Mirroring Facial Expressions and Emotions in Dyadic Conversations

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Abstract

This paper presents an investigation of mirroring facial expressions and the emotions which they convey in dyadic naturally occurring first encounters. Mirroring facial expressions are a common phenomenon in face-to-face interactions, and they are due to the mirror neuron system which has been found in both animals and humans. Researchers have proposed that the mirror neuron system is an important component behind many cognitive processes such as action learning and understanding the emotions of others. Preceding studies of the first encounters have shown that overlapping speech and overlapping facial expressions are very frequent. In this study, we want to determine whether the overlapping facial expressions are mirrored or are otherwise correlated in the encounters, and to what extent mirroring facial expressions convey the same emotion. The results of our study show that the majority of smiles and laughs, and one fifth of the occurrences of raised eyebrows are mirrored in the data. Moreover some facial traits in co-occurring expressions co-occur more often than it would be expected by chance. Finally, amusement, and to a lesser extent friendliness, are often emotions shared by both participants, while other emotions indicating individual affective states such as uncertainty and hesitancy are never showed by both participants, but co-occur with complementary emotions such as friendliness and support. Whether these tendencies are specific to this type of conversations or are more common should be investigated further.

Keywords: Emotions, Multimodal Corpora, Mirroring

1. Introduction

This paper deals with mirroring facial expressions and the emotions which they have been judged to convey (Navarretta, 2014a) in an audio- and video-recorded corpus of dyadic first encounters (Paggio and Navarretta, 2011). More specifically, we want to determine to what extent the participants in the encounters mirror each others facial expressions and which emotions these mirroring expressions show.

The mirror neuron system which has been discovered in both animals and humans (Rizzolatti, 2005; Rizzolatti and Fabbri-Destro, 2008) is a mechanism according to which a particular group of neurons, the so-called mirror neurons, become active both when individuals perform a specific motor act and when they observe a similar act done by others. Researchers have found that the mirror neuron system is central in many cognitive processes including action learning (di Pellegrino et al., 1992), the development of empathy (Gallese et al., 2004) and social skills (Dapretto et al., 2006).

Mirroring body behaviours, and especially facial expressions, are common in social interactions and are important social cognitive mechanisms since they enable the observer to understand not only the goal of an observed motor act, but also the intention behind it (Rizzolatti, 2005; Rizzolatti and Fabbri-Destro, 2008). Moreover, facial expressions are strong indicators of emotions together with the tone of voice and other body behaviours. It is important to understand how mirroring behaviours occur and what they indicate in different communicative situations as a first step towards their modelling in human-machine interaction. Synchrony in both speech and body have also been identified in many studies (Condon and Sander, 1974; Esposito and Marinaro, 2007; Esposito and Esposito, 2011), and the strong impact of facial expressions on communica-

tion has also been demonstrated in a fMRI study by Dimberg and colleagues (Dimberg et al., 2000). They prove that both positive and negative emotions can be evoked unconsciously and suggest therefore that important aspects of emotional face-to face communication can similarly occur on an unconscious level. Emotional copying behaviours have also been implemented and tested in embodied software agents (Mancini et al., 2007; Krämer et al., 2013).

In first encounters not only major emotions, but also so called minor emotions (Ekman, 1992), attitudes, and affective epistemic states (Allwood et al., 1992) are very common, therefore they have all been included in this study and are referred to as emotions in what follows.

In a preceding study, we found that both speech overlaps and overlapping facial expressions are frequent in the first encounters (Navarretta, 2013; Navarretta, 2014a) and that speech overlaps increase during the encounters while the number of overlapping facial expressions remain stable. We hypothesised that mirroring facial expressions occur immediately and do not partially depend on the degree of familiarity of the participants the same way as speech overlaps do, inter alia (Campbell, 2009; Campbell and Scherer, 2010). In this study, we want to determine whether the overlapping facial expressions are mirroring and which emotions the mirroring facial expressions convey. The participants in the first encounters face each other, thus mirroring facial expressions should be frequent, but we do not expect all mirroring facial expressions to convey the same emotion, but also that they can convey emotions which are complementary, such as insecurity and support. In the following, we call an emotion which is shown by both participants at the same time a *shared emotion*. These shared emotions should not be confounded with so-called social shared emotions which refer to the emotional experiences which individuals recount and share with others especially after

having experienced negative events (Rimé et al., 1998). Figure 1 shows an example of mirrored behaviour in the first encounters. In the picture, both participants laugh and make the same arm movement showing that they are amused. The main aims of the present work are thus to de-

Figure 1: Mirroring behaviours

termine a) to what extent the participants in the first encounters mirror each others facial expressions, b) which emotions these expressions show, and c) how they are related to the communicative situation. We also want to establish the degree of association between the features of the mirroring facial expressions.

