

5 through 6 was no less than about 75 percent of that on days 1 through 2 was not true for three of the North Carolina rats.

This is the first confirmed case of resistance to anticoagulant rodenticides by Norway rats in the United States. It is not known whether cross-resistance to all anticoagulants occurs, or whether a single autosomal gene is involved, or whether the phenomenon is present but not fully recognized in other U.S. populations (7). Details of the North Carolina field and test data have been presented elsewhere (8).

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7. Further investigations are in progress under a grant from the Philadelphia urban rat control program; rat populations in urban areas will be sampled and tested.
8. W. B. Jackson, paper presented at the Vertebrate Pest Conference, Fresno, California, 7-9 March 1972.
9. We appreciate the assistance of C. Wright in identifying the resistance site, of D. Patterson in collecting the rats in North Carolina, and of B. Walker and B. Marsh in collecting the rats in Cleveland. Supported by a grant from the research committee of the National Pest Control Association and by the Cleveland Health Department.

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Cardiac Change as a Function of Attention to and Awareness of Continuous Verbal Text

Abstract. *A 17-minute passage taken from a patient's talking in a psychoanalytic interview was played to 40 subjects, including trained therapists, therapists in training, and inexperienced undergraduates. Subjects were alerted to the organizing theme (termination of the patient's treatment) and asked to attend to direct and indirect references to this theme. Tonic heart rate, averaged over 30-second periods, was lower when clues were present on the tape than during control periods when clues were not present. Profiles of phasic heart rate were drawn for 11-second periods that overlapped the end of each clue and control passage. Profiles associated with clues were significantly lower than profiles for control passages; profiles for recalled and recognized clues showed a wave form distinct from that of profiles associated with unrecognized clues.*

Heart rate tends to drop when attention is directed to an external stimulus (1, 2). Two types of changes have been reported. A tonic decrease was found by Lacey *et al.* (3) in a study of the effect of different types of stimulus situations on mean heart rate; mean rates tended to decrease in situations that required attention outward (for instance, flashing lights) and tended to increase in situations that required attention inward (such as mental arithmetic). A phasic decrease was reported by Lacey (2) in a reaction-time experiment. Heart rate was monitored beat-by-beat from the time a warning signal flashed to the time the subject made a motor response; heart rate showed a systematic drop during the preparatory interval, and reached a minimum at the moment when the response was made. He also found that reaction time was inversely correlated with the size of the drop.

The stimuli used in most of these

studies have been fairly explicit and isolated in time; examples are warning tones, flashing lights, and discrete pictures. We wanted to determine whether subtle differences in meaning, when embedded in continuous prose, would also be reflected in tonic and phasic changes in heart rate. If stable cardiac measures could be found, they might permit continuous monitoring of attention with a minimum of interference. Lacey's formulation would predict both the decrease and stabilization in mean heart rate and in beat-by-beat changes at time points when attention was being directed to parts of the stimulus. We also wished to determine how physiological changes interacted with conscious awareness. Were these changes always an accompaniment of awareness, or did they sometimes occur independently of it? If the latter were the case, could attention be gauged more sensitively by cardiac responses than by cognitive measures of awareness?

The stimulus consisted of a 17-minute, tape-recorded segment of a patient talking during a psychoanalytic session. Only the patient's voice was heard. Three practicing psychoanalysts listened to the tape and indicated those parts that, in their opinion, pertained to the theme of termination of treatment; from their ratings, 22 references were selected. Some were clear references to termination in a disguising context (*In-dependence Day*; *Liberty*, Kansas), and some used metaphor or analogy ("When do you wean the baby?"; "I dreamed of being on a long train trip and having to get off"). The clues were carefully spaced by filler words and silence so that the median separation was 22 seconds; only one pair of clues was less than 10 seconds apart.

Each of the 22 termination clues was marked by a tone on the second track of the stimulus tape (the text of the stimulus was on the first track). The 20 control clues were marked by a different tone. Neither tone was audible to the subject. None of the control clues had been chosen by any of the original judges as a reference to termination; these clues consisted of such filler phrases as "That doesn't happen very often," "Assuming it was obvious," and so forth. The control clues were spaced at least 11 seconds from each other and from any of the termination clues. The marker tones were positioned to coincide with the last word in each clue phrase. The tones were used in the data analysis to mark the heart beats associated with each clue; a special program searched for each tone and computed the beats-per-minute heart rate for the 5 seconds before and after each tone.

Forty subjects, about equally divided among professional therapists, therapists in training, and inexperienced undergraduates, were asked to listen to the tape and pay particular attention to references to termination of treatment. Examples of such references were not given; rather, the subjects were free to choose whatever appealed to them as a clue, but they were asked not to talk or make any motor response while the tape was running. The subjects were told to be ready to recall the references to termination in their original wording after the tape had stopped. Electrodes were then attached to the index and middle fingers of the left hand, to the right wrist, and to the left ankle; leads ran to an Electronic Industries data logging system, which made a digital

recording of beat-by-beat heart rate, galvanic skin response, and basal skin resistance. Only the heart rate data are reported here.

