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ABSTRACT

The author reports the results of a study based on an assumption that there might be an association of certain acoustic variables with the telling of lies. Twenty subjects were asked to perform two tasks, each involving four short oral responses, one of which was a lie. The responses were subjected to spectrographic analysis, and the task of the experimenter was to predict which of the four responses in each set was the lie. When minimum duration of response was used as the criterion, the lie responses were accurately identified with a high degree of reliability. The second part of the study involved twenty additional subjects, who were asked to replicate the lie identifications on the same responses simply on the basis of what they heard on a tape. They were unable to make accurate identifications of lie responses, regardless of whether or not they were informed of the duration cue. The author views this study as an initial attempt to reveal certain interrelationships between components of the encoding process. (RN)

ACOUSTIC CORRELATES OF LIES

by

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ACOUSTIC CORRELATES OF LIES

The present study was instigated by a bit of admittedly imperfect reasoning suggesting the possible association of certain acoustic variables with the telling of lies: Certain physiological variables are involuntary correlates of lying (*e.g.*, galvanic skin resistance, heart rate, vaso-constriction, pupil dilation, etc.) [3 7]. These involuntary physiological variables also accompany certain of the emotions (*e.g.*, fear, excitement, depression, etc.) [1,2] . The realization that the vocal manifestation of certain involuntary acoustic correlates (pitch, duration, intensity, etc.) accompanies these emotions as well [4,5,8] might lead us to suspect that "therefore" acoustic variables may also be associated with lying.

Every adult has experienced situations in which a teller-of-a-falsehood has exposed himself with his own voice, and in a most obvious way. Reflection upon such instances tends to make the above conjecture too obvious to warrant any elaborate pursuit. The phenomenon to be pursued here, however, is that of the more subtle lie - that in which no acoustic cues are detected by the "naked ear." If such subtle cues do exist, they might best be uncovered by an analysis of the sound spectra.

It seems, then, that we have two hypotheses. Stated in null form:

1) The attempted detection of lies through spectographic analysis will not differ significantly from chance expectation.

2) The attempted detection of lies with the unaided ear will not differ significantly from chance expectation.

PROCEDURE - I

The subjects consisted of twenty female students (from a beginning speech course at the Pennsylvania State University) between the ages of 18 - 21. (Male voices would have been less compatible with the spectographic equipment to be used later.) The subjects were otherwise heterogeneous.

The physical environment was such that individually the subjects were seated before a microphone which provided input into a tape recorder. The recorder and its operator were situated behind the subject. The experiment took place in a sound-proof room.

Each subject individually performed two closely related tasks: Seated in the room, the subject was handed an envelope and a blank index card and instructed to "pick a number from 1 to 4, write the number on the card, put the card in the envelope, and seal the envelope." These directions were followed with the experimenter absent from the room and thus ignorant of the number recorded by the subject. The experimenter returned to the room and informed the subject that she was going to be asked a series of questions of the type, "Is it [the number chosen] one? Is it two?, etc." She was instructed to orally respond "no" to each of these questions.

Obviously, one of the answers would be a lie (the answer corresponding to the number written on the card). [1]

The subject was further informed that each question would be followed by a slight pause, terminated by a "click"; and was instructed to give her response after the click. The pause was induced to account for the "latency effect" observed with certain physiological correlates of this "is it one -- is it two -- " type of stimulus. Frequently, a reduction of skin resistance, or increase in heart rate, or other kinds of autonomic nervous system (ANS) response, will not follow the stimulus immediately, but rather will lag behind by as much as two seconds or so. [2] The click mentioned above was simply the releasing of an "instant stop" mechanism on the tape recorder. As soon as an oral response was recorded, the stop mechanism was again engaged. (This allowed an optimum voice/silence ratio on the tape to later facilitate putting a maximum number of responses on one spectogram.)

Let us return now to our subject and her task. The four questions ("Is it one? Is it two?, etc.") were asked in order, each followed by the pause, the click, and the response. The first series of questions, however, was a trial task with no responses actually recorded. (The "trial" aspect of this first set of questions was not realized by the subjects.) This trial task allowed the experimenter to correct the mechanics of the subject's responses ("Remember to wait for the click." "Answer sooner after the click," etc.) without contaminating any data. The dry run also served to minimize reactions to the mere confrontation of the experimental environment and task, on top of whatever reactions might be accompanying the lie response. Next, the subject was informed that the questions would be asked again, but in random order. Again, question-pause-click-response; this being the "real" task with the responses recorded. (The random order was introduced to eliminate any "anticipation effect"; that is, a gradual build up of "anxiety" as the selected number is approached in the sequence.) Four responses were recorded, one for each number from one to four. The procedure described here was followed for each of the ənty subjects.