The paper is organised as follows: in section 2. we account for the corpus and its annotations. Section 3. describes the study of co-occurring facial expressions and related emotions, and section 4. contains a discussion of the results. Finally in section 5. we conclude and present future work.

2. The Data

Our data are the annotated multimodal Danish NOMCO corpus of first encounters consisting of twelve dyadic conversations. The conversations involve six female and six male participants, aged between 19 and 36 years. The participants met for the first time and talked freely in order to get acquainted. Each subject participated in two encounters, one with a female and one with a male and the conversations were video- and audio-recorded in a studio at the University of Copenhagen (Paggio and Navarretta, 2011; Navarretta, 2004). The annotations of the corpus are freely available and include speech transcriptions aligned at the word level, and shape and functional descriptions of communicative body behaviours which have been annotated with pre-defined features from the MUMIN annotation scheme (Allwood et al., 2007). The functional features are common to all gestures while the shape descriptions are specific to each gesture type. Shape and function features are unrelated and gestures can be assigned more functions. The kappa scores obtained for facial expression annotations in inter-coder agreement experiments were between 0.6-0.7 (Paggio and Navarretta, 2011; Navarretta, 2014b) and the annotations used in this study are agreed upon by three annotators. Table 1 shows the shape and feedback features of facial expressions which are relevant to this study. The shape features comprise general face, eyebrows, lips and mouth. The two function attributes *FeedbackBasic* and

Attribute	Value
GeneralFace	Smile, Laugh, Scowl, FaceOther, None
Eyebrows	Raise, Frown, BrowsOther, None
Mouth-Lips	CornersUp, CornersDown, None, Protruded, LipsOther, Retracted,
Mouth-Open	OpenMouth, CloseMouth, None
FeedbackBasic	CPU, FeedbackOther, SelfFeedback, None
FeedbackDirection	FeedbackGive, FeedbackElicit, None

Table 1: Facial expression features

FeedbackDirection are related to feedback. The first attribute is assigned if feedback expresses Contact, Perception and Understanding (CPU), if it only shows Contact and/or Perception *(*FeedbackOther) (Allwood et al., 1992), or if the participant is providing feedback to his own contribution *SelfFeedback*. The second attribute *FeedbackDirection* indicates whether feedback is given or elicited.

The emotions which the facial expressions are judged to convey were annotated combining the MUMIN open-ended emotion label list (Allwood et al., 2007) with bipolar values for Pleasure, Dominance and Arousal dimensions, PAD henceforth, as proposed by Kipp and Martin Kipp and Martin (2009). They simplify Russell and Mehrabian (1977)'s three-dimensional emotion model. Differing from the work in (Kipp and Martin, 2009), no intensity value was assigned to the emotions in the Danish first encounters (Navarretta, 2012). The annotators considered both speech and facial expressions in order to determine whether a facial expression expressed an emotion and to assign a label and PAD value to that emotion. Inter-coder agreement tests on the emotion annotations resulted in a kappa score of 0.61 for 26 emotion labels (16 labels were chosen by the coders in the experiment), while the scores for PAD values were between 66% and 80%. The lowest agreement value was reached for Arousal and the highest for Pleasure. More information on the annotation of emotions and the motivation behind the chosen annotation strategy is in (Navarretta, 2012). The PAD value and emotion label combinations in the first encounters are in Table 2. Emotions with negative Pleasure value and positive Arousal and Dominance values were not found in the first encounters.

In Figure 2 a snapshot from the annotation tool is given.

The list of emotions found relevant to the first encounters comprises 28 values including the None value. The ten most frequent emotions in the first encounters and their PAD values are shown in Figure 3.

