1986

The Relative Efficiency of Computer Controlled, Adaptive and Learner Centered Training on Transfer of Training in a Computer Simulation Task

Lois-Ann Kuntz
University of Central Florida

Find similar works at: https://stars.library.ucf.edu/rtd

University of Central Florida Libraries http://library.ucf.edu

Showcase of Text, Archives, Research & Scholarship

THE RELATIVE EFFICIENCY OF COMPUTER CONTROLLED, ADAPTIVE,
AND LEARNER CENTERED TRAINING ON TRANSFER OF TRAINING IN A
COMPUTER SIMULATION TASK

BY

LOIS-ANN KUNTZ
B.S., University of Georgia, 1984

THESIS

Submitted in partial fulfillment of the requirements
for the Master of Science degree in
Industrial/Organizational Psychology
in the Graduate Studies Program
of the College of Arts and Sciences
University of Central Florida
Orlando, Florida

Summer Term
1986

ABSTRACT

There is a need for effective cost efficient training programs. Individual differences have been shown to be the most important variable in many training programs and they should be paid special attention in the design of training programs. Compared in this experiment is computer-controlled (lockstep) training, adaptive training, and learner-centered training. Learner-centered and adaptive training are geared to the individual. Instead of lockstep training, learner-centered training allows the trainee to determine the amount or sequence of training at different levels of proficiency. Adaptive training is training based on the participant's performance. As the participant's performance improves he or she is graduated to a harder level of the training program. In this experiment the dependent variable was the average number of crashes in the transfer trials. The ANOVA indicated there was a significant difference of type of training, $F(2, 27) = 4.20$, $p=0.0251$. Planned comparisons were performed to verify the hypotheses such that learner-centered would have the least number of crashes in transfer followed by adaptive and

computer-controlled group having the most errors in transfer. As predicted the computer-controlled training group had significantly more crashes than adaptive and learner-centered in the transfer, $F(1,27)=8.15$, $p=0.0040$, and $F(1,27)=3.48$, $p=0.0348$, respectively. Contrary to the hypotheses there was no significant difference between the adapted training group and the learner-centered training group, $F(1,27)=0.9764$, $p=0.3336$. As there was no significant difference between adaptive and learner-centered training groups this research suggests that as long as the trainee has some input into his or her training whether adaptively or self-paced, the learning will be superior to learning in a pre-programmed manner.

ACKNOWLEDGEMENTS

I would like to give a heartfelt thanks to my committee members, Dr. David Abbott and Dr. Janet Turnage, especially my committee Chairman, Dr. William Wooten, for all their assistance given to me during my thesis preparation. I am extremely grateful to the employees of Essex Corporation for their technical support and consideration. I am indebted to Mr. Martin G. Smith of Essex for his computer programming of the experimental task, if not for his efforts this experiment would have existed forever only in my mind. Lastly, I thank my family and friends for their financial and emotional support.

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

The continued necessity of training programs and the
rising cost of those programs forces utilization of the
most cost-effective training available. Unfortunately for
training program managers, no two people learn exactly
alike. Training regimens are typically geared to the
"average" participant when in fact most of the trainees
are not "average."

Transfer of Training

In discussing training techniques, it is necessary to
determine if the training will in fact transfer. Transfer
of training refers to the effects of prior training on
succeeding performance on a task, which may or may not
differ in some way from the task utilized in the original
training. In the case of a novel transfer task, the
initial interest is to consider how the training and
transfer tasks differ (Briggs, 1969). It is also,
important to note that the amount of training, or practice
should influence the amount of skill displayed in the
transfer task situation (Duncan, 1953).

The simplest form of transfer of training is stimulus
generalization. Stimulus generalization is defined as a

1

response that has been conditioned to a certain stimulus yet also occurs when another similar stimulus is presented. Stimulus generalization is a theoretical basis for the explanation of more complex forms of transfer. The magnitude of such a generalized response depends on the degree of similarity between the original stimulus and the stimulus given as a test of generalization (McGeoch & Irion, 1961).

A similar phenomenon is response generalization. Response generalization is defined as a stimulus that has been connected with a response, that also elicits responses that are similar to the original response (Robinson, 1932). Response generalization may depend on prior learning of equivalent behavior routes to a goal (Hull, 1935). Both stimulus generalization and response generalization are divided into primary and secondary levels. The stimulus or response is the primary level and the generalized stimulus or response is the secondary level. Most important to both of these conditions is the similarity of the primary and secondary response or stimulus.

