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OREGON UNIV EUGENE DEPT OF PSYCHOLOGY
LOW COST SIMULATION OF PILOTING TASKS.(U)

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JAN 80 G M REICHER, B J DAVIDSON, H L HAWKINS N00014-77-C-0643

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Technical Report

LOW-COST SIMULATION OF PILOTED

10 Gerald W. Hatcher
Brian J. Davidson
Harold L. Hawkins
Gilbert G. Good

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✓ An attempt was made to validate a low cost, low fidelity, computer driven flight simulator. The validation is required so that the simulator can be used as a criterion task to see whether we can predict flight performance on the basis of performance on other tests of individual cognitive ability like attentional flexibility, visual representational skill, priority setting and planning. The simulator was based on instrument flying rather than visual contact flying and incorporated secondary tasks to further tax the pilot's capacity. Simulator performance is correlated with hours of flight training, the best correlations coming from conditions which impose additional task demands. ✓

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Gerald Reicher, Brian Davidson, Harold Hawkins, Gilbert Osgood¹
University of Oregon

Although the conceptual problem of breaking down complex tasks into component abilities does not require that the complex tasks be practical ones, obviously the spin off from this type of research would be much greater if important practical tasks were analyzed. We have taken the task of piloting an airplane as an example of an important practical task. This report describes an attempt to validate an inexpensive flight simulator. If "flying" the simulator proves highly related to piloting, it will make sense to attempt to predict simulator performance on component tasks. Besides its practical importance, piloting has the advantage of being well-studied and of having many valid simulations reported. It also has well-defined component tasks and seems to require the sorts of cognitive component abilities we wish to study.

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over more specialized high fidelity alternatives were flexibility for measurement or training and portability.

Our support for this thinking comes from a variety of sources. It is clear from the huge simulation literature that well thought out simulators can be a training aid. For example see Crawford and Brock, 1977 for a recent review. Povenmire and Roscoe, 1971 for simulator training in primary flight training, Reid and Cyrus, 1974 for formation flight training, Trollip, 1977 for training on holding patterns; Ketchel, 1977 for air combat training. Many simulators are designed to look and act as much as possible like an airplane. The large simulator at Williams Air Force Base is perhaps one of the extremes in fidelity in on the ground simulators. However, there are reports of good performance of small computer based simulations in predicting performance on the large simulators and on training. The people at the Human Resources Laboratory at Williams report that the small computer based simulation developed at Arizona State when informally evaluated seemed to be a good predictor of performance on the large simulator. This is not to say that these inexpensive simulations could take the place of the large simulators in specific advanced training or familiarization exercises which go on at Williams and with the Air Combat Maneuvering Range Program. But it may be an indication that the general skills needed to fly airplanes might be assessed and trained by using inexpensive computer simulations.

There has been a clear message in the literature that in training, considerations of task analysis and training design can be more important than realism (see Caro, 1973). Recent examples come from Trollip, 1977 and Finnegan, 1977. They showed that training on holding patterns could be effectively

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carried out using computer aided instruction which did not emphasize fidelity at all. They emphasized (as did Caro) that for the purposes of training, the computer can do things which most simulators cannot in that they can provide a more effective learning environment by optimizing feedback and the like. The flexibility to allow maximization of learning or measurement parameters can be very important as long as the essential aspects of the task to be learned or measured have been successfully abstracted and incorporated. Our research assumes that the abstraction of component abilities is possible and can be done practically. The ability to arrive at good predictions of pilot performance with an inexpensive, unrealistic model is one test of this assumption. More stringent and interesting tests will be to see whether we can abstract and isolate general cognitive components useful in a variety of other skills. Support for useful abstraction of general cognitive abilities as components of piloting comes from Taylor and Parker (1959) for spatial tests as predictors of training success. Fleishman and Ornstein (1960) found factors predicting pilot performance were control precision, spatial orientation, multi-limb coordination, response orientation, rate control, kinesthetic discrimination and Gopher and Kahneman (1971) found that differences in attention predicted advanced placement of pilots.

