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Eye contact perception at distances up to six meters

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AN ABSTRACT OF THE THESIS of Daniel L. Scarl for the Master of Science in Psychology presented May 20, 1985.

Title: Eye Contact Perception at Distances up to Six Meters.

APPROVED BY MEMBERS OF THE THESIS COMMITTEE:

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Common experience suggests that most people can tell whether they are being looked at by another person who is about 8 m away. However, the results of past experiments, which used distances of no more than about 3 m, have implied that this cannot be done if the person looked at (Receiver) judges only by the iris-sclera

configuration of the person looking (Sender). This is true even if eye contact is defined simply as identifying on-face gazes (FGs). It has been suggested that in everyday experience eye contact is accompanied by cues other than iris position, and that these non-iris-position (NIP) cues to Receiver account for recognition at longer distances. The hypotheses of the present experiment are that FGs can be identified at considerably more than 3 m, without NIP cues; and that this happens because as features of Sender's lower face fall within Receiver's central vision at longer distances, Receiver is able to use them for triangulating the position of Sender's irises.

Twenty-six men and 18 women acted as receivers with a male Sender at distances of 2, 3 $\frac{1}{3}$, 4 $\frac{2}{3}$, and 6 meters. It was expected that FG recognition at 6 m would occur, but would be hampered when Sender's lower face was masked. To detect the presence of NIP cues and to distinguish their effects from those of masking the lower face, a half-silvered mirror was at times placed in front of Receiver. Since Receiver was enclosed in a booth to darken his or her side of the mirror, he or she could see Sender clearly; but Sender's view of Receiver was blocked, so that he could not respond to the sight of Receiver returning his gaze by giving NIP cues to Receiver.

Accuracy of FG recognition was not significantly lower in the mask or mirror conditions than in the no mask or mirror condition, and was significantly above chance expectation in all

three. The use of a mask did not appreciably hinder FG recognition at 6 m, but did enhance it somewhat at 4 2/3 m. These results showed that FGs were recognized at 6 m, and that NIP cues were not a factor in the subjects' performance. It is suggested that masking enhanced performance at 4 2/3 m by eliminating distractions to using iris-sclera configuration, while at 6 m it left both of Sender's eyes visible and within central vision.

With female subejcts, it was found that high visual acuity aided FG recognition at 6 m when no mask was used. This is in accord with the contention that the high visual acuity of central vision enables the use of lower facial features as reference points for determining iris position. There was not enough variation in visual acuity among the male subjects to assess this effect.

EYE CONTACT PERCEPTION AT DISTANCES UP TO SIX METERS

by

DANIEL L. SCARL

A thesis submitted in partial fulfillment of the
requirements for the degree of

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TO THE OFFICE OF GRADUATE STUDIES AND RESEARCH:

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INTRODUCTION

"Without eye contact, people do not feel that they are fully in communication."

This quotation from Argyle and Dean (1965, p. 289) summarizes a great many comments on the function of eye contact, in both the humanities and in scientific literature. One of its implications is that in order to communicate fully with each other, the members of any group of two or more people must be close enough to each other for each person to know when they are being looked at by any other member. How close does this mean?

Common experience would suggest that it means within a distance of about eight to nine m, but experimental research has indicated a shorter distance. Just how much shorter depends on the definition of eye contact that is used.

By the strictest definition, eye contact consists of two people looking directly at each other's eyes, rather than anywhere else on each other's faces. To the best of my knowledge, studies of the discrimination of eye contact from gazes at other parts of the face have used distances of no more than two m between the gazer (Sender) and the person gazed at (Receiver). At this distance Ellgring (1970) found that no more than 29% of eye contact gazes were correctly identified, while the corresponding figure from an unpublished similar experiment by Kruger and Huckstedt

(cited in von Cranach & Ellgring, 1973) was only 10%. Lord and Haith (1974) used distances of 103 cm and 176 cm. Even at the closer distances, no more than 67.5% of gazes at the subject's eyes were correctly identified. Furthermore, these experiments reported sizable percentages of gazes directed at other parts of the face that were falsely identified as eye contact. Eye contact cannot be reliably distinguished from gazes directed near the eyes (Lord & Haith, 1974; von Cranach & Ellgring, 1973).

It may be said, however, that any gaze directed at a person's face constitutes looking at the person. Indeed, Yarbus (1967) showed that looking at a photograph of person usually involves fixating various parts of the face for about 1/3 second each, often with about as much time spent fixated on the mouth as on either eye. It seems, then, that the critical distinction is between gazes on the face and gazes directed off the face, even though, in a strict sense, this is not necessarily eye contact. Therefore I will define eye contact here as two people gazing at each other's faces.

According to a survey of literature on the recognition of gaze directions by von Cranach and Ellgring, the most commonly cited paper on recognition of eye contact--by either definition--is Gibson and Pick (1965) in which subjects were asked to distinguish between gazes (FGs) and off-face gazes. Because much of the present experiment replicates this work, I will describe it in some detail here. A Sender-Receiver distance of two meters

was used, and Sender gazed either at the bridge of Receiver's nose or at any of six other target spots, which were located 10, 20 and 30 cm to either side of the bridge of Receiver's nose. Sender's head was held either directly facing Receiver, or turned 30° to the right or left. When Sender's head was facing Receiver, about 84% of the FGs were correctly identified, and about 40% of the closest off-face gazes were reported as FGs. Accuracy was somewhat less when Sender's head was turned.

According to Gibson and Pick (1965), these results show that "The ability to read the eyes seems to be as good as the ability to read fine print on an acuity chart" (p. 394). Vine (1971) states that a number of later studies have assumed that eye contact discrimination is accurate on the basis of these results and those of a study by Cline (1967). Clearly, they do show FG identification to be more accurate than discrimination of eye gazes from other FGs. However, two meters is a rather short distance. After a thorough review of the literature, I have found only one FG recognition experiment which used a greater distance. This was an unpublished work by von Cranach et al (cited in von Cranach & Ellgring, 1973) using 1.5 m and 3 m. This spacing of target spots was wider than Gibson and Pick's, and the reported percentages of perceived FGs for the target spots were combined across five positions of Sender's head. Therefore no exact comparison between the two works is possible, but von Cranach's results at 3 m were considerably less accurate than his results at 1.5 m, and probably

less accurate than Gibson and Pick's.