Previous studies of the emotions in the Danish first encounters (Navarretta, 2012; Navarretta, 2014a) have pointed out that the emotions conveyed by the participants' facial expressions are strongly connected to the type of interaction, that is meetings between people who do not know each other in advance. On the one hand, the participants are kind and want to make a good impression, on the other hand, they can be slightly embarrassed or insecure. Con-

Emotions	P	A	D
Amused, Excited, Happy, Interested, Ironic, Joking, Proud, Satisfied, Self-Confident, Supportive	+	+	+
Disappointed, Hesitant, Unconfident, Uncomfortable, Uninterested	-	-	-
Certain, Friendly	+	-	+
Awkward, Embarrassed, Puzzled, Shy Uncertain, Uneasy	-	+	-
Engaged, Surprised	+	+	-
Docile, Thoughtful	+	-	-
Irritated	+	+	-
None			

Table 2: List of emotions and their PAD values

	Smile	Laughter	FaceOther
Smile	201	35	18
Laughter	109	52	18
Scowl	4	0	0
FaceOther	10	0	4

Table 3: Contingency table for General face

	Frown	Raise	BrowsOther
Frown	9	15	2
Raise	10	57	0
BrowsOther	4	0	0

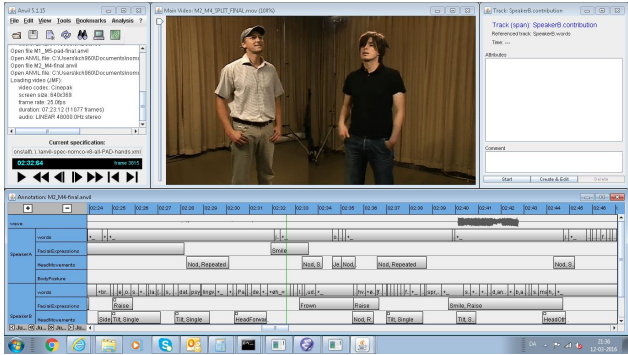Table 4: Contingency table for Eyebrows

Figure 2: Mirroring behaviours

sequently, the most common emotions shown in the conversations have positive PAD values and express amusement, interest, friendliness and support. Other common emotions are self-confidence, certainty, hesitancy, embarrassment and uncertainty which indicate individual affective states. These are often connected to the function of self-feedback in the annotations.
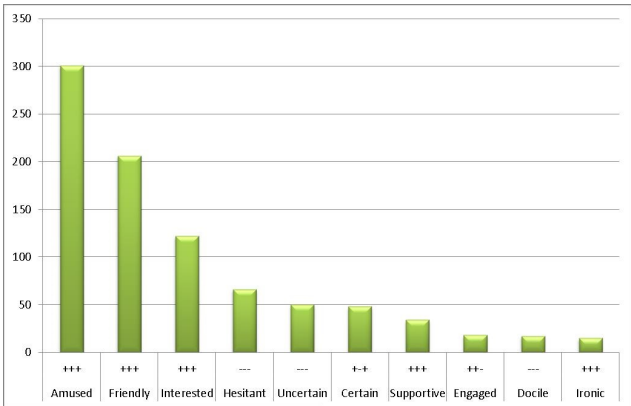

Figure 3: Most frequent emotions

3. Extracting Mirroring Facial Expressions: Method and Results

Mirroring facial expressions are considered facial expressions of the participants which co-occur, that is facial expressions that overlap temporally and are described by the same shape attribute and value pairs. No restrictions are posed on the overlaps, thus mirroring facial expressions can overlap completely or partially, and the minimal overlap is 41.67 milliseconds corresponding to a frame in the ANVIL tool (Kipp, 2004) which was used for annotate.

The association degree between the facial expression features of the first and second participant is calculated via chi square tests. The association is considered to be strong if the chi square p is < 0.005. The contingency table for the general face values are in Table 3. As expected, the association between overlapping general Face values is strong. The large majority of smiles (86%) and laughs (98%) produced by one participant co-occur with smiles or laughs produced by the other participant. There are 668 smiles in the corpus, and 60% of them are mirrored. A facial expression of one participant can overlap with more facial expressions of the other participant, thus the percentage figures of co-occurring expressions and the total number of their occurrences in the data can vary slightly depending on which participant's facial expressions one starts from.

In 22% of the occurrences, a smile of one participant co-occurs with a laugh produced by the other participant. There are 217 occurrences of Laugh in the corpus. Of these instances, 104 or 48%, co-occur with Laugh by the interlocutor and are therefore mirrored. The remaining occurrences overlap with smiles and to a lesser extent to other facial expressions, all annotated with the label FaceOther. Thus, the participants often smile or laugh at the same time. There are 476 occurrences of raised eyebrows in the corpus and 104 of them (22%) are mirrored. The correlation of co-occurring eyebrows is not statistically significant, $p = 0.06$, however, the contingency table of eyebrow positions (Table 4) shows that raised eyebrows often co-occur.

