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THE EFFECTS OF ABOVE REAL-TIME TRAINING (ARTT) IN AN F-16 SIMULATOR

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ABSTRACT

In this application of ARTT, 24 mission-capable F-16 pilots performed three tasks on a part-task F-16A flight simulator under varying levels of time compression (i.e., 1.0x, 1.5x, 2.0x, and random). All subjects were then tested in a real-time (1.0x) environment. The three tasks under study were an emergency procedure (EP) task, a 1 versus 2 air combat maneuvering task, and a stern conversion or air intercept task. In the EP task, all ARTT pilots performed the EP task with 28% greater accuracy, and were better at dealing with a simultaneous MIG threat, reflected by a six-fold increase in the number of MIG kills compared to a real-time control group. In the stern conversion task, there were no statistical differences between group. In the ACM task, those pilots trained in the mixed time accelerations were faster to acquire lock, and were faster to kill both MIG threats than the other groups.

These findings are generally consistent with previous findings that show positive effects of task variation (including time variations) during training. Also discussed are related research findings that support the benefits of ARTT, and ARTT's impact on emergency procedure training. Further, a synthesis of mutli discipline research outlining the underlying theoretical basis for ARTT is presented. A proposed model of ARTT based on an analogy to Einstein's theory of special relativity is suggested. Conclusions and an outline of future research directions are presented. Successful current commercialization efforts are related as well as future efforts.

INTRODUCTION

Above Real-Time Training (ARTT) refers to a training paradigm that places the operator in a simulated environment that functions at faster than normal time. In the case of air combat maneuvering, a successful tactical air intercept which might normally take five minutes, would be compressed into two or three minutes. All operations of the intercept would correspondingly be accelerated such as airspeed, turn and bank velocities, weapons flyout, and performance of the adversary. In the presence of these time constraints, the pilot would be required to perform the same mission tasks to the same performance criteria--as he would in a real time environment. Such a training paradigm represents a departure from the intuitive, but not often supported, feeling that the best practice is determined by the training environment with the highest fidelity. ARTT can be implemented economically on existing simulators. It is important to realize that ARTT applications require the simulated velocity of the targets and other entities to increase, not the update rate. Over 25 years ago, NASA Dryden's flight test engineers recognized that if one could program a simulator to operate in "fast time", one could give test pilots a more accurate experience or "feel" of real-word stresses that would be present in the aircraft [1] [2].

The bulk of support for ARTT, in simulators, comes from anecdotal reports from NASA. Researchers at the NASA Dryden Flight Research Center during the X-15 program in the late 1960's needed a mechanism to address the X-15 test pilots' post flight comments of being "always behind the airplane..." and "... could never catch up" [3] Clearly, there were some differences between the perceived time in the well-practiced simulator flights and perceived time in the experimental aircraft. NASA Dryden's Jack Kolf originated the fast-time simulation concept and the first time NASA used fast time simulation was toward the end of the X-15 program.

Pilots compared practice runs at various time constants with flights they had already flown. A fast time constant of 1.5x felt closest to their flight experience and was planned on being implemented in the lifting body programs, but lack of funding precluded the program from fully developing the capability. Regardless, NASA's test pilots at DFRC have endorsed the use of "fast time" simulation as part of the training process[1] [2].

Vidulich, Yeh, and Schneider [4] examined the utility of time compression as a training aid for training a basic air traffic control skill (a high performance skill) [16]. One group practiced the intercept with the target plane traveling at 260 knots. The second group practiced the intercept at 5200 knots - 20 times real time! The subjects in this group received between 72-80 trials per hour during training. Both groups were then tested in real time. The time compressed group was significantly better at identifying the turn point; there was no difference between groups on estimating roll out heading for the intercept.

Guckenberger, Uliano, and Lane [5], using a table top tank gunnery simulator, trained naive subjects on three tank gunnery scenarios under five acceleration factors (i.e., 1.0x, 1.5x, 2.0x, sequential, and mixed). Their results demonstrated that training time could be cut up to 50% with performance staying equal to or surpassing a real-time control group. Further, in one **ARTT group (mixed presentation) their mean performance scores were 50% higher than the control group (1.0X).**
Commercialization of ARTT into the mainstream is already being implemented by nine U.S. companies, see future research directions for details.

