An Analysis of Intention Formation as a Function of Prospective Memory in Air Traffic Controllers

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An Analysis of Intention Formation as a Function of Prospective Memory in Air Traffic Controllers

By

Jennifer Nagle
B.S., University of Montevallo at Montevallo, 2002

A Thesis Proposal Submitted to the Department of Human Factors & Systems In Partial Fulfillment of the Requirements for the Degree of Master of Science in Human Factors & Systems
Embry-Riddle Aeronautical University Daytona Beach, Florida

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This thesis was prepared under the direction of the candidate's thesis committee chair, Christina Frederick, Ph.D., Department of Human Factors & Systems, and has been approved by the members of her thesis committee. It was submitted to the Department of Human Factors and Systems and has been accepted in partial fulfillment of the Requirements for the degree of Master of Science in Human Factors & Systems.

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Abstract

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Prospective memory, or memory for future intents, is an important part of everyone’s daily life. Air traffic controllers whose jobs are based in an environment that taxes their memory resources for extended periods of time rely on this type of memory. Controllers objectives often change based on incoming information and the amount of traffic they are controlling. It is important to investigate how controllers form intentions for future events, what processes facilitate retrieval of this information, and establish what influence experience may have. This study proposes to assess controllers in an air traffic scenario by employing a cognitive task analysis to determine when intentions are formed. The experimenter expects that controllers who form explicit intentions for specified future actions will perform better and that experience will facilitate intention formation.
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Introduction

Few careers are as mentally demanding of human memory capacity as air traffic control. What is remembered and what is not remembered can be as simple as leaving an aircraft in a holding pattern or forgetting to give aircraft on a collision course new coordinates. Prospective memory, a term coined by Meacham and Leiman, (1982) is the memory for future events. The relevance of prospective memory in the daily lives of everyone has led to a substantial amount of research in the recent past. This research has shed new light on memory mechanisms and laid the ground for theories to explain why people forget to do things in the future as well as what processes facilitate remembering intended tasks. Research in this area has led to techniques that teach people how to better use their memory, and distinguish between what has been done and what they are supposed to do (Sehulster, 1995). Considering the high mental workload that air traffic controllers often face, it is important to fully understand how this group forms prospective memories to ensure that these memories are retained for later retrieval. How controllers plan for future actions and retain the information can make the difference between life and death for the millions of passengers and crew whose lives are in their hands. The current study will examine the effects of intention formation on the performance of prospective memory tasks as well as evaluate the influence experience may have.

Prospective Memory Theory

There are several different theories that involve prospective memory but they all seem to revolve around a model that consists of multiple phases embedded in the action of remembering a future intention. Kliegel and colleagues (2000) developed a paradigm that sorts out four different phases of prospective memory. The first phase is the formation of an intention by the person (intention formation). In this phase the person develops an intention for the future action
and develops a plan to carry out that action. For example, an individual may need milk from the store so this person would form the intention to go by the grocery store after work. The second phase is the interval of time that the intention must be retained for later retrieval. In this phase the person is going about their daily activities even though they intend to do something later. With the previous example, the person may have to work all day and are unable to get the store to buy milk immediately. The interval between the time when the intention is formed and the time they get the milk is called the "intention-retention phase." The third phase is the "intention initiation phase." In this phase, the person must initiate the particular action at the appropriate time. The person getting the milk may be reminded on the way home that they need milk when they see the grocery store (an external cue). This is a very important phase due to the fact that if the intention is not initiated at the appropriate time the whole process model is inadequate. It is not acceptable if the person in the example gets home from work and remembers to get milk, they are already home and have forgotten their prospective memory task. "According to the proposed model, successful initiation should depend particularly on monitoring processes, cognitive flexibility, and inhibition (Kliegel et al. 2002)." When the person monitors the task closely they are more likely to carry out the task appropriately. However, how closely a person monitors a task can depend on whether or not the task is of great importance to them. The fourth phase of the process model is the "intention execution phase." In this phase, the person initiates the action at the appropriate time and carries out the action in the manner required. How the person carries out this action is interdependent upon how they planned to do the task and the circumstances in which the task takes place. Although these factors are important, the cognitive flexibility of the person is the most important factor in this phase. It is essential for the person to be able to switch from concurrent ongoing tasks and be able to execute the prospective task. In a
study of this model by Kliegel, Martin, McDaniel, and Einstein (2002), they tested the underlying functions of each phase of the process model. They examined the relationship between prospective memory and the underlying factors that may impact prospective memory which include “cognitive flexibility, planning, inhibition, problem solving, verbal and non-verbal functions.” This study found that in the “intention formation” phase the most important underlying factor in how participants plan to carry out the intended action. The “intention retention” phase did not show any relation to any of the underlying factors. The “intention initiation” phase showed significant relation to the cognitive flexibility and problem solving factors showing an increase in successful performance. In the last phase, “intention execution,” was found to significantly coincide with the factor of cognitive flexibility. This study lends evidence to the theoretical model of the multiple phases of prospective memory, and to the suggestion that research in this area should look at individual phases to find the underlying factors in prospective memory (Kliegel et al., 2002).

**Prospective Memory and Related Memory Types**

Since the inception of studies on prospective memory, it has been apparent that two other types of memory play an important role in prospective memory: retrospective memory and working memory. Retrospective memory, or the memory for past events, has been identified as an integral piece in the underlying processes of prospective memory. In prospective memory a person not only has to remember what their future task is (prospective component), but they must also remember what task they are supposed to do (retrospective component) (Rendell & Thomson, 1993; Mizuno, 2001). Retrospective memory not only acts as a function of prospective memory but it also plays a role in remembering the prospective task has been completed (Mizuno, 2001). It has also been shown that there is a significant decline in the
reliability of retrospective memory with increasing age, which could be cited as an underlying factor in performance decrements on prospective memory tasks for the elderly (Kvavilashvili, Kornbot, Cockburn, & Milne, 2000). However, other studies found only faint relations between the processes of retrospective memory and performance on prospective memory tasks (Cockburn, 1995; Einstein, Holland, McDaniel & Guynn, 1992; Einstein & McDaniel, 1990; Kliegel et al., 2000; Kvavilashvili, 1997). It is important to note that a prospective task should not rely heavily on the retrospective component of the task. Prospective memory relies on different processes than retrospective memory does and the heavy use of retrospective components could confound the results of the prospective memory task (Mizuno, 2001). To elaborate, if a participant is required to remember too many bits of information in addition to the prospective memory task, their memory may be too encumbered with extraneous information to properly remember and execute the future task. Analyses of prospective memory for everyday tasks show that there are many underlying factors that “require more than just retrospective memory” (Kliegel et al, 2002). Another type of memory that has been identified as having an integral role in prospective memory is working memory. According to Baddeley and Logie (1999), working memory “is comprised of those functional components of cognition that allow humans to comprehend and mentally represent their immediate environment, to retain information about their immediate past experience, to support the acquisition of new knowledge, to solve problems, and to formulate, relate, and act on current goals.” Research has pointed to the capacity of working memory as a predictor for performance variance on prospective memory tasks. Marsh and Hicks (1998) proposed that components of working memory “such as planning… appear to be critical to successful event-based prospective memory” (p. 336). In a study by Martin and Schumann-Hengsteler (2001), they found that the inhibitory function of
working memory to suppress some information while attending to other information can be a predictive factor in the performance on prospective memory tasks.

