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Problems in the Recognition of Gaze Direction

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1 Introduction

1.1 PROBLEM

Gazing at the partner is an important element of non-verbal communication; eye-contact, gaze orientation towards the partner, and gaze aversion are behaviours which are frequently studied and cited in explanations of social behaviour. In this connection the question arises as to the function of the perception of gaze direction in the communication process.

Interaction may be defined as "mutual reference" in the behaviour of social partners, while *communication* is the "exchange of messages" in a communication system that consists of the partners and a common *code* (von Cranach, 1971b). The code defines the relationship between a repertoire of *signals* and their *meanings*. The communication partners are *sender* and *recipient* with respect to any single signal (cf. Introduction to

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this volume). According to our definition of interaction and communication, we may talk about interactive and communicative behaviour when we refer to the interactive and communicative acts of *one* of the partners.

It is generally agreed that looking behaviour functions as a means to monitor and observe the partner (information seeking) and serves as a communicative signal as well; it may thus be considered as both interactive *and* communicative behaviour. The communicative functions of looking behaviour are relatively well explored, and are summarized in several survey articles (Argyle and Kendon, 1967; Duncan, 1969; Vine, 1970; von Cranach, 1971). As far as this subject has been investigated so far, looking behaviour seems to signal the readiness or the reluctance to communicate by exchanging other signals, and to coordinate the communicative behaviour of both partners. In their particular characteristics both functions depend on the communicative and situational context. Another frequently studied aspect of looking behaviour is the role it plays in mother–child communication, especially as a releasing signal in infants (see Vine, Chapter 5). It can also exert arousing or threatening effects in a variety of species (Vine, 1970; and see Hindmarch, Chapter 6).

All assumptions concerning special signal functions of the gaze presume that it can be correctly assessed to a high degree. In this chapter we report on the design and results of studies in the recognition of gaze direction. Our interest is focused on the following questions: How good is the accuracy of gaze assessment by the recipient or by an observer unconcerned in the communication? Which factors affect it? How can it be improved? The answers we have obtained seem to show that the behaviours of the sender are coordinated to facilitate the recipient's impression of being looked at or looked away from.

1.2 TERMS, CONCEPTS AND OPERATIONS

The comparison of studies on looking behaviour is complicated by unclarity in the use of terms, concepts, and related operations. It can be noted that the same terms are used for different concepts, or different terms for the same concepts, and that the underlying concepts are inadequately represented by the observational operations chosen, as illustrated in Table 1. The finding that most of the concepts are operationally based on the recognition of gaze direction adds to the justification of our present methodological enquiries.

TABLE 1

Some terminology in research on looking behaviour

Term	Concept	Operation
1 "One-sided gaze" *or* "looking at the partner" *or* "visual orientation towards the partner", *or* "eye-gaze"	The sender looks at the face of the recipient, mainly at the eye region	Assessment of "gaze direction" ("line of regard", "focus") by judging pupil, *and/or* iris location, of one eye or both eyes by an observer or the recipient, *and/or* by inference from head position, *or* by self-report, *or* by previous instruction to the sender to fixate a specified target
2 "Mutual gaze"	Both partners look into each other's face, *or* eye region, thus acting simultaneously as sender and recipient	Gaze direction of both partners assessed by a combination of operations as described in (1)
3 "Eye-contact"	Both partners look into the other's eyes, *or* into one eye only, and both are aware of this mutual gaze; *or* the concept is identical with (2)	Assessed as in (2)
4 "Gaze movement" *or* "gaze shift"	Turning the gaze further towards or away from the partner	Assessment of movement of the eyeball in the socket as indicated by changes in the configuration of sclera, iris and pupil (as in (1)), *and/or* assessing head movement
5 "Gaze duration"	Duration of (1), (2) or (3)	Assessment of time period between a gaze movement towards the partner and a further movement away from the partner (see (4))

TABLE 1—*contd*

Term	Concept	Operation
6 "Omission of gaze" *or* "unreciprocated gaze"	One partner does not look at the other	Assessed as in (1)
7 "Gaze avoidance" *or* "gaze aversion" *or* "cut-off"	A person avoids looking at the partner especially if being looked at, *and/or* moves the gaze away from the partner; distinguished from (6) by the presence of "intent". (In this case, (2) and (3) rarely or never occur)	Assessed as in (1) or (4)
8 "Mutual gaze avoidance" *or* "mutual gaze aversion" *or* "mutual cut-off"	Both partners avoid looking at the other	Assessed as in (1) or (4)

2 The accuracy of gaze assessment

2.1 METHODOLOGY

2.1.1 *Aspects of accuracy*

In discussing the accuracy of gaze assessment, it is important to distinguish between objectivity, that is inter-rater reliability of observation, and validity of judgement. Information on inter-rater reliability, that is the agreement of different observers on a judgement, is necessary but, as will be discussed later, is not sufficient for evaluating the accuracy of gaze assessment. Information about the objectivity of gaze assessment is only available in studies in which observers register the gaze behaviour. As far as recipients of gaze signals are concerned, such independent information cannot be obtained.

The assessment of judgement validity, that is the correspondence between signals which have been sent and received, is possible only in experiments in which the sent signals can be controlled. Validity is a necessary criterion in establishing the accuracy of gaze assessment.

2.1.2 *Variables*

Independent variables of spatial arrangement which are of relevance in the assessment of gaze behaviour are commonly as follows: (a) the *distance* between sender and recipient; (b) the *distance* between sender and observer; (c) the *angles* between sender–recipient and sender–observer. Independent variables of gaze behaviour usually are as follows: (a) the *gaze duration* (generally a relatively fixed temporal interval between 3 and 5 seconds); (b) the *gaze direction* (the fixation points selected); (c) the *head position* of the sender.