THEORETICAL UNDERPINNINGS

Psychophysical research into time perception has shown the relativistic nature of time perception in humans [8] [9] [10]. Relativistic nature is defined as linking a human observers perception of time to that particular observer's "stimulation state" or "time norm" analogous to Einstein's theory of special relativity linking relative velocities to a particular observer frame of reference norm. It is noteworthy that this analogy was arrived at independently by Jones [8], Guckenberger [5] and Toumodge [10] from three different fields. Hahn and Jones have even developed working models [11] though their work is primarily in the area of Audio training. Dr. June Skelly is attempting to extend the Audio finding to the arena of Visual training and has already generated some impressive initial results [8]. Brevity of this paper format precludes further in depth synthesis of multi discipline research to support the theoretical basis for ARTT, suffice it to indicate that ARTT now has a firm theoretical basis upon which to build. The foundations for ARTT and Human perception are well established. Time perception can be altered if a particularly boring or interesting task is introduced, or if the arousal state of the subject is changed through external environmental cues [12]. Humans perceive time differently depending upon the individual's "stimulation state" or "time norm" This stimulation state is based, in part, on the sensory cues in the environment and the interactivity level between the individual and his/her environment. Perceived time, therefore, is tied to the particular individual at his/her particular stimulation state to form a "time frame of reference" for that individual. Cohen [13] discusses evidence for an interrelationship between one's "inner clock" and sensory/motor functioning where each can influence each other to alter the perception of time. Most high performance tasks involve both sensory/motor and cognitive skills. Further Wright-Patterson Researchers have developed a method of Rapid Communication (RAP-COM) which improved throughput and retention [14].

When this subjective time reference is perceived as long, it may offer a unique advantage for providing training on critical high performance skills. This artificially accelerated frame of reference may give the operator more "time" in which to actually perform key elements of the mission. It is important to note that when using ARTT more compressed training trials can be performed in the same amount of time. The very realization that the operator has more time may lead to better decision making and situational awareness. It may give the operator the edge that makes the difference in today's modern battlefield. More training trials per unit time is reason enough to implement ARTT. As long as no negative training is introduced, more economic training can occur on existing simulators. The simplest case for ARTT is improved simulator usage either by more trials per unit time per trainee, or higher trainee throughput. Recent experiments extending ARTT to virtual reality have shown ARTT produces higher performance, reduced frustration and stress, reduced temporal workload using validated NASA Wewerinke TLX scales [7].

RESEARCH OBJECTIVES AND HYPOTHESES

The objectives of this task is to conduct research regarding: (1) the relative effectiveness of ARTT versus conventional training on different simulator platforms; (2) the relative effectiveness of alternative implementations of ARTT; and (3) the impact of ARTT versus conventional training on total time. Prior research suggests that training in a time accelerated environment should lead to poor performance versus a control group, but should lead to greater performance on a real-time transfer task. Second, it is expected that there will be group differences in training as a function of the time acceleration constant that is used. Third, it is obvious that training time will be reduced in direct proportion to the time acceleration constant used. Finally, it is not expected that training under various time manipulations will lead to negative transfer of training to a real-time task.

METHOD

Subjects

Twenty-four mission-capable F-16 Air Force pilots from the 56th Tactical Training Wing, MacDill Air Force Base, Tampa served as subjects for this experiment. This subject pool had 743 mean flight hours (range of 300-3400), and 134 mean simulator hours (range of 30-500). All subjects were recruited on a voluntary basis in accordance with American Psychological Association (APA) Principles for Research with Human Subjects. Prior to testing, subjects were given written instructions informing them as to the general nature of the experiment.

Equipment and Materials

Two Avionics Situational Awareness Trainers (ASAT) were used as the testbed for this study. The ASAT is a low-cost F-16A cockpit trainer designed primarily to train in the beyond visual range (BVR) environment. The hardware components that make up the ASAT consist of three personal computers (PCs). The host computer is a PC-AT with an i386 CPU and a i387-20 co-processor, which drive the head-up (out-the-window) and radar electro-optic (REO) displays and collect the data coming from the stick and throttle. Another PC-AT computer (i286), drives the radar warning receiver display. Sound and vibrational cues are provided through the third PC which drives a stereo amplifier, seat and back cushion-mounted speakers, and sub woofers. Aural cues available in the ASAT include radar sensor tones, engine and air noise, missile launch, and gunfire, radar warning receiver (RWR) tones, and missile seeker head tones.

Graphics for the head-up display are high resolution, 1024 x 1024 RGB, with a 63.36 kHz horizontal scanning frequency. The monitor for the head-up and visual display is a 19-inch color CRT monitor which is mounted in front of the pilot on top of the cockpit enclosure, and gives the pilot a 23° X 23° field-of-view. The REO display simulates that of the F-16A Block 15S AN/APG 66 radar, and is presented on a 5" monochrome monitor. It is driven by the i386 and is controlled through switch activation on the throttle and by a radar control panel located on the left side of the simulator. The panel contains active switches to control antenna azimuth, antenna elevation and target history selection. The radar warning receiver (RWR) simulates the ALR-69 RWR, and the display consists of a 9" EGA resolution color monitor. All symbology is generic and unclassified.

The side-stick controller and throttle are high fidelity copies of the controls used in the actual F-16A. The stick can experience a maximum deflection of 0.25" in each of the four axis (forward, backward, right, left), and is equipped with buttons that allow the performance of different functions which include four way trim, missile release, gun triggering, missile select button (AIM 9-J/L), and a return to search switch. The throttle controls thrust from idle to full military power and beyond through five stages of afterburner. (It should be noted that no change in thrust results in the ASAT from afterburner stage 2 through stage 5; the afterburner has only two states: on and off.) Other throttle functions include: four way radar cursor, UHF/VHF transmit switch, missile uncage button, speed brake switch, antenna elevation knob, chaff/flare release button, and dog fight switch.