Means of Studying Prospective Memory

The complexity of prospective memory has led to a multitude of different ways that it can be examined. Among these are event-based, time-based, activity based, and event-cue frequency tasks (Einstein & McDaniel, 1990; Kvavilashvili & Ellis, 1996; Ellis et. al, 1999). These tasks can also be tested in different environments under either naturalistic or laboratory settings (Meacham & Leiman, 1982; Einstein & McDaniel, 1990).

The two most popular methods of studying prospective memory are event-based and time-based tasks. An event-based task occurs when a particular event occurs. For example, an air traffic controller can give clearance for landing in the event that the runway is clear. A time-based task involves commencing the task at a particular time. For example, a controller may have to put off giving clearance for 10 minutes for a particular reason but the controller must remember to give that clearance at the appropriate time in the future. These two types of tasks have been used in many different studies to determine what factors may relate to prospective memory and both tasks have been required to commence during other on-going tasks. For example, in one study a participant had a time-based task of reminding the experimenter to make a phone call while the participant was completing other computer related tasks. It is also important to mention that cues play a large role in event-based and time-based prospective memory tasks differently from event-cue frequency tasks. Cues can serve as reminders in both of these tasks, but in different ways. There are very few external cues provided in time-based tasks. Often it is up to the person to remember what time an event must take place unless there is some external alarm that provides the cue for the task. In d’Ydewalle, Luwel, and Brunfaut’s
(1999) study, they used event-based and time-based tasks to assess the importance of ongoing activities in prospective memory. They found that the amount of time employed in time-based tasks is an important factor in performance, especially when using elderly participants. In this instance, the longer the amount of time from when the instructions were given to the time the task was to be completed, the worse the participant would perform. In a study by Vortac and colleagues (1993), they used event-based tasks embedded in a simulation to determine “how external cues support memory for the content of to-be-performed actions.” They found that for event-based tasks it seems that the most important factor that facilitates remembering of the action is the cue component as compared with time and other factors. For example the cue component in the afore mentioned air traffic control scenario is the runway being clear of traffic. It is important to delineate between the cue being present throughout the study as a constant reminder and the cue facilitating remembering when present only at a certain time in the study. In this study they found that the cue being present throughout the session did not facilitate remembering. It seems that the cue only aids in memory if it is presented at the time the action is required (Vortac et al, 1993).

Activity based prospective memory tasks refer to the execution of the prospective task after an ongoing task has been completed. An example of this would be a pilot contacting the control tower after they have completed a maneuver. In this example, the ongoing task is the act of performing the maneuver and the activity-based task is contacting the next tower upon completing the maneuver. Activity-based tasks are different from event-based and time-based tasks in that the ongoing task is not interrupted to complete the activity. The lack of interruption during the ongoing task has been found to facilitate remembering of the specified task at the appropriate time (Kvavilashvili & Ellis, 1996). In a later study by Kvavilashvili and colleagues
(2000), they found that participants performed better in the activity-based tasks than either the event or time-based tasks. They also found that participants either remembered the task or did not remember the task, there was very little "partial recall" (responses that were late or insufficient to be a correct response).

Event-cue frequency refers to the frequency with which a target word is embedded in an ongoing prospective memory task. Many of the tasks that are employed in studying prospective memory use "repeated-instance" (Einstein & McDaniel, 1990) targets to allow the participant many chances to exhibit the desired response for the task. This type of task has been distinguished from the "single-instance" (Ellis, Kvavilashvili, & Milne, 1999) use of targets where the participant only has one chance to exhibit the desired response in an all or nothing fashion. In past research, it was thought that "repeated-instance" targets would facilitate remembering and boost performance (Kvavilashvili & Ellis, 1996). However, a more recent study by Ellis, Kvavilashvili, and Milne (1999) found that event-cue frequency does not aid in prospective remembering when examined over the whole study which contradicts previous findings on this facet of prospective memory. Changes in performance are only seen when looking at results from the beginning of the study to the end of the study. This suggest a practice effect instead of the frequent cue presentation aiding the performance of the participant.

Factors Affecting Prospective Memory

Research has shown that there are many factors that affect prospective memory, the most significant of which are time, reminders, age, and anxiety. Each of these factors affect prospective memory on their own but can also have a collaborative effect. For example, a person could be elderly, a drug user, stressed out, with very little motivation and that person would not
be likely to perform well on a prospective memory task. These factors can also affect prospective memory in positive or negative ways, or both depending on circumstance.

Time is an important factor in prospective memory as evidenced in the way that prospective memory is studied in time-based tasks. There are two specific relations to time in prospective memory, when the future intention is formed and the amount of time that the intention must be retained in a person's memory before the action. In a study by Brandimonte and Passolunghi (1994), they found that the first three minutes after instructions have been given for the task is the critical time for forgetting, but very little forgetting is found after this period of time. Studies on when the future task is to take place have shown that, at least in pill taking, morning times facilitate remembering of the prospective task better than evening times (Wilkins & Baddely, 1978). The time that the intention must be remembered has led researchers to some conflicting results. Some researchers feel that this interval of time has no effect on prospective memory tasks (Einstein, Holland, McDaniel, & Guynn, 1992), while other researchers have found that this interval can have detrimental effects on prospective memory tasks (Meacham & Leiman, 1982).

Remembering past or future actions are also essential factors affecting prospective memory. People often employ many means of remembering, including internal cues like rehearsal of the intended action, and external cues like notes to remind them of the prospective action. In a study by Meacham and Leiman (1982), they found that external memory aids boosted performance on prospective memory tasks. In their study, they had participants put colored tags on their key chains to help them remember to mail postcards to the researchers at the appropriate times. They found that external cues were more reliable in the facilitation of
remembering than internal cues because the external cues were a visible reminder to perform the desired action.

