Long-Distance Transmission of Facial Affect Signals

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This study examined the distance at which certain facial expressions can transmit affect messages. A man and a woman assumed facial expressions that were selected carefully to represent six affects. These expressions were shown in still photographs and in live portrayals to 49 observers who composed four groups which were 30, 35, 40, and 45 meters away from the stimuli. Photographs and live portrayals produced comparable results. Every observer was able to label the expressions accurately although accuracy declined as distance increased. Extrapolation from the data suggested that some messages may be sent far beyond the distances used in this study. These results raise important issues about the transmission of facial signals over distance and suggest that the face is a long-distance transmitter of affect signals.

Key Words: Facial expression

INTRODUCTION

Research has shown that some facial expressions function as signals of affect and that these signals can have definite, universal meanings (for reviews see Ekman et al., 1972; Ekman, 1973). Facial expressions share certain important properties with other communicative signals (e.g., Altmann, 1967; Marler, 1968). One of these properties is the "strength of transmission" (Moynihan, 1970) or how far from its source a signal remains effective. Little is known about how far facial expressions transmit information, although Hall (1966) claimed that at 30 ft (9.15 m) and beyond the details of facial expression disappear. Our study was designed to show that facial expressions can send affect messages much farther, well beyond the distances at which intimate, face-to-face interactions occur.

Studying the transmission of facial signals is complicated by the many variables which can influence the sending and receiving of visual information in the face: expressor variables (facial size and physiognomy, age, sex, degree and location of muscle contractions, etc.), observer variables (visual acuity, skill, and knowledge, etc.), and environmental variables (ambient light, lighting of the face, stimulus background, orientation of the observer and expressor, etc.). Our experimental procedures controlled or measured the most significant variables affecting the distance range of facial signals. Some of the conditions in which communication via facial expression naturally occurs were approximated by having unpracticed observers judge the live expressions of models. Artificiality was introduced by using a prescribed list of verbal responses and a restricted number of posed expressions which were not seen in their usual context. Photographs as well as live portrayals were used as stimuli to determine whether the judgments of each would be similar enough to allow the use of photographs alone in future research. Four groups of observers, each at a different distance, judged these stimuli.

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METHOD

Selection of Facial Expressions

A stepwise procedure was devised to select expressions which would obviously, rather than subtly, signal six affects: happiness, sadness, fear, anger, surprise, and disgust. These affects were chosen because previous research had shown that they have the most reliable associations with facial expressions and that these associations are universal (Ekman et al., 1972). Only one expression was selected for each affect to avoid too many judgments for one session and to make the expressors' task easier. In order to explore the maximum distances over which the face can transmit information, muscle movements were identified which would create the most visible expressions with the least ambiguous meanings.

The first step to identify muscle movements was to select pictures for each affect which had been found in previous studies to yield high agreement among observers who judged affect (Ekman and Friesen, 1976b). Next, these pictures were scored with the Facial Action Coding System (Ekman and Friesen, 1976a, 1978) to identify the muscle movements which expressors would have to perform to reproduce each expression. Movements of the body or head and changes in gaze direction which typically accompany affect were ignored. The most frequent score in each sample of affect pictures was chosen to comprise a set of instructions to expressors for performing the six expressions. Because stronger muscle contractions produce clearer, more visible expressions, maximum contraction of the muscles producing the expressions was specified in these instructions. Finally, the mouth opening was made equal across all expressions so that the configuration of the mouth was the signal rather than whether it was open or closed. These steps produced stimulus expressions which looked extreme but natural, as exemplified in Fig. 1.

Figure 1. Two of the stimulus photographs (not to scale) used in this study: (a) the woman's happy expression, (b) the man's fear expression.

Expressors, Photographs, and Observers

Two expressors were chosen who differed substantially in many respects including sex, head size, physiognomic features, and age (46 years for the male, 34 for the female). They could accurately and reliably perform the required muscle movements because they had previously received extensive training in voluntary contraction of their facial muscles. Their portrayals of the selected expressions were photographed, printed on black and white matte paper, and enlarged with equal print densities to the life size of each expressor.

Observers were 49 adult volunteers (30 female) who were assigned randomly to groups and paid \$2.50 each. There were 13, 11, 12, and 13 observers nearest to farthest from the stimuli respectively.

