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Effects Of Video Game Playing And Training On Unmanned Aerial Vehicle Performance

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EFFECTS OF VIDEO GAME PLAYING AND TRAINING ON UNMANNED AERIAL VEHICLE PERFORMANCE

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This thesis, submitted by Kathryn Feltman in partial fulfillment of the requirements for the Degree of Masters of Arts from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done and is hereby approved.

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Kathryn Feltman
July 26, 2014

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ABSTRACT

The popularity of unmanned aerial vehicles (UAVs) has resulted in the need to determine who is suitable to learn to operate UAVs. The present study examined the likelihood that action video game players (VGPs) would make better potential candidates for learning to become UAV pilots. Additional training is also examined as a factor to determine how well training assists with maintaining situational awareness and vigilance during performance of the task, which are beneficial skills for UAV pilots to possess. Ninety-two undergraduate students participated in the study, and piloting skills were tested using the Multi-Attribute Task Battery-II, which consists of generalizations of piloting tasks. VGPs had superior performance on many of the tasks compared to non-video game players, and individuals that received training performed better than those that did not receive training. These findings indicate that VGPs may make a potential candidate group for UAV pilots without needing previous pilot experience.

CHAPTER I

INTRODUCTION

The use of unmanned aerial vehicles (UAVs) has significantly increased throughout the past decade. UAVs in possession of the Department of Defense (DOD) has increased from 167 in 2002 to close to 7,500 in 2010 (Gertler, 2012). This increase in use has mainly been seen within various branches of the military, such as the Navy and Air Force; however, UAVs are also being used more frequently in other government agencies. Some of these agencies include the Department of Homeland Security and the U.S. Coastguard, which use UAVs for assistance in law enforcement and border patrol (Department of Defense, 2007). A variety of factors have contributed to the popularity of UAVs, including the following: UAVs' ability to remotely identify enemy activity, the ability to track targets for extended periods of time, the safety of the operator that remains at a ground control station, and UAVs' cost efficiency (Gunn, Warm, Nelson, & Bolia, 2005; McKinley & McIntire, 2009; Mouloua, Gilson, & Hancock, 2003).

The growth in the use of UAVs has also been seen within the commercial industry, mainly in the areas of surveillance and advertisement (Williams, 2007). In 2012 congress mandated that the Federal Aviation Administration (FAA) create a plan for the safe integration of UAVs into the national airspace ("FAA modernization and," 2012) by September of 2015, which is expected to result in a dramatic increase in the number of

UAVs in operation. As UAVs become integrated into the national airspace, new uses of UAVs will begin to be seen, such as Amazon considering the use of drones for delivery of packages in 30 minutes or less (Stern, 2013).

The rapid growth of UAV use is subsequently creating a staffing shortage of those that are capable of operating UAVs. The Air Force is currently struggling to train pilots fast enough to keep up with the demand for UAV pilots (Hoagland, 2013). In 2008, Defense Secretary Robert M. Gates asserted that military services needed to “re-examine their culture and their way of doing business,” and “think outside the box in problem solving” in regards to the staff shortage (Shanker, 2008). There are two main issues that have been identified as being the potential cause of the staff shortage. One is that the UAV career field is failing to properly prescreen and determine the most qualified individuals to fly UAVs, and this is resulting in an attrition rate three times higher than that of traditional pilots. The second is that, within the military, UAV pilots are not able to meet the promotion education and training opportunities that other officers are able to, which equates to less interest in pursuing the UAV pilot career path (Hoagland, 2013).

One potential solution to alleviate the staffing problem that has been proposed by the DOD is to change the operation structure of UAVs so that one operator is able to monitor multiple UAVs at one time (Culbertson, 2006; Cummings, Clare, & Hart, 2010; Tsach et al., 2007). This would change the role of the operator from a hands-on role to a monitoring of systems role. Another potential solution to the staffing problem is to change the requirements for eligibility to operate a UAV by removing the necessity that a UAV operator also be a licensed pilot. During the entirety of the operation of a UAV, the pilot remains grounded at a remote location, raising the question of the necessity that the persons eligible to operate also be licensed as pilots.

Presently, individuals wanting to learn to operate civil UAVs are required to possess a commercial pilot certificate with instrument and multiengine ratings (University of North Dakota, 2013). Within the military, the requirements to operate a UAV are even stricter. Current Air Force guidelines require that to operate the RQ-1/MQ-1 Predator, the operator must be a fighter/bomber pilot or a Weapons Systems Officer. This requires potential candidates to successfully complete the training required of manned aircraft and be qualified as combat pilots, which also requires medical and physical certification that may not be necessary for a UAV pilot since they do not need to cope with the same environmental and physical stressors associated with operating a manned aircraft under these circumstances (Triplett, 2008). In fact, it has been demonstrated that individuals without prior flight experience are able to learn to successfully fly the U.S. Army Hunter and Shadow systems (Williams, 2007). This indicates that more research is needed to determine whether or not it is necessary to have manned aircraft flight experience in order to successfully fly an unmanned aircraft. As UAVs become a commercial enterprise and changes are made to allow UAVs into national airspace, this will become a more pertinent issue.

The operation of UAVs requires that an operator and sensor perform a variety of duties, such as monitoring displays, monitoring for potential technical problems, and responding to errors that arise in flight. The operator is also sometimes responsible for the take-off and landing of the UAV (Gunn et al., 2005). The cognitive demands that result from the multitasking of these duties have been shown to cause an increase in workload, stress and a reduction in situational awareness as experienced by the operator (Dixon, Wickens, & Chang, 2005; Guznoz et al. 2011; Mouloua, Gibson, Krig, & Hancock, 2001; Parasuramen et al., 2003; Sterling & Perala, 2007).

Increasing the number of UAVs that a single operator is responsible for will likely create a variety of concerns, with one concern being how this increase in UAVs will affect the workload experienced by the operator. It has been shown that when a person monitors multiple UAVs the workload increases and causes more errors in performance (Baber et al. 2011). Although a large amount of the monitoring will be done by the system, and will alert the operator of potential problems, there is still the question of what effect this increase in the number of UAVs to monitor will have on the workload experienced by the operator. The reliance on an automated system to alert the operator of errors often causes an operator to become complacent, which can lead to poor performance (Miller & Parasuraman, 2007).

Individuals that regularly play action video games have been shown to improve on a variety of cognitive abilities. For example, action video game players (VGPs) have been shown to switch between cognitive tasks more readily than non-video game players (NVGPs; Boot et al., 2008; Cain, Landau, & Shimamura, 2012). Action VGPs have also been found to have quicker reaction times to visually identifying targets than compared to NVGPs (Dye, Green, & Bavelier, 2009). The ability to readily switch between cognitive tasks and the similarities between video game playing tasks and UAV operations may make VGPs a likely potential candidate for a group of individuals capable of flying

UAVs without prior flight experience and for the operating of multiple UAVs (McKinley, McIntire, & Funke, 2011).

Workload

Workload can be defined as “the combination of task demands, or load factors, and the operator’s response” (Mouloua, et al., 2001). In the current operations of UAVs workload has been found to be one of the causes of pilot errors (Tvaryanas, Thompson, & Constable, 2006). The effects that workload has on performance becomes difficult to determine, due to the different effects of a high workload versus a low workload. Workload is often difficult to understand because although a high workload is typically associated with performance decrements, a low workload can be equally as problematic (Mouloua et al. 2001). A low workload is typically associated with boredom, which can decrease the operator’s performance and increase operator errors (Miller & Parasuraman, 2007; Mouloua et al., 2001).

Finding the right balance between high and low workload will be crucial for UAVs to be used successfully with minimal accidents. This task becomes difficult when considering the change in operating multiple UAVs at one time versus just one UAV. Changing the operations in this manner would result in an increase in how much automation is used to control the UAVs, which could reduce the workload experienced by the operator, and in turn create boredom operator and the likelihood for more errors (Miller & Parasuraman, 2007). As the amount of automation used to operate a UAV increases, so does the likelihood of complacency of the operator. When the operator becomes complacent, there is a greater chance for errors to result from the operator not responding to automation malfunctions (Parasuraman, Molloy, & Singh, 1993).

Presently, UAVs are controlled in three different settings, these are full manual control, supervisory control, and full automation. Manual control is known to place a high workload on the individual controlling the UAV, by overwhelming the operator with the responsibility of maintaining a majority of the UAV's functions, and thus limits the number of UAVs one operator can manage (Liu et al., 2009; Mouloua et al., 2003). Full automation enables the operator to control multiple UAVs at once by relying on the automation to direct the flight. Full automation can increase the boredom experienced by the operator, which in turn can cause an increase in errors, and slower and erroneous reactions (Liu et al., 2009). The involvement of the operator impacts the workload or boredom that the operator experiences; less involvement typically causes more boredom and more involvement causes a higher workload experienced (Damilano, Guglieri, Quagliotti, & Sale, 2011).

Several studies have also found that the type of task required of the operator affects the workload that is experienced. It has been shown that the type of terrain or weather changes both increase the amount of workload that is experienced by the operator (Schipani, 2003). Other tasks, such as constant communication between the operator and other personnel or changes in the mission, have also been identified as potential areas to increase workload experienced by the operator (Dixon, Wickens, & Chang, 2005). Automation can also affect workload that is experienced by the operator by the automation taking command of a certain task and thereby shifting the workload so that the operator is responsible for a different task, not fully decreasing workload but instead changing it (Liu et al., 2009; Parasuraman & Riley, 1997).

As automation advances and a single operator is responsible for multiple UAVs at one time, the workload experienced will begin to change from requiring physical demands of the operator (to control the vehicle) to more mental demands (monitoring the different flights and attending to problems that arise), which will continue to increase operator workload (Liu et al., 2009). These changes in the automation will make it possible for multiple UAVs to be controlled at one time by one operator, but this increase in workload has been shown to result in declines in performance and increases in errors (Chen, Durlach, Sloan, & Bowens, 2005; Schulte, Meitinger, & Onken; 2009; Sterling & Perala, 2007).

