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Vocal Cues to Deception: A Comparative Channel Approach

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The study investigated the leakage potential of different voice and speech cues using a cue isolation and masking design. Speech samples taken from an earlier experiment were used in which 15 female students of nursing dissimulated negative affect produced by an unpleasant movie or told the truth about positive affect following a pleasant movie. Several groups of judges rated these speech samples in five conditions: (1) forward or clear, (2) electronic filtering, (3) random splicing, (4) backwards, (5) pitch inversion, (6) tone-silence sequences. The results show that vocal cues do indeed carry leakage information and that, as reflected in the differences among the conditions masking different types of cues respectively, voice quality cues may be centrally implicated. In addition, gender differences in decoding ability are discussed.

The question of whether deception can be detected on the basis of a variety of behavioral cues provided by the deceiver has sparked a sizable number of studies in the past decades. First, physiological psychologists

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tried to assess the possibility of using polygraph methods for lie detection (Orne, Thackray, & Paskewitz, 1972; Lykken, 1974; Podlesny & Raskin, 1977). Then the interest of psychologists studying nonverbal behavior was awakened by Ekman and Friesen's (1969) seminal article on "nonverbal leakage and clues to deception." Initially attention was directed primarily to nonvocal aspects of behavior, particularly the face and the body (Ekman & Friesen, 1974). More recently, the vocal channel of communication has been studied intensively in terms of its potential for the detection of deception (see Scherer, 1981; Zuckerman, DePaulo, & Rosenthal, 1981, for overviews).

In many studies of the nonverbal behavior of deceivers, the instruments of detection were naive human observers who were presented with samples of deceiver behavior in different channels of communication (such as audio, visual, or audiovisual combined). The purpose of these studies was to assess the degree to which a particular channel leaks information about deception (Ekman, Friesen, & Scherer, 1976; Ekman, Friesen, O'Sullivan, & Scherer, 1980; DePaulo, Zuckerman, & Rosenthal, 1980). Contrary to cue measurement studies in which objective coding methods are used to determine the covariation of deception with particular facial or vocal cues (see Ekman & Friesen, 1974; Ekman, et al., 1976; Scherer, 1979, 1981), the observer-attribution method makes it difficult to isolate the particular cues that carry the leakage and that allow observers to attribute deception correctly. One approach to identifying potentially significant cues is to use cue-masking and isolation methods (Scherer & Scherer, 1982). The masking of content in speech has a venerable history in vocal communication research (Starkweather, 1956) and has since been further refined (See Scherer, 1982).

In the collaborative study reported here, many of the available masking and isolation techniques for vocal cues were used with the same set of speech samples from a study investigating the dissimulation of negative affect. Since each of these methods masks or isolates different vocal cues, the study was expected to shed some light on the question of the relative leakage potential of different vocal cues. Table I shows an overview of the various techniques and of the vocal cues that are likely to be retained or to be masked by the respective technique. It was expected that speech samples that retain most of those cues that had been identified as deception information carriers in past research, particularly fundamental frequency of the voice (Ekman et al., 1976; Scherer, 1979, 1981; Streeter, Krauss, Geller, Olson & Apple, 1977), best communicate deception to naive observers.

Table I. The Effect of the Speech-Masking Methods on Major Paralinguistic Cues

	Vocal Cues						
Type of masking	Loudness	Fundamental frequency (Pitch)	Intonation	Voice quality	Tempo	Pauses	Rhythm
Backwards	Unchanged	Unchanged	Distorted	Distorted	Unchanged	Unchanged	Distorted
Random spliced	Unchanged	Unchanged	Partially masked	Unchanged	Partially masked	Fully masked	Distorted
Filtered	Partially masked	Unchanged	Unchanged	Fully masked distorted	Unchanged	Unchanged	Unchanged
Pitch inversion	Partially masked	Unchanged	Partially masked	Fully masked	Partially masked	Unchanged	Partially masked
Tone silence	Fully masked	Fully masked	Fully masked	Fully masked	Partially masked	Unchanged	Partially masked