Von Cranach (1971) has concluded that no appreciable accuracy is possible in detecting FGs from a sender much more than 10 feet (3.05 m) away, if one uses only the iris-sclera configuration of the sender's eyes. He does not deny that eye contact is often recognized over greater distances, but attributes this to the use of another person's head position as a signal that one is being looked at. Argyle and Cook (1976, p. 49) criticize that attribution on the grounds that "if we adopt this viewpoint, we would accept--virtually as an operational definition--that what looks like gaze to the target person is gaze." However, they offer no other explanations of how a person can distinguish FGs over distances at which, they agree, "... the eyes alone could not possibly be distinguished" (p. 49).

Along with iris position, such factors as head position and alterations in facial expression and body orientation comprise the visual cues that tell a person when he or she is being looked at. Iris position is unique among these in that in a given situation there is one and only one position that is truly associated with eye contact, and that endures precisely as long as eye contact endures. Non-iris-position cues (NIP cues), on the other hand, are indeterminate in consistency and duration, and some are indeterminate in number as well. (A behavioral definition of NIP cues will be given below). For instance, a person's eyebrows may often raise during eye contact, but not always remain raised until eye

contact is ended; and smiling often occurs, but varies in intensity. It is true that NIP cues can be qualified and used as experimental variables, as has been done with head position. Nonetheless, it seems most satisfactory to define the maximum distance at which eye contact can be identified as the greatest distance at which FGs can be discriminated when NIP cues are eliminated.

It might be concluded from the published literature that FG recognition over more than 3 m indeed depends entirely on NIP cues. However, there is at least one other possibility.

As distances increases, more of the image of Sender's face falls within Receiver's central vision. At illumination bright enough for its cone cells to function--i.e., bright enough for colors to be seen--the normal human eye produces the sharpest image at the very center of vision. The sharpness of an image η degrees away from the center of vision falls off as η increases. Assuming the acuity of center-most vision to be 1, the equation $\log_{10} \text{Acuity} = -.30(\log_{10} \eta) -.39$ fits data gathered from numerous past experiments (Le Grand, 1967, p. 139-140), providing that $\eta \leq 5^\circ$. (For values of η greater than 5° , changing the constant from $-.39$ to $+.18$ produces the proper equation.) The curve is shown in Figure 1. At some point along it, there must be a demarcation between what is seen sharply enough to be useful in a task such as FG recognition and what is not. Assuming that η at this threshold point is no more than $2^\circ 6'$, and assuming that Receiver is looking at one of Sender's eyes, then at a distance of 3 m or less

Figure 1

ACUITY

Visual acuity as a function of eccentricity η from visual center. The curve is logarithmic, but visual acuity is defined as equal to 1 at $\eta = 0$ (where, mathematically, it would be infinite). The point (50', .43) represents the fovea's boundary. X marks the lowest non-zero value of η for which experimental data has been obtained.

none of Sender's facial features other than one eye and one eyebrow will fall within Receiver's more accurate vision. As the distance increases, other facial features will be included. Receiver may then be able to locate the position of the iris in relation to these features--especially the nose, which is immobile regardless of facial expression. This illustrated in Figure 2 which, for reasons to be explained in the discussion, assumes the threshold to be the boundary of foveal vision, at $\eta = -.50'$.

Almost no work relevant to this hypothesis has been published to date. Cline (1967) tried covering the lower half of Sender's face, and found that it had no effect on FG detection; but he used a distance of only 122 cm, at which only a small area of Sender's face would be in Receiver's central vision. To the best of my knowledge, no other published work gives any indication of what parts of the face, other than the eyes, might be useful to FG recognition.

The present experiment was designed to test the hypothesis that a receiver uses the features of Sender's lower face in doing so. It did this by comparing the results of having Sender's face masked, and not masked, over a range of distances up to 6 m. In order to allow comparison of the present results with those of Gibson and Pick (1965), the shortest distance was 2 m, and a comparable set of gaze target spots was used.

The use of a mask as an independent variable raised the

Figure 2

Area within the foveal vision of a subject fixating Experimenter's right eye, at each distance. Relative size and spacing of the eyes, irises and nose is accurate to life.

A: 2 m

B: $3 \frac{1}{3}$ m

C: $4 \frac{2}{3}$ m

D: 6 m

possibility of a confounding variable, because covering facial features also hides any facial cues that Sender might be giving. In fact two past experiments (Lord, 1974; Lord & Haith, 1974) had their senders masked at all times precisely in order to eliminate NIP cues. Therefore if masking was to be used to test the usefulness of facial features themselves, some additional means had to be used to determine the effect of NIP cues. In order to show the validity of the device used for this, I must first discuss an aspect of what NIP cues are.

NIP cues may be defined as any behavior of Sender, other than eye movement, that occurs markedly more often when Sender looks at Receiver. Why is it that some behaviors occur only, or markedly more often, when looking at another person? There may be any number of specific reasons, for specific behaviors and situations; but seeing the other person's face is the common factor. Moreover, in the situation of a gaze recognition experiment with Receiver looking at Sender during gaze intervals, NIP cues are only those behaviors present as a function of Sender looking back at him or her. Thus NIP cues may be defined as those behaviors of Sender which are a function of visual interaction between Sender and Receiver. (This point can be made intuitively clear by considering that we would expect Sender to give more NIP cues--or at least have a harder time not giving them--if Receiver were to smile or otherwise visibly react when being gazed at by Sender.) All other features of Sender's appearance that may be visible to

Receiver-except iris position--are independent of the direction of Sender's gaze. Thus they are not NIP cues and may be considered as part of the normal, or baseline, appearance of Sender.

A way to separate the effects of NIP cues from the effects of covering facial features, then, is to interrupt the visual interaction between the two people, and compare the results obtained in that connection with those obtained when their interaction was not interrupted. This can be done by blocking Sender's view of Receiver, which was accomplished here by placing a half-silvered mirror just in front of Receiver, and having relatively little light on Receiver's side of it, during some of the trials. The mirror then left Sender clearly visible to Receiver, but Receiver's face was hidden from Sender. The visible interaction could not take place, nor could the NIP cues that were dependent upon it.

METHOD

SUBJECTS

Data was used from 44 subjects, consisting of 26 women and 18 men. They ranged in age from 18 years to 45 years, with one subject's age not recorded. The mean age was 26.1 years, median 23.5 years, and standard deviation 9.05 years.

