar hypothesis. For the surprised yes-no questions, a

raised level for AU 1+2 were found, which I consider support for the Phonetic Sum hypothesis.

Although the distressed and angry yes-no questions provide evidence for the Affect > Grammar hypothesis, there is indication for the occurrence of a Phonetic Sum in these sentences. Moreover, a large part of surprised yes-no questions support the Phonetic Sum hypothesis. The Grammar > Affect hypothesis is not supported by the present data. In table 21 below I repeat findings for each type of yes-no question.

Table 21 The yes-no questions with additional affective meaning show evidence for the Affect > Grammar hypothesis and for the Phonetic Sum hypothesis

Yes-no questions	
Anger	Affect > Grammar
Surprise	Phonetic Sum
Distress	Affect > Grammar

The overall research question of this thesis is how affective and linguistic functions of eyebrows can be combined in NGT. So far, the data on yes-no questions imply that there are two options for combining affective and linguistic function of eyebrows in NGT. The linguistic marking can be mixed with or intensified by the affective marker; in this case a Phonetic Sum is formed. The second option is that only the affective marker is used.

4.4 Affective Wh-questions

In a neutral NGT wh-question eyebrows are raised and/or frowned. In this section I discuss the wh-questions that have additional affective meaning in relation to the hypotheses. I start off by analysing the AUs that were used and then interpreted them in relation to the hypotheses. In section 4.4.1-3 I discuss the angry, surprised, and distressed wh-questions. In section 4.4.4 I compare the distribution of AUs in wh-questions with different affective meanings. It will be concluded that all the distressed and angry wh-questions support the Phonetic Sum hypothesis, while the surprised wh-questions provide evidence for the Grammar > Affect hypothesis.

4.4.1 Angry wh-questions

In this section I discuss the angry wh-questions that were elicited in this study. I start off by reformulating the predictions for each hypothesis. The wh-questions with the wh-sign sentence-final and the wh-questions with the wh-sign sentence-initial are discussed separately. It is concluded that the brow positions that are used in angry wh-questions support the Phonetic Sum hypothesis.

The new predictions allow for more variation in the present data compared to the initial predictions based on literature. Only the predictions of the Grammar > Affect and Phonetic Sum hypothesis are altered. The Affect > Grammar hypothesis predicts the single occurrence of AU 4. The Grammar > Affect hypothesis predicts that, either AU 4 or AU 1+2 may occur. The Phonetic Sum hypothesis predicts that in case AU 4 is used, its intensity is raised compared to the neutral wh-questions. The Phonetic Sum hypothesis also predicts the co-occurrence of AU 1+2+4. Note that the Phonetic

Sum hypothesis also allows for these AU to occur simultaneously. See table 22 for a summary of the original and new predictions on angry wh-questions.

Table 22 Predictions by different hypotheses on angry wh-questions with wh-sign sentence-final

Hypothesis	Predictions	
	<i>Original</i>	<i>New</i>
Affect > Grammar	AU 4	AU 4
Grammar > Affect	AU 4	AU 4 / 1+2/ 1+2, 4 / 4, 1+2
Phonetic Sum	AU 4	AU 4 / 1+2+4 / 1+2, 4 / 4 , 1+2 / 1+2, 4 / 4, 1+2

In table 23 below the results on the angry wh-questions with the wh-sign sentence-final are presented. Again, AU that are not predicted by any of the hypotheses are in italic script. One sentence was not recorded during the elicitation task, i.e. sentence 2 by Respondent 1. The absence of data of sentence 2 by Respondent 1 is shown by 'X'.

Table 23 Action Units used in angry wh-questions with wh-sign sentence-final

Sentence number	Wh-sign	Respondent 1	Respondent 2
8	HOW	1+2B, 4B, 4A	4D
3	WHAT	4E, 4C	4D
5	WHAT	4E, 1C+2C	4D
6	WHAT	4C, -, 4B	4D
1	WHERE	4E, 4B	4D
4	WHO	1C+2C, 4D, 1C+4C, 4B	4E, 4D
7	WHO	4E	4E
10	WHO	-	4D, 4C
2	WHY	X	4D
9	WHY	4D, 1C+2C	4D, 1C+4C

In thirteen out of nineteen of the wh-questions with the question word sentence-final, AU 4 was used exclusively. Two thirds of these instances were signed by Respondent 2. In one instance there was no eyebrow movement present, i.e. sentence 10 by Respondent 1.

In four sentences, sentences 4, 5, 8, and 9 by Respondent 1, a combination of AU 1+2 occurred, either before of after AU 4. However, these cases in which AU 1+2 are combined with AU 4, simultaneously or sequentially, can only be considered evidence for the Phonetic Sum hypothesis if intensity levels of AU 4 are raised. I will firstly discuss the angry wh-questions with the wh-sign sentence-initial. Following, I will compare the intensity levels of all angry wh-questions to the neutral wh-questions.

For the angry wh-questions with the wh-sign sentence-final, the predictions are the same as for the wh-questions with a sentence-initial wh-sign. In all but one of the

angry wh-questions with the wh-sign sentence-initial, AU 4 is present. In three sentences AU 4 is combined with AU 1+2. These include sentences 4, 7, and 9 by Respondent 1. In one case, only AU 1+2 are present, this is the only sentence that supports the Grammar > Affect hypothesis. The results are presented in table 24 below.

Table 24 Action Units used in angry wh-questions with wh-sign sentence-initial

sentence number	Wh-sign	Respondent 1	Respondent 2
8	HOW	4E	4D
3	WHAT	4B, 4C, 4B	4D
5	WHAT	4C, 4B	4D
6	WHAT	4E	4D
1	WHERE	4E,4B	1C+2C
4	WHO	1D+2D+4D, 4D	4E
7	WHO	4E, 1C+2C+4C	4D
10	WHO	4D	4D, 4C
2	WHY	1C+4C, 4D, 4C	4D
9	WHY	1C+2C+4C, 1D+2D, 1C+4C	4D

AU 4 is present in almost all the angry wh-questions. However, the occurrence of AU 4 may be evidence for any of the hypotheses. The Phonetic Sum hypothesis is supported by the present data if the intensity levels of AU 4 in angry wh-questions are higher compared to neutral wh-questions. So, for the Response items of neutral wh-questions and the angry-wh-questions I coded the highest intensity level of AU 4 in the sentence. In the figures 17 and 18 the percentages of intensity levels of instances of AU 4 in neutral and angry wh-questions with the wh-sign sentence-final are shown in figures 17 and 18. Note that in angry yes-no questions AU 4 does not occur at A-level. In addition, intensity levels D, and E are much more frequent in the angry wh-questions compared with the neutral sentences. In fact, in the neutral wh-questions AU E occurs only two times, while in angry wh-questions it occurred 11 times. Hence, the angry wh-questions provide evidence for the Phonetic Sum hypothesis.

