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**THE PROGRESSION-REGRESSION HYPOTHESES
IN PERCEPTUAL-MOTOR SKILL LEARNING**

DISSERTATION

**Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of the Ohio State University**

By

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CHAPTER I INTRODUCTION

A recent experiment by Garvey and Mitnick (1957) demonstrates that the conception of perceptual-motor skill development may be markedly aided by making human performance logically analogous to the performance of electronic apparatus. This study and its consequent conclusion is in the tradition of research which has attempted to define a human transfer function, i. e., the simplest mathematical equation describing the transformations and translations imposed on an input (stimulus) which accounts for the particular form of the output (response). Since the procedure for deriving such a function for electronic systems entails the presentation of a known input, the measurement of the output, and the derivation of a suitable descriptive equation, it is apparent that a parallel in psychological technique exists: the specification of a stimulus, the measurement of the response, and the expression (mathematical or verbal) of the relationship between them. The work of Garvey and Mitnick devolves from this similarity in technique; the logic of their experiment, concerned with the analysis of tracking behavior and its development with practice, stems from the general consideration that a human operator in a closed loop system tends to function to reduce over-all system error. If the human component of the system is replaced by an electronic mechanism,

which also serves the function of minimizing system error, then it can be assumed that both the man and his electronic replacement are performing similar operations. Garvey and Mitnick found that the type of mechanism which is analogous to human performance varies as a function of the amount of practice the human operator has experienced. Early in training, in response to rate and acceleration inputs, human performance is analogous to a mechanism with only one integrator; with practice, performance analogous to that of a two-integrator mechanism is achieved. The rationale of the experiment which led to these conclusions is that with a constant velocity input the necessary mechanism to reduce error to zero must include two integrators (Fig. 1); if the input is of constant acceleration, three integrators will be necessary to reduce error to zero.

If, for example, only one integrator is employed for a constant velocity input, a constant amount of error will result. For human performance the analogy stipulates that if the operator in a tracking task bases his control responses on the velocity characteristics of the input, he will generate a constant error; should the control responses be based on error amplitude (position), an increasing error will result. Similarly, if the input is of constant acceleration, control responses based on the velocity characteristic of displayed error will generate increasing error, while control responses based on the

Fig. 1. The mechanism necessary to reduce error to zero with a constant velocity input (After Garvey and Mitnick, 1957). Paths A, B, and C represent, respectively, the position, velocity, and acceleration components of system error.

acceleration characteristic will generate a constant error. (A mathematical proof of these statements is included by Miquelon (1958), Appendix A.) The results of the Garvey and Mitnick study are seen in Fig. 2, where error data for fast, medium, and slow speed inputs are summarized. The data for Day 25 indicate that the human trackers have effectively reduced error to zero, and hence are behaving analogously to the appropriate mechanisms which are necessary to achieve similar results.

Inspection of the change over the days summarized suggests the hypothesis that with practice the human operator tends to respond selectively to more subtle aspects of the stimulus if such responding leads to greater control and error reduction; there are at least three

Fig. 2. Average lag error within trials as a function of practice (After Garvey and Mitnick 1957).

such aspects or characteristics of a moving stimulus: (1) position (error amplitude), (2) velocity (rate of change of error), and (3) acceleration (rate of change of the rate of change of error). The position of a moving cursor with respect to a target or null position is the most obvious stimulus characteristic; velocity and acceleration represent progressively less obvious cues. In order to minimize error in a complex task, however, the human operator must learn not only to respond to all three of these but also to assign differential weights to each in the determination of appropriate error-reducing responses. It is in the determination of such weights for a machine system that the transfer function was utilized, and the extension of this analysis to human performance was initiated. One of the first of these efforts was by Tustin (1947), who utilized a pursuit tracking task to collect data for the derivation of a transfer function descriptive of human performance. While the specific equation is of small concern here, it is important to note that a simple linear differential equation was claimed sufficient if a "remnant" term was added which described the non-linearities introduced by the human into the control system. With regard to the weights assigned by the human in Tustin's study, input velocity received twice the value (actually 2.3 times as great) assigned to the error amplitude component. Walston and Warren (1953) found

position weighted approximately 5 times as great as velocity in a pursuit tracking task, while in a compensatory task position received 82 times as much relative weight. It is likely that the difference in weighting on the pursuit task may be accounted for on the basis that Tustin seems to have used a velocity order control system, while Walston and Warren used position control dynamics. This difference in task complexity probably accounts also for the discrepancy between compensatory and pursuit task weightings; velocity information is probably not of great relevance for performance in a compensatory task with only position dynamics (Briggs and Fuchs, 1960) .