A total of 69 subjects were recruited. Sixty five of these were in beginning level psychology classes at Portland State University, which offered extra credit for participation. The four others included three students who received extra credit at a nearby community college, and an undergraduate psychology major from Portland State University.

Although several pre-trial subjects had been run previously, some experimenter errors and equipment failures occurred while running the first few subjects. It also became apparent during that time that minor changes had to be made in the experimenter's actions. With one exception, to be explained under Procedure, these changes were made while the first 10 subjects were being run, and the data from these subjects was discarded. Five later subjects did not complete the procedure, and the results from 10 other subjects were discarded due to experimental error, subject error, ambiguous recorded responses, and defective vision in one

eye of one subject.

All subjects were tested with an eye chart (Graham-Field #2867-1261) with Snellen Print at a distance of 20 feet (6.1 m), and no one with poorer than 20/30 vision was used. The visual acuity rating of one subject was not recorded; of the remaining 43, 36 had 20/15 (the highest rating possible with the chart), three had 20/20, two had 20/25 and two had 20/30. Subjects who wore glasses for distance vision wore them both while using the eye chart and during the experiment.

Treatment of all subjects was in accord with the American Psychological Association's Ethical Principles in the Conduct of Research with Human Participants (1973).

EXPERIMENTER

The experimenter (Sender) for all subjects was myself: a 38 year-old man with a goatee and moustache, with grey-green irises of 13 mm diameter, eyes showing 27 mm of sclera horizontally and normally open to 8 mm vertically. However, it was found to be necessary for Experimenter to open his eyes wider than usual, in order that his eyebrows not cast shadow on his eyes. His eyes were then open 11 mm vertically. While running the first 10 subjects, he learned to do this consistently, by having the uppermost light bulbs of his chair apparatus just within peripheral vision. This assured uniform eye opening at all times under varying lighting conditions.

It became evident during the experiment that experimenter's right eye was somewhat dominant over his left eye, and that the left eye tended to wander under the strain of the intense lighting used in the mirror condition. This was minimized by limiting the number of subjects run each day, and by using non-prescription eye drops as needed.

The effects of experimenter bias on results have been well established (e.g., Rosenthal, 1966), and observer expectations have been shown to affect eye contact experimentation (White et al, 1970). In the present situation, the experimenter could not claim to be without expectations. Therefore care was taken to assure that he was not aware of the performance of any subjects until all subjects had been run. The device used to record responses was placed in a separate room, so that the somewhat different sounds that it made in recording YES and NO responses could not be heard by experimenter. No recorded responses were looked at until all data had been gathered.

APPARATUS AND MATERIALS

Subject's Apparatus

An armless chair of adjustable height was provided for subjects. In order that a half-silvered mirror act as a window for Subject and as a mirror for Experimenter, Subject's chair was enclosed by a 1.22 m square booth, shown in Appendix A. Its rear wall was formed by a wall of the room, and one of its sides was a curtain

that provided entry. Its front had a 46 cm wide by 94 cm high extension to provide leg room, and was fitted with a 30 cm square hole. The hole was alternately filled with a clear lucite window and a half-silvered mirror. (The mirror's silvering was damaged in two spots, but neither was near Subject's line of vision. All 69 subjects were asked whether these spots had distracted them in the experiment, and only one answered affirmatively.) A padded chin rest of adjustable height was mounted inside the booth at the center of the window/mirror's lower edge. About 30 cm to each side of it was a button switch, the one on the subject's right labelled YES and the other labelled NO.

As shown in appendix A, seven gaze target spots were marked on the outside front of the booth, on a horizontal line running through the center of the window/mirror. They were labelled 1 through 7, consecutively from left to right, by a numeral about 18 cm directly above each other. Target spot 4, located at the bridge of Subject's nose, was marked only by spots directly above and below it on the upper and lower edge of the mirror and window. It was the only target spot on Subject's face. Spots 3 and 5 were marked by dots on the mirror and window, and the remaining spots by dots on the front of the booth.

The gaze target spots were intended to replicate as closely as possible those of Gibson and Pick, but had to be placed just in front of Subject on the front of the booth. Gibson and Pick say that their target spots were "on the wall just behind O's

(Subject's) head" (p.391). Therefore the placement of the present experimenter's target spots was approximately 33 cm in front of those of the earlier experimenter, and the 10 cm spacing that Gibson and Pick used had to be compressed here to compensate for the spots being closer to Experimenter.

An 8.7 cm spacing would intersect the same visual angle in the present experiment as Gibson and Pick's had, at the 2 m distance that the earlier experiment had used. However, it would have intersected a much smaller visual angle at 6 m than would have a 10 cm spacing placed behind Subject. This would mean that the position of Experimenter's irises, while gazing at an off-face target spot, would be inordinately closer to their position while gazing at spot 4. It would therefore be harder for subjects to discriminate FGs at 6 m, even if they would have been able to do so using Gibson and Pick's original apparatus. On the other hand, a larger spacing of the target spots would make it easier for present subjects to discriminate FGs at 2 m than it was for Gibson and Pick's subjects.

The compromise decided upon was a spacing of 9.1 cm, which produced the same visual angles the Gibson and Pick apparatus would have produced at a distance of $3 \frac{1}{3}$ m--the second shortest distance used. Table I shows comparisons of the visual angles produced by the target spots with those produced by target spots with a 10 cm spacing but placed 33 cm further back, for the four distances used.

TABLE I

ANGLES OF VISION INTERSECTED BY THE DISTANCES BETWEEN TARGET SPOT 4 AND DESIGNATED TARGET SPOTS, AT EACH DISTANCE

Target Spots	Experi- menter	Distance			
		<u>2 m</u>	<u>3 1/3 m</u>	<u>4 2/3 m</u>	<u>6 m</u>
3, 5	Gibson & Pick [*]	2° 27'	1° 37'	1° 9'	54'
	Present ⁺	2° 36'	1° 34'	1° 7'	52'
2, 6	Gibson & Pick [*]	4° 54'	3° 8'	2° 18'	1° 49'
	Present ⁺	5° 12'	3° 8'	2° 14'	1° 44'
1, 7	Gibson & Pick [*]	7° 20'	4° 41'	3° 26'	2° 43'
	Present ⁺	7° 46'	4° 41'	3° 21'	2° 36'

* In Gibson & Pick, Target spots were 10 cm apart and placed behind Subject.