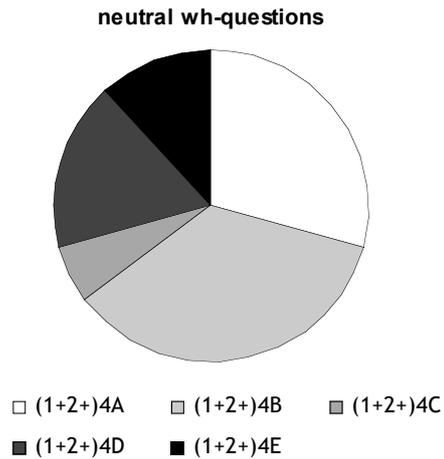


Fig. 17 Intensity levels of AU 4 in neutral wh-questions by Respondent 1 and 2

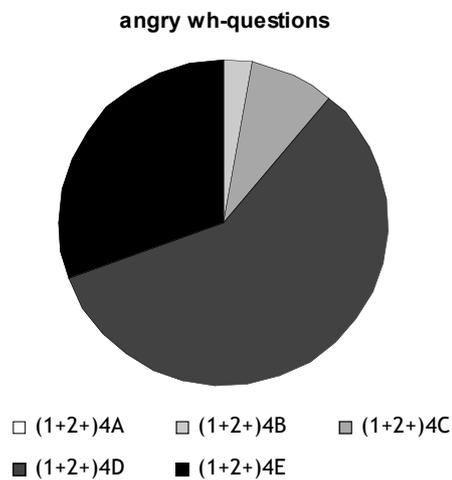


Fig. 18 Intensity levels for AU 4 in angry wh-questions by Respondent 1 and 2

4.4.2 Surprised wh-questions

In table 25 below the predictions made by each hypothesis are shown. Following generalisation 1.4, I predict that wh-questions are marked linguistically either by AU 4, AU 1+2, or a sequential combination. For the affective expression of surprise AU 1+2 are required. Thus, the Affect > Grammar hypothesis predicts that in all cases AU 1+2 will be present. The Grammar > Affect hypothesis predicts that in surprised wh-questions AU 1+2 and/or 4 are present. The Phonetic Sum hypothesis allows for a sequential and/or simultaneous combination of AU 4 and AU 1+2. Moreover, the Phonetic Sum hypothesis predicts that when AU 1+2 are exclusively present in a sentence, intensity levels are raised in comparison to the neutral wh-questions in which only AU 1+2 were used.

Table 25 Predictions by different hypotheses on surprised wh- questions

Hypothesis	Predictions	
	<i>Original</i>	<i>New</i>
Affect > Grammar	AU 1+2	AU 1+2
Grammar > Affect	AU 4	AU 4 / AU 1+2 / 1+2, 4 / 4, 1+2
Phonetic Sum	AU 1+2+4	AU 1+2/ 1+2+4/ 1+2, 4 / 4,1+2/ 1+2, 4 / 4,1+2

See table 26 for the AU that were used per item and signer in the surprised wh-questions with the wh-sign sentence-final.

Table 26 Action Units used in surprised wh-questions with wh-sign sentence-final

sentence number	Wh-sign	Respondent 1	Respondent 2
8	HOW	4A, -	1B+2B+4B
3	WHAT	1D+2D+4B	1C+4C, 1D+2D+4D
5	WHAT	1B+2B, -, 1C+2C	1D+2D+4B
6	WHAT	1D+2D	4C, 4B
1	WHERE	1E+2E, 4C, 1C+2C	1C+2C+4B
4	WHO	1D+2D+4C	1C+2C
7	WHO	1C+2C, 4C, 4B, 4A	1C+2C+4B, 1D+2D, 1C+2C+4A
10	WHO	1E+2E, 4C, 1C+2C	1C+4C
2	WHY	1B+2B, 1D+2D, 1B+2B, 4B	1D+2D
9	WHY	1D+2D+4C, 1B+2B+4B	4D, 4C

In twelve out of twenty of the elicited surprised wh-questions with the wh-sign sentence-final, AU 1+2 are combined with AU 4 either sequentially, or simultaneously. This is the case for twelve sentences: sentences 1, 2, 3, 4, 7, 9, and 10 by Respondent 1, and for sentences 1, 3, 5, 7, and 8 by Respondent 2. These cases provide counter-evidence for the Affect > Grammar hypothesis. What is more, these sentences can only provide exclusive evidence for the Phonetic Sum hypothesis if intensity levels of AU 1+2 are raised. I analyse the intensity levels of AU 1+2 of the wh-questions with the wh-sign sentence-initial and sentence-final together in the next section.

In three cases only AU 4 was used. These cases are evidence for the Grammar > Affect hypothesis. In four cases, sentences 5 and 6 by Respondent 1, and sentences 2 and 4 by Respondent 2, only AU 1+2 are used. Again, these cases can only be considered evidence of the Phonetic Sum hypothesis if intensity levels are raised.

In table 27 below the results of the surprised wh-questions with the wh-sign sentence-initial are presented.

Table 27 Action Units used in surprised wh-questions with wh-sign sentence-initial

sentence number	Wh-sign	Respondent 1	Respondent 2
8	HOW	1B+2B	1C+2C+4C
3	WHAT	1C+2C, 4D, 4B	1D+2D+4B
5	WHAT	4C, 1D+2D	1D+2D+4A
6	WHAT	4C	4A
1	WHERE	1D+2D, 4E	4D
4	WHO	1D+2D, 4E, 1C+2C	1D+2D+4B, 4B
7	WHO	1D+2D, 1B+2B	1D+2D+4C
10	WHO	1C+2C+4B, 4D	X
2	WHY	1C+2C, 4D	1C+4B, 1C+2C+4B
9	WHY	1C+2C, 4E, 4D, 4C	X

In twelve out of twenty surprised wh-questions with the wh-sign sentence-initial, AU 1+2 and AU 4 are combined either sequentially and/or simultaneously. This is the case in items 1, 2, 3, 4, 5, 9, and 10 by Respondent 1, and sentences 3, 4, 5, 7 and 8 by Respondent 2. As was the case with the surprised wh-questions with the wh-sign sentence-final, in three cases only AU 4 is used, these sentences provide limited evidence for the Grammar > Affect hypothesis.

In many surprised wh-questions AU 1+2 occur. In order for these sentences to provide evidence for the Phonetic Sum hypothesis the intensity levels of these occurrences of AU 1+2 need to be higher than the intensity levels of occurrences in the neutral wh-questions. To test this I listed the highest intensity level of AU 1+2 for each neutral and for each surprised wh-question by Respondent 1 and 2. I included all occurrences of AU 1+2 and AU 1+2+4. In the neutral wh-questions there are ten instances of AU 1+2 at D-level, eight at C-level, three at B-level, and one at A-level. For surprised wh-questions the distribution of intensity levels is as follows; B-level (two sentences), C-level (ten sentences), D-level (seventeen sentences), and two sentences at E-level. In both the neutral and surprised wh-questions the largest portion of data has intensity levels at C-level and D-level. In the neutral wh-questions 38% of the occurrence of AU 1+2 are at C-level, and 48% of the occurrences are at D-level. In comparison, in the surprised wh-questions 32% of the occurrences are at C-level, and 55% of the occurrences of AU 1+2 are at D-level. These percentages are similar and I thus conclude that there is no raise in intensity level for these sentences and these sentences do not provide evidence for the Phonetic Sum hypothesis.

In this initial analysis I included all instances of AU 1+2 and of AU 1+2+4. Recall however that an instance of 1+2+4 at an intensity level may already support the Phonetic Sum hypothesis. In contrast, the Phonetic Sum hypothesis predicts that when AU 1+2 are exclusively used in a sentence, the intensity levels should be raised in comparison to the neutral wh-questions in which only AU 1+2 was used. Therefore, I also counted the instances of AU 1+2 for the neutral and surprised wh-questions. Again, no difference in intensity levels was found.

Looking closely at the occurrences of AU 1+2+4 in the present data a pattern arises that is not found in the other sentence types. That is, in these configurations AU 4 is used at a lower intensity level than AU 1+2. These items include item 10 by

Respondent 1, and items 3, 4, 5, 7, and 8 by Respondent 2. Apparently, in these cases AU 1+2 are pulling the eyebrow up, but do not succeed completely because of the counter-active pulling of AU 4, the Brow Lowerer. Although, I did not predict this option, these occurrences of AU 1+2+4 may be considered evidence for the Phonetic Sum hypothesis. That is, the syntactic signal of the eyebrows is affected but not dominated by the affective signal. Hence, at least part of the surprised wh-questions provide evidence for the Phonetic Sum hypothesis.

Concluding, the many configurations of AU 1+2+4 and sequential occurrences of AU 4 and AU 1+2 are counter-evidence for the Affect > Grammar hypothesis. The linguistic signal in the surprised wh-questions is affected but not dominated by the expression of affect. The Phonetic Sum hypothesis is thus supported by the surprised wh-questions.

