SESSION V MODELS AND METHODS IN PSYCHOLOGICAL RESEARCH

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Developing probability limits for longitudinal physiological data

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The objective of this study was to determine what amount of change in heart electrophysiology is necessary to yield a significant difference between a baseline condition and an experimental treatment condition. In a single-subject longitudinal design, a modification of a *t* test was applied to baseline data, and the performance levels for both .05 and .01 probability levels were obtained. It was concluded that it is both ethically sound and physiologically safe to permit a subject in this type of experiment to physiologically respond at levels that would reach both the .05 and the .01 levels of significance.

Traditionally, psychologists have been interested in testing the robustness of an experimental design and statistical analysis (Bremner, Yost, & McKenzie, 1982; Kratochwill, 1978; Norton, 1952; Shine, 1982). Norton (1952) studied several skewed data populations to demonstrate the validity of the *F* statistic with erratic data sets. Shine (1982) used a similar statistical technique and tested the robustness of an analysis of variance when applied to data in a single-subject experimental design. Following Shine's publication, several single-subject experiments using human electrophysiology as the dependent measure (Bremner, Strauss, & Samples, 1985; Bremner et al., 1982; Eddy & Moise, 1985) were published. One of the measures used in these studies was cardiac component analysis (CCA). CCA reflects changes in heart physiology that are related to both physiological (Armstrong, 1985) and psychological stress (McKendree, 1982). The CCA technique (Eddy, McKendree, McKenzie, & Bremner, 1982) divides the typical EKG response into components (P, Q, R, S, and T) and then measures the time duration of each component. This study uses a single-subject design similar to those cited above to analyze the CCA measure.

The objective of this study was to examine the efficacy of CCA as a dependent measure for psychological experiments. We asked the question: How much difference must there be in the duration of the PQ or ST component of the EKG of a single subject under different experimental

conditions in order to reach the accepted .01 and .05 significance level? Furthermore, can this amount of difference in PQ or ST duration be both feasibly and ethically obtained? These questions are of particular importance with regard to CCA research, since there is a possibility of endangering the health of a subject in an attempt to obtain significant results.

METHOD

Subject

The subject used in this study was a 45-year-old male with 20 years of experience in both meditation and biofeedback. The subject was chosen because he was considered an "expert" in each of the experimental tasks.

Apparatus

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

Both EEG and EKG data were gathered and stored using standard methodology. In recording the EEG data, scalp electrodes served as transducers over the right and left occipital cortex. The EEG data have been reported as a part of a study already published by Yost, Bremner, and Fox (1985). In recording the EKG, two paste-on Mid-west Monitoring pregelled electrodes were placed diagonally in the right intercostal space between the 10th

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and 11th ribs. 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 through a speaker to the subject. The subject sat in a soundproof Industrialized Acoustics Chamber. This chamber contained a well-padded chair, a mandala on the wall opposite the chair, and the other paraphernalia necessary for electronic instrumentation.

A Digital Equipment Corporation PDP-11/24 computer converted the analog heart signal to digital data (A/D conversion) and also ran the CCA program. An Appleworks program (Lissner, 1983) was used on an Apple IIe computer to create a data matrix.

Procedure

After being instrumented for both brain and heart electrophysiological recording, the subject entered a soundproof chamber, and the electrode leads were attached to the amplifier. The subject performed three tasks: meditation, while concentrating on the mandala on the far wall; hand levitation, while looking at his right hand; and biofeedback, while listening to feedback from the left-side occipital lead. The tasks were presented in a counter-balanced order from week to week. The left-side occipital EEG signal was used for the biofeedback signal, and the CCA data were the dependent measures. The subject performed each of the three tasks for 60 sec once a week on the same day of the week at the same time of day for 44 weeks. Note that only the data recorded during the biofeedback task were used in this study.

The EKG data that were collected during the three tasks were A/D converted and mathematically analyzed by a CCA computer program (Bremner, Yost, & Zintgraff, 1985). This computer program located the P, Q, R, S,

and T points of the electrocardiographic signal. After finding each of these points, the program determined the length of the PQ and ST subcomponents. The PQ value was operationally defined as the time that elapsed from the beginning of the heartbeat to the bottom of the Q wave, and the ST value was defined as the time that elapsed from the bottom of the S wave to the end of the heartbeat. The PQ and ST durations were chosen for this study because they were of consistent durations. The PQ and ST duration times were both collected for 20 consecutive heartbeats, and their means and standard deviations were calculated.

Analysis

The equation for the correlated t test was algebraically solved for the difference in the means (X). From the data collected during the feedback condition, an Appleworks spreadsheet was used to compute the theoretical value of X with probability levels of .01 and .05. This was done by substituting the means and standard deviations for the biofeedback data in the transposed t test equation. The actual mathematical manipulations were performed in an Appleworks spreadsheet computer program.