The data of Walston and Warren corroborate that of Russell (1951); with a positional control and a comparable input, position was weighted 5 times as much as velocity: for a simpler input, it received about twice as much weight, and for more complex inputs, position received about 4 times as much weight. This suggests that under conditions of "task induced stress" (stress produced by increasing task complexity or difficulty) the relative weight assigned to the position component of displayed error will increase.

The most recent and extensive investigations on the human transfer function were carried out and reported by the Goodyear Laboratories (1955). This research differs from that previously cited in that instead of deriving the function from best fit equations,

an analog of the human was so designed that the man's control responses, after subtracting the analog's performance, provided the input for the adjustment of amplifier gain settings (analogs of the weights assigned by the human operator); this system is shown in Fig. 3. The specific technique of adjusting the analog's amplifier gains to match these to the human's performance involved alternating the human controller with the analog and adjusting the analog's gain settings to achieve better simulation. The success of

Fig. 3. The Goodyear pilot analog schematic.

simulation was remarkable, in that subject could not discriminate on the basis of the effects of control responses on the display whether they or the analog were actually in control at any given time. A comparison of the weights assigned by two subjects in this study is shown in Table 1.

TABLE 1
The Relative Weights Assigned by Two Pilots
to the Magnitude and Higher Derivatives of
Error in a Simulated Aircraft System
(after Fitts, et al., 1959)

Pilot	Position	Velocity	Acceleration
VO	1	1.41	0.14
JB	1	30.0	2.00

Subject JB was an experienced jet pilot, while subject VO was experienced only in light aircraft; it is apparent that the more experienced pilot (JB) weighted both velocity and acceleration stimulus components relatively more than the inexperienced pilot. This suggests, like the data of Garvey and Mitnick, that the level of control exerted by the human is dependent upon the amount of training he has received. It suggests also that the level of complexity of the machine dynamics will in part determine the weighting of these components, since both studies which employed higher order controls (Tustin and the Goodyear Laboratory) reported higher relative

weightings for the velocity component than did the studies utilizing only position control dynamics (Walston and Warren, Russell).

Thus the available data suggests both hypotheses and operating assumptions for the testing of these hypotheses. Within the latter category are two assumptions: (1) Approximations of the weights assigned by a human operator in a man-machine system to stimulus components can be obtained by substituting an electronic analog in his place. (2) The relative weights assigned to the more subtle stimulus aspects (velocity and acceleration characteristics) will be relatively greater than the weight assigned to a more obvious component (position) only if the complexity of the machine dynamics requires such weighting for minimal error and stable performance. Granting these assumptions, the following hypotheses can be tested: (1) The level of control attained by the human (analogous to the complexity of an electronic system performing the same function of error minimization) progresses from a lower or more simple level to a higher, more complex one as a function of practice (i. e., progressing from behavior in which subject emphasizes error amplitude to that which is determined more extensively by the higher derivatives of the error signal; this follows from both the Goodyear report and the study by Garvey and Mitnick. (2) Under "task-induced

stress"¹ (as defined previously) the human operator regresses to a lower order of control, as suggested by Russell (1951), who reported that relative weights assigned to the stimulus position component increases as the tracking task becomes more complex. These hypotheses are termed the "progression" and "regression" hypotheses respectively (Fitts, et al., 1959).

The regression hypothesis, has received attention by Miquelon (1958), who attempted to test this hypothesis by analyzing lead-lag error scores. While his results tended toward confirmation of the regression hypothesis, they were not unequivocal. It seems quite apparent that an adequate test of both the progression and regression hypotheses requires the measurement of the weights assigned to stimulus components and the plotting of these relative weights as a function of practice in performing a skilled task.

¹ For a discussion of the concept of "stress", the reader is referred to Lazarus, et al., (1952); as used in this report, "stress" is operationally defined solely as an increase in task complexity and/or difficulty.

CHAPTER II METHOD

A. Procedure

The subjects performed a compensatory tracking task in the system described in Fig. 4. The display was an oscilloscope, the

Fig. 4. The experimental system.

machine dynamics through which subjects tracked consisted of two integrations, and subjects control was a spring centered control column. A random signal provided the input, and the difference between this signal and subjects control movements comprised the error shown on the display. The subjects were instructed to keep the cursor on target; their ultimate goal was to achieve and hold zero error.