In addition to stimulus and response generalization there are factors, such as a principle or method which is not specific to the training situation, that are elicited by similar situations. An example of transfer of a principle is an experiment conducted by Hendrickson and

Schroeder (1941). Groups of participants practiced shooting an air rifle at a submerged target. Some participants were taught the principle of refraction. All the participants were then transferred to shooting at a target at a shallower depth. Those participants who were taught the principle of refraction had greater transfer than the uninformed control subjects by an amount that increased with the completeness of the explanation. One of the first experiments on transfer of methods was conducted by Woodrow (1927). He compared the effects of two different training methods. Three groups were given six tests of memorization and, after an interval of four weeks and five days, six other tests similar in form but different in content were given. During the interval, a control group received no training, a practice group had routine practice in learning poetry and nonsense syllables with no instruction about methods of learning, and a training group had practice with these materials, plus instruction in memorization techniques. The training group had the advantage in transfer despite equivalent training time and materials among the groups.

The usual paradigm of a transfer of training task generally includes two independent groups of subjects, the experimental group(s) and the control group. The experimental group(s) engages in a training task and then is tested on a trasfer task. The control group

experiences only the transfer task. The groups should be equated before the training to insure that training and not a difference indigenous to one of the groups is making the effect.

Transfer of training studies also incorporate principles of directional relationships. Video with display, for example, when a participant initiates action in one direction with the control device the cursor on the display screen does not necessarily move in the initiated direction. This directional relationship of the cursor control and the display involves stimulus-response congruence. This congruence of stimulus-response in certain directional relationships is an acknowledgement that some relationships are predictable from what one has learned. In 1951 Gibbs performed one of the earliest experiments on directional relationships and transfer. One group trained with a predictable stimulus-response method and transferred to an opposite method. The second group of participants received the unpredictable, incongruous method first and then transferred to the predictable relationship. The results confirmed the predicted relationship took fewer trials to learn. Transferring, however, showed that the group that transferred from unpredictable to predictable tasks achieved criterion in less than two trials on the average. The group that transferred from the predictable

to the unpredictable task took on the average more than twenty-five trials to criterion.

Learning complex, abstract, meaningful materials and the solution of problems by means of ideas are to a great extent functions of transfer (McGeoch, 1948). When a participant has insight into a problem, in a situation where no directions were given in order to find a solution, previous experience in a similar situation or transfer appears to be a major contributing condition. Likewise, transfer is a basic factor in originality. A creative person has, among other factors, the sensitivity to the applicability of what is already known to new problem situations (McGeoch, 1948).

From this transfer of training review, several factors stand out as very important when designing a training program. Most important seems to be the fidelity between the training and the transfer task. As the training task more closely approximates the transfer task, greater success with transfer occurs. Another factor that was revealed was the influence of stimulus generalization and response. The design of a training program should incorporate stimuli or responses that may facilitate the training or should occlude the same when they may confound the training. A final factor disclosed by the literature was that participants in training who are informed of certain principles that would help them understand the

training will have an advantage in the transfer over uninformed participants.

Video Game Simulation

With the advent of modern microprocessors and video displays, a new approach to the use of job samples as predictors of performance is possible. Video displays can simulate job samples that are impossible or expensive to obtain otherwise. With an all volunteer military force, video games may fill the challenging need of new instructional techniques (Baker, 1981). An additional benefit of video games is that they can accommodate trainees with low verbal skills (Stone, 1983). Finally performance on the games is not due to lack of motivation because they are so intrinsically appealing and fun.

Video games clearly involve tracking, search, and attention. Most games require these perceptual motor skills as well as eye-hand coordination and at least short stretches of continuous movement. Examples of occupations that have these same job tasks are radar operation, word processing, and air traffic controlling. A documented observation on taxi drivers reveals that video games require some of the same skills as driving a taxi does. In this instance even taxi drivers in their 50's could be consummate video game players giving further evidence that

the games and the driving require the same skills
(Greenfield, 1983). Training on video games requires no
supervision and therefore less of a manager's time.
However, commercial video games do have two distinct
disadvantages as trainers. First commercial video games
cannot be modified for training purposes and secondly, the
games usually take 20 to 30 minutes of participation for a
stabilized measure of performance. Obviously video games
designed for specific training needs are preferable.
Video training games are easy to develop for such needs.

