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SESSION IX
COMPUTER APPLICATIONS IN SINGLE-SUBJECT RESEARCH DESIGNS

Michael Yost, *Presider*

A longitudinal study of cardiac component analysis

FREDERICK J. BREMNER, MICHAEL YOST, and CLIFTON ZINTGRAFF
Trinity University, San Antonio, Texas

The purpose of this study was to examine the reliability of a physiological event over several weeks. The physiology analyzed was the electrical event of the heart. Two operationally defined components of the typical heart response were examined. The technique gave very reliable data within a given day. Moreover, when the data for 20 weeks were added, the overall standard deviation was very small, but there were unpredictable physiological variations from day to day. The data suggest that comparisons between psychological tasks using physiological events as the dependent measure are best done in close temporal contiguity.

Bremner, Yost, and McKenzie (1982) reported that EEG data can be used as dependent measures in single-subject designs, and that it is legitimate to use standard inferential statistics in analyzing these data (Bremner & Yost, 1984; Yost, Bremner, & Fox, 1984). The approach developed by Bremner et al. (1982) in analyzing EEG data was extended by Brown (1983), who showed that physiological manipulations of the brains of anesthetized cats could be discriminated by single-subject multivariate analysis of variance. Moreover, Brown demonstrated that replications of this single-subject technique were reliable by testing seven replications (seven cats) with Fisher's combined probability test.

Eddy, McKendree, McKenzie, and Bremner (1982) reported that the applications of single-subject design and inferential statistics to components of the electrocardiogram (cardiac component analysis, CCA) was also a powerful technique. Since there were only two replications (two subjects) used in this study, it was difficult to determine whether single-subject designs were reliable across replications when the electrophysiology of the heart served as a dependent measure. In a recent study (Bremner, Strauss, & Samples, 1985), the reliability across subjects was demonstrated by applying Fisher's test (Hays, 1963) to three replications of the same single-subject experiment. In that experiment, the dependent measure was identical to that used by Eddy et al. (1982).

The authors' mailing address is: Department of Psychology, Trinity University, San Antonio, TX 78284.

The present study tests the reliability of single-subject analysis of the CCA technique in a different way. The Bremner et al. (1984) study tested for reliability across subjects' replications; the current study tests the reliability of replications within a single subject over time. In short, this is a methodological study to test the longitudinal reliability of the CCA technique.

METHOD

Subject

The subject in this experiment was a 40-year-old male with 10 years of experience in meditation exercises and biofeedback training. Our goal was to use an expert subject with years of practice on each of the tasks. Table 1 contains the experimental design.

Apparatus

The apparatus consisted of the following segments: recording, biofeedback, and data analysis. The recording circuit made use of Data Incorporated (2124) solid-state amplifiers, a Johnson stripchart recorder, a Tektronics (5103N) CRT, and a Vetter 700 series, seven-channel analog tape deck.

The electrophysiological data-recording and storage methods were standard. For the EEG, scalp electrodes served as transducers over the right and left occipital cortex (01 and 02) referenced to each ipsilateral ear. These EEG leads were each connected to a Data Incorporated amplifier, which was connected to the stripchart recorder

Table 1
Experimental Design

Tasks	Days 1	2	3	20
Meditation	20 PQ Scores 20 ST Scores			
Hand Levitation	20 PQ Scores 20 ST Scores			
Biofeedback	20 PQ Scores 20 ST Scores			

and the analog tape recorder. For the heart response, two paste-on Midwest Monitoring pregelled electrodes (Model No. 1A-5S) were placed diagonally, one in the left subclavicular space and the other over the right intercostal space between the 10th and 11th rib. These leads were connected through one of the Data Incorporated amplifiers to the recording system.

The biofeedback circuit (Helmer, 1975) presented filtered EEG alpha waves to the subject via a loud speaker. The subject was tested in a soundproof Industrial Acoustics Chamber, which contained a well-padded chair, the mandala (Ornstein, 1977), and paraphenalia necessary for electrophysiological instrumentation.

The data-reduction and statistical-analysis functions were performed as follows. Converting the analog heart signal to digital data (A/D conversion) was performed by a Digital Equipment Corporation PDP-11/24 computer, which also ran the CCA program. An IBM 3031 computer was used to obtain a set of descriptive statistics on the output of the CCA program. These were sent on-line to an IBM PC-XT, which performed the inferential statistical analysis and graphing of results.