After the electrodes had been attached, the subject remained in isolation for 2 to 4 minutes while the recordings on the polygraph were checked to make sure that all signals were functioning and reasonably well stabilized. The instructions were then given, and stimulus tape and digital tape were started in synchrony with a pacing clock. The clock time, in seconds, and the two sets of marker tones were recorded on the digital tape along with the physiological information.

When the stimulus tape was finished, each subject was asked to recall all references to termination. Recall of specific wording was encouraged so that the reference could be precisely located in the protocol. Recall was scored only if the clue could be unambiguously reconstructed from the subject's report at the end of the session, and only if all words in the clue were present; single words or paraphrases did not count. Recognition was next scored by giving the subject a transcript of the protocol and asking him to underline all termination references that he had noticed while listening.

Tonic changes were determined by measuring mean heart rates for particular intervals when termination clues were present as compared with those when clues were absent. All but two subjects recalled at least one termination clue, and the clue chosen by the largest number of subjects (49 percent), "How do you know when to stop?" was the reference point for the first analysis. This clue occurred in minute 9 of the stimulus, together with a second clue, chosen by four subjects, "Nurse until the milk runs out." No control clues were contained in this segment. Minute 8 of the stimulus contained three control clues and no termination clues. We computed mean heart rate during minute 9 for each subject and compared it to the value during minute 8. Mean heart rate was lower in minute 9 for 29 subjects and higher for 11 ($P < .01$, two-tailed sign test). This suggests that when material related to termination was present in the tape—that is, when attention was being directed to the stimulus—heart rate decreased.

Because heart rate tended to decrease over time during the 17-minute listening period, it might be argued that

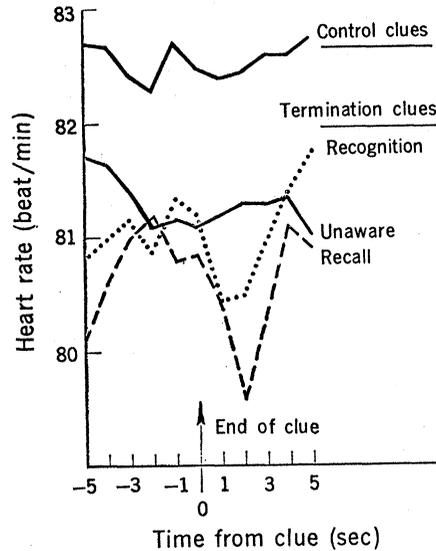


Fig. 1. Averaged heart rate response as a function of relevance (termination clues present or absent) and fate of the clue (recall, recognition, or unawareness). The heart rate is depressed for all classes of termination clues. When the subject is unaware of the clue, the course of heart rate is fairly steady through time. When the clue is either recognized or recalled, a distinct wave form is found, with the lowest heart rate at the end of the clue period.

heart rate in minute 9 was lower simply because this interval came later, and not because more attention was paid to the stimulus. To counter this argument, we compared a segment that contained two termination clues (minutes 3 and 4) with a segment that contained no clues and that came later in the protocol (minute 6). Once again, mean heart rate was lower during the segment that contained the termination clues, even though this segment preceded the control segment; 29 subjects had lower mean rates during the critical segment than during the control ($P < .01$, two-tailed sign test).

Did the change in heart rate merely reflect changes in attention, or did it also pick up changes in awareness, as measured by recall of the critical clues? To test this point, we computed mean difference scores between minutes 8 and 9 for subjects who recalled one or more termination clues during minute 9 and compared them with scores for subjects who recalled no clues during minute 9. The two sets of scores were not significantly different. Results were similar when we compared difference scores for subjects who recalled one or more termination clues during minutes 3 and 4 with scores for the remaining subjects. It would appear that a drop in heart rate reflects an increase in attention to

the critical parts of the stimulus material, presumably because these parts contain information about termination, but that this increase does not necessarily result in greater recall of the termination clues. In other words, tonic changes in heart rate may pick up shifts in attention that cognitive measures (for example, recall of clues) may miss.

Phasic changes were determined from recordings from 34 of the 40 subjects, which gave detailed beat-by-beat information in the vicinity of each of the 22 termination clues and 20 control clues; the records of the remaining 6 subjects could not be scored in this manner because of transient errors in the recording process. Heart rates (in beats per minute) were computed for the 5 seconds before and after each marker tone this put all subjects on an equal time base.

The 11-second profiles for termination clues and those for control clues were averaged for each of 34 subjects. The 68 sets of averages were then analyzed by a repeated-measures analysis of variance (4). The mean heart rate for termination clues was significantly lower than the mean for control clues ($F = 14.64$, $P < .001$). As in the comparisons made for longer time intervals, heart rate dropped in the vicinity of the termination clues and rose in the vicinity of the control clues. Again we checked to see whether the mean drop for each subject was related to his awareness of the termination clues and found that total number of clues recalled was moderately correlated ($r = .25$) with mean drop in heart rate. To study this relation more precisely, we partitioned the termination clues for each subject into three sets: clues that were recalled, those recognized, and the remainder, of which the subject was unaware. The 11-second profiles were averaged by set for each subject, and the three averages, together with the control averages, were analyzed with a repeated-measure analysis of variance.