As with any type of memory, the affects of age are readily apparent. However, the research on how age affects prospective memory has led to differing opinions. Some researchers believe that prospective memory decreases with an increase in age depending on the type of task (i.e. elderly subjects perform worse on time-based prospective tasks versus event-based prospective tasks) (McDaniel & Einstein, 1993). However, other researchers did not reach this same conclusion. d’Ydewalle, Luwel, and Brunfaut (1999) found that elderly participants performed as well and in most cases better than younger participants on both time- and event-based tasks. In the same study it was also found that it is not so much age that affects prospective memory or the type of task (event-based or time based), but the way the information was presented to the participant. This part of the study found that if the information was given to the participant in a slow, concise manner instead of a rapid, misleading manner, the subject retained more information and performed well on the task regardless of age.

Although one would think that anxiety would cause detriments in prospective memory, it can actually act as an aid. In a study by Cockburn and Smith (1994), they found that anxiety can act in a way that promotes a person to check the required task repeatedly to ensure that it is undertaken properly. Participants in their study who experienced higher levels of anxiety were more likely to check their errors and correct them (often before errors were even made). The participants in this study tended to monitor their activities more the higher their anxiety levels and engaged in more rehearsal when given the information they were to remember (p. 275). This monitoring of actions lead to more correct responses, responses upon being prompted, and knowing that a response should be made but not being able to recall the correct response, were
all a result of high anxiety. Higher deficiencies in working memory were also reported for this high-anxiety group. Participants whose levels of anxiety were lower tended to forget to give responses altogether (even when prompted) or gave wrong responses. This study also reported that forgetting to ask for something or needing a prompt to ask for the item in question were associated with increased aging which they associated to an overload of the participant’s working memory (Cockburn & Smith, 1994).

Air Traffic Control

In the industry of air traffic control, it seems clear that prospective memory plays a fundamental role. Controllers are often putting off tasks until future times due to air traffic, ground traffic, and a variety of other reasons. To lend support to this, it is necessary to point out the jobs that air traffic controllers are responsible for and what prospective memory components can be found in these jobs. According to the Federal Aviation Administration (FAA), the main job of an air traffic control specialist is to “direct air traffic so it flows smoothly and efficiently.” This type of controller works in FAA airport control towers and possible jobs include giving pilots necessary directions for takeoff and landing, clearances for air traffic and altitude, and basic “advice based on numerous sources – their own observations and information they receive from the National Weather Service, Air Route Traffic Control Centers, Flight Service Stations, and aircraft pilots (Retrieved from National Air Traffic Controllers Association (NATCA) website).” Air traffic control specialists are responsible for all aircraft coming into and leaving their airspace, which can range from approximately 5 – 200 miles. Memory components associated with an air traffic control job include recall of aircraft call numbers, altitudes, speeds, location of aircraft in the air, and landmarks that pilots can use as navigational aids among others. There are over 15,000 air traffic controllers in the United States and they guide over 60
million aircraft to their locations yearly (Retrieved from NATCA website). Controllers must continually assess and reassess the current situations and circumstances and often make changes in the flight path for aircraft on a moments notice. Planning for future intentions is a major advantage for controllers. Having a solid plan gives a controller the framework to go by even if changes need to be made depending on circumstance (Boudes et al., 2000). Distractions also play a major role in how well a controller may perform in a stressful situation. There are many distractions that can occur in an air traffic control situation where the controller is often in control of more than one aircraft within their airspace. It is important to be aware of all on-going activities, and use cues to promote memory of actions to be performed. In an article by Dornheim, he notes that "prospective memory is at the heart of distractions." To prevent problems with distractions, he suggests that planning be involved and external cues used to facilitate remembering in situations where distractions are common (Dornheim, 2000). In a study of air traffic controllers, the experimenter used an air traffic control simulation to assess the prospective memory of controllers in order to determine how retrieval was facilitated. This study concluded that visible external cues were pertinent in the retrieval of the prospective task at the time the task was to be performed but cues present throughout the task tended only to act as a distraction (Vortac et al., 1993). Visible external cues can come in the form of "flight strips" which the controller uses to write down the altitudes, destinations, and other pertinent information. These flight strips act as a memory aid for controllers so they may dedicate their attention to a single aircraft while multiple aircraft are within their airspace. Flight strips are also used in air traffic control as legal documents to account for the whereabouts of aircraft during a controller's shift. If a tragedy were to occur, a controller's flight strips would be consulted to ascertain where potential problems could have taken place.
Embry-Riddle Aeronautical University is among thirteen facilities in the United States that train students for a career in air traffic management. The curriculum for the air traffic management program is delegated by the FAA under the Collegiate Training Initiative. The Air Traffic Management department at Embry-Riddle features coursework related to the FAA’s air traffic control handbook and FAA regulations as well as state-of-the art simulation training. The air traffic control simulators on campus are integrated with the meteorology labs to create a realistic air traffic environment. Upon graduation from the Air Traffic Management program at Embry-Riddle, controllers must go through the FAA air traffic control academy before they can be employed in their field. Once controllers have completed their training at the air traffic control academy, they must work in their field for 1-3 years before becoming certified.

Cognitive Task Analysis

In air traffic control, one of the most important facets of a controller is the ability to think procedurally. In any scenario that a controller is given, there are certain procedures that must be followed and planning for these procedures allows the controller to execute the tasks smoothly and efficiently. One way to test this procedural knowledge in an air traffic control environment is a verbal cognitive task analysis wherein the participant is asked to verbalize any thoughts that they may have about the task they are completing. For the purposes of this study, the controllers would be asked to verbalize all thoughts that they may have about their intentions for the aircraft in their airspace. When the participant has completed the task, the experimenter would then transcribe and analyze the verbalizations of the participant. For this study, prospective memory statements would be deciphered from other statements made during the scenario. Prospective memory statements may include “I’m going to turn the aircraft” or “I’ll probably just bring him straight into the airport” just to name a few. This will give the researcher an idea of the quantity
and frequency of prospective memory statements used by the controllers. The results of the verbalizations can be further examined through decomposition of the phrases that the controllers utilized during the scenario. These phrases will be broken down into present action statements, description of present action statements, future action statements, future cognition statements, question/status check statements, and other statements. The framework for the current study is based on a similar framework suggested by Seamster, Redding, and Kaempf (1997) in “Applied Cognitive Task Analysis in Aviation.” This publication suggested that concurrent verbal task analysis should be analyzed by taking statements made by participants and decomposing them into action, precursor, and interpretation statements. It was also proposed that further analysis utilize descriptive statistics including “frequencies and means for the number of primary and alternate actions required to solve the problem” (Seamster, Redding, & Kaempf, 1997). Precursor statements involve the intention part of an action and satisfy the question “why are you taking this action” (Seamster et. al, 1997). Action statements involve the steps that a participant would take in order to attain a desired resulting action. The interpretation statements take into consideration the results of the actions taken by the participant and what indications those results may have.