4.4.3 Distressed wh-questions

In table 28 below I summarise predictions on the distressed wh-questions. AU 1+4, with less evidence of AU 1, expresses speaker distress. Thus, the Affect > Grammar hypothesis predicts that in distressed wh-questions AU 1+4 are present. A wh-question is marked linguistically either by AU 4 or AU 1+2. The Grammar > Affect hypothesis predicts that AU 4, AU 1+2, or a sequential combination are present. The Phonetic Sum hypothesis predicts that AU 1+4 and AU 1+2 or AU 4 are combined either simultaneously and/or sequentially. In case of AU 4, the intensity level is raised.

Table 28 Predictions by different hypotheses on distressed wh- questions

Hypothesis	Predictions	
	<i>Original</i>	<i>New</i>
Affect > Grammar	AU 1+4	AU 1+4
Grammar > Affect	AU 4	AU 4 / AU 1+2 / AU 1+2+4 / AU 4, 1+2 / AU 1+2, 4
Phonetic Sum	AU 1+4	AU 1+4 / AU 1+2+4 / 1+2+4/ 1+2, 1+4/ 1+4, 1+2

In table 29 below the results are presented of the distressed wh-questions with the wh-sign sentence final. In all but one wh-question with the wh-sign sentence-final, AU 4 occurs. Notably, there is little evidence of AU 1. This was also seen in the distressed yes-no questions. AU 4 by itself does not discriminate between the three hypotheses. I will discuss this more elaborately further on in this section.

Table 29 Action Units used in distressed wh-questions with wh-sign sentence-final

sentence number	Wh-sign	Respondent 1	Respondent 2
8	HOW	4D, 4C	4D, 1C+4C, 4B
3	WHAT	4E	4D
5	WHAT	4D	1D+2D

6	WHAT	4D, 4B	1C+4C, 1C+2B+4C
1	WHERE	4E	1C, 4B
4	WHO	X	4D, 1C+2C+4C
7	WHO	4E, 4C	1D+2D+4B
10	WHO	4C	4C, 1C+2C+4C
2	WHY	4D	4D, 4C, 4B
9	WHY	4D, 4C	1D+2D+4C

In sentences 4, 6, 7, 9, and 10 AU 1+2+4 occurs. These combinations of 1+2+4 are considered evidence for the Phonetic Sum hypothesis. Also sentence 8 in which AU 1+4 occurs with a preceding and a following AU 4 is considered evidence of the phonetic sum hypothesis. In only one sentence AU 1+2 is exclusively present. This sentence is evidence for the Grammar > Affect hypothesis.

Again the wh-questions with the wh-sign sentence-final show a similar distribution compared to the wh-questions with the wh-sign sentence-initial. In all items AU 4 is present. In two cases AU 4 is combined with AU 1+2; these cases are considered evidence of the Phonetic Sum hypothesis.

Table 30 Action Units used in distressed wh-questions with wh-sign sentence-initial

sentence number	Wh-sign	Respondent 1	Respondent 2
8	HOW	4D, 4C, 4B	4D
3	WHAT	4D	4D
5	WHAT	4D, 4C	4D
6	WHAT	4C, 4D	4D
1	WHERE	4D	4C
4	WHO	4E, 4D	4D
7	WHO	4B, -	4D, 4B
10	WHO	X	1C+2C+4C
2	WHY	4E, 4D	1C+4C, 1C+2C+4B
9	WHY	4E	4D

The Phonetic Sum hypothesis predicts, in contrast with the Affect > Grammar and Grammar > Affect hypothesis, that the single occurrences of AU 4 have higher intensity levels in distressed wh-questions than those in neutral wh-questions. Thus, I counted frequencies of intensity levels of AU 4 in the distressed wh-questions and compared them with intensity level of AU 4 in neutral wh-questions. Compare the figures 19 and 20 in which the intensity levels of AU 4 are depicted. (I repeat figure 17 as 19 for convenience.) Note that in distressed wh-question intensity level D is more frequent than in the neutral wh-questions. Furthermore, 4A does not occur in the distressed sentences, and 4B is much less frequent. Hence, the items with exclusive occurrence of AU 4 provide evidence of the Phonetic Sum hypothesis.

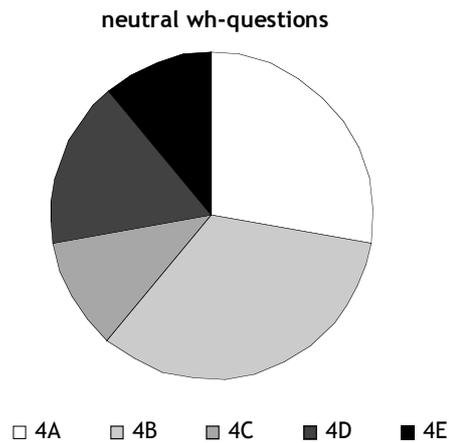


Fig. 19 Intensity levels of AU 4 in neutral wh-questions by Respondent 1 and 2

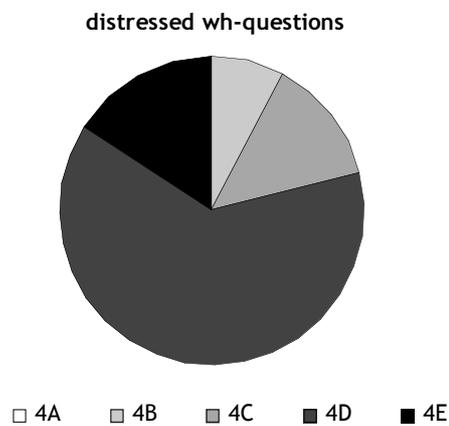


Fig. 20 Intensity levels of AU 4 in distressed wh-questions by Respondent 1 and 2

The Phonetic Sum hypothesis also predicts that intensity levels of AU 1 is higher in the distressed wh-questions, then in the neutral wh-questions. However, the number of occurrences of AU 1 in the distressed wh-questions is so low that comparison has no statistical relevance. In general, the combination of AU 1+4 is rarely used by Respondent 1 and 2 and is not the prototypical way to display speaker distress in NGT; rather, AU 4 is used combined with other (manual) prosodic cues.

4.4.4 Conclusion: affective wh-questions

In this section I summarise the interpretation of the present data on the wh-questions with additional affective meaning. The angry and distressed wh-questions provide evidence for the Phonetic Sum hypothesis, because the intensity levels of AU 4 are higher in the angry and distressed items than in the neutral items by Respondent 1 and 2. The surprised wh-questions do not provide support for the Affect > Grammar hypothesis. That is, in many cases AU 4 is present. Raised intensity levels for 1+2 were not found thus the Phonetic Sum hypothesis as not supported directly. However, in configurations of AU 1+2+4 the intensity level of AU 4 was comparatively low. This is surprising because this has not been the case in other

sentence types. Hence, the question signal is altered due to the expression of affect in these items and they are thus considered evidence for the Phonetic Sum hypothesis. In the distressed items the combination of AU 1+4 was not found, and speaker distress seems to be associated with AU 4 rather than AU 1+4. In almost all distressed wh-questions AU 4 raised in intensity level or was combined with AU 1+2. Hence, the distressed items also provide evidence for the Phonetic Sum hypothesis. See table 31 for an overview of hypotheses that are supported by the three different affective meanings.

Table 31 Wh-questions with additional affective meaning, whether the wh-sign is sentence-final or sentence-initial, provide evidence for the Phonetic Sum hypothesis

	Wh-questions
Anger	Phonetic Sum
Surprise	Grammar > Affect
Distress	Phonetic Sum

4.5 An Analysis of NGT sentences realised with additional affect

In this section I summarise the findings of the present chapter and give a general analysis of the data. I start off by summarising the results on the yes-no questions with additional affective meaning and the wh-questions with additional affective meaning. Then, I integrate the analyses of the complex yes-no questions and wh-questions and give a phonetic explanation for the combination of linguistic and affective functions of eyebrows in NGT, arguing that independently of function, AU 4 dominates other signals.