+In the present experiment, they were 9.1 cm apart and placed in front of Subject, which is assumed to be 33 cm in front of Gibson & Pick's placement.

Experimenter's Apparatus and Materials

The subject's view of Experimenter's apparatus is shown in Appendix E. Experimenter's chair was a wooden classroom desk chair fitted with a headrest. Attached to its front was a vertical piece of wood panelling, which hid all of the seated experimenter, except his head and neck, from the subject. In front of this was attached an inverted "A" constructed of two thin wooden beams and a cross brace, fastened to the panelling at its bottom and tipped forward at about 30° from vertical. The top of each beam supported two 200 watt incandescent bulbs and, just below them, a 300 watt incandescent bulb. Each cluster of bulbs was backed by aluminum foil spread over wire mesh, to reflect its light onto Experimenter's face and to shield it from Subject's vision.

These six bulbs provided all illumination for the experiment. The 300 watt bulbs were controlled by an on-off switch, and the 200 watt bulbs were controlled by a pair of rheostats wired in series. When the subject's booth was fitted with its mirror, all bulbs were on at full brightness. Approximately 230 foot-candles of illumination then fell on Experimenter's face, and approximately six foot-candles passed through the mirror to the subject. When the booth was fitted with the clear window, the 300 watt bulbs were turned off and the rheostats adjusted to a marked setting, so that the same amount of light reached the subject while approximately 54 foot-candles fell on Experimenter's face.

When Experimenter's apparatus was placed in positions further

away from Subject, less of its light reached Subject directly, but more was reflected off the far wall of the room. Therefore the amount of light reaching Subject remained fairly constant in the various positions, but the illumination of Experimenter's face relative to the illumination of the background decreased when Experimenter was further away.

The experimenter's chair was also fitted with an on-off switch controlling a tape cassette player, and a button switch similar to those in the subject's booth. All three button switches were wired to separate channels of an event recorder, which was located in another room.

The chair and all apparatus attached to it formed a unit that could easily be moved to any of four spots marked on the floor, directly in front of the subject. When the chair was at these spots, Experimenter's face was 2 m, 3 $\frac{1}{3}$ m, 4 $\frac{2}{3}$ m and 6 m from the subject's face.

The experimenter was supplied with 22 different schedules of 12 numbers, each number representing one of the target spots. These were randomly drawn up from the numbers 1 through 7, with the constraint that, on each schedule, the number 4 appear six times and each of the other numbers appear once.

Experimenter's mask was a standard white cotton surgical mask. Its strings were tied to rubber bands so that it could be slipped on and off quickly.

PROCEDURE

Appendix D is a copy of the complete instructions given to all subjects.

After being tested with the eye chart, each subject was seated in the booth. The chin rest was adjusted so that the subject's eyes were level with the target dots when viewed from Experimenter's chair, and the height of Subject's chair was adjusted for comfort. Subjects were told that Experimenter would be looking either directly at them or near their faces during gaze intervals, and instructed to press the YES button in the former case and the NO button in the latter. A portion was played of the cassette recording of the signals marking the approach of a gaze interval, its start, and its finish, and the signals' meanings were explained.

Three practic gaze intervals were done with the clear pane in the booth's window and Experimenter's face uncovered, then three more with the half-silvered mirror in place and Experimenter masked. Subjects were told that Experimenter would be unable to see them through the mirror, and were instructed to keep their heads upright and on the chin rest so that Experimenter would know where to look when looking at them.

After checking that Subject understood what to do, Experimenter then set up the mirror/no mirror--and mask/no mask conditions and Experimenter's chair distnace for the first trial. Each subject was run through the 16 combinations of conditions and distances (mirror/no mirror by mask/no mask by the four distances). The

sequence of combinations was varied between subjects, with 24 different sequences used. Subjects were given a block of 12 gaze intervals under each combination, for a total of 192 gaze intervals. Some subjects were given more (although only 192 would be used as data), when a gaze or an entire block had to be re-done for some reason. No data was used from any subject for whom more than two blocks had to be re-done.

Since changing between the mirror- and no mirror conditions and re-setting the lighting appropriately required at least half a minute, it was done only once with each subject, after half the trials had been completed. With the mirror or window in place, two blocks of 12 gaze intervals were given at each of the four Experimenter-Subject distances, one block with Experimenter masked and the other without mask. For the first block at a given distance Experimenter was masked, or not masked, in the same way that he had been for the last block of the preceding distance. When eight blocks had been given in this manner, the mirror was replaced by the window or the window replaced by the mirror, and the procedure repeated for eight more blocks.

The gaze interval signals consisted of a cassette tape recording of the following repeated sequence played on a recorder wind instrument: D above middle C for one second; one second of silence; C above middle C for $\frac{1}{2}$ second, marking the start of a gaze interval; $2\frac{1}{2}$ seconds silence; G above middle C for one second, marking the end of the gaze interval; five seconds silence.

Between gaze intervals, Experimenter would look down at his schedule until the first signal sounded. He then placed the back of his head on the headrest and gazed at a spot on his apparatus that was directly in front of him but below his line of sight to Subject. At the second signal he raised his gaze directly to the target spot specified by the schedule, and held it there until the third signal sounded. He then lowered his gaze, moved his head forward so as to see the schedule easily, and marked the latter by the number of the target spot which he had just used.

While running one subject, Experimenter found that while the mirror was in place he could often tell how the subject was responding. This was because that particular subject was responding before the end of the gaze interval, before Experimenter looked down, and did so by pressing a button hard enough to move the front of the booth. This caused the image that experimenter saw in the mirror to shift, in a direction determined by which button was pressed. In order to prevent a recurrence of such feedback, all subsequent subjects were instructed to not respond until the third tone sounded.

RESULTS

The dependent variable used was a score of accuracy in identifying FGs during the 12 gaze intervals given under each combination of conditions, ranging from -6 to +6. It was calculated as the difference between the number of correct YES responses and the number of incorrect YES responses. Thus a score of -6 would be obtained by a subject who gave incorrect responses on all 12 intervals, and a score of +6 by a subject who responded correctly on all 12. A score of 0 would be obtained by a subject who always gave the same response, and would be the most likely score of a subject responding at random. Table II shows mean scores and standard deviations for subjects by sex and for sexes combined. Mean scores at each distance, under each condition, are also shown in Figure 3.