Some studies have been conducted in an attempt to determine the number of UAVs that one operator can successfully maintain without experiencing adverse problems due to increased workload. Liu et al. (2009) found a significant difference in performance when the operator-to-UAV ratio was at 1:4 versus 1:1, and when the ratio was at 1:4 versus 1:2. It has also been found that increasing the number of unmanned vehicles (UVs) a sensor controlled from one to three significantly increased participants' subjective workload; however the difference was less apparent when the number of UVs increased from three to five (Baber et al. 2011). The goal for future UAV operations is to operate with one operator for up to four UAVs, although this will require operators to reallocate cognitive resources and attention to the maintenance of more than one UAV (Rice, 2009). A single operator being responsible for more than one UAV at a time increases the likelihood of the operators missing automation failures that occur during flight (Tirre, 1998).

Increasing the number of UAVs that one operator is responsible for has been shown to impact how that operator experiences workload and increases the cognitive complexity of the task (Cummings & Guerlain, 2007). Since the operation of a single UAV is already associated with problems of workload, increasing the number of UAVs that a single operator is responsible for will have implications on performance. With the interest in increasing the ratio of operators to UAVs, further research is needs to examine how to make that transition more plausible with the fewest errors possible.

Situational Awareness

Situational awareness was also cited by Tvaryanas et al. (2006) as a potential causal factor for UAV mishaps. Endsley (1995) defines situational awareness (SA) as "The perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future", and pointed out that for a pilot to successfully complete a flight, the pilot is reliant on a "current assessment of the changing situation, including details of the aircraft's operational parameters, external conditions, navigational information, other aircraft, and hostile factors". Although the tasks required of a UAV pilot differ from those of pilots operating a manned aircraft, many of the same factors still apply.

It is known that SA involves a range of complex cognitive processes which include attention, memory, perception, spatial ability, and executive control (Goettl, 1997). SA is often limited to the capacity of working memory and attention, and is affected by the operator’s goals and expectations which influence what information is attended to, how that information is perceived, and how it is subsequently interpreted (Endsley, 1995). An increase in automation may assist the operator in the use of attentional resources, but this may also increase errors associated with missing information. SA is also affected by what tasks the operator is required to complete, and how these tasks affect the perceived workload. Svensson and Wilson (2002) found that pilots’ SA became worse as the information they received became increasingly complex, and that as workload increased the increase in workload in turn affected SA and performance.

The ability to maintain SA is a crucial part of successfully operating and controlling aircrafts. O’Brien and O’Hare (2007) examined the ability of individuals to improve their SA with training and found improved performance as measured by the use of a simulated air traffic controller task. This demonstrates that although SA is a complex subject and a source of pilot error, it is a skill that operators can improve with training.

Situational awareness is found to be reduced in UAV pilots as compared to manned aircraft pilots, which is believed to be due to factors such as the loss of tactile and vestibular sensory information, increased autonomy of the vehicle and the remote location of the operator (McAree & Chen, 2013). Since operators of UAVs remain grounded at a remote location for the duration of a UAV’s flight, they lose out on many of the experiences that manned aircraft pilots have that assist in the maintenance of situational awareness. Not experiencing some of the physical aspects of a flight may play a large role in the difficultly to maintain situational awareness that is seen in UAV pilots.

Vigilance

Vigilance poses another concern for individuals operating UAVs. The tasks that UAV operators are faced with required that a high amount of vigilance be present in order to watch for targets and to monitor the overall flight of the UAV. These tasks often result in boredom for the individual and a loss of vigilance. Loss of vigilance is often associated with situations that require sustained attention over a period of time, such that is often seen in various aviation tasks (Warm, Dember, & Hancock, 1996). There has also been research that has demonstrated that as workload is reduced, it has the effect of creating a decrement in vigilance (Warm et al., 1996; Wiggins, 2011).

The automation that is available in UAV operation also includes the ability for the automatic location of targets, which allows for the UAV system to search for the target instead of the operator being solely responsible for searching for a target (Mouloua et al., 2003). The operator then becomes responsible for determining whether the target is correct and taking the subsequent proper actions. Reacting to what the system has discovered requires the operator to remain vigilant to make a determination of what actions must be taken, so in effect, the operator still maintains a high workload and vigilance level (Scerbo, 1998).

Actively engaging the operator in a task during the monitoring of the flight has been demonstrated to make the operator more vigilant, as demonstrated in a study with air traffic controllers (ATCos). The study examined ATCos on a highly automated simulate air traffic control (ATC) task for which the main duty of the ATCos was to simply monitor incoming flights. When the ATCos were only monitoring the incoming flights, a significant vigilance decrement was found, however when the ATCos were given the task of clicking on incoming flights they became more vigilant (Pop, Stearman, Kazi, & Durso, 2012). As automation for UAVs increases, and the role of the operator becomes one of monitoring the overall flight and less actual control of the flight, vigilance decrements will likely be seen. It will be important to either find individuals that are capable of maintaining high vigilance while monitoring the flight or to design the system so that the operator is able to remain actively involved in the flight throughout its duration.

In a review on the topic of vigilance, Hancock (2013) discusses the need to consider the individual’s motivation for remaining vigilant during a task. He contends that it is important to determine whether the motivation is intrinsic or extrinsic, when it is primarily extrinsic, the level of associated stress is increased and this plays a role in the cause of the decrement in vigilance. The task of operating a UAV is mainly extrinsically motivated, due to it being the performance of a specific job, and if Hancock’s assessment of vigilance is accurate, that makes it likely that these individuals will experience a great amount of stress during the course of monitoring the UAV.

Although it was previously thought that tasks that require vigilance from an operator were not very stimulating and those requiring the operator to be vigilant were often faced with boredom, recent research has shown that tasks that require higher vigilance causes a decrease in performance due to information-processing demand placed on the operator (Gunn et al., 2005; Johnson & Proctor, 2004).

Video Game Players

Several studies have demonstrated that many of the skills acquired while playing video games are often transferrable to other tasks. For example, numerous studies have demonstrated that playing the video game called Space Fortress, which was developed by cognitive psychologists as a training and research tool, increased flight performance for space cadets and increased performance on a helicopter flight simulation game (Boot, Kramer, Simons, Fabiani, & Gratton, 2008; Donchin, Fabiani, & Sanders, 1989; Gopher, Weil, & Bareket, 1994; Hart & Battiste, 1992). The transferability of these skills is of interest to UAV research in terms of pilot selection, in order to determine the feasibility of changing pilot requirements so that a pilot license, or at least a commercial pilot license, is not required in order to learn to operate UAVs.

Video game players (VGPs) typically are able to switch between cognitive tasks more readily than non-video game players (NVGPs; Boot et al., 2008; Cain, Landau, & Shimamura, 2012). VGPs have also been demonstrated to notice changes in visual stimuli quicker than those who do not play video games. It has been shown that video game players differ in their search strategies while engaged in a visual search task. VGPs use broader search strategies than NVGPs, which may be the result of VGPs being capable of encoding more visual information than NVGPs at a given time, or that they utilize different search strategies than NVGPs (Clark, Fleck, & Mitroff, 2011). VGPs are also able to locate targets that appear in both the peripheral and central visual fields more quickly and accurately when compared to NVGPs (Sungur & Boduroglu, 2012). The improved visual attention that VGPs show results from their ability to distribute attention across space, efficiently perform dual tasks and process streams of briefly presented visual stimuli (Green & Bavelier, 2003, 2007).

VGPs have also been shown to have a better ability for sustained visual attention (Donohue, Woldorff, & Mitroff, 2010), which allows them to quickly and accurately focus attention to the position of visual stimuli. VGPs appear to be better able to process visual stimuli very quickly which could enable them to have more cognitive resources available for processing other perceptual information, such as auditory stimuli. Donohue et al. (2010) demonstrated VGPs' ability to better discriminate the non-simultaneity of auditory and visual stimuli at closer intervals than NVGPs were able to. Whether due to VGPs' ability to focus more quickly on visual stimuli or their ability to process those stimuli more quickly is unknown. Overall, they found that those with extensive video game playing experience were better able to distinguish between events occurring close in time together, which may allude to enhanced multisensory perception and integration. UAV operators would benefit from these abilities since the operating of UAVs involves a multi-tasking environment, while monitoring the progress of the UAV and watching for any errors that arise.

Many of cognitive skills that are gained from video game playing can also be gained at older ages beyond childhood. Action video game playing has been used as a training tool to improve the speed of information processing in individuals with slower-than-normal speeds of processing, such as the elderly or victims of brain trauma (Dye, Green, & Bavelier, 2009). Similar research has shown that action video game playing may provide a reliable training regimen to reduce gender differences in college students in visuospatial cognition (Feng, Spence, & Pratt, 2007). Both of these studies indicate that many of the skills acquired through action video game playing are able to be acquired at later stages in life, which may indicate that action video game playing could be used as a supplemental tool for training to operate UAVs.

Since the goal for future use of UAVs is to have one operator monitoring multiple UAVs at once, it will be beneficial to have individuals that have a high ability for visual processing and are able to efficiently allocate attention across the UAVs and react to any problems that arise. A single operator in charge of multiple UAVs will create a higher workload for the operator, which will result in the operator to needing to be able to concentrate on a primary task (such as watching for targets and monitoring flight progress) while simultaneously being prepared for any automated alerts that arise during flight. These two tasks require operators to be able to switch between two modes of attention allocation which can result in various mistakes in cognitive performance (Cummings, Clare, & Hart, 2010). However, the demonstration that VGPs are able to switch between cognitive tasks more readily than NVGPs would likely benefit the performance of a UAV operator, enabling operators to readily switch between these modes of attention.

Training

Training on an automated task that requires an individual to remain vigilant and situationally aware throughout the duration of the task has been shown to be beneficial. However, the length of additional training may be of less importance. One study found that participants' performance did not significantly vary if the participants received long

(60 min.) versus short (30 min.) training (Singh, Sharma, & Singh, 2005). Although no difference was found in the amount of training received, training on a task improves performance and may assist in the reducing the loss of situational awareness, the amount of workload experienced by the operator and vigilance decrements.