Early in our research we tried to obtain one of several practical working simulations. These were either not available or not compatible with our equipment. We then wrote our own simulator for use on our laboratory computer and the studies reported were done on this version. Due to computer problems on the laboratory computer one of us is currently implementing a second version on his TRS 80³.

Our primary target for this research is the more sophisticated pilot and we have arbitrarily designated the instrument pilot as reaching this level of sophistication. Thus, we are not just looking for someone who can drive a plane but someone who can deal with other complexities at the same time, as would any pilot flying for military or commercial purposes. Thus, we have made our simulation task very demanding. Maintaining direction is made demanding by stiff simulated winds and by simulated turbulence. A secondary computation task is also required. Subjects are given a speed and a distance and asked to compute the time required to fly the distance. In most cases where a decision had to be made about how close the simulator should be to the real thing, we decided that the cognitive task should be similar but the motor task different. Subjects maintain direction with two push-buttons, one for each direction. Instrument and control dynamics are not those commonly found in planes. Finally, calculations were not made on a flight computer and the procedures were different than is commonly used.

Our expectations were that the simulator tasks without secondary tasks would not be as related to flight proficiency as would the simulator tasks with the secondary tasks. In general, we expected the more demanding tasks to be more discriminating. These expectations came from the belief that tracking ability alone would not be a good indication of advanced performance on a flight task whereas the ability to deal with task complexity would. In preliminary work we found that people seemed to rely on some type of visualization ability even for direction maintenance on the simulator. The logic of instrument flying and earlier research (e.g., Taylor and Parker, 1959) led us to believe that visualization or spatial abilities would be an important factor

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in skilled piloting. Thus, we included a visual interference task to see whether we could impair the better pilots. An auditory interference task was expected to have less interfering effect on the good pilots than the visual interference task.

Method

Subjects were recruited from the Lane Community College Flight Technology Program. The trainees ranged from pre-solo to instrument instructor. Information on flight training experience and test scores was gathered. Twenty-four trainees signed up to participate, eighteen came to the first session. However, because of numerous computer failures all of the subjects did not provide data for all conditions. Failures either prevented subjects from finishing a condition or prevented subjects from being tested at all resulting in some subjects refusing to return for later testing. Subjects were paid \$3.50 per hour and were promised a bonus if they participated in 18 hours of testing which would have boosted their earning to \$5.00/hr.

Work on the simulator was scheduled to take 3 hours. Because of computer problems this was sometimes broken up into two or three different sessions on different days.

(see Figure 1, page following)

The simulation consists of three instruments. One is similar to a directional gyro, one is similar to a turn indicator, one is similar to a course deviation indicator and TO/FROM indicator of a VOR receiver. Note that altitude is not represented in the version of the simulator reported here. Subjects are given successive courses to hold in no wind, no