Some of the first work utilizing video game
simulation as trainers included the gunnery trainer
designed for the Army by Perceptronics, as well as a Navy
designed war game (NAVTAG) for tactical training in
officer wardrooms on board ships (Jones, 1984). More
recently the Navy had designed for them the comprehensive
video simulation known as Naval Electronics Systems
Command. Its capabilities include: exploration of new
strategic and tactical concepts, ability to test war
plans, examination of new technologies and their effects,
evaluation of Navy programs, and training and education of
Naval commanders and students. Included in the simulation
is platform movement, realistic detection, engagements and
logistics that additionally incorporate satellites,
conventional communications networks, and intelligence
detectors. The specific simulated capabilities are:

submarine and anti-submarine warfare, air and anti-air warfare, surface ship engagements, minefields, and amphibious warfare. The games are generally a week long and of daily eight-hour duration (Stein, 1984). Currently the Army also is using video technology to train soldiers in such diverse areas as equipment repair and gunnery (Crawford, 1983). In civilian use, video technology has been used to train firefighters in the Orlando Fire Department (Burroughs, 1985). Human resource personnel should be more aware of the training possibilities in video simulation.

Of particular importance for dangerous tasks that would require such video game simulation is the learning that has taken place from the training. A trainee faced with the dangerous situation he or she had been trained for should have learned the task as well as possible through the training. In many cases there are no second chances and inadequate learning from the training could have very serious repercussions. Finding the best training method in these cases would be more important than economy. More research into individualized training is important for all circumstances, but especially dangerous situations.

As video technology continues to surge foward, even more methods of simulation become available. Animation is found in Dragon's Lair. The game Dolphin is a sound

dependent game that gives auditory cues. Full body movement is incorporated into Joyboard by Amiga. This Joyboard is a platform that allows twists and tilts for maze, skiing, and shoot out games (Shapiro, 1983). Obviously video simulation games have safety and cost advantages among others in training. Because training on video games can be so flexible in sequencing and scheduling it is easy to take into account individual differences among participants.

Individual Differences

A review of eight years of literature on the experiments conducted at the Naval simulators laboratory in Orlando, Florida (Lintern, Nelson, Sheppard, Westra, & Kennedy, 1981), showed that individual differences accounted for more of the explained variance than equipment features or practice. This finding lends support to the idea that in training programs the participants are not "average." Individual differences can be separated into several different dimensions. According to Tyler (1965) there are differences in intelligence, school achievement, aptitudes and talent, personality, interests and values, and cognitive style. Besides these individual differences there are group differences such as sex, age, race, social class, and handicaps. Concerning groups in

employment and training programs, the main concept from two decades of study is that different programs work better for different groups, that is if they in fact work (Saks, 1984).

In 1962 the Manpower Development and Training Act was a new beginning for the labor market related research field. The Act specified sums of federal money for research on the nation's employment and training programs. The Comprehensive Employment and Training Act continued the practice of funding research involved in employee training. In 1982 the Job Training Partnership Act declared its goal was to help expand work opportunities and utilize the knowledge of the behavioral and social sciences to aid in the solution of this country's employment and training problems (Robson, 1984).

To take into account the importance of individual differences in training, a learner-centered computer training process for motor skilled tasks has been suggested. To test this learner-centered training on a motor skill task a video game has been suggested. The purpose of the proposed research is to examine the relative efficiency of computer-controlled, adaptive, and learner-centered (self-paced) training on a video game task.

Computer-Controlled Training

Computer-controlled training allows the learner to train through a set sequence of task difficulty levels. Computer training has been shown to significantly decrease the time of technical training over conventional training in military context. In a study conducted by Dossett and Hulvershorn (1983) two groups of Air Force personnel were divided into those receiving conventional training and those receiving computer-assisted instruction. The mean training time for the conventionally trained participants was significantly higher than for the computer-assisted group. Computer training (as well as video training) also has the advantages of providing training in tasks in which conventional methods are considered inadequate or risky (Lane & Waldrop, 1985).