Co-occurring lip positions and mouth openness are not strongly correlated, $p = 0.6$ and $p = 0.09$ respectively. 81% of the lip position CornersUp, and 60% of the value OpenMouth are mirrored.

	Amus.	Certa.	Docile	Excit.	Friend.	Happy	Hesit.	Interes.	Satisf.	Support.	Surpris.	Uncert.
Amused	87	0	1	5	40	3	2	12	3	11	10	3
Interested	3	7	0	2	4	2	3	3	1	1	0	3
Friendly	27	8	0	2	22	0	2	5	2	0	1	3
Satisfied	0	0	0	0	3	0	0	0	0	3	0	0
Certain	2	0	0	1	2	0	1	5	0	0	2	0
Uncertain	0	1	1	0	2	0	1	0	0	1	1	1
Supportive	4	2	0	0	1	0	3	1	0	3	0	0
Surprised	3	2	0	0	1	0	0	0	1	0	0	1
Happy	0	0	0	0	0	0	0	0	0	0	0	4
Hesitant	0	0	5	0	5	0	0	5	0	2	0	2
Excited	0	0	0	1	0	0	0	0	0	0	0	0

Table 5: Contingency table for Emotion labels

	Dominance Plus	DominanceMinus
DominancePlus	313	54
DominanceMinus	40	20

Table 6: Contingency table for Dominance

Mirroring facial expressions often convey emotions in these data (65% of their occurrences), and the association between co-occurring emotions is strong. Table 5 shows the contingency table of the most frequently co-occurring emotions in the data. Amusement, which is the most common emotion in the first encounters with 301 occurrences, is also the emotion that is most frequently showed by both participants, 194 cases, that is 64% of the occurrences. This is not surprising since Laugh and Smile often indicate Amusement. The second most frequently shared emotion is Friendliness which is conveyed by mirroring facial expressions in 21% of its occurrences. Friendliness, however, co-occurs most frequently with Amusement (33% of its occurrences). More interestingly, the contingency table of co-occurring emotions shows that Surprise and Support often co-occur with Amusement, 65% and 41% of their occurrences, respectively, and that Interest also co-occurs with Amusement quite often (12% of its occurrences). Emotions corresponding to the participants' epistemic affective state are seldom shared and only rarely co-occur with other emotions. Examples are Self-confidence, Certainty, Hesitancy and Uncertainty. The association between Pleasure values assigned to co-occurring facial expressions is not statistically significant ($p = 0.22$). Similarly, the Arousal values assigned to co-occurring facial expressions are not strongly associated ($p = 0.07$). On the contrary, there seems to be a correlation between co-occurring Dominance values ($p = 0.0059$). The contingency table for these values is in Table 6.

The table shows that a DominancePlus value is often assigned to co-occurring facial expressions, while negative Dominance values more rarely co-occur.

4. Discussion

Our study of overlapping facial expressions in Danish first encounters confirms that facial expressions are often mirrored also in the case in which people meet for the first time. The study also confirms that mirroring behaviours are frequent (Gergely and Watson, 1996; Rizzolatti and Fabbri-Destro, 2008) and they are an important phenomenon in face-to-face communication and social life (Eisenberg and Fabes, 1992; Gallese et al., 2004).

Not surprisingly, the most frequently mirrored expressions are smiles (60% of the occurrences) and laughs (48% of the occurrences) which are also the most common facial expressions in the data. Laughs and smiles are often recognised to express different degrees of amusement or happiness and it is not strange that they often co-occur. The observation that smiles make people smile (Ekman, 1992) is thus also confirmed in these data. The effect of smiles on people has recently also been proved in human-machine communication (Krämer et al., 2013).

Also, raising eyebrows are often mirrored in the first encounters (20% of their occurrences). Other facial traits that are often mirrored are the lips and mouth positions CornersUp and OpenMouth (81% and 60% of the occurrences respectively). These are also often associated with smiles and laughter and thus they confirm the co-occurrence of the general face expressions.

Over 65% of the mirrored facial expressions in the data convey an emotion and the emotion which most often is shown by both participants is Amusement. Since both mirroring laughs and smiles, and laughs co-occurring with smiles convey "shared" Amusement, "shared" Amusement can be conveyed by the same facial expression (Smile or Laugh by both participants) or by different although related expressions (Smile by a participant and Laugh by the other). Amused facial expressions are in most cases connected to a feedback function in the encounters, that is self-feedback, feedback giving and/or eliciting.