Procedure

The experiment was conducted in one session in the largest indoor area available, a campus parking structure. Observers' visual acuity was measured individually, aided by their usual correction (if any), using a Snellen wall chart. Each group of observers saw the stimuli from only one distance and was seated either 30, 35, 40, or 45 m away from the stimuli, the maximum separation permitted by the building's dimensions. A pilot study had shown that accurate labeling of most expressions would decline rapidly over this distance range. The expressors and photographs were in a portable studio that recreated the same lighting and background conditions in which the photographs had been taken. A panel hid the expressor's body so that only the head could be seen. Looking through the open end of the studio, the observers could clearly see the faces and photographs without glaring reflections. They were told the purpose of the experiment, that they might see the same expression or the same photograph more than once, and that they should judge each stimulus without trying to remember previous judgments. On each trial observers had 2 sec to focus on the stimulus location and accomodate to the lighting before seeing the stimulus expression. During a trial, either an experimenter displayed a photograph or an expressor performed an expression once. In both cases the stimulus could be seen for 3 sec. Observers had up to 10 sec to circle one label from a list of six affects. There were 4 trials of each of the 6 expressions by each expressor for a total of 48 live performances. These combinations were duplicated by the display of photographs. All trials were mixed randomly with respect to expressor, expression, and presentation mode (except for minor constraints (e.g., not more than two consecutive presentations of the same expression)).

RESULTS

The observers' visual acuity, as measured by the lowest line of the Snellen chart completed correctly, ranged from 20/40 to 20/10 with a mean of 20/18. The groups of observers who were seated at the different viewing distances did not differ in their mean acuity, $F(3, 45) = 0.59$, $p = 0.62$.

Even at the farthest distance every observer judged the stimuli significantly better than chance ($p < 0.01$, exact binomial, with the expectation that $\frac{1}{6}$ of the 96 trials would be correct by chance alone). This measure does not reveal which of the six expressions observers could identify at each distance, but this issue is addressed below. To estimate the farthest distance each expression could be identified, a straight line was fitted to observers' scores as a function of the four experimental distances. Figure 2 shows the observed mean scores at each distance for each expression and expressor combination. A line was fitted for each of these combinations and was used to predict the distances at which accuracy would decline to chance levels. Unfortunately, these levels cannot be known exactly because the expectations of chance success for any one expression depends upon how well the other expressions could be identified and eliminated as choices. In this experiment the nonnegative affect expressions, happiness and surprise, were identified so well that they probably were eliminated as choices when the other expressions were presented. Therefore, the expectation of chance success was set conservatively at one-fourth of the trials for the four negative affect expressions and at one-sixth for happiness and surprise. The predicted distances where accuracy would decline to these chance levels were checked by comparing them to the accuracies observed at the experimental distances to insure that the predictions were not overestimates. Goodness

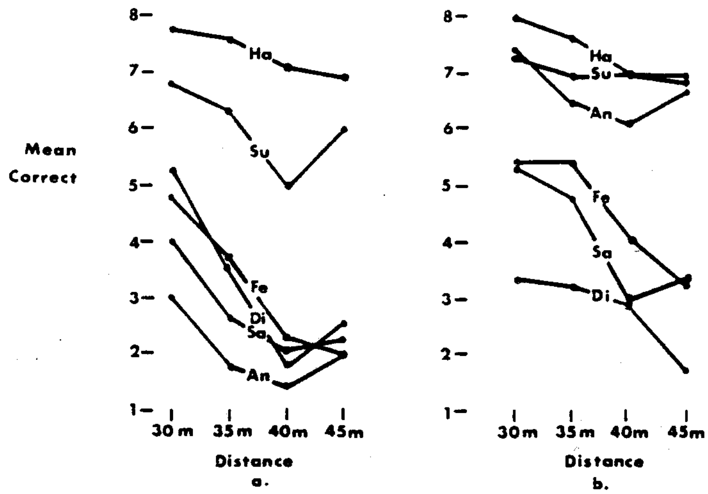

Figure 2. Graphs of the mean number of correct responses at each distance for each expressor and expression combination: (a) woman. (b) man: Ha = happiness. Su = surprise. Fe = fear. Di = disgust. Sa = sadness. An = anger. Eight correct = 100%.

of fit tests indicated that lines of a higher degree would not add to predictive accuracy except for the woman's expression of anger. This analysis indicated that the limit of accurate transmission of the woman's anger had been reached at 35 m; expressions of her sadness, fear, and disgust at 40 m; expression of the man's disgust at 45 m; and expressions of his sadness and fear at 54 m. Predictions for the limit of accurate transmission of happiness, surprise, and the man's anger were from 100 to 220 m. too far beyond the experimental distances to maintain confidence in their reliability. All these predictions should be interpreted as rough estimates only for the particular expressions, expressors, and conditions of this experiment. They suggest that equally extreme expressions signalling different affects transmit to different distances, and that while most of these affect signals transmit only as far as the range of distances used in this study, some can transmit much farther.[1]