Adaptive Training

Charles Kelley (1969) posited the concept and techniques of adaptive training. Adaptive training is training in which the stimulus varies according to the subject's performance. The idea is that people vary with the amount of training each individual needs. Adaptive training allows for the trainee to advance or stay at the level they are at until they reach a predetermined

criterion. Williges and Williges (1978) expanded on the idea of individual training such that adaptive training allows only one logic system for the learners, such that individuals progress in training in a designated sequence. Individuals may prefer to train at different ability levels whether they reach a predetermined performance criterion or not. Adaptive training, though suited to an individual's progress, may not be typical of the training sequence an individual would choose for him or herself.

Learner-Centered Training

Learner-centered training allows the subject to decide when and if he/she wants to progress in the training. Learner-centered training is more economical because it does not need elaborate logic schemes for selecting criteria and sequence, or take as much time to develop their own internal feedback technique (Williges & Williges, 1977). Pinkus and Laughery (1970) studied subject-paced learning in examining recoding and group processes in short-term memory. Subject-paced learning was found superior to constant-paced learning with the results indicating that superiority was achieved by the allocation of learning time not the total amount of learning time.

Williges and Williges (1977) found that learner-centered training was more efficient than adaptive training which was more efficient than controlled or fixed difficulty training. These three types of training were used to teach subjects a two-dimensional pursuit-tracking task. The task utilized a large mainframe computer that required an experimenter to manually change the task difficulty based on subject performance. Subjects were then required to reach an exit criterion before participating in the transfer task. The transfer task was more than twice the duration of the training task and had three task difficulty levels that varied from the changes in task difficulty in the training. Part of the equipment used, an isometric controller, did not provide a distance cue to facilitate accurate positioning. The transfer task was a seven-minute tracking session, in which task difficulty shifted each minute. Participants who were trained under learner-centered procedures had fewer tracking errors in performance than the participants of the other groups. The problem with using an exit criterion to compare training methods is that the relative efficiency of the method cannot be determined. The subjects can receive as much training as they need but this lack of restriction gives no indication about how long the different methods take for training. Training time is an important consideration for cost efficiency.

Barrett, Greenawalt, Thornton, and Williamson (1977) compared adaptive, self-adaptive (learner-centered), fixed sequence, and fixed-task training. In this research, not only was type of training examined but also perceptual style was assessed by several tests. The task was a perceptual concept-formation task. Four groups of participants were presented 30 training cards which had symbols on them. The participants also had 10 decision rules as to action taken contingent upon which number or numbers appeared on the card. For example, decision rule number 1 was: "If 1 and 11 appear, take action 1." For the fixed task group all 10 of the decision rules were exposed. The fixed sequence participants were shown decision rules in pairs of two. The self-adaptive training allowed the participants to control their own pace of presentation of the decision rules. The adaptive training used participants' response time to determine the progress through the 10 decision rules. The participants upon mastery of the 30 cards and 10 rules were given 10 criterion test cards. The study found fewer errors were made in the self adaptive condition, but adaptive training had a significantly lower completion time.

Williges, Williges, and Savage (1977) also studied fixed sequence training. Fixed sequence (shifting difficulty) was determined by learner-centered training. Shifting difficulty evolved because most subjects chose a

strategy of keeping task difficulty low initially and
rapidly increasing task difficulty to the criterion
level. In Williges, Williges, and Savage (1977), adaptive
training also performed more efficiently than the shifting
difficulty method of training. The participants of this
experiment were given six 30-second trials with a
10-second rest between trials on a pursuit rotor. For the
transfer task there were three levels of difficulty in
terms of speed. The main effect of training type was
significant with the most effective being adaptive, then
fixed difficulty, and then the shifting difficulty. This
experiment will not utilize the shifting difficulty model
because the premise of that model is to simulate
learner-centered training.

Problem Statement

More research needs to be conducted to find the most
economical training methods, especially on the personal
computers that are so widely available now. This
experiment utilized the much more economical personal
computer. The use of a more economical tool lends further
support to the potential savings provided by
learner-centered training. Also, as previously stated,
video simulation needs more exploration as a training
method. Important to consider, too, were the basic tenets

of transfer of training. A task was designed to incorporate the three types of training, computer-controlled, adaptive, and learner-centered, as well as transfer of training theory. The transfer task closely approximated the training task. It was a mirror image of the original training tracking task. Also, the transfer task was at a speed difficulty level that the subjects all had opportunity to train on. To prevent the confounding variable of the amount of time individual subjects had spent on video games, the cursor device used was one that is not used in video arcades. Rather one was incorporated that required a left-to-right hand motion rather than an up and down motion.