Usually the subject or observer is asked to give his judgement according to the criteria mentioned below. These criteria differ in their theoretical implications and in the degree of differentiation required for the judgement, and lead to diverse consequences for the subsequent statistical analysis and its interpretation.

2.1.3 *Criteria*

We assume that in judgement of gaze direction there is a continuum of possible gaze directions, judged by describing the points fixated at various times. Through statistical analysis information can be obtained about the degree and direction of misjudgements. Conclusions can then be made regarding the perception of gaze behaviour in general.

In most experimental situations used in assessing judgement ability, the recipient is asked to look constantly at the eye region of the sender. "One-sided gaze" and "mutual gaze" can in this case be considered operationally identical. In the case of judged "eye-contact" or "one-sided gaze" (sometimes identified in experiments as "positive reaction" or "face reaction") the judgement dimension is dichotomized while the signal dimension remains continuous. This operation is based on the assumption that only the presence or absence of eye-contact or one-sided gaze is relevant in interaction. The statistical analysis generally takes into account the distribution of positive reactions at the different fixation points. Assertions can be made about perception of eye-contact or one-sided gaze, that is the perception of a specific aspect of gaze behaviour.

2.1.4 *Experimental paradigms*

Studies on gaze behaviour are generally concerned with dyadic situations. The dyadic situation provides the best possibility for the control of the input signals. A characteristic experimental set-up usually shows the following features (cf. Fig. 1). The sender of gaze signals looks at

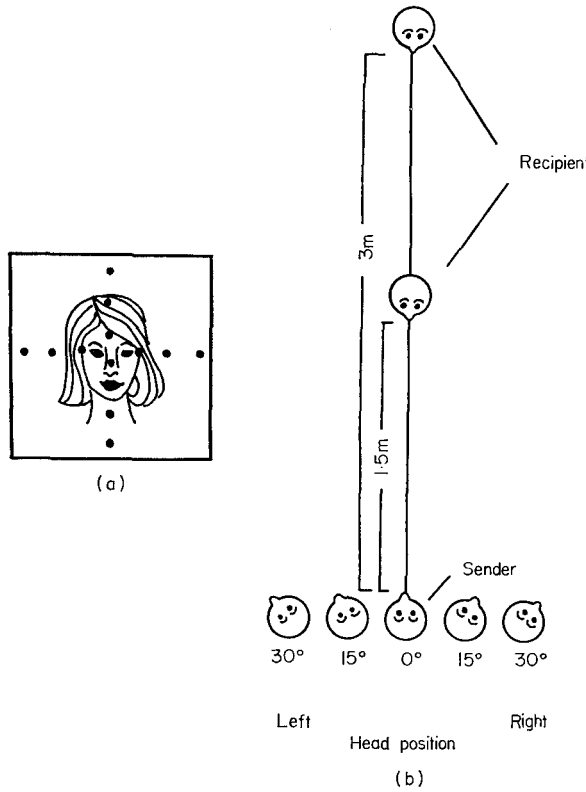

Fig. 1. Features of a typical experimental set-up for the assessment of recognition of gaze direction under different conditions.

(a) Typical distribution of target points.
(b) Schema of typical experimental arrangements.

points within or beyond the face of the recipient according to a previously determined random succession. The recipient and/or differently placed observers make their judgements. In some studies the gaze behaviour of the sender is oriented to a board with target points on it (Cline, 1967). In experiments with such a set-up the most important input variable, that is gaze direction, is controlled by instruction to the sender. In this way it is possible to make assertions about the validity of gaze recognition. The paradigm has been limited to a dyad of sender and recipient. An extension to several recipients by suitably controlling the behaviour of the sender is possible, but until now this has not been attempted.

The paradigm, however, is artificial, because it presumes a single direction of communication. The sender's signal must be decoded by the recipient. It is impossible for the recipient to address the other in turn with dialogic signals. No attention is paid to the fact that in real interaction the distinction between sender's and recipient's functions is difficult, if not impossible, for the investigator to make, as both partners are acting simultaneously as sender and recipient. Also, all additional contextual signals of a natural interaction are missing. The presence of earphones and the temporal succession of gaze signals determined in advance also contribute to the artificiality of these experiments.

In much of the remaining discussion we make no distinction between recipient and observer with reference to the accuracy of gaze signal assessment. This is justified because the conditions for the observer grow more and more similar to those for the recipient when the fixation points are at a greater distance from the face. The situation of the observer differs from that of the recipient because the conditions for perception are less favourable for the observer. In the most favourable case the observer is placed just left or right behind the recipient, necessarily further from the sender. Depending on the position of the observer, the accuracy of his observation will therefore be less than that for the recipient of gaze signals. However, the assumed gradual similarity between recipient and observer refers only to accuracy of gaze assessment in experiments made according to the above paradigm. In real interactions, with their associated contextual factors, a clear distinction must be drawn between recipient and observer judgements.

2.2 INTER-OBSERVER RELIABILITY OR OBJECTIVITY

The objectivity of gaze behaviour assessment is reported sometimes in percentage values and sometimes in correlation coefficients. The data reported for the assessment of eye-contact or one-sided gaze range from 66 per cent (Vine, 1971) to 98 per cent (Exline *et al.*, 1965). Intercorrelations range from 0.50 (Mehrabian and Williams, 1969) to 0.98 (Exline, 1963). The evaluation of these figures is difficult: different criteria are used for the variables assessed; sometimes these are not clearly described; and they are sometimes missing. For example, Strongman and Champness (1968) report 95 per cent observers' agreement on registration of eye-contact although they do not provide more information. Generally, as was suggested above, the concepts "eye-

contact" and "one-sided gaze" are not differentiated in objectivity or validity experiments; one-sided gaze is most frequently registered as eye-contact.

