NAVIGATION AIDS IN ROUTE TRAINING:

INCREASE NAVIGATION SPEED, DECREASE ROUTE RETENTION?

by

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ABSTRACT

In the case of one car following another to a destination, it is very effective at getting the second vehicle to the destination quickly; however, the driver of the second car may not learn the route. Yet, for individuals, such as firefighters, law enforcement, and military personnel, it is imperative that a route be learned quickly and accurately and that an awareness of the situation is maintained while they traverse the given route. This leads to three questions, (a) will navigation aids affect initial route navigation; (b) will navigation aids affect retention; and (c) will navigation aids affect situation awareness while en route? The hypotheses of this study were that navigation aids would significantly increase the speed at which a person can initially navigate a route, but the use of the aids would significantly decrease the retention of the route navigated. The findings of this study support the hypotheses. The results suggest that participants that followed a confederate and participants that were given verbal directions were quicker and made fewer errors than participants that reviewed a map or initially figured the route out on their own (control group). The study also showed that as the participants navigated the route for a second time with no navigational assistance, the ones that reviewed a map or that were in the control group outperformed participants that initially had a confederate to follow or were given verbal directions their first time through. Finally, no real effects were found on the participants' situation awareness during the retention portion of the study.

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LIST OF ACRONYMS/ABBREVIATIONS

ANOVA	Analysis of Variance
CIC	Navy Combat Information Center
EEG	Electroencephalograph
GPS	Global Positioning System
HUD	Head-Up Display
IRB	Internal Review Board
LAN	Local Area Network
MDMP	Military Decision Making Process
RPD	Recognition-Primed Decisions
SA	Situation Awareness
SAGAT	Situation Awareness Global Assessment Technique
TRADOC	U. S. Army Training and Doctrine Command

CHAPTER ONE: INTRODUCTION

The use of mazes and routes has been utilized since the basic learning studies of Watson (Watson & McDougall,1928) and Skinner (1938). In a separate area of research, the use of route learning and map layouts was studied for city design. By 1970 (Appleyard), the distinction between routes (knowing an area by landmarks), surveys (knowing an area by an overall spatial elements) and maps for the purpose of city grids, layout, and planning had been well defined. Throughout the 1970's mazes and routes were used for understanding human spatial cognition (Piaget & Inhelder, 1969; Hart & Moore, 1973; Siegel & White, 1975; Evans, 1980), but actual scientific study of routes and methods of improving the learning of routes were not initiated until the mid 1980's (Palij, Levine, & Kahan, 1984; Perrig & Kintsch, 1985). The research of the eighties and nineties examined the fundamental aspects of route and survey knowledge and retention (Thorndyke & Hayes-Roth, 1982; Moeser, 1988; Taylor, Naylor, & Chechile, 1999) and set the foundation of knowledge for this research. Researchers in the nineties have focused on viewpoints and orientation (Shelton & McNamara, 2001), as well as computer and virtual/ augmented reality applications (Witmer, Bailey, & Knerr, 1996).

For certain individuals, such as firefighters, emergency responders, law enforcement, and military personnel, it is imperative that a route be learned quickly and accurately. This is so an awareness of the situation is maintained while they traverse the given route. In the case of the firefighter, for example, he/she is faced with the choice of entering a burning building to search for survivors immediately, without knowing exits, stairs, room locations, or waiting for blueprints to be sent or downloaded to have a map. If the firefighter waits for the map, time must be taken to memorize the map before entering the burning building.

Current technology allows for other choices as well. Should the firefighter take a walkie-talkie for verbal directions? Is technology available to have a head up display (HUD) showing routes or the use of augmented reality to give virtual guides through the building? If the technology is available, is it even a good choice for the firefighter to use it? What if these devices fail from the smoke, heat or fire, will the firefighter recall the route?

Taking into consideration these situations and concerns, research into the use of navigation aids and what consequences their use might have becomes an important topic. For the purpose of this study, navigation aids referrers to any item, event, or person that assists the traveler in navigating through the route. Navigation aids include a guide of any kind, a guidance system, signs and markers, audio or visual directions, or any other means of aid in finding the way through a route. There is a small set of common navigation aids, such as compass and map, way points, and guides. In addition, now there is the integration of the global positioning system (GPS) into these fundamental aids.

Recent technological advancements are providing equipment that also presents potential use as a navigation aid. For instance, the use of HUD's and augmented reality allow virtual objects to be placed before a person and viewed as if in the real. Furthermore, tactile devices (R. Gilson, personal communication, November 12, 2004) that use vibration could also potentially be used as a navigation aid when implemented into a system where signals regarding the route are relayed to the device while the wearer is traversing the route. By presenting information in front of the user, these devices can keep a person's vision on the route ahead, potentially allowing for better maintenance of situation awareness.

There are two aspects of situation awareness (SA) that come into play regarding route retention. One is the notion that using a navigation aid focuses the attention of the trainee on the aid rather than learning the route. The second is the possibility that using a navigation aid focuses the attention of the trainee on the aid rather than on maintaining an awareness of the secondary events (fire, enemies, dangers, etc.) taking place on the route they traverse. The maintenance of SA is essential for decision making while en route. The individuals on these given routes must be able to make life or death decisions quickly and accurately.

As previously stated, there exists a need for research into the use of navigation aids and the consequences their use might have. This study address this need by investigating the effect the use of navigation aids has on the ability to traverse a route and on the retention of knowledge of that route. In addition, the ability to maintain situation awareness while attempting to recall the route in navigation was examined. It was hypothesized that the navigation aid will increase the speed at which a route is initially traversed; however, retention of that route will decrease with the use of aid.

CHAPTER TWO: LITERATURE REVIEW

To begin this study, the current state of several fields of research first had to be reviewed. The primary areas that needed to be reviewed were navigation and route learning and the effects they have upon situation awareness. It was also found pertinent to review means of measuring SA to better understand how to measure the constructs of the study. The workings of spatial memory and Decision making were also examined in order to better understand how the learning of routes takes place. Finally, the effects experience has on learning, memory and Decision making were also considered.

Navigation/ Route learning

Route learning (both visual and text) involves changes in local orientation throughout the encoding experience, with new route legs described from different orientations. A principal reference vector, such as North, could therefore be established for the entire environment. Previous work on real, virtual, and imagined environments has suggested that the first-person view is best for the initial orientation (Palij, Levine, & Kahan, 1984; Wilson, Tlauka, & Wilbur, 1999). However, when dynamic scenes are viewed from multiple perspectives over time, recognition of still images is fastest and most accurate when the viewpoint of the still image matches the perspective one had at the particular time point in question (Garsoffky, Schwan, & Hesse, 2002), supporting a changing principal reference vector which is a known given direction, such as a North arrow on a map.

Route and map are two sources of learning spatial reference that differ on a number of potentially important dimensions. Route learning is done by the perspective of a ground-level

observer within the space. It requires updating of local orientation through first-person movement and turns. The global structure of the space must be inferred from the information available in first-person views. In contrast, survey learning involves a perspective external to the space or an above, Gods-eye view. The space can be viewed from a fixed orientation, and the properties of the global structure are more easily accessed (Shelton & McNamara, 2004). Comparisons of route-level navigation and map learning have yielded a variety of behavioral results (Moeser, 1988; Thorndyke & Hayes-Roth, 1982). For example, Thorndyke and Hayes-Roth (1982) have shown that extensive navigation leads to survey-like knowledge that is equivalent to the knowledge available from map learning. However, the results from another study were not equivalent. Moeser (1988) compared nursing students with two years of experience in navigating a hospital to naïve participants who studied only floor plans. The naive participants were able to perform significantly better than the nursing students on judgments of distance and pointing directions, suggesting that the nursing students were not showing survey knowledge despite extensive experience. These results suggest that the development of survey knowledge with experience is not necessarily automatic (Taylor, Naylor, & Chechile, 1999).

For survey learning, it is possible that survey information might be represented in an orientation-free reference system, with no explicit establishment of a principal reference vector. There are no obvious theoretical predictions about differences between the visual and text-based presentations, other than gender. Previous research has shown better performance for map learning compared with either route or survey texts (Perrig & Kintsch, 1985). No differences were observed for text learning versus visual learning conditions aside from the differences in orientation effects, suggesting that participants could effectively learn the environments from

either modality (Shelton & McNamara, 2004). That is, participants who learned a route text or movie were faster on route recognition than on survey recognition, whereas participants who learned a survey text or movie were faster on survey recognition than on route recognition (Shelton & McNamara, 2004).

Route encoding has a much greater reliance on maintaining the sequence of events, whereas survey encoding can use the global properties to help organize locations (Shelton & McNamara, 2004). Differences between route and survey encoding have been observed using neuroimaging (Shelton & Gabrieli, 2002). When participants were scanned during the encoding of route and survey movies, the results indicated that survey encoding activated a subset of the brain regions activated by route encoding. The additional activated regions associated with route encoding suggested processes such as integration of spatial information and larger mnemonic loads (Shelton & McNamara, 2004). Another way to increase the amount of route or survey retention is to use text descriptions (Ferguson & Hegarty, 1994; Perrig & Kintsch, 1985; Taylor & Tversky, 1992).

Situation Awareness

Researchers over the last two decades have continued to narrow the definition of situation awareness and apply its concepts to different circumstances and personnel. The term situation awareness (SA) has been used with pilots, air traffic controllers, fire fighters, and others who are involved in situations that require quick decisions under stress (Gilson, Garland, & Koonce, 1994).

A popular definition of situation awareness, offered by Endsley (1988), is “perception of the elements in the environment within a volume of space and time, the comprehension of their meaning, and the projection of their status in the near future.” This was simplified by Howell (1993) to read, “SA involves an operator keeping track of a lot of information from a variety of sources over time and organizing or interpreting this information”. Later, Endsley (1995) expanded her definition into a model of situation awareness including three levels. The first is a perception of the elements of the current situation. This is an understanding of the physical environment a person is in. The second is a comprehension of the situation. Here the dynamics of the physical elements and people in the situation must be understood, in terms of their movement and purpose. Third is the projection of future status of the situation. Situation awareness occurs over time; therefore, the effect on current events on the near future is the last level of this definition of situation awareness. SA encompasses not only an awareness of key elements in the situation, it encompasses a gestalt (‘big picture’) comprehension and integration of that information in light of operational goals, along with the ability to project future states of the system. These higher levels have been found to be critical to effective functioning in complex environments, such as those faced by soldiers (Endsley, 1999). Furthermore, situation awareness, according to the U. S. Army Training and Doctrine Command (TRADOC)(1994), is defined as “the ability to have accurate real-time information of friendly, enemy, neutral, and non-combatant locations; a common, relevant picture of the battlefield scaled to specific levels of interest and special needs.” This final definition is pertinent to all soldiers on all battlefields.

In a study by Kaempf, Klein, Thordsen, and Wolf (1996), it was investigated how SA influences Decision making in a Navy Combat Information Center (CIC) and found that SA is an

important factor in decision quality. Furthermore, fluidity of the situations and the incompleteness of available information ensure that the problems attacked by natural decision making are inherently ill-defined (Klein, Orasanu, Calderwood & Zsambok , 1993).

Measuring SA

Endsley (1988) developed the Situation Awareness Global Assessment Technique (SAGAT), an explicit measure that involves stopping a simulation and asking questions about what has just occurred. Other direct measures of situation awareness include: queries about situational information at the end of a scenario, recall of displays, and information seeking measures such as eye movements on primary or secondary tasks (Tenney, Adams, Pew, Huggins & Rogers, 1992). Past studies have also used physiological measures, such as heart rate, eye blink, and EEG (Electroencephalograph) activity, as indicators of effort in mental processing and, therefore, situation awareness (Vidulich, Stratton, Crabtree & Wilson, 1994). Based on the simplicity and reliability of a secondary task measure for SA, this study used counting items for a secondary task as a measure of SA.