The final 5 days consisted of tracking under "task-induced stress". During these periods subject was required to control both the primary task, see above, and a secondary compensatory tracking task. The latter task was a simple positional tracking system as described by Gain and Fitts (1959). In the secondary task the needle or pointer of a meter constituted subjects display and this was deflected from a null position by a simple-sine input of .06 cpm. The subjects controlled via a knob located to the right of the meter. During these "stress" trials subject controlled the secondary system with his left hand while tracking the primary display with his right hand. Instructions emphasized the necessity of doing as well as possible on both tasks.

Throughout training subjects received 9 trials per day; each trial had a duration of 120 seconds, with an inter-trial interval of 60 seconds. Knowledge of their performance was accessible to all subjects throughout the 25 days of training; it was hoped that this would facilitate and maintain their motivational level. In addition, and based on the same rationale, subjects were told the purpose of the experiment and the value of their roles were emphasized.

Within the over-all system of which subjects and their task was a part (Fig. 4), the output of subject is summed algebraically with the output of the human analog circuit and this result provides the feedback loop for the analog. The function of this feedback is to

optimize the parametric setting of the amplifier gains (analogous to subjects weighting of stimulus characteristics) such that the error produced by the differences between the man and the analog is at a minimum. Only one of the three parameters--position, velocity, and acceleration--could be varied on any one trial; therefore, two of these were fixed at the mean of previously measured values while the third was permitted to "search" for the setting which optimized the simulator's performance relative to the human operator. The searching was carried out by a servo-mechanism.

Scores provided by the system were: (1) the error produced by the operator (difference between the input and the system output) , (2) the simulator's error (the difference between the man and the analog circuit) ,(3) the operator's error on the second task, and (4) the gain settings used by the analog for position, velocity, and acceleration which enabled it to match the output of the human operator.

The operator's error was not scored for the first 10 seconds of the 120 second trial in order to remove initial transients from total trial error and thus achieve a more reliable measure of subjects performance. The first 5 seconds of performance on the secondary task were not scored for the same reason.

B. Apparatus

The primary tracking task, analog circuitry and scoring apparatus were provided by a PACE analog computer of computer group 16-31R. This computer, together with a REAC (Reeves Electronic Analog Computer) Model C-10, provided the complex of circuiting of the system shown in Fig. 4; a circuit diagram of this system appears in Appendix A. The secondary task was a SETA (Simplified Electronic Tracking Apparatus) as described by Gain and Fitts (1959). The input to the SETA was provided by a Hewlett-Packard low frequency function generator.

C. Subjects

Serving as subjects were 6 male undergraduate volunteers; all subjects were paid for service in the experiment.

CHAPTER III RESULTS

Training

The weights assigned to the stimulus components throughout the experiment are summarized in Fig. 5. The trends during training are evident: position gain, representing the weight assigned by subjects to error amplitude, decreases during training

Fig. 5. Mean weights (analog gain settings) assigned to stimulus components during training and transfer.

while acceleration gain increases; the weight assigned to the velocity component of the stimulus fluctuates around a line having a generally downward trend. Analysis of this data¹ (Table 2) reveals that these scores or weights for each of the stimulus characteristics not only differ with respect to one-another but also underwent differential changes as a function of training, as seen in the significant ($p < .01$) "measures" and "measures by days" effects. The significant ($p < .01$) "subjects by days" interaction indicates, of course, different rates of change on each of the measures employed for these subjects.

TABLE 2
Analysis of Variance of the Training Data
Presented Graphically in Fig. 6

<u>Source</u>	<u>df</u>	<u>MS</u>	<u>F</u>	<u>P</u>
Measures	2	11,112.495	104.58	< .01
Two-day blocks	9	368.332	2.14	< .10, > .05
Subjects	4	188.650	2.41	N.S.
Meas. x subjects	8	106.255	1.36	N.S.
Meas. x days	18	241.782	3.08	< .01
Days x subjects	36	171.983	2.19	< .01
Days x subjects x Meas.	72	78.398		

¹ The training data were summarized and analyzed in two-day blocks; the daily average scores per subject are presented in Appendix B.