Procedure

The subject was instrumented for heart and brain electrophysiological recording and then seated in the soundproof chamber where the electrode leads were attached to the amplifiers. He subsequently performed three tasks: a meditational task looking at a mandala (Ornstein, 1977), a hand levitation task looking at the right hand (Hyman, 1978), and a biofeedback task while listening to the left-side occipital lead (Bremner & Moritz, 1972). Each of these tasks lasted for 60 sec. This procedure was repeated once a week on the same day at the same time for 20 weeks. From week to week, the tasks were presented in a counterbalanced order.

The electrophysiological data, recorded during these tasks, were A/D converted and then mathematically analyzed. (The EEG data will be presented at meeting of the Biofeedback Society in April 1985.) The electrophysiology of the heart was analyzed by a revised version of the CCA program. The current CCA program finds the peaks and valleys of the P, Q, R, S, and T waves of the typical electrocardiogram. After the peaks and valleys are found, the program determines the duration of the subcomponents PQ and ST. The PQ component is operationally defined as the elapsed time from the start of the heartbeat to the bottom of the Q wave, and the ST component is the elapsed time from the bottom of the S wave to the end of the heartbeat. These points were picked because they are very consistent. These two values are collected

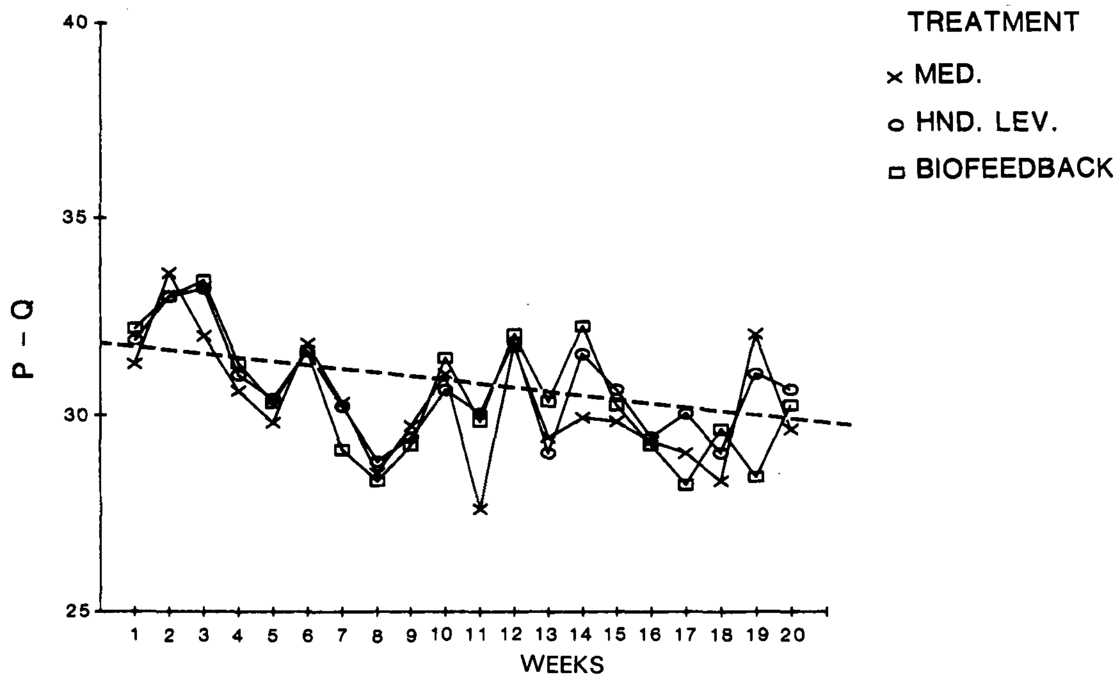

Figure 1. The means for the PQ interval for each of the three tasks for the 20 weekly sessions.

for 20 consecutive heartbeats, and their means and standard deviations are calculated. This version of the CCA program is more flexible than the Eddy et al. (1982) version, in that the current version allows the user, through menu-driven interface, to change parameters that affect the operational definitions in use. This feature allows, and is used only in, adapting the program to different experimental settings (e.g., to adjust for the inherent maturational differences between children's and adults' data).

RESULTS

The means for the PQ interval for each of the three tasks are presented in Figure 1. Since all three tasks covary, a single regression line was fitted to the mean value for each day for all three tasks. We fitted a regression line to the means of each of the tasks, but, since they overlapped, we represented these three regression lines with the same line. The mean values plotted were very good estimators of the PQ interval because the standard deviation for any task mean (approximately 30 msec) on any given day was small (SD < 3).