The ASATs communicate via a PC-based ethernet network at the asynchronous rate of approximately 10-14 packets per second. For the purpose of this experiment, the network was modified so that each ASAT communicated through a Hewlett-Packard i386, 33 mHz PC which served as the experimental interface.

This PC controlled task selection, trial start and stop times, duration, data storage, and other experimental information. In this design, the PC would also send messages to either ASAT instructing the simulator to activate or deactivate certain functions (e.g., sound) that were required for a subject to perform a given task. Special purpose *C* and assembly software was written to handle these special requirements

Procedure

The subjects' first mission was to familiarize themselves with the simulator, including its displays, controls, and handling qualities. These aspects of the simulator are probably different than what the subjects are normally accustomed to. Since the F-16A model is no longer in service with the U.S. Air Force, only some of our subjects had ever flown it. Based on preliminary test subjects, we do not believe this to be a problem since the F-16A and F-16C models have sufficiently similar aerodynamic and avionics characteristics. The subjects were given approximately forty-five minutes for familiarization across a wide variety of scenarios. During this time, the subjects were encouraged to experiment with the controls, displays, and the flying characteristics of the simulator.

After the familiarization period there was about a fifteen minute break. The subjects then flew an assigned order of the three tasks at an assigned ARTT value. These assignments have been made beforehand and represent a complete counterbalancing of the four ARTT conditions, three tasks, and 24 subjects. For each task, the subject flew 10 trials at the assigned group, subjects were presented with a random presentation of the first three time constants. The within-group factor tested a trial effect with each subject receiving 10 training and 4 test or transfer trials. Dependent variables included varied flight performance data such as time-to-lock, time-to-kill, hit/miss percentage, mission performance times, and emergency procedure checklist performance. Specific data collected were a function of the task being performed

Training Tasks and Initial Conditions. The three tasks used for this study are listed and explained below. A task ended when the subject "killed" the target(s) or when the task timed-out. We limited any given task to five minutes to optimize data storage. For each hop for each task, the subject had unlimited fuel. The subject did not have access to any ground control intercept (GCI) or airborne AWACS information. The following task briefings were the only information available.

> Task 1 - One versus Two Air Combat Maneuvering. Two bogeys on the nose at 25,000 ft. Goal was two valid face shots on the initial merge. Continue to engage the bogeys until they have been killed, or until the experimenter terminates the hop.
>
> Task 2 - Stern Conversion. Bogey was 40 miles on the nose at 20,000 ft. Goal was to perform stern conversion and position for a possible AIM 9J missile or gun shot as quickly as possible. Maximum distance for weapons employment was 1500 ft. The subject was required to maintain a 30 degree aspect cone at no more than 1500 feet before permission to fire was given. This allows for adequate data collection. This hop ended when the bogey has been killed or when the experimenter terminates the hop.
>
> Task 3 - Emergency Procedure. In this task, the subject was flying over enemy area suspected of having energy pulse weapons (better known as "power sucker"). The subject must deal with two external threats. Namely, the "power sucker" and an enemy bogey. When the subject was painted by one of these weapons, he heard (and felt) a constant low rumbling noise indicating an imminent and catastrophic power loss. If this happened, the emergency procedure (EP) to defeat this weapon was as follows:
>
> 1) fire energy decoy (missile);
> 2) change heading left 10 degrees; 3) hit energizer (flare);
> 4) change heading right 10 degrees; 5) fire energy decoy (missile);
> 6) hit energizer (flare).

If the subject performed the procedure above exactly, and in the correct order, the "power sucker" would be defeated and aircraft power would be restored. If not, the subject would crash. The goal of this task was to perform the EP above as quickly as possible while at the same time successfully engaging a hostile bogey.

RESULTS

Raw flight performance data originally collected at a 10-14 Hz iteration rate were reduced into trial summaries. Summary data were then analyzed using the Statistical Package for the Social Sciences (SPSS) [15]. The multivariate analysis of variance (MANOVA) syntax for SPSS was used as the overall design structure for the analysis; however, univariate F tests were calculated for specific planned comparisons of interest. These planned comparisons focused on identifying statistically-reliable differences between the performance of the four time acceleration groups in training, and performance comparing the average of the three training blocks (for a given task/dependent variable combinations) with the two transfer trial blocks.