Cognitive task analysis has also been utilized in studies that research expert and novice differences. In a study by Neville, Fowlkes, Nelson, and Bergondy-Wilhelm (2003), a verbal cognitive task analysis was used to ascertain expert/novice differences in large team situations. In this study, 12 participants were briefed on a particular mission and interviewed about how they would deal with the situation and how they would guide other team members given that scenario. Participants were assigned to groups based on their level of expertise and designation. The researchers transcribed the interview recordings and decomposed the statements into “data
elements.” The findings of this study showed that the more experienced participants utilized better strategies, were aware of more possible problems/outcomes to a given situation, and were also more aware of other teammate’s responsibilities while novices tended to “focus on salient and superficial aspects of a domain” (Neville, Bergody-Wilhelm, Fowlkes, & Nelson, 2003). Seamster, Redding, Cannon, Ryder, and Purcell (1993) employed a cognitive task analysis of expertise in en route air traffic controllers in order to expand the current ATC curriculum and provide better training strategies. This study included three analyses the first of which “compared how controllers with different levels of expertise develop and solve static air traffic problems.” The second reanalyzed the data from the first phase for verification and further analyzed the frameworks and mental models that controllers use. The third analysis focused on particular strategies that may be a part of a controller’s mental model and how work overload may affect these strategies. Participants were split into three groups: novices, intermediates, and experts and were assigned to pairs within their level of expertise and the ATC scenarios they were given included three levels of complexity (65%, 100%, and 125% complexity). During the initial analysis, a simulation of an air traffic scenario was utilized to allow the participants to work through different problems while being videotaped. During the second phase of analysis, the controllers were shown the videos and asked questions regarding why they took the actions that they did. The third analysis phase allowed the researchers to look at “cognitive strategies” that controllers use in high workload situations. In this phase, the participants were asked to verbalize what they were doing throughout a highly complex air traffic simulation. The verbalizations were transcribed and coded into three main categories of strategies: planning strategies, monitoring strategies, and workload management strategies. The analyses consisted of breaking down and identifying controller’s primary tasks; identification of controller’s mental
models while controlling air traffic within their designated air space; validation of the tasks and mental models; and analysis of the strategies that controllers use given higher workload situations. Subject matter experts were consulted at each phase for validation purposes and to make sure that the analyses and results were appropriate measures. The findings of the study suggest that “expert air traffic controllers possess a complex knowledge base of ATC concepts, principles, procedures, regulations, and strategies…that allow the controller to circumvent the limitations of the normal human information processing” (Seamster, Redding, Cannon, Ryder, & Purcell 1993). This study concluded that expertise in ATC enhances facets (including mental models, strategies, etc.) of performance that are not restricted by the constraints on “information processing” that novices may come across (Seamster et. al 1993).

Air traffic control can be a stressful environment often requiring numerous memory resources. It is important for controllers to plan their actions and deal with all situations in a calm, concise manner. How controllers form these plans for future intentions is a major area of study that has not been examined thoroughly. It is important to understand how controllers form intentions and retain these intentions to better facilitate how they will deal with a potentially life threatening situation. This study hypothesizes that intention formation and experience will facilitate retrieval of the intended future action and aid in the proper execution of the required tasks. Specifically, this study will test the following hypotheses:

There will be a main effect for experience in that the more experienced groups will perform better and use more prospective memory than the less experienced groups.

There will also be a main effect for complexity in that the complex scenario will take a longer duration to complete than the simple scenario and utilize more prospective memory.
In addition, there will be an interaction for the level of experience and the complexity of the scenario in that there will be more prospective memory statements employed by the more experienced controllers in the complex scenario than the less experienced controllers in the simple scenario.
Method

Participants

The subject population included 26, currently enrolled, Embry-Riddle Aeronautical University students whose major or minor included Air Traffic Management (ATM). The population consisted of 22 males and 4 females who ranged in age from 20 to 24 (mean age 21.5). Participants were assigned to four different groups based on their experience in air traffic control and the complexity of the scenario. The first two groups consisted of 13 experienced air traffic management students who were in the third class (ATM 405) of simulation training or who had taken 12 or more ATM courses (if registered in both ATM 401 & ATM 405 together). Half of the participants in this group were given the complex scenario and the other half was given the simple scenario. The other two groups consisted of 13 less experienced controllers in their second simulation training course (ATM 401) or who had taken 11 or fewer ATM courses (if registered in both ATM 401 & ATM 405 together). As with the experienced group, half of the less experienced group received the complex scenario to complete and the other received the simple scenario to complete. Each participant was compensated with a five dollar gift card to a local grocery store.

Materials

The experiment took place in an air traffic control lab environment with a computer set up for each participant. Each computer ran an air traffic control scenario with a display of the air space and all peripheral devices necessary to complete the task. Participants were audio recorded to document all vocalized statements. Flight strips were available to document written prospective memory cues in addition to the audio documentation. One individual acted as the pilot of the aircraft in the scenario and was instructed to only answer specific questions and not
to speak to the participant. This person was at the computer adjacent to the participant so that he/she could hear the participant’s instructions clearly. The pilot was working at a computer with a display of the air space and all necessary controls to complete their task as pilot. The simulation was displayed on an Adacel System running ATEEG Software which has been approved by the FAA for air traffic control training. The experimenter orally presented all directions necessary to perform the task from a written script to ensure that the directions given were the same for each participant. A demographics page consisting of questions that were pertinent to the study was used to control for factors such as age, semesters in the air traffic control program, and other necessary data. Informed consent forms and debriefing forms were also included.

Design

The design for this study was a 2x2 between subjects, fully factorial, experimental design. The independent variables were level of experience and complexity. The first independent variable, level of experience, consisted of two levels: more experienced and less experienced. More experienced participants had at least two air traffic control simulation classes, and were currently working on their third simulation class as well as having taken 12 or more air traffic management curriculum courses. Less experienced participants consisted of those people who were currently taking the second air traffic control simulation class or had taken 11 or less air traffic management curriculum courses. The second independent variable, complexity, consisted of two levels: complex and simple. The complex scenario consisted of 8 aircraft with 2-3 changes within the scenario. There were four visual approaches and four ILS approaches required during the scenario, and traffic was programmed to become heavy mid-way through the scenario when four aircraft were landing at separate airports at approximately the
same time. The simple scenario consisted of 5 aircraft with 1-2 necessary changes within the scenario. In the simple scenario all traffic was inbound headed for an ILS approach at “Eagle” airport and all aircraft were programmed to land in succession if set up correctly by the controller. The dependent variables were: time needed to complete the simulated scenario, number of prospective memory statements made during the scenario including prospective memory actions and cognitions, and errors incurred during the scenario including missed approaches, airspace violations, and separation conflicts.