In the second task, each subject was instructed to write the numbers from one to four, omitting any one of the numbers. This time the questions were of the type, "Is one on the list? Is two on the list?, etc.," and the subject was instructed to answer "yes" to each question. Again, of course, one of the responses was not a true one. The remainder o. this second task was the same as the first.[3]

EQUIPMENT

The equipment used in the task phase consisted of an Ampex tape recorder and a reasonably high-quality microphone. (The subject-to-microphone distance was controlled during the performance of the tasks to minimize contamination of the intensity variable.) For the analysis phase, the taped responses were fed from the recorder directly into a Kay Sonograph from which four sound spectograms per subject were made: two "no" and two "yes" spectograms, each displaying two responses. The spectograph settings were held constant for each individual subject but did not need to be controlled across all subjects.

ANALYSIS

The reader may have noticed that the hypothesis which predicted acoustic cues in lying made no prediction as to what those cues might be. The experimenter reasoned that the tip-off might reside in any of the acoustic properties of the voice; and, moreover, might even lie in different cues for different subjects.

Accordingly, the first problem in the analysis was the search for the clues. This was approached in the following manner: The four "no" spectra for three subjects (chosen at random) were examined carefully, and the acoustic properties for each response described in considerable detail. The experimenter then opened the corresponding envelopes to discover the response for which the lie was told. Thus, the next step was to examine the acoustic description for this response, looking for ways in which its acoustic properties differed from the other three responses.

The only difference found between the lie responses and the true responses was that the lie responses were invariably shortest in duration (approximately 0.03 sec. shorter than the third longest, and approximately 0.09 sec. shorter than the longest response). It was thus concluded that the cue for lie detection - among these subjects' responses anyway - was that of minimum duration. An examination of these subjects' "yes" responses supported this observation. (Subsequent examination suggested that minimum duration was the only reliable cue for the other subjects as well.)[4]

Hence, the remainder of the analysis consisted of measuring the duration for the remaining 17 subjects' "yes" and "no" responses and using the criterion of minimum duration to predict which was the lie response. After the predictions were recorded, the envelopes were opened and the accuracy of the predictions evaluated.

RESULTS

These predictions and their corresponding correct answers are presented in Table I. Of the thirty-four predictions, twenty-four were correct. The accuracy of these predictions is statistically significant well beyond the 0.01 level of confidence. (The actual probability of these results having occurred by chance is less than .0000001.)[5] We can conclude, therefore, that for the subjects and tasks studied, decreased duration of the vocal response was a significant acoustic cue accompanying the lies. Accordingly, we may reject the first null hypothesis.

PROCEDURE II

The second null hypothesis was tested in a very simple fashion. Ten new subjects (students from the same beginning speech course) were oriented as to the purpose and methodology of the present study. They were then asked to listen to the taped "yes" and "no" responses discussed above and predict the lie response simply on the basis of what they heard. The performance on this task was rather poor, with the average accuracy being slightly less than that expected by chance. (Pr. = .58).

Next, ten more subjects were informed that a cue to the true lie responses resides in the minimum duration characteristic. With this information, these ten listened to the taped responses and made their predictions. The results again were such that the average accuracy was slightly less than chance expectation. (Pr. = .52).

These results suggest that the acoustic cues associated with lying (in the present study) are not detectable by the unaided ear. We are thus unable to reject the second null hypothesis.

DISCUSSION

It appears that this study was successful in finding an involuntary acoustic manifestation of lies for the subjects and conditions studied. Unfortunately, the implications of this finding are not as clear-cut as is the finding itself.

For sure, the findings do not imply that spectographic analysis would be applicable in practical lie-detection situations, since acoustic voice variables may be altered voluntarily.

Moreover, there is only a weak relationship between this study and previous studies relating vocal acoustic variables and emotion; since the earlier studies examined either voluntary emotions, or obvious "naked ear" acoustic characteristics, or both [e.g., 4,5,8].

