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SACCADIC EYE MOVEMENTS IN DECEPTION

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by

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Lie detection, as currently practiced, relies heavily on the use of measures of autonomic activity. It is presumed that lying is emotionally more arousing than truth telling and that the increase in affective arousal is mirrored in the measures used in the conventional polygraph. We do not dispute the possibility that telling an untruth may be emotionally arousing. But this is not the entire picture. Zuckerman and Driver (1985) presented a four factor model of behavioral cues to deception, which, in addition to factors such as: attempted control, arousal, and affect, also includes cognitive factors, the category into which the present work falls.

Rather than proposing this approach as an alternative to the conventional indices, e.g., skin conductance or cardiovascular changes, we see it as an adjunct to those measures. Pertinent to this, Greene, O'Hair & Cody (1985) have said that "... although Ss may use inhibitory control to suppress leakage cues, this capability may be lost when demands of central processing are high." This is an argument for diversifying measures. For example, it would follow that including several measures, both cognitive and physiological, assuming their individual effectiveness, could increase the sensitivity of each measure alone. A subject's attempt to manipulate a particular measure would presumably create an additional processing burden, and this, in turn, would increase the probability that another measure would "leak", i.e., reveal, the added load.

We are not unique in proposing the use of markers of cognitive activity in the detection of deceit. For example, Farwell and

Donchin (1989), following this approach, found that the P300 wave of the EEG, widely used as an indicator of cognitive activity, consistently discriminated "guilty" from innocent conditions. More recent work with the event-related potential (Allen, Iacono & Danielson, in press, 1991) also exemplifies this class of research, and with equal success.

The working hypothesis for the present research effort is that the liar must fabricate an interdependent pattern of untruths in order to answer questions in a consistent manner. Closely related to this is the view that secondary, or so-called, "derived", facts, i.e., deductions from those in a deception model, are not as readily available to the liar as to the truth-teller. It is relatively simple, for example, for a person to regurgitate a prepared incorrect biographical fact upon interrogation, such as that he is 32 rather than his correct age. But in determining what his high school graduation date is, so as to be consistent with the incorrect age, would not be quite as simple. Generating such information, consequently, will be cognitively more demanding than if the answer were the truth. Recognizing the importance of this effect, Furedy, Davis & Gurevich (1988) took pains to control this source of variation in their study in order to isolate the factors they were investigating. It is the intention of this study, however, to capitalize on, rather than to control. this effect.

How might the greater cognitive demand of generating a plausible lie or series of lies be reflected in biobehavioral measures? Zuckerman and Driver (1985) suggest that speech characteristics, pupillary responses and gestures may be indicants of the greater complexity of cognitive activity associated with lying. With respect to speech characteristics, there are data suggesting that response latencies increase during lying (Donchin, 1990; Temple & Geisinger, 1990) and there are more frequent pauses during speech as a function of task complexity (Goldman-Eisler, 1968). Greater pupillary dilation is also associated with task complexity (Kahneman, 1973). Related to these studies is the finding that task demand, which would be increased by lying, according to the thesis developed above, is a factor that leads to a reduction in the frequency of gestures ("illustrators") (Ekman & Friesen, 1972). To these we have added electroöculographic (EOG) measures (Baker, Goldstein & Stern, 1992).

For many years this laboratory has been investigating the use of gaze control or oculomotor variables as indices of cognitive activity. Much of the work has been devoted to exploring the cognitive correlates of blinking (Bauer, Goldstein & Stern, 1987; Goldstein, Bauer & Stern, 1992; Goldstein, Walrath, Stern, & Strock, 1985; Orchard & Stern, 1990; Stern, 1988; Stern, Goldstein, & Walrath, 1984; Stern, Walrath & Goldstein, 1984). Moreover, considerable attention has been devoted to the use of information derived from saccadic eye movements to make inferences about cognitive activity (Dunham, Wolf, & Stern, 1990; Fogarty & Stern, 1989; Stern, 1978; Stern, Bremer, & McClure, 1974). In the application to be described here, the cognitive activity in question is that taking place while subjects are attempting to deceive.

In a recent study (Baker, Stern & Goldstein, 1992), a series of autobiographical questions, constructed on the basis of a pretest questionnaire, was presented to subjects on a computer display. They were told to lie in response to a subset of the questions which, on an earlier occasion, they had answered truthfully. Details of their psychophysiological responses were compared to those made in response to another subset of questions that had been answered truthfully on both occasions.

During these sessions, vertical eye movements (including blinks), horizontal eye movements and head movements in the horizontal plane were recorded. The focus of this study will be on measures derived from the lateral electrodes, i.e., those pertaining to horizontal eye movements.