**Procedure**

The session began with the participants reading and signing all informed consent forms. The participants then filled out the demographics page and returned it to the experimenter without putting their name on it to ensure confidentiality. The participant was then shown the map of the scenario and given 3 minutes to familiarize themselves with the air space and their flight strips. During this time, the participants were allowed to ask all questions they had pertaining to the scenario. The experimenter then instructed the participants to speak aloud all thoughts regarding the simulation while engaged in the scenario and were asked to describe their actions as if the experimenter did not understand their actions. For instance, if a plane comes into the field of view of the participant, the participant should explain that they have accepted the handoff, what intentions they have for that aircraft, and any other descriptors that are necessary. After all instructions had been specified, the experimenter asked participants if there were any other questions and let them know that participation is completely voluntary and they may leave at any time without penalty. The scenario began and took the participant no longer than 35 minutes to complete. When the scenario was initialized, the audio recording and timing began. The complex scenario consisted of eight aircraft coming into and leaving the airspace, aircraft
taking off and landing, and required changes in altitudes and directions of the aircraft. The simple scenario consisted of five aircraft coming into the airspace or taking off and all aircraft landed at “Eagle” airport. Statements were coded into six different categories including future action statements, future cognition statements, present action statements, description of present action statements, question/status check statements, and other statements. Future action (FA) statements encompass those statements that convey a specific intended future action (i.e. prospective memory statements). An example of a future action statement would be “I need to start descending Delta soon.” The next statement category is future cognition statements (FC). This category includes those statements that a controller may speak to show his/her awareness of an action in the future, or to serve as reminders/place holders when he/she does not have a clear idea of what the exact intended action may be. A future cognition statement example would be “the aircraft is outside of my airspace so I can not do anything with it yet.” A present action (PA) statement included those statements describing what the participant was currently doing. For example: “American 1021 turn left heading 180.” Descriptions of present action (DPA) statements are those statements that describe present actions that have been taken. For instance, after the controller has turned American 1021 he/she would explain why they performed that action: “I am turning the aircraft left for spacing purposes.” Question/status (Q/S) check statements are comprised of those statements employed by the controller to gain information as to the status of the aircraft’s destination or other pertinent information. An example of a question/status check statement would be “what is your altitude?” Other statements included all statements not classified in the previous categories. Examples of other statements included: “Oh,” “Umm,” “Alright,” etc. For the purposes of this study, the two categories that were considered to contain prospective memory vocalizations were the future action statements and
the future cognition statements. When the scenario had been completed, the participants were debriefed and given the opportunity to ask any lingering questions they may have had about the study.
Results

Data

Data for the dependent variables of time, number of prospective memory statements (including future action and future cognition statements), and errors were collected from 26 participants over a three week period. Results from the dependent variables were divided among the independent variables by level of experience and complexity of the scenario. Data were then analyzed using a between subjects analysis of variance (ANOVA), correlations, and descriptive statistics.

Prospective Memory

A between subjects ANOVA was employed to test the relationship between level of experience, complexity of scenario, and the number of future action statements made. Results showed that the overall model was not significant, $F(3, 26) = .71, p = .56$. Refer to Table 1 for means and standard deviations related to this analysis, and Table 2 for source table information. In addition, results from a between subjects ANOVA showed that the overall model examining the relationship between scenario complexity, level of experience, and the number of future cognition statements was not significant, $F(3, 26) = .753, p = .532$. Refer to Table 3 for means and standard deviations related to this analysis, and Table 4 for source table information.

Time

A between subjects ANOVA was employed to test the overall model examining the relationship between level of experience, complexity of scenario, and the amount of time needed to complete the scenario. Results indicated that the overall model was significant $F(3, 26) = 3.570, p = .03$. Furthermore individual effects tests showed that complexity of scenario was a significant independent variable in this model $F(1, 26) = 7.09, p = .01$. However, the effect of
level of experience was not found to significantly impact the amount of time taken to complete the scenario, $F_{(1, 26)} = 3.46, p = .08$. In addition the interaction of level of complexity and level of experience was not found to significantly effect time, $F_{(1, 26)} = .298, p = .59$. Refer to Table 5 for means and standard deviations related to this analysis, and Table 6 for source table information.

**Errors**

A between-subjects ANOVA was used to examine the effects of experience level and complexity of the scenario on the number of errors made. Results indicated that the overall model was not significant, $F_{(3, 26)} = 1.209, p = .33$. Refer to Table 7 for means and standard deviations related to this analysis, and Table 8 for source table information.

**Table 1.**

<table>
<thead>
<tr>
<th>Course</th>
<th>Scenario</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
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<td>8.17</td>
<td>9.4</td>
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<tr>
<td></td>
<td>Simple</td>
<td>4.71</td>
<td>3.4</td>
<td>7</td>
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<td></td>
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</tr>
<tr>
<td>405</td>
<td>Complex</td>
<td>5.33</td>
<td>3.4</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Simple</td>
<td>4.29</td>
<td>2.3</td>
<td>7</td>
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<tr>
<td></td>
<td>Total</td>
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**Table 2.**

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<th>F</th>
<th>Sig.</th>
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<td>.28</td>
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<td>9.34</td>
<td>.34</td>
<td>.56</td>
</tr>
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</table>
Table 3.

<table>
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<th>Scenario</th>
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<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
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<td>6.50</td>
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<tr>
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<td></td>
<td>Simple</td>
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<td>Total</td>
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<td>26</td>
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Table 4.

Analysis of Variance of experience vs. complexity on future cognition statements

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<th>Sig.</th>
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<td>.54</td>
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<td>.45</td>
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Table 5.

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<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
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<td>2.7</td>
<td>7</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td>405</td>
<td>Complex</td>
<td>26.29</td>
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<td>6</td>
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<td>7</td>
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<td>5.1</td>
<td>13</td>
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<tr>
<td>Total</td>
<td>Complex</td>
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<td>12</td>
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<td></td>
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<td>25.92</td>
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<td>26</td>
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Table 6.

Analysis of Variance of experience vs. complexity on time

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<th>Sig.</th>
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</thead>
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<td>Level of Experience</td>
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<td>.08</td>
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<td>Complexity of Scenario</td>
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<td>114.35</td>
<td>7.09</td>
<td>.01</td>
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<tr>
<td>Experience*Scenario</td>
<td>1</td>
<td>4.75</td>
<td>.29</td>
<td>.59</td>
</tr>
</tbody>
</table>

Table 7.