The effect of differentially strict criteria in the evaluation of agreement level between observers has been shown by Vine (1971) through observations of filmed interactions. He found an appreciable increase in the inter-rater reliability while registering the eye-contact, when, instead of his strict criterion of $t<0.25$ s, Exline's criterion (1963) of $t<2.0$ s discrepancy in the observer's judgements of the timing of senders' gazes was used. Different situations and conditions of observation may also influence the inter-observer reliability. With observations from video-tape recordings, Mehrabian and Williams (1969) obtained the lowest agreement between observers ($r=0.50$) for eye-contact as compared with other categories of non-verbal behaviour. It is probable that film and video tape recordings do not offer optimal possibilities for the observation of these variables; the detection of agreement between observers working *independently* is, however, possible. In simultaneous direct observation of several persons during interaction, a further factor may influence the level of inter-rater reliability: in judging whether an eye-contact occurs, the observers can form shared strategies. Stephenson and Rutter (1970) showed that naïve observers in groups formed shared strategies, which were, however, different for the separate groups of observers. It is obvious that training observers together under similar conditions can lead to a high although not necessarily valid agreement. Presumably the frequently reported high inter-observer reliabilities are obtained partly because of these shared strategies after training (Vine, 1971).

Information on the objectivity of the agreement of several observers can obviously give only a very rough estimate of the accuracy of observation and therefore the possibility of observing gaze behaviour. More detailed results on the accuracy achieved in the observation of gaze behaviour can be expected from studies on validity in which the behaviour of the senders' is itself controlled.

2.3 VALIDITY

2.3.1 *Differentiation within the face*

Whether or not different visual target points within the face, and including eye-contact, can be differentiated has been studied in a

preliminary experiment by Krüger and Hückstedt (1969) and also by Ellgring (1970). In both cases the senders, at a distance of 80 or 200 cm, looked, in a random order, at 7 points of the eye region: forehead, bridge of the nose, tip of the nose, right and left eye, right and left face edge (on the axis of the eyes). The recipients were instructed to report which point the sender was fixating. Krüger and Hückstedt (1969) found in two sender–recipient couples 35 per cent correct judgements for the eye region at a distance of 80 cm and 10 per cent correct judgements at a distance of 200 cm.

With a homogeneous group of 17- and 18-year-old school-girls ($N=16$) Ellgring detected higher values: 41 per cent and 49 per cent correct judgements at a distance of 80 cm, 21 per cent and 29 per cent correct judgements at a distance of 200 cm, for the right and left eye respectively. These values fall above random expectation. Direct gazes at the eyes were no better assessed than were gazes towards other points within the face (Fig. 2).

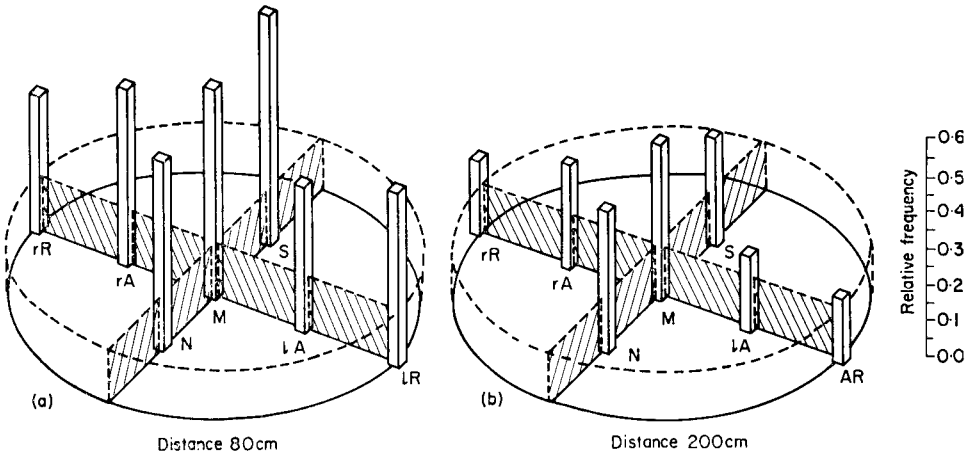

Fig. 2. The differentiation of directions of gaze to points within the face. Frequency of correct judgements are relative to the frequency of the senders' gazes to the different target-points. (From Ellgring, 1970.)

Target points:

S Forehead	rA right eye
M Middle (bridge of the nose)	lA left eye
N Nose	rR right border of face
	lR left border of face

The second level (– –, cross-hatched) correspends to a frequency of 14.3 per cent (chance frequency).

However, responses were given with different frequencies for the various fixation points (which were fixated with equal frequencies). It is therefore concluded that the probabilities for the naming of each fixation point are not equal. Relating the number of correct responses to the total number of times a point was selected by the recipient, the resulting fraction reflects the bias associated with each point. Comparing the above scores with the corresponding scores obtained by relating the number of correct judgements to the total number of fixations, only small differences are evident for the points in the eye region. It can be seen in Fig. 3 that gazes towards the more rarely mentioned edge points are more often correctly assessed.

It is probable that the recipient tends to name the eyes when unsure of the fixation. The recipient only names less favoured points when convinced of the accuracy of his judgement.