Spatial Memory

With an understanding of situation awareness, the next logical discussion is with the memory techniques that might be used in memory of spaces (Shelton & McNamara, 2001). This refers to maps, auditory directions, virtual walk-through, models, etc. any means of mentally representing space in one's mind. Past research of route memory suggests that first landmarks are memorized and association of actions are paired with the landmarks. Next, as the pairing

continues, it evolves into survey knowledge (Siegel & White, 1975). This simplistic view has been altered upon over the years. First, representations of room-sized spaces have been shown to be orientation dependent when learned from a single viewpoint (Rieser, 1989) or even multiple viewpoints (Diwadkar & McNamara, 1997; Shelton & McNamara, 1997). That is to say, that people, in general, have a hard time rotating a given special representation from the original view that they learned the space. Therefore, if a real route is to be learned in a virtual training environment, the route needs to be in the same orientation that the person will travel the path in the real world.

Spatial skills are known to vary widely in the normal adult population (e.g., Hegarty & Kozhevnikov, 1999; Just & Carpenter, 1985), and one hallmark of spatial skill variability has been sex differences (Vandenberg & Kuse, 1978) where males have shown to be significantly better at spatial learning and retention. Shelton and McNamara (2001) outlined a framework for understanding orientation-dependent performance in spatial memory. According to this framework, spatial learning involves encoding locations by first establishing a spatial reference system, such as “north” is up on a map.

Decision Making

With an understanding of situation awareness, the next step is the application of SA in decision making. In order to make good decisions in the combat environment it is necessary to make an accurate assessment of the situation (Wellens, 1993). This holds true for most extreme environments.

An area of current research that implements SA in decision making is naturalistic decision making (Randel, Pugh, & Reed, 1996; Klein, 1993). High-risk personnel, such as fire fighters or soldiers in the field, must be prepared to make split-second decisions that could save or lose lives. Naturalistic decision making encompasses environments with time constraints, changing conditions, and stress where recognition-primed decisions (RPDs) are hypothesized to take place (Klein, 1989). Kline (1998) describes RPDs as a means to show how people use past experience to make decisions. These RPDs allow the person to have preplanned actions trained and ready to be executed in given situations that require quick response. The findings of RPDs and the ability to make better decisions with RPDs was based, in part, on better situation awareness.

Experience and Training

More experienced personnel demonstrate superior skills. In a study conducted for the Army Research Institute, not only could experienced officers identify significantly more locations of their own and enemy troops than less experienced officers, they could also identify the highest threat areas from the enemy which the less experienced officers did not do at all (Strater, Endsley, Pleban, & Matthews, 2001). Research suggests that some of the differences between experts and novices in decision making may be due to a difference in ability to perceive meaningful patterns (Shanteau, 1987) and to associate certain action with those patterns (Means, Salas, Crandall & Jacobs, 1993). Experts have been shown to use visually-based schema that are specific to their area of expertise (Hunt, 1989). While situation assessment by a skilled worker appears to take place very quickly, the basis for it is built up by continual appraisal (Sarter &

Woods, 1991). Therefore, the sooner a person can become aware of the patterns of a given situation forming, the sooner RPDs can be initiated to correctly deal with the situation.

One form of learning patterns is rehearsal. The available research has shown that virtual environment mission rehearsal has been effectively used. Examples of this include to improve pilots' understanding of mission plans (Nullmeyer, Bruce, Conquest, & Reed, 1992); enhance subsequent use of available flight time (Lintern, Sheppard, Parker, Yates, & Nolan, 1989); improve target detection of objects at greater ranges (Krebs, McCarley, & Bryant, 1999); and enhance route knowledge within buildings (Witmer, Bailey, Knerr, & Parsons, 1996). Virtual environments were also found to be as effective as more traditional rehearsal strategies, i.e., map-study, with regard to training navigational accuracy (Williams, Wickens, & Hutchinson, 1994).

CHAPTER THREE: METHODOLOGY

Hypotheses

The hypotheses consisted of two parts: (1) navigation aids will significantly increase the speed at which a person can accomplish a navigation task, but (2) the use of the aids will significantly decrease the retention of the route navigated. It was hypothesized that this study would suggest significant differences between voice commands and follow the leader scenarios against the results of memorizing a map ahead of time. The study utilizes four types of navigation aids to training. The control groups used no aid, while the experimental groups used either a map before route, verbal directions from the experimenter during route, or they followed a leader through the route.

It was expected that the participants that follow a leader through the route would have the least retention based on mental attention resources used to follow the leader and less time observing the route. Based on the work of Witmer, Bailey, Knerr, and Parsons (1996), it was also expected that these results would show congruence between the use of the navigation device in virtual environment and live navigation/orientation studying. Also, based on the works of Hegarty and Kozhevnikov (1999), Just and Carpenter (1985), and Vandenberg and Kuse (1978), male participants are hypothesized to perform better than female participants.

Variables

Independent variables. The independent variables in the experimental groups were navigation aid types: map and directions (map), verbal directions (verbal), and a person to follow (follow). The control group (control) received no aid in learning the routes.

Dependent variables. For this study, the dependent variables were the participants' time through the routes and number of wrong turns (errors) while on the route. To measure situation awareness, the study used the number of people counted in the virtual environment routes and number of orange pieces of tape counted in the real maze.

Participants

This study had 84 participants from the central Florida area. Approximately 60 were students of the University of Central Florida. The participants' ages ranged from 9 to 75 with a mean of 26. Forty-one of the participants were male and forty-three were female.

Apparatus

This study used a demographic questionnaire (see Appendix B), written and verbal instructions of the study (see Appendix C), a sheet of math problems (see Appendix D).

The two PC systems running the Windows XP operating system were used. The systems were networked together over a LAN for use with the multi-player function of the *Ghost Recon*™ game.

The PC game Tom Clancy's *Ghost Recon* Gold Edition ™ was used for the virtual navigation environment. The game was a first-person shooter with 3-D graphics. It had realistic city and building environments that were used for scenarios.

The physical maze consisted of seven turns and a correct route measuring 240 feet. The maze was constructed of three-foot wood stakes and natural jute twine set around a street lamp on the edge of a large grass field. The walkways were approximately two feet wide and the total area of the maze was a 2400 square feet (40X60 ft). Layouts of the maps used in the study are shown in Appendix A and an image of the real maze is shown in Appendix F. A stopwatch was used to measure the time through the routes

Procedure

The participant entered into the lab area, was given a consent form to review and sign and a demographic survey. General instructions were given using written forms and reviewed verbally with the participant. After this, the participant was given instructions on how to use the *Ghost Recon*™ controls and allowed to become familiar with the controls and *Ghost Recon*™ environment for five minutes or until the participant felt comfortable with the controls.

The participant next began the scenarios. There were six scenarios. The first was the experimental scenario where the participants were assigned to one of the four variable groups mentioned above. This was done using the Latin Squares method of randomization. In scenarios two through five, the participants used a different, specified navigation aid for each scenario as follows: scenario two, map; scenario three, verbal; scenario four, control; scenario five, follow.

The sixth scenario was the real maze. In the real maze scenario, participants were again assigned to one of the four variable groups using the Latin Squares method of randomization.

Each scenario consisted of six steps. First, the participant reviewed any navigation aid until they stated they were ready to proceed. Second, the participant would begin the training phase of the experiment and navigate through the route. Third, the participant would perform math problems (fourth step) from the math sheet for three minutes. Fifth, the participants would begin the test phase of the study by navigating the route a second time with no navigation aids. Finally, in the sixth step the experimenter would record all data for the training and test time through the maze, number of errors on the training and test phase and the count of the secondary task to measure SA on the test phase.

In each scenario, the participants made approximately seven turn decisions with the navigational aid(s) based on the group the participant was assigned. Speed and accuracy were measured and recorded with a stopwatch and the number of wrong turns was recorded as well. The secondary, SA task, was measured on the Test portion of each scenario. This was done by having the participants count the number of personnel seen while en route, which were presented as orange tape tied on the lines of the physical maze and as computer-generated personnel in the virtual world.

After completing the route, the participant was given a math worksheet consisting of eleven large number multiplication problems and ten long-division problems. The participant was given three minutes to complete as many problems as he or she could before starting the test phase of the scenario. This was done to stop any mental rehearsal of the route, so that a clearer test of the retention of the learned route could be measured. After the three minutes, the participant

navigated the route a second time with no aids regardless of the group assignment in order to gauge retention of the route. Measures of time through route, errors (wrong turns), and number of personnel or orange tape counted were recorded. After one scenario was completed, the participant moved directly to the next scenario until all six where completed.

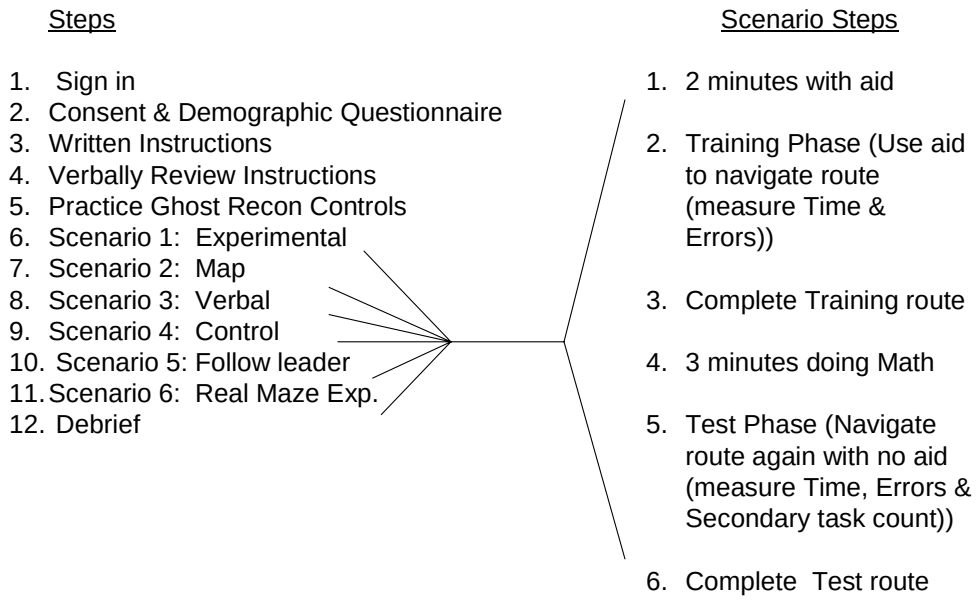


Figure 1. Procedure flow chart

After the participant completed all six scenarios, he was debriefed, received extra credit or was paid in the amount of ten American dollars, and dismissed from the study.

CHAPTER FOUR: RESULTS

The study was divided into the four groups (map, verbal, control, follow) and analyzed on their training and test times through the scenarios, training and test errors made, and test section secondary task count. The results section first reports the combined findings of the entire study. Second, the experimental virtual scenario one, followed by the real maze scenario are presented. Next, the results for the virtual control scenarios, which are scenarios two through five, are presented. The differences between training and test times, and the number of errors made in the scenarios were compared.

All the tables in this chapter are organized to show the mean score, in seconds or number of errors, and relevant information of each group and category in the first half of the table. In the second table is a chart sorting the groups from the best performing group to the worst for each category.

Combined Results

This first section reports the study's overall results. Table 1 shows the findings of the overall study.