Training on a task that requires someone to maintain a high level of situational awareness in order to perform accurately has been demonstrated to improve maintenance on situational awareness in individuals that started out with poor situational awareness (O'Brien & O'Hare, 2007). The training likely assists the participants in effectively managing their attention, to use planning, and future prediction, which increases their performance. Through training participants on a complex task assists the participants in becoming aware of precisely what it is that they are required to attend and respond to.

Another study examining SA training in individuals on a police shooting simulator found that individuals that received SA training reported a higher level of subjective SA and decision making during a critical situation compared to a control group. SA trained group recorded both a higher number of shots fired and a greater number of hits on target compared to the control group (Saus, Johnsen, Eid, Riisem, Anderson, & Thayer, 2006).

Training an individual on a task that requires the maintenance of vigilance has been demonstrated to reduce the negative effects that are often experienced by vigilance tasks. Training on a vigilance task may allow for individuals that tend to have lower SA to learn how to manage their attentional resources in order to have higher SA during a task, which may allow the individual to perform the task closer to those who tend to already have a higher amount of SA without training.

The Current Study

The successful operation of a UAV requires a complex set of cognitive skills that are subjected to decrement based on factors such as workload experienced by the operator, the number of UAVs that the operator is responsible for, the situational awareness the operator has, and the amount of vigilance required of the task, or lack thereof. Given the interest in increasing the amount of UAVs one operator is responsible for and to increase the number of people capable of operating UAVs, further examination on how these factors manifest themselves in UAV operations in a variety of settings is needed.

The present study will examine to what effect video game playing experience and training have on performance on tasks on an updated version of the Multiple-Attribute Task Battery (MATB-II; Comstock & Arnegard, 1992) in order to determine the likelihood of changing the requirements for operating a UAV and for changing the operator-to-UAV ratio. For an operator to successfully operate a UAV, there are variety of simultaneous tasks that must be conducted. The MATB-II was selected to examine how participants are able to cope with multiple tasks that must be monitored simultaneously and require the participant to respond to automation failures that arise. Previous studies that have used the MATB-II have found it to be a valid method for assessing aviator performance (Caldwell & Ramspot, 1998; Wilson, Caldwell, & Russell, 2007).

It is hypothesized that the participants who are VGPs, which will be defined by self-reporting of current video game playing, will not only perform better on the practice session, but will also perform better after having received training on the MATB-II tasks, than NVGPs, which will be defined as self-reporting no current video game playing. Subjective workload will also be measured using the Workload Rating Scale (WRS) which is built into the MATB-II program and is based on the NASA Task Load Index (NASA-TLX; Hart & Staveland, 1988). It is expected that with training, subjective workload will be lower for both the VGP group and the NVGP group, although the VGP group should report lower workload. Participants will also be asked whether or not they have had any prior flight experience.

Previous research has demonstrated that individuals that play video games are better at certain cognitive skills, than those who do not play video games. It is expected that the VGPs in this study will be able to perform better on the MATB-II tasks. It is also expected that the VGPs will not show significant vigilance decrements. The individuals that receive training are expected to perform better than those who do not receive training. Individuals that play video games and perform well on the MATB-II tasks would make a likely candidate group for learning to fly UAVs quickly, due to the transfer of the cognitive skills gained from video game playing.

CHAPTER II

METHOD

Participants

Participants consisted of 92 undergraduate students from the University of North Dakota. Fifty-eight participants were females, 34 were males, and the average age of participants was 20 years old. Six participants' data was excluded in analysis because the participants did not complete the full study. All participants reported normal to corrected 20/20 vision.

For those who reported video game playing, the average number of days of played per week was 2.5 days, and the average hours per week were 5.5 hours, with a maximum of 30 hours per week and a minimum of 1 hour per week reported. The average age of starting video game playing was 8 years old. Eight participants reported as having had prior flight experience.

Participants were recruited using an online study sign-up through the psychology department, and through placement of fliers throughout the psychology department and the aviation department buildings. Participants that were enrolled in a psychology course were offered extra credit as compensation for participation, at the rate of ½ credit for every ½ hour of participation.

Materials

Multi-Attribute Task Battery-II. The Multi-Attribute Task Battery II (MATB-II) is an updated version of the Multi-Attribute Task Battery (MATB) developed by Comstock and Arnegard (1992). The MATB was designed to study operator performance and workload using simultaneously presented tasks that are generalizations of piloting tasks. The tasks available are system monitoring, tracking, communication, and resource management. For the purposes of this study, the communications task was not be utilized. The MATB-II also has a scheduling display that allows for the participant to "look ahead" at their expected workload, and this display indicates to the participant when the tracking task is in manual or automated mode. Detailed descriptions of the MATB-II tasks that will be used in this study are provided in the Appendix (B).

Workload Rating Scale. Workload was assessed using the Workload Rating Scale (WRS) which is built into the MATB-II program and is based on the NASA Task Load Index (NASA-TLX; Hart & Staveland, 1988). When workload is assessed, the WRS appeared in a full window on the computer screen, and the MATB-II paused while the participant responded to the WRS. The WRS uses a sliding scale to rate workload on six different subscales. The slider presents in the middle of the scale, and for each subscale the participant slides the slider over to "high" or "low". The subscales are as follows: mental demand, physical demand, temporal demand, performance, effort, and frustration. After adjusting the slider for each subscale, the participant was required to select "save all" before being able to move on with the MATB-II program (Appendix C).

Computer/joystick. The computer that was used for the MATB-II program is an Intel Pentium 4 Processor. The joystick that was used is a Logitech Extreme 3D Pro.

Demographics. Demographics were collected through a questionnaire (see Appendix D). Participants were requested to provide demographic information such as year in school, age at time of participation, whether participants have any visual problems (such as color blindness, etc.), and whether contact lenses or glasses are used.

Video game playing. Participants were asked to self-report on their extent of playing of video games and the types of video games played (see Appendix E).

Flight experience. Participants were asked how many hours of flight experience they have had, and the extent to which they have had flight experience (see Appendix F).

Procedure

Participants were placed into either the training or no training group, which was assigned based on appearance within the lab (even-numbered participants received training; odd-numbered participants received no training). Participants were all given a consent form to sign, then self-reported on the demographics questionnaire, video game playing questionnaire, and flight experience questionnaire. Following completion of the questionnaires, all participants were given a packet of instructions to read that described how to perform the tasks presented on the MATB-II (see Appendix F). After reading the instructions, all participants completed a 5 minute practice session on the MATB-II.

Once participants completed the 5 minute practice session on the computer, the participants that were in the no training condition went on to complete the 10 minute test session. The participants that were in the training condition completed a 20 minute training session after the 5 minute practice session. After completing the training session, the participants in the training condition completed the 10 minute test session. Following the practice session the participants were asked to rate their subjective workload using the WRS and those results were also recorded automatically through the MATB-II program on the computer.

After completing the practice session, the participants in the non-training group began the MATB-II test run, which was for a total of 10 minutes. The participants in the training group participated in a 20 minute training session after completion of the practice session. During the training session, participants had the opportunity to complete another practice session on the MATB-II that will not be recorded for results. During the training session the researcher was available to assist the participant in selecting appropriate responses and answer any questions about the program that the participants had.

Following the completion of the 20 minute training the participants in the training group completed the same 10 minute test session that was recorded for results, as did the non-training group. Prior to running this session, participants were offered a 5 minute break. Following the test session participants again rated subjective workload using the WRS. The MATB-II program also has the ability to be paused during a test or practice session, if for any reason the participant needed a break.

The sequence of presentation of the MATB-II tasks consisted of each of the tasks being presented at various intervals, such as 4 seconds into the program, 1 minute 12 seconds into the program, etc. The sequence of appearance of tasks was presented in various orders, such as a pump failure followed by the tracking task switching from automatic to manual mode, followed by another pump failure then a system monitoring failure. The workload rating scale was presented at the end of the initial practice session, at the end of the training session, and at the end of the test session. The presentation of the tasks remained the same for each of the participants.

CHAPTER III

RESULTS

Separate analyses were performed on each of the three tasks, and for the Workload Rating Scale (WRS). Within each of the analyses there were differing numbers of participants included, due to participants' scores being removed for being outliers on the specific task. Repeated-measures analysis of variance (ANOVA) were performed on the tasks, with five time measurements as the within-subject factor, and two between-subjects factors, which were training vs. no-training and video game player vs. non-video game player. The five time measurements, labeled T1, T2, T3, T4 and T5 (for times, see table 1 below), consisted of scores for each task type averaged over 2 minute intervals for the 10 minute duration of the test. Six participants were excluded from all analyses because they did not complete the 10 minute test.

Table 1

Descriptions of Time Frames

Time Frame	Minutes
T1	0-2
T2	2-4
T3	4-6
T4	6-8
T5	8-10

Resource Management

Two separate repeated-measures ANOVAs were conducted to analyze the resource management data, one for Tank A and one for Tank B. Measurements were taken every 30s of how far the participant maintained each tank above or below the goal of 2,500 units. These differences were then averaged across the 2 minute intervals to create the data to be analyzed. For this task, there were 31 participants in the training group, 46 participants in the no-training group, and 37 video game players and 40 non-video game players. Ten participants were not included in the analysis due to being outliers on the task, by either not completing the testing period or not responding to the resource management task during testing.

For the analysis of Tank A, Mauchly's test indicated that the assumption of sphericity had been violated, χ^2 (9) = 218.67, *p* < .01, therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity (ε = .41). There was a significant effect of training, *F* (1, 73) = 12.86, *p* < .01. Pairwise comparisons showed that the training group (*M* = 3.38, *SD* = 108.28) maintained Tank A levels closer to 2,500 units than did those in the no-training group (*M* = -499.8, *SD* = 89.24) throughout the 10 minute test. There was a significant interaction found for training and maintenance of tank levels across the time measurements, *F* (1.63, 119.07) = 3.75, *p* < .05. Pairwise comparisons found a significant difference between T2 and T3, and T3 and T4 (see table 2 below for means and standard deviations), where the training group maintained Tank A levels significantly closer to the 2,500 units than the no-training group.

