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Facial reactions to facial expressions in subjects high and low in public speaking fear

ULF DIMBERG and LEIF CHRISTMANSON

Department of Psychology, Uppsala University

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This study investigated whether subjects high and low in public speaking fear react with different facial electromyographic (EMG) activities when exposed to negative and positive social stimuli. A High-fear and Low-fear group were selected by help of a questionnaire and were exposed to slides of angry and happy faces while facial-EMG from the corrugator and zygomatic muscle regions were measured. The subjects also rated the stimuli on different emotional dimensions.

Consistent with earlier research it was found that Low fear subjects reacted with increased corrugator activity to angry faces and increased zygomatic activity to happy faces. The High fear group, on the other hand, did not distinguish between angry and happy faces. Rating data indicated that the High fear group perceived angry faces as being emotionally more negative.

The present results are consistent with earlier studies, indicating that the facial-EMG technique is sensitive to detect differential responding among clinical interesting groups, such as people suffering from social fears.

Key words: Electromyography, facial reaction, facial expression, social fear, emotional reaction.

Ulf Dimberg, Department of Psychology, Uppsala University, Box 1854, S-751 48 Uppsala, Sweden.

Earlier research demonstrates that people suffering from fears for different objects react with emotional responses accompanied by increased autonomic activity when exposed to fear-relevant stimuli (Dimberg, *et al.*, 1986; Fredrikson, 1981; Hare, 1973; Klorman *et al.*, 1975). For instance, Dimberg *et al.* (1986) found that subjects high in social fear (fear of public speaking) reacted with larger skin conductance responses and heart rate decelerations as compared to low fear subjects, when exposed to slides of neutral faces.

Social anxiety, in contrast to specific fears such as snake phobia, can be classified as comprised of several dimensions. One common prominent factor is the confrontation to other people in social encounters (for a discussion on the concept of social anxiety, see Schlenker & Leary (1982)). A public speaking performance is characterized by several important social factors, such as face-to-face interaction, gaze and eye-contact, which have proved to be socially fear provoking. For instance staring evoke escape (Ellsworth *et al.*, 1972) and eye-contact is an important base in the construction of dominance hierarchies (Strongman & Champness, 1968). Marks (1969) consistently suggested that one important factor in social phobia is fear of eyes and eye-contact. It has also been demonstrated that facial expressions used as conditioned stimuli in aversive autonomic conditioning, are potent elicitors of emotional responses. For instance, Dimberg (1986*a*) reported evidence that angry faces induced an excitatory and happy an inhibitory effect on aversively conditioned autonomic responses (for a review on emotional reactions to facial expressions see Dimberg (1988*a*)).

Important emotion theories agree that facial expressions are biologically prewired and intimately related to emotions (Darwin, 1872; Ekman, 1972; Izard, 1977; Tomkins, 1962). It is obvious that an important basis for the presumed biological roots of facial expressions is their role as potent stimuli as elicitors of emotional reactions in face-to-face interactions (Buck, 1984; Dimberg, 1983, 1988*a*; Öhman & Dimberg, 1984).

Based on the proposition that facial muscles are related to emotional activity, a number of studies have been performed in which facial electromyographic (EMG) activities were measured while subjects were exposed to different emotional situations (for reviews on facial-EMG and emotion see Dimberg, 1990*a*; Fridlund & Izard, 1983). It was found that imagery induced positive and negative emotions evoked facial-EMG responses which were interpretable as positive and negative emotional reactions, respectively (e.g. Schwartz *et al.*, 1976). Furthermore, in a series of studies which were performed to elucidate whether the facial-EMG response is a general component of the emotional reaction, Dimberg and co-workers found that facial-EMG reflected consistent emotional reactions to different types of *visual* as well as *auditory* stimuli (Dimberg, 1982; 1986*b*; 1987*a, b*; 1988*b, c*; 1990*b*, 1990*c*; Dimberg & Lundquist, 1988, 1990; Dimberg & Thell, 1988). For instance, subjects exposed to slides of angry facial expressions reacted with increased corrugator activity whereas slides of happy faces spontaneously elicited increased zygomatic activity (Dimberg, 1982, 1988*b*; Dimberg & Lundquist, 1988, 1990). The corrugator muscle is normally used when frowning whereas the zygomatic muscle elevates the corner of the mouth to express a smile (Hjortsjö, 1970).