Results of the Baker et al. (1992) study showed that deception produced a reliably longer reaction time (RT) from question onset to vocal response in 6 of 10 subjects. Utilizing the horizontal eye movements, reaction time was partitioned into several components. The first component, the time devoted to reading the questions, failed to discriminate lying from truth-telling. The second, the time spent thinking of an answer (so-called "think time"), detected lying in 5 of the 10 cases. Breaking down think time further, that part of think time spent in making saccadic eye movements was subtracted, leaving only that portion in which the subject was fixating. This "fixation time" measure was significantly longer under deception conditions in 9 of the 10 subj3cts. Apparently, saccadic activity while generating an answer is irrelevant to deception, essentially adding only noise. The discriminating factor is the time spent fixating. We presume that it is during this period that the subject is generating an answer. Whatever the mechanism, the high proportion of successful detections is encouraging.

Although these temporal characteristics of the response were the main focus of the Baker, Goldstein & Stern (1992) study, other data from that study, viz., post-response activity, are available but have not yet been analyzed in the detail necessary to draw any further conclusions. Specifically, we refer to what have been termed "lateral eye movements" (LEMS) in the literature (Day, 1964).

The study of LEMs has had a stormy history (Charlton, Bakan & Moretti, 1989). Much of the controversy has focused on whether LEMs reflect cerebral lateralization. It is well accepted that most subjects, when required to answer question requiring thought, exhibit lateral eye movements (Ehrlichman and Weinberger, 1978). It is also reasonably well established that many subjects demonstrate "consistency" in the direction of these lateral movements under anxiety arousing (Gur and Gur, 1975), or stress (Tucker, 1977), conditions. However, whether the direction of the LEM is diagnostic of cerebral lateral dominance in the execution of the required task, and whether this, in turn, is a function of the nature of the processing evoked by a stimulus, are questions for which the evidence is ambiguous. One finding that might be relevant to the detection of deception is the increase of left LEMs under stress conditions (Tucker, Roth, Arneson & Buckingham, 1977). Since the lying can be viewed as more demanding than telling the truth, this suggests that the frequency of left LEMs would be greater under lie conditions. The issue of hemisphericity (relevent to the direction of the initial movement), however, is less of a concern to us in the present context than is the utilization of eye movements, in general, in the detection of deceit.

It should also be pointed out that the study of LEMs has been restricted, by definition, to the first lateral eye movement that occurs following the presentation of a thought-provoking question. The data we propose to study here are not, therefore, restricted to LEMs, as usually defined. Instead, we propose to investigate all saccadic movements made after the verbal response has been made and prior to the next trial.

Despite the apparent difference between classical LEMs and the eye movements we propose to study, we advance the proposition that this focus is consistent with the theoretical basis for studying LEMs. That is, if the characteristics of the first saccade following task presentation is informative of the underlying thought processes demanded by that task, there is no reason to consider subsequent saccadic activity made in the process of executing that task any less informative. This is the assumption that underlies the present work.

Informal observations of the data of the Baker et al. (1992) study suggest that saccadic data may differentiate lying and truth-telling in the intertrial period extending from the point when the subject indicates readiness for the next trial, up to the beginning of the next trial. The subject has read the question and answered it. The question has been removed from the screen and the subject has indicated readiness for the next one. A period ensues during which the subject may be reviewing the answer and, in the event that it was a lie, checking it for accuracy. It seems reasonable that this might be a period in which the effects of lying will be manifested. These hypotheses, of course, are quite informal. Since there are no data in the literature that may be brought to bear on these issues, the proposed research is exploratory in nature, encouraged by the observations regarding fixation time alluded to above.

METHOD

The present study will utilize raw data, of which a portion has already been analyzed and reported in the Baker et al. (1992) study. The postresponse intertrial period will be the target of this investigation. This is the period starting from the point when the subject indicates readiness for the next trial and ends at the outset of the following trial.

Measures. The measures selected were all analyzed using the ratio (A-B)/(A+B), which was calculated for the first five seconds of the six second intertrial interval following each of the lie and truth questions. "A", in this ratio, represents the day 1 value (when all questions were answered truthfully) and "B" represents the day 2 values. One ratio was calculated for the truth items across days and another for the lie items across days. This ratio is the same as that used in the Baker et al. (1992) study and is designed to control for variations in day 1 baseline levels among questions when evaluating responses on day 2.

Transformations were carried out in instances where the data or the nature of the measure suggested that the distributions would not be normal.

RESULTS

Saccadic Behavior

Seven ANOVAs were conducted on saccade variables. For the first three, 2X2 ANOVAs were performed for each subject, with lie/truth (L/T) as one variable and direction (DIR) of saccades as the second. The measures analysed were: median saccade amplitude/trial; total of saccade amplitudes/trial; and total number of saccades/trial.