In NGT, the angry and distressed yes-no questions were signed with exclusive use of AU 4. This was considered to form evidence for the Affect > Grammar hypothesis: the grammatical marker expressed by AU 1+2 was absent. By contrast, in the surprised yes-no questions, intensity levels of AU 1+2 were raised in instances when AU 1+2 or a configuration of AU 1+2+4 was used in the neutral version. Also, some counter-evidence for the Affect > Grammar hypothesis was found by the occurrence of AU 1+2+4, this marker is found in neutral yes-no questions, but is not used to express surprise. Thus, the surprised yes-no questions were considered evidence for the Phonetic Sum hypothesis.

In the angry and distressed wh-questions the intensity level of AU 4 was raised. I thus considered these sentences evidence for the Phonetic Sum hypothesis. In the surprised wh-questions some counterexamples were found for the Affect > Grammar hypothesis. That is, in many sentences AU 4 was combined with AU 1+2. This AU 4 is a grammatical marker for wh-questions. Moreover, intensity levels of AU 1+2 were not raised in comparison with the neutral wh-questions. However, intensity levels of AU 4 were comparatively low in configuration of AU 1+2+4. The question signal was thus slightly influenced but certainly not dominated by the expression of surprise. I thus conservatively considered them evidence for the Grammar > Affect hypothesis. In table 32 the findings are summarised for each type of complex sentence. All in all, the complex wh- and yes-no questions seem to provide evidence for all three hypotheses.

Table 32 All three hypotheses are partly supported

	yes-no questions	Wh-questions
	AU 1+2 / 1+2+4	AU 4 / AU 1+2 / AU 1+2, 4 / AU 4, 1+2
angry AU 4	Affect > Grammar AU 4	Phonetic Sum Raised intensity levels of AU 4
distress AU (1+)4	Affect > Grammar AU 4	Phonetic Sum Raised intensity levels of AU 4
surprise AU 1+2	Phonetic Sum Raised intensity levels of AU 1+2	Phonetic Sum / Grammar > Affect No raised intensity levels of AU 1+2, but lowered intensity of AU 4 Counterexamples for Affect > Grammar

The formulated hypotheses were based on the idea that the function of an eyebrow movement may play a role in the way in which it is combined with other functions of the eyebrows. For example, I hypothesised that if the brow movement is used linguistically it may dominate an affective function. This is the Grammar > Affect hypothesis. The Affect > Grammar hypothesis is based on the idea that the affective functions of the eyebrows may overwhelm the linguistic functions of eyebrows. However, the linguistic or affective status of a marker does not account for its dominance in the present data. The angry and distressed yes-no questions show that an affective marker may overwhelm a linguistic marker. In contrast, the surprised wh-questions show that the reverse pattern may also occur; in these cases the grammatical signal was only slightly influenced by the expression of surprise by the eyebrows.

The combination of brow movements that were used in the complex sentences cannot be explained on the basis of their linguistic or affect function. However, when the results are considered from a phonetic point of view, a more consistent pattern arises. Consider table 32 above. A combination of AU 4 for anger or distress with AU 1+2 / AU 1+2+4 in the yes-no questions results in AU 4. Also in the wh-questions the combination of AU 4 all result in wh-questions with AU 4. Thus, in all these cases the AU 4 dominates over the other AUs and the end result is AU 4. In the surprised yes-no questions a combination of AU 1+2 or AU 1+2+4 (yes-no questions) with AU 1+2 (surprise) results in AU 1+2 or 1+2+4 with raised intensity levels. I therefore argue that in NGT AU 4 dominates AU 1 and 2, irrespective of whether it is used for linguistic or affective purposes.

I observed in the present data the wh-questions can have various markers, both AU 4 and AU 1+2 being an option. In contrast to the surprised yes-no questions, intensity levels of AU 1+2 are not raised in the surprised wh-questions. The occurrence of AU 4 as an optional wh-marker apparently may have prevented intensity levels of AU 1+2 to be raised. This idea supports the fact that AU 4 in a sense is stronger than AU 1+2. Moreover, some influence of AU 1+2 on configurations of AU 4 is reported; the relative intensity of AU 4 was lowered in configurations of AU 1+2+4. Hence, in the surprised wh-questions a Phonetic Sum occurred, but not in its original form.

Based on the observation that AU 4 will dominate when combined with other AU, I make new predictions for the topic sentences and declarative sentences. For both

sentence types, in the angry and distressed items, only AU 4 will occur. In the surprised items, only AU 1+2 occur with raised intensity levels on the topic but not on the comment part of the topic sentences. See table 33 below.

Table 33 New predictions for the complex declarative sentences and complex topic sentences

	Declarative sentences Linguistically underspecified	Topic sentences AU 1+2, -
angry AU 4	AU 4	AU 4, 4
distress AU (1+)4	AU 4	AU 4, 4
surprise AU 1+2	AU 1+2	AU 1+2 , 1+2

Summarising, none of the hypotheses on the complex sentences was exclusively supported or rejected by the present data. However, a phonetic analysis is given for the results. This analysis presumes that AU 4 is phonetically stronger than AU 1 and 2. Further analysis on the remaining data will give more insight on the combined functions of eyebrows in NGT.

5 Conclusions

In this thesis, I investigated the combination of affective and linguistic functions of eyebrows in NGT. A lot has been written about the syntactic use of eyebrows in NGT, and much is known about the general use of eyebrows to express emotions in human communication. In this thesis, it is shown that NGT signers adapt emotional facial expressions during signing to display affect. Furthermore, in some cases display of affect may alter the linguistic signal.

It was hypothesised that when linguistic and affective function of eyebrows are combined, one of these functions would prevail because of its linguistic or affective status, or that a Phonetic Sum would occur which combines muscle actions for both functions. Surprisingly, it was found that a Phonetic Sum occurs in which the Action Unit 4 appears to have the most phonetic weight.

In this chapter, I summarise the findings of this study and answer the research question that was formulated in the Introduction. Secondly, I discuss some alternative explanations for the findings and make suggestions about research methodology for future studies. Moreover, I discuss the findings with respect to the notion of non-manual layering in signed languages (Wilbur, 2000). Consequently, I discuss the question whether layering is a modality effect on language. Finally, I make suggestions for future research.

5.1 A Phonetic account

First of all, I present a description of the form of eyebrow positions in different NGT sentence types. Secondly, I summarise the findings on the complex questions and refute alternative explanations for the present analysis. Finally, I answer the research question as it was formulated in the introduction.

5.1.1 The form of eyebrow positions in NGT sentence types

The present study has provided a more detailed description of the form of eyebrow positions that serve syntactic functions in NGT than is reported by Coerts (1992). In addition, more variation is reported on the use of brow movements in NGT sentence types than is described by Coerts (1992). This variation was detected partly because a more detailed transcription system was used. In this section I try to explain the variation that was found.

Original descriptions of declarative sentences in NGT contrast them with yes-no questions. That is, in yes-no questions eyebrows are raised, while in declarative sentences they are not. However, in my data a lot of variation occurred in the use of eyebrows in declarative sentences. Therefore, I suggest that brow positions in these sentences are linguistically underspecified. Consequently, other linguistic or paralinguistic functions of eyebrows can be freely expressed.

Coerts (1992) described the brow position in yes-no questions as ‘brows up’, following the terminology of the Edinburgh Non-manual Coding System (ENCS). In this thesis, two variations of ‘brows up’ are found for neutral yes-no questions: AU 1+2 or AU 1+2+4. The ENCS does not allow describing the distinction between these

two brow positions. Thus, FACS allows for more variation to be observed because ENCS is a coarser description system.