For the emergency procedure (EP) task, number of MiGs killed, time to complete EP, and percent of EP performed correctly were analyzed by group. Analysis of the EP flight data demonstrated a significant increase in MIG kills from training to transfer for all accelerated conditions ($F_{3,20} = 10.87, p < .01$) with the 1.5x and 2.0x conditions slightly outperforming the mixed group. The three accelerated groups, at the conclusion of the last transfer block, had a better than six-fold advantage in the number of MIG kills compared to those trained at real-time (see Figure 2 on next page.) Further, the EP results demonstrated that all the groups trained under accelerated time conditions produced significantly higher accuracy in performing an emergency procedure in the transfer condition than did a real-time control group. The mixed and the 2.0x groups performed the EP near perfectly (100% and 96.6%, respectively). The 1.5x group's accuracy was almost 90%, while the control group scored the lowest at about 72%. (see Figure 1 on next page.)

When comparing performance in training on the number of MIG kills, there is also a significant difference between the groups ($F_{3,20} = 3.95, p < .05$). Both the 1.5x and 2.0x groups performed better in training when compared to the 1.0x and mixed groups. This finding was not expected, and is not consistent with what is known about the contextual interference phenomenon.

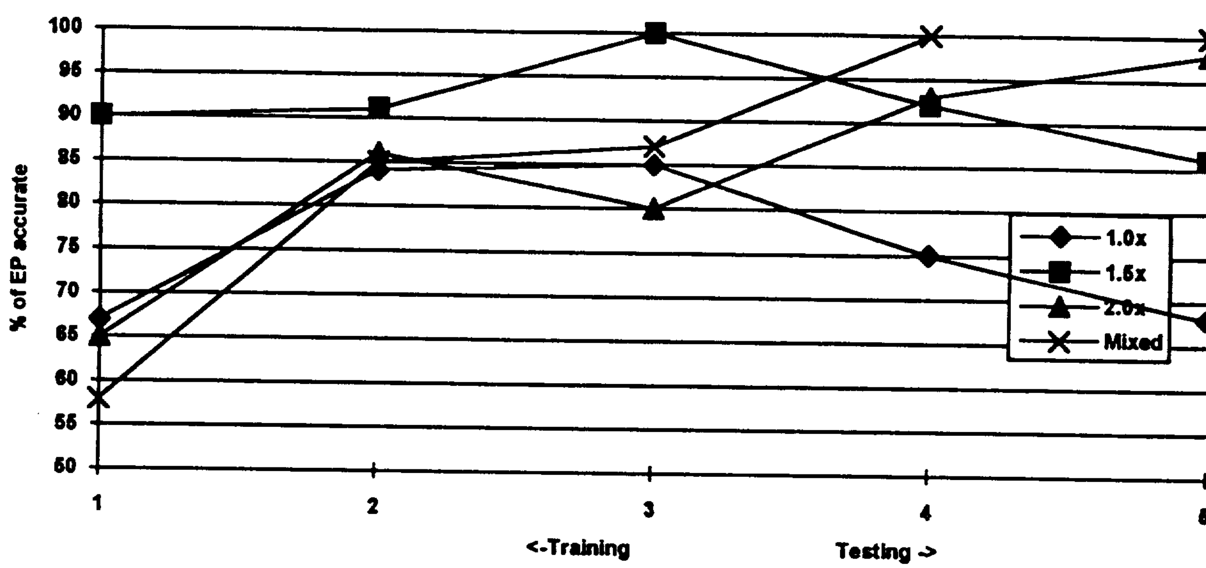

Figure 1. Mean percentage of EP performed correctly by trial block
Block 1..3 = training, Block 4..5 testing

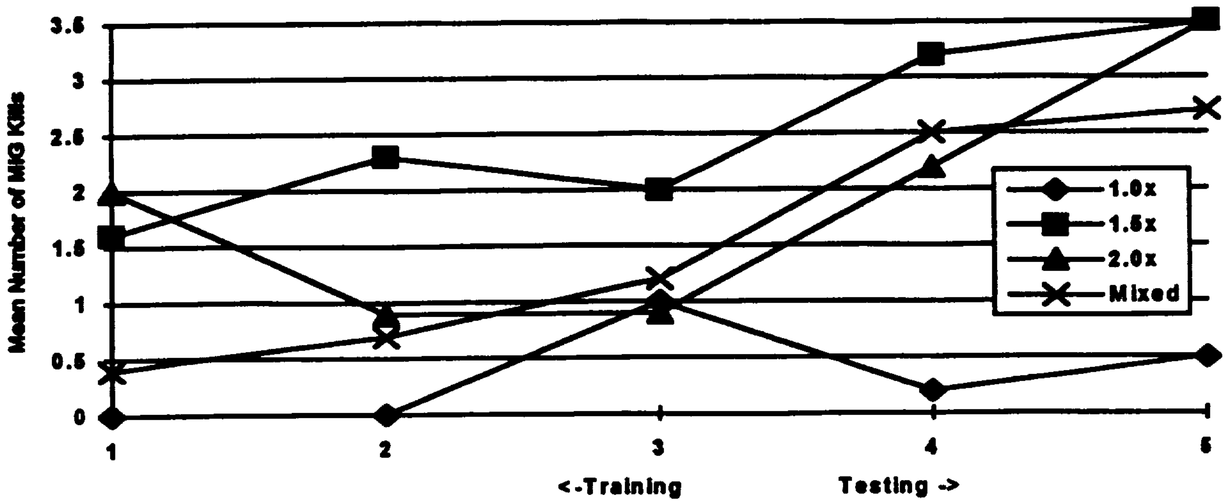

Figure 2. Mean Number of MiG Kills by trial block
Block 1..3 = training, Block 4..5 testing