Table 1. Overall Means from Combining All Scenarios

	Training Time	Training Error	Test Time	Test Error	Difference
Map	132.52	2.17	98.37	0.76	34.16
Verb	141.99	0.37	162.28	1.44	-20.29
Follow	100.80	0.22	205.86	2.52	-105.06
Control	146.33	3.21	99.60	1.21	46.73

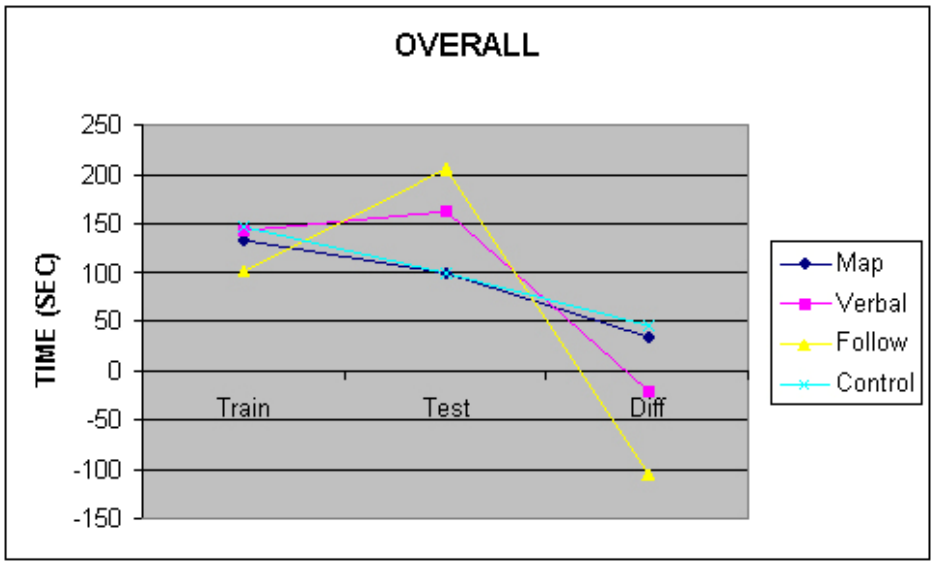


Figure 2. Overall results from combining all scenarios by means

Table 2. Performance of Groups Ordered Best to Worst: Combining All Scenarios

	Training Time	Training Error	Test Time	Test Error	Difference
Best	Follow	Follow	Map	Map	Control
|	Map	Verb	Control	Control	Map
|	Verbal	Map	Verb	Verb	Verb
Worst	Control	Control	Follow	Follow	Follow

Table 1 shows the findings of the study based on the means alone. A 5 x 4 (experimental areas: training time, training error, test time, difference in times, and test error by groups: map, verbal, control, follow) analysis of variance (ANOVA) revealed a significant difference between the groups. Using Tukey's LSD, post hocs show differences in all five experimental categories that correspond with the findings shown in Figure 2 and listed in Table 2. The differences in the groups are as follows: training time $F(3, 477)=11.764$, $p<.005$, the follow group is significantly faster than the other three which all finished in the same time frame. For training error $F(3, 477)= 107.564$, $p<.005$, the follow and verbal groups have approximately the same low number of errors, followed by the map group and the control group with the most errors. For test time $F(3, 477)=39.076$, $p<.005$, the map and control groups, have approximately the same fastest test times, followed by verbal and the follow group with the worst time. In the differences in times, $F(3, 477)=87.830$, $p<.005$, the control group had the most improvement in time followed by the map group. The verbal group lost time from the first trial and the follow group test time nearly doubled its training time. For test error $F(3, 477)=15.182$, $p<.005$, it mirrors that of the test time section where the map group performed the best followed by the verbal, control, and follow groups in order.

Virtual Experimental Results

This section presents the virtual experimental scenario (scenario one) only. Table 3 shows the findings of the virtual experimental scenario.

Table 3. Virtual Scenario Means and SD

	Training/SD	Train Error/SD	Test/SD	Test Error/SD	Difference /SD
Map	275.00/89.02	4.00/2.68	219.24/83.63	1.95/2.33	55.76/74.94
Verb	188.24/16.54	0.29/0.56	209.67/66.27	1.81/3.22	-21.43/67.80
Follow	143.18/30.18	0.14/0.35	184.64/44.28	0.95/1.46	-41.45/ 58.78
Control	282.25/93.81	4.30/2.56	200.10/69.23	1.45/2.09	82.15/101.16

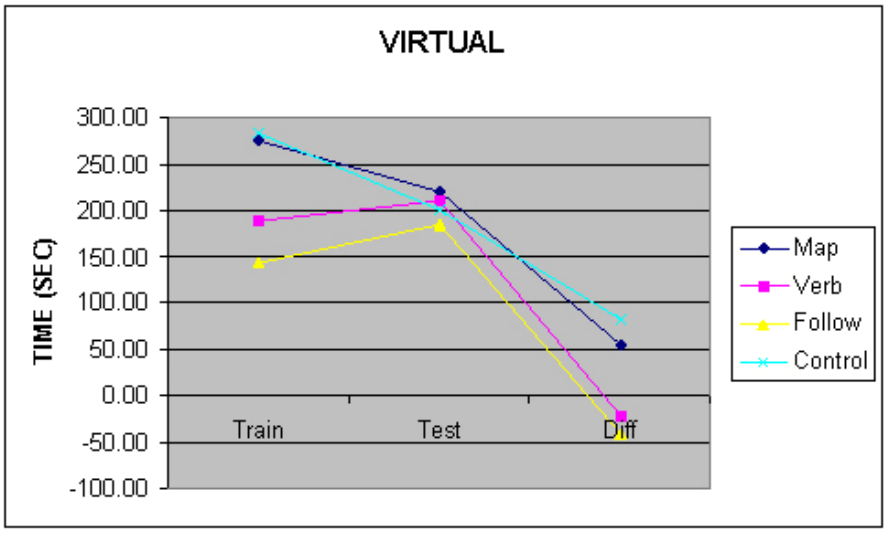


Figure 3. Virtual scenario results by means

Table 4. Performance of Groups Ordered Best to Worst: Virtual Scenario

	Training/SD	Train Error/SD	Test/SD	Test Error/SD	Difference /SD
Best	Follow	Follow	Follow	Follow	Control
|	Verb	Verb	Control	Control	Map
|	Map	Map	Verb	Verb	Verb
Worst	Control	Control	Map	Map	Follow

Table 3 shows the findings of the scenario based on the means alone. Next, a 5 x 4 analysis of variance was conducted, as was done for the overall results. The ANOVA revealed a significant difference and post hocs showed differences in all five experimental categories that corresponds with the findings shown in Figure 3 and listed in Table 4. Using the Tukey's LSD, the differences in the groups are as follows: In the training time, $F(3, 561)=16.818$, $p<.005$, the follow group is significantly fastest which is followed by the verbal group and the map and control group were virtually tied for slowest. For training error, $F(3, 561)=132.431$, $p<.005$, the follow group had the least, verbal and map tied in the middle and the control group had the most errors. In test time, $F(3, 561)=31.014$, $p<.005$, the four groups were in order from the follow group, control, verbal, to the map group as the worst. For the differences in times, $F(3, 561)=96.149$, $p<.005$, the control group had the most improvement in time followed by the map group. The verbal and follow groups lost time from the first trial. In test error, $F(3, 561)=10.178$, $p<.005$, the follow group was best followed in order by control, verbal, and map groups.

Real Maze Results

This section reports the real maze (Scenario six) results. Table 5 shows the basic findings of the real maze.

Table 5. Real Scenario Means and SD

	Training/SD	Train Error/SD	Test/SD	Test Error/SD	Difference /SD
Map	53.05/22.90	2.48/2.20	36.76/10.20	0.86/1.24	16.29/20.56
Verb	39.76/6.12	0.67/0.86	46.14/12.31	1.62/1.16	-6.38/10.02
Follow	27.38/32.23	0.00/0.00	57.45/32.89	2.80/2.46	-27.33/32.23
Control	60.48/27.18	3.43/2.40	44.76/25.65	1.81/1.94	15.71/23.79

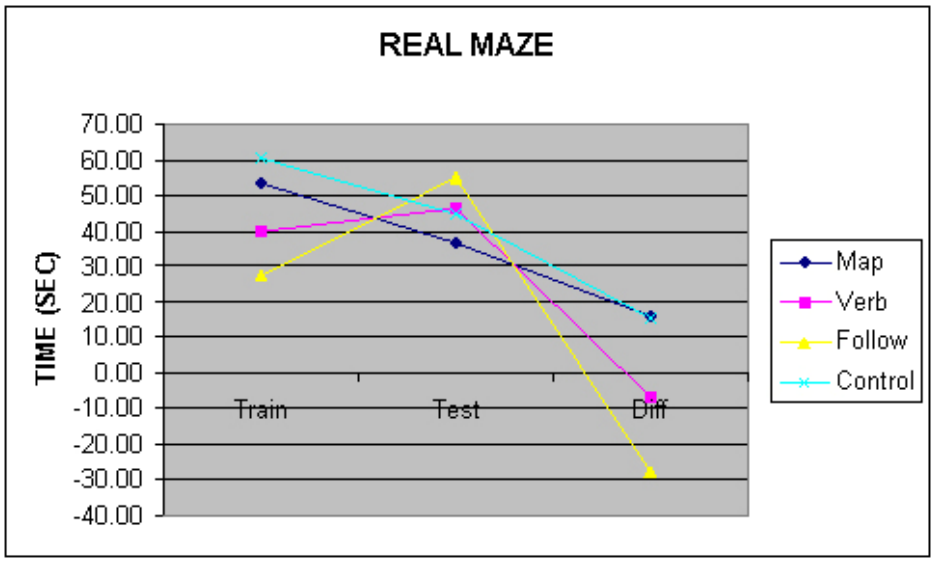


Figure 4. Real scenario by means

Table 6. Performance of Groups Ordered Best to Worst: Real Scenario

	Training/SD	Train Error/SD	Test/SD	Test Error/SD	Difference /SD
Best	Follow	Follow	Map	Map	Map
|	Verb	Verb	Control	Verb	Control
|	Map	Map	Verb	Control	Verb
Worst	Control	Control	Follow	Follow	Follow

Table 5 shows the findings of the scenario based on the means alone. A 5 x 4 analysis of variance was conducted. The ANOVA revealed a significant difference. Using the Tukey's LSD, post hocs showed differences in all five experimental categories which corresponds with the findings shown in Figure 4 and listed in Table 6. The differences in the groups are as follows: first, training time, $F(3, 560)=9.654$, $p<.005$, shows the follow group as significantly faster than verbal which finished second, followed by the other two which finished in the same time frame after verbal. For training error, $F(3, 560)=105.474$, $p<.005$, the results displayed the same pattern as training time. In test time, $F(3, 560)=33.644$, $p<.005$, the groups were ordered as map, control, verbal, and follow groups with each group getting significantly worse than its predecessor. As for the differences in times, $F(3, 560)=85.684$, $p<.005$, the map and control group had equivocally the most improvement in time while the verbal group lost time from the first trial and the follow group test time nearly doubled its training time. Finally for test error, $F(3, 560)=18.099$, $p<.005$, the map group performed the best followed by the verbal, control, follow groups in order.

Scenarios Two through Five Results

This section reports the virtual scenarios two through five (Scenario two = map, three = verbal, four = control, five = follow). The means in training time, training error, test time, test error, and the difference between training and test times is reported for each scenario. These scenarios used different routes for navigating to deter any learning effects. To compare the separate routes, *z*-scores were calculated so that the different maps could be compared. They were computed using the difference from the best possible time through the route and the mean

time. Table 7 shows these results broken into the means, the best possible time through the scenario minus the mean, and the percent difference between the actual means and the best possible time.

Table 7. Virtual Scenarios 2 through 5 Means and Difference from Best Possible Score

	Training /From Best /%	Train Error	Test/ From Best /%	Test Error	Difference
Map	116.77/-47.77/-40.9%	1.64	83.55/-14.55/-17.3%	0.44	33.23
Verb	155.99/-18.99/-12.2%	0.32	179.46/-42.46/-23.7%	1.30	-23.48
Control	139.29/-60.29/-43.28%	3.13	89.29/-10.29/11.5%	0.99	50.00
Follow	104.75/+50.25/+48.0%	0.10	248.04/-93.04/37.5%	3.57	-143.29 (-93.04 corrected)

From Best = the time difference from the best possible time through the scenario, % = the percent difference from the best possible time, which was used to compare to the other groups.