Coerts (1992) describes a brow raise on the topic in a sentence with topic-comment structure. In the present thesis this brow raise only involved AU 1+2. Thus, Coerts' notion of brow raise is ambiguous; in yes-no questions it may refer to AU 1+2 or 1+2+4, in topics it can only refer to AU 1+2. The wh-questions in this thesis are marked differently from earlier descriptions in literature (Coerts, 1992; Pfau, 2005). The distribution of markers is different from the description by Coerts (1992). Moreover, the spreading of these markers extends over the full sentence in almost all cases and is not dependent on the position of the wh-sign in the sentence. Coerts (1992) describes AU 4 as the marker of wh-questions. In our data AU 1+2 was also found to be a possible marker. Interestingly, these two markers can be combined in a sentence. More research is needed to determine the functions of these two markers. Table 34 below summarises the findings of this thesis in comparison to the description of eyebrow movements in NGT by Coerts (1992).

Table 34 Findings concerning neutral sentence types in NGT

NGT sentence type	Coerts (1992)	Present thesis
declarative sentence	eyebrows in neutral position	Linguistically underspecified
topic sentence	eyebrows up on topic	AU 1+2 on topic
yes-no question	eyebrows up	AU 1+2, or AU 1+2+4
wh-question	eyebrows down	AU 4, and/or AU 1+2

5.1.2 Affect displays influence question signals in NGT

The present thesis shows that display of affect influences the syntactic use of eyebrows in NGT sentences. The extent to which brow movements are influenced differs per sentence type and emotion, but also depends on the types of Action Units that are used. I argue that AU 4, whether used linguistically or affectively, is stronger than Action Units 1 and 2. Hence, phonetics rather than the linguistic or paralinguistic function of eyebrow movement is important in this hierarchy.

In all the distressed and angry questions that were analysed, AU 4 occurred almost exclusively. In the yes-no questions this occurrence was analysed as Affect > Grammar, because the linguistic signal in yes-no questions, which involves either AU 1+2 or AU 1+2+4, was no longer visible. In contrast, in the wh-questions this occurrence of AU 4 was analysed as a Phonetic Sum because intensity levels were raised. Alternatively, this raise in intensity level may also be due to the fact that in these cases signers express anger at a high intensity level to begin with. It may be the case that the explicit instruction for the expression of an emotion induces high levels of muscle action. If we look at the data from this perspective the data could also be analyzed as support for the Affect > Grammar hypothesis. The same explanation could hold for the raise in intensity levels of AU 1+2 in the surprised yes-no questions.

The gradient nature of affective expression thus gives rise to an alternative interpretation of the data: the distressed and angry wh-questions as well as the surprised yes-no questions may show that Affect dominates Grammar. Both the angry and distressed *yes-no* questions are evidence for the Affect > Grammar

hypothesis. Thus, the simplest solution to explain all our data would then be that the Affect > Grammar hypothesis is supported by all our data.

However, when applied to the surprised items, the Affect > Grammar hypothesis is not supported by the data. First of all, the surprised wh-questions should have shown the single occurrence of AU 1+2 in most cases. This single occurrence of AU 1+2 was present in five of the surprised wh-questions. Secondly, in the surprised yes-no questions, configurations of AU 1+2+4 occur, which are counter-evidence for the Affect > Grammar hypothesis. Hence, the Affect > Grammar hypothesis is refuted by the data.

In the last paragraph of the *Results and Analysis* chapter, I give an alternative explanation for the findings of this study, that is, AU 4 is phonetically stronger than AU 1 and 2. Thus, independently of its linguistic or paralinguistic status, AU 4 dominates over AU 1+2. New predictions for the declarative sentences and complex topic sentences were made which may be tested in future research.

5.1.3 Research question

In the Introduction I formulated the following research question:

How can affective and linguistic functions of eyebrows be combined in an NGT sentence?

Affective and linguistic functions may be combined when the eyebrow forms are the same. In contrast, when the forms for these functions differ, AU 4 dominates the signal independently of its linguistic or paralinguistic status. Thus, a phonetic account is proposed to explain the patterns that are found in the data.

5.2 Sign language prosodic research

In this section I discuss the findings of the present study in relation to previous research on non-manuals in signed language. First of all, I discuss two methodological issues that are raised by the findings of the present study. Consequently, I make suggestions for adaptations of glossing conventions. Secondly, I argue that the present data support the notion of non-manual layering as suggested by Wilbur (2000), but not the simultaneous layering within one articulator as suggested by Wilbur (2003). Following that, I focus on the question whether layering is a modality effect on the form of sign language. Finally, I make suggestions for future research.

5.2.1 Methodological issues

There are two related methodological issues that are raised by the findings of this study. Both issues concern the information that is reported in the glosses of signed sentences. It is common practice to denote the syntactic functions of eyebrows by a line above the gloss with an abbreviation of their linguistic functions (e.g. 'wh', or 'q'), but not by their form, e.g. what brow position was used. Thus, notations as 'wh' and 'q' may refer to various brow positions. In previous descriptions frowned eyebrows were identified as wh-markers in NGT (Coerts, 1992). In the present study various markers occur in wh-questions, for which I have no explanation. Comparison to other reported wh-questions may provide useful clues to an interpretation of these markers.

Until now these comparisons were not possible because glosses seldom provide information on brow movements. I thus argue that this notation by function is an unnecessary reduction of information that makes future interpretation of data impossible. Following Crasborn (p.c.), I suggest that the glosses of non-manual signals give information on the forms rather than the linguistic functions of those signals.

Secondly, I argue that the transcription system that is used to describe sentences should provide more detail. In specific, I suggest that FACS (2002) is used for future descriptions of brow movements in signed languages. The data in the present study show that the forms of brow movements are often described with a too coarse transcription system. For example, instances of AU 1+2 and AU 1+2+4 were all described as 'brows up' Coerts (1992). In this thesis it is shown that there is a linguistic difference between these two forms; a configuration of AU 1+2+4 are not used on a topic. Fortunately, there is a comprehensive system for brow movements available, i.e. the Facial Action Coding System (2002) which has been proven useful for sign language research by various researchers (Baker-Shenk 1983, 1986; present thesis)

Because non-manuals are important on all structural levels of signed languages, they should be reported in detail. FACS (2002) provides a system to do that. I thus suggest that sign linguists should provide FACS descriptions on the forms of brow movements with the glosses, while the meaning becomes transparent in the translation of the example.

5.2.2 Non-manual layering

Wilbur (2000) suggests that non-manual prosodic cues in signed languages may be combined simultaneously. In addition, she suggests that this layering may also take place within one articulator. This is not surprising considering that in spoken languages these cues may be expressed through one channel, i.e. the mouth. According to Wilbur, the layering within an articulator requires that the forms for these various functions are distinct enough. Affective and linguistic signals in the face differ in their onset, offset, apex structures, and scope in the sentence in ASL, according to Wilbur. Because the onset, offset, apex structures, and scope of brow movements differ for affective and linguistic functions, I hypothesised, following Wilbur (2000; 2003) that these functions may be expressed simultaneously. This does not seem to be the case in NGT when the eyebrow movements for these functions differ. Either the affective or linguistic function is shown, depending on the muscles involved. Hence, non-manual layering does not take place within one articulator, in the case of the NGT eyebrows. However, I would predict that other articulators take over the remaining function. However, I would predict that other articulators take over the remaining function because otherwise the intention of the information will not be clear. Thus, layering may take place by spreading over various articulators.

5.2.3 Layering as a modality effect?

When structural properties of languages in the visual-gestural modality (i.e. signed languages) and oral-auditory modality (i.e. spoken languages) differ, this is considered to be a *modality effect* if the differences are due to this difference in communicative channel. Wilbur (2000; 2003) proposes that layering is a modality effect of language.