Next, the time to complete the EP procedure, and percent of EP procedure performed correct were analyzed. As time went on, all the groups completed the EP checklist items quicker, although that difference was not statistically reliable When comparing the accuracy performance, however, both the 2.0x and mixed conditions performed the checklist task significantly better than either the 1.0x or 1.5x groups, when later tested at real-time ($F_{3,20} = 7.45$, $p < .002$). In fact, subjects in the mixed group scored perfectly in the transfer condition. The 1.0x and 1.5x groups actually saw a slight decrease in accuracy performance from training to transfer. There were no mentionable differences between the groups in training.

For the stern conversion task, time to reach criterion, stern score, and distance at lock were analyzed by group. Analysis of the stern conversion task showed that the 1.5x group performed only slightly better than the other groups in the time to reach a preset position criterion. The 1.5x group performed the task faster in training *and* in transfer but the reader will note that these findings are not statistically significant.

For the distance at lock variable, which represents a measure of radar target acquisition performance, the 2.0x and 1.5x groups performed slightly worse in training, indicating that subjects in those two groups took somewhat longer to locate and lock the bogey. With this variable, the greater the range at which the bogey is identified and locked, the better opportunity a pilot has to make decisions. In transfer, the 1.0x and 1.5x groups continued to improve, however, the mixed group showed a significant decrease in the first transfer trial block ($F_{3,20} = 37.64$, $p < .001$)(see Figure 3. This latter finding could be due to the relative uncertainty of the initial closure speeds and range-to-target caused by mixing the accelerated conditions.

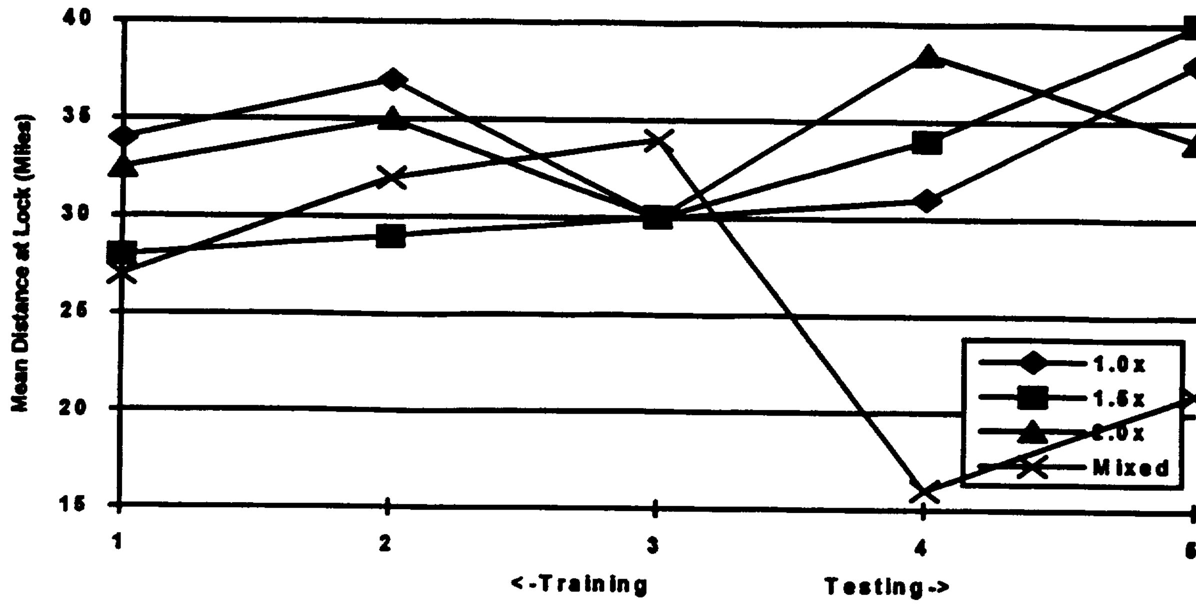

Figure 3. Mean distance at lock by trial block
Block 1..3 = training, Block 4..5 testing

For the stern conversion score, there are no significant differences between groups in training or between training and transfer performance among the four groups. The scoring procedure used for the stern task is based on a subjective rating that is often given by instructor pilots (IPs) to students. The score is based on assessing both the closure speed and aspect angle during the conversion. The idea being that when the pilot rolls-out behind the bogey (low aspect angle), the pilot should not be more than three miles or less than one mile behind the bogey. As a rule-of-thumb, the closure speed should also be in proportion to the distance (e.g., at 2 miles, 200 knots closure speed). Although not statistically different, there is an actual decrease in performance from the last training block to the first transfer block followed by a slight increase in performance at the last transfer block. In the end, performance for the 1.0x group is higher than the other groups. The results of the stern conversion, taken together, tends to suggest that piloting tasks that involve well-learned (at real-time) and continuous responses to both internal (ownship) and external (bogey) positioning cues might not benefit from above-real-time simulation.