METHOD

Deception Speech Samples

Speech material from one of the first experimental deception studies, the Ekman and Friesen (1974) study on dissimulation of negative affect, was used in the present experiment. Since the procedures used have been discussed in detail in the original publications by Ekman and his collaborators (Ekman & Friesen, 1974), a short summary will suffice in the present context. Ekman and Friesen asked female nursing students to take part in a study supposedly designed to test the ability of the future nurses to hide unpleasant feelings in dealing with patients. During the study, they took part in several interview sessions during which they were shown either pleasant films or unpleasant (surgery and burns) films and were asked either to openly describe the film and their feelings or to deceive about the content of the film and their feelings vis-à-vis a female interviewer. For the present study, excerpts from the subjects' speech during the interview in the pleasant film honest description condition (honest) and the unpleasant film deception condition (deception) were used. The confound between positive affect/honest reporting and unpleasant affect/dissimulation was not accidental but purposely chosen to achieve both maximal contrast between the conditions and ecological validity. Deceiving about negative affect and telling the truth about positive affect are the most frequently encountered situations related to truthfulness both in the hospital setting and in daily life. For ease of reference, we will refer to "honest" and "deceptive" conditions in the remainder of the paper rather than use the longer, accurate description. Out of a total of 31 subjects studied by Ekman and Friesen, the 15 subjects (speakers) from the replication experiment (Ekman & Friesen, 1974) were used because of superior audio quality of their recordings. One honest and one deceptive sample was obtained for each speaker.

Preparation of the Stimulus Tapes

The speech samples used in the experiment were segments excised from the beginning and middle of the interviews conducted in the Ekman and Friesen (1974) study. The initial stimulus tapes were prepared such that the first 15 speech samples recorded on the tapes were from each of the 15 speakers of the Ekman and Friesen study. The second speech samples from those same speakers constituted the second 15 samples recorded on the stimulus tape. Within this constraint, the order of the honest and deceptive samples was randomly varied. This procedure, though it has desirable features of control, makes it more difficult to demonstrate significant effects of the detection of deception; i.e., the procedure leads to conservative detection results. In order to control for sequence effects, a second tape was prepared that contained the same speech samples in reverse order. Each sample lasted 18 seconds and the interval between any two successive samples was 45 seconds long.

The speech samples recorded on these tapes were the original samples excised from the Ekman and Friesen interviews and were not altered in any way. The two tapes were used in the "forward," or "clear," speech condition of the experiment. Copies of these tapes were used to produce all the masked versions of the speech samples. Thus, all but the random-spliced version of the tapes retained the same order of the honest and deceptive samples. The random-spliced tapes contained a different order of honest and deceptive segments, although they observed the constraint that only 1 sample of each speaker occur among the first 15 samples presented to the judges.

Cue Masking and Isolation Techniques

Each of the two "forward" speech tapes were subjected to the masking procedures described in detail below.

Electronic Filtering

A Kronhite low pass filter with a dB offset of 48 dB at the filtering frequency was used to remove energy in the frequency range above 500 Hz.

Random Splicing

Using the Giessen Speech Analysis System, consisting of a PDP 11/35 and appropriate periphery, speech samples were digitized and stored on disk. Using a computerized version of the random-splicing procedure described by Scherer (1971), the digitized samples were divided into 250-msec segments. These segments were then rearranged in a random order and copied onto analogue tape via digital to analogue converter.

Backward Speech

The original speech samples were rerecorded on full-track, reel-to-reel audiotapes. The full-track tapes were then played backwards such that the original, or ''forward'' speech signal was reversed. The resulting ''backward'' speech was then recorded onto two audiocassette tapes that maintained the sequences and orders of the original tapes.

Pitch Inversion

The speech samples were subjected to a procedure that inverted the frequencies of successive phones in the words. The ''pitch inversion'' was accomplished by a balanced modulator using a carrier frequency within the audio band (approximately 3 Khz). The modulator folds the incoming audio spectum around the carrier frequency. Such an inversion of the spectrum destroys the normal harmonic relationships that make for intelligibility, although it leaves the stress pattern and intensity contours intact.