Calculations were performed by a Honeywell level 66 computer using the Honeywell GCOS implementation of SPSS. A $2 \times 2 \times 2 \times 4$ mixed-model analysis of variance using orthogonal polynomial contrasts was run, using one between-subjects factor (Sex) and three within--subjects factors (Mirror x Mask x Distance). Two female subjects were not used in this analysis due to missing scores, leaving an N of 42. Both the linear and quadratic components of distances were significant ($F(1,40) = 216.715, p < .001$,

TABLE II
MEAN SCORES AND STANDARD DEVIATIONS, BY CONDITION,
DISTANCE AND SEX

	<u>Both Sexes</u>		<u>Males</u>		<u>Females</u>	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
<u>No Mask or Mirror</u>						
Total	2.28	1.91	2.92	1.86	2.28	1.95
2 m	3.82	1.47	3.83	1.34	3.81	1.57
3 1/3 m	2.55	1.68	2.44	1.69	2.61	1.70
4 2/3 m	1.41	1.66	1.50	1.58	1.35	1.74
6 m	1.36	1.73	1.39	1.79	1.35	1.72
<u>Mask</u>						
Total	2.45	1.88	2.60	1.90	2.35	1.87
* 2 m	4.05	1.59	4.33	1.45	3.84	1.67
* 3 1/3 m	2.58	1.61	2.83	1.75	2.40	1.50
4 2/3 m	1.98	1.61	1.94	1.35	2.00	1.79
6 m	1.25	1.54	1.28	1.56	1.23	1.56
<u>Mirror</u>						
Total	2.41	1.82	2.39	1.67	2.43	1.92
2 m	3.89	1.30	4.00	1.08	3.81	1.44
3 1/3 m	2.55	1.62	2.50	1.38	2.58	1.79
4 2/3 m	1.64	1.69	1.33	1.71	1.85	1.67
6 m	1.59	1.67	1.72	1.13	1.50	1.98

TABLE II (Continued)

MEAN SCORES AND STANDARD DEVIATIONS, BY CONDITION,
DISTANCE AND SEX

	<u>Both Sexes</u>		<u>Males</u>		<u>Females</u>	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
<u>Mask and</u> <u>Mirror</u>						
Total	2.15	1.94	1.72	1.98	2.45	1.86
2 m	3.57	1.61	3.17	2.01	3.85	1.22
3 1/3 m	2.50	1.47	2.06	1.47	2.81	1.42
4 2/3 m	1.82	1.91	1.17	1.95	2.27	1.78
6 m	0.73	1.59	0.50	1.46	0.89	1.68

For the asterisked distances in the mask condition, N equals 24 for females, 18 for males and 42 for total subjects. For all other distances and conditions, N equals 26 for females, 18 for males and 44 for total subjects.

Figure 3

SCORE

Mean score at each distance,
for each condition.

- No Mask or Mirror
- Mask
- +— Mirror
- +- Mask and mirror

and $F(1,40) = 15.110$, $p < .001$, respectively). The cubic component was not significant ($F(1,40) = 0.278$, $p > .20$). No main effects, other than distance were significant. The significant interaction effects were of Sex x Mirror ($F(1,40) = 4.266$, $p = .045$), Mirror x Mask ($F(1,40) = 5.808$, $p = .021$), Mask x the quadratic component of Distance ($F(1,40) = 5.18$, $p < .05$ and Sex x Mask ($F(1,40) = 4.080$, $p = .050$).

Figure 4 shows that neither using the mask nor using the mirror, by themselves, produced scores significantly different from the no mask or mirror condition, with little difference between the scores of males and females. It can be seen, however, that the use of mask and mirror together produced a sizable drop in male scores. Male subjects scored lower than females at all distances in this condition, whereas sex differences in the other conditions were smaller and not consistent over distance. The significance of this was confirmed by individual t -tests for comparison of independent means, comparing male and female scores, for each condition and for all conditions combined. The result was significant only for the mask and mirror conditions ($t(42) = 2.46$, $p = .018$). The drop in male scores under this condition accounts for all the significant interaction effects except for Mask x (quadratic) Distance.

The present dependent variable, correct YES responses minus incorrect YES responses, is a more useful and comprehensive measure of subject performance than the percentage of YES responses out

Figure 4

Mean score under each condition, with distances combined, by sex.

MALE
FEMALE

of total responses, which Gibson and Pick (1965) used. However, in order to allow comparison of the present results with those of Gibson and Pick, the percentage of YES responses given while Experimenter was gazing at each target point was calculated. Gibson and Pick used a distance of 2 m, and did not use a mask or mirror. Figure 5 shows that the present results from the no mask or mirror condition at 2 m are similar to their results, even when allowance is made for the different apparent spacing of target points (Table I, p. 14).

Percentages of YES response were also calculated for each distance, under each condition. The results for the no mask or mirror condition are shown in Figure 6.

Simple t-tests, to test the hypothesis that the score obtained at 6 m was greater than $\emptyset$, were run for the scores each sex and of combined sexes, under each condition. Only the test for males under the mask and mirror condition failed to reach significance ($t(17) = 1.448$, $p < .05$, one tailed). For females under the mask and mirror condition, $t(25) = 2.683$, significance with a one-tailed $p < .01$; all other tests produced a significance of at least $p < .005$ (one-tailed). For the no mask or mirror condition, the mean score for combined sexes were significantly above $\emptyset$ at the .005 level (one-tailed), $t(43) = 5.239$.

The hypothesis that facial features must be seen with central vision to aid iris position determination rests on the assumption that the high visual acuity of central vision is important; or,

Figure 5

Comparison of percentages of YES responses at each gaze target point for present experiment at 2 m under no mask or mirror condition ($n=44$), and for Gibson and Pick ($n=6$).

--o-- Gibson & Pick

—•— Present

Figure 6

Comparison of percentages of YES responses at each gaze target point, for each distance, under the no mask or mirror condition.