Table 2

Means and Standard Deviations for Resource Management Task for Tank A

	Mean Score		Standard Deviation	
Time Frame	Training	No-Training	Training	No-Training
T1	-70.19	-350.6	191.09	333.89
T2	2.04	-492.52	214.57	749.05
T3	-30.63	-610.49	171	901.11
T4	68.04	-558.88	175.42	991.98
T5	36.98	-596.8	203.32	1,033.11

The analysis of Tank B found Mauchly's test indicated that the assumption of sphericity had been violated, χ^2 (9) = 200.66, $p < .01$, therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = .47$). The main effect of maintaining tank levels significantly changed over time, F (1.89, 138.14) = 3.73, $p < .05$. Pairwise comparisons demonstrated that T1 significantly differed from T2; T2 significantly differed from T3; T3 significantly differed from T4 and T5; and T4 significantly differed from T5 (see table 3 below for means and standard deviations). These differences show that participants began the task maintaining the tank relatively close to the desired units, but performance significantly declined during the 4 to 6 minute period (T3), and then improved somewhat towards the end, but not back to the original levels of performance. A significant effect for training between subjects was also found, F (1, 73) = 14.37, $p < .01$. Participants in the training group (M = 44.67, SD = 109.27) maintained tank levels closer to 2,500 units than did participants in the no-training group (M = -491.99, SD = 90.05).

Table 3

Mean and Standard Deviations for Resource Management Task for Tank B

Time Frame	Mean	Standard Deviation
T1	-216.11	371.34
T2	-276.56	685.53
T3	-413.27	782.49
T4	-321.2	837.84
T5	-239.17	852.45

Tracking

For the tracking task, measurements were taken every 15s while the task was in "manual mode" of the root mean square deviation from the center point in pixel units to determine how close the participant was keeping the target on the center point. There were 38 participants in the training group, 40 in the no-training group, and 36 video game players and 42 non-video game players. Eight participants' data were excluded from analyses due to being outliers on this task, determined by those who did not respond to the tracking task.

Mauchly's test indicated that the assumption of spherecity had been violated, χ^2 (9) = 323.75, $p < .01$, therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = .44$). The main effect of tracking scores were found significant, indicating that participants' maintenance of the target on the center point changed over time, F (1.66, 12.54) = 6.32, $p < .01$. Pairwise comparisons showed that there were significant differences between T1 and T3, T4, and T5; and between T2 and T3, T4, and T5 (see table 4 below for means and standard deviations). Participants' tracking of the target improved as time passed during this task. There was also a significant effect for video game playing found, F (1, 74) = 21.38, $p < .01$. Pairwise comparisons indicate that video game players (M = 38.74, SD = 1.66) maintained the target closer to the center point than did non-video game players (M = 49.2, SD = 1.54).

Table 4

Means and Standard Deviations for Tracking Task

Time Frame	Mean	Standard Deviation
T1	46.24	12.87
T2	45.12	11.73
T3	43.99	11.04
T4	43.57	11.24
T5	43.37	11.68

Systems Monitoring

The systems monitoring task records reaction times for every correct response to light or scale corrections, every missed response, and the number of false responses emitted, that is, pressing one of the buttons for the lights or scales when unnecessary. For this task 12 participants' data were not included due to being outliers, based on not responding to the task. There were 35 participants in the training group, 36 participants in the no-training group, and 35 video game players, 36 non-video game players. Repeated-measures ANOVAs were conducted separately for reaction times for correct responses averaged across the two minute intervals, missed responses averaged across the two minute intervals, and false responses emitted averaged across the two minute intervals.

For reaction times of correct responses, Mauchly's test indicated that the assumption of sphericity had be violated, χ^2 (9) = 25.84, *p* < .01, therefore degrees of freedom were corrected using Huynh-Feldt estimates of sphericity (ε = .92). The main effect of reaction time was found to be significant, indicating that participants' reaction times changed throughout the course of the 10 minute test, *F* (3.67, 246.06) = 4.11, *p* < .01. Pairwise comparisons found significant differences for participants between T1 and T4 and T5; T2 significantly differed from T3; and T2 and T3 significantly differed from T4 (see table 5 below for means and standard deviations). This demonstrates that participants improved their reaction times throughout the duration of the 10 minute test.

Table 5

Means and Standard Deviations for Systems Monitoring Task for Correct Responses

Time Frame	Mean Reaction Time	Standard deviations
T1	3.14	1.28
T2	2.88	1.4
T3	2.99	0.97
T4	2.49	0.85
T5	2.7	1.04

The errors of omission were converted into proportions by taking the number of errors made and dividing that by the total number of opportunities for correct responses during that time frame. The analysis of errors of omission had 37 in the training group, 38 in the no-training group, and 35 video game players, and 40 non-video game players. Mauchly's test indicated that the assumption of sphericity had be violated, χ^2 (9) = 19.81, $p < .05$, therefore degrees of freedom were corrected using Huynh-Feldt estimates of sphericity ($\varepsilon = .95$). A main effect of errors made was found, indicating that participants' number of errors changed throughout the duration of test, F (3.8, 269.78) = 9.04, $p < .01$. Pairwise comparisons found significant differences between T1 and T4; T2 and T4; T3 and T4; and T4 and T5 (see table 6 below for means and standard deviations). The number of errors of omission appear to have remained fairly steady throughout the trial, however, during the six to eight minute time period (T4) the number of errors significantly declined.

Table 6

Means and Standard Deviations for Systems Monitoring Omission Errors

Time Frame	Mean Proportion	Standard Deviations
T1	0.37	0.32
T2	0.36	0.33
T3	0.37	0.31
T4	0.28	0.28
T5	0.38	0.28

The errors of omission also found significant effects of training and video game playing. The training group performed better than did the no-training group, F (1, 71) = 6.99, p = .01. The training group (M = 0.26, SD = 0.04) made fewer errors of not responding than did the no-training group (M = 0.42, SD = 0.04). The video game players outperformed the non-video game players, F (1, 71) = 6.66, p = .01. Video game players (M = 0.27, SD = 0.05) made fewer errors than did non-video game players (M = 0.42, SD = 0.04).

There were no significant findings for errors of commission, indicating that time, training, and video game playing did not have an effect on the number of errors of commission participants made.

Workload Rating Scale

Twenty-six participants were not included in WRS data analysis, due to not having saved results. A one-way ANOVA was conducted on the workload rating scales. None of the measures were found to reach significance, however, “Own Performance”, approached significance, F (3, 62) = 2.46, p = .07. Tukey’s post hoc test found that the difference between video game players that received training (M = 31.13, SD = 24.61) and non-video game players that did not receive training (M = 50, SD = 21.46) approached, but did not reach significance (p = .08), here a higher number corresponds to poorer performance.

CHAPTER IV

DISCUSSION

Video Game Playing

It was hypothesized that video game players would perform better on the MATB-II than the non-video game players. The findings of this study were consistent with this hypothesis, VGPs were found to have had improved performance on a variety of the MATB-II tasks. The tracking task found that participants improved their performance as time passed. It appears that there were no decreases in vigilance experienced during this task. However, this may have occurred because participants did not need to continually track in manual mode for the duration the test, instead, it switched from manual to automatic throughout. VGPs performed significantly better than NVGPs on the tracking task, which may be due to the similarities between the joystick used in the study to those used in video game playing. This demonstrates that video game players may be able to quickly adapt to learning to manually control a UAV when necessary.

The VGPs better performance on the tracking task also demonstrates that VGPs were able to monitor and respond appropriately when the tracking task switched from automatic to manual mode, which is important due to the need for UAV pilots to be prepared to take manual control of the UAV if automation errors arise. VGPs may have a better ability to monitor the tracking task and take manual control of the joystick when necessary due to their better ability at efficiently allocating attention across multiple tasks. This is consistent with other findings in which VGPs have demonstrated a faster speed of processing of visual information (Dye, Green, & Bavelier, 2009).

On the systems monitoring task participants' reaction times improved the longer that they performed on the task. Errors of omission remained relatively steady throughout the task, but improved significantly during the six to eight minute period. This shows that for both the correct responses and the errors of omission, participants performed better throughout the task, although for the last two minutes of the task omission errors increased again. VGPs performed better than NVGPs, suggesting that video game playing experience may improve their ability to attend to and respond to the systems monitoring task. Although VGPs' reaction times were not quicker than those of NVGPs, VGPs' fewer errors of omission suggests that VGPs are better at attending to this task. Errors of commission found no significant results, indicating that training and video game playing experience have no effect on whether or not participants erroneously press the buttons.

The finding that VGPs performed well on the systems monitoring task is consistent with other findings in which VGPs have demonstrated a better ability for sustained visual attention (Donohue, Woldorff, & Mitroff, 2010), that enabled them to attend to visual stimuli across the visual field. The finding that VGPs made fewer errors of omission than did NVGPs, but did not have significantly faster reaction times demonstrates that VGPs are processing the visual information and then making an accurate response based upon the input of the visual information available, and are still able to do so in a fairly quick manner. This is in line with other studies that have found speeded visual processing in VGPs without a simultaneous decrease in accuracy (Dye, Green, & Bavelier, 2009). This particular skill would be beneficial of UAV pilots due to the large amount of visual stimuli that they must monitor and respond to.

VGPs' better performance on not omitting responses might be due their improved ability to readily switch between cognitive tasks (Boot et al., 2008; Cain, Landau, & Shimamura, 2012). VGPs' ability to switch between tasks of tracking and then responding to the systems monitoring task, is likely due to this ability since to have better performance on both of these they would have needed to switch back and forth.