Friendliness is the emotion which, second to Amusement, is most often shared by both participants (21% of its occurrences). Interestingly, Friendliness which is also expressed by smiles and laughs in these data overlaps with Amusement very frequently and is related to feedback giving in most occurrences. In some cases Friendliness shown by a participant and Amusement shown by the other participant are conveyed by the same facial expression, while in other cases they are conveyed by the two related expressions Smile and Laugh.

As expected, emotions which indicate affective states such

as Certainty, Self-confidence, Hesitancy, Embarrassment and Uncertainty are usually not shared. Furthermore, there are a number of emotions which co-occur with complementary emotions, as it is the case for the pairs Hesitancy-Support, and Uncertainty-Friendliness. Co-occurring complementary emotions in the data show that the participants want to encourage their interlocutor by expressing friendliness, interest or support when the interlocutor shows uncertainty on how to start or complete an utterance. Moreover, when a participants laughs the interlocutor smiles friendly. In the corpus, a number of emotions are expressed via smiles. These emotions are for example Friendliness, Interest, Support, Uncertainty and Hesitancy. This confirms that smiles have multiple functions (Ekman and Friesen, 1976). Thus, mirrored facial expressions do not necessarily convey the same emotion. It must be noted, however, that the NOMCO Danish data are annotated with very coarse-grained shape features, and therefore they do not allow to distinguish fine-grained differences between similar facial expressions such as Duchenne and non-Duchenne smiles. In the future, more fine-grained facial expression descriptions such as those proposed in Ekman and Friesen's Facial Action Coding System (FACS) (Ekman and Friesen, 1978) should be added to the data in order to distinguish more types of facial expression and measure to which degree mirroring only involves coarse-grained traits or also more fine-grained ones.

As previous analyses of first encounters have shown (Navarretta, 2012), this study confirms that the emotions shown in the first encounters reflect the communicative situation: the participants want to give a good impression, are kind and friendly. They are also slightly embarrassed and support each other during the interaction.

The fact that only Dominance values in co-occurring facial expressions are significantly correlated is a bit surprising, but it could be somehow related to the previously discussed cases of co-occurring complementary emotions. However the difference between the three PAD dimension must be investigated further. Since the first encounters are only one type of conversation, mirroring facial expressions and the emotions they convey need further investigation in more types of data.

5. Conclusions and Future Work

In this paper, we have described research aimed to determine the occurrences of mirroring facial expressions and the types of emotion which they convey in an annotated corpus of first encounters. We have defined mirroring facial expressions as overlapping facial expressions that are described by the same shape features in the annotations. No restrictions on overlaps have been posed.

The results of our study show that the majority of smiles and laughs and one fifth of the occurrences of raised eyebrows in the corpus are mirrored. In general, our results confirm research that considers mirroring behaviours as a natural phenomenon in human interaction (Gergely and Watson, 1996; Rizzolatti et al., 2002; Rizzolatti, 2005; Rizzolatti and Fabbri-Destro, 2008). Our study has also showed that smiles and laughs often co-occur in the first encounters.

The analysis of the emotions conveyed by co-occurring facial expressions confirms our starting hypothesis that only some types of emotion are shared by the participants. In fact, the only emotions which are often shared by the participants are amusement and friendliness. Amusement is also the emotion that most frequently co-occurs with the largest number of other emotion types in these data.

Emotions which describe individual attitudes or affective states, such as self-confidence and uncertainty, are not shared. Our study also indicates that a participant who hesitates or is uncertain about how to start or continue an utterance is often met by expressions of support, interest and friendliness, thus many co-occurring emotions are complementary.

Our data also confirm that smiles, and to a lesser extent laughs, convey multiple types of emotions, and this is also the case when they are mirrored.

One serious limitation of the annotated data which we have used is the coarse-grained description of facial expressions. Thus, subtle differences between facial expressions cannot be distinguished in the annotations. Furthermore, since the emotions in the corpus are strongly related to the type of interaction (Navarretta, 2012; Navarretta, 2014b) it is not possible to generalise conclusions from the results obtained.

In the future, we will analyse mirroring behaviours and connected emotions in more types of data and add more fined grained facial descriptions to the first encounters annotations in order to be able to identify how fine-grained mirroring is. We will also investigate whether mirroring behaviours are more common in some of the first encounters than in others, and we will compare the behaviour of one participant in two different interactions to establish to what extent it is influenced by the different interlocutors' behaviour.

6. Acknowledgements

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