Descriptive Statistics: Total Errors

<table>
<thead>
<tr>
<th>Course</th>
<th>Scenario</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>401</td>
<td>Complex</td>
<td>1.67</td>
<td>1.4</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Simple</td>
<td>1.57</td>
<td>1.7</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1.62</td>
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<td>13</td>
</tr>
<tr>
<td>405</td>
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<td>.5</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Simple</td>
<td>2.57</td>
<td>3.0</td>
<td>7</td>
</tr>
<tr>
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<td>Complex</td>
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<td>1.2</td>
<td>12</td>
</tr>
<tr>
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<td>Simple</td>
<td>2.07</td>
<td>2.4</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1.62</td>
<td>2.0</td>
<td>26</td>
</tr>
</tbody>
</table>

Table 8.

Analysis of Variance of experience vs. complexity on errors

<table>
<thead>
<tr>
<th></th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of Experience</td>
<td>1</td>
<td>.05</td>
<td>.01</td>
<td>.92</td>
</tr>
<tr>
<td>Complexity of Scenario</td>
<td>1</td>
<td>6.31</td>
<td>1.65</td>
<td>.21</td>
</tr>
<tr>
<td>Experience*Scenario</td>
<td>1</td>
<td>7.58</td>
<td>1.98</td>
<td>.17</td>
</tr>
</tbody>
</table>

Demographics

The sample of 26 participants included 22 males and four females ranging in age from 20 to 24 with a mean age of 21.5. All participants had a class standing of senior (21 participants) or junior (5 participants), and majors varied from 11 ATM majors, 11 Aeronautical Science majors,
two Aerospace Studies majors, to one Safety major. For descriptive statistics, participants were grouped into the ATM 401 class if they had completed less than half of the required ATM courses, and the 405 course if they had completed more than half. Overall, there were a total of 2,137 statements made, with a mean of 82.19 and 42 total errors made with a mean of 1.62. Refer to Table 9 for specific statement totals, and Table 10 for specific error totals.

Table 9.

Total statements: Both scenarios

<table>
<thead>
<tr>
<th>Future Action</th>
<th>Future Cognition</th>
<th>Present Action Of Present Action</th>
<th>Description</th>
<th>Question/ Status Check</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Statements</td>
<td>133</td>
<td>117</td>
<td>1168</td>
<td>290</td>
<td>207</td>
<td>223</td>
</tr>
</tbody>
</table>

Table 10.

Total errors: Both scenarios

<table>
<thead>
<tr>
<th>Missed Approach</th>
<th>Airspace Violation</th>
<th>Separation Conflict</th>
<th>Total Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Errors</td>
<td>21</td>
<td>14</td>
<td>7</td>
</tr>
</tbody>
</table>

The simple scenario took approximately 24 minutes to complete with a range of approximately 19 minutes to exactly 29 minutes. Nine participants did not use their flight strips, and five participants did. There were a total number of 916 statements spoken in the simple scenario with a mean of 65.43, and a total of 29 errors with a mean of 2.07. The complex scenario took approximately 28 minutes to complete with a range of around 20 minutes to approximately 35 minutes. All participants used their flight strips. In the complex scenario, 1,221 statements were voiced with a mean of 101.75, and a total of 13 errors with a mean of 1.08. Refer to Table 11 for specific statement totals, and Table 12 for specific error totals.
Table 11.

Statement totals by complexity

<table>
<thead>
<tr>
<th></th>
<th>Future Action</th>
<th>Future Cognition</th>
<th>Present Action</th>
<th>Description Of Present Action</th>
<th>Question/Status Check</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple Scenario</td>
<td>61</td>
<td>55</td>
<td>490</td>
<td>108</td>
<td>97</td>
<td>105</td>
<td>916</td>
</tr>
<tr>
<td>Complex Scenario</td>
<td>72</td>
<td>62</td>
<td>678</td>
<td>182</td>
<td>110</td>
<td>118</td>
<td>1221</td>
</tr>
</tbody>
</table>

Table 12.

Errors by complexity

<table>
<thead>
<tr>
<th></th>
<th>Missed Approach</th>
<th>Airspace Violation</th>
<th>Separation Conflict</th>
<th>Total Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple Scenario</td>
<td>17</td>
<td>7</td>
<td>5</td>
<td>29</td>
</tr>
<tr>
<td>Complex Scenario</td>
<td>4</td>
<td>7</td>
<td>2</td>
<td>13</td>
</tr>
</tbody>
</table>

Participant results were also analyzed descriptively by level of experience. Participants who were considered ATM 405 students made a total of 479 statements and 18 errors in the simple scenario and 495 statements and 3 errors in the complex scenario. Participants in the ATM 401 category voiced a total of 437 statements and 11 errors in the simple scenario and 726 statements and 10 errors in the complex scenario. Refer to Table 13 for specific statement totals, and Table 14 for specific error totals.
Table 13.

Statements by level of experience

<table>
<thead>
<tr>
<th></th>
<th>Future Action</th>
<th>Future Cognition</th>
<th>Present Action</th>
<th>Description Of Present Action</th>
<th>Question/Status Check</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATM 405</td>
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<td>24</td>
<td>264</td>
<td>50</td>
<td>57</td>
<td>54</td>
<td>479</td>
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<tr>
<td>Total</td>
<td>30</td>
<td>20</td>
<td>302</td>
<td>68</td>
<td>24</td>
<td>52</td>
<td>495</td>
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<tr>
<td>ATM 401</td>
<td>31</td>
<td>31</td>
<td>226</td>
<td>58</td>
<td>40</td>
<td>51</td>
<td>437</td>
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<tr>
<td>Total</td>
<td>42</td>
<td>42</td>
<td>376</td>
<td>114</td>
<td>86</td>
<td>66</td>
<td>726</td>
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</table>

Table 14.

Errors by level of experience

<table>
<thead>
<tr>
<th></th>
<th>Missed Approach</th>
<th>Airspace Violation</th>
<th>Separation Conflict</th>
<th>Total Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATM 405</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simple</td>
<td>10</td>
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<td>18</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
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<td>18</td>
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<td>ATM 405</td>
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<td>0</td>
<td>3</td>
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<tr>
<td>Total</td>
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<td>0</td>
<td>3</td>
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<tr>
<td>Total</td>
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<td>1</td>
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<td>11</td>
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<tr>
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<td></td>
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<tr>
<td>Complex</td>
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<td>4</td>
<td>2</td>
<td>10</td>
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<tr>
<td>Total</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>10</td>
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</table>

Participants compared to Subject Matter Experts

The participant population was also compared to two individuals who were considered experts in their field. These experts had completed the ATM curriculum at Embry-Riddle
Aeronautical University and are currently working on Master’s degrees in related fields. One subject matter expert completed the simple scenario and another subject matter expert completed the complex scenario. Table 15 illustrates the differences between subject matter experts (SME) and the participant population. It seems that on average, SMEs utilized more FA, FC, and PA statements while vocalizing about the same DPA statements and less Q/S and other statements in the simple scenario. In addition, SMEs had fewer total statements in the simple scenario. In the complex scenario, SMEs vocalized more FA and FC statements, vocalized far less PA statements, the same number of DPA statements, and fewer Q/S and Other statements. They also vocalized fewer statements overall.