For the WRS the NVGPs that did not receive training rated their performance as being poorer than did the VGPs that received training. It appears that individuals with video game playing experience that also receive training thought that they performed better than did VGPs that did not receive training, and NVGPs in either condition. The VGPs may already have some confidence in their ability to perform, but the added training boosts their confidence.

Training

Training was found to produce improved performance on several of the tasks, which is consistent with the hypothesis of the effect that training would have. Training improved participants' ability to maintain the tank levels in the resource management task. It is likely that the additional training increased situational awareness, which enabled the participants in this group to maintain tank levels better than those that did not receive training. For the maintenance of Tank B, tank levels began as being maintained at close to 2,500 units, then during T3 (4min-6min) this maintenance significantly declined, and later improved but not to the same degree as the beginning. This may demonstrate that there was a decrease in vigilance during the T3 period, but then participants became more aware again and increased the tank levels. The effect of better performance from training, may indicate that individuals that receive training can learn to increase situational awareness and vigilance, which could indicate that individuals without flight experience can learn the tasks needed of pilots in order to fly UAVs.

The participants that did not receive training may have experienced a reduction in vigilance from not receiving training that would enable them to handle the information-processing demands that were placed on them to monitor all of the tasks. The decreased performance may have been due to the high vigilance that was required to monitor all tasks, since previous research has shown that this decrease is often due to information-processing demands placed on the operator (Gunn et al., 2005; Johnson & Proctor, 2004).

The individuals that received training were also shown to improve on the systems monitoring task, by committing fewer errors of omission than did the no-training group. It is likely that the training these individuals received improved their SA, which enabled them to be more aware of the responsibilities that needed to be completed. This finding is similar to what was found in previous studies on training in situational awareness, in which training improved participants' situational awareness for the task they were completing (Saus, et al., 2006; Sing, Sharma, & Singh, 2005).

Implications

The findings that video game playing and training have improved performance on some of the MATB-II tasks suggests that VGPs may be a good candidate group for learning to fly UAVs. The current operations of UAVs requires that an operator is able to continually visually monitor the progression of the UAV’s flight while being prepared to respond to any errors that arise (Dixon, Wickens, & Chang, 2005; Guznoz et al. 2011; Mouloua, Gibson, Krig, & Hancock, 2001; Parasuramen et al., 2003; Sterling & Perala, 2007). In order to perform well on the MATB-II tasks, the participants need to maintain a high level of vigilance throughout the trial, as well as remain situationally aware, which will both assist in managing the high workload that is experienced throughout the completion of the task. These skills are all important for performing well while operating a UAV.

Training may improve performance by allowing the participants to gain a better understanding of how the MATB-II system works and how to remain vigilant. The increased understanding may also assist in reducing the workload that is experienced by having more awareness for the tasks presented. However, VGPs may benefit more from the training by already possessing the cognitive skills necessary to remain vigilant and respond accurately. The additional training may give VGPs further opportunity to access the cognitive skills that allow them to improve on tasks that require additional attentional resources.

This study demonstrated that individuals that received training or were VGPs were able to perform better on the MATB-II tasks than their counterparts. This means that VGPs likely possess the cognitive skills that would make them better UAV operators. By already possessing the skills necessary for maintaining performance on the

MATB-II, VGPs, and particularly VGPs that receive training, are able to perform better on the MATB-II which is similar to what is required of UAV operators.

Limitations

One of the limitations of this study is that the video game questionnaire may not have addressed all pertinent questions. The questionnaire did not specify if participants were to report on current video game playing habits or video game playing habits in general. Since all participants were current university students and the study was completed during the school year, it is likely that participants were playing fewer hours of video games than normal. Future research using university students may need to differentiate on the questionnaire current video game playing and video game playing during times when school is not in session (summer, winter break, spring break) to determine if there is any effect of current playing or during times when school is not in session.

Another limitation of this study was how video game players were differentiated from non-video game players. The study originally proposed to compare “expert” video game players against non-video game players, however, only seven participants fell into the “expert” category. Therefore, individuals that reported any number of hours of video game playing were considered VGPs and those that reported none were considered NVGPs. If more participants were included or if the questionnaires had been worded differently there may have been more “experts” included in the analysis.

Another limitation of this research may be that the video game questionnaire did not specify how recently the participants have been engaging in video game playing.

Previous research on the cognitive skills that are acquired from video game playing specified during data collection the amount of video game hours played within the previous six months, and differentiated VGPs by having played at least five hours per week, and NVGPs as having not played (or played very little) video games during the six months (Bavelier & Green, 2008). It is possible the participants did not accurately report video game playing based on how they have been recently playing.

Future Research

Future research in the area may want to consider ways to recruit more action video game players. Perhaps prescreening for video game players would be beneficial to increase the number of video game players that participate in the research. This study was unable to compare expert video game players to non-video game players, and it is likely that the experts would have yielded different results. However, due to the inability of recruiting individuals that met expert level criteria for video game playing, this study had to compare VGPs to NVGPs. Future research would need to examine the effect of expert VGPs.

In the future it be beneficial to consider examining a longer test period. A test period lasting for a longer period than ten minutes to gain a better idea of any vigilance decrements that occur. The delivery modality of the video game as well as whether it is an action video game or not, may also be an important area to explore. The growing popularity of video game players such as the Nintendo Wii or the Xbox Kinect that involve the entire body during game play instead of just handheld controllers may have an effect on the skills obtained.

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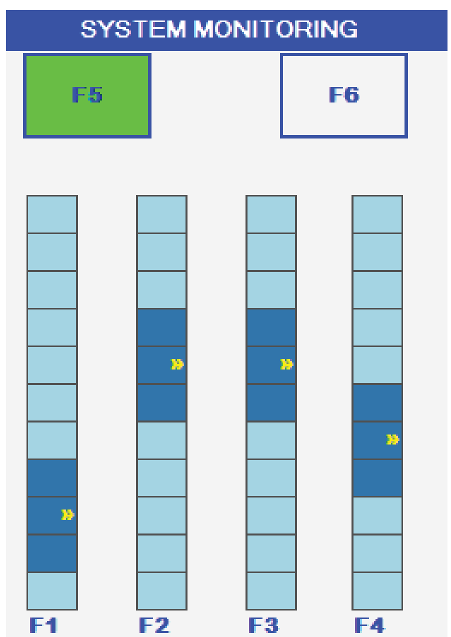
APPENDICES

Appendix A

Description of MATB-II Tasks

System Monitoring. (See Figure 1 below) The system monitoring task is divided into two subtasks, which consist of warning lights and scales. During a run there are two warning lights, one which is to remain green for the duration of the run, and the other which is to remain the background color but will turn to red throughout a run. The participant is required to maintain the green light as green by pressing the F5 key whenever it turns to the background color. Also, the participant must monitor the second light by ensuring that it remains the background color by pressing the F6 key anytime that it turns to red.

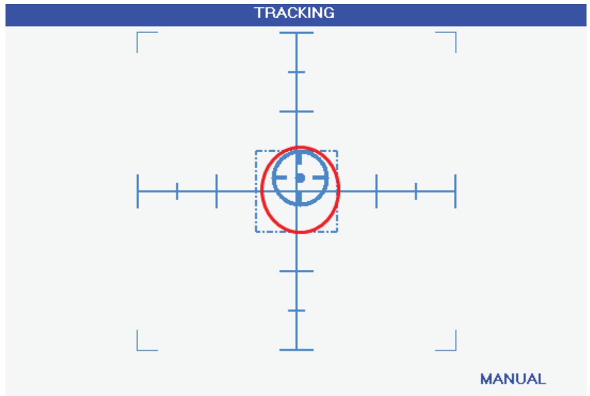
Figure 1. Systems Monitoring Task Example



The second portion of the systems monitoring task, which is monitoring scales, requires the participant to monitor four scales that move in an up and down fashion. Each scale has a "light" on it which the participant must monitor to ensure that these stay within the middle of the scale. When a light on a scale deviates from the middle towards the upper or lower end of the scale, the participant must correct it by pressing the function key that correspond to that scale using the keyboard (F1, F2, F3, F4). The participant's time to correct the problems that arise for each of the subtasks for the systems monitoring task are recorded within the program, under both an overall MATB-II file and for an individual systems monitoring file.

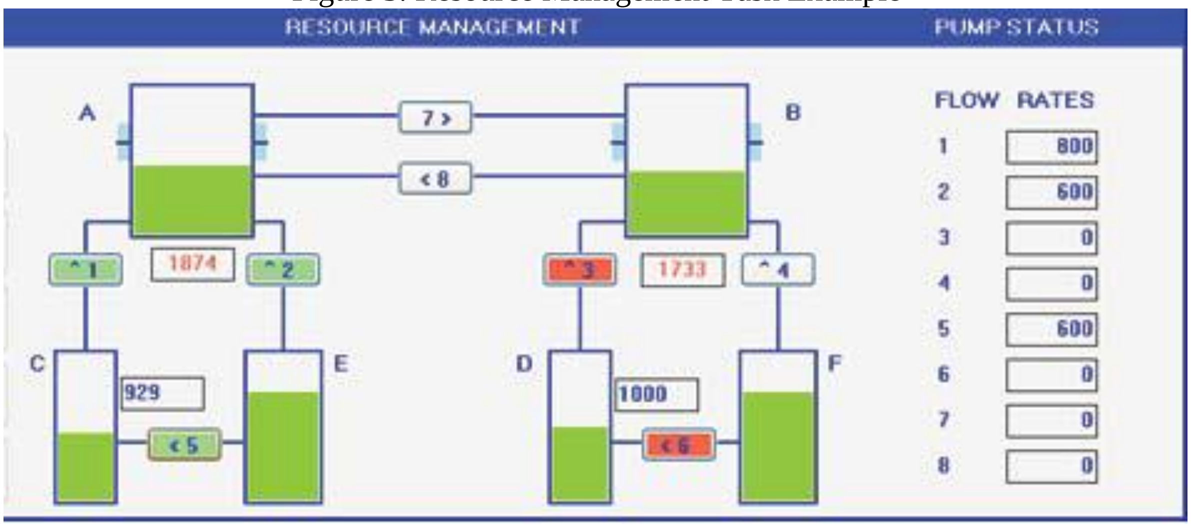
Tracking. (See Figure 2 below) The tracking task requires the participant to use a joystick to keep a target within the center of a box. The tracking task switches between manual mode or automatic mode. The tracking task states in the bottom right-hand corner which mode it is, by stating either "MANUAL" or "AUTO ON". While in manual mode, the participant is required to manually use the joystick to keep the target within the center of the box. While on automatic mode the target will remain within the box, however, "automation failures" will occur in which the target will go outside the box and the tracking task will switch into manual mode, for which the participant will need to correct it by using the joystick to manually move the target back into place. The MATB-II will collect data by calculating the root mean square deviation of the target center point from the center point in pixel units at a 15 second interval.