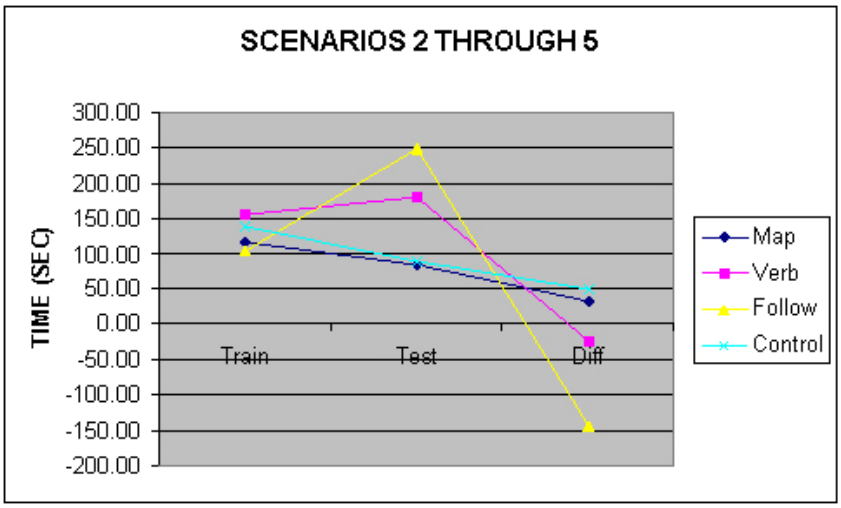


Figure 5. Virtual scenarios 2 through 5 by means

Table 8. Performance of Groups Ordered Best to Worst: Virtual Scenarios 2 through 5

	Training	Train Error	Test	Test Error	Difference
Best	Follow	Follow	Control	Control	Map
|	Verb	Verb	Map	Map	Control
|	Map	Map	Verb	Verb	Verb
Worst	Control	Control	Follow	Follow	Follow

Table 7 gives a chart showing the findings of the scenarios based on the means alone. A 4 x 2 ANOVA $F(3, 311)=45.824$, $p<.005$ showed a significant difference between the groups. The Tukey's LSD between these given groups showed that all the given times in Table 8 and shown in Figure 5 for training time and test time are significantly different except for the test time of map and control, where control time is shown to be closer to the best time, just not by a significant margin.

Secondary Results

The demographics or age, education, military experience, and previous experience with Ghost Recon each individually showed no significant effects on participants' performances in the study.

In regards to gender, aside from the control groups, men had significantly faster times and less errors in all scenarios, $F(1, 478)=15.344$ to 28.540, $p<.005$ with the exception of verbal command retention time, $F(1, 77)=.271$, $p=.604$ where the men and women performed equally.

Computer gaming self-rated overall expertise, where men reported a significantly higher mean than women, $F(1, 84)=16.560$, $p<.005$, had a linear relationship to performance, where the

higher the gaming rating, the quicker the times for the participant. These findings held true for the real maze as well, $F(3, 645)=4.906$, $p=.002$ (real test time). An ANCOVA using Wilk's Lambda, $F(25,47)=1407$, $p<.005$, showed that the effects of the self-rated computer gaming skills and gender covaried. Therefore, in male participants alone, no performance differences were found regardless of self-reported skill. Likewise, no performance differences were found in females based on self-rated skill.

SA Findings

Statistical analysis of the secondary task suggested no significant differences were found within or between the groups. This study was only looking at the results the training had on the final retention of the route. Therefore, these findings were for the test portion of the scenarios only and do not look at the effect using aids en route has on SA.

CHAPTER FIVE: DISCUSSION

Hypotheses Testing

This study asked the question: "Can retention of learning a route be enhanced with navigation aids?" The hypotheses therefore are, (1) navigation aids will significantly increase the speed at which a person can accomplish a navigation task, but (2) the use of the aids will significantly decrease the retention of the route navigated. The overall findings displayed in Table 1 support these hypotheses. The overall results combined the data from all scenarios of the study and used a 5 x 4 ANOVA to study the data. Table 2 shows that participants that used navigation aids en route (*e.g.*, following another person or have verbal directions given while in route) were significantly faster than participants that reviewed a map before navigating the route or that went though the route on their own. Furthermore, participants that used the en route navigation aids did not increase their time through the route and tended to have more errors the second time they navigated the given route. On the other hand, participants that did not have en route navigation aids performed much faster the second time through the route and had significantly less errors than those using navigation aids.

The overall results, as shown in Table 1, support these hypotheses. The training times suggest that following another person through a route is significantly faster than the other three methods for traversing a route. Further supporting these hypotheses, the test time showed that the map and control groups had better recall of the routes than verbal or follow groups. In the differences in times, the control group had the most improvement in time followed by the map group. The verbal group lost time from the first trial and the follow group test time nearly doubled its training time.

Not only did the times back the hypotheses, but the errors made en route for the training phase versus the test phase supported the hypotheses as well. This was seen in the training results by the follow and verbal groups having few errors while the map and control groups had multiple errors, whereas in the test results, the map group performed best followed by the verbal group, with the control and follow groups having the most errors.

The findings of the overall study, the control scenarios two through five, and scenario six (real maze) had similar patterns, but slight differences were found between them and scenario one (virtual experimental scenario). Scenario one agreed with the other groups in the training times and errors. Even though the differences in times matched the other groups, there was a difference in the test times and errors. The follow group had the best time for the scenario in the training and test times, as well as, training and test error for scenario one alone. This inconsistency could be from a number of effects. The first of which is a possible learning effect of the participants. Scenario one was the first scenario that participants navigated in the video game environment. After the fist scenario or two, the participants may have become settled into the study causing a regression toward the means effect. Next is the fact that the virtual building, used for the experimental scenario, allowed participants to leave the set route and reconnect to it at a later point losing very little time in place of going back from a dead-end. Also, this scenario had the least number of real decision points (five) where the rest had approximately seven.

In scenario five, the multi-player setting, even though identical in appearance to the single-user setting, was shown to be 50.25 seconds faster to travel than the single-user setting. This was simply a discrepancy in the *Ghost Recon* game play. Therefore, a 50.25 second correction was used in all statistical research using scenario five data.

Demographic Discussion

In regards to gender, for the verbal command retention time, the men and women performed equally. This supports past research in gender differences (Goldstein, D., Haldane, D., & Mitchell, C., 1990: Fennema, E., & Sherman, J., 1977). Once a pattern was noticed by the researcher, additional data was gathered on the remaining thirty-one participants in the study. In the control setting, where the participants found their own way through the scenario, over half of the final twenty female participants from the study followed the same route that they went through the training portion on the scenario. In contrast to this, nine of the final twelve male participants studied followed a new, more direct route in the test portion on the scenario. This is a significant difference in findings, X^2 (1, N = 31) = 6.23, P=.03 and links these results to study to findings of past spatial ability studies (Goldstein, D., Haldane, D., & Mitchell, C., 1990; Hegarty & Kozhevnikov 1999).

These two significant findings could have application for the population of military, first responders, etc., for which this study is designed. Females seem to recall information better from auditory directions and seem to prefer to follow the path they first followed over using this information as survey knowledge and shortening the path as the males preferred.

Computer gaming self-rated overall expertise, where men reported a significantly higher average than women, had a linear relationship to performance, where those with self-reported higher gaming ability had quicker times across the scenarios. These findings held true for the real maze as well. This finding coincides with the game play research of Sims and Mayer (2002) who found that results of work done in a gaming environment were equivalent to that in the real

world. Computer gaming self-rated individual expertise paralleled the overall expertise ratings and findings. Interestingly, a Wilk's Lambda ANCOVA, $F(31, 40) = 1238.945$, $P<.005$, showed that the effects of the self-rated computer gaming skills covaried with gender. These results were check by looking at the females and males as separate groups. The scores of females had no significant differences based on self-reported gaming ability. Males alone also showed no significant differences in this area.

Regardless of differences found, the overall results of the study are clear. The fastest means to traverse a route was shown to be following someone who knows the path. The best way to retain a route was shown to be reviewing a map before first navigating the route.

The use of the map may be shown as the best learning based method for two reasons. The first is that of survey learning. After reviewing a map, the participant has an overview knowledge of the entire scenario to be navigated. With this knowledge, if a wrong turn is made, the participant has a better internal map of the area. Furthermore, expectation of future turns and landmarks from the map allow the participant to plan ahead. The second reason that the map may give the best result is that by reviewing the map before the training run through the scenario, the participant gets to essentially review the layout twice. By studying the route by reviewing a map and navigating the route before the actual time to traverse the route, the participant doubles the time invested into studying the route. This simple repetition of the scenario, on its own, should lead to greater retention.

As for the control group, in general, participants that found their way through the training section with ease had no problems getting through the test section, while those that became lost

in the training section had a harder time and seemed to still have many errors on the test section. This is an area of possible future research.

SA Discussion

Situation awareness is of high importance. The secondary task showed no significant differences between the groups or the demographics on any of the six routes. This leads the researchers to believe that none of the studied route learning methods would be have an affect on a person's ability to maintain situation awareness.

CHAPTER SIX: CONCLUSION

This study looked at recall of a route that was learned through a walk through with a navigation aid. The results of the study supported the hypotheses. Navigation aids significantly increase the speed at which a person can accomplish a navigation task. This is an important finding on its own. In some cases, time may not be available to learn a route or recall of a route may not be needed after it is completed. It was suggested that the use of the aids would significantly decrease the retention of the route navigated. If retention of the route is not needed, having a navigation aid that acts as a guide or having verbal directions is shown to be the best method to travel. If retention is vital, the user should spend time reviewing a map ahead of time and paying attention to the route and not an aid.

In regards to gender, men retain the routes better except with one navigation aid: verbal directions. Here the men and women performed equally. This would suggest that auditory reinforcement is best for mixed gender groups, but it does not outweigh the findings of the study. Regardless, of the fact that the females did as well as the males in the verbal scenario, the results for the female participants alone still matched the overall results. This suggests that the use of a map still has the best retention of the route for males and females.

Topics for Future Research

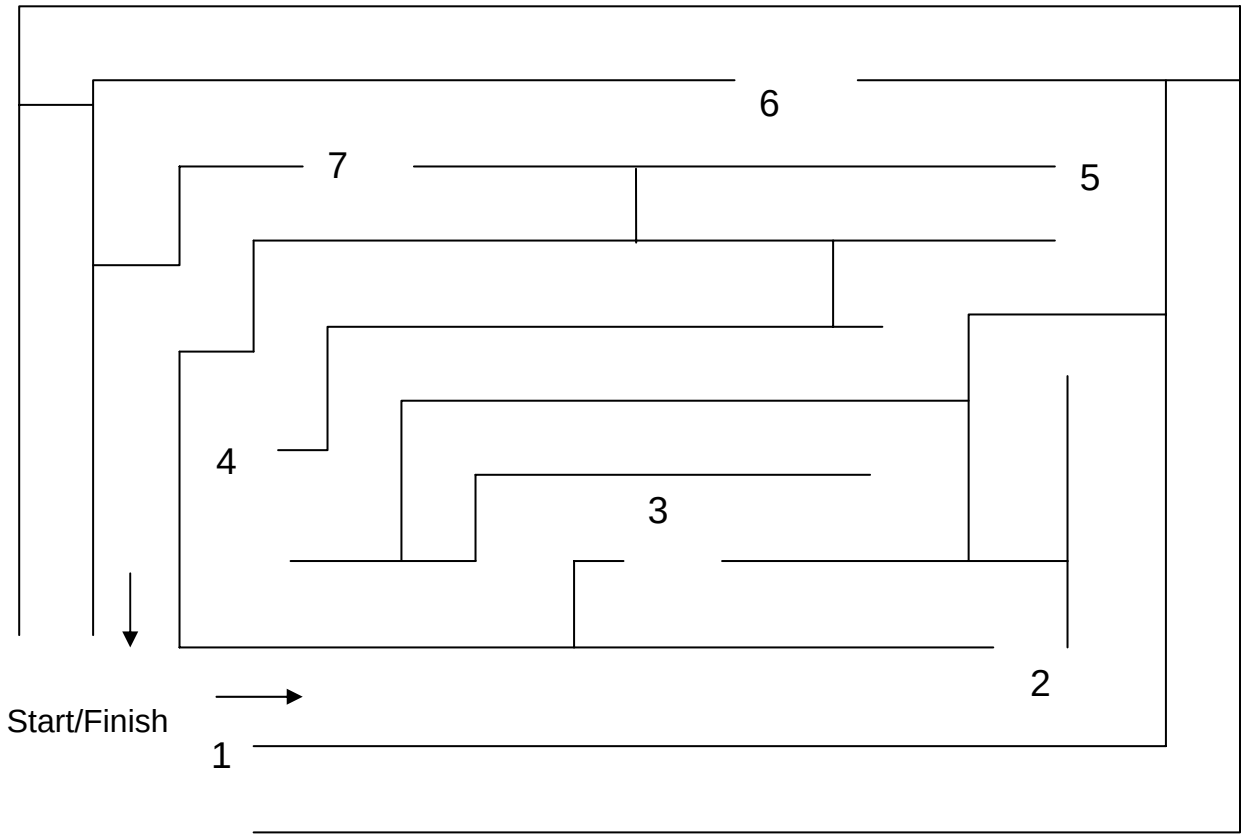
There are three primary areas of research that need to be performed to further advance this research. First is the simple manipulation of this study's variables. This includes looking into other navigation aids, such as using a map while en route, written directions or tactile aids. Also, other forms of follow-the-leader could be included. One of which would be to use a HUD

and have an arrow pointing the way through the route. Another manipulation should look at exit methods or in other words: learn route A to B, test route B to A. This would be beneficial to the firefighter as in the example given in this study. This would look at participants that navigate a route with an aid and need to return without it. Finally, this study looked at the training section of the scenarios as simply training and therefore did not seek to find any effects of a secondary task on time differences between training and test times. The effects of secondary task are relevant especially for navigation tasks that do not get a dry or practice run through a route such as this study provided.

