Control System Analysis of Pursuit Tracking in Special Education Students

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The present study was motivated by a desire to do some research within the framework of Powers' Control System Theory(1973). It is rare in Psychology to be able to accurately predict people's behavior in any task to any great degree. The Pursuit Tracking Task as analyzed by William Powers is an interesting exception. He has stated that he is able to predict behavior in this task to a high degree of accuracy. We chose the task of Pursuit Tracking for this exploratory study because of the promise it held foraccurate predictions of behavior.

We chose to study special education students because of their availability at our place of employment, namely, Bancroft School which is a private, special education school in Haddonfield, NJ, and because of our interest in coming up with testing procedures which might have a high interest value to the students, tell us something about their cognitive functioning and have a low demand on verbal abilities.The Pursuit Tracking Task was presented as a computer game.

The questions we hoped to answer in this study were:
(a) How accurately can one predict student's behavior in this task?
(b) What does performance in this task relate to? The dependent variable consisted of measures of students' performance in six trials of Pursuit Tracking. The independent variables consisted of one task variable(Easy/Difficult) and three subject variables(IQ, attentiveness in the classroom, behavior problems at home).

Method

Description of Task--Subjects were seated in front of a Commodore-64 Computer. On the screen there appeared a bar which was red on the ends and green in the middle. The subject had control over the vertical movements of the red lines by means of a game paddle. The computer moved the green part up and down in a random fashion. The subject's job was to chase after the green part with the red parts so that the three parts remained in a straight horizontal line. There were two levels of task difficulty(easy/difficut)

which referred to how fast the computer moved the green line. For the Easy task the green line moved slowly while on the Difficult task, the green line moved considerably faster.A computer program generated the two different difficulty levels.

Description of Subjects--The subjects were 22 students in the "ACT UNIT" whose parents had given permission for their participation in this study. The ACT UNIT is composed of students who follow a more academically-oriented program at Bancroft School. Of course, this selection of subjects limits our conclusions to people with similar characteristics. The mean IQ was 73 with a range from 43 to 104. The mean CA was 15.96 years with a range of 12.5 to 20 years old. The educational classifications included MH(13),NI(1),EMR(1),ED(7).

Description of Procedure--Each student was given six trials on the Pursuit Tracking Task. Half the students, were randomly given three trials of the Easy Task first, then the Difficult Task. This was reversed for the other half of the students. On the third and sixth trial, the students exact responses during the task was saved to disk for later analysis from which a computer program calculated the "transfer function." On each trial, some summary statistics of their performances was printed out on the printer. The total procedure took about 30 minutes .

Description of Other Data Collected--The subjects' parents completed Achenbach's Child Behavior Checklist which provides measures of behavior problems as perceived by the parents.

In addition,the teachers gave ratings of the students with respect to how well they payed attention and concentrated in the classroom. The ratings could vary from 0 to 100 and referred to the percentage of time the students typically attended during a typical day.

The students' latest IQ scores were obtained from Bancroft School records.

Results

Accuracy Data.

How accurately can performance on Pursuit Tracking be predicted? To answer this question, a "transfer function" was calculated from the experimental data by means of a computer program. The transfer function is defined as the

response of a person to a unit disturbance. From the transfer function, the person's behavior in the Pursuit Tracking task can be predicted and compared to the observed behavior. An example of the transfer functions obtained in the Easy and Difficult Tasks are shown in Figure 1 along with the definitions of the terms: negative peak, delay to peak, and delay to axis return. The mean percentage of variability accounted for in the Easy Task was 88.45. The mean percentage of variability accounted for in the Difficult Task was 86.04. These two means are not different statistically(t=1.31, p=.19). In terms of correlation, these means translate to .94 and .93, respectively, and provide a comparison of the actual behavior in the Pursuit Task to the theoretically predicted behavior.

It was found that the performance of the students was different as a function of task difficulty. The dependent variable was the " stability number " which Powers defines as: 1-square root of ((the expected variability if the person does not try to track/ (the observed variability)). The mean value of the stability number for the Easy Task was 4.54 versus 3.61 for the Difficult Task. Thus, the students tracked better on the Easy Task. The t-value was 1.78,p=.08.

The transfer functions for the students were further analyzed. The Easy Task had a larger negative peak, the peak occurred sooner, and it took longer to return to the axis.

Correlational Data.

What does performance on the Pursuit Task relate to? Does it relate to IQ? The correlation between stability number and IQ was .37, p=.09. Thus some relationship may exist but the evidence is marginal.

Does Pursuit Tracking relate to a student's classroom attentiveness? The correlation between stability number and teacher ratings of attentiveness was .30, p=.17 . Thus the answer seems to be no. However, the correlation between classroom attentiveness and one aspect of the transfer function, namely, the time to return to the horizontal axis during the Easy Task was .62, p=.04.

Does performance on the Pursuit Tracking relate to behavior problems? All correlations were not significant. Thus we must say no. The factor of " Delinquency " in boys and girls and " Depressed Withdrawal " in girls were the highest of the nonsignificant correlations.

Discussion

We found that it was possible to predict student performance on the Pursuit Tracking task to a high degree of accuracy. Performance on Pursuit Tracking was sensitive to Easy/Difficult task differences. We found that Pursuit Tracking performance was independent of behavior problems and perhaps, was very weakly related to IQ and classroom attentiveness.

The Easy/Difficult task differences are interesting. They seem to indicate that students can not be viewed as processing the two tasks in the identical way. This is rather surprising. When one thinks of a temperature control system in a house, it would be as if the properties of the system changed as it was asked to control the same room at two different temperature levels.

To gain a better understanding of which control system properties changed, a computer simulations approach can be taken. Using Powers(1979) control system simulator, the properties of the control system can be systematically varied. The output of the control system simulator can then be fed into the transfer function program. Thus, one can see how the transfer function changes with changes in a control system such as input sensitivity, output sensitivity, feedback constant, and slowing factor constants.

The effort to find the correlates of performance on the Pursuit Tracking task was negative from a practical viewpoint. It is clear that performance on this task would not allow a very good prediction about how bright a student was, whether the student would present a behavioral problem to the teacher or whether the student would have difficulties paying attention.

Future research involving this task could go in many directions. The fact that it is possible to predict behavior so accurrately encourages one to believe in Powers' analysis of this task. It remains to be seen whether this task will be useful in a practical or theoretical way.

References

The computer programs used in this study will be made available to people who would like to do research with the Pursuit Tracking Task. Interested people should contact:

David M. Goldstein, Ph.d., 801 Edgemoor Rd., Cherry Hill, NJ 08034 (609) 667-0166.

Powers, W. Behavior: The Control of Perception. Chicago: Aldine Publishing Company, 1973.

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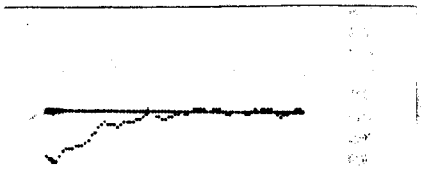
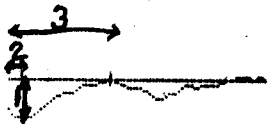


EASY TASK



DIFFICULT TASK
1= negative peak
2= delay to peak
3= delay to axis return

Figure 1: A typical transfer function for the Easy and Difficult Pursuit Tracking Task with certain characteristics defined.