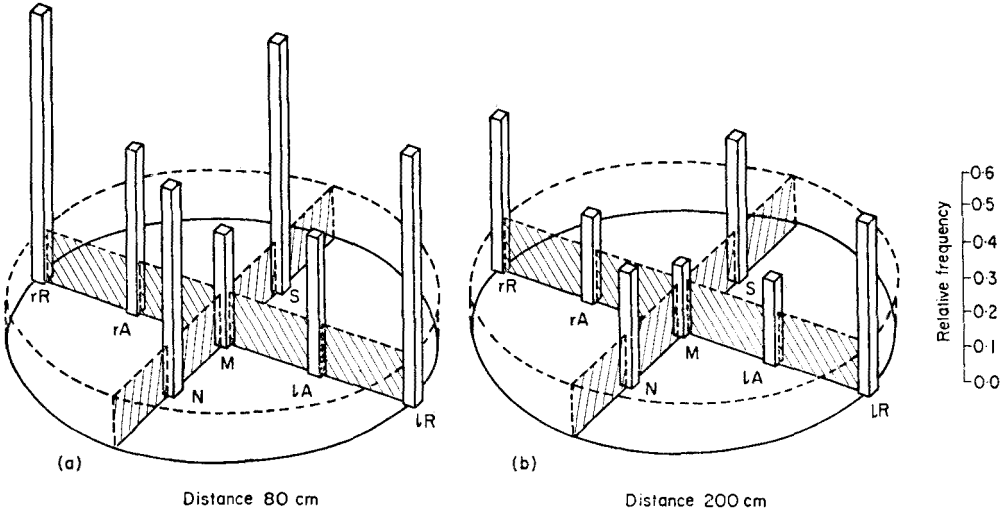

Fig. 3. The differentiation of directions of gaze to points within the face. Frequency of correct judgements relative to the frequency of the receivers' naming of the different target points. (From Ellgring, 1970.)

Target points:

S Forehead	rA right eye
M Middle (bridge of the nose)	lA left eye
N Nose	rR right border of face
	lR left border of face

The second level (– –, cross-hatched) corresponds to a frequency of 14.3 per cent (chance frequency).

The influence of distance between subjects on the recognition of gaze direction by observers is emphasized by the results of Stephenson and Rutter (1970). They found that with increasing distance (61 cm, 182 cm, and 305 cm), eye-contact is more frequently reported and that gazes, especially at the ear or shoulder, are increasingly recorded as eye-contact. They conclude that "work on eye-contact using observers behind one-way screens is of dubious value" (p. 392).

In spite of the evident difficulty in assessing eye-contact in normal interactions, participants are generally convinced of the presence of eye-contact. It is likely that additional signals other than the looking behaviour alone are operating (e.g. head position or other context factors). The more easily perceptible one-sided gaze to the face in general is probably sufficient for the subjective conviction that eye-contact is present. On the other hand, the possibly high probability of a gaze directed towards a partner during natural interaction actually being an eye-gaze cannot be dismissed. In the latter case, errors would only infrequently occur when judging a gaze towards the face as eye-contact (Argyle, 1970). However, this argument can only be supported by subjective evidence of observers and is circular in nature. A method for objective and accurate assessment of looking behaviour in natural interaction without observer errors is needed for the resolution of this problem.

To summarize, the results of the assessment of eye-contact show that even under the most favourable conditions eye-contact cannot be registered reliably by the receiver and/or observer. It is impossible for the recipient of gaze signals to distinguish between eye-contact and one-sided gaze at the general area surrounding the eyes.

2.3.2 *Gaze at the face*

In most publications, as in those of Gibson and Pick (1963) and Cline (1967), fixation of the bridge of the nose is considered eye-contact. However, in the way defined above, this is not eye contact but just a one-sided gaze towards the face. In references to eye-contact recognition the paper of Gibson and Pick is most commonly referred to. Their conclusion, "The ability to read the eyes seems to be as good as the ability to read fine print on an acuity-chart . . ." (p. 394), is used to justify the suitability of the variable "eye-contact". We will therefore discuss this paper in more detail. The main critical arguments apply to Cline's (1967) work as well; he repeated the experiment of Gibson

and Pick with more elaborate variation of the sender–receiver conditions.

In the Gibson and Pick experiment a sender and six recipients of gaze signals were utilized. At a distance of 200 cm, the recipients judged whether they were looked at. The seven fixation points lay horizontally at intervals of 10 cm along the eye axis with the bridge of the nose as the mid-point. The head positions of the sender were as follows: pointing straight ahead, 30° to the right and to the left. Each point was fixated 25 times in the three head positions. To measure the accuracy of assessment, standard deviations of the three frequency distributions were used. On the basis of the equally high standard deviations, corresponding to 8–9 cm deviation from the mean of the distributions and to an angle of 2.8°, the authors concluded "that accuracy for the perception of gaze is independent of head pointing" (p. 391). Because of the constant errors (shifting of distributions in the direction of head pointing), however, they state that "evidently the perception of eye pointing is somewhat influenced by the perception of head pointing" (p. 391).

For at least three reasons the standard deviation is not in fact sufficient for measuring the accuracy of judgements.

1. The standard deviation provides no information about the mean. However, for the 30° head-turn conditions, the means differ by one unit (10 cm) in the direction of the head-turn and away from the central fixation point (the bridge of the nose). This means that the most frequent judgements in the turned-head conditions were wrong.
2. The standard deviation covers the area in which 64 per cent of the cases occur. But even within this area a considerable proportion of mistakes is included.
3. Extreme values are strongly weighted by the squaring procedure. The possibility cannot be excluded that the wrong positive reactions may consist of different types of errors. When the fixation point is close to the bridge of the nose, the mistakes may be due to the limited resolving power of the eyes. If the fixation point is more distant (20 cm or further) and false positive reactions are reported, then lack of attention or carelessness (as it occurs in vigilance tasks) might be the causal factor. This type of error is given a stronger weight if dispersion measures such as standard deviation are used. This weighting cannot be justified by the theory.