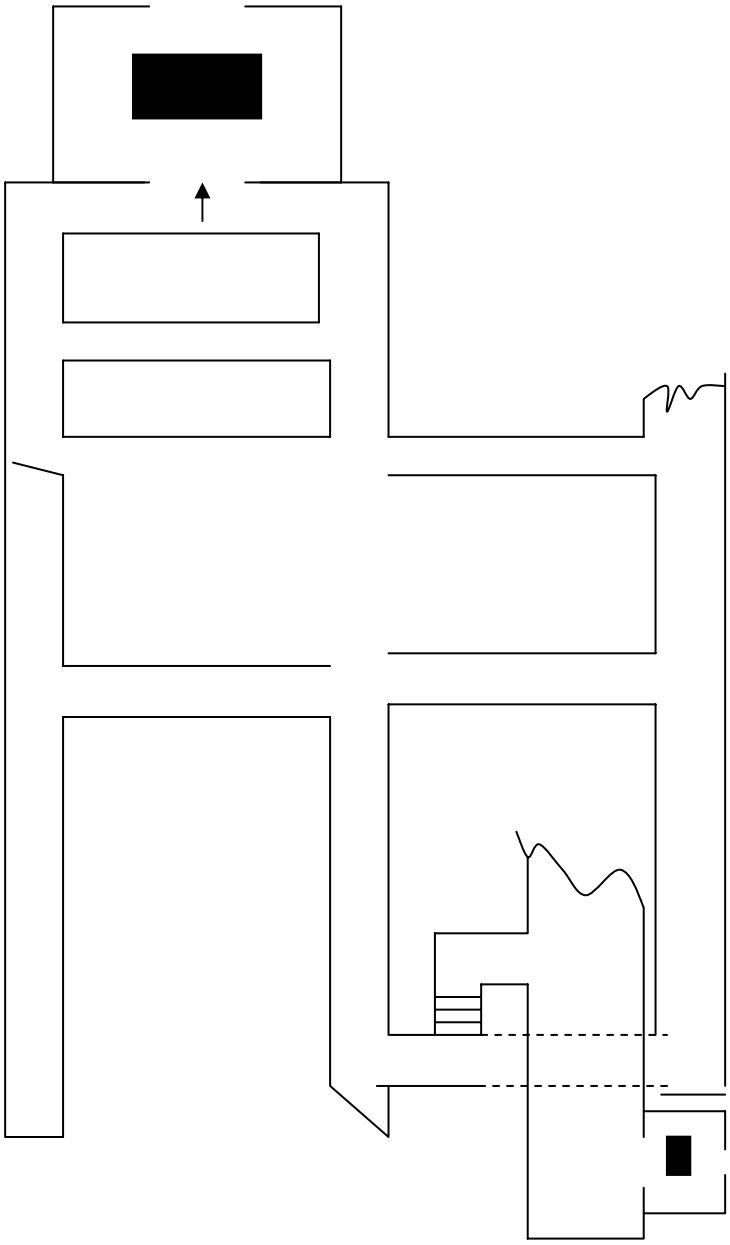
Second is to understand which form of training is best for what sort of people. The results were fairly conclusive, but the study did show that there are differences in people. It is possible that, based on personality, background, or other given traits that people can be grouped into visual, auditory, or tactile for example. Research performed by Derryberry, (2002) showed that attentional control could be an underlying issue of different people and the type of training that is best for them. Furthermore, personality traits such as introversion and extroversion have been shown to have an effect on training (Costa & McCrae, 1992) as well. Ways of testing for these topics should be used in future research.

APPENDIX A: MAPS

Real Outside Maze

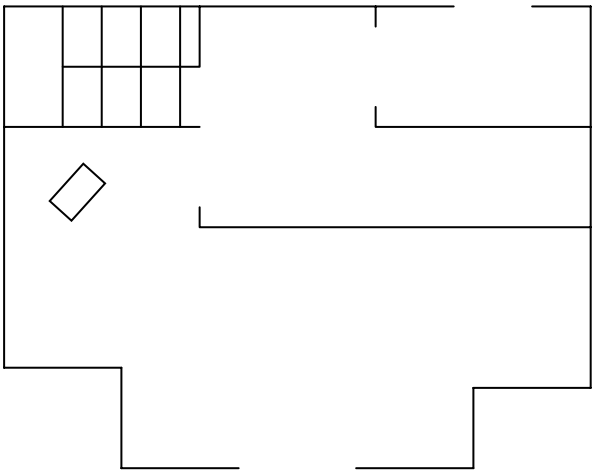


Maze 1 (Test Maze)

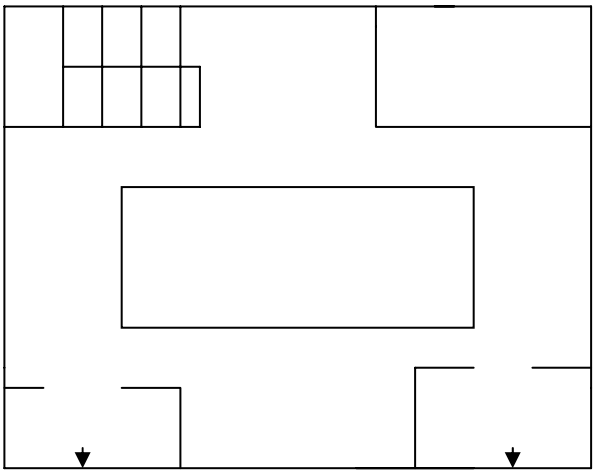


Maze 2 (Map Maze)