The hypotheses follow:

H1- Learner centered training will have the fewest number of crashes in transfer

H2- Adaptive training will have the next fewest crashes in transfer

H3- Computer controlled training will result in the largest number of crashes

METHOD

Subjects

Thirty right-handed male subjects were recruited from the University of Central Florida. Only right-handed males participated to avoid any confounding variables of gender and handedness (Johnson, Haygood, & Olson, 1982; Williges & Williges, 1977, 1978). Subjects were recruited as volunteers from undergraduate psychology classes and as necessary from other social science undergraduate classes. Subjects were randomly assigned to the treatment groups by alternating the condition for each subject as they signed up. A tally was kept to insure the subjects were all run according to this pattern.

Training Task

The task involved a pursuit tracking video game program implemented on a personal computer. Research on tracking performance has utilized either a pursuit or a compensatory display. Two moving elements appear in pursuit tracking: a target which gives the input signal, and a cursor which shows the output generated by the participant in his or her endeavor to match the target.

17

One observes a fixed target in compensatory tracking and the cursor moves in response to the difference between the input and output signals (system error). A participant receives more information from pursuit than compensatory display because pursuit provides separate information on the input and output signals while only the difference in the two signals appears in the compensatory display (Poulton, 1969).

The video game was designed like a driving course. The driving course consisted of a series of curves. Performance was measured by the number of crashes (cursor runs outside the barrier). Each trial was 2 minutes in duration. There were five levels of speed and at each level there was a speed increase of 100 percent. Because the speed increased so drastically as a function of the program, the track was widened by 50% across levels.

Experimental Design

The design included a practice trial (or pre-test), the experimental condition, and two post-tests. The independent variable was type of training. There were three levels of training: controlled (the computer-controlled the advancement of the subjects in the trials); adaptive (as the subject achieved a certain criterion; his speed was increased), and

subject-controlled (the subject progressed, slowed, or stayed at the same level as he chose). The dependent variable was the average number of crashes in the post-test or transfer conditions.

Procedure

The pre-experimental trial consisted of two minutes of the task at the fourth-speed level. The experimental phase comprised 15 trials of a training session. Then participants received a two-minute rest. The two post-test trials lasted 2 minutes each at the fourth-speed level but this course was a mirror image of the original track. Subjects in the computer-controlled condition received two trials of the first level and three trials each of the other levels. They were unable to alter the training level in any way. Proficiency of rounding the curves was the measure that determined the advancement of the subject for the adaptive training group. The subject's performance was measured every 30 seconds. If a subject had less than 30 crashes in 30 seconds, he was advanced one speed level. If the subject did not attain that proficiency level he remained at the same level he had been performing on. The subjects in the learner-centered training group determined for themselves which level they performed on, and at any time during the 14 practice

trials could advance or reduce to any level they chose or remain on the same level for as long as they wished. Incorporated into the program was feedback for all subjects in the form of a tally of crashes and an indication of which level the subject was on. Wiener (1974) found that groups who had knowledge of results, whether adaptive or fixed, performed significantly superior to those groups who had no knowledge of results.

Equipment

The task was performed on an IBM-AT compatible personal computer. The controlling device for the subject was a "mouse." The mouse was a hand-held input device used in conjunction with a "Mouse Board" (Mouse Systems Corporation, Santa Clara, CA 95051). This board allowed subjects to trace their movements onto the screen without a visible lag from the visual cues displayed. The screen resolution was 640 x 200 pixels. The large number of pixels or picture elements allowed for better resolution and therefore better viewing. The Mouse Board was 9 x 11 inches and had a smooth surface which allowed the mouse with its flat bottom to slide freely.