A mixed design, 4(distance) × 2(presentation mode) × 2(expressor) × 6(expression) analysis of variance with repeated measures on the last three factors was conducted with the number of correct responses as the dependent variable. The significant sources of variance and their error terms are given in Table 1. Duncan's Multiple Range Tests on the means in Table 2 showed that accuracy decreased significantly with increasing distance except between 40 m and 45 m, where there was no significant difference. Simple main effects and simple interaction effects of two- and three-way interactions involving the presentation mode, expressor, and expression variables helped to clarify the effects of these variables. In general, judgments about the man were more accurate than judgments about the woman except that accuracy was the

Table 1. Summary of Omnibus Analysis of Variance

Source	MS	df	F
A (distance)	38.01	3	5.02^{b}
S/A (error)	7.58	45	
C (expressor)	128.22	1	177.16^{c}
A X C	2.42	3	3.35^{a}
C X S/A	0.72	45	
D (expression)	151.41	5	92.38^{c}
D X S/A	1.64	225	
B (presentation mode) X D	6.86	5	7.11^{c}
B X D X S/A	0.96	225	
C X D	39.02	5	40.23^{c}
C X D X S/A	0.97	225	
B X C X D	3.58	5	5.82^{c}
B X C X D X S/A	0.62	225	

^{a} $p < 0.05$
^{b} $p < 0.01$
^{c} $p < 0.001$

[1] Preliminary findings from subsequent research using only the male's pictures indicate that expert observers can accurately label expressions of happiness and surprise at 100 m.

Table 2. Mean Number of Correct Responses to All the Man's and Woman's Stimuli at Each Distance

	Distance			
Expressor	30 m	35 m	40 m	45 m
Man[a]	36.69	34.36	30.08	28.92
Woman[b]	31.38	25.54	19.67	21.69

[a] Error MS = 3.96

[b] Error MS = 4.33

Note. Maximum score = 48.

same for the happy expression of each expressor, and the woman's live disgust expression was better judged than the man's. Usually, there were no significant differences between judgments of live expressions and pictures, but sometimes either the live or photographic stimuli were judged significantly better, depending unpredictably on expressor and expression combinations. Expressions were not judged with equal accuracy, and their rank order varied slightly depending on the expressor and presentation mode. Multiple Range Tests showed that happiness and surprise were judged invariably better than the other expressions except for the man's anger which was judged equally well.

DISCUSSION

These results show that the face is a long-distance transmitter which can signal affect much farther than the boundaries of intimate interaction. Observers can receive some affect messages 45 m away from the face. Extrapolations based on the data suggest that some expressions can probably be identified at more than 100 m. To appreciate how far these distances are in relation to contexts for social interaction, consider that no spectator watching a Shakespearean play in the Globe theater could have been more than 27 m from any player. The farthest a member of the House of Representatives can sit from the speaker's rostrum in the House Chamber is 25 m. As another index to the power of facial signals, consider the world's record javelin throw, 94.58 m, which is approximately how far professional baseball players can throw. If this distance represents an upper limit to the range of hand-propelled weapons, then some affect messages probably can be recognized beyond primitive combat ranges.

Judgments of pictures and live expressions appear to be similar enough to justify using only pictures in the future when experimental conditions are comparable to those in this study. The absence of interactions between the distance and the presentation mode variables indicates that the effects of distance are similar for both types of stimuli. Also, there was no main effect of presentation mode despite the obvious differences between pictures and live portrayals. However, as experimental conditions diverge from those of this study (e.g., a greater distance range or more ambiguous, quicker, and less visible expressions), the comparability of pictures and live portrayals becomes more uncertain.

Our demonstration of the face's capacity to send affect signals over long distances is an initial exploration of relationships between distance and the transmission of facial information. Such parameters of facial expression as the muscles contracted, the number recruited, the degree of contraction, and the areas of the face involved might have systematic effects on the visibility of facial messages. Future studies could also examine the effects produced by characteristics of the model (e.g., sex, age, head size, skin color, facial hair, physiognomic qualities, use of cosmetics), different environmental circumstances, and other types of observers (e.g., expert). Comparing the ranges of different affect signals, other facial signals such as identity, age, sex, and ethnicity (Ekman, 1978), and signals in vocal and other visual channels would show the relative strength of transmission of these signals. Research on these issues could help us to understand the evolutionary significance of communicative movements and certain physical features (e.g., the sclera and facial hair), the patterns of control on muscle movements in deception, and the use of certain muscles in deliberate communication (e.g., the brow raise in greetings). Theories of the function, development, and evolution of the face and its signals should consider the role of the face in distant communication (e.g., between unfamiliar groups) as well as in intimate interactions (e.g., between mother and infant).

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