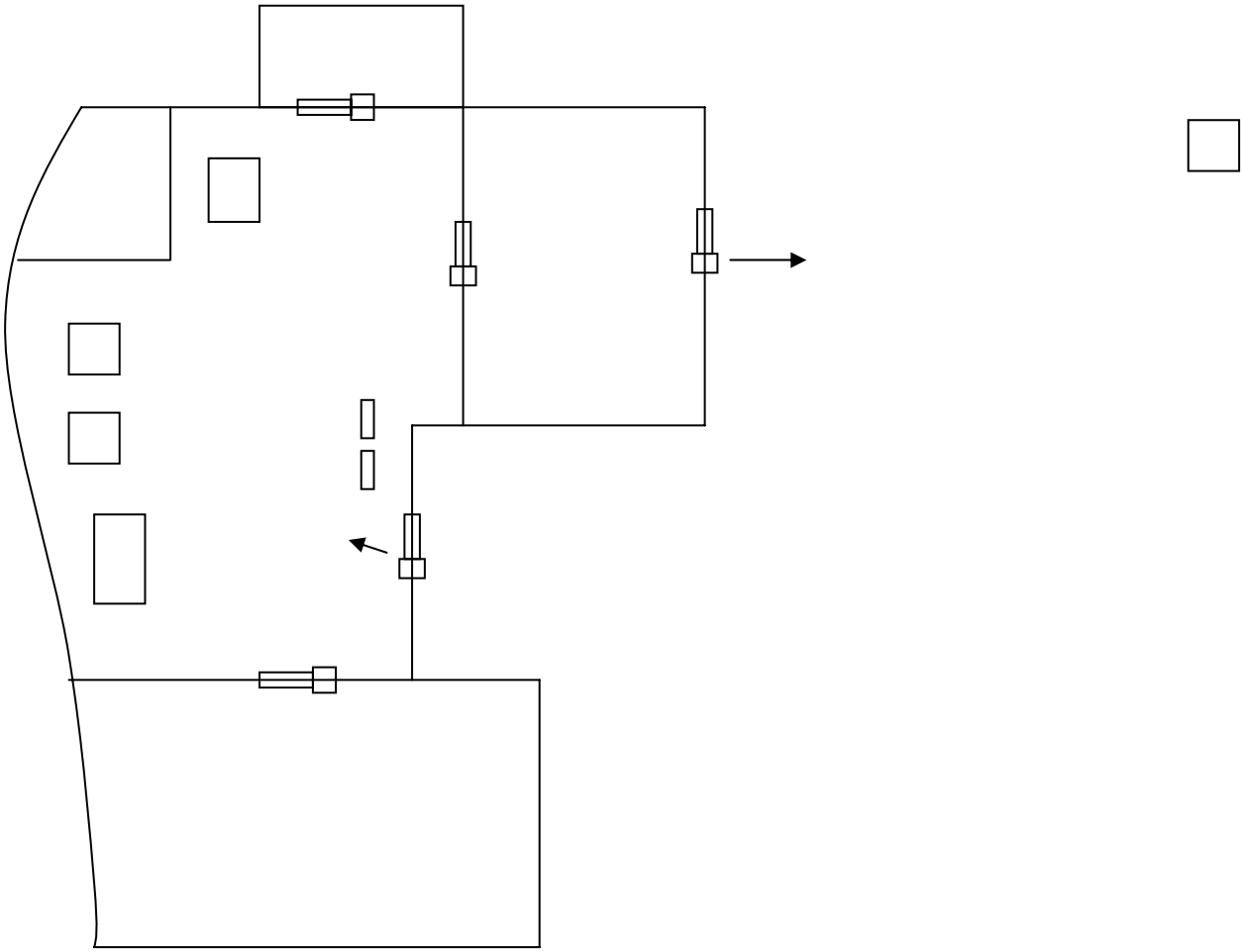
1st Floor



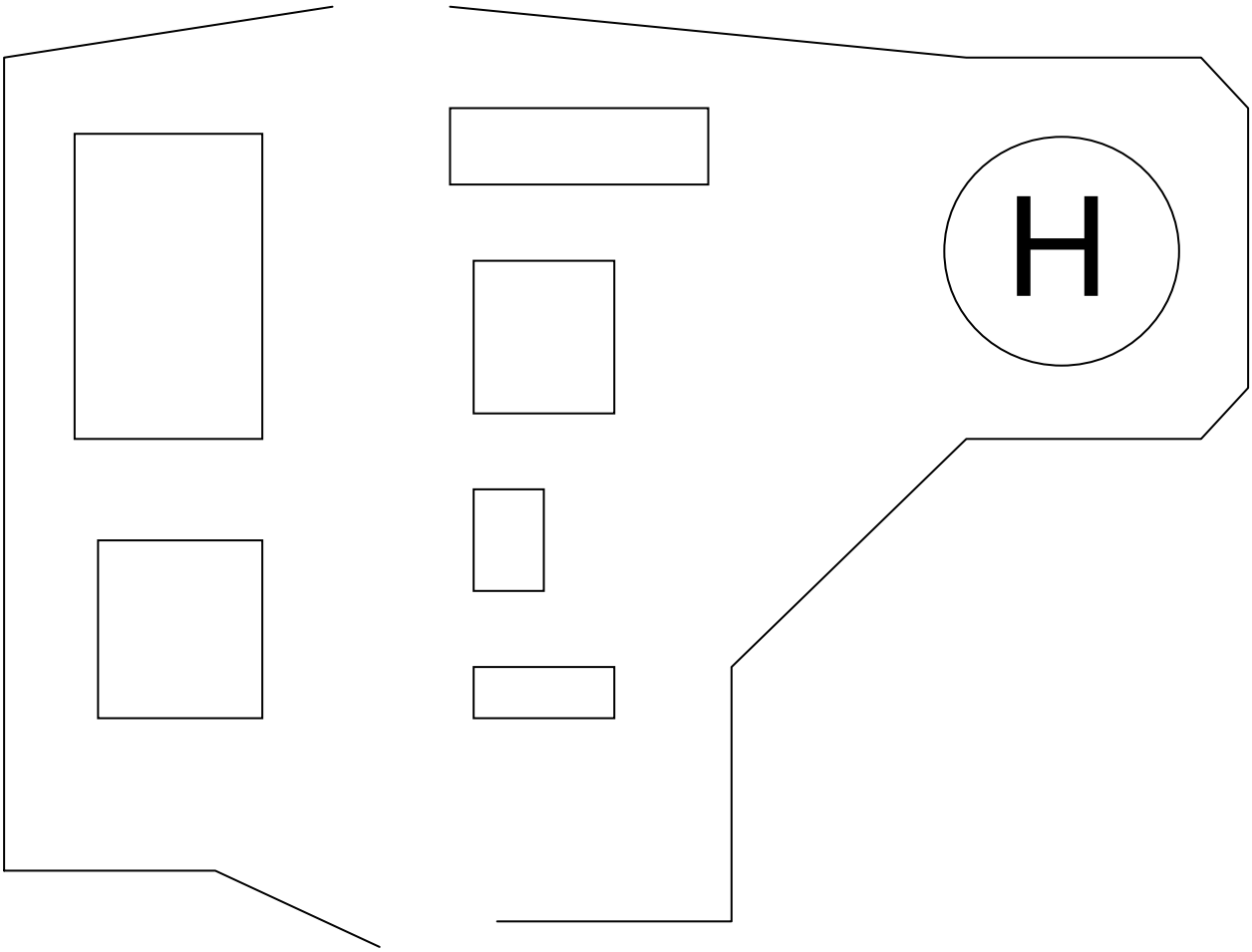
2nd Floor



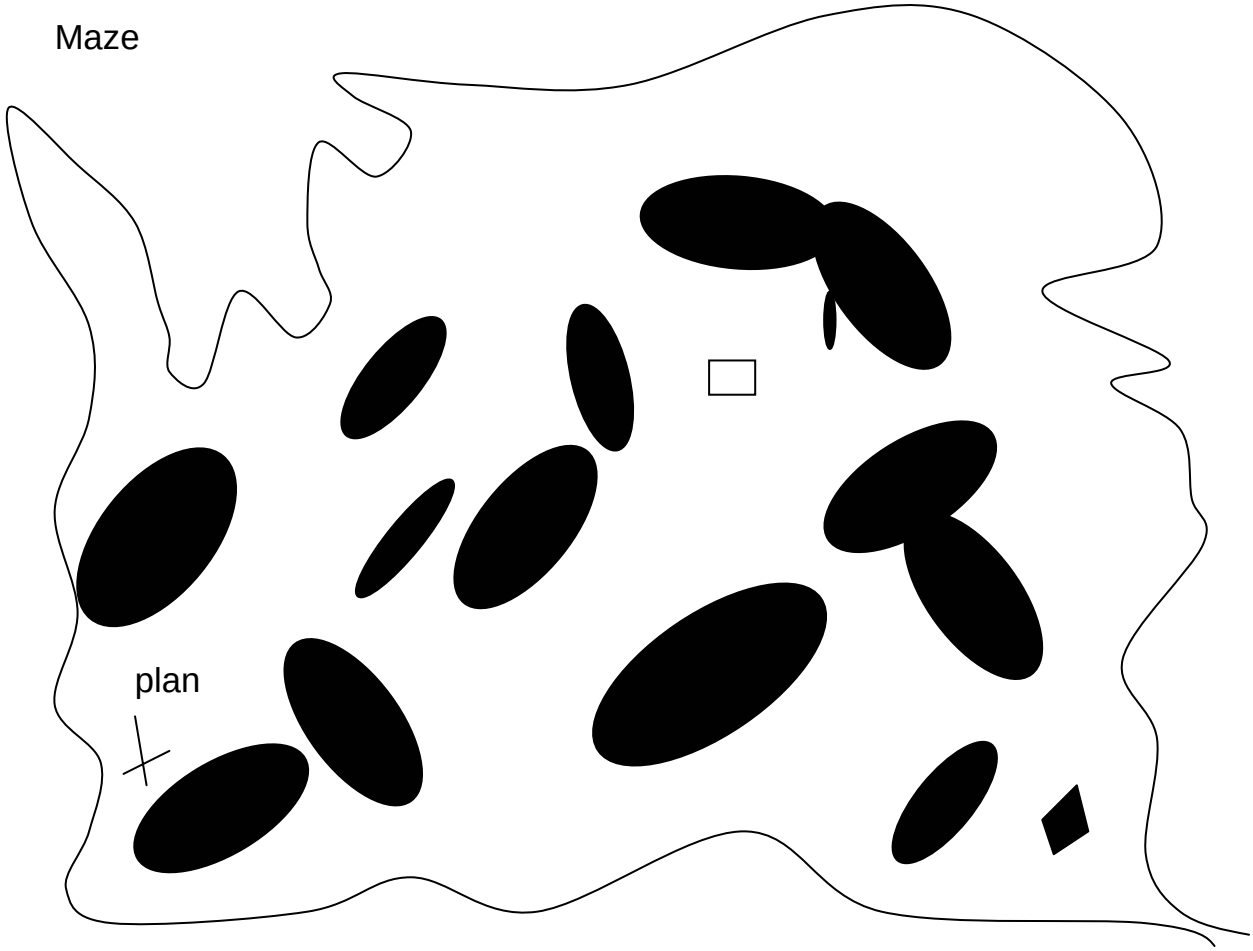
Maze 3 (Maze for Verbal Directions)



Maze 4 (No Aid)



Maze 5 (Follow the Leader)



APPENDIX B: DEMOGRAPHIC QUESTIONNAIRE

Questionnaire

Navigation Aids in Route Training:
Increase Navigation Speed, Decrease Route Retention?
Survey

Demographic Questions:

Participant number:_____

Directions:

Please read each of the following questions carefully. Complete each question by circling the answer, number, or range of numbers that best describes your answer. Only circle one answer and do not circle in-between the answers. When you complete the survey notify the research assistant.

1. Age: _____

2. Gender: Male Female

3. Education: some high school HS diploma/GED some college AA BS/BA

Some graduate Masters PhD

4. Military experience: None (if none go to question 6)

(Branch) Army Navy Marines Air Force Coast Guard
Years: _____
Specialty (MOS/AFSC):_____

6. Computer game experience:

Average hours of play per month:_____

	Over all:	Not familiar	familiar	Very Familiar	Expert	Pro
7. Types	Shooter:	Not familiar	familiar	Very Familiar	Expert	Pro
	Tactical:	Not familiar	familiar	Very Familiar	Expert	Pro
	Quest:	Not familiar	familiar	Very Familiar	Expert	Pro
	Flight:	Not familiar	familiar	Very Familiar	Expert	Pro

8. Have you ever played Ghost Recon? Yes No

9. If yes, how often: once few times several times Mastered the game

APPENDIX C: WRITTEN INSTRUCTIONS

WELCOME!

To the:

Navigation Aids in Route Training: Increase Navigation Speed, Decrease Route Retention?

Study.

- Have you read and signed a consent form? If not, please do so at this time.
- This study is designed to test training methods and does not score your personal abilities.
- You will be asked to walk through 5 mazes in a video game and one real maze. You will walk through each maze twice.
- You will work through 3 math equations between each walk through.
- In the game, you will count the number of enemy soldiers you see on the correct path.
- In the real maze, you will count the number of red tape pieces you see on the correct path.
- Before the first walkthrough in the video game you will be given 5 minutes to practice using the game.
- The controls in the game you need are as follows: press W to move Forward, S to move Backward, V to see in the dark, the spacebar to open doors, and use the mouse to look in any give direction.
- Please walk at you normal pace in the real maze.

Once you are ready please let us know,

Thank you~

APPENDIX D: MATH SHEET

Participant #_____

1. 123
   X456

2. 789
   X123

3. 321
   X456

4. 111
   X888

5. 123
   X555

6. 222
   X999

7. 333
   X656

8. 123
   X123

9. 123
   X321

10. 123
    X919

11. 123| 456

12. 222| 456

13. 333| 456

14. 456| 456

15. 45 | 456

16. 156| 987

17. 189|876

18. 29 |765

19. 189|879

20. 199| 654

21. 378
    X867

APPENDIX E: INTERNAL REVIEW BOARD APPROVAL

University of Central Florida

Office of Research

September 7, 2004

John Holmquist
University of Central Florida
US Army
12350 Research Pkwy.
Orlando, FL 32826

Dear Mr. Holmquist:

With reference to your protocol entitled, "Navigation Aids in Route Training: Increase Navigation Speed, Decrease Route Retention?," I am enclosing for your records the approved, expedited document of the UCFIRB Form you had submitted to our office.

Please be advised that this approval is given for one year. Should there be any addendums or administrative changes to the already approved protocol, they must also be submitted to the Board. Changes should not be initiated until written IRB approval is received. Adverse events should be reported to the IRB as they occur. Further, should there be a need to extend this protocol, a renewal form must be submitted for approval at least one month prior to the anniversary date of the most recent approval and is the responsibility of the investigator (UCF).

Should you have any questions, please do not hesitate to call me at 407-823-2901.

Please accept our best wishes for the success of your endeavors.

Cordially,

Barbara Ward

Barbara Ward, CIM
Institutional Review Board (IRB)

Copies: IRB File

APPENDIX F: IMAGE OF REAL MAZE

APPENDIX G: DATA

Scores:	Particpant		1	2	3	4	5	6	7	8	9	10
	Test Maze (1)	Category	1	2	3	4	1	2	3	4	1	2
		Training Time	218	179	123	327	269	199	129	186	234	182
		Training Error	2	0	0	3	4	0	0	1	1	0
		Retention Time	165	218	373	207	184	176	216	200	185	301
		Retention Error	0	3	4	1	1	0	5	3	1	5
		Enemy	5	5	5	4	6	6	6	6	4	6
MAP	Maze 2	TT	91	91	127	207	104	219	104	80	99	100
		TE	1	1	1	2	1	3	0	0	1	0
		RT	74	77	81	125	71	84	94	76	88	91
		RE	0	0	0	1	0	0	0	0	1	0
		Enemy	4	5	3	4	4	4	4	4	4	4
Verbal	Maze 3	TT	145	191	149	204	169	166	157	160	161	
		TE	0	2	2	2	0	0	0	0	0	
		RT	146	208	154	151	162	153	157	168	480	
		RE	0	3	0	2	0	1	0	1	8	
		Enemy	5	2	4	5	2	3	6	3	8	
No Aid	Maze 4	TT	114	136	155	185	107	162	102	230	137	124
		TE	2	2	1	2	1	3	2	6	4	1
		RT	86	94	85	124	85	96	87	85	103	86
		RE	0	0	0	3	0	1	0	0	1	1
		Enemy	5	2	4	5	5	5	3	4	4	4
Follow	Maze 5	TT	118	113	117	120	119	119	114	117	117	
		TE	0	0	0	1	1	0	0	1	0	
		RT	160	165	164	480	165	480	184	169	480	
		RE	0	1	0	8	0	8	2	0	8	
		Enemy	5	3	4	4	6	6	2	5	12	
	Real Maze	Category	1	2	1	1	2	1	2	2	3	3
		TT	50	55	51	74	38	62	45	30	30	28
		TE	2	1	0	4	0	5	1	1	0	0
		RT	27	67	48	39	36	42	39	43	38	30
		RE	0	2	0	0	0	2	2	3	0	2
		Enemy	6	5	6	5	8	6	6	6	7	5