Figure 2. Tracking Task Example



Resource Management. (See Figure 3 below) The resource management task is a generalized fuel management system. There are six different fuel tanks that are labeled A-F. There are also eight pumps that feed into the various fuel tanks, and these are labeled 1-8. Tanks A-D also have next to them their remaining fuel levels, which are affected by fuel consumption and the actions the participant performs on the connected pumps. The fuel levels are updated every 2 seconds. For this task, the participant is required to maintain the fuel levels in tanks A and B within +/- 500 units of 2,500 units each. The goal is to maintain as close to 2,500 units as possible, but +/- 500 units of this is an acceptable range. The box that contains the fuel amount will turn red if the amount of fuel is above or below the acceptable range. To adjust fuel levels in tanks A and B, the participant needs to press the pump number on the keyboard to turn the pump ON; pressing the key again turns on the corresponding pump in order to transfer fuel to or from the tank. The pump will turn green when it is on, remain the background color when it is off, and turn to red when it is a “failed state” and is nonfunctional. Pump flow rates are also indicated on the screen so that the participant may determine which pump to activate in order to reach the acceptable range on the tank.

Figure 3. Resource Management Task Example



Scheduling Display. (See figure 4 below) The scheduling display provides a "look ahead" view for the Communications task (which is not used in this experiment) and for the Tracking task Manual and Automatic modes. The scheduling display allows the subject to "look ahead" for up to eight minutes in the future at activity of the tracking task. The display shows the beginning and/or ending (and duration) of the task from 0.0 minutes (present) to 8.0 minutes into the future. The green bar indicates the time during which the tracking task is in manual mode. At other times the green bar graph is replaced by a thin red line. The thin red line indicates times at which the subject will not need to attend to the tracking task. The display also shows the elapsed time of a session in the lower left of the panel. The display also shows when the MATB-II is scheduled to stop execution by showing perpendicular intersecting lines at the end of the red thin lines. The red thin lines do not extend beyond the time at which MATB-II is scheduled to stop execution. Figure 4 below shows a run with the tracking event taking place over the next two minutes, and with an elapsed time of six seconds. The tracking task is currently in manual mode, and is on the right side of the display. There is a second tracking manual session in the “look ahead” view.

Figure 4. Scheduling Display Example

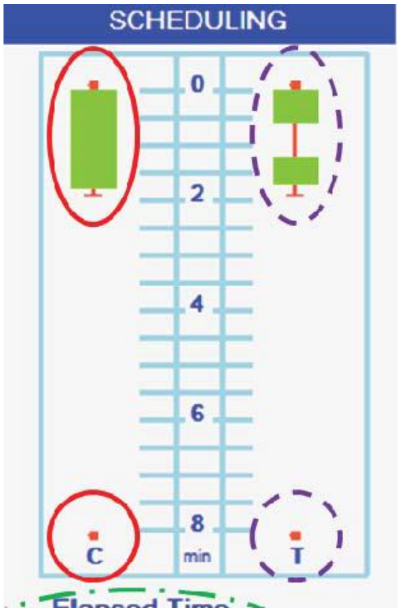
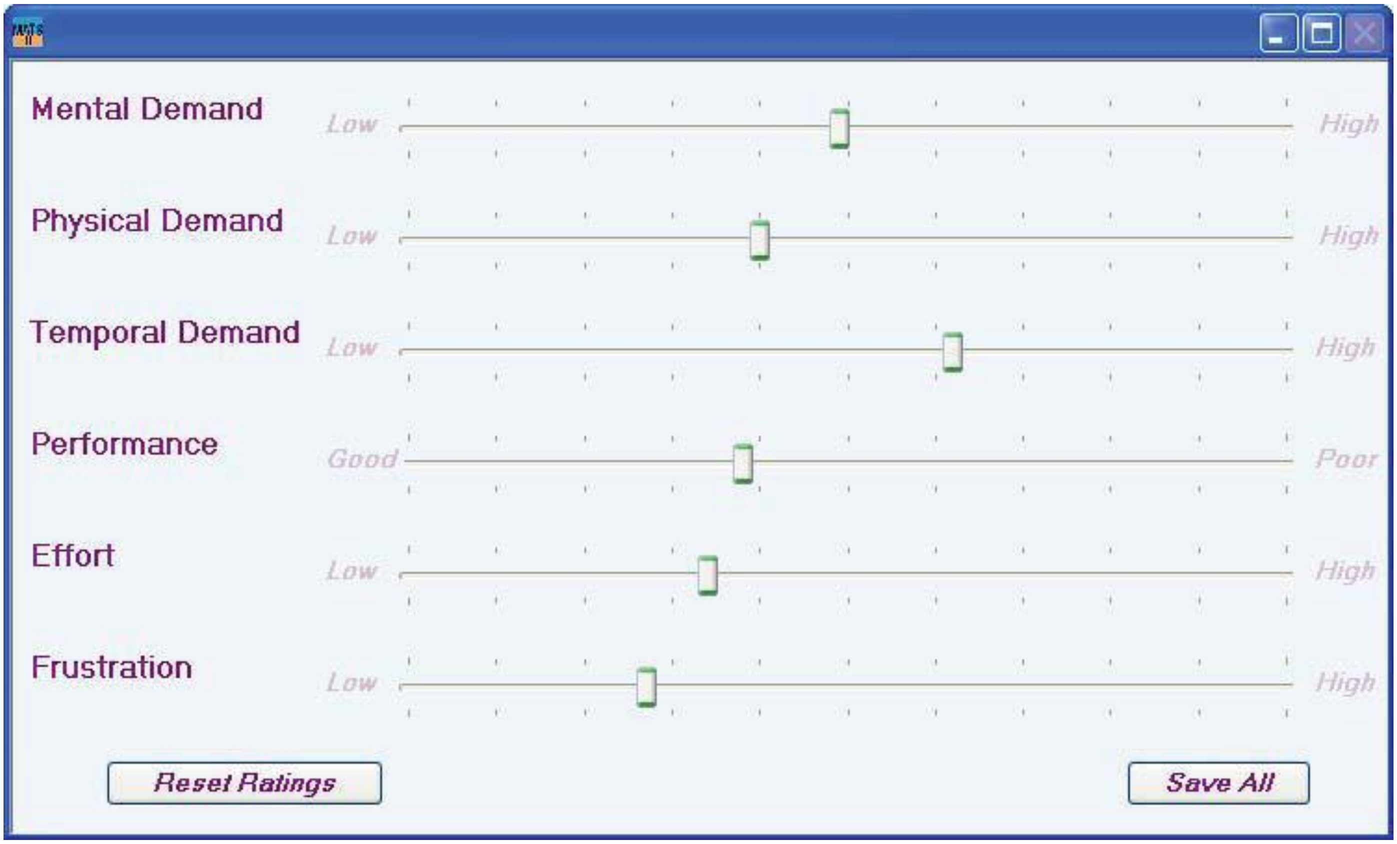


Figure 5. Workload Rating Scale Example



Appendix B

Demographics

Date:______________________________

Before we begin, I would like you to answer the following questions. Thank you.

1. Sex: _____ Male ______ Female
2. . Age: ______________________
3. Education History:
   A. High School Graduate Year: ____________________ Degree: __________________
   B. College Graduation Year: ______________________ Degree: __________________

   If currently in college, circle class: FR SO JR SR

   C. Graduate School GraduationYear(s): ______________________________________

   Degree(s): ____
4. Using the following scale, please circle the number which corresponds to your current health level in comparison to others your age
5. 1 Excellent 2 Above Average 3 Average 4 Below Average 5 Poor

1	2	3	4	5
Excellent	Above Average	Average	Below Average	Poor

6. If you are currently taking any medication(s), would you please describe the type(s) and quantity(s) below.

____

____

____

____

7. Do you have 20/20 uncorrected vision? __________Yes ____________No

8. If you answered NO to number 6, do you wear:

_______Glasses _______Contacts _______Both

_______Neither

9. Do you have any other visual impairments, such as color blindness?

________Yes ________No

If Yes was selected, please state the impairment(s) below:

____

____

____

Appendix C

Video Game Playing

Action Video Games include both computer and game-console games (e.g., X-Box, Playstation 2) which require that your attention is shifted around the game field frequently. Grand Theft Auto 3 and Super Mario Cart are examples of Action Video Games while Tetris is not. Based on this information, how many days per week do you play Action Video Games?