Information about the accuracy of gaze recognition by percentage of correct versus wrong responses for the different fixation points seems to be more adequate in this case. A re-examination of their data then shows the following results: Gazes at the bridge of the nose (the face) are correctly perceived in 84 per cent of the cases when head position is straight. However, 40 per cent (left) and 36 per cent (right) of fixations directed 10 cm out from the bridge of the nose, that is outside the face, are judged as glances at the face as well. When head position is turned to the right or left by 30°, only 52 per cent (right) and 36 per cent (left) of the glances at the face are judged correctly. There is an increase in face reactions for fixations at points 10 cm out from the bridge of the nose, in the direction of the head position: 56 per cent (right point, head to the right) and 68 per cent (left point, head to the left) of these gazes are judged as being directed to the face. For the corresponding fixation points opposite to the head turning, however, only 12 per cent (left lateral point, head turning to the right) and 8 per cent (right lateral point, head turning to the left) of the fixations are judged incorrectly as glances at the face. Here, the results for only three out of seven fixation points are reported. But the general trend holds for the others too, except that percentage of wrong face reactions decreases for points more distant from the bridge of the nose.

What conclusions are to be drawn from the data? We suggest the following:

1. The high proportion of incorrect as well as correct positive responses suggests a general reaction tendency towards "feeling that one is being looked at".
2. The head position has a strong influence on the perception of gaze behaviour. Gibson and Pick themselves draw attention to this; their emphasis on the "ability to read the eyes" (p. 394) is therefore all the more astonishing.
3. By reason of the considerable number of errors which occurred, it is difficult to understand the conclusion of this paper that gaze perception is not problematic and that the variable "eye-contact" can be assessed with satisfactory accuracy.

Cline (1967) repeated the experiment by Gibson and Pick with a more refined experimental set-up. His recipients observed the reflection of the sender, who fixated points located around the head of the recipient. One involved fixating the bridge of the nose as a central point. In all

experiments, the deviations of the fixation points from the central point were between 4° (8.5 cm) and 12° (25.9 cm), with a distance of 122 cm between sender and recipient. In one condition the head position was varied (straight ahead versus turned to the right by 30°). The standard deviation of the frequency distribution of judgements over each fixation point was taken as a threshold and the mean discrepancy as a constant error. Cline's results correspond approximately to those of Gibson and Pick. Constant errors in the sense of an over-estimation of the deviation from the central point, which was higher for vertical deviations than for horizontal ones, were noticed. The constant errors were, however, not discussed in relation to assessment accuracy as was the case in Gibson and Pick's paper. As for Gibson and Pick, an influence of the head position on perception of gaze direction was noticed: "Head position and eye position interact to produce a perceived direction which falls between these positions." (p. 50.) When eye and head pointed in the same direction, a rather small constant error was obtained. When the head was straight ahead and the eye position was varied, the eye direction determined the constant discrepancy. With reference to the one-sided gaze, Cline states: "Accuracy for being looked at is quite high, and accuracy for other lines of regard are somewhat lower." (p. 50.) It is important to remember this limitation in the studies of Gibson and Pick and of Cline. These studies focus on the one-sided gaze and not on eye-contact, that is the gaze from eye to eye. (Also see note, p. 442.)

Anstis, Mayhew and Morley (1969) examined the recognition of gaze directions using senders, their television images, and a diaphragm (artificial eye), at a distance of 84 cm. The recipients judged the gaze direction as projected on a scale lying 6 cm above and 42 cm away from the eye level. Results showed that under all three conditions the mean of assessment of gazes towards the bridge of the nose corresponded to the actual gaze direction. Five degree to 20 degree gaze angles were over-estimated in the same direction as the gaze. Turning the head, and similarly the diaphragm, showed constant errors (which were much stronger for the diaphragm). Unfortunately, information on the range of judgements is lacking. The authors conclude that gaze direction assessment is mainly determined by the position of the pupil in the visible part of the eye. The small distance between the signal sources and the recipients only allow us to draw limited conclusions with respect to normal interaction; at a greater distance, less favourable visibility conditions need to be taken into consideration.

In two experiments, Krüger and Hückstedt (1969) examined the conditions in which recipient and observer consider the gaze of the sender to be directed at the recipient's face (one-sided gaze). Fixation points were the bridge of the nose and three points at intervals of 6, 16, and 26 cm in a vertical (experiment 1) or a horizontal direction (experiment 2). The head position of the sender was varied as follows: straight ahead, 20° (experiment 1) and 25° (experiment 2) to the left and to the right. In experiment 1, the gaze duration was varied between one second and three seconds. The observer was placed at an angle of 90° or 42° to the sender–receiver axis at a distance of 150 cm or 300 cm from the central point of the axis. The recipients and observers judged whether the senders looked at them. Two female senders, recipients, and observers took part in experiment 1, and 10 female senders, recipients and observers in experiment 2. The results show that at a distance of 300 cm a one-sided gaze is more frequently perceived as such than at a distance of 150 cm. Similarly, the number of misjudgements increases considerably; gazes at points outside the face are more frequently considered to be one-sided gazes. If the gaze duration is longer (experiment 1), a slight tendency towards more frequent "face" judgements is shown.

The head position influenced gaze perception since the recipients more frequently considered gazes oriented in the direction of the head position to be one-sided gazes. Therefore misjudgements were encountered more frequently. Generally, the observers discriminated much worse than did the recipients. A certain differentiation between the particular gaze directions was evident, but the proportion of correct judgements was small. The head position of the sender with regard to the recipient's position had a strong influence on the observer's judgement. When the head position of the sender was straight, twice as many face judgements were registered as with a lateral head position. Moving the head by 25°, the frequency of judging lateral targets as being fixated changed in favour of the direction of head turning. If the observer was at a right angle to the sender–receiver axis, a one-sided gaze was more often registered than if the angle was 42°. When the sender turned his head towards the observer, a one-sided gaze at the recipient was very rarely registered by the observer. The personality characteristic of extraversion (see Brengelmann and Brengelmann, 1960) had an influence on the behaviour of the observer, in that observers with high values of extraversion perceived more gazes

to be orientated towards the face than do observers with lower values of extraversion.

Thus, the judgement of the one-sided gaze is not based on gaze direction only, but depending on the conditions for perception is strongly influenced by the distance between sender and recipient, the head position of the sender, the position of the observer (all location conditions), and also by personality characteristics. When the conditions for perception are not favourable, the influence of the gaze direction itself becomes weak compared with the above mentioned factors.