Scores:	Particpant		11	12	13	14	15	16	17	18	19	20
	Test Maze (1)	Category	3	4	1	2	3	4	1	2	3	2
		Training Time	130	176	164	180	122	199	170	220	201	196
		Training Error	0	0	0	0	0	4	0	0	1	1
		Retention Time	166	169	164	174	180	170	166	170	180	273
		Retention Error	0	0	0	0	1	0	0	0	0	8
		Enemy	4	7	4	4	4	4	4	5	5	4
MAP	Maze 2	TT	99	80	83	147	100	96	87	264	95	
		TE	2	1	1	3	0	1	0	9	0	
		RT	89	72	75	93	87	79	85	93	84	
		RE	1	0	1	0	0	0	1	0	0	
		Enemy	4	4	4	3	4	4	4	5	4	
Verbal	Maze 3	TT		165	162	164	187	182	183	215	170	
		TE		0	0	0	2	0	1	2	0	
		RT		174	153	164	160	160	160	310	206	
		RE		2	2	1	1	2	0	5	3	
		Enemy		3	4	4	2	7	10	4	5	
No Aid	Maze 4	TT	154	156	155	152	164	132	110	142	141	
		TE	4	1	0	1	2	5	3	2	3	
		RT	89	84	82	90	92	90	88	96	94	
		RE	0	0	0	0	1	1	1	1	1	
		Enemy	5	3	4	2	4	5	5	3	5	
Follow	Maze 5	TT		109	109	111	139	117	117	119	114	
		TE		0	0	0	1	0	0	0	0	
		RT		202	217	480	166	185	370	245	165	
		RE		3	0	8	1	2	7	4	1	
		Enemy		3	3	5	3	7	8	2	3	
	Real Maze	Category	3	4	4	3	4	4	1	1	1	2
		TT	28	40	43	30	100	111	26	83	43	45
		TE	0	2	2	0	7	8	0	4	1	0
		RT	66	36	23	84	38	38	28	56	30	68
		RE	5	2	1	4	0	2	0	3	0	3
		Enemy	7	4	6	7	4	8	6	3	7	6

Scores:	Particpant		21	22	23	24	25	26	27	28	29	30
	Test Maze (1)	Category	1	3	2	4	1	3	3	4	1	2
		Training Time	302	117	191	194	207	118	113	363	480	187
		Training Error	8	0	0	2	3	0	0	5	8	0
		Retention Time	240	178	282	186	205	185	210	200	422	185
		Retention Error	4	1	4	1	0	0	3	3	5	1
			6	4	6	4	4	5	5	5	8	5
	Maze 2	TT		171	100	133	125					118
		TE		4	1	2	2					0
		RT		106	88	105	103					95
		RE		2	0	2	0					0
				5	4	4	4					4
	Maze 3	TT		169	167	179	161	170	163	162		169
		TE		1	0	1	0	0	0	0		0
		RT		480	137	163	170	168	202	152		334
		RE		8	0	0	0	0	1	0		5
				8	5	7	5	6	9	3		4
	Maze 4	TT		170	119	127	191					134
		TE		1	2	2	5					2
		RT		84	97	132	85					86
		RE		0	1	0	0					1
				4	4	4	5					4
	Maze 5	TT		112		115	112	107	109	109	118	110
		TE		0		0	0	0	0	0	0	0
		RT		225		173	236	163	164	480	480	160
		RE		5		1	4	0	0	8	8	1
				3		4	4	1	4	1	2	2
	Real Maze	Category	2	1	2	2	3	3	3	3	4	4
		TT	44	70	41	36	36	56	128	74	31	30
		TE	1	5	0	0	1	3	9	4	0	0
		RT	62	55	45	39	37	43	144	35	102	33
		RE	2	3	2	1	2	3	8	0	4	0
			5	4	5	5	6	6	7	5	7	8

Scores:	Particpant		31	32	33	34	35	36	37	38	39	40	41
	Test Maze (1)	Category	3	4	1	2	3	3	1	2	4	4	1
		Training Time	116	204	188	178	116	113	280	230	323	294	334
		Training Error	0	2	0	0	0	0	4	2	6	5	5
		Retention Time	171	171	167	172	170	182	190	181	480	170	265
		Retention Error	0	0	0	0	0	2	1	1	8	0	3
			5	6	3	6	5	4	4	4	4	4	5
	Maze 2	TT	89	143	93	92	93	92	122	212	454	115	142
		TE	0	3	1	0	2	0	3	4	7	2	3
		RT	80	91	82	86	86	81	103	127	135	98	141
		RE	0	1	0	0	0	0	0	3	4	0	2
			4	4	3	4	4	4	4	6	5	3	6
	Maze 3	TT	158	171	164	157	162	162	165	178	164	172	188
		TE	0	1	1	0	0	0	0	0	0	0	2
		RT	154	154	320	156	171	170	177	172	296	153	164
		RE	0	0	5	0	1	0	0	0	4	0	1
			2	4	6	2	5	6	4	2	5	3	1
	Maze 4	TT	130	140	128	132	103	255	139	209	258	178	156
		TE	2	2	4	3	3	6	4	7	7	4	4
		RT	118	122	81	90	88	100	128	105	150	84	121
		RE	2	3	0	1	2	2	3	2	3	1	2
			4	4	6	5	5	5	1	3	3	4	3
	Maze 5	TT	110	113	113	111	107	108	111	108	113	108	114
		TE	0	0	0	0	0	0	0	0	1	0	0
		RT	173	159	182	160	164	158	480	480	182	480	480
		RE	2	0	2	0	0	0	8	8	2	8	8
			2	1	3	3	3	4	11	5	3	7	2
	Real Maze	Category	4	4	2	1	1	1	1	2	2	2	3
		TT	27	29	32	33	31	31	91	40	40	39	32
		TE	0	0	0	1	0	0	7	1	1	1	0
		RT	117	115	32	30	25	27	31	36	44	55	45
		RE	3	9	0	0	0	0	1	0	1	3	3
			6	7	6	5	6	6	4	6	10	5	5

Scores:	Particpant		42	43	44	45	46	47	48	49	50	51	52
	Test Maze (1)	Category	2	3	4	1	2	3	4	1	2	3	4
		Training Time	170	119	199	228	191	118	480	193	182	174	264
		Training Error	0	0	4	2	0	1	7	4	1	1	7
		Retention Time	403	164	169	168	169	166	223	190	173	177	162
		Retention Error	12	0	0	0	0	0	5	3	0	0	2
			3	3	5	4	4	3	3	6	6	5	5
	Maze 2	TT	112	106	82	149	88	113	142	125	149	158	94
		TE	1	0	2	3	1	1	2	2	6	4	1
		RT	81	76	72	82	74	78	107	83	108	113	78
		RE	0	0	0	0	0	0	1	0	1	3	0
			4	5	4	4	5	3	5	4	5	5	3
	Maze 3	TT	174	149	159	167	156	164	166	164	165	180	164
		TE	2	0	0	0	0	0	0	0	0	1	0
		RT	174	149	132	135	143	160	150	163	159	177	158
		RE	2	0	0	0	0	0	0	0	0	2	0
			3	3	7	3	6	3	2	9	2	5	4
	Maze 4	TT	133	122	86	192	103	124	166	147	153	155	121
		TE	3	3	0	5	2	4	5	4	3	3	3
		RT	83	83	80	90	83	85	90	91	91	92	81
		RE	0	0	0	0	0	2	1	0	2	0	0
			4	4	5	3	3	4	4	6	3	2	3
	Maze 5	TT	110	109	111	111	110	110	112	111	110	110	112
		TE	0	0	0	0	0	0	0	0	0	0	0
		RT	480	98	160	176	171	159	480	165	187	480	178
		RE	8	0	1	1	2	0	8	0	5	8	3
			4	2	5	2	4	4	6	4	3	9	4
	Real Maze	Category	3	3	3	4	4	4	4	1	1	1	1
		TT	29	28	28	85	49	31	31	32	42	32	59
		TE	0	0	0	4	3	0	0	1	1	1	4
		RT	32	36	30	32	26	40	48	52	34	30	32
		RE	1	1	1	1	0	1	3	4	0	0	2
			6	6	6	4	5	7	4	7	5	8	6

Scores:	Particpant		53	54	55	56	57	58	59	60	61	62
	Test Maze (1)	Category	1	2	3	4	1	2	3	4	1	2
		Training Time	198	192	169	168	238	178	173	337	398	170
		Training Error	2	1	0	0	5	0	0	7	6	0
		Retention Time	178	188	164	157	196	171	171	218	263	165
		Retention Error	0	0	2	0	3	0	0	3	3	0
			4	4	5	5	6	5	5	5	5	5
	Maze 2	TT	91	99	111	87	91	99	94	180	170	97
		TE	0	2	1	0	0	1	0	2	2	2
		RT	77	91	94	78	75	91	86	107	92	76
		RE	0	1	0	0	0	0	0	1	0	0
			35	5	4	5	3	4	4	4	4	4
	Maze 3	TT	169	162	169	166	160	160	169	173	160	154
		TE	0	0	0	0	0	0	0	0	0	0
		RT	151	208	213	210	216	204	160	246	156	152
		RE	0	2	0	0	1	2	0	6	3	0
			2	7	3	6	7	6	7	4	2	5
	Maze 4	TT	122	122	173	120	134	90	120	189	129	89
		TE	3	3	5	3	3	2	3	8	3	1
		RT	84	86	86	81	101	78	89	107	122	87
		RE	0	0	0	0	3	0	1	3	3	1
			3	6	4	4	4	5	5	5	4	3
	Maze 5	TT	110	113	109	115	111	111	117	115	107	111
		TE	0	0	0	0	0	0	0	0	0	0
		RT	167	165	160	168	166	160	163	346	159	169
		RE	0	1	1	2	0	0	0	6	0	2
			2	2	5	5	4	3	4	4	2	3
	Real Maze	Category	2	2	2	2	3	3	3	3	4	4
		TT	34	30	35	44	25	25	30	31	85	40
		TE	0	0	0	0	0	0	0	0	6	3
		RT	36	33	32	46	54	34	77	120	84	43
		RE	2	0	1	1	4	1	6	7	5	3
			4	6	6	6	8	4	4	4	5	3

Scores:	Particpant		63	64	65	66	67	68	69	70	71	72	73
	Test Maze (1)	Category	3	4	1	2	3	4	1	2	3	4	1
		Training Time	183	349	317	176	168	292	336	172	118	246	245
		Training Error	0	8	5	0	0	3	7	0	0	3	3
		Retention Time	168	181	164	178	165	232	222	167	164	175	169
		Retention Error	0	1	0	0	1	1	6	0	0	0	0
			4	6	4	4	4	3	3	4	5	4	4
	Maze 2	TT	117	127	84	86	88	126	114	87	153	107	142
		TE	3	3	0	0	1	3	1	0	3	2	2
		RT	86	87	71	84	84	87	88	78	78	77	80
		RE	0	0	0	0	0	1	1	0	0	0	0
			5	5	3	4	4	4	4	5	4	4	4
	Maze 3	TT	183	158	165	161	166	169	171	174	166	162	160
		TE	1	0	0	0	0	0	0	1	0	0	0
		RT	169	155	153	157	162	150	153	148	480	152	178
		RE	0	0	0	0	1	1	0	0	8	0	1
			3	4	4	3	3	1	3	7	6	4	5
	Maze 4	TT	208	133	87	106	156	128	272	107	188	129	137
		TE	4	4	1	2	4	3	7	2	6	3	4
		RT	128	84	84	81	82	82	84	86	101	78	86
		RE	3	1	0	0	0	1	0	0	2	0	2
			4	5	3	5	2	4	5	5	8	4	3
	Maze 5	TT	118	112	114	111	111	110	110	108	110	112	108
		TE	0	0	0	0	0	0	0	0	0	0	0
		RT	172	480	314	158	480	480	157	163	159	160	166
		RE	0	8	4	0	8	8	0	0	1	1	0
			4	4	2	5	6	5	1	5	1	2	1
	Real Maze	Category	4	4	1	1	1	1	2	2	2	2	3
		TT	47	41	37	30	86	51	43	40	34	46	26
		TE	3	1	3	2	6	1	0	2	0	3	0
		RT	38	32	25	37	52	38	49	38	64	65	29
		RE	2	2	0	1	1	0	1	1	3	4	1
			6	5	5	6	5	6	6	7	5	4	9