Both velocity and acceleration gains were expressed as ratios to position gain in order to assess relative weight changes during training; these are seen in Figs. 6 and 7 respectively. The empirical curves indicate that velocity gain was greater throughout training than position gain; its relative increase seems largely accounted for in the decrease in position gain, since velocity gain itself shows a slightly downward trend throughout training (Fig. 5). Acceleration

Fig. 6. Changes in the position/velocity ratio during training.

Fig. 7. Changes in the position/acceleration ratio during training.

gain was initially of much smaller magnitude than position gain, but progressed to a size roughly equal to the weight accorded position gain. In order to obtain an approximation of the asymptotic values of these curves, a second degree least squares polynomial equation of the form

$$Y = A \xi_0 + B \xi_1 + C \xi_2$$

was fitted by the method of orthogonal polynomials;¹ these are also shown in Figs. 6 and 7. The asymptotic value for the position/velocity ratio is approximately .34, while for the position/acceleration ratio the value is approximately 1.02. Such values have relevance in making comparisons with previous research (see the section to follow) .

The usual indicator of tracking performance, RMS error, is summarized in Fig. 8; it is readily apparent that subjects achieved some degree of proficiency at the experimental task. The relation to the RMS error metric of the weights given the stimulus characteristics as well as the inter-relations among these weights is reported in Table 3.

¹ The writer is indebted to Mrs. Peggy Soughers for the fitting of these curves.

TABLE 3
Inter-Correlations Among the
Primary Performance Measures

	Velocity Gain	Acceleration Gain	RMS Error
Position Gain	.6002	-.5305	.8586*
Velocity Gain		-.0735	.4427
Acceleration Gain			-.5195
Position, Velocity, and Acceleration			.8646**

* Significant at the .01 level

** Significance level untested.

Fig. 8. Amount of error on the primary tracking task.

It is interesting to note that position gain is the best predictor of RMS error, since the progression hypothesis predicts that perceptual-motor skill development consists of the reduction of the weight assigned to the position component of the stimulus, with a resultant relative increase in the weights assigned to the velocity and acceleration characteristics.

Transfer

The shift in assigned weights from the training period to the transfer condition ("task-induced" stress), apparent in Fig. 5, was analyzed (Table 4) and found to be significant ($p < .01$ for the

TABLE 4
Analysis of Variance of the Changes in Stimulus
Component Weights From Training to Transfer

<u>Source</u>	<u>df</u>	<u>MS</u>	<u>F</u>	<u>p</u>
Measures	2	1,443.97	11.16	< .01
Subjects	4	440.84	3.34	
Training-transfer	1	17.14	.28	
Meas. x subjects	8	129.34	2.13	
Meas. x training-transfer	2	759.57	12.51	< .01
Subjects x training-transfer	4	131.81	2.17	
Meas. x subjects x training-transfer	8	60.73		

"measures by replications" interaction). Despite the obvious relative shift in velocity and position weights during transfer, the "measures by days" interaction failed to yield a significant F (Table 5); however, the over-all difference among measures was

TABLE 5
Analysis of Variance of the Changes in Stimulus
Component Weights During Transfer

<u>Source</u>	<u>df</u>	<u>MS</u>	<u>F</u>	<u>p</u>
Measures	2	5,978.42	21.63	< .01
Subjects	4	392.04	2.31	
Days	4	103.18	.90	
Meas. x subjects	8	204.46	1.20	
Meas. x days	8	276.34	1.63	
Subjects x days	16	114.06	.67	
Subjects x days x Meas.	32	169.91		

significant ($p < .01$). The relatively few transfer days employed may account for this failure to find this interaction to be significant. That subjects in fact performed under stress during transfer may be seen in part in Fig. 9, which presents their performance on the secondary task. The stress condition depended for its effectiveness on the active attempt to perform well on both the primary and

Fig. 9. Amount of error on the secondary tracking task.

secondary tasks, therefore subjects performance on each task during transfer indicates the extent to which they made this attempt. The evidence of their improvement on both tasks, dependent upon their active participation, is seen in Figs. 5 and 9.

