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Age-Related Changes in Detecting Unexpected Air Traffic and Instrument Malfunctions

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The projected increase in elderly general aviation pilots in North America has raised concerns that aviation safety will be compromised. The present research used a flight simulator to examine change detection in young vs. older recreational pilots. Change detection was assessed in terms of the ability to detect unexpected and potentially critical events: the introduction of nearby air traffic and instrument malfunctions. The results show that older pilots missed more potentially critical events than their younger counterparts.

Introduction

The number of elderly recreational pilots in Canada and the United States is increasing due to the large number of ageing `baby-boomers'. This situation has raised concerns within the general aviation community and regulatory bodies about flight safety with older recreational pilots. Although commercial aviation statistics suggest that crash risk remains stable as pilots age from their late forties to late fifties (Li et al., 2003), there is no such longitudinal analysis for recreationally flying pilots and certainly not for pilots who are older than 60 years.

Safety concerns with elderly pilots is well-founded insofar as specific perceptual/cognitive abilities have been shown to decrement with age. Moreover, age has been shown to account for significant variability in flying skill when measured by a flight summary score (Yesavage, Taylor, Mumenthaler, Noda, & O'Hara, 1999). Studies of performance on complex tasks, such as driving an automobile, suggest that age-related decrements in perceptual/cognitive processing speed (Deary & Der, 2005) and working memory capacity (Fabiani & Wee, 2001) may pose problems for older pilots especially under heavy workload situations (Hardy & Parasuraman, 1997).

Of primary interest for the present research the ability to detect changes in the environment can be compromised by age (Pringle, Irwin, Kramer & Atchley, 2001). This age-related deficit in change detection can contribute to poor decision making in complex tasks (Caird, Edwards, Creaser & Horrey, 2005). The ability of pilots to detect changes in the environment (e.g., the presence of other aircraft) or within the cabin (e.g., changes in system status) is clearly important to flight safety.

The present research examined change detection in young vs. older recreational pilots. The pilots flew a series of routes on a medium-fidelity flight simulator constructed to resemble the cockpit environment of a Cessna 172. Pilots were requested to maintain a predetermined altitude. Altitude maintenance is considered to be representative of the pilot's most important priority: to fly the airplane. Although small deviations from a selected altitude will not necessarily jeopardize safety in day VFR conditions, remaining at a set altitude demonstrates that the pilot is paying attention to the performance instruments and has an idea of the aircraft's energy state. Pilots were requested to make position reports on the radio, as normally required in VFR conditions.

Change detection was examined by introducing 'critical events' throughout each flight. These events were either the appearance of nearby air traffic or an instrument malfunction. Pilots were required to press a yoke-mounted button when they identified a critical event.

Methods

Participants. Seven younger (mean 24.4 years, SD = 4.1) and seven older (mean 65.7 years, SD = 5.4) male pilots participated in the study. Four of the younger group held Private Pilot's Licenses (PPL), two had Commercial Pilot's licenses (CPL), and one had a Student Pilot Permit but had met all requirements for PPL and was ready for the flight test. Five of the older group held PPLs and two held CPLs. All pilots had a minimum of 90 hours total flight time. The average total flight time of the younger group was 196.4 (SD = 124.6), and in the older group the average was 1114.8 (SD = 156.9). Although the older group had more flight time, the younger group was flying more regularly, with an average in the past 6 months of 40.6 hours as compared with an average of 16.1 hours for the older pilots. All pilots met Transport Canada medical requirements to hold at least a Class 3 medical, which includes measures of visual acuity and hearing. All pilots reported being unfamiliar with the geographic region used in the study.

Design. A 2 (Age: young vs. old) x 2 (Workload: low vs. high) design was used with repeated measures on the second factor.

Flight Simulator Environment. The flight simulator was constructed to resemble the cockpit environment of a Cessna 172. Hardware components were mounted at approximately the correct heights and angles, including the pedals, screens, and yoke. The yoke, pedals, and radio and navigation equipment were made by Performance Flight Controls Inc. A USB Cirrus `Mooney Style' Flight yoke was used, as were USB Cirrus `General Aviation' Rudder Pedals with toe-break, and the Precision Flight Controls Avionics stack with Remote Instrument Console. Flight controls were calibrated based on pre-experiment validation with experienced pilots.

Three 23" wide-screen LCD displays were used as the front `out-the-window' view. The three LCDs were arranged edge-to-edge to form an array slightly above eye level. Each display was run at its native 1920x1200 resolution with 4-times anti-aliasing enabled. Combined, these displays provided approximately a 18 degree vertical and 115 degrees horizontal field of view.

Three 21" 4:3 aspect ratio LCDs were also used, each run at its native 1600x1200 resolution with 4-times anti-aliasing enabled. One displayed the aircraft instruments in front of the pilot, below the main out-the-window screens. A second was placed 90 degrees to the left of the pilot as the left `out-the-window' view. The final screen was used by the experimenter to observe, start, pause, and stop the simulator.

Radio chatter was accomplished using pre-recorded MP3s that were played back on a host PC as the experiment took place. Pilots wore an aviation-like headset and microphone through which the radio chatter and engine noise produced was played.