——— 2 m
 ——— 3 1/3 m
 - - - 4 2/3 m
 6 m

more generally, that high visual acuity aids iris position determination at greater distances. If this is so, we would expect visual acuity to be a significant factor for eye contact discrimination. In this experiment, each subject was rated at one of four levels ranging from 20/15 (high acuity) to 20/30 (low acuity). For each of the four conditions, a one-way ANOVA was run on the effect of visual acuity on the scores of all subjects (excepting one woman for whom visual acuity was not recorded), with distances combined. It was significant only for the no mask or mirror condition ($F(3,168) = 4.312$, $p = .0059$). Further one-way ANOVAs, on each sex and each distance separately, showed no significance of visual acuity on the scores of male subjects under any condition or at any distances. For female's scores, it was significant at 6 m under the no mask or mirror condition ($F(3,21) = 3.622$, $p = .030$).

Since an instruction to not respond until the third signal tone sounded was added after a number of subjects had been run, a t-test for comparison of independent means was used to compare the scores of the last 10 consecutive subjects run before that addition with the scores of the 10 run immediately afterwards. For the no mask or mirror condition, the variation between the two groups was not significant ($t(18) = .0575$, $p > .20$, two-tailed). Since the difference between the two means was less for each of the other conditions than for the no mask or mirror condition, it was concluded that no further t-tests were necessary.

DISCUSSION

Since neither the mask effect nor the mirror effect was found to be significant by itself, it is clear that NIP cues were not significant in this experiment. The present results do confirm that people are able to tell when they are being looked at from as far away as 6 m, without these cues. Although the scores at 6 m were not high, they were--with the exception of the mask and mirror condition--quite significantly above $\emptyset$. NIP cues undoubtedly do contribute to the accuracy of FG recognition in everyday experience, but it is evident that they are not entirely responsible for it.

Figure 3 (p. 24) illustrates the mean values shown in the Both Sexes column of Table II (pp. 22-23). Examination of the line representing the no mask or mirror condition shows that the present results do not contradict those of past studies using shorter distances. FG recognition did fall off sharply as distance increased, as previous researchers had predicted it would (Argyle & Cook, 1976)--up to 4 2/3 m; but from that distance to 6 m, the drop was quite small.

Since iris-sclera configuration could not be perceived at 6 m, these results imply that some other visual information becomes useful to FG recognition at this distance. The hypothesis that

it is something involving Sender's lower face seems, at first consideration, to be only partially supported by Figure 3. To the extent that this hypothesis is correct, we would expect the use of the mask to have lowered scores at 6 m, so that the drop from $4 \frac{2}{3}$ m to 6 m would be comparable to the drops between other consecutive distances. In fact the former was comparable to the other drops under the mask condition, but this was due more to an elevated score at $4 \frac{2}{3}$ m than to a lowered score at 6 m.

This discrepancy may be explained, however, by recalling that visual acuity falls off as the image departs from the center of vision (Figure 1, p. 6) and the assumption that at some point on this curve there exists a threshold for what is seen centrally enough to be useful in determining the position of Sender's irises.

Current research on gaze perception is far from indicating where this threshold lies. I will assume here that it is at or near the boundary of the fovea, at approximately 50' eccentricity (Le Grand, 1968). This is far from proven but not arbitrary. At this point acuity has already fallen off to about 43% of its maximum (Figure 1), so that it is unlikely that the threshold can be much more eccentric. Furthermore, the fovea and its neural connections are constructed so as to form and transmit to the brain a sharper image than can the rest of the retina (Frisby, 1980), and in the brain the fovea's image is received by a much larger area of the cortex than areas corresponding to other parts of the retina of comparable size (Wertheimer, 1981). Researchers have

in fact been surprised to find no alternation in the acuity curve. (Figure 1) at the fovea's boundary (Le Grand, 1967).

Assuming that the threshold is at 50' eccentricity, it is also necessary to know where Subject's gazes were fixated in order to know what part of Experimenter's face was seen with foveal vision. Subjects were not asked this, but since fixating at one eye gives the greatest feeling of eye contact, it seems reasonable to suppose that this is what subjects did. Several subjects in fact mentioned having done so, while talking with Experimenter after having completed the experiment.

Figure 2 (p. 7) shows the areas of Experimenter's face within foveal vision, assuring Subject's gaze to be centered on his right eye. At the two shortest distances, there was nothing except the one eye within 50' radius that seems likely to aid the determination of iris position. The only other facial feature in foveal vision is the eyebrow, which alters with facial expression so that it would not be a reliable reference point. Moreover it is horizontal rather than vertical, and so would be of little use in determining horizontal shifts of the iris. Thus subjects would have to rely on iris-sclera configuration, which is more or less adequate at these distances. Masking should therefore have little effect here, as was the case.

At 6 m, the other eye lay entirely within foveal vision, so that both irises could be seen accurately. Moreover the entire nose was within foveal vision, marking the vertical line halfway

between the eyes so that any horizontal deviation of the irises would be more apparent. In other words, Subject could use the bottom of Experimenter's nose (the most visible part of it) to triangulate the position of the irises. A slight shift by one iris towards the nose, not quite noticable in itself, would become noticable in combination with the equal shift away from the nose by the other iris. Thus, masking should lower scores at this distance by covering the nose; but scores should not drop to $\emptyset$, even though iris-sclera configuration may be useless at this distance, because both eyes are still in foveal vision. This agrees with the results shown in Figure 3.

At 4 2/3 m, only part of the other eye is within 50' radius, while the nose is barely within it. Using the nose as a reference point for only the fixated iris is possible, but would not be as effective as using it to triangulate both eyes. The latter would be possible only if Subject's gaze were fixated somewhere between the eyes, which would sacrifice both the feeling of being in eye contact and whatever iris-sclera configuration was visible. In sum, covering Experimenter's lower face at this distance should have deprived Subject of very little useful information. It may in fact have eliminatd some distraction of facial features impinging on central vision, and thus aided concentration on iris-sclera configuration. This would account for the rise in score in the mask condition at 4 2/3 m.

The overall pattern of the effect on scores of masking at

the four distances--negligible at the shortest two, positive at the third and negative at the farthest--is a quadratic function peaking at or near $4 \frac{2}{3}$ m. Its significance is confirmed by the ANOVA result showing Mask x (quadratic) Distance significant at $p < .05$.

The claim that features must fall within Receiver's central vision in order to aid FG recognition rests on the premise that they must be seen with a high degree of visual acuity. If this is so, it should follow that the subject's visual acuity, which was measured with an eye chart 6.1 m away, should have a positive effect on scores--at least at 6 m when no mask is used.