Since the weights assigned by subjects to the stimulus components are in fact the gain settings utilized by the human analog to match human performance, a measure of the degree of such matching serves to indicate the closeness of the approximation of the gains to the weighting of the analogous aspects of the stimulus. The difference between the output of the analog and the output of the

subjects constitutes the error presented graphically in Fig. 10,

Fig. 10. Mean analog error in matching subjects performance.

which indicates some early improvement in performance, later deterioration, and an inexplicable rise in error on the final block of days. It is apparent that matching did not continue to improve throughout training; this may have occurred because of the procedure used to estimate the value of the gain settings invariant on any single trial. It was assumed that the best single prediction

of the actual value of these settings was the arithmetic mean of the scores on previous trials when the analog had been permitted to vary and set a given gain value. Since the mean used was a cumulative one, containing all previous scores, the analog was limited in its performance by its inability to change its over-all output at the same rate at which subjects adjusted their weights and therefore their output. The existence of any error at all simply attests to the initial assertion that the analog technique provides only an approximation of the response determining processes and is not intended as a high fidelity simulation of the human operator in a closed loop continuous control system.

CHAPTER IV

DISCUSSION OF RESULTS

The training results conform to the predictions made by the progression hypothesis; at the outset of training, the position and velocity components of displayed error are given almost equal weight in the determination of the control responses. The decrease in position weighting, relative to velocity, indicates an early stage in the progression to a higher order of control, one in which the velocity characteristics of displayed error plays an increasingly greater role in determining the response. The lowest level of control, one in which error amplitude (position) is the largest single determinant of the response, is not evident in these results, although the relative increase in the weight accorded velocity (seen in Fig. 6) indicates that the velocity level of control only becomes clearly established after some practice. The primary reason for the lack of a strictly positional order of control is that the adoption of such a basis for control responses would undoubtedly have led to instability in the system. The validity of this assertion may be seen in the transfer data; on those days wherein position weighting is relatively and absolutely greater than velocity, the RMS error score is higher than at any other time. The size of this error is even somewhat greater than Fig. 8 indicates, since many of the trials on the initial days were incapable of being

scored (since no scoring scale was gross enough to record the large error made by subject) , and therefore the maximum possible score was assigned to such trials in the computation of the RMS scores.

The relative increase in the acceleration component weighting is dramatically illustrated by Fig. 7; acceleration progresses to almost equal to the weight assigned to error amplitude from an initial starting point of being almost 1/7 of the weight given the position characteristic of the stimulus. Thus from the middle of training (Fig. 5) subjects are at a point in learning with respect to acceleration which is similar to their initial point with respect to velocity. The failure of subjects to give acceleration characteristics greater weight than that accorded position seems explicable in terms of the system in which subjects operated. Human performance in a closed loop continuous control system functions to reduce system error and achieve stability (i. e. , maintain control) ; in pursuit of these goals, a controller determines his control response on the basis of the error displayed to him and attempts to find the optimal relative weights of error characteristics which will minimize that error. The contention here is simply that acceleration was weighted optimally for system control and error reduction, and thus it was necessary for subjects to give it greater weight.

Although direct comparability with previous values of the relative weights for the velocity and acceleration stimulus components is somewhat limited since the means of determining these weights and the systems in which they were utilized vary considerably, it is interesting to note that the ratios of the weights reported in the Goodyear study (1955) show some similarity with the values found here. Examination of Table 6 indicates that subjects of the present

TABLE 6
Comparison of Ratios Reported by the Goodyear
Laboratories and the Present Research

<u>Pilot</u>	<u>Pos. /Vel.</u>	<u>Pos. /Acc.</u>
V. O.	.71	7.14
J. B.	.03	.50
P. R.	.34	1.02

study ("P. R. ") fall between the values for the two pilots (V. O. represents an individual with experience in flying light aircraft while J. B. represents a pilot with jet flight experience), indicating a level of control somewhat beyond the velocity order of pilot V. O. and approaching the acceleration level of pilot J. B. This is in accord with the interpretation of these results already presented.

The transfer data reported in Fig. 6 constitute an empirical restatement of the regression hypothesis; error amplitude receives

greater weight during the initial days of transfer, after which the response is more largely determined by the velocity characteristic of displayed error. The decrease in the weight accorded the acceleration characteristic is probably to be accounted for by the stress condition itself. The small amount of available time to concentrate on the primary task prevented the utilization of this most subtle aspect of the display; the excessively high RMS error scores during transfer (Fig. 8) would seem to attest to this interpretation.