In the papers mentioned so far, the recognition of the gaze direction of the resting eye was sought. However, in normal interaction gaze and head movements can function as additional signals. The influence of these factors on the recognition of eye direction has been studied in several experiments by von Cranach, Hückstedt, Schmid and Vogel.[1]

The first of these experiments was similar to that of Krüger and Hückstedt; the same persons participated in the experiment. A distance of 150 cm between sender and recipient was selected. The fixation points were located on the eye axis, 6, 16 and 26 cm left and right of the bridge of the recipient's nose. For each fixation the senders gazed at one starting point and then looked to one of the fixation points, according to instructions given through earphones. In one session, the sender performed 780 fixations moving from each target point to all other target points, with five repetitions of each movement in random order. The fixations lasted 3 seconds. The recipients judged whether or not they were looked at. The experiment was repeated three times; in experiments 1 and 3 the tone signal announcing the fixation was suppressed, and in experiment 3 two observers sat on the left and right behind the recipient. The distribution of the "face" judgements was compared with that in the Krüger and Hückstedt (1969) experiment carried out under the same conditions (see Fig. 4).

No improvement in the discrimination performance was obtained as a result of additional gaze-turning. Increased face judgements were noticed, mainly with the outer fixation points. The additional gaze movement leads to the effect that people feel looked at more often. The increasing response tendency for the outer points is found mainly when a gaze movement in the direction of the face has taken place. With the observers this effect is much less evident. When the gaze is directed towards their standpoint, rather more face judgements are noticed.

[1] Unpublished experiments, Max-Planck-Institut für Psychiatrie, Munich, 1968.

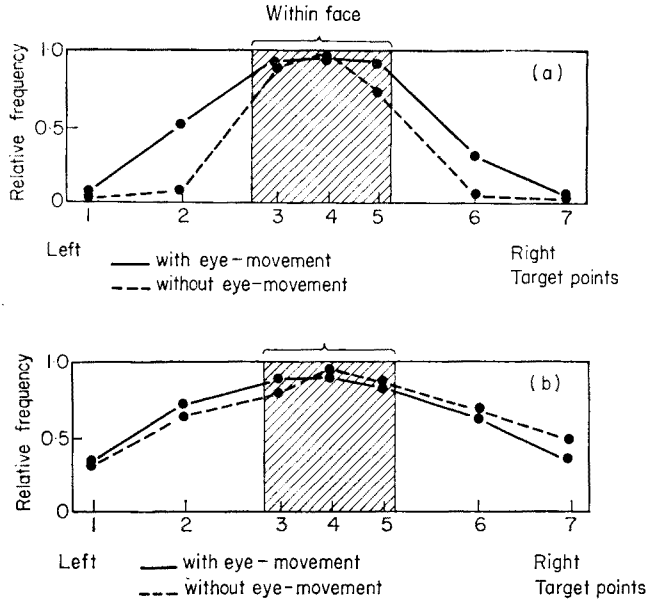

Fig. 4. (a) Relative frequency of the face reaction of the recipients. (b) Relative frequency of the face reaction of the observers.

When it is directed away from the observer fewer face judgements are given than without gaze turning.

These results show that gaze direction and gaze movement are to be considered independent factors in gaze recognition. An interaction effect of these factors in the sense of creating a stimulus configuration should have resulted in an improved discrimination; this, however, was not the case for the results observed.

In a continuation of this experiment the interaction between gaze direction and head position and head movement was examined under two distance conditions. Efforts were made to approximate "natural" behaviour in interactions. It was assumed that, depending on the distance between sender and recipient, the judgements of the recipients are based on a shared effect of these factors: gaze direction, head movement, and the sender's head position following this movement. Here, the distance between sender and recipient was 150 cm or 300 cm. The observer was placed 150 cm away at right-angles to the centre of the sender–recipient axis, which yields a distance to the sender of 168 cm or 212 cm. The subject looked at one of the seven fixation points on the

eye-axis of the recipient. The fixation points were located symmetrically at a distance of 5.5 cm, 16 cm and 26 cm from the bridge of the nose (itself a fixation point). The head assumed five positions with 0°, ±15° and ±30° angles to the sender–recipient axis, with head movements between these positions. The sender was given instructions as to the fixation point and the head movements via earphones.

The list of stimuli consisted of all combinations of the 20 possible head movements with the 42 possible gaze movements in a random order (840 instructions, in which each point was fixated six times). The recipients and observers indicated by pressing a button when they felt the sender's gaze to be orientated towards the recipient's face. Under all conditions more than chance numbers of correct distinctions were made between one-sided gaze and omission of gaze, when judgements on the three facial points (bridge of the nose, right and left edge of the face) were regarded as correct (see Fig. 5). Despite the statistical significance achieved, Fig. 6 shows that the observers misjudged a considerable proportion of the gazes.

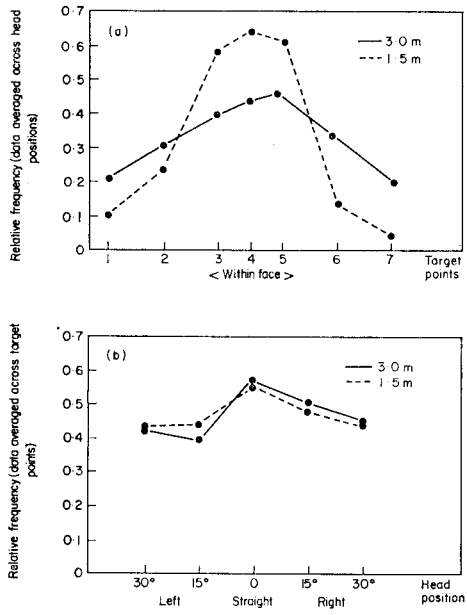

Fig. 5. Relative frequency of face reaction of recipients: (a) in relation to target points; (b) in relation to head position.