For the air combat maneuvering (ACM) task, time to first lock, time to reach criterion, and number of valid missile shots were analyzed by group. For time to first lock, which is a measure of the speed at which a pilot acquires his adversary on radar, all groups except the 1.0x group saw a significant increase in lock time from the last training block to the first transfer block ($F_{3,20} = 2.92$, $p < .05$). In comparing the groups at the final transfer block, both the mixed and 1.0x groups performed significantly better than either the 1.5x or 2.0x group. The 2.0x group also outperformed the 1.5x group in transfer (see Figure 4).

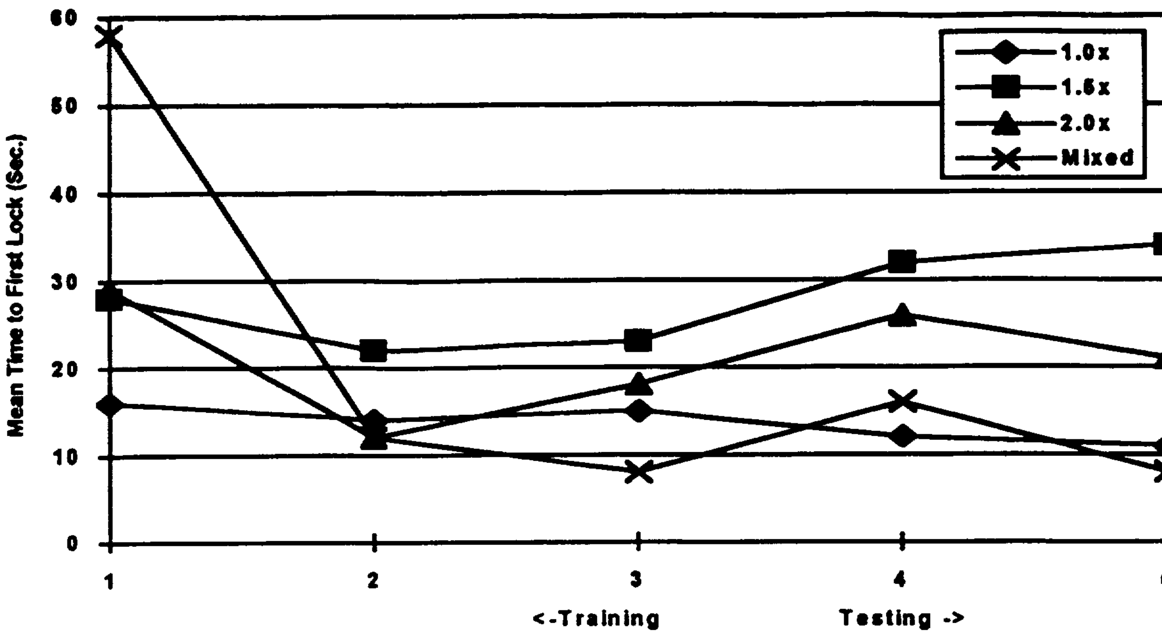

Figure 4. Mean time to first lock by trial block
Block 1..3 = training, Block 4..5 testing

For the time to reach criterion, there was no significant difference between groups from training to transfer. In comparing the last transfer block, however, the mixed group performed significantly better than either of the other groups ($F_{3,20} = 4.55, p < .014$) (See Figure 5).