0 1 2 3 4 5 6 7

Number of hours played per week = _______

If you do play Action Video Games (i.e., did not answer 0 to the above two questions) please fill in the following information:

For how many months have you played this # of hours per week? _________________

At what age did you start playing action video games? __________________________

What are your 3 favorite Action Video Games? (In no particular order)

Appendix D

Flight Experience

1. Total hours of flight time: ____________________
2. Total hours as pilot in command on cross-country flights: _________________________
3. Total hours of instrument flight (actual and simulated)

   A = _______________________

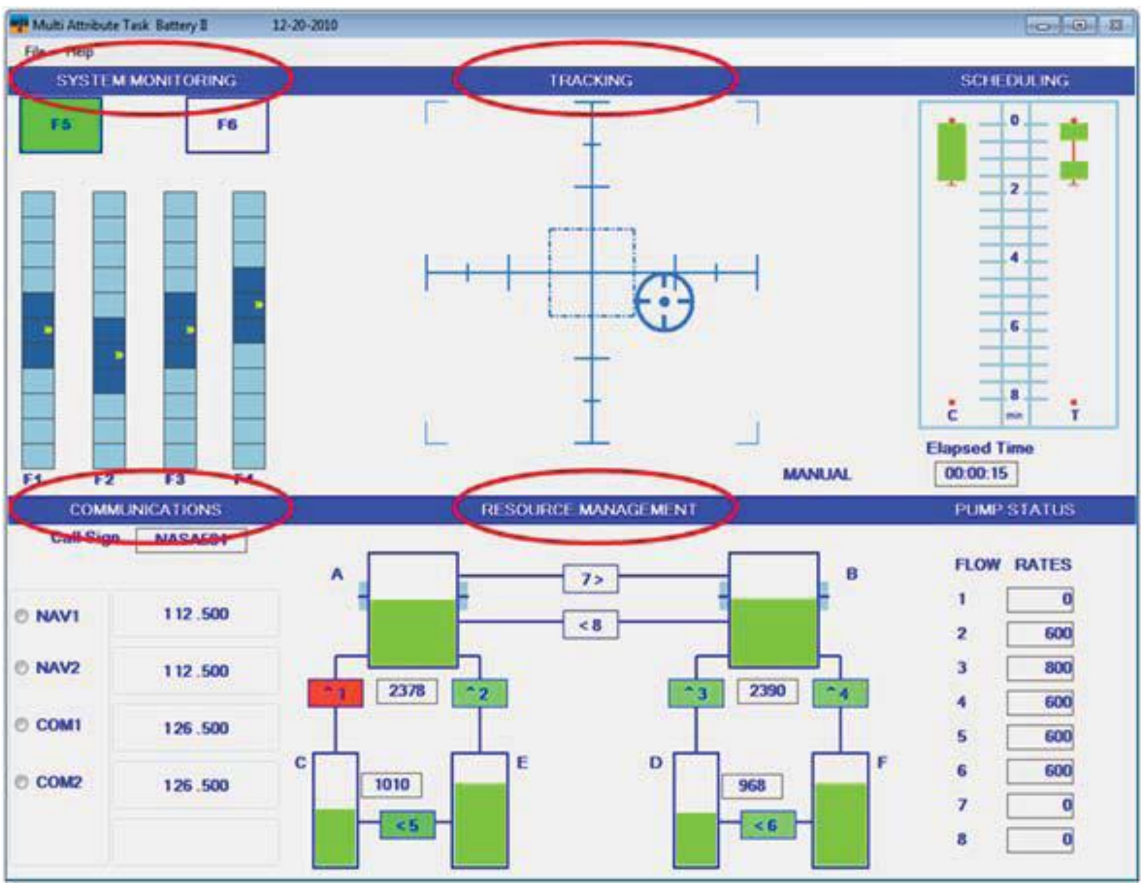
   S = _______________________
4. Total hours of simulated flight: ________________________

Appendix E

MATB-II Instructions

The tasks in MATB-II simulate the kinds of tasks that pilots perform during flight. The MATB-II main window contains four different tasks and a scheduling display that allows you to preview the workload. The tasks you will be expected to respond to are the following: monitoring, tracking, and resource management. There is also a communications task, but this task will not be used in this experiment. Figure 6 below shows what the complete MATB-II display looks like. A Workload Rating window may also be presented to you at any time during a run, or after a run.

Figure 6. Complete MATB-II Display



The MATB-II Graphical User Interface has some features common to the Windows Operating System; however, some commands have been modified or changed. Such commands are presented in the table below.

If you try to close the application by clicking the Close (X) button in the title bar, no action will be taken. That button is disabled. The experimenter will inform you if and under what conditions you should use these window controls.

Table 7. MATB-II Commands

Actions	Commands
START	Click on the Start option of the File Menu or hit CTRL-S
PAUSE	Click on the Pause option of the File Menu or CTRL-P
RESUME	Click on the Resume option of the File Menu or CTRL-R
QUIT	Click on the Exit option of the File Menu or CTRL-X

Systems Monitoring Task

The system monitoring task appears in the upper left corner of the Main Application Window and is divided into two sub tasks: the warning lights and the monitoring scales. The warning lights are in the balloon at the top of Figure 7 while the scales are in the lower balloon in the upper portion of the panel. During a run, the green light on the left is normally “On”. If the green light should turn “Off”, you are to indicate that you detect this by pressing the F5 key.

The light on the right is normally "Off"; however, a red light does come on occasionally. Your task is to detect the red light, and to respond by clicking on it with the mouse, or by pressing the F6 key.

Figure 7. Systems Monitoring Task

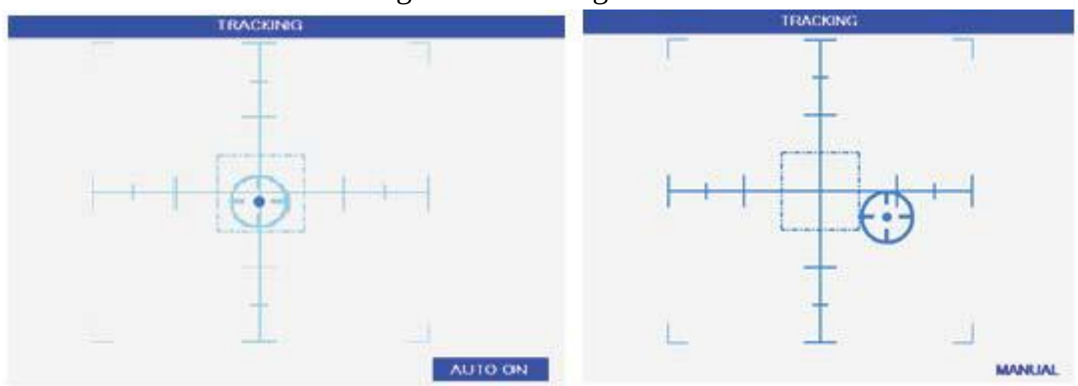
The second part of the system monitoring task involves monitoring four scales with lights that normally fluctuate around the center of the scale, usually within one unit in each direction from the center. Your goal is to make sure that the lights on the scales keep fluctuating around the center of the scale. If you notice that the lights in a particular scale have an offset (it looks too high or too low), you must press the function key that correspond to that scale using the keyboard (F1, F2, F3, F4).

Tracking Task

The upper central region of the MATB-II window contains the tracking task. Your job is to keep the target in the center of the rectangular box when the task is in the MANUAL mode. The current mode is displayed as either "MANUAL" or "AUTO ON" in the lower right corner of the window. When the mode changes between AUTO and

MANUAL, the grid changes color from a lighter shade of blue to a darker shade of blue (Figure 8).

Figure 8. Tracking Task



The overall purpose of this task is to keep the aircraft (represented by a blue circle) within the dotted rectangular area in the center of this task. Try to maintain this at all times. You control the aircraft with movements of the joystick. If you do not control the aircraft with the joystick, it will drift away from the center. If the aircraft leaves the rectangular area, try to bring the aircraft back to the center as quickly as possible.

Resource Management Task

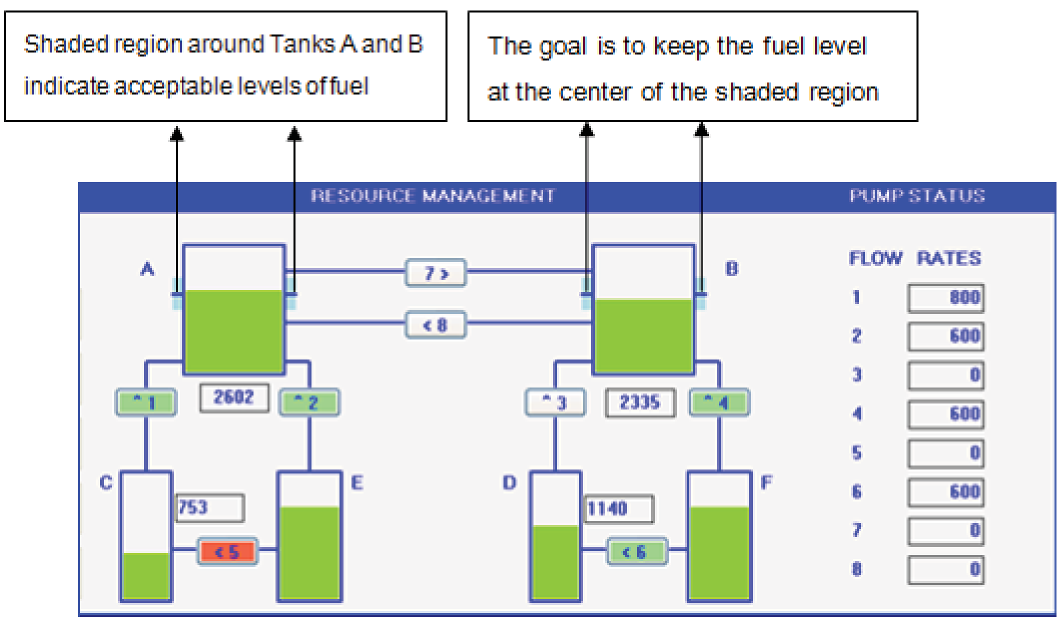
The lower right region of the MATB-II main window contains the resource management task. Figure 4 below displays the elements that comprise this task. The rectangular regions identified with the letters A-F represent fuel tanks. The green levels within the tanks represent fuel levels. Along the lines which connect the tanks are pumps which transfer fuel from one tank to another in the direction indicated by the arrows.