The direct support offered for these hypotheses also constitutes indirect support for the assertion of Birmingham and Taylor (1954), Garvey and Mitnick (1957) and Fitts, et al., (1959), that analogies between human performance and the performance of electronic systems can provide testable hypotheses in the growth of a theory of perceptual-motor skill development. The conception of such development in terms of electronic functioning seems, in the light of the results of this study, a clearly valuable contribution, in that hypothetical, internal characteristics of the human controller are specified and open to empirical test. The specific technique necessary to test such hypotheses has shown itself to be not only feasible but remarkably efficient; it offers rapid approximations of subtle characteristics of human responding more sensitive than the usual measures of tracking performance. That such scores are more

sensitive is apparent in a comparison of Figs. 5 and 8; weights accorded stimulus components continue to change beyond the point at which RMS error becomes stable.

The conclusions to be drawn from this report seem apparent: perceptual-motor skill performance rests upon the development with practice of the performer's ability to perceive and weight more subtle stimulus cues in the determination of more adequate error-minimizing responses. The technique utilized in this investigation holds out the promise that an adequate theory of perceptual-motor skill learning may be built upon the empirical generalizations tested herein.

CHAPTER V

SUMMARY

Two hypotheses regarding the development of perceptual-motor skill were tested. The first of these, the progression hypothesis, predicts that learning a perceptual-motor skill entails weighting more subtle aspects (velocity and acceleration characteristics) of the displayed error signal more heavily; the second, the regression hypothesis, predicts that under conditions of stress the relative weighting will "regress" to a heavier emphasis on more apparent stimulus characteristics (error amplitude) but that recovery from stress will evidence the properties predicted by the progression hypothesis. The technique employed to test these hypotheses was a system in which a human analog, consisting of analog computers and servo-mechanisms, was utilized to attempt to match the performance of a human operator; the gain adjustments for the position, velocity, and acceleration characteristics (corresponding to the weights assigned by the human in the system) were provided automatically by a servo-mechanism. These gain settings were treated as approximations of the weights assigned by the human operator.

The results confirmed the hypotheses; the technique proved to be efficient and rapid, and it was concluded that the beginning of a theory of perceptual-motor skill learning may be found in these results.

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APPENDIX A

CIRCUIT DIAGRAM OF THE EXPERIMENTAL APPARATUS

APPENDIX B
SUMMARY OF GAIN SCORES
(MEAN OF THREE TRIALS)

DAYS																					
S _g	Gain	1	2	3	4	5	6	7	8	9	10										
1	POS	27	24	39	30	30	12	20	54	22	20	37	0	20	12	22	10	2	0	0	13
	VEL	25	36	42	29	41	18	42	65	65	57	45	52	8	49	40	22	14	6	35	40
	ACC	6	0	0	0	2	10	0	17	43	13	18	55	5	30	33	9	4	13	7	5
2	POS	27	14	44	14	39	20	13	9	11	24	6	1	7	15	5	39	13	10	13	3
	VEL	21	40	80	25	66	46	31	29	19	65	41	17	30	21	32	17	33	17	51	24
	ACC	24	3	0	13	0	2	3	0	8	0	3	9	8	4	5	12	10	7	33	0
3	POS	53	35	80	18	23	41	19	17	33	18	26	16	8	5	44	19	8	13	44	0
	VEL	57	40	60	34	40	82	21	58	47	31	41	66	23	37	28	37	30	58	80	55
	ACC	6	0	0	0	21	19	6	3	12	3	5	0	5	5	31	11	9	0	19	5
4	POS	53	46	36	34	28	35	11	23	12	12	13	2	0	0	24	10	9	24	43	38
	VEL	31	28	60	43	21	63	18	11	9	49	52	44	34	39	35	22	49	35	58	46
	ACC	9	0	7	10	3	0	3	0	5	8	7	8	5	6	20	7	7	7	23	12
5	POS	30	32	33	33	29	3	11	8	24	26	2	18	7	47	25	3	10	6	11	0
	VEL	60	62	85	75	52	28	18	37	25	50	28	79	33	14	57	32	20	13	7	20
	ACC	9	7	6	10	2	0	38	16	0	4	25	42	9	0	15	3	7	12	8	7

AUTOBIOGRAPHY

I, Alfred Herman Fuchs, was born on November 29, 1932; I received my secondary school education in the public schools of Cliffside Park, New Jersey, and my undergraduate training at Rutgers University which granted me the Bachelor of Arts degree in 1954. In September, 1954, I entered Ohio University and received the Master of Arts degree in 1958; I had already enrolled at The Ohio State University in October, 1956, where I held the position of Teaching Assistant from that date until June, 1959. From June, 1959, until the present I have held the position of Research Assistant at the Laboratory of Aviation Psychology at The Ohio State University Research Foundation.