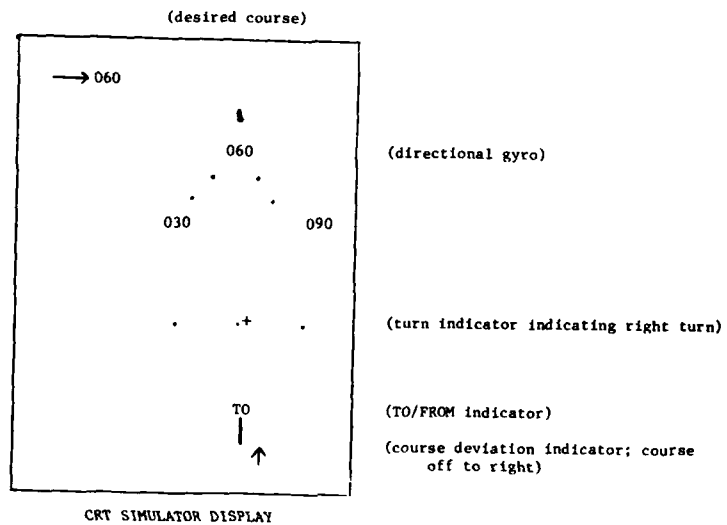


Figure 1

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turbulence conditions (Easy Condition), moderate wind (about 20% of the speed of the plane) and turbulence conditions (Moderate Condition), heavy wind (about 50% of the speed of the plane) and turbulence conditions (Difficult Condition). Simulated wind moved the position of the plane as a vector independent of the heading vector. Simulated turbulence changed the heading. Each individual task set contained 4 courses and if flown perfectly would take about 8 minutes. In practice each took about 10 minutes, depending on skill level, totaling about 90 minutes of simulated time in the three hour session. Subjects controlled the plane's heading by pushing one of two buttons. The longer the button was held down, the steeper the turn. To come out of a turn the opposite button had to be pressed. Subjects were to fly the course as directly as possible, correcting for wind and turbulence as necessary.

After lengthy instructions, subjects were given the easy, moderate and difficult conditions in that order without other tasks. During this time subjects could ask questions and experimenters would make suggestions, as necessary. Next, three sets of medium difficulty simulator tasks were accompanied by an auditory interference task, a visual interference task, and a computation task. The auditory interference task required subjects to say whether the first of two tape-recorded tones was higher or lower than the second. The tone pairs were presented at a rate of 12 per minute. The visual interference task required subjects to keep track of a tic-tac-toe game and to say whether X's or O's won or draw. The tape-recorded task was presented by verbal instructions such as "X in square 7...O in square 2", etc at a rate of about 10 per minute. The computation task required subjects to compute time to the next station given air speed and distance on a 3 x 5 card. Subjects were required to write the time of station passage and the estimate of time to

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the next station in fractions of hours and in seconds. The last set of three tasks repeated the sequence of interference tasks used in the second set of three with the only difference being that the difficult simulator conditions were used.

Two of the pilot trainees were beginners with less than 10 hours. They both had a great deal of trouble with the moderate difficulty simulator task, so we did not give them the difficult simulator task. This hurt our correlations because they would certainly have performed poorly had we put them through that ordeal.

Because of the small number of subjects remaining at the end of this primary simulation task, we decided against running more advanced simulation tasks designed to discriminate among more advanced pilots. These tasks include difficult versions of holding patterns, approach patterns and a VOR orientation task.

Results

Our primary interest is in whether the simulator provides a valid measure of piloting skill. We decided on two achievement measures and one judgemental measure, although the later (ratings by the trainee's instructor's) is not yet available. The achievement measures are number of training hours (range between 3 and 150) and rating achieved (range between pre-solo and instrument instructor). Rating achieved has not proven valuable because surviving data are too bunched up in the middle of that small range of five categories.

Data on simulator performance to be reported here are rank orderings of traces of "ground track" relative to desired course. Judgements were subjective based primarily on accuracy and smoothness. Two judges (one with some flying experience, one without) ranked the traces; the average correlation between raters for the different conditions was .92. The two ranks were averaged and the average scores were ranked. Example tracing are shown in Figure II. (See page following).

Recall that there were two levels of simulation task difficulty during which the calculation task was simultaneously administered. Correlation between training hours and simulator performance with the simultaneous calculation task was $-.54$ for the easier task and $-.68$ for the difficult task. Since one is the highest rank, the negative correlations with hours of training are as expected. These correlations would be somewhat higher if we have low scores for the two pre-solo pilots who could not complete the difficult simulator conditions.

A few words of caution are in order about interpretation of these high correlations. Much data were lost due to computer failures and subject attrition so that the numbers of observations are small (14 for the easier tasks, 11 for the difficult task, not counting the two beginning pilots who were unable to complete it). Although both of the scores are significant (we are using a t-test with $p < .05$ throughout) the actual values of the correlations should not be taken as good estimates of accounted for variance.