Tone-Silence Sequences

The speech samples were processed by AVTA (Jaffe & Feldstein, 1970), a specialized computer system that served, for the present experiment, primarily as a threshold device. The operator of the system set the threshold such that any speech signal that could be detected by the (trained) normal human ear was considered to be above threshold. The system transformed signals above threshold into a voltage that was sent to a 1,200-Hz, gated oscillator that (a) generated a tone that lasted as long as the duration of the voltage, and (b) transmitted the tone electronically to an audiotape recorder. Thus, the combined system produced an audiotaped sequence of tones and intervening silences that accurately represented the original sequence of speech sounds and silences for each speech sample.

It should be noted that although judges were able to hear the verbal content in the forward or clear conditions, which was not the case in any of the masking conditions, this cannot have differentially affected the results since Ekman and Friesen gave their subjects a script to follow in responding to the interviewer. Thus, verbal content is rather standard throughout.

Judgment Scales

Each of the 30 speech samples was rated in terms of a set of 10 10-point, unipolar adjective scales. The adjectives, and one of the two orders in which they were presented to the judges, were *dominant,* *relaxed, sociable, positive, competent, strong, likable, fast-speaking, honest,* and *active*. Each scale ranged from 0 to 9. The 0 indicated that the characteristic (adjective) was "not at all true" of the person who uttered the speech sample. The range from 1 to 9 indicated that the characteristic was increasingly true of the speaker, with 1 to 3 indicating "mildly true," 4 to 6 indicating "moderately true," and 7 to 9 indicating "extremely true." The other order in which the adjectives were presented was a reversal of the first one; i.e., the first adjective scale presented was *active* and the final one was *dominant*.

The set of 10 scales was typed on a single page, the heading of which was simply the number of the stimulus speaker. Thus, there were two pages with the same speaker number at their head; one page contained one order of the scales and the other page, the reversed order. One page was used for rating that speaker in the *honest* condition and one for rating her in the *deception* condition. There were, therefore, 30 pages that were assembled into a booklet in the order in which the speakers were presented on the stimulus tapes; recall that no repetition of a speaker occurred until after all 15 speakers were presented.

Recall, too, that the speech samples were presented to the judges in four different orders. One order and its reverse characterized the *forward* speech condition and four of the masking conditions. However, the speakers, and therefore speech samples, were presented in another order and its reverse in the *random-spliced* condition. Thus, four different booklets, representing two different orders and their reverse, were assembled for the experiment.

Judges and Procedure

The experiment was conducted in a language laboratory that contains 60 desks, each of which is equipped with a stereo headphone connected to a central control unit at the front of the laboratory. All of the headphones are the same make and model (Bell & Howell, Model No. 4195). Three audiocassettee decks are located in the central control unit. Each of them can be used to transmit recorded information via the headphones to all of the desks simultaneously or to one or more desks selected by the operator. The unit also makes it possible to provide the same reception characteristics for all the headphones.

The judges were 123 university undergraduates[5] who volunteered to

[5]The judges were students at the Univesity of Maryland Baltimore County.

participate in the experiment in order to satisfy a course requirement. Eighty-two of the judges were women and 41 were men. Table II presents the distribution of male and female judges in the six masking conditions and two orders of the experiment.

The judges arrived at the laboratory in groups of from 3 to 12. Each of the judges in a group was seated at a desk and asked to read the consent form that was on top of the booklet on the desk and to sign it if he or she was willing to participate in the study. (All of those who came to the laboratory decided to participate.) The subjects were then asked to complete another sheet requesting demographic information. After all the subjects finished providing the information requested, they were asked to turn to the sheet and to read the instructions typed on it while listening to them via their headphones. The judges then read and heard the following instructions.

> In the study, you will hear 30 speech samples. [For all but the forward speech condition, the second sentence was: The samples have been changed to mask their

Table II. Distribution of Male and Female Judges in the Methods of Presentation and Orders of the Experiment[a]

Methods	Gender	Order 1	Order 2	Sum
Forward speech	M	3	2	5
	F	7	10	17
Backward speech	M	2	4	6
	F	9	6	15
Filtered speech	M	2	4	6
	F	9	6	15
Ramdom-spliced	M	5	3	8
	F	5	7	12
Pitch inversion	M	7	1	8
	F	3	9	12
Tone-silence	M	5	3	8
	F	5	6	11

[a]Of the males, 24 participated in Order 1 and 17 in Order 2; of the females, 38 participated in Order 1 and 44 in Order 2. All the judges heard the honest and deceptive speech samples. The total number of judges in the experiment was 123.