RESULTS

A one-way analysis of variance (ANOVA) was performed to determine if there was a significant difference between the types of training. The qualitative independent variable was the type of training the subject received, of which there were three levels: computer-controlled; adaptive; and learner-centered. The dependent variable was the average number of crashes in the transfer trials. The ANOVA indicated there was a significant difference of type of training, $F(2,27)=4.20$, $p=0.0251$ (see table 1). Planned comparisons were performed to verify the hypotheses such that learner-centered would have the least number of crashes in transfer followed by adaptive and computer-controlled group having the most errors in transfer. As predicted the computer-controlled training group had significantly more crashes than adaptive and learner-centered in the transfer, $F(1,27)=8.15$, $p=0.0040$, and $F(1,27)=3.48$, $p=0.0348$, respectively. Contrary to the hypotheses, there was no significant difference between the adapted training group and the learner-centered training group, $F(1,27)=0.9764$, $p=0.3336$. All groups did decrease the number of crashes from the practice trial conducted at level four to the average number in the transfer trials.

Computer-controlled decreased 15.8%, adaptive decreased by 22.2%, and the learner-centered group by 27.9%. These findings indicate that training did take place. There was no significant major effect in percent decrease $F(2,27)=2.4418$, $p=0.1043$, but there was a significant difference in percent decrease between learner-centered and computer-controlled groups $F(1,27)=4.8360$, $p=0.0346$. All groups decreased their number of crashes by at least 15% in the transfer condition (see table 2).

TABLE 1

SUMMARY TABLE FOR THE ONE-FACTOR ANALYSIS OF VARIANCE

MAIN EFFECT OF TRAINING

SOURCE	SS	df	MEAN SQUARE(MS)	F Ratio
Training	10008.0	2	5004.0	4.2019
Subjects	32154.0	27	1190.89	
Total	42162.0	29		

TABLE 2

PERCENT DECREASE IN ERRORS FROM TRIAL 1 TO TRANSFER

TRAINING GROUP	MEAN CRASHES		PERCENT DECREASE
	PRE	POST	
Computer C	185	155.7	15.8
Adaptive	143.5	111.7	22.2
Learner C	176.1	126.9	27.9

DISCUSSION

There is an existing need for effective cost efficient training programs. The initial development of a training program should include principles of transfer of training. Training that is not based on fostering transfer will not be worthwhile. Similarity between the training and transfer is the most important of the transfer priciples. Video game simulation is suggested to be similar to tasks that for reasons of cost or danger cannot be trained on directly. Video game simulation also takes into account individual differences. Individual differences have been shown to be the most important variable in many training programs and they should be paid special attention in the design of training programs. Learner centered and adaptive training are geared to the individual. Instead of lockstep training, learner-centered training allows the trainee to determine the of amount or sequence of training at the different levels of proficiency. Adaptive training is training based on a trainees performance. As the participant's performance improves he or she is graduated to a harder level of the training program. Compared in this experiment is computer-controlled (lockstep) training, adaptive training, and learner-centered training.

In this experiment computer-controlled (lockstep) training was hypothesized to have the greatest number of errors of the three training groups. In the planned comparisons both learner-centered and adaptive training had significantly fewer errors than the computer-controlled group. Also hypothesized was that learner-centered training would have the fewest errors. This hypothesis was not supported. The mean of the number of errors for the adaptive group was less than the mean of the number of errors for the learner-centered but there was no significant difference between the groups.

The combination of video game training and individualized training seems to be optimum in training tasks requiring perceptual motor skills. Important elements incorporated into this experiment from video games include motivation, easily modified parameters, the portability of personal computers, feedback as well as visible improvement in performance, and training that did not require supervision. Training based on performance or subject input is preferable to lockstep training and results in better transfer. As there was no significant difference between adaptive and learner-centered training groups, it appears that as long as the trainee has some input into his or her training whether adaptively or self paced, the learning will be superior to learning in a pre-programmed manner. Designing computer video game

training programs for jobs requiring perceptual motor skills is in many ways ideal especially with the availability, economy, and ease of operation found with a personal computer. This research suggests that video game training results in improved performance and individualized training results in improved performance as well.

REFERENCES

Baker, J. D. (July, 1981). Principles for design of
    educational games and simulations. Proceedings of
    the 1981 Summer Computer Simulation Conference.
    Washington, DC.

Barrett, G. V., Greenawalt, J.P., Thornton, C. I.,
    Williamson, T.R. (1977). Adaptive training and
    individual differences in perception. Perceptual
    and Motor Skills, 44, 875-880.

Burroughs, W. (1985, September). [Class lecture,
    Assessment Centers Graduate Class]. University of
    Central Florida, Orlando.

Crawford, C. (1983, December). Programmed to play.
    Science Digest, 79.