Figure 2 represents the means of the ST interval for each task for each day. The technique for fitting the regression line for these data is described for the PQ data above. While the deviations from the regression line for the ST data are larger than those for the PQ data, the three task means covary (see Figure 2), as did the PQ interval data. Moreover, the SD for each task mean (82 msec) for each day is small (2.5). We added the ST scores for all 20 days for each treatment together and found that the mean for each treatment was the same (82.1 msec) and that the standard deviations for the tasks ranged from 2.7 to 3.0.

DISCUSSION

Figures 1 and 2 indicate that the regression lines for these longitudinal data have a small negative slope, which is expected for a long-time practitioner of meditation. This study also deals with the reliability of these physiological data as dependent measures. The PQ-interval data show reliability in several ways. First, the means for each task for each day show little variability and, in addition, similar tasks show similar values. On the other hand, different tasks obviously show significant differences (Eddy et al., 1982). Finally, the variance of the means from the regression line is small (see Figure 1).

Although these two dependent measures are different (mean PQ = 30 msec; mean of ST = 80 msec), they have similar reliability characteristics. However, there is one obvious exception: The variations about the regression line are larger for ST than for PQ. This is most apparent during the first several weeks of the study, and represents a kind of Skinnerian "start-up effect." As the weeks progress, the fluctuations about the regression line decrease.

Taken as a whole, these data suggest that the CCA technique is very reliable within days, even across tasks, but that it is less reliable between days. Therefore, when the tasks reported here are used as baseline tasks, as in our laboratory, it is best to present the baseline tasks in the

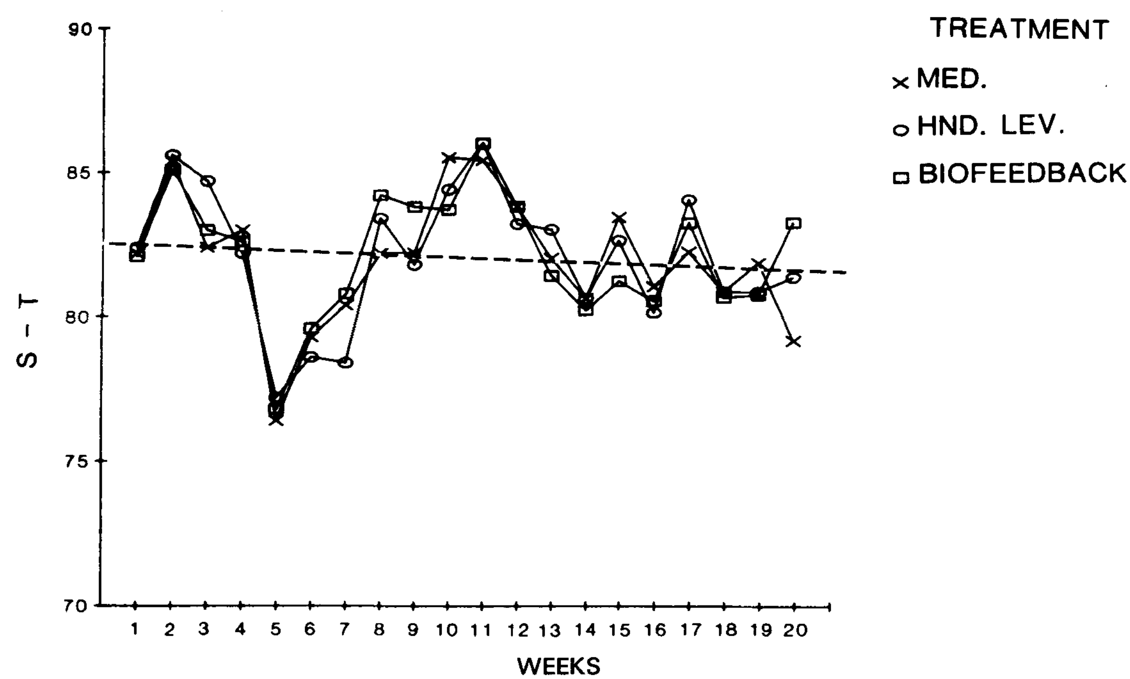

Figure 2. The means for the ST interval for each of the three tasks for the 20 weekly sessions.

same session with the experimental task. That is, even in highly controlled single-subject designs, the natural physiological variation between days might well mask the difference between baseline and experimental data unless they are in close temporal proximity.

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