The influences of gaze direction and head position are different for recipients and observers. With the recipients the influence of "gaze direction" prevails. At a greater distance the head position becomes

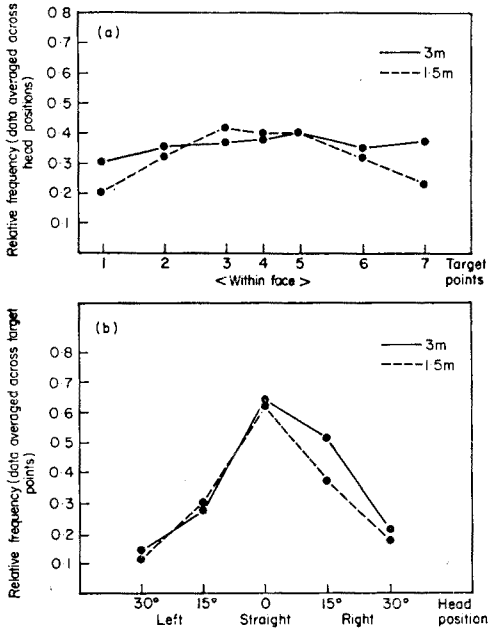

Fig. 6. Relative frequency of face reaction of observers: (a) in relation to target points; (b) in relation to head position.

more important in the assessment of the one-sided gaze, while the relevance of gaze direction decreases; the greater distance leads to more frequent positive judgements. Under both conditions, due to the unfavourable location of the observers, their judgement, even at a short distance, is determined to a great extent by the head direction. Therefore face judgements occur more frequently when the sender's head is straight or only slightly turned or when turning of the head into a straight position has preceded this. With the recipients, the greater distance from the sender leads to more frequent "face" judgements. Generally, under unfavourable perceptual conditions the importance of gaze behaviour in assessing the one-sided gaze, compared with other factors, especially the position of the head, decreases appreciably.

2.4 THE IMPROVEMENT OF GAZE RECOGNITION BY TRAINING

According to the above experiments, assessment of eye contact and one-sided gaze is, to say the least, problematic. To achieve greater accuracy of judgement, two procedures are possible. First, after a thorough study of the factors influencing the judgements of both observers and recipients, they can be informed about the possible sources of errors. Secondly, the extent to which the recognition of gaze signals can be positively influenced by learning procedures can be investigated. Mention of the importance of learning factors in the recognition of gaze signals is found in an unpublished study by von Cranach *et al.* Recipients who were first tested at the experimental distance of 300 cm from the sender then showed, at a distance of 150 cm, a slight tendency towards better discrimination of gaze direction itself and less dependence on the sender's head position than persons who had this distance as their starting condition. It should be noted that the subject did not receive any explicit feedback about the correctness of his judgement. After questioning the receivers, it seemed possible that their improved performance might be attributed to an increase in motivation, resulting from the improvement in conditions of perception between the first and second conditions.

To date, we are aware of only one experiment in which the subjects were given explicit feedback: Ellgring and von Cranach (1972) used a standard situation for gaze behaviour recognition, with the difference that, after each judgement, the point actually fixated was communicated to the participants. Senders and recipients sat facing each other at a distance of 300 cm. Outside the face of the receiver four fixation points were marked on the eye-axis at a distance of 20 cm and 40 cm horizontally to either side of the bridge of the nose (points 2, 1; 4, 5; and 3). Above the head of the sender was fixed a row of five small numbered lamps, which corresponded to the fixation points. The sender fixated for 2.5–3 seconds on each different point according to a formerly determined random order; each point was fixated 50 times in the experiment. On hearing a buzzing sound the recipient ($N=10$) decided which point the sender was fixating. The sender then gave the feedback specifying the point he was fixating, and the corresponding lamp on the ledge above his head flashed to give a more specific orientation.

With all subjects, a general learning effect in the direction of better discrimination of gaze signals (see Fig. 7) was evident. The effect, how-

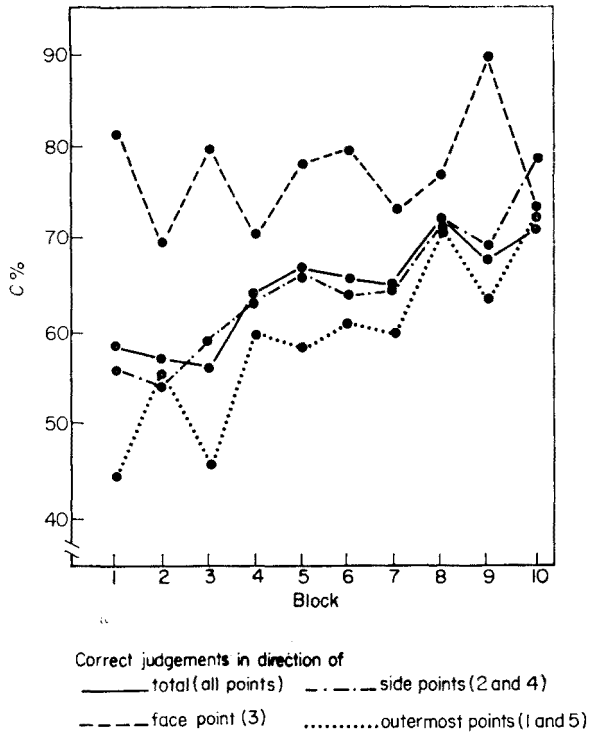

Fig. 7. Correct judgements. Relative frequencies ($C\%$) averaged for different fixation points. $N=10$, Block $=50$ fixations.

ever, differed for the various fixation points. The learning effect increased with the distance between fixation points and bridge of the nose, while no clear trend was noticed in fixations of the bridge of the nose. In addition, the direction of errors changed during the learning experiment. For the analysis of this question only the lateral points 2 and 4 were taken into account. At the beginning, misjudgements in the direction of the face occurred more frequently; this type of error decreased continuously, approaching the frequency of errors in which fixations of the lateral points inside the face are perceived as fixation of the points outside the face (see Fig. 8).