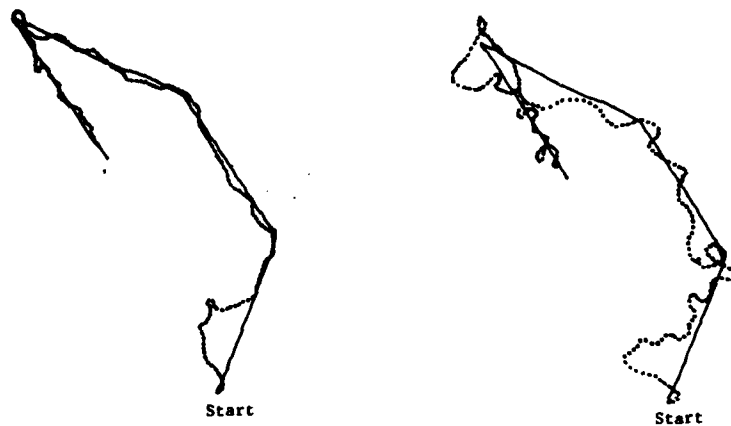


Fig. 11 Tracings of desired courses (solid line) and actual performance (dotted line ground track). The better tracing is from an instrument instructor with 1000 flying hours including 140 flight training hours. The other tracing is from a private pilot with 60 hours of flying time including 40 hours of training. Tracings are from the most difficult simulator condition and computations were required.

We expected high correlations between the two calculation tasks which differed only in difficulty of the simulator task. The significant correlation was .83.

Since we believed that direction maintenance without task complexity would not be an important predictor, we expected low correlations between the simulator task alone and the combined simulator and calculation tasks. For the moderate difficulty condition the non-significant correlation was .14 for the difficult conditions, however, the significant correlation was .73. Thus it appears that the same subjects are doing well on the difficult conditions regardless of whether or not there is a calculation task for added complexity.

We hoped to gain some insights about coding processes through the use of the interference conditions but the small numbers of data points and possible insensitivity of the rank order data make it unclear whether visual interference was more harmful to experienced pilots than to non-experienced pilots. There is not a meaningful pattern of significant differences and what data there are do not suggest that visual interference was more important to experienced pilots than auditory interference. We believe that the absolute scores derived from the various statistics which we are recovering from the data will be more sensitive to this matter than ranks. The advanced pilots were so much better than the poorer pilots that the differences caused by interference might not have been great enough to be picked up by changes in ranks.

Discussion

We believe that we have tentative validation of the simulation task; the simulation seems to be sensitive to some of the important aspects of pilot

training. Naturally we would like to have a more complete validation but due to lack of availability of highly skilled pilots we believe that further development is best done at another location.

It seems likely to us that discovering good pilot ability is best done with techniques using information overload. Many pilot tasks are not demanding in most situations. Turning onto a final approach path smoothly, for example, can be done relatively easily by most fairly experienced pilots when there is nothing else to do. On instruments, in turbulence with one or two radios out, and going twice normal speed might make this task more challenging and discriminating of those who can handle bad situations while piloting. This is the sort of challenge that can be set up by a simulation. Another measurement issue is repeatability. One does not have to wait for a windy day to check out cross wind landings or gusty wind landings and such situations are exactly repeatable for measurement considerations. Finally, there is the issue of measurement recording accuracy. One need not judge distance from desired course or smoothness and accuracy of turns by eye. Ground track can be plotted exactly along with other statistics such as numbers of course corrections. Thus the flexible simulator allows more discriminable, repeatable, accurate measurement.

Our current goal is to use the simulator on our readily available subjects to see whether we can predict simulator performance (during training and at asymptotic levels) by performance on other cognitive abilities. The tasks which we have ready to go measure ability to represent visual material, the ability to set priorities, attentional flexibility, and planning ability.