It has further been demonstrated that facial-EMG reactions differ between clinical interesting groups (Dimberg, 1990*b*; Schwartz *et al.*, 1976). Schwartz and co-workers found that depressed as compared to non-depressed patients differed in facial responsiveness. For instance, depressed subjects did not react, as non-depressed subjects, with increased zygomatic activity to positive emotional imagery. In the study performed by Dimberg (1990*b*) it was found that subjects, which by help of a snake fear questionnaire were classified as relatively high in snake fear, reacted with a more negative facial-EMG response pattern as compared to subjects relatively low in snake fear.

Thus, converging studies indicate that facial-EMG activity reflect emotional responses and that the facial-EMG technique may be a sensitive tool to detect different response patterns among clinical interesting groups such as people suffering from specific fears. One interesting question is whether subjects suffering from social fear react with different facial-EMG responses when exposed to fear-relevant stimuli, that is to social stimuli. The present study was performed to examine this question. Two groups of subjects were selected on the basis of their responses to a questionnaire on fear of public speaking performance. The two groups, High and Low in fear, were exposed to slides of negative (angry) and positive (happy) social stimuli while their facial-EMG activity from the corrugator and zygomatic muscle regions were measured. They were also exposed to neutral slides (geometric figures). The prediction was that subjects low in fear should react similarly to subjects exposed to facial stimuli in earlier studies (e.g. Dimberg, 1982), that is increased corrugator activity to angry faces and increased zygomatic activity to happy stimuli. Furthermore, since social stimuli were expected to evoke more negative reactions among high fear subjects, it was predicted that these subjects should overreact with more corrugator activity in general when exposed to angry and happy stimuli, and particularly so to the negative stimuli. Furthermore, to examine whether the groups perceived the facial stimuli differently, the subjects were also required to rate the stimuli on different dimensions. It was predicted that the High fear group should perceive social stimuli, particularly angry faces, as more negative.

METHOD

Subjects

Thirty students at Uppsala University were selected from a larger pool of 245 persons by help of a Swedish translation (Fredrikson, 1983) of the Public Report of Confidence as a Speaker (PRCS) questionnaire

(Paul, 1966). The PRCS questionnaire includes 30 items in which maximum fear rating of 30 indicates high fear, whereas zero indicates no fear. The 15 highest scoring subjects were selected to form the High fear group with a mean rating of 23.8 (SD = 2.24) whereas the mean for the 15 subjects in the Low fear group was 5.7 (SD = 1.45).

Apparatus and data scoring

The subjects were individually tested in a sound attenuating experimental chamber. The slides were projected onto a screen about 2 m in front of the subjects and produced a visible size of 33 × 22 cm. The exposure time (8 sec) was controlled by help of an electronic timer.

The slides of facial expressions were selected from Ekman & Friesen's (1976) "*Pictures of facial affect*" showing males displaying an angry or a happy facial display. The neutral stimuli (simple geometric figures) were selected so that they were overall equal to the luminance of the facial stimuli.