RESULTS AND DISCUSSION

The results of the study are presented in Figures 1 and 2. Figure 1 is the data representing the PQ duration times, whereas Figure 2 represents the ST duration times. These figures contain the means for biofeedback baseline data (in milliseconds), and the means necessary to obtain a difference with a probability of .01 and .05.

Note that a regression line has been fitted to each of the three vectors of means. The distance between the regression lines represents the increase in PQ or ST duration necessary to reach a univariate statistically signifi-

Figure 1. Analysis of PQ component.

Figure 2. Digitized EEG signal.

cant difference. It is obvious from the parallel regression lines in the figures that the difference necessary to reach a significant difference with both PQ and ST is less for .05 than it is for .01. It should be noted that we have assumed that the variances of each set of data are both equal and independent. Although this is the usual assumption, it is doubtful that it would hold true for two sets of physiological data.

The importance of these results is that they are well within the normal physiological limits of the duration of these components for human beings. In the McKendree (1982) study, the difference between the baseline data and a maximum cognitive performance task was as large as 10 msec. In a study using children as subjects (Bremner, Strauss, & Samples, 1985), the ST duration changed by as much as 8 msec, even though the experimental tasks were nonstressful. In short, it appears that it is feasible to change the PQ duration enough (4 msec on the average) to reach the .05 level of significance without endangering the well-being of the subject. In order to obtain these differences, we used biofeedback, a very stable baseline task. With this in mind the difference needed (at $p < .05$) to show a change in the ST duration was approximately 1.5 msec (on the average) when comparing biofeedback to our theoretical task. If the ST duration of the EKG is sensitive to psychological workload, as Armstrong (1985) suggests, then the high stability of this measure should be useful in revealing differences in psychological tasks. Although the PQ duration was slightly more variable, the average amount of change necessary was still less than 2 msec. Since the PQ duration is considered to be a measure of physical change, it should be sensitive to small reaction time differences.

Finally, it is apparent that it does not take strong psychological or physical stress to produce changes of 1-

2 msec, and we therefore need not worry about the ethical issue of overstressing the subjects in this type of study.

REFERENCES

- ARMSTRONG, G. C. (1985). Computer-aided analysis of in-flight physiological measurements. *Behavior Research Methods, Instruments, & Computers*, 17, 183-185.
- BREMNER, F. J., STRAUSS, R. N., & SAMPLES, S. D. (1985). Computer analysis of physiological events during complex task performance: Heart electrophysiology as a dependent measure in children. *Behavior Research Methods, Instruments, & Computers*, 17, 173-175.
- BREMNER, F. J., YOST, M., & MCKENZIE, R. (1982). Computer-managed inferential statistical analysis of EEG data. *Behavior Research Methods & Instrumentation*, 14, 300-302.
- BREMNER, F. J., YOST, M., & ZINTGRAFF, C. (1985). Computer applications in single-subject research designs: A longitudinal study of cardiac component analysis. *Behavior Research Methods, Instruments, & Computers*, 17, 319-322.
- EDDY, D. R., MCKENDREE, J., MCKENZIE, R., & BREMNER, F. J. (1982). Component analysis of EEG by computer. *Behavior Research Methods & Instrumentation*, 14, 290-293.
- EDDY, D. R., & MOISE, S. L. (1985). A comparison of single-subject and traditional statistical designs in steady-state evoked potential research. *Behavior Research Methods, Instruments, & Computers*, 17, 323-326.
- HELMER, R. J. (1975). Modulator and filter circuits for EEG biofeedback. *Behavior Research Methods & Instrumentation*, 7, 15-18.
- KRATOCHWILL, T. R. (1978). *Single subject research: Strategies for evaluating change*. London: Academic Press.
- LISSNER, R. (1983). *3 E-Z Pieces: Integrated spread sheet, word processing and data base for Apple II computers*. Los Angeles: Haba Systems.
- MCKENDREE, J. E. (1982). Electrocardiographic correlates of psychological state. *Texas Psychologist*, 34, 13-16.
- NORTON, D. N. (1952). *An empirical investigation of some effects of non-normality and heterogeneity on the f-distribution*. Unpublished doctoral dissertation, State University, Iowa.
- SHINE, L. C. (1982). Multivariate single-subject ANOVA. *Educational & Psychological Measurement*, 42, 87-94.
- YOST, M., BREMNER, F., & FOX, C. (1985, April). *Biofeedback: A longitudinal study on a single subject*. Paper presented at the meeting of the Biofeedback Society of America, New Orleans, LA.