Analysis showed it to be significant at both 6 m and $3 \frac{1}{3}$ m in the no mask or mirror condition, and at 6 m in the mirror condition--but only for the scores of female subjects. The effect could not be analyzed in the male sample because of insufficient variation in visual acuity among the male subjects: while (with the exception of the mask and mirror condition) means and standard deviations of scores were comparable for both sexes, all of the males except one had 20/15 vision. (Means and standard deviations remained comparable when only subjects with 20/15 vision were considered.) Thus the following five paragraphs actually refers to results obtained only with scores of the female subjects.

At 2 m, iris-sclera configuration may be so visible that more than minimal visual acuity is not important in its perception. Moreover, the measure of visual acuity made at 6.1 m may not apply

to a subject's visual acuity at 2 m. Thus it is understandable that no significant effect was found here.

At 3 1/3 m, iris-sclera configuration becomes harder to perceive, so that the subject's visual acuity at this distance--insofar as the measurement at 6.1 m was valid for it--should have a significant effect. This was the case for the no mask or mirror condition; why visual acuity was not significant or even approaching significance for the mirror condition as well is not clear.

High visual acuity did not significantly aid FG discrimination at 4 2/3 m under any condition, but approached significance in the mask condition. This contrasts with its significance at 3 1/3 m--and at 6 m--when no mask was used. It may be taken as further evidence that something unique was happening at this distance--i.e., subjects were torn between relying on diminishingly visible iris-sclera configuration or triangulating iris location with other facial features.

At 6 m, high visual acuity definitely aided FG discrimination in the no mask or mirror condition. This is shown both by the low alpha level from the ANOVA (.0131) and by the fact that only one of the six women with less than 20/15 vision obtained a score above $\emptyset$ at this distance and condition. Visual acuity also had a significant effect in the mirror condition at this distance, but not in either condition where Experimenter was masked. This supports the hypothesis that FG discrimination at 6 m depends on being able to see features of the lower face sharply, and is

in accord with the idea that they are useful only within the high visual acuity of central vision.

At the same time, these data from female subjects suggest that a visual acuity of 20/15 may be needed for FG discrimination at 6 m. This is not a firm conclusion, since only six women in this study had less than 20/15 vision. In any case, the standard of 20/20 vision was defined as the level of visual acuity typical of adults with uncorrected vision; since most people in this country who are nearsighted now have corrective lenses or glasses, 20/15 may be more typical of the population.

The poor scores obtained in the mask and mirror condition by males--and perhaps by females at 6 m--were unexpected. I can offer no plausible explanation for them; since neither the mirror nor the mask had any such effect by themselves, it is hard to see why their interaction should produce it. However, since people are neither masked nor separated by half-silvered mirrors in real life, this phenomenon does not seem to alter the conclusion that FGs can be identified at 6 m without NIP cues.

The calculation of percentages of YES responses out of total responses for each gaze target and conditioned confirmed that the present results, at the 2 m distance in the no mask or mirror condition, are similar to those obtained by Gibson and Pick (1965) under similar circumstances (Figure 5, p. 26). It should be recalled that the apparent spacing of the present target spots matched Gibson and Pick only at $3 \frac{1}{3}$ m, appearing to be slightly

wider spaced at 2 m and slightly closer spaced at the farther distances (Table I, p. 15). Thus the present scores at 2 m may be slightly inflated. Even allowing for this, it is clear that they are comparable to those of the earlier experiment. On the other hand, it is probable that had the present range of distances been used with equipment matching that of the older experiment, scores would have been slightly higher at 6 m.

The percentages of YES responses were calculated for all four distances, for each condition. In all conditions, it was evident that as distance increased, the true positive responses (spot 4) decreased only slightly, while false positive responses increased markedly. Figure 6, of the no mask or mirror condition, is typical (p. 27). This supports findings (von Cranach & Ellgring, 1973; Martin & Rovira, 1981) that as gaze direction becomes harder to perceive, a bias develops to identify gazes as eye contact.

SUMMARY AND CONCLUSIONS

The above results definitely show that FG recognition occurs at 6 m in the absence of NIP cues, albeit not with great accuracy. Thus the question of just how great a distance it can occur at has not been answered, but requires an experiment using still greater distances. It does appear likely at this time that the answer will lie near or within the range of eight to nine m, which was given at the beginning of this thesis as the limit suggested by common experience.

Since the accuracy of FG recognition was found to be low at 6 m, it is reasonable to conclude that NIP cues do play an important role at greater distances. On the other hand, it should be remembered that the subjects in this experiment were asked to discriminate FGs from gazes that were fairly close to their faces, even at the farthest target points. In many situations in life, Sender is likely to be looking farther away when not looking at Receiver's face, so that FGs are easier to discriminate.

The present findings do not contradict past research, done with distances of 3 m and less, which showed accuracy of FG discrimination falling off sharply with increasing distances. What is shown here is that from approximately $4 \frac{2}{3}$ m to at least 6 m, it falls much off much less rapidly. This indicates that

subjects were using something other than iris-sclera configuration alone at 6 m. The hypothesis was presented that facial features furnished reference points for determining Sender's iris location when, at sufficiently great distances, they fell within Receiver's central field of vision. This idea seems reasonable, and received some support from the present results. However, it is far from established. Further work is necessary to determine just which facial features are useful and to what degree, and to locate the actual degree of eccentricity from the center of vision that acts as a threshold.

Male subjects always worked with a same-sexed Sender in this experiment, while female subjects always worked with an opposite-sexed Sender. Therefore sex differences might be expected in the results. However, the only significant sex difference found was that males scored lower than females in the mask and mirror condition. No reason for that difference was apparent.

Finally, it should be noted that there was a great deal of variance between individuals, as indicated by the large standard deviations seen in Table II. Standard deviations remained large even when visual acuity was controlled in addition to distance. For instance, although visual acuity was highly significant for female subjects at the 6 m distance in the no mask or mirror condition, the standard deviation of those with 20/15 vision was still 1.50 with a mean score of 1.84. Thus, the conclusions that may be drawn from this study have a statistical validity, but the factors used

as variables here are not sufficient for predicting an individual's maximum distance for eye contact recognition.