That is, signed languages express more information simultaneously (layered), and spoken languages express more information sequentially. This effect of modality is supposedly due to the fact that the visual input channel allows the signer to express information using various articulators simultaneously.

I argue that in order to be able to compare signed and spoken languages and determine modality effects, research on both modality types should be based on face-to-face conversations. In a face-to-face conversation, both signers and speakers have all channels available and may or may not use them. In such contexts, spoken languages may be less uni-channelled than previously assumed: the communication may include many events that are perceived visually.

Studies on spoken languages have demonstrated that the eyebrows are used for various conversational purposes (Ekman, 1979, 1999b; Kraemer & Swerts, 2004). Ekman (1979) reports on the use of eyebrows as conversational signals during speech. Kraemer & Swerts (2004) report on the importance of brows in the perception of focus in Italian and Dutch. What is more, brow raise has been found to serve similar syntactic functions in spoken languages as in signed languages (Jouitteau, 2004). That is, in French, yes-no questions may be marked by rising intonation, or raised eyebrows. The linguistic functions and forms of non-manual signals in spoken languages are at least partly language-specific (Kraemer & Swerts, 2004). Thus, in spoken languages too the visual channel plays an important communicative function.

5.2.4 Future research

There are a number of issues left for future research. First of all, for topic sentences, yes-no questions, and wh-questions, various markers were identified. However, I could not determine whether there are differences in meaning associated with these different forms. There are various approaches to determine this. One could go through a corpus and see if similar forms are made in natural conversation and look at the contexts in which they are used. Another approach could be to ask a native signer to give judgements on the meaning of such forms.

Besides the eyebrows, other articulators may provide important clues for the expression of affect in NGT as well. The data that were collected for this study can be used to describe other non-manual or manual cues to affect as well. For example, how are the manual prosodic cues adjusted? In addition, 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, will other articulators be adapted? If so, then in which way?

It has been argued that syntactical non-manuals look very similar across signed languages (Brita Bergman, 1984; Coerts, 1992). In the present study, at least one difference has been found between NGT and ASL; NGT allows for yes-no questions to be expressed by AU 1+2+4 or AU 1+2, while ASL signers will only use AU 1+2. Comparative studies of signed languages using FACS may show more differences between signed languages than have been previously reported. Moreover, the interaction between linguistic and affective functions of eyebrows, or the interaction of AU may differ between signed languages.

Importantly, the phonetic conflict that occurs when different functions are combined within an articulator is found in various prosodic cues. For example, it has been shown

that when identical body leans are used for different linguistic functions in NGT, this results in an enhancement of the movement. When body leans have conflicting movements, other linguistic structures are put into action (Kooij, Crasborn, & Emmerik, 2004). More research is needed to determine which factors are important to explain such data. In this thesis a phonetic account is given, i.e. the phonetic weight of an Action Unit is proposed to be determinant. Importantly, it would also be interesting to investigate the role of perception.

Finally, I would like to emphasise the importance of a comparison between face-to-face interaction between signers and speakers. This MA project has shown that signers use their physical means (articulators) dynamically. This is not a unique property of signed languages. Instead, research has shown that speakers use more than one articulator when available. Here too, functions of one articulator may result in phonetic conflicts. Hopefully, these findings will inspire other linguists to look beyond words and into face-to-face interaction.

References

- Baker, C., & Cokely, D. (1980). *American Sign Language. A Teacher's Resource Text on Grammar and Culture*. Silver Spring: T.J. Publishers.
- Baker-Shenk, C. (1983). *A microanalysis of the nonmanual components of questions in American Sign Language*. University of California, Berkeley, Berkeley.
- Baker-Shenk, C. (1986). Factors affecting the form of question signals in American Sign Language. In D. Sankoff (Ed.), *Diversity and diachrony*. (pp. 407-414). Amsterdam/Philadelphia: Benjamins.
- Bellugi, U., & Fischer, S. (1973). A comparison of sign language and spoken language. *Cognition, 1*, 173-200.
- Bergman, B. (1983). Verbs and Adjectives: Morphological Processes in Swedish Sign Language. In J. Kyle & B. Woll (Eds.), *Language in sign: An international perspective on sign language. (Proceedings of the Second International Symposium of Sign Language Research in Bristol, U.K. in July 1981)* (pp. 3-9). London: Croom Helm.
- Bergman, B. (1984). Non-manual components of signed language: Some sentence types in Swedish Sign Language. In F. Loncke, P. Boyes Braem & Y. Lebrun (Eds.), *Recent Research on European Sign languages (Proceedings of the European Meeting of Sign Language Research held in Brussels, September 19-25, 1982)* (pp. 49-59). Lisse: Swets & Zeitlinger.
- Brennan, M., Colville, M.D., Lawren, L. and Hughes, G. (1984). *Words in Hand: a structural analysis of the signs of BSL*. Carlisle/Edinburgh: British Deaf Ass./Moray House Coll. of Ed.
- Chen, A. (2005). *Universal and language-specific perception of paralinguistic intonational meaning*. Nijmegen: Radboud University Nijmegen.
- Coerts, J. (1986). *Niet-manuele signalen in gebarentalen. Een inventarisatie van de functies van niet-manuele signalen in gebarentalen & een verslag van een onderzoek naar de functies van deze signalen bij 50 SLN-gebaren*. Unpublished MA thesis, University of Amsterdam, Amsterdam.
- Coerts, J. (1992). *Nonmanual grammatical markers. An analysis of interrogatives, negations and topicalisations in Sign Language of the Netherlands*. Amsterdam: Universiteit van Amsterdam.
- Colville, M. D., Denmark, M., Mason, C., Denmark, C., & Brennan, M. (1984). *Edinburgh Non-manual Coding System (ENCS)*. Edinburgh: Edinburgh BSL Research Project, Moray House College.
- Crasborn, O. (2001). *Phonetic implementation of phonological categories in Sign Language of the Netherlands*. Utrecht: LOT.
- Darwin, C. (1872). *The expression of emotions in man and animals*. London: John Murray.
- Deuchar, M. (1984). *British Sign Language*. London: Routledge & Kegan Paul.
- Ekman, P. (1979). About brows: emotional and conversational signals. In M. von Cranach, K. Foppa, W. Lepenies & D. Ploog (Eds.), *Human Ethology: claims and limits of a new discipline*. Cambridge: Cambridge University Press.
- Ekman, P. (1992a). Are There Basic Emotions? *Psychological Review, 99*(3), 550-553.
- Ekman, P. (1992b). Facial Expression and Emotion. *American Psychologist, 48*(4), 376-379.