> content.] Please listen carefully to each sample and rate it on all of the 10 characteristics that are listed on the page in front of you. Rate each characteristic on the scale of 0 to 9 that follows it. The 0 indicates that the characteristic is *not at all* true of the person. The range from 4 to 6 indicates that the characteristic is *moderately* true, and the range from 7 to 9 indicates that the characteristic is *extremely* true of the speaker.
>
> Please check only *one* blank space on each scale, but be sure to check *all* 10 scales. Also, be sure to rate *every* speech sample you hear.
>
> Immediately after you have heard a speech sample, make your rating on the basis of your first impressions. You will have 45 seconds to rate each sample, so do not spend much time thinking about your impressions.

After the instructions were finished, the judges were told that the first sample was a practice sample to allow them to become familiar with the sound of the sample and the use of the scales. They were also told that they would have a 2-minute break after rating the first 15 speech samples.

No special order was used in presenting the stimulus tapes of the different speech conditions to the judges. However, an effort was made to obtain similar numbers of judges for the different conditions.

RESULTS

Preliminary Considerations

Examination of the intercorrelations among the 10 dependent variables showed such high correlations that a reduction in the number of variables seemed indicated. To aid in the data reduction process, a principal components analysis was computed with results shown in Table III.

The first unrotated principal component reflected the high degree of intercorrelation among the 10 variables. Armor's theta, an index of internal consistency, was found to be very high, .97 (Armor, 1974; Rosenthal, 1982). Orthogonal varimax rotation, however, showed that the variable *relaxed* loaded more highly on its "own" factor than it did on the first factor. Thus, all subsequent analyses were carried out on two dependent variables: *relaxed,* and a new supervariable, *positive-competent,* constructed by averaging the ratings obtained from the remaining nine variables after each had been converted to standard (z) scores.

The effective reliability of the new supervariable was .95; that of the

Table III. Principal Components Factor Loadings

Scale	Unrotated		Rotated[a]	
	1	2	1	2
Dominant	.96	−.03	.86	.41
Relaxed	.59	.76	.17	.95
Sociable	.96	−.07	.89	.37
Positive	.98	.06	.84	.50
Competent	.98	.09	.82	.53
Strong	.99	.01	.88	.46
Likable	.94	−.08	.87	.36
Fast	.80	−.50	.94	−.08
Honest	.93	.12	.77	.53
Active	.97	−.16	.94	.30
Latent roots	8.409[b]	.896	6.840	2.465

[a]Orthogonal varimax rotations.
[b]Armor's theta (internal consistency reliability) = .97.

variable relaxed was substantially lower, .48.[6] The effective reliability of judges' ability to discriminate between lying and truth-telling was .88 for the positive-competent variable but .00 for relaxed.[7] The high degree of reliability in discriminating lying from truth-telling for the positive-competent variable means only that judges agreed with one another; it does not, by itself, indicate accuracy at detecting lies.

Positive-Competent Factor

Table IV presents the mean ratings of the positive-competent factor for each of the six methods of audio presentation of honest and deceptive communications. The main effect of audio presentation was significant at the .003 level ($F(5, 111) = 3.90$, eta = .39). Most of this effect (98%) was a function of the strong positive ratings given to clear speech presented either forward or backward and the strong negative ratings given to the content-filtered speech samples.

The main effect of honesty of communication yielded an F ratio of 3.36 with 1 and 111 *df*. The p value for the F is .07 and the r is equal to .17. Although not statistically significant, the findings suggest tentatively

[6](MS Speakers-MS Speaker × Judges)/(MS Speakers) was used to compute the reliability (see Guilford, 1954; Rosenthal, 1982).

[7](MS Speakers × Honesty-MS Speakers × Honesty × Judges)/(MS Speakers × Honesty) was used to compute the reliability (Rosenthal, 1982).