This shows that a more accurate discrimination can be achieved through explicit feedback. This improvement in accuracy does, however, not occur for gazes orientated directly towards the face. We might assume that this discrimination has been over-learned in ontogenesis (see Vine, Chapter 5). For the points further from the face the condi-

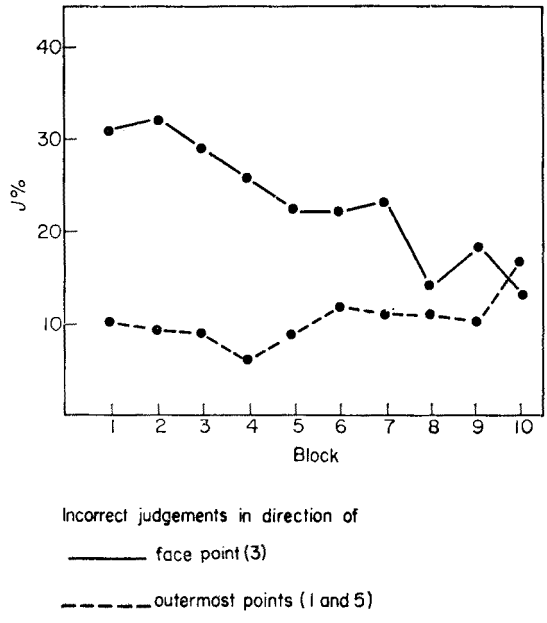

Fig. 8. Incorrect judgements when targets are side points (2 and 4). Relative frequencies ($\mathcal{J}\%$).

tions for perception are similar for receiver and observer. It is therefore to be expected that after a relatively short training period (the experiment lasted 45 minutes), a considerable improvement of the discrimination performance of observers might be achieved.

3 Discussion

Let us now consider the consequences of the findings we have reviewed for the use of gaze variables in empirical investigations.

All the studies considered imply an experimental paradigm that contains, as an essential element, a sender who distributes his gazes on and around the recipients' eyes and face. In a strict sense, the validity of the findings is restricted to this very kind of behaviour. In natural communication, should the sender behave differently (looking dichotomously either at the recipients' eyes or distinctly away from his face, as Argyle, 1970, and Vine, 1971, have argued), the above results would not apply. To our knowledge, however, no independent data exist on the true distribution of sender gazes in social situations. Possibly this data

would be difficult to obtain, even using a modern eye-camera. In the meantime, the burden of proof of validity rests with those who use the variable.

It should also be pointed out that the assessment of vertical variations of gaze direction has not been sufficiently studied, although vertical gaze movement may carry considerable information in natural interaction.

Probably the most striking aspect of the empirical results is that it seems hardly justified to talk about a variable of "eye-contact" in the sense of a "mutual meeting of gazes, and being aware of the event". Objectively, the partner's gaze into the eyes cannot be accurately recognized, and it is no better recognized than the gaze at other points of the face. Thus it seems justified to replace this concept by the "mutual gaze". Subjectively, of course, "eye-contact" remains of importance.

But the assessment of the mutual and the one-sided gaze also turns out to be a difficult matter. With our few studies, using mainly one paradigm, a number of factors could be identified such as gaze movement, head direction, head movement, distance, duration and personality variables that impair the judgement of the receiver. The interaction of these factors is only partly clarified in that, especially for the observer, additional factors may influence the observations. The observer's judgement is further impaired by his location. Under some conditions its variance is almost completely determined by other factors than gaze direction. For this reason, the validity of the observer's judgement depends predominantly on the experimenter's choice of specific observational circumstances. Any experimenter would be wise to test his observer's accuracy of discrimination (the validity of their judgements); testing objectivity alone seems insufficient. It might be useful to redefine the variable, namely from "one-sided or mutual-gaze" towards a less specific term like "orientation". Finally, the possibility of improving the receiver's and observer's judgement by training, a simple and economic but as yet more or less unused device, should be stressed.

Considering these findings, we may try to achieve a better understanding of gaze communication in general (von Cranach, 1971a, 1971b). It is clear that the feeling of being looked in the eye or the face is a subjective experience embodying the decoded meaning of varying perceived signals, the specific patterns of which depend on situational factors. Thus the sender will always exhibit a pattern of movements and positions of the body, head and eyes, which may, when looking at a human partner, be accompanied by specific additional movements,

such as eye blinks (von Cranach *et al.*, 1969), or eye-brow movements and smiles (Eibl-Eibesfeldt, 1967, pp. 410ff); while the recipient decodes only the sender's visual attention. Looking behaviour, its encoding and decoding, thus possesses its own syntax, and may therefore serve as an example of the properties of communicative behaviour in general.

Note

Vine (personal communication) recently drew our attention to an ambiguity in the published accounts of the constant error in perceived gaze direction when the sender's head is turned away from the recipient (cf. pp. 429–433). This ambiguity may be due to inconsistencies of terminology and description, but it appears that Cline (1967) may have found that perceived direction is *intermediate* between eye direction and head direction, whereas Anstis *et al.* (1969), Krüger and Hückstedt (1969), and apparently Gibson and Pick (1963), found that gaze deviation from the direction of head-turn was *over*-estimated rather than under-estimated. Although Cline's report is confusing (see Anstis *et al.*, p. 478; Vine, 1971, p. 323), a re-analysis of his data suggests there may be an actual conflict of results here. Further experiments are needed to discover whether procedural differences might be responsible.

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