- Ekman, P. (1994). Strong Evidence for Universals in Facial Expressions: A Reply to Russell's Mistaken Critique. *Psychological Bulletin*, 115(2), 268-287.
- Ekman, P. (1999a). Basic Emotions. In T. Dalgeish & M. Power (Eds.), *Handbook of Cognition and Emotion*. Sussex, U.K.: John Wiley & Sons, Ltd.
- Ekman, P. (1999b). Emotional and conversational nonverbal signals. In L. S. Messing (Ed.), *Gesture, Speech, and Sign* (pp. 45-55): Oxford University Press.
- Ekman, P. (1999c). Facial expressions. In T. Dalgeish & M. Power (Eds.), *Handbook of Cognition and Emotion*. New York: John Wiley & Sons Ltd.
- Ekman, P., & Friesen, W. V. (1978). *Facial Action Coding System*. Palo Alto, CA: Consulting Psychologists Press.
- Ekman, P., Friesen, W. V., & Hager, J. C. (Writer) (2002a). Facial Action Coding System. Salt Lake City, Utah: Research Nexus.
- Ekman, P., Friesen, W. V., & Hager, J. C. (2002b). *FACS Investigator's guide*. Salt Lake City: Research Nexus.
- Engberg-Pedersen, E. (1990). Pragmatics of nonmanual behaviour in Danish Sign Language. In W. H. Edmondson & F. Karlsson (Eds.), *SLR '87: Papers from the Fourth International Symposium on Sign Language Research. Lappeenranta, Finland July 15-19* (10 ed., pp. 121-128). Hamburg: Signum.
- Fischer, S. (2005, Wednesday, November 23). *Prosody and operator scope marking in Western and Asian sign languages*, Max Planck Institute for Psycholinguistics, Nijmegen.
- Hager, J. C., & Ekman, P. (1995). Essential Behavioral Science of the Face and Gesture that Computer Scientists Need to Know. In M. Bichsel (Ed.), *International Workshop on Automatic Face- and Gesture- Recognition Preceedings*. Zurich, Switzerland: MultiMedia Laboaratory.
- Jauch, C. (1994). *Eine Studie der nonverbalen Kommunikation beim Erzählen eines Erlebnisses in Deutschschweizerischer Gebärdensprache* (P. Hain, Trans.). Zürich, Switzerland: Verein zur Unterstützung der Gebärdensprache der Gehörlosen.
- Jouitteau, M. (2004). *Gestures as Expletives: Multichannel Syntax*. Paper presented at the 23rd West Coast Conference on Formal Linguistics.
- Kooij, E. v. d., & Crasborn, O. (2006). *Pointing signs and palm-up as signals of clause finality*. Bielefeld.
- Kooij, E. v. d., Crasborn, O., & Emmerik, W. (2004). *Movements of the head and body: interaction of different linguistic functions in Sign Language of the Netherlands (NGT)*. Paper presented at the International Conference on Tone and Intonation, Santorini, Greece.
- Kooij, E. v. d., Crasborn, O., & Emmerik, W. (to appear). Explaining body leans in Sign Language of the Netherlands: pragmatics required. *Journal of Pragmatics*.
- Krahmer, E., & Swerts, M. (2004). More about brows: A cross-linguistic study via analysis-by-synthesis. In C. Pelachaud & Z. Ruttkay (Eds.), *From brows to trust: evaluating embodied conversational agents* (pp. 191-216). Dordrecht: Kluwer.
- Kyle, J., & Woll, B. (1985). *Sign language: the study of deaf people and their language*. Cambridge: Cambridge University Press.
- Lane, H. (1984). *When the mind hears* (1989, Vintage ed.). New York: Random House.
- Lawson, L. K. (1983). Multi-Channel Signs in British Sign Language. In J. Kyle & B. Woll (Eds.), *Language in sign: An international perspective on sign language*.

- (*Proceedings of the Second International Symposium of Sign Language Research in Bristol, U.K. in July 1981*) (pp. 97-105). London: Croom Helm.
- Liddell, S. (1980). *American Sign Language syntax*. The Hague: Mouton.
- McIntire, M. L., & Reilly, J. S. (1988). Nonmanual Behaviors in L1 & L2 Learners of American Sign Language. *Sign Language Studies*, 17(61), 351-375.
- Meier, R. P. (2002). Why different, why the same? Explaining effects and non-effects of modality upon linguistic structure in sign and speech. In R. P. Meier, K. Cormier & D. Quinto-Pozos (Eds.), *Modality and Structure in Signed and Spoken Languages* (pp. 1-26). Cambridge, UK: Cambridge University Press.
- Meier, R. P., Cormier, K., & Quinto-Pozos, D. (Eds.). (2002). *Modality and Structure in Signed and Spoken Languages*. Cambridge, UK: Cambridge University Press.
- Ortony, A., & Turner, T. J. (1990). What's basic about basic emotions? *Psychological Review*, 97, 315-331.
- Pfau, R. (2005). *Phrasal layers and Prosodical spreading in Sign Languages*. Paper presented at the Sign Volant workshop, Milano.
- Reagan, T. (1995). A sociocultural understanding of Deafness: American Sign Language and the culture of Deaf people. *International Journal of Intercultural Relations*, 19(2), 239-252.
- Reilly, J. S., & Bellugi, U. (1996). Competition on the face: Affect and Language in ASL motherese. *Journal of Child Language*, 23(1), 219-239.
- Reilly, J. S., McIntire, M. L., & Seago, H. (1992). Affective Prosody in American Sign Language. *Sign Language Studies*, 21(75), 113-128.
- Schermer, T. (1990). *In search of a language. Influences from spoken Dutch on Sign Language of the Netherlands*. Unpublished PhD, Eburon, Delft.
- Schroeder, O. (1985). A problem in phonological description. In W. Stokoe & V. Volterra (Eds.), *SLR '83: Proceedings of the 3rd international symposium on sign language research* (pp. 194-202). Silver Spring, MD: Linstok Press.
- Steiner, C. (2000). *Über die Funktion des Anhebens der Augenbrauen in der Deutschscheizerischen Gebärdensprache*. Zürich, Switzerland: Verein zur Unterstützung der Gebärdensprache der Gehörlosen.
- Stokoe, W. C. (1960). *Sign language structure. An outline of the visual communication systems of the American Deaf* (1993 Reprint ed.). Silver Spring, MD: Linstok Press.
- Stokoe, W. C. (1978). *Sign language structure* (2nd ed.). Silver Spring, MD: Linstok Press.
- van Gijn, I. (2004). *Sentential complementation in Sign Language of the Netherlands*. Utrecht: LOT.
- Vogt-Svendsen, M. (1983). Positions and movements of the mouth in Norwegian Sign Language (NSL). In J. Kyle & B. Woll (Eds.), *Language in sign: an international perspective on sign language* (pp. 85-96). London: Croom Helm.
- Wilbur, R. B. (2000). Phonological and prosodic layering of nonmanuals in American Sign Language. In K. Emmorey & H. Lane (Eds.), *The signs of language revisited. An anthology to honor Ursula Bellugi and Edward Klima* (pp. 215-244). Mahwah, NJ: Lawrence Erlbaum Associates.
- Wilbur, R. B. (2003). Modality and the Structure of Language: Sign Languages versus Signed Systems. In M. Marschark & P. E. Spencer (Eds.), *Oxford Handbook of Deaf Studies, Language, and Education* (pp. 332-346). Oxford: Oxford University Press.

- Wilbur, R. B., & Patschke, C. (1998). Body leans and marking of contrast in ASL. *In: Journal of Pragmatics*, 30(3), 275-303.
- Zeshan, U. (2004). Interrogative constructions in signed languages: cross-linguistic perspectives. *Language*, 80(1), 7-39.

Appendix A Elicitation items

Topic sentences

1. $\frac{1+2+4}{\text{INDEX}_1}$ $\frac{\quad}{\text{MOTHER}}$ $\frac{4}{\text{INDEX}_{3b}}$ $\frac{1+2+4}{\text{DEAF INDEX}_{3b}}$
 ‘My mother, she is deaf.’

2. $\frac{4 + \text{squinted eyes}}{\text{MAN INDEX}_{3b}}$ BAG FORGET
 ‘That man, he forgot his bag.’

3. NEIGHBOUR BOY INDEX_{3b} RECENT MOVE
 ‘The boy next-door has moved recently.’

4. GIRL INDEX_{3b 3b} SEE₁
 ‘That girl saw me.’

5. PROFESSOR INDEX_{3b 3b} ON₁ SUPERVISE
 ‘That professor supervises me.’

6. $\frac{1+2}{\text{MAN INDEX}_{3b}}$ FOLLOW₂ ON₁
 ‘That man, he followed me.’

7. $\frac{4 + \text{eye gaze}}{\text{BOOK INDEX}_{\text{book}}}$ INDEX_{3b} FINISH CL:READ_{book}
 ‘That book, he finished reading it.’

8. $\frac{\quad}{\text{CUP INDEX}_{2,3b}}$ $\frac{1+2}{\text{INDEX}_{3b}}$ BREAK CL:FALL_{cup}
 ‘The cup, the broke it and it fell.’