What we have, however, is evidence of a phenomenon of which we were unaware and for which we have no obvious explanation; but for which we might very much wish to seek an explanation. That is, if the simple act of telling a one-word, low-risk lie predictably affects the vocal mechanism in ways to which the speaker is oblivious (and the listener, as well, for that matter); and if predictable myographic peculiarities (vocal duration changes) accompany supposedly unrelated ANS responses (see fn. 3), then some kind of interrelation between certain encoding "components" must exist. The nature of that interrelationship might shed some light on psycholinguistic and encoding theory.

To specify the nature of the encoding activity responsible for the results of the present study will of course require much additional research and much speculation. We'll have to wait for the research, but may as well begin the speculation: One appealing interpretation that comes to mind is that the study's results might provide evidence of emotion (i.e., ANS responses) acting as "noise" in some identifiable phase of the encoding process. To the extent that the encoding process consists of semantic, lexical, phonological, syntactic and myographic "components," we might label the activity of one of these components as a dependent variable in the present study by making the following assumption: Given a set of four one-word responses, each using the same verbal symbol ("no" or "yes"), the activities of the semantic component, lexical component, phonological component, and syntactic component of the encoding process should be identical. Perhaps contrary to our expectations we find, however, that with the introduction of "noise" (in the form of emotion) the activity of the myographic component (that which governs the motor responses of the speech mechanism) is not identical, but rather is noticeably altered.

Stepping out still further on the same limb, we might even say that in the case of these particular supposedly identical responses, what has happened is the following: For the three true responses, the activities of the encoding components are identical. In the case of the false response, however, the subject engages in the same lexical activity as for the true responses, but then has that lexical output rejected by the semantic component since it does not in fact match the subject's impression of a response appropriate in meaning. The false response nevertheless continues to be processed by the syntactic component the same as had the true responses, and again undergoes an identical processing by the phonological component. Thus, perhaps, the mismatch in the semantic component either was directly responsible for the variation in the myographic component, or perhaps the mismatch in the semantic component triggered the ANS responses which then triggered the variation in the myographic component.

In any case, what we might have here is a demonstration of the sensitivity to "noise" (whatever that is) in at least one of the encoding components and/or evidence of interrelationships between the encoding components. It would seem that additional experimental investigation of the effect of internal noise on the activity of encoding components would be of considerable value in understanding the total encoding (and thus communication) process.

TABLES AND FIGURES

Subject #	"No" Responses Predicted Lie #	Actual Lie #	Success of Prediction	"Yes" Responses Predicted Lie #	Actual Lie #	Success of Prediction
1	1	3	-	3	2	-
2	2	2	+	4	4	+
3	3	3	+	2	2	+
4	4	4	+	1	2	-
5	2	2	+	1	1	+
6	1	3	-	2	2	+
7	2	2	+	1	1	+
8	1	1	+	4	3	-
9	4	3	-	3	1	-
10	3	3	+	2	2	+
11	3	3	+	4	3	-
12	4	4	+	2	2	+
13	2	2	+	3	3	+
14	4	2	-	3	1	-
15	2	2	+	1	1	+
16	1	1	+	4	4	+
17	3	3	+	4	4	+

Table 1. Predicted answers (on the basis of minimum duration), actual answers (number corresponding to lie response), and success of prediction ("+" = correct prediction, ("-" = incorrect prediction). (Fr. ≤ 0.01)

FOOTNOTES

1. The writer sees this procedure as serving a dual purpose. First, it provides for a control of the vocal responses to be later analyzed. Secondly, it enforces the notion of the low-risk subtle lie; therefore seemingly minimizing the likelihood of the subject to manifest vocal cues, but maximizing the curiousness of those cues if she does.

2. Another way to look at this pause after the stimulus question is as a sort of "build up period" for whatever emotion might accompany the oral response.

3. Although the present study did not examine psychophysiological variables, we can be certain that ANS responses were accompanying the vocal responses. (The "pick a number" lie format is an extremely reliable method of triggering ANS responses.) In light of this study's results it would be interesting to look for a correlation between amounts of ANS activity and amounts of acoustic peculiarity accompanying lies.

4. Although an analysis of intensity (obviously only cursory with a spectograph), fundamental frequencies, formant frequencies, etc., yielded nothing in the present study; the results of the duration information suggest that other acoustic properties might be worth investigating with more sophisticated equipmemt.

5. Pr. $(N=34, r=24) = \frac{N!}{r!(N-r)!} p^r q^{N-r}$. See [6].

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