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Appendix A

Front View of Subject's Booth

Appendix B

Subject's View of Experimenter's Apparatus

Appendix C
Analyses of Variance

<u>Source</u>	<u>Mean Sums of Squares</u>			<u>F_{main}</u>	<u>F_{by sex}</u>
	<u>Main</u>	<u>by Sex</u>	<u>Residual</u>		
SEX	1.53	-	9.96	.15	-
MIRROR	1.82	10.21	2.39	.76	4.27*
MASK	.54	1.94	2.15	.25	.90
DISTANCE					
Linear	614.58	.40	2.84	216.72**	.14
Quadratic	34.83	1.27	2.31	15.11**	.55
Cubic	.45	1.82	1.63	.28	1.12
MIRROR x MASK	10.25	7.25	1.77	5.81*	4.08*
MIRROR x DISTANCE					
Linear	.05	1.21	1.60	.03	.76
Quadratic	.18	.46	2.45	.07	.19
Cubic	.00	.05	.10	.02	.57
MASK x DISTANCE					
Linear	.84	.78	2.16	.39	.36
Quadratic	14.59	.43	2.81	5.18*	.15
Cubic	5.11	.49	2.93	1.74	.17
MIRROR x Mask x DISTANCE					
Linear	2.25	2.77	2.17	1.04	1.28
Quadratic	1.43	.14	1.82	.79	.07
Cubic	.50	.79	1.66	.30	.48

* signifies $p \leq .05$, ** signifies $p < .001$.

In every analysis, the main effect has one degree of freedom, the Sex x Source effect has one degree of freedom, and the residual mean sum of squares has 40 degrees of freedom.

APPENDIX D

INSTRUCTIONS TO SUBJECTS

Do you wear any glasses or lenses to help your distance vision, that you are not wearing now?...I'd like to start by getting a measure of how sharp your distance vision is. Would you stand right here, with your toes on the mark, and I'll get an eye chart...

As a subject, you'll be sitting inside this booth and looking out of its window. Would it make you uncomfortable to be inside it for a while?

Okay. I'll explain those numbered dots on the front of the booth in a minute, but right now, would you look inside the booth. (Experimenter pulls back booth's curtain for Subject.) The height of the chair is adjustable. It should be set so that you're comfortable with your chin resting on the chin rest. The chin rest may also have to be raised or lowered, but I'll have to check that from outside. Would you try it now, and we'll get it adjusted for you...

To your right is a button marked YES, and on your left is a button marked NO. Now, I'm going to be sitting in front of you, where you can see my face through the window. At certain times, which I'll explain in a minute, I'll be looking either directly at you, or at one or another of the numbered dots on the front of the booth--which will be near your face. After each time you'll have about five seconds to decide whether I was looking directly

at you or not. If you think I was looking directly at you, I'd like you to press the YES button on your right; if you think I was not looking directly at you, I'd like you to press the NO button on your left. So by pressing the right hand button you're saying "yes, you were looking at me," and pressing the left--hand button means "no, you weren't looking directly at me."

Except for ~~breaks~~, I'd like you to keep your head upright, with your chin on the chin rest.

Is everything I've said so far clear?

Now I'm going to play part of a cassette recording, which has a series of tones to mark the times when I'll be looking either at you or some spot near your face.

First, this relatively long, rather low-pitched tone will be a warning that I'm about to look either directly at you or at one of several spots near you: ****.

This short, high-pitched tone means you should now watch me to see where I'm looking: ****. It doesn't matter where I was looking before that tone tone sounds, but please pay attention to where I look after it. I'll continue to look, either directly at you or at a spot near you, for about 2½ seconds, until we hear this tone: ****. Do not pay any attention to where I'm looking after that last tone. Instead, decide whether or not I was looking directly at you in the time between these last two tones, and press either the YES button on your right or the NO button on your left. I'll play all three tones once more now.

****. Now you would get ready to watch where I'm looking;

****. Now you would watch where I'm looking;

****. And now you would press either the YES button on your right, if I was looking straight at you, or the NO button on your left if I wasn't. (The following two sentences were added after some subjects had been run.) Please do not press a button until you hear the last tone. You'll then have five seconds to press one of the buttons before the next low-pitched warning tone sounds.

Is there anything about what I'd like you to do that you're not sure of? Okay. I'm going to change the lighting now. This is about the way it will look throughout the experiment... And now I'm going to turn on the machine that will record when you press a button. I'll be back in a few seconds...

Okay, let's do a little practice. Press the YES button, or the NO button, to indicate whether or not I seemed to be looking directly at you. Even though right now this is practice, try to be as accurate as you can. Are you ready?

**** **** ****.

Okay, now at times I'll be wearing a face mask; and at times the clear window you're looking through will be changed to a one-way mirror, so I'll let you get a look at both of them now... Now the mirror will cut out some of the light getting to you, but I'll turn up the lights to compensate. (Experimenter changes window to mirror, adjusts lighting, and puts on mask.)

Now I won't be able to see you through the mirror, so please

be sure to keep your chin on the chin rest and not tilt your head, so that I'll know where to look when I'm looking at you. Okay, are you ready?

**** **** ****.

We'll be doing this in two--minute stretches now. At the end of each two minutes I'll stop the cassette for at least a few seconds, and you'll have a short break, so you can stand and stretch at those times if you'd like.

Is there anything about what you should do in this experiment that you're not sure of? Okay, then, let's start. (Experimenter sets Experimenter's chair position, leaves mirror in place or changes it to window, and takes off mask or leaves it on, as called for, for the first block of gazes.)

APPENDIX E

INFORMED CONSENT

I, _____ hereby agree to serve as a subject in the investigation of recognition of eye contact, entitled "Perception of Eye Contact Over Distances up to 25 Feet," conducted by Daniel Scarl.

I understand that the study involves sitting with my chin on a chin rest, within an enclosure that will at times be darkened, but which will contain a window whcih I will always be able to see out of; that frequent breaks will be available; that the study involves short but frequent periods of eye contact between myself and the experimenter, who will at times wear a mask covering a part of his face; and that I may be asked to spend as long as approximately an hour in the experiment.

It has been explained to me that the purpose of this study is to learn about how accurately people may be able to tell whether they are being looked at, and how they are able to make that judgement. Daniel Scarl has agreed to answer any questions that I may have about the study.

I have been assured that any information that I supply or that relates to my individual performance in the study will remain confidential, and that the identity of all subjects will remain anonymous.

I understand that I am free to withdraw from participation in this study at any time without jeopardizing my relationship with Portland State University, or affecting my grade in any class.

I have read and understood the foregoing information.

_____ Date _____ Signature