Three one-way ANOVAs (lie/truth) were performed. The first was an analysis of total saccade time. The second and third measures dealt with the variance of saccade amplitudes in a trial. In the second ANOVA, deviations were taken around the mean amplitude of that trial, and, in the third ANOVA, they were taken around the mean amplitude of the entire session, i.e., day. The results for each subject are presented in Table 1.

Table 1. Results of 2X2 (lie/truth and left/right) ANOVAs on: median amplitude of saccades per trial, total amplitude of saccades per trial and total number of saccades per trial. Results of one-way (lie/truth) analyses of variance on total saccade <u>time</u> (TotTime), variance of saccade amplitudes in a trial around the trial mean (s^2trial), and the variance of saccade amplitude around the session (i.e., day) mean (s^2day). Asterisks indicate p-values at or less than α = 0.05.

Subject	Med Amplit L/T	DIR	TXD	Tot Amplit L/T	DIR	TXD	Tot Number L/T	DIR	TXD	TotTime	s^2trial	s^2day
1												
2												
3												
4		*										
5					*							
6					*			*				
7												
8		*			*							
9	*				*	*	*	*				
10										*		

The final saccade analysis was a 2X5 ANOVA conducted with lie/truth as one variable and frequency of saccade amplitudes in five consecutive 50 A/D unit bins (from 0 to 250 A/D units) as the second variable. Though this analysis was somewhat redundant with that of median amplitude, it focussed on the shape of the distribution rather than a measure of its central tendency. Results showed no relationship (interaction) between truth status and the distribution of saccade amplitudes for any subject.

<u>Fixation Measures</u>

Six ANOVAs were performed on fixation measures for each subject. The first five were 1-way ANOVAs on the following fixation measures: fixation frequency (FixF), median fixation duration (FixD), largest fixation duration/trial (MaxFD), variance of fixation durations in a trial around the mean duration of that trial (s^2trial), and the variance of fixation durations in a trial around the mean duration of the entire session, i.e., day (s^2day). The results of these analyses are presented in Table 2. The final fixation analysis was a 2X4 ANOVA with truth/lie as one variable and the frequency distribution of fixation durations in four 500 ms bins (0-500, 500-1000, 1000-1500 and 1500-2000 ms) as the second variable.

Table 2. Results of one-way ANOVAs (lie/truth) on: fixation frequency (FixF), median fixation duration (FixD), largest fixation duration/trial (MaxFD), variance of fixation durations in a trial around the mean duration of that trial (s^2trial), and the variance of fixation durations in a trial around the mean duration of the entire session, i.e., day (s^2day). Asterisks indicate p-values at or less than α = 0.05.

Subject	FixF	FixD	MaxFD	s^2trial	s^2day
1					
2					
3		*			*
4					
5			*	*	*
6					*
7					
8					
9	*		*	*	*
10			*		

The final fixation duration analysis was a 2X4 ANOVA with lie/truth as one variable and frequency of fixation durations in four consecutive 500 ms bins (from 0 to 2000 ms) as the second variable. As with the analagous saccade analysis, this analysis was somewhat redundant with that of fixation duration, but again, it focused on the shape of the distribution rather than a measure of its central tendency. Only 3 subjects showed a significant Deception X Bin interaction: #3, #7 and #9, not adding much to the fixation duration analysis.

DISCUSSION

It is apparent that little, if any, support can be garnered from these results for the hypothesis that post-response saccadic or fixation activity differentiates truth-telling from deception. Considering the small proportion of the total number of effects analyzed that were significant, this conclusion is all the more emphatic.

Once the subject has indicated a readiness for the next trial, the effects of the previous trial are essentially over. An informal observation of blink activity supports this interpretation; there was a noticeable and consistent decrease in blinking toward the end of the 5 sec period under analysis. In many instances, there were no blinks at all in the final seconds of the ITI. In previous work (e.g., Goldstein, Bauer & Stern, 1992), reduction in blink rate in anticipation of an imminent event was the most consistent finding.

So as to restrict our focus to the portion of the ITI most likely to exhibit a residual of the prior question, all of the one-way analyses reported in the results above were repeated excluding the final two seconds of the five-second period. The results were equally negative, showing some spotty, but unsystematic significance.

It should be emphasized that the all the analyses reported above were performed on data from the same subjects who showed such a dramatic deception effect in the Baker et al. (1992) study. Given these contrasting results for the same subjects, the present data strengthen the conclusions in that study. Thus, there is a significant effect of deception when a subject is responding to a question, but when the subject is no longer occupied with the answer, the differential effects of lying and truth-telling disappear. Whether the effects of deception would have dissipated in the absence of the anticipatory effect (e.g., with a much longer intertrial interval), is an empirical question.

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