The mean heart rates for the four sets of clues were significantly different from each other ($F = 6.02$, $P < .001$), and a Dunnett test showed that rates for recalled clues were significantly lower than those for control clues and were the primary reason for the low overall rate for termination clues. Rates for the other two classes of clues were not significantly different from control values. There was also a significant effect over time ($F = 2.23$, $P < .025$) and, as

a result, separate trend analyses were performed for each of the four profiles (Fig. 1). The control profile showed no significant trend, the profile for recalled clues showed a significant cubic and quintic component, that for recognized clues showed a significant cubic component, and the clues of which the subject was unaware showed no trend (5). These data suggest that awareness of the clue (as manifested by later recognition or recall) is reflected in a cardiac profile with a pronounced cubic component (two inflections); as such, the profile shows a good approximation to the cubic curves reported by Roessler *et al.* (6) for cardiac response to random tones, and to the curves reported by Schwartz and Higgins (7) for cardiac reactions to a simple motor response or to its ideational equivalent. All four profiles show an accelerative component after stimulus onset; this component is followed by a decelerative drop. When subjects in the present experiment were aware that a meaningful verbal clue was present in the protocol, their cardiac change closely followed the pattern shown by other subjects in response to explicit sounds or warning lights.

Our data support the work of Lacey (2) and his colleagues to the extent that attention to an external stimulus is reflected in a drop in mean heart rate. We would add that cubic change in rate is a good predictor of later recall; such a rate change seems to be a sign that the stimulus is being converted into

long-term storage. Other, more subtle aspects of the cardiac profile seem to parallel changes in amount of attention being invested in the stimulus, and may pick up variations that are not reflected in later conscious report.

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ceding the stimulus (1), or moderate slowing of background rhythms suggestive of "microsleep" (2).

Interruptions in the steady stream of thought are characteristic of patients with seizures and schizophrenic thought disorders. Paradoxically, these individuals may make prompt, almost reflexively immediate responses a few moments before or after the unexplained interruption. Scrutiny of simultaneous EEG's from scalp and limited subcortical placements has disclosed no change consistently related to the delayed reaction time or interrupted speech unless a frank seizure coincidentally occurs (3). Use of the high-speed digital computer, implanted electrodes, and averaged EEG from intervals immediately preceding or succeeding the stimulus (that is, time-locked to the stimulus) has led to demonstration of significant correlations between poststimulus evoked potentials or power spectra and response direction in trained cats in response to visual or auditory stimuli (4). If the wide variations in reaction time associated with certain acute or chronic brain syndromes reflect abnormal neuronal activity that is discernible at the scalp only as nonspecific slow and sharp activity, sorting of spectra time-locked to stimuli and associated with long and short reaction times may distinguish a more specific relation of erratic response to underlying disturbance in physiology.

Three lines of evidence legitimize this endeavor. (i) Although the irregularities of the EEG that occur in nearly half of the subjects with acute psychoses are of a nonspecific type, recordings from subcortical electrodes in such individuals have demonstrated spike activity related to disturbances in mental state (5). (ii) One of the few consistent objective psychologic measures in patients with schizophrenia is the considerable variability of reaction time, particularly in the processing of relatively complex verbal information (6). (iii) When deviations of both EEG and consciousness are more severe, as during epileptic absence, there is an unmistakable association between reaction time and abnormal discharges recorded in scalp or subcortical EEG's.

An auditory recognition task for verbal stimuli was used, in which the subject was read a list of 50 to 60 one-syllable words, half of which contained the letter G, N, I, or K and half of which did not. The subject was seated with eyes closed in a comfortable re-

Electroencephalographic Spectra and Reaction Time in Disorders of Higher Nervous Function

Abstract. *Cerebral electrical abnormalities associated with variability of attention and responsivity were sought in individuals with schizophrenia and epilepsy. Experimental and control subjects were given stimulus-response tasks, and average power spectra for brief electroencephalographic epochs preceding responses of short and long latency were compared. Spectra that precede long-latency or erroneous responses resemble the "ramp" configuration of spectra computed from scalp electroencephalograms for 1-second epochs triggered by (time-locked to) focal subcortical spikes.*

Extraordinary variability of attention, mood, and activity are characteristics of the stream of thought or behavior in a number of neurological and psychiatric disorders and suggest frequent and abrupt fluctuations in the regulation of underlying neural processes. The hypothesis tested in this study was that such variability might be temporally associated with the deviations from nor-

mal frequency and voltage commonly recorded in the scalp electroencephalogram (EEG) of individuals with a variety of severe behavior disorders and psychoses and in some patients with epilepsy. Examinations of EEG spectra associated with short and long reaction times in normal controls have yielded conflicting results, but in general indicate either no systematic change pre-