Bipolar facial-EMG was measured on the left side of the face over the corrugator and zygomatic muscle regions by help of Beckman surface miniature silver/silver chloride electrodes filled with Beckman's electrode paste. The electrodes over the corrugator region were attached slightly above the eyebrow on an imagined line through the medial border of the iris respectively directly over the border of the eyebrow head. The two electrodes over the zygomatic region were attached midway along a line joining the lower edge of the cheekbone and the corner of the mouth with an inter-electrode distance of about 1.5 cm (Fridlund & Cacioppo, 1986). Before the electrodes were attached the skin was cleaned and slightly rubbed with the electrode paste. To minimize the influence from noise such as 50 Hz noise emanating from electrical equipment, the raw-EMG signal was visually inspected on a Tektronix oscilloscope. The electrodes were connected to Hewlett Packard bioelectric amplifiers with bandpass filters set at 50 and 1000 Hz. The raw-EMG signal was analysed by a contour following integrator with time constant set at 1 sec. The contour follower was a variant of that described by Fridlund (1979) and provides a DC output which is directly proportional to the envelope of the raw waveform. The output signal was recorded on a Hewlett Packard 7700 Recorder and was manually scored second by second during the stimulus presentations as change in microvolt from the pre-stimulus level. Thus, phasic facial responses were scored.

Ratings of facial stimuli were performed for happiness, friendliness, anger, fear, hostility and directedness on 10 points scales with "not at all" at one end and "very much" at the other end.

Procedure

The subjects were instructed that the aim of the study was to measure physiological responses to different stimuli. To cover the purpose of the facial muscle registration and consequently minimize the influence of demand characteristics (Fridlund & Izard, 1983) they were told that sweat gland activity should be measured in their faces. That is, the subjects were not aware of that their facial muscle activity was going to be measured.

The experiment consisted of two phases. Facial-EMG was measured during both phases. During the first phase, subjects were exposed to 10 presentations of each angry and happy faces as well as neutral geometric stimuli. The stimuli were presented in a balanced order. The second phase consisted of a single presentation of the angry and happy stimuli, respectively, during which the subjects also rated the pictures. Note that during this phase the subjects were instructed to first look at the stimuli during the exposure and then to rate the stimuli *after* the exposure. That is, immediately after each presentation the subjects were required to rate the stimuli on the different scales. Thus, since the subjects, as during the first phase, were instructed to sit calmly and pay attention to the pictures even during this second phase, the registration of facial-EMG was not influenced by movement artifacts originated from the rating/writing procedure, but rather of the instruction to again pay attention to the pictures with the aim to rate them after exposure.

Design and statistical analysis

The basic design was a Group × Stimulus × Muscle × Trial split plot factorial (Kirk, 1968) with Group as the between subjects factor and Stimulus, Muscle and Trial as repeated measures. Before statistical analysis the facial-EMG data were collapsed over seconds and were evaluated by ANOVA and *a priori* *t*-tests.

Table 1. *The mean facial-EMG response for the corrugator (corr.) and zygomatic (zyg.) muscles to the different stimuli for High and Low fear groups during the first experimental phase.*

	Angry		Happy		Neutral	
Group	Corr.	Zyg.	Corr.	Zyg.	Corr.	Zyg.
High	0.107	0.152	−0.074	0.202	0.137	0.122
Low	0.171	0.094	−0.064	0.427	0.018	0.037

RESULTS

The facial-EMG data for the first experimental phase were evaluated in a Group (High vs Low) × Stimulus (angry vs happy vs neutral) × Muscle (corrugator vs zygomatic) × Trial (10) ANOVA.

Mean facial-EMG data for the first phase are given in Table 1. The ANOVA indicated an overall tendency for the Muscle factor, $F(1,28) = 3.32$, MSe = 2.06, $p < 0.10$, which was due to larger zygomatic than corrugator responses. The Muscle × Stimulus interaction also tended to be significant, $F(2,56) = 3.04$, MSe = 2.52, $p < 0.10$, indicating that the stimuli evoked different response patterns. Specific comparisons between means showed that happy stimuli evoked more zygomatic than corrugator activity, $t(28) = 3.06$, $p < 0.005$, whereas there was no such difference for angry and neutral stimuli. Specific comparisons within groups showed that it was only the Low fear group which significantly reacted with larger zygomatic than corrugator responses to happy stimuli, $t(28) = 2.77$, $p < 0.005$.

The facial-EMG data for the second experimental phase were evaluated by a Group (High vs Low) × Stimulus (angry vs happy) × Muscle (corrugator vs zygomatic) ANOVA.