Scores:	Particpant		74	75	76	77	78	79	80	81	82	83
	Test Maze (1)	Category	2	3	4	1	2	3	4	1	2	3
		Training Time	218	179	212	453	181	175	473	323	181	176
		Training Error	1	0	4	8	0	0	8	7	0	0
		Retention Time	322	179	167	221	164	166	182	480	171	167
		Retention Error	4	2	0	3	0	0	0	8	0	0
			4	5	3	6	3	3	5	4	5	4
	Maze 2	TT	250	154	92	139	100	116	203	170	105	106
		TE	6	2	0	2	1	1	4	3	1	2
		RT	167	87	79	81	98	75	110	93	78	83
		RE	4	1	0	0	0	0	2	1	0	0
			5	3	4	5	3	3	4	3	4	4
	Maze 3	TT	180	164	168	167	164	164	208		161	164
		TE	1	0	0	0	0	0	3		0	0
		RT	480	193	159	153	150	146	177		151	154
		RE	8	2	0	0	0	5	1		0	0
			4	4	3	3	2	5	3		2	5
	Maze 4	TT	186	194	91	204	225	117	182	140	322	92
		TE	4	6	2	7	5	3	5	4	8	2
		RT	158	200	84	99	103	75	120	130	80	80
		RE	4	6	0	2	2	1	3	2	1	0
			5	2	4	6	6	4	4	3	3	3
	Maze 5	TT	147	111	109	110	112	110	111		109	114
		TE	2	0	0	0	0	0	0		0	1
		RT	480	480	480	251	458	480	480		158	308
		RE	8	8	8	0	0	8	8		0	8
			2	1	6	3	3	7	5		2	6
	Real Maze	Category	3	3	3	4	4	4	4	1	2	3
		TT	30	30	28	58	41	49	63	100	44	
		TE	0	0	0	4	2	3	3	4	2	
		RT	41	38	28	41	31	42	45	34	40	
		RE	1	2	1	0	0	2	1	1	2	
			4	6	7	5	5	6	4	5	4	

Scores:	Particpant		84	Catetgory key
	Test Maze (1)	Category	4	1
		Training Time	359	MAP
		Training Error	7	
		Retention Time	183	2
		Retention Error	1	VERBAL
			5	
	Maze 2	TT	139	3
		TE	4	FOLLOW
		RT	123	
		RE	1	4
			5	NO AID
	Maze 3	TT	167	
		TE	1	
		RT	480	
		RE	8	
			6	
	Maze 4	TT	179	
		TE	5	
		RT	118	
		RE	3	
			5	
	Maze 5	TT	110	
		TE	0	
		RT	158	
		RE	0	
			2	
	Real Maze	Category	4	
		TT	62	
		TE	4	
		RT	44	
		RE	0	
			5	

Scores:

Particpant								PC/Games							
	Age	Gender	Edu	Milit	Branch	Yrs	Specialty	hrs/month	OverAll	Shtr	Tctcl	Qst	Fly	PlyGR	often
1	21	0	4	0				60	2	2	3	3	1	1	3
2	48	1	7	1	Army	4	Chpln Asst	1	2	2	1	1	2	0	
3	24	0	7	0				0	0	0	0	0	0	0	
4	26	1	6	0				0	0	0	0	0	0	0	
5	34	0	6	0				17	2	3	2	2	1	0	
6	38	1	8	0				0	1	1	1	0	0	0	
7	40	0	7	1	Navy	11	Engineer	7	2	2	2	1	2	0	2
8	24	0	5	0				10	2	4	3	1	0	0	
9	22	0	3	0				5	1	1	0	1	0	0	
10	23	1	6	0				5	1	1	0	2	0	0	
11	25	0	3	0				1	1	2	1	1	4	0	
12	11	0	0	0				4	3	3	3	0	2	1	1
13	13	0	0	0				4	3	2	3	1	0	0	
14	24	0	5	0				10	1	1	1	0	0	0	
15	9	0	0	0				5	2	3	0	2	1	0	
16	14	0	1	0				10	2	2	1	2	2	1	2
17	16	0	1	0				6	3	3	3	3	3	1	2
18	20	1	3	0				2	1	1	1	1	0	0	
19	24	0	5	0				10	3	2	2	3	1	1	1
20	69	1	3	0				0	0	0	0	0	0	0	
21	75	0	3	1	AF	3	Mechanic	0	0	0	0	0	0	0	
22	32	1	0	0				0	0	1	0	0	0	0	
23	21	1	0	0				35	2	1	1	3	1	0	
24	32	0	2	0				0	0	0	0	0	0	0	
25	35	0	6	1	Army	13	Aviator	0	1	0	0	0	0	0	
26	19	0	3	0				15	3	2	2	3	0	0	

27	20	1	3	0	48	3	0	1	2	0	0		
28	26	1	5	0	0	0	0	0	0	0	0		
29	35	1	4	0	0	0	1	0	0	0	0		
30	20	1	4	0	0	0	0	0	0	0	0		
31	21	1	4	0	3	3	3	0	0	0	0		
32	21	1	4	0	2	0	0	0	0	0	0		
33	21	1	4	0	2	1	1	1	1	1	0		
34	21	0	3	0	10	1	1	0	1	1	0		
35	22	0	3	0	10	2	1	2	3	2	0		
36	22	0	5	0	15	2	2	1	1	0	1	3	
37	18	1	3	0	2	1	1	0	1	1	0		
38	31	1	6	0	0	0	0	0	0	0	0		
39	29	1	8	0	0	0	0	0	0	0	0		
40	18	1	3	0	0	1	1	0	1	0	0		
41	21	1	4	0	0	0	0	0	0	0	0		
42	19	1	3	0	3	0	1	0	0	0	0		
43	22	0	3	0	5	0	0	1	1	0	0		
44	18	0	3	0	27	3	3	2	4	1	0		
45	21	1	3	0	3	1	0	0	0	0	0		

Scores:

Particpant								PC/Games							
	Age	Gender	Edu	Milit	Branch	Yrs	Specialty	hrs/month	OverAll	Shtr	Tctcl	Qst	Fly	PlyGR	often
46	19	0	3	0				40	2	3	2	1	0	0	
47	19	1	3	0				28	2	2	2	2	2	0	
48	19	1	3	0				250	2	0	1	2	0	0	
49	19	0	3	0				4	1	2	1	1	1	1	2
50	27	0	4	0				0	0	0	0	0	0	0	
51	22	0	3	0				10	1	2	1	2	1	1	1
52	22	0	4	0				5	1	1	0	1	1	0	
53	20	0	3	0				0	1	1	0	1	0	0	
54	18	1	3	1	AF	1		0	1	1	1	1	0	0	
55	22	0	3	0				6	1	2	1	2	1	0	
56	20	0	3	0				20	2	2	0	2	0	0	
57	20	0	3	0				0	1	1	1	1	0	0	
58	22	0	3	0				40	2	2	2	2	1	0	
59	19	0	3	0				20	2	2	2	2	2	0	
60	19	1	3	0				0	0	0	0	0	0	0	
61	19	1	3	0				0	0	0	0	0	0	0	
62	18	0	1	0				3	1	2	1	2	0	0	
63	20	1	3	0				0	0	0	0	0	0	0	
64	18	1	3	0				2	1	0	0	0	0	0	
65	19	1	3	0				5	1	2	1	1	1	0	
66	19	0	3	0				20	2	2	1	1	0	1	2
67	20	1	3	0				15	1	1	1	3	1	0	
68	18	1	3	0				0	0	1	0	1	0	0	
69	18	1	3	0				15	1	0	0	0	0	0	
70	19	0	3	0				25	3	3	3	2	2	0	

71	20	0	3	0	3	1	2	1	1	1	0	
72	21	1	3	0	1	0	0	0	0	0	1	2
73	21	0	6	0	3	0	0	0	2	0	0	
74	21	1	3	0	0	0	0	0	0	0	0	
75	20	1	4	0	0	0	0	0	0	0	0	
76	19	0	3	0	24	2	2	1	3	2	0	
77	18	1	3	0	0	0	0	0	0	0	0	
78	19	1	5	0	0	0	0	0	0	0	1	1
79	18	0	3	0	3	1	1	1	1	1	0	
80	20	1	3	0	0	0	0	0	0	0	1	1
81	22	1	3	0	5	1	0	1	0	0	0	
82	19	0	3	0	8	1	0	1	0	1	0	
83	18	1	4	0	30	2	2	1	1	0	0	
84	26	0.4881	7	0	0	1	1	1	0	0	1	2

APPENDIX H: ANOVA CHARTS

Oneway ANOVA Game Route by Category

		Sum of Squares	df	Mean Square	F	Sig.
Exptraintime	Between Groups	168264.657	3	56088.219	5.099	.002
	Within Groups	1792846.672	163	10999.059		
	Total	1961111.329	166			
Exptrainerror	Between Groups	342.600	3	114.200	28.697	.000
	Within Groups	648.669	163	3.980		
	Total	991.269	166			
Exptesttime	Between Groups	1380.028	3	460.009	.052	.984
	Within Groups	1446025.924	163	8871.325		
	Total	1447405.952	166			
ExpTraintestdiff	Between Groups	158155.301	3	52718.434	13.233	.000
	Within Groups	653329.842	164	3983.719		
	Total	811485.143	167			
Exptesterror	Between Groups	3.358	3	1.119	.246	.864
	Within Groups	742.797	163	4.557		
	Total	746.156	166			
Exptaskcount	Between Groups	.601	3	.200	.119	.949
	Within Groups	273.950	163	1.681		
	Total	274.551	166			

Oneway ANOVA Real Maze by Category

		Sum of Squares	df	Mean Square	F	Sig.
Realtraintime	Between Groups	4032.546	3	1344.182	3.099	.031
	Within Groups	34264.514	79	433.728		
	Total	38297.060	82			
Realtrainerror	Between Groups	67.147	3	22.382	5.678	.001
	Within Groups	311.407	79	3.942		
	Total	378.554	82			
Realtesttime	Between Groups	2843.125	3	947.708	1.852	.145
	Within Groups	40419.140	79	511.635		
	Total	43262.265	82			
RealTraintestdiff	Between Groups	10482.952	3	3494.317	4.710	.004
	Within Groups	59353.619	80	741.920		
	Total	69836.571	83			
Realtesterror	Between Groups	34.155	3	11.385	3.555	.018
	Within Groups	253.026	79	3.203		
	Total	287.181	82			
Realtaskcount	Between Groups	3.172	3	1.057	.601	.616
	Within Groups	139.045	79	1.760		
	Total	142.217	82			

Oneway ANOVA OVERALL STUDY

		Sum of Squares	df	Mean Square	F	Sig.
TrainingTime	Between Groups	173097.343	3	57699.114	11.764	.000
	Within Groups	2324831.395	474	4904.708		
	Total	2497928.738	477			
TrainingError	Between Groups	841.184	3	280.395	107.564	.000
	Within Groups	1235.605	474	2.607		
	Total	2076.789	477			
TestTime	Between Groups	1068618.239	3	356206.080	39.076	.000
	Within Groups	4320876.749	474	9115.774		
	Total	5389494.987	477			
Diff	Between Groups	1878247.960	3	626082.653	87.830	.000
	Within Groups	3421608.211	480	7128.350		
	Total	5299856.171	483			
TestError	Between Groups	220.880	3	73.627	15.182	.000
	Within Groups	2298.737	474	4.850		
	Total	2519.617	477			
Count	Between Groups	14.759	3	4.920	1.102	.348
	Within Groups	2116.331	474	4.465		
	Total	2131.090	477			

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