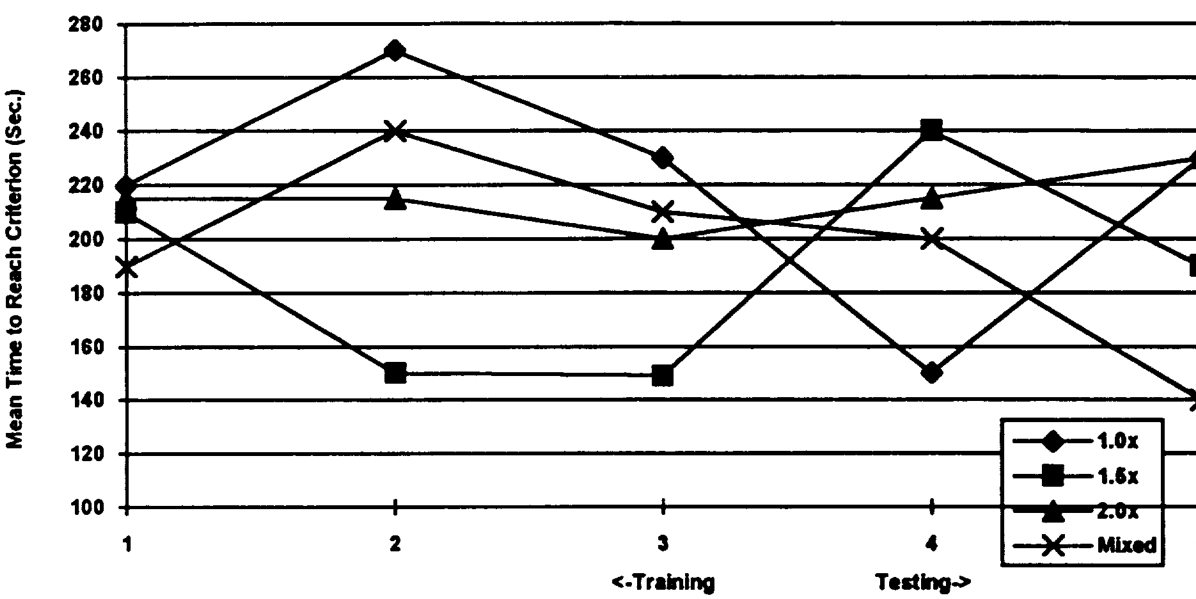

Figure 5. Mean time to reach criterion by trial block (ACM)
Block 1..3 = training, Block 4..5 testing

Finally, the mean hit/miss percentage were analyzed and revealed no significant differences between group in either training or transfer Upon further inspection, it was apparent that this metric was somewhat biased due to the performance of the missiles. This point is expanded in the discussion section below.

DISCUSSION

The EP results demonstrated that all the groups trained under accelerated time conditions produced significantly higher accuracy in performing an emergency procedure in the transfer condition than did a real-time control group. The mixed and the 2.0x groups performed the EP near perfectly (100% and 96.6%, respectively). The 1.5x group's accuracy was almost 90%, while the control group scored the lowest at about 72%. This finding in particular demonstrates that ARTT may have potential to train procedural tasks with greater accuracy and in less time. In the EP task, the difficulty of the task was increased by placing all groups under the additional (simulated) stress of having to perform the EP during a secondary air combat task. **An unexpected result was each ARTT group, the number of enemy MiGs killed was six times higher than the 1.0x groups when compared in the real-time transfer blocks.** There was also no significant difference between the groups when analyzing the time to complete the EP variable. The subjects, after a few trials, mastered the procedure and their performance stabilized. This seems to indicate that ARTT does not necessarily effect the speed with which pure motor tasks are performed, rather ARTT benefits the internal decision making process.

Results of the stern conversion tasks are less clear, and neither support or refute the ARTT concept. For this task we attempted to implement ARTT by increasing the velocities of the ASAT and the bogey. In retrospect, due to the physics and geometry of the stern task, we failed to create a savings or reduction in training time which is a central tenet in ARTT. The task forced the ARTT groups to take essentially the same time in training as the real-time control group. In other experiments we have been successful by speeding up targets, ownship, or both. This was not the case for the stern task. Moreover, pilots differ greatly in their approach to performing the task. Some would perform a low/high or high/low vertical conversion while some would initially offset left or right and perform a "standard" conversion. This made it difficult to establish useful measures of performance. Tasks such as the stern conversion that could be performed successfully using one or more alternate strategies, did not produce useful measures.

The air combat maneuvering (ACM) task also produced mixed results. Again, the fact that pilots have different flying styles leads to difficult performance assessment. The pilots were instructed to take two valid face shots - one at each bogey. A "valid" shot was one in which the range from the bogey was less than or equal to six miles and the aspect angle was between 135 and 180 degrees. The ASAT software modeled only the older AIM-9J and AIM-9L missiles. Unfortunately, when the raw data were inspected, it became clear that the pilots had great difficulty achieving "valid" missile shots, as they were defined, regardless of the group they were assigned. The explanation for this phenomenon lies in the performance of the missiles and the attack profiles preferred by the pilots. Specifically, the AIM-9L is capable of a high aspect kills, but its performance is significantly worse than the newer AIM-9M which the pilots are familiar with. The hit/miss percentage metric, therefore, cannot be considered a true reflection of pilot/weapon performance. In addition, most pilots chose to "offset" or break right or left to create more of an advantageous aspect angle. With a less than optimal high aspect kill performance of the AIM-9L missiles, the fight usually degenerated into a tail chase with a time savings disappearing since both the ASAT and the MiGs were both accelerated.

There were some trends in the ACM task that, although are not statistically significant, bear some mentioning. The mixed group were 11% faster in disposing of the two MiGs. The mixed group also showed the fastest reduction in time to first lock from training to transfer. Finally, the hit/miss percentage score was highest in the 1.5x and 2.0x groups.