Simulation software was run on a set of five identical PCs, each containing an AMD X2 4200+ Dual-Core processor, 2Gb of ram and an NVidia GeForce 7800GTX based video card. The five PCs were networked via 1Gb Ethernet. All computers ran Windows XP (Service Pack 2) operating systems. Four of the PCs were used to render a single channel of the out-the-window view (three in front, one as the left cockpit window). The final PC was used to host the simulation and to draw the plane's instruments. The flight simulation was run using X-Plane version 8.21 with the Global Scenery pack installed for Canada on maximum scenery resolution settings. A custom plug-in was developed to control data recording, critical event timing and execution, air traffic, weather, and instrumentation failures.

Critical Events. Two types of critical events were used in the experiment: nearby air traffic and instrument malfunctions. Nearby air traffic appeared based on the aircraft's position at the time that the event was initiated, and moved on the screen at approximately the same altitude as the pilot's aircraft. Traffic disappeared after two minutes if the pilot failed to respond. The instrument malfunctions included freezing one of the following: Attitude Indicator (AI), Vertical Speed Indicator (VSI), Airspeed Indicator (AS), Heading Indicator (HI), Turn and Bank Indicator, or the Fuel Indicator. Instrument freezing persisted for 4 minutes.

Each flight contained a total of eight critical events (four of each type) which were dispersed at present times throughout the flight scenarios. Pilots were required to press a response button and verbally identify when an unexpected event occurred. A response caused the disappearance of the event. Response button presses were recorded automatically such that accidental presses or misses could be identified. The experimenter provided an additional check by recording if the pilot made a verbal identification. Two critical event sequences were used and the order event sequences was counterbalanced across the conditions.

Flight Scenarios. Two 25-minute flight scenarios were used. One was a low-workload scenario and the other a high-workload scenario. In the low-workload scenario, the visibility was excellent, the air was smooth, radio navigational aids were available, and there were convenient landmarks. In the high-workload scenario, the visibility was slightly better than VFR minima, moderate turbulence and a light crosswind was present, radio navigational aids were unavailable, and the terrain was mainly lakes and trees.

Procedure. Pilots received a scripted briefing on the flying task and were given an opportunity to ask questions and complete flight planning. They were instructed to treat the flights realistically and were required to make radio calls and keep track of flight status as they normally would. Pilots vary widely in the amount of time they take to complete flight planning, with some pilots taking several hours to plan. To reduce planning time the experimenter providing information the pilot requested such as radio frequencies. Calculations of ground speed and fuel consumption before flight were not required since the information was not given.

Each flight commenced at 2500 feet above sea level (ASL) in cruise flight configuration, with the starting airport in view just in front of the pilot's aircraft. The radio stack settings had local frequencies displayed by default which could be changed.

Pilots first completed a practice flight, for which the weather conditions were approximately halfway between those in the low- and high-workload scenarios. Eight critical events similar to those in the other conditions occurred in the practice session to acclimatize pilots with the use of the identification button and verbalization procedure. The experimenter pointed out the function of all knobs and buttons and encouraged the pilot to tune different radio frequencies, trim the aircraft, and become familiar with the layout. Pilots were also encouraged to practice VFR navigation using the map.

Following the practice session, pilots completed the two approximately 25-minute experimental flights. The workload condition order was counterbalanced, with approximately half of each age group randomly assigned to fly each workload condition first.

Results

Critical Events Missed. The percentage of critical events that were missed was analyzed in a 2 (Age: young vs. old) x 2 (Workload: low vs. high) mixed ANOVA. As shown in Figure 1, there was a significant main effect of age, $F(1,12) = 10.68$, $p = .007$.., where substantially more critical events were missed by the older pilots than by the younger pilots. No other effects were significant.

Altitude Maintenance. Pilots were requested to maintain a predetermined altitude throughout each flight. Altitude maintenance is considered to be an important priority. Altitude above sea level of the aircraft in meters was recorded at 5 hz. starting five minutes after the flight commenced. A 2 (Age: young vs. old) x 2 (Workload: low vs. high) mixed ANOVA of the mean absolute difference between the desired altitude and the actual altitude showed a significant main effect of workload $F(1,12) = 5.24$, $p = .04$. No other effects were significant. This shows (a) that the workload manipulation successfully increased difficulty and more importantly, (b) the older pilots were able to maintain control of the aircraft as well as the younger pilots.

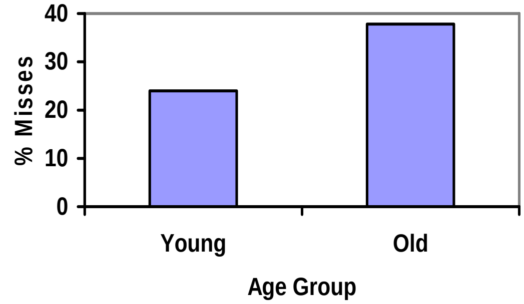

Figure 1. Percentage of Critical Events Missed.

Conclusions

This study identifies change detection as a critical age-related safety concern with recreational pilots: older pilots do not notice the occurrence of unexpected nearby traffic and abnormal instrument readings as well as younger pilots.

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