There are 8 pumps labeled with the numbers 1-8. Each one of the pumps is represented by a rectangular box with a number inside it that identifies the pump, and an arrow that indicates the direction of the fuel. The pumps are used to transfer fuel from the supply tanks to the main tanks.

Deactivated pumps are colored in gray, activated pumps are green, and failed pumps are red. Note in Figure 4 that pumps 1, 2, 4, and 6 are active, pumps 3, 7, and 8 are inactive, and pump 5 is failed.

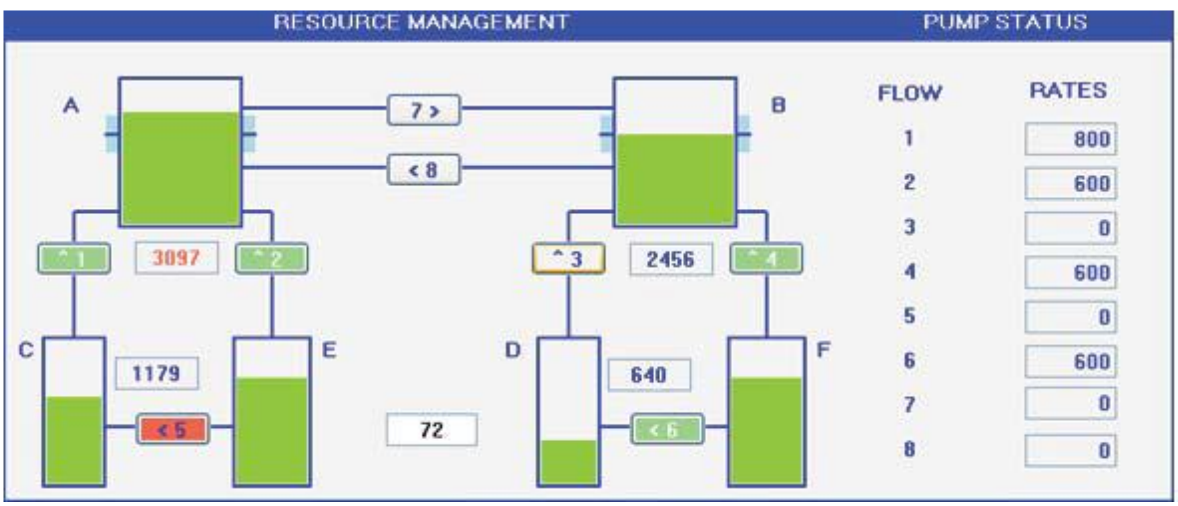
When a pump activates, the numbers change in the “Pump Status” area. Under “Pumps Status”, two columns of numbers are present. In the first column, numbers 1 through 8, correspond directly to the pumps in the diagram. The second column indicates the flow rate in units per minute for each pump when it is on.

Figure 9. Resource Management Task



In Figure 10, the numbers underneath tanks A and B and to the right of tanks C and D represent the amount of fuel for each of those tanks. Those numbers will be increasing and decreasing as the fuel levels change. The capacity for the main tanks, A and B, is 4,000 units each. The supply tanks, C and D, contain a maximum of 2,000 units each. Tanks E and F are supply tanks that have an unlimited capacity-they never run out. The areas shaded in light blue on the side of tanks A and B indicate the critical levels of fuel for those tanks. You must transfer fuel to tanks A and B in order to meet these criteria because the fuel in tanks A and B is consumed.

Figure 10. Resource Management without Instructions



When the resource management tasks begins, the fuel level for tanks A and B is at 2,500 units.You are to keep the level of fuel from dropping below this level as indicated by the marker on either side of these pumps. As time passes, tanks A and B lose fuel. These tanks would eventually become empty without the transfer of additonal fuel. Tanks C and D only lose fuel if they are transferring fuel to another tank.

Let's consider the process of transferring fuel. Each pump can only transfer fuel in the direction indicated by the ^ arrow in its label. The pumps are activated by either clicking on them, or by pressing the number key corresponding to the pump that you wish to activate. A pump is actively transferring fuel when it turns green.

So far, you've seen two conditions for the pumps: ON and OFF. If you press the pump number on the keyboard just once, you will turn the pump ON; pressing the key again turns the pump OFF, and so on. If a tank fills up to its capacity, all incoming pump lines will be turned off automatically. This is because a full tank cannot receive any more fuel. You will have to turn those pumps back on at a later time, if the fuel level of the tank goes below critical level. Furthermore, if a tank becomes empty, all outgoing pumps will automatically be turned off. This is because an empty tank can no longer transfer fuel. In that case, the proper action is to supply fuel to an empty tank before turning on the pump that transfers fuel of it.

At some point during the execution of the resource management task, one or more of the pumps may fail. When a pump fails, its label turns red. Depending on the level of fuel in the tank affected, you might need to transfer fuel from one main tank to another main tank to compensate for the loss of fuel. You can cross feed fuel from one main tank to the other by activating either pump 7 or 8.

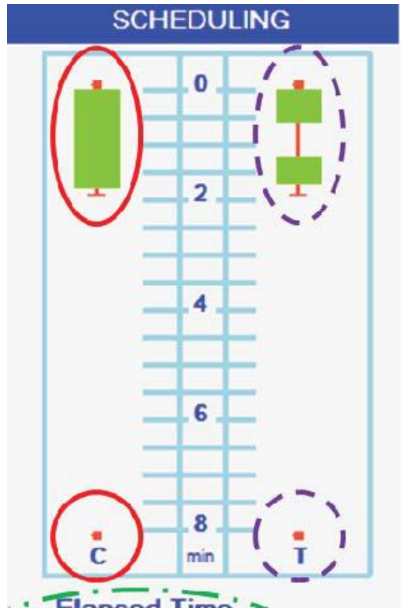
If you have questions, please interrupt your reading and ask for assistance.

Once again, the overall goal is to maintain the fuel level in tanks A and B close to 2,500 units each for as long as you possibly can. There may be more than one way to achieve this goal; you may use the method that works best for you. If the fuel level in these tanks should deviate from this level, please return the fuel level back to this point as soon as possible.

Scheduling Display

The purpose of the scheduling display (figure 11) is to depict the start and duration of the manual tracking task. The indicator is “T” for the tracking task. The scheduling display is also used for the communication task, which is not being used in this experiment, so disregard the “C” indicator. The scheduling display allows you to “look ahead” from 0 (present) to 8 minutes into the future. The thin red line indicates times at which tracking actions are not required of you. In MATB-II the time is tracked by the elapsed timer using the notation hh:mm:ss. For example, 1 hour, 35 minutes and 30 seconds is represented as 01:35:30.

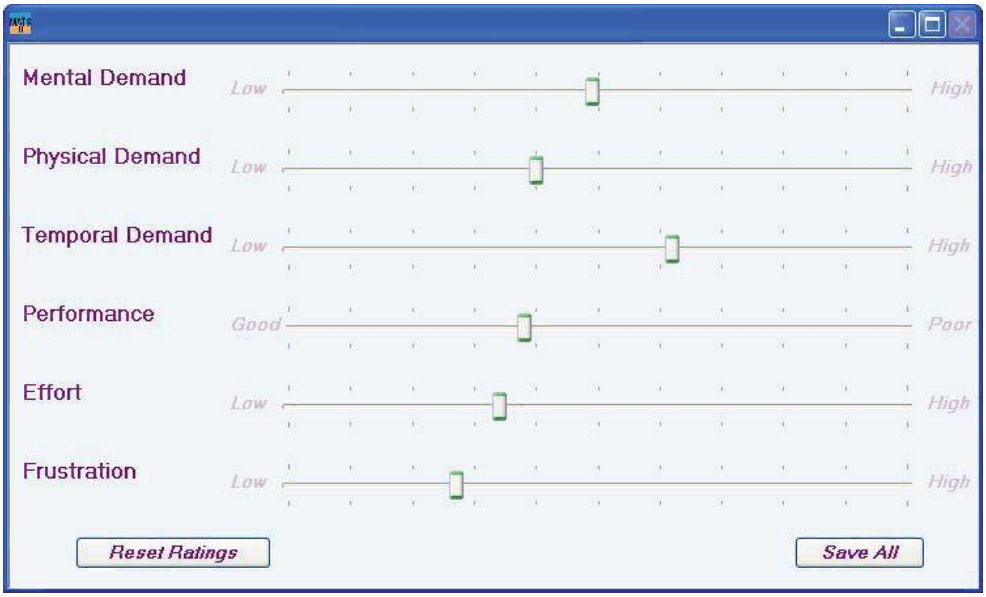
Figure 11. Scheduling Display



Workload Rating Scale (WRS)

The WRS can be presented to you at any time during the operation of the Multi-Attribute Task Battery (Figure 12). You must move each one of the sliders in order to activate the “Save All” button that is used to submit your answers. After a certain time, usually 30 seconds, the window disappears (a timeout occurs). Upon return to the MATB-II screen, the simulation resumes. Once again, you will need to move each one of the sliders of the subscales to be able to submit your responses.

Figure 12. Workload Rating Scale



The NASA Task Load Index was developed by the Human Performance Group at NASA Ames Research Center (Hart and Staveland, 1988). It uses six subscales to provide an overall workload rating: Mental Demand, Physical Demand, Temporal Demand, Own Performance, Effort and Frustration. The Own Performance subscale ranges from “Good” to “Poor”. The other fiver subscales range from “Low” to “High”. The meaning of each rating scale is explained in the table below.

Table 8. Workload Rating Scale Description

Terms used in the Rating scales	**Explanation**
Mental Demand	The level of mental activity required to perform the tasks.
Physical Demand	The amount of physical activity required to perform the tasks.
Temporal Demand	Time pressure that you experienced (slow or rapid pace).
Performance	How well you think you performed.
Effort	How hard you worked to achieve your level of performance.
Frustration	How did you feel while performing the tasks, ranging from relaxed to very stressed.

Now that you have read how to use the Multi-Attribute Task Battery, you are ready to interact with it. Ask the person in charge of this test to initiate the MAT Battery.