CONCLUSION

Based on the results of this research, tasks that contain simple psychomotor or procedural components such as the emergency procedure task performed on the F-16 ASAT clearly benefit from ARTT. Moreover, this research demonstrated that task type and task content are differentially affected by ARTT. The ARTT groups showed higher performance scores when compared to a real-time control group in transfer for the EP task. For tasks with more complex cognitive components such as the ACM and stern conversion, there was no clear advantage in the ARTT groups compared to a real-time control group. The stern and ACM tasks allowed for alternative performance strategies that pose particular measurement and interpretation problems.

ARTT potential benefits for emergency procedure training can not be over emphasized. The increase accuracy of performing EPs bears further study because of the obvious implications for safety training. Many real-world emergencies require accurate performance of checklist procedures under sometimes extremely stressful circumstances. In this study those trained under an accelerated condition not only performed the primary EP more accurately, they also were able achieve a significantly greater number of MIG kills (6x) on a concurrent secondary task.

ARTT obviously has utility in the weapons training process, further, consider it may be possible to accelerate a pilots "time norm" in the cockpit just prior to combat the ARTT pilot advantage in the time dimension will increase combat effectiveness and situational awareness.

With respect to the initial research objectives:

1. ARTT was more effective than conventional real-time training in the case of EP task. The stern conversion and ACM task results were mixed.
2. For those significant effects, the group that provided the greatest performance improvements was the one that mixed the presentation at different speeds. This supports the contention that task variety in training leads to higher performance.
3. The impact of the ASAT study on training time is inconclusive due to methodological considerations.

Finally, as expected none of the ARTT groups experienced any negative transfer of training to real-time transfer tasks.

The results of this experiment can be seen as further support of the benefits of training at Above-Real Time. The emergency procedure task results illustrate the performance increases obtainable using ARTT on existing simulators. The other two tasks did not restrict the pilot's actions sufficiently to allow useful measures to be obtained. American pilots are arguably the finest pilots in the world, but their independence and cunning that make them great, also makes them difficult to restrict and measure. Consider the evolution of research listed below:

- The first use of "fast time" or ARTT in simulators was Jack Kolf at NASA Dryden over 20 years ago. [1[
- NASA'S initial success was followed by successes in the lifting body program as well. [2].
- The success of ATC by the FAA study. [4]
- Success of VIGS time saving and performance increase. [5]
- Emergency procedure in F-16 accuracy increase [6]
- Virtual time in VR reduced stress and workload [7]

Applications of ARTT to simulators seems to have merit. The theoretical frame work for ARTT continues with synthesis from many diverse fields, most notably audio perception who's relativistic working models may transfer to illuminate ARTT's working relativistic model.

ARTT and the intrinsic time adaptability of man is a vast field of great potential.

FUTURE RESEARCH DIRECTIONS

Near-term work will focus on expanding the application of ARTT for emergency procedure training. We are also beginning to explore techniques to test the effectiveness of ARTT on subsequent performance in the actual aircraft.

The overall aim of the ARTT concept is to exploit the time adaptability of humans and foster a new way of thinking about time manipulation in the man-machine interface. Future research directions might include safety, education, medical, and entertainment applications. For example, it would be possible to increase the voice and data communication rate over a network to allow crews or teams to train at faster than real-time.
Also, as scientists explore the concept of ARTT and virtual time, the real world bond we have with perceived time

will weaken. Time flow could be controlled for the benefit of the trainee. New training methods that are time flexible will change form, fit and function of the man-machine interface. ARTT programs are initially planned in simulation and training with follow on to use of ARTT in other man-machine interfaces. Emergency procedure training for pilots, both commercial and military is envisioned as the initial proving ground.

Current and near future Research Projects include:

- ARTT for airborne weapons training
- Virtual Time Adding the fourth Dimension to Virtual Reality: Next Generation Man-Machine Interfaces
- Above Real Time Communication
- ARTT applications in a DIS environment
- ARTT applications in Video Decompression
- ARTT Theoretical model: Relativistic Time-Speed Reading-Speed Listening -> Speed Simulating
- Time adaptive training and time adaptive human computer interfaces
- Slower than real-time in the human-computer interface to benefit the elderly, disabled and disadvantaged

Commercialization of ARTT into the mainstream is already being implemented by nine U.S. companies, see below for outline of details.

ARTT commercialization has begun:

- ECC has modified six different simulators to include the technique
- Silicon Graphics Flight, Shadow and Dogfight simulations now support ARTT
- Coryphaeus Designers' Workbench now supports the ARTT interface
- Pellucid's OPEN-GL library is planning support
- Link, fellowship for advanced simulation and training has been awarded to further ARTT research
- TWA is considering participating in a pilot program
- Total Quality Tennis has contracted to build ARTT simulators
- The Chicago Cubs are negotiating to improve batting through ARTT simulation
- Most importantly, NASA and the Airforce are seeking to support further research for the use of ARTT in emergency procedures training and improving air safety

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