Table IV. Mean Ratings of Positive Competence for Six Methods of Audio Presentation of Honest and Dishonest Communications

	Honesty				Interaction
Method	Honest	Dishonest	Difference	Mean	effect[a]
Forward speech	1.88	.94	.94	1.41	.74
Backward speech	1.14	1.43	−.29	1.28	−.49
Filtered speech	−2.28	−2.42	.14	−2.35	−.06
Random-spliced	.06	− .31	.37	− .13	.17
Pitch inversion	− .38	− .36	−.02	− .37	−.22
Tone-silence	.19	.11	.08	.15	−.12
Mean	.10	− .10	.20	0[b]	

[a]The differences between honest and dishonest communications correcting for main effect of honesty; these define the interaction effect.
[b]The grand mean is zero because this variable was constructed from the mean of nine Z-scored variables.

that, averaging over all methods of presentation, the speakers tended to be judged more positive-competent when telling the truth than when lying.

Another significant effect was the interaction of honesty of communication and method of presentation ($F(5, 111) = 2.42, p = .041$, eta $= .31$). Eighty-five percent of the interaction resulted from the strong opposite effects obtained from the forward speech versus the backward speech condition. When played forward, honest speech was judged to be more positive-competent than was dishonest speech. When played backward, however, honest speech was judged relatively less positive-competent than was dishonest speech. (See the last column of Table IV for the residual differences defining this interaction effect.)

Finally, the interaction of gender with honesty of communication was nonsignificant ($F(1, 111) = 1.93, p = .168, r = .13$). However, given Hall's (1979) demonstration that women appear to be better decoders of nonverbal information than men, separate analyses of the male and female judgments were performed. The results show that the female judges were significantly able to differentiate honest from deceptive communications, with honest communications rated as more positive-competent ($t(111) = 2.28, p = .03$, r $= .29$). The male judges were unable significantly to distinguish the honest and deceptive communications ($t(111) = .32, r = .04$).

Relaxed Factor

The mean ratings of the relaxed factor for each of the six methods of audio presentation of the honest and deceptive communications are shown in Table V. The main effect of method of audio presentation was significant ($F(5, 111) = 11.33, p < .001$, eta = .58). Most of the effect (93%) was a function of the very high ratings of relaxed given to the forward speech method of presentation and the very low ratings of relaxed given to the content-filtered and pitch-inverted methods.

Neither the main effect of honesty of communication (($F(1, 111) = .050, p > .50$) nor the interaction of honesty of communication by method of presentation was significant ($F(1, 111) = 1.417, p = .224$). The third column of Table V, however, indicates that the forward speech and the tone-silence segments yielded honest/dishonest differences opposite in direction to those obtained by the four other masked versions of the speech samples. For the forward speech and tone-silence segments, truth telling was judged to be more relaxed than lying; for the other four versions, truth-telling was judged as less relaxed. The contrast that evaluated this effect yielded an $F(1, 111)$ of 6.79 ($p = .02$, $r = .24$). The finding, however, must be interpreted with considerable caution because the contrast was not planned.

Finally, the judges' gender interacted significantly with honesty of communication ($F(1, 111) = 10.78, p = .002, r = .30$). The nature of this interaction (Table VI) was such that the female judges rated honest communications *more* relaxed than deceptive communications, whereas the male judges rated the honest communications *less* relaxed than the deceptive ones.

Table V. Mean Ratings of Relaxed for Six Methods of Audio Presentation of Honest and Dishonest Communications

	Honesty			
Method	Honest	Dishonest	Difference	Mean
Forward speech	6.06	5.83	.23	5.94
Backward speech	4.71	4.78	−.07	4.75
Filtered speech	3.22	3.37	−.15	3.30
Random-spliced	4.60	4.70	−.10	4.65
Pitch inversion	3.56	3.71	−.15	3.64
Tone-silence	4.37	4.05	.32	4.21
Mean	4.42	4.41	.01	4.41

Table VI. Mean Ratings of Relaxed by Female and Male Judges of Honest and Dishonest Communications

	Honesty			
Judge gender	Honest	Dishonest	Difference	Mean
Female	4.54	4.28	.26	4.41
Male	4.31	4.53	−.22	4.42
Mean	4.42	4.40	.02	4.41