References

- Carc, P. W. Aircraft simulators and pilot training. Human Factors, 1973, 15(6), 502-509.
- Crawford, A. M. & Brock, J. F. Simulation for performance measurement. In Pope, L. T. & Meister, D. (Eds.) Symposium Proceedings: Productivity Enhancement: Personnel performance Assessment in Navy Systems, 1977.
- Finnegan, J. P. Transfer of a computer-assisted instrument procedure's trainer to flight. In Neal, A. S. & Palasek, R. F. (Eds.) Proceedings of the Human Factor's Society 21st Annual Meeting, p. 377-381, 1977.
- Gopher, D. & Kahneman, D. Individual differences in attention and the prediction of flight criteria. Perceptual and Motor Skills, 1971, 33, 1335-1342.
- Ketchel, J. M. The air combat Maneuvering Range (ACMR), A new approach to aircrew training. In Neal, A. S. & Palasek, R. F. (Eds.) Proceedings of the Human Factor's Society 21st Annual Meeting, 1977.
- Povenmire, H. K. & Roscoe, S. N. An evaluation of ground-based flight trainers in routine primary flight training. Human Factors, 1971 13(2) 109-116.
- Reid, G. B. & Cyrus, M. L. Transfer of training with formation flight trainer. Air Force Human Resources Lab. Technical Report, AFHRL-TR-74-102, December 1974.
- Taylor, E. K. & Parker, J. W. Spatial tests as predictors of success in air-force training. Wright Air Development Center Air Research and Development Command, Publication #TR-59-361, December 1959.
- Trollip, S. R. A computer-based simulator. In Neal, A. S. & Palasek, R. F. (Eds.) Proceedings of the Human Factor's Society 21st Annual Meeting, pages 372-376, 1977.

Footnotes

14.

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Navy	Navy
1 Dr. Ed Aiken Navy Personnel R&D Center San Diego, CA 92152	1 MR. GEORGE H. GRAINE NAVAL SEA SYSTEMS COMMAND SEA 05LIC2 WASHINGTON, DC 20362
1 Dr. Arthur Eichrach Behavioral Sciences Department Naval Medical Research Institute Bethesda, MD 20014	1 LT Steven D. Harris, MSC, USN Code 6021 Naval Air Development Center Warminster, Pennsylvania 18974
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1 Dr. Robert Breaux Code M-71 NAUTRAQUIPCEN Orlando, FL 32812	1 CDR Robert C. Kennedy Naval Aerospace Medical and Research Lab Box 29407 New Orleans, LA 70182
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Navy

1. JMS OLDF
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PENSACOLA, FL 32503
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NRS Branch Office
425 Summer Street
Boston, MA 02210
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U.S. ARMY RESEARCH INSTITUTE
5001 EISENHOWER AVENUE
ALEXANDRIA, VA 22304
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U.S. ARMY RESEARCH INSTITUTE
5001 EISENHOWER AVENUE
ALEXANDRIA, VA 22304
1. Technical Director
U.S. Army Human Performance Lab
Aberdeen Proving Ground, MD 21005
1. Dr. Harold E. O'Neill, Jr.
Attn: DEPT. 10
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22304

1. Dr. Robert C. Grier
U. S. Army Research Institute for the
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Naval War College
Providence, RI 02946

Marines

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Education Center, MCDEC
Quantico, VA 22124
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Corps Matters
Code 100H
Office of Naval Research
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Arlington, VA 22217
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Coventry CV4 7AL
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- 1 DR. MICHAEL ATWOOD
SCIENCE APPLICATIONS INSTITUTE
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Stanford, CA 94305
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Univ. of California
Davis, CA 95616
Chapel Hill, NC 27514
- 1 Center for the Study of Learning
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Oakland, CA 94612
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Livingston House
Livingston Park
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ENGLAND
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Department of Psychology
Carnegie Mellon University
Pittsburgh, PA 15213
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Stanford, CA 94305

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Camp 120, CA 94020
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^a $\chi^2 = 0.76$, $df = 1$, $p = 0.38$. ^b $\chi^2 = 0.91$, $df = 1$, $p = 0.34$.

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Psych. Factors Lab., Univ.
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Dept. of Psychology
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Psych. Factors Lab., Univ.
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Madison, Wis. | 19 | Dr. David H. Kahn
Dept. of Psychology
University of Illinois
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Department of Computer Science
Futgers University
New Brunswick, NJ 08903
- 1 Dr. Richard Snow
School of Education
Stanford University
Stanford, CA 94305
- 1 Dr. Kathryn T. Spoehe
Department of Psychology
Brown University
Providence, RI 02912
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Dept. of Psychology
Yale University
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