The data for the second phase are illustrated in Fig. 1. As can be seen in the figure and as indicated by the ANOVA, the groups tended to react with different facial reactions to the angry and happy stimuli, $F(1,28) = 3.17$, MSe = 1.11, $p < 0.10$, for the Group ×

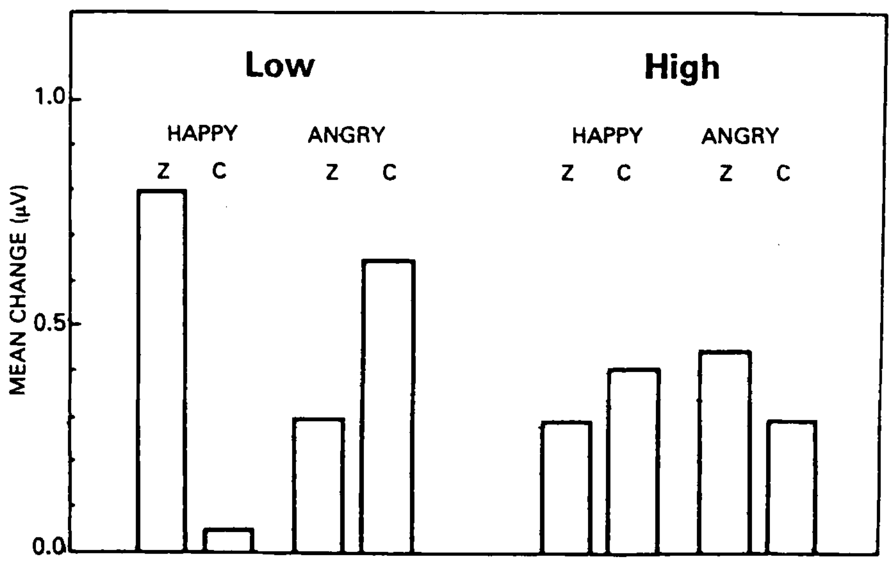

Fig. 1. The mean facial-EMG response in μV for zygomatic (Z) and corrugator (C) muscle regions for low- and high-fear subjects exposed to angry and happy faces.

Table 2. *The results from t-tests between High vs Low groups for rating scores.*

	Stimulus	
Ratingscore	Angry	Happy
Negative	2.63	0.67
Positive	−1.82	−0.96
Directed	−0.59	−1.05

Muscle × Stimulus interaction. As predicted the Low fear group reacted with increased corrugator activity to angry faces and increased zygomatic activity to happy faces. The High fear group, on the other hand, did not distinguish between the response patterns to angry and happy facial stimuli. Separate *t*-tests confirmed that the corrugator muscle response to angry faces and the zygomatic muscle response to happy stimuli differed significantly from zero for the Low fear group. No other effects were evident.

Before the rating data were analysed, the angry, fear and hostility scores were pooled to a Negative rating score whereas happy and friendly were collapsed into a Positive score. These scores and the directness score were evaluated by help of *t*-tests in comparisons among means between High and Low fear groups. The results of these comparisons are given in Table 2.

As can be seen the High fear as compared to the Low fear group perceived angry faces as more negative. This was further confirmed by the comparison for positive ratings, indicating that the Low fear group perceived angry faces as more positive. No other comparisons were statistically significant.