9. WOMAN $\frac{\text{squinted eyes}}{\text{INDEX}_{3b}}$ INDEX₁ FILMING
 ‘That woman, I filmed her.’

10. INDEX₁ FATHER $\frac{\text{squinted eyes}}{\text{INDEX}_{2,3b}}$ BLIND INDEX_{2,3b}
 ‘My father, he is blind.’

Appendix A Elicitation items

Yes-no questions

1. $\frac{1+2}{}$
WITH
'Are you coming with?'

2. $\frac{1+2+4}{}$
INDEX₂ BROTHER DEAF INDEX₂
'Is your brother deaf?'

3. $\frac{1+2+4}{}$
INDEX₂ CAR BREAK INDEX₂
'Is your car broken?'

4. $\frac{1+2+4}{}$
INDEX_{3b} DRIVE INDEX_{3b}
'Is he driving?'

5. $\frac{1+2+4}{}$
INDEX₂ HUNGRY INDEX₂
'Are you hungry?'

6. $\frac{4}{}$
INDEX₂ TIRED INDEX₂
'Are you tired?'

7. $\frac{1+2}{}$
INDEX₂ HAPPY INDEX₂
'Are you happy?'

8. $\frac{1+2+4}{}$
INDEX₂ BIKE ₂COME₁
'Did you come by bike?'

9. $\frac{1+2+4}{}$
INDEX₂ WALK HERE
'Did you walk over here?'

10. $\frac{1+2+4}{}$
INDEX₂ DEAF INDEX₂
'Are you deaf?'

Appendix A Elicitation items

Wh-questions (wh-sign/general question sign sentence-final)

1. $\frac{1+2}{}$
 TOGETHER GO-TO WHERE
 'Where are the two of us going to?'

2. $\frac{4}{}$ $\frac{1+2+4}{}$
 INDEX₂ DRIVE WHY
 'Why are you driving?'

3. $\frac{4}{}$
 INDEX₂ DO WHAT PU
 'What are you doing?'

4. $\frac{4}{}$ $\frac{1+2+4}{}$
 PRESENTING WHO PU
 'Who is presenting?'

5. $\frac{4}{}$
 INDEX₂ WANT WHAT PU
 'What do you want?'

6. $\frac{9}{}$
 MAN_{3a} SAY₁ ON₂ WHAT PU
 'What did that man say to you?'

7. $\frac{1+2+4}{}$
 COMING-WITH WHO PU
 'Who is coming with?'

8. $\frac{4}{}$
 INDEX₂ DONE INDEX₂ HOW PU
 'How did you do that?'

9. $\frac{4}{}$
 INDEX₂ DO WHY/PU
 'Why did you do that?'

10. $\frac{4 + \text{searching eye gaze}}{}$
 DONE INDEX_{2(that)} WHO PU
 'Who did that?'

Appendix B Questionnaire (language) backgrounds

Emoties in Nederlandse Gebarentaal

Dit formulier is bedoeld voor het onderzoek naar het uitdrukken van emoties in Nederlandse Gebarentaal.

Het formulier heeft twee delen. In het eerste deel vragen we u om achtergrondinformatie. Het tweede deel bestaat uit verschillende vragen waarin u kunt aangeven of u toestemming wilt geven voor publicatie en verspreiding van de video-opnamen.

ACHTERGRONDINFORMATIE

Naam:

Adres:

Postcode & woonplaats:

Telefoon:

Fax:

SMS:

Email:

Geboortedatum:

Man/Vrouw

We willen graag weten of u uit een dove familie komt en op welke manier u communiceerde toen u jong was. Wilt U de onderstaande vragen beantwoorden?

Zijn uw ouders horend?

vader

ja/nee

moeder

ja/nee

Uit welke plaats komen uw ouders? vader

moeder.....

Als u dove ouders heeft, gingen uw ouders naar een Dovenschool?

vader ja/nee

moeder ja/nee

Zo ja, naar welke school?

vader

moeder.....

Welke opleiding hebben uw ouders?

vader ja/nee

moeder ja/nee

Bebruikten uw ouders gebarentaal?

vader ja/nee

moeder ja/nee

Vanaf welke leeftijd gebruikt u gebarentaal?

..... jaar

Waren er andere mensen in uw directe omgeving (familie, vrienden, etc) die gebarentaal gebruikten?.....

Op welke school hebt u gezeten?.....

Wat voor soort onderwijs heeft u daar gehad?

eentalig (Nederlands)

TC (totale communicatie)

tweetalig (Nederlands en NGT)

Wat is de hoogste opleiding die u heeft afgemaakt?.....

Maakt u deel uit van de Dovengemeenschap? ja/nee

Op welke manier? sportclub

Dove vrienden

Doven ontmoetingscentrum

TOESTEMMINGSVERKLARING

Als u het met de stelling eens bent kunt u het hokje ervoor aankruisen.

- Ik verleen mijn medewerking aan dit scriptieonderzoek naar het uitdrukken van emoties in Nederlandse Gebarentaal.
- Ik geef toestemming dat er video-opnamen van mij gemaakt worden voor dit project.
- Ik heb er geen bezwaar tegen als video-opnamen getoond worden aan andere onderzoekers.
- Ik heb er geen bezwaar tegen als de video-opnamen getoond aan studenten gebarentaal (aan de universiteit en Hogeschool).
- Ik heb er geen bezwaar tegen als (delen van) de video-opnamen gebruikt worden in publicaties over gebarentaalonderzoek
- Ik heb er geen bezwaar tegen als (delen van) de video-opnamen verspreid worden via Internet
- Ik heb er geen bezwaar tegen als ik met naam bedankt wordt in publicaties

Plaats :

Datum:

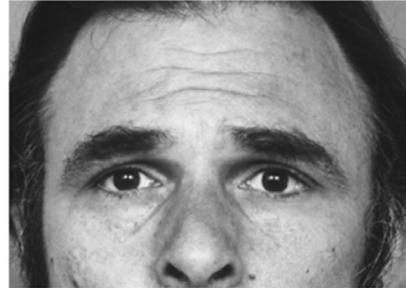
Handtekening deelnemer:

Appendix C Action Units

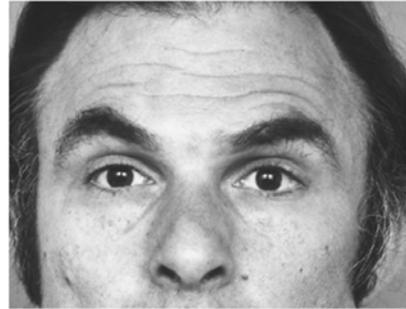
All figures depicting Action Units were taken from FACS (Ekman et al., 2002a)

Action Unit	Name
-------------	------

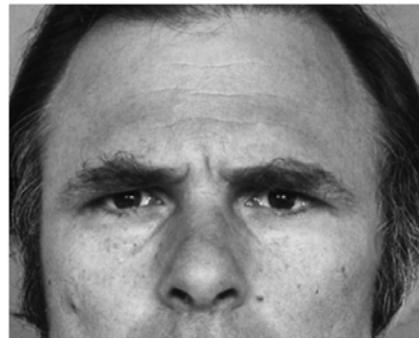
AU 1	Inner Brow Raise
-------------	------------------



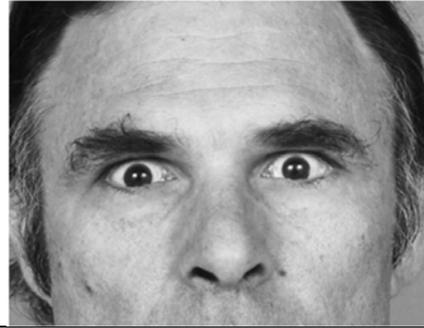
AU 2	Outer Brow Raise
-------------	------------------



AU 4	Brow Lowerer
-------------	--------------



AU 5 Upper Lid Raise



AU 7 Lids Tight



AU 9 Nose Wrinkle