DISCUSSION

The results of the experiment clearly support the prediction derived from earlier research that vocal cues do indeed carry information about deception. The main effect of honesty of communication (i.e., the honest versus deceptive speech samples) on the positive-competent ratings shows that the judges were able to detect a difference, or differences, in speaker behavior between the honest and deceptive conditions. The high correlations among the judgment scales, however, indicates that the effect is not specific to the judgment (scale) of honesty. On the other hand, the judges had not been told about the nature of the samples they were asked to rate and had not been requested to focus their attention on an honest/dishonest distinction. Furthermore, as mentioned above, the nature of the highly controlled stimulus presentation in this study, i.e., presenting an honest or a deception sample for a particular speaker to any one judge, does not permit the judgment of potential deception in relation to an honest baseline. Given the clear difference between the rating of the two conditions obtained in spite of this impediment, it is quite conceivable that judges who are requested to distinguish between honest and deceptive samples and who are given a baseline may well do better than did the judges in the present experiment.

Inasmuch as vocal cues do seem to leak information about deception, do the results allow for the identification of which vocal cues are involved? While the pattern of the results is far from conclusive, it does point in a certain direction. The significant interaction effect for the positive-competent ratings suggest that the relevant cues were accurately interpreted in forward speech but misinterpreted when presented in backward speech. Apparently, the deception-carrier cues change their nature and meaning when presented backwards. Inspection of Table I shows that the cues that are most affected by the reverse presentation are intonation, voice quality, and rhythm. An examination of the results for the other masking techniques may help to clarify which of these cues seems to be centrally involved. The results obtained for the random-spliced speech are most interesting in this respect. Although the interaction effect is fairly small, the mean difference (Table IV) between the honest and deceptive conditions is the second highest and in the right direction. Since the random-splicing procedure is designed to eliminate intonation and rhythm cues (producing method-specific rhythm cues), it seems reasonable to hypothesize that voice quality is the cue most implicated as a carrier of deception information. Unfortunately, voice quality is a cover term for a large number of different vocal cues that are very difficult to define and measure (see Laver, 1980; Scherer, 1982). Which of these are involved, and why a reverse presentation apparently creates an opposite expression of the cue or cues, needs further exploration.

There are a number of alternatives to the above explanation. A de-emphasis of the difference obtained by the random-spliced method suggests the possibility that speech rhythm and intonation, both of which are strongly time- and sequence-determined, carry deception information and are thus misinterpreted upon reversal of the speech flow. Another possibility has to do with the relation of the various vocal cues to speech content. Objective voice analysis of the segments used in the present study suggests that some of the speakers increased their fundamental frequency (FØ) in the deception condition (Scherer, 1981). The higher frequency might have been either a function of the tensing of the vocal musculature under stress (Scherer, 1979) or a self-presentation strategy in which deceptive speech content is produced with greater expressiveness (via higher FØ, greater FØ variability, and more accented speech).

The results of the "relaxed" factor are less clear. Again, however, there is some indication that the cues used for the attribution of relaxation may carry information about deception. The unplanned comparison of the forward speech and tone-silence methods of presentation with the four other methods hints that the cues have to do with pausing and tempo, since these are the only cues available in the tone-silence condition.

That the female judges may have distinguished the honest and deceptive conditions with somewhat greater accuracy tends to support Hall's (1984) argument that women are especially attuned to the nonverbal dimension of social relations. On the other hand, it seems to contradict some of the findings reported by Rosenthal and DePaulo (1979) suggesting that women are relatively better able than men to decode visual information whereas men may be relatively better able to decode vocal information. This apparent contradiction might disappear if the dimensions on which the ratings are being made are taken into account (se Ekman et al., 1980). While voice seems to best convey status and competence cues (Scherer, Scherer, Hall, & Rosenthal, 1977; Waldert-Lauth & Scherer, 1983), the visual channel may be particularly suitable for the communication of the affective dimensions of social relationships (DePaulo & Rosenthal, 1979).

Finally, it should be noted that the different methods of masking speech have effects of their own. This is particularly so for electronic filtering. All the filtered speech samples were strongly devalued in terms of their positive-competence ratings. Clearly, there is the danger of ceiling or floor effects if method-specific characteristics obscure the informational value of particular cues. One of the tasks faced by investigators in the general area of vocal/verbal research is to improve the quality of masking techniques in such a way as not only to isolate or mask particular cues in a precise manner but also to render them more acceptable to the human ear.

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