Table 15.

<table>
<thead>
<tr>
<th>Participants compared to subject matter experts</th>
<th>Future Action</th>
<th>Future Cognition</th>
<th>Present Action</th>
<th>Description Of Present Action</th>
<th>Question/ Status Check</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATM 405 Simple Mean</td>
<td>4.29</td>
<td>3.43</td>
<td>37.71</td>
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<td>8.14</td>
<td>7.71</td>
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<td>4.43</td>
<td>32.29</td>
<td>8.23</td>
<td>5.71</td>
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</tr>
<tr>
<td>SME Simple Total</td>
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<td>9</td>
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<td>8</td>
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<td>3</td>
<td>54</td>
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<tr>
<td>ATM 405 Complex Mean</td>
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<td>3.33</td>
<td>50.33</td>
<td>11.33</td>
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<td>62.67</td>
<td>19</td>
<td>14.33</td>
<td>11</td>
<td>121</td>
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<tr>
<td>SME Complex Total</td>
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<td>11</td>
<td>28</td>
<td>19</td>
<td>1</td>
<td>4</td>
<td>77</td>
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</tbody>
</table>
Correlations among variables

For correlation analyses, the participants were grouped by number of overall courses they had taken from the ATM curriculum as a measure of expertise. The data was then broken down by level of complexity and correlations were generated among the following variables: expertise level, FA statements, completed future actions, FC statements, completed FC actions, total errors, missed approaches, airspace violations, and separation conflicts. Some interesting trends were noticed in this data.

No correlations within the complex scenario reached significance (see Table 16).

However, in the simple scenario separation conflict was positively correlated with expertise and reached significance, \( p < .05 \). Correlations between expertise and the variables of FA, completed FA, and FC approached significance, \( p < .10 \) in the simple scenario.

Table 16

| Correlations between level of experience and outcome variable for each scenario |
|---------------------------------|-----------------|-----------------|
|                                 | Complex | Simple |
| Future Action                   | -.18    | -.39*   |
| Completed Future Action         | -.18    | -.42*   |
| Future Cognition                | -.22    | -.37*   |
| Completed Future Cognition      | -.21    | -.24    |
| Total Errors                    | -.11    | .32     |
| Missed approach                 | -.04    | .09     |
| Airspace violation              | -.01    | .35     |
| Separation conflict             | -.16    | .50**   |

\( p < .10 \)
\( p < .05 \)

In the complex scenario, the following trends were also identified. Future action statements were correlated with completion of future intentions, \( r = 1.00, p < .01 \), indicating that participants completed 100% of future action statements. When students completed intended future actions, they were more likely to utilize FC statements, \( r = .87, p < .01 \), and complete
these future cognitions, \( r = .87, p < .01 \). Participants who vocalized FC were also likely to complete these future cognitions, \( r = .99, p < .01 \), indicating that approximately 99% of future cognition statements were actualized. Those participants who missed approaches were more likely to have more total errors, \( r = .80, p < .01 \). In addition, participants who had airspace violations were more likely to vocalize FA statements, \( r = .58, p < .05 \), complete those future actions, \( r = .58, p < .05 \), and have more total errors, \( r = .75, p < .01 \).

In the simple scenario, the following trends were identified. Participants who vocalized FA statements were more likely to complete those actions later, \( r = .98, p < .01 \). Those participants who completed their future actions were more likely to utilize FC statements, \( r = .55, p < .05 \), and complete those future cognitions, \( r = .58, p < .05 \). Participants who used FC statements were also more likely to complete those future cognitions, \( r = .96, p < .01 \). Those participants that missed approaches also tended to have more total errors, \( r = .88, p < .01 \). Airspace violations were significantly correlated with total errors indicating that with more airspace violations, there were more total errors, \( r = .79, p < .01 \). Separation conflicts were also significantly correlated with total errors showing that those participants who had more separation conflicts also had more total errors, \( r = .68, p < .01 \).
Discussion

Upon examination of the data, only one of the three original hypotheses was found to be significant. Results did not support the hypothesis that the experienced group would perform better and use more prospective memory statements than the inexperienced group. Although the descriptive data did show that the more experienced group verbalized the highest number of prospective memory statements and committed the fewest errors, statistically there were no differences across groups. These results could be explained by the small number of participants included in the study, or from experienced controllers internalizing more of their future actions and planning activities.

The results demonstrated that the complex scenario took a longer duration to complete than the simple scenario. However, although the results show that those controlling the complex scenario did use more prospective memory statements than the simple scenario group on average, again this finding was not statistically supported. While complexity of the scenario did affect the amount of time needed to complete the scenario, complexity only elicited a small and not significant difference in prospective memory usage in this study. This could be due to the fact that although the complex scenario did take longer to complete, it also was more difficult requiring the participants to focus more on their present actions than what their future actions could be.

In addition, the hypothesis that the experienced group in the complex scenario would utilize more prospective memory than the less experienced group in the simple scenario was also not supported. It was found in this case that the number of prospective memory statements utilized by the more experienced and less experienced groups in their respective scenarios were very similar (see Table 13). One possible explanation for this finding could be that the more
experienced group was internalizing more of their planning strategies and future intentions than the less experienced group. The hypothesis that there would be an interaction among the previous variables was also not supported.

Although three of the hypotheses from this study were not supported, findings in this study did indicate some interesting relationships. Controllers from the current study were compared to subject matter experts in an effort to examine the relationship of experience and prospective memory. Analyses showed that overall, the subject matter experts tended to use fewer overall statements in most categories. This finding suggests that more of the underlying cognitive processes may be internalized in subject matter experts than in the participant population, which could be a function of training and experience. In the case of the less experienced groups it may have been that they were internalizing more of their planning strategies and prospective memory usage while vocalizing more of their present actions. In this study the less experienced groups also tended to have more present actions and description of present action statements. This could have been caused by a weak strategy for lining up the aircraft for the approaches which may in turn have required the controller to vector the aircraft further than a more experienced controller.