DISCUSSION

The present results demonstrated that subjects high and low in public speaking fear react with different facial-EMG responses when exposed to negative and positve social stimuli. Low fear subjects reacted differently to angry and happy faces. Angry faces elicited increased corrugator activity which was particularly manifest during the phase when subjects were supposed to rate the stimuli. Happy faces evoked increased zygomatic activity. So far these data replicate the results obtained in earlier studies (Dimberg, 1982, 1988*b*; Dimberg & Lundquist, 1988, 1990) and the data are consistent with the proposition that facial stimuli are potent elicitors of emotional reactions (e.g. Dimberg, 1983, 1988*a*) and that facial muscles are closely related to emotional activity (e.g. Darwin, 1872). High fear subjects, on the other hand, did not distinguish between angry and happy stimuli. In fact, they did not display any particular facial response patterns to either stimuli. It is interesting therefore to note that high fear subjects perceived the stimuli as more negative than low fear subjects. As expected, this was particularly pronounced for angry faces. This is consistent with the proposition that social stimuli are more negative and threatening for subjects high in social fear. However, it is not possible to simply interpret data as that the facial reaction for high fear subjects reflects a negative facial response. In such case subjects should overreact with corrugator activity when exposed to negative social stimuli.

These results then seem contradictory. That is, why do subjects not overreact with corrugator activity in the group high in social fear when exposed to supposedly negative social stimuli? One alternative way to interpret these data would be from a social interaction point of view. From this perspective the facial muscles do not simply function as a correlate to the emotional state but also as a signal for emotional communication. Alternative interpretations would therefore be that the absence of different responding between corrugator and zygomatic muscles in the high fear group is an effect of for instance submissive behaviour, resulting in a facial reaction which carries aspects of an appeasing smile. A further interpretation may be that the detected facial-EMG reactions reflect mimicking behaviour, to which subjects high in social fear are insensitive. Although this latter interpretation is consistent with results obtained in earlier studies (e.g. Dimberg, 1982) it is important to note that analogous facial-EMG reactions are detected in other emotional situations which exclude the interpretation that the facial response is an outcome of only mimicking behaviour (e.g. Schwartz *et al.*, 1976; for a review see Dimberg, 1990*a*). For instance, slides of snakes and flowers evoke negative and positive facial-EMG reactions, respectively (Dimberg, 1986*b*; Dimberg & Thell, 1988). An alternative interpretation could therefore be that the evoked facial responses reflect both emotional reactions and at least partly mimicking behaviour in the present context. Some of these questions may be explored in future studies by specifically comparing reactions to social stimuli with facial reactions to other emotional stimuli such as slides of snakes. Another explanation may be that the facial reaction during the second phase could be obscured by the specific instruction to rate the stimuli and it is possible that high fear subjects are more sensitive to such manipulations. Thus, future studies may address this question by more specifically manipulate instructional factors.

Furthermore, another possible interpretation could be that the responses during the first phase were obscured by the fact that subjects were exposed to a mixed presentation of both different faces as well as geometric figures. This procedure was different compared to other studies performed in the similar paradigm. For instance, in the snake fear study (Dimberg, 1990*b*) subjects were exposed to repeated stimulations of the same category. Thus, it is possible that the mixed presentations of the different stimuli in the present study increased the relative stimulus novelty which probably obscured the genuine emotional response pattern by evoking a response influenced by surprise and/or orienting activity. Some support for this hypothesis was found in an analysis in which the first five presentations were compared to the five latter presentations. That is, if the response patterns were influenced by factors such as novelty, one could expect that the latter five trials should evoke a more genuine response pattern than the first five presentations. The analysis showed a clear tendency that the latter five presentations evoked different response patterns to angry and happy faces which were similar to earlier studies (e.g. Dimberg, 1982) whereas the first presentations did not. Consequently, one way to further explore whether subjects high in social fear react more negatively to social stimuli is to replicate the present study with experimental parameters more similar to those in earlier experiments such as in the snake fear study (Dimberg, 1990*b*).

In summary, the present study indicated that subjects high in public speaking fear react with a distorted facial-EMG reaction to social stimuli. While low fear subjects react with a negative and a positive facial-EMG response to angry and happy facial stimuli respectively, the high fear subjects do not display any particular reactions to the stimuli. These data indicate that, besides being sensitive to detect different response patterns between depressed and non-depressed subjects (Schwartz *et al.*, 1976) as well as different responses among subjects high and low in fear of snakes (Dimberg, 1990*b*), the facial-EMG technique appears to be sensitive to detect different response patterns among subjects high and low in social fear.

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