Dossett, D.C., & Hulvershorn, P. (1983). Increasing
    technical training efficiency: Peer training via
    computer-assisted instruction. Journal of Applied
    Psychology, 68(4), 552-558.

Duncan, C. P. (1953). Transfer in motor learning as a
    function of degree of first-task learning and
    inter-task similarity. Journal of Experimental
    Psychology, 45, 1-11.

Gibbs, C. B. (1951). Transfer of training and skill
    assumptions in tracking tasks. Quarterly Journal
    of Experimental Psychology, 3, 99-110.

Greenfield, P. (1983). Video games and cognitive skills.
    Proceedings of a Symposium on Video Games and Human
    Development: A Research Agenda for the '80s (19-24)
    Cambridge, MA: Monroe C. Gutman Library, Harvard
    Graduate School of Education.

Hendrickson, G., & Schroeder, W. H. (1941). Transfer of training in learning to hit a submerged target. Journal of Educational Psychology, 32, 205-213.

Hull, C. L. (1935). The mechanism of the assembly of behavior segments in novel combinations suitable for problem solution. Psychological Review, 42, 219-245.

Jones, M. B. (1984). Video games as psychological tests. Simulation and Games, 15(2), 131-157.

Kelley, C. R. (1969). What is adaptive training? Human Factors, 11(6), 547-556.

Lane, N. E., & Waldrop, G. W. (1985). Computer-based instruction (CBI): Considerations for a user-oriented technology data base (EOTR 85-5). Orlando, FL: Essex Corporation.

Lintern, G., Nelson, B. E., Sheppard, D. J., Westra, D. P., & Kennedy, R. S. (1981). Visual Technology Research Simulator (VTRS) human performance research: Phase III (NAVTRAEQUIPCEN 78-0060-11). Westlake Village, CA: Canyon Research Group, Inc.

McGeoch, J. A. (1948). The psychology of human learning: An introduction. New York: Longmans, Green and Co.

McGeoch, J. A., & Irion, A. L. (1961). The psychology of human learning (rev. ed.). New York: David McKay Company, Inc.

Pinkus, A. L., & Laughery, K. R. (1970). Recoding and grouping processes in short-term memory: Effects of subject-paced presentation. Journal of Experimental Psychology, 85(3), 335-341.

Poulton, E. C. (1969). Tracking. In E. A. Bilodeau (ed.) Principles of skill acquisition. Academic Press, New York.

Robinson, E. S. (1932). Association theory today; an essay in systematic psychology. New York: Century.

Robson, R. T. (Ed.) (1984). Employment and training R & D: Lessons learned and future directions. Proceedings of the National Council on Employment Policy (pp. v-xvi). Kalamazoo, MI: W.E. Upjohn Institute for Employment Research.

Saks, D. H. (1984). A research agenda for employment and training policy in the eighties. Proceedings of the National Council on Employment Policy (pp. 43-71). Kalamazoo, MI: W.E. Upjohn Institute for Employment Research.

Shapiro, N. (1983, December). Next: Video verite. Science Digest, p. 83.

Stein, K. J. (1984). Navy using computerized war games. Aviation Week & Space Technology, 120(21), 181-187.

Stone, A. (May 1983). Video games and social behavior. Proceedings of a Symposium on Video Games and Human Development: A Research Agenda for the '80s (16-18) Cambridge, MA: Monroe C. Gutman Library, Harvard Graduate School of Education.

Tyler, L. E. (1965). The psychology of human differences. New York: Appleton-Century-Crofts, Inc.

Wiener, E. L. (1974). An adaptive vigilance task with knowledge of results. Human Factors, 16 (4), 333-338.

Williges, B. H., & Williges, R. C. (1977). Learner-centered versus automatic adaptive motor skill training. Journal of Motor Behavior, 9(4), 325-331.

Williges, R. C., & Williges, B. H. (1978). Critical variables in adaptive motor skills training. Human Factors, 20(20), 201-214.

Williges, B. H. Williges, R. C., & Savage, R. E. (1977). Models for automated motor skills training. _Proceedings of the 21st Annual Meeting of the Human Factors Society_ (pp. 18-22), San Francisco, CA: The Human Factors Society, Inc.

Woodrow, H. (1927). The effect of type of training upon transference. _Journal of Educational Psychology_, _18_, 159-172.