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Ab initio pilot training for traffic separation and visual airport procedures in a naturalistic flight simulation environment

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ABSTRACT

The purpose was to evaluate a training method for *ab initio* student pilots to improve situational awareness, performance of airport procedures and of aircraft separation during Visual Flight Rules (VFR) flight in a simulated naturalistic environment. Loss of separation between aircraft is a frequent cause of accidents involving instructional flights. There are no established simulator training methods for *ab initio* student pilots to develop these abilities. This study describes a simulator training method, which is evaluated in a pretest-training-posttest design with 53 *ab initio* student pilots (23 females) assigned to a training and a control group.

The results show that in posttest the training group demonstrated superior situational awareness and performance, and reported lower workload related to airspace monitoring, building a mental picture of the traffic situation, and coordination with other aircraft in the traffic circuit than the control group. Student pilots evaluated the training materials (the flight simulation environment, radio communication, the briefing and the application on the tablet PC) as useful.

This study shows benefits of simulator training for traffic conflict avoidance and VFR airport procedures which can be introduced early during the *ab initio* syllabus. This study provides a safe simulator method that is useful for both, the teaching and the learning process.

1. Introduction

Midair collision is a key safety risk (EASA, 2015) and one of the top ten causes of fatal accidents in general aviation (FAA, 2015). Midair collisions occur also during flight training. A study of the Australian Transport Safety Bureau (ATSB, 2017) shows that a substantial number of flight training occurrences were caused by loss of minimum aircraft separation, operational non-compliance and airspace infringement. An analysis of the training accident reports retrieved from the National Transportation Safety Board between 2005 and 2014 showed that midair collision was one of the most frequent occurrences during flight training (Lee, Bates, Murray, & Martin, 2017). Midair collisions occurred 3.5 times more frequent in dual than in solo flight instruction and led 3.5 times more often to fatal than to non-fatal accidents (Lee et al., 2017). Several research studies recommend the revision of training practices for including traffic awareness and collision avoidance (Koglbauer & Leveson, 2017; Lee et al., 2017; Shook, Bandiero, Coello, Garland, & Endsley, 2000).

The objective of this study is to evaluate a training method for *ab initio* student pilots to improve situational awareness, performance of aircraft separation and Visual Flight Rules (VFR) airport procedures in a simulated naturalistic environment.

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The training method involves theoretical information and practical exercises for understanding and performing VFR airport procedures in interaction with an Air Traffic Controller (ATC) and other aircraft flying in the traffic pattern. The training equipment consists of a flight simulator, simulation of traffic and ATC communication, an application on a tablet PC and a sighting device.

1.1. Situational awareness problems of *ab initio* student pilots

Situational awareness is defined as the perception, comprehension and prediction of goal-relevant information within time and space (Endsley, 2000). Endsley (2000) specified three levels of situational awareness (SA): perception (Level 1 SA), comprehension (Level 2 SA) and projection (Level 3 SA). SA problems of *ab initio* student pilots working towards the private pilot license (PPL) have been investigated in a survey study with flight instructors (Shook et al., 2000). Shook et al. (2000) reported moderate and frequent problems of *ab initio* student pilots (Level 1 SA) with perception of other traffic and other key elements especially under high workload and distractions. Common difficulties with comprehension (Level 2 SA) reported by Shook et al. (2000) were the use of a wrong mental model, the lack of mental models, or student pilots' inability to form a coherent mental picture from the given information such as impact of events, timing of events and tasks. In addition, Shook et al. (2000) found that more than 90% of flight instructors reported moderate to frequent comprehension problems of *ab initio* student pilots in understanding task priorities, airspace, ATC and airport procedures. Problems with projection (Level 3 SA) such as recognizing trends and implication of information and development of contingency plans have been reported by 90% of flight instructors (Shook et al., 2000). Shook et al. (2000) point out the need to improve SA skills of all student pilots because SA problems are reduced but not eliminated by flight experience. They suggested an emphasis on future training for task management, building mental models necessary for understanding information (e.g., airspace, airport, ATC procedures and understanding ATC radio communications) and recognizing trends and implications of information. Other aspects to be addressed in the future are training for basic procedures and traffic awareness.

The development of mental models implies the interaction with a system. "These models serve to help direct limited attention in efficient ways, provide a means of integrating information without loading working memory, and provide a mechanism for generating projection of future system states" (Endsley, 2000, p. 11). Mental pictures are snapshots of the real situation developed with the information contained in the mental model that includes perceived cues (Kallus, Barbarino, & van Damme, 1997). Thus, for developing and maintaining a mental picture of the traffic situation in the airport area student pilots need both a mental model of the airport procedures and the actually perceived cues (e.g., verbal ATC communication, traffic). They also need to rotate the mental picture and anticipate the future positions of traffic.

1.2. Current training practice and requirements

EASA European Aviation Safety Agency (2011) recommends to cover in the PPL(A) flight instruction syllabus: "(ii) aerodrome and traffic pattern operations, collision avoidance precautions and procedures; [...] (xi) operations to, from and transiting controlled aerodromes, compliance with air traffic services procedures, communication procedures and phraseology" (p. 178). Collision avoidance procedures are currently addressed in theoretical lessons on VFR. There is no generally accepted timing and manner of introducing radio communication, traffic awareness and conflict avoidance training. The training organizations must introduce in-flight radio communication practice before allowing the trainees to fly solo. This is usually after 20 or 30 flight hours, towards the end of the *ab initio* practical flight training which lasts for 45 h.

A current training philosophy is to teach initially the control of the aircraft, and add progressively other part-tasks, such as navigation, radio communication and so on (Menzel, 2016; Transport Canada, 2004). "The instructor should do all radio work until the student has a reasonable proficiency in flying the circuit" (Transport Canada, 2004, p. 99–100). Early in the flight training program the instructors expect student pilots to focus on practicing the control of the aircraft without paying attention to the communication with the ATC and prevention of conflicts with traffic in the vicinity. Thus, student pilots miss valuable learning opportunities if they fly many hours without emphasizing the monitoring and understanding of the traffic situation and without taking separation decisions.

This is problematic because student pilots may learn inadequate attention control strategies and prioritization of information, such as ignoring the radio communication and other aircraft. Using a computer game Gopher, Weil, and Siegel (1989) compared the results of different training schedules on the performance of a complex simulated task including the control of the space ship (position and velocity) and the destruction of mines that attempt to damage the ship. They used four training groups: one group was instructed to emphasis the ship control, another group to emphasize the mine handling, a third group trained both tasks with variable priority of ship control and mine handling, and finally, a control group was instructed to perform all tasks without emphasis. In each group the duration of the training was 10 h. The results showed that performance on the whole-task test was better in the emphasis change group than in the ship control and mine handling groups, indicating that response strategies practiced as isolated part-tasks may have negative effects on the performance of the whole task of intermediate or higher level of complexity (Gopher et al., 1989). The whole-task performance required different skills than the performance of the part-tasks (e.g., attention control and allocation skills) and the s-dual task instruction was necessary for adequate task prioritization. Gopher et al. (1989) showed that in the absence of emphasis-change instruction, the control group spontaneously developed suboptimal, but stable strategies for complex task management. The performance was lowest in the control group. In contrast, subjects that received instruction on managing both tasks with