Correlational analyses of this study showed that when the controllers planned future intentions they were more likely to carry out those actions, which lends support to Kliegel, Martin, McDaniel, and Einstein’s (2002) findings. This study showed that controllers who used prospective memory were more likely to act on those intentions at the appropriate time later in the scenario regardless of experience or complexity of the scenario, which supports the theory that planning for future intentions facilitates remembering of the future intention. Other correlational analyses show that participants in the complex scenario who utilized FA statements
and completed those actions were less likely to commit airspace violations, which indicates that
the controllers who planned out their actions were less likely to commit this type of error.

The current study was important to undertake in order to ascertain how air traffic
controllers utilize their prospective memory in their daily job. In addition, it was important to
assess participants during different stages of their training in order to find out how controllers
utilize their prospective memory throughout their training cycle. Although the results of this
study did not support all of the hypotheses, there were several limitations that could have played
an important role in the non-significance of this study. First, it was very difficult to get students
to participate in the study, or to actually show-up for testing when scheduled. These problems
may have arisen because the lab used for testing was only available after 5 p.m. and students
were not able to come for testing at that time. Another difficulty that arose was the fact that
many students had problems vocalizing their thoughts and actions. This may have been caused
by the internalization of their thoughts, their level of comfort during the scenario to vocalize their
thoughts, or constructs introduced in training that may cause certain procedures to become
automatic and internalized. In addition, it was difficult to establish a more experienced and less
experienced group. This issue became apparent when many of the participants were enrolled in
both the Jacksonville (ATM 405) and Orlando (ATM 401) simulation courses. To dispel this
problem, transcripts for the participants were consulted to establish how many courses the
participants had taken. The participants were considered more experienced if they had taken
more than half of the required ATM courses, and considered less experience if they had taken
less than half of the required ATM courses in this instance. Other limitations that were not
previously discussed that should be examined in future studies include what roles fatigue,
boredom, and complacency may have on participants. Although the current study did not assess
the relationship that these variables may have had, it is important to find out if they do have an effect on prospective memory performance and what these effects may be. Even with these limitations, the study did yield interesting results that have been discussed previously.

Conclusion

Very little research has been conducted in air traffic control to examine how prospective memory influences the later retrieval of the intended action. The purpose of the current study was to examine the intention formation phase of prospective memory in the hopes of finding that this phase directly affected whether or not a controller remembers the intended action. While the hypotheses of this study were not in general supported, it seems that there is some relationship between the formation of an intention (FA/FC statements) and acting on that action later. Factors that may have been problematic in this study included a small sample size and the inability to clearly establish a more experienced and less experienced group.
References


Appendix A

Informed Consent Form
AN ANALYSIS OF INTENTION FORMATION AS A FUNCTION OF PROSPECTIVE MEMORY IN AIR TRAFFIC CONTROLLERS

CONSENT FORM

Conducted by Christina Recascino
Embry-Riddle Aeronautical University
Department of Human Factors and Systems

The experiment in which you are about to participate will be investigating the effects of intention formation on prospective memory performance during ongoing tasks in an air traffic control scenario. During this study, please follow all instructions given and do not talk to the other participants as any distractions may interfere with completion of the task.

This experiment should take about 30 minutes to complete. You are encouraged to ask any questions that you may have before the scenario begins. Please understand that you are free to withdraw from this study at any time. You are instructed to vocalize any and all thoughts you may have about the scenario while you are working in the scenario. You will be given 3 minutes to familiarize yourself with the airspace, flight strips, and all other pertinent materials. When the scenario begins, you will be timed and audio recorded. In each scenario there will be 5-11 aircraft traveling inbound and through your airspace. Please perform all normal air traffic control functions to the best of your ability. Your participation is greatly appreciated and you may receive compensation for participating in this study.

You will be asked to complete an initial questionnaire, which is used for classification purposes only. Please understand that all information provided as well as the results obtained will be completely confidential.

Your signature on this form means that you understand these instructions, and that you agree to voluntarily participate in this study. If you have any further questions concerning this experiment, or would like to learn about the results of this study, please contact me at (386) 226-7037.

Date ____________________ Name (Please Print) ____________________

________________________ Signature __________________________

Experimenter
Appendix B

Demographics Sheet
<table>
<thead>
<tr>
<th>Participant #</th>
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<tbody>
<tr>
<td>Age</td>
<td>Gender</td>
</tr>
<tr>
<td>Class Standing:</td>
<td>Freshman</td>
</tr>
<tr>
<td>Major</td>
<td>Minor</td>
</tr>
<tr>
<td>Current Air Traffic Management Course:</td>
<td>401</td>
</tr>
<tr>
<td>Have you had any alcohol within the last 24 hours?</td>
<td>Yes</td>
</tr>
<tr>
<td>If yes, how much?</td>
<td>What kind?</td>
</tr>
<tr>
<td>Have you taken any medications that may interfere with memory in the past 24 hours?</td>
<td>Yes</td>
</tr>
<tr>
<td>If yes, how much?</td>
<td>What kind?</td>
</tr>
</tbody>
</table>
Appendix C

Flight Strip: Simple Scenario
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<th>Flight</th>
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</thead>
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<td>AAL1021</td>
<td>0101</td>
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<tr>
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<td>COA1121</td>
<td>0102</td>
<td>80 OCEAN + EGL</td>
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<td>B737/G 101</td>
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<td></td>
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<td>N134ER</td>
<td>0104</td>
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<td>AAL1111</td>
<td>0105</td>
<td>NWY + EGL</td>
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<td>A310H/G 104</td>
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Appendix D

Flight Strip: Complex Scenario
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<th>Flight Number</th>
<th>Aeronautical Information</th>
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Appendix E

Controller-Error Worksheet
Participant #__________ Date__________

Pilot, please mark whether or not the participant had any of the following mistakes, which aircraft they made the mistake with, and the approximate time into the scenario the mistake was made. For separation conflict, please mark whether it was a lateral, vertical, or longitudinal conflict.

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<th>Missed Approach</th>
<th>Airspace Violation</th>
<th>Separation Conflict</th>
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Appendix F

Debriefing Form
Debriefing Form

The study in which you just participated was designed to assess intention formation on prospective memory performance during ongoing tasks. Prospective memory is one's memory for future events and intention formation is when a person forms the intention to perform a future task. The experimenter wanted to see if *when* a person forms an intention to do a future action actually facilitates retrieval and proper execution of that future action. The audio recordings of your vocalizations during the scenario will be transcribed for further analysis to ascertain whether or not intention formation is a facilitator in prospective memory tasks. The results of this study could aid future training materials for air traffic controllers. We thank you for your participation in this study.