2007

Changes in Cognitive and Sensory Abilities of Older Pilots Parallel Those Observed in the General Population

C.A. Miller

A. Chaparro

CHANGES IN COGNITIVE AND SENSORY ABILITIES OF OLDER PILOTS PARALLEL THOSE OBSERVED IN THE GENERAL POPULATION

C.A. Miller
Wichita State University
Wichita, Kansas

A. Chaparro
Wichita State University
Wichita, Kansas

This investigation compares young and older pilots with age-matched controls from the general population on cognitive and sensory abilities. Cognitive assessments included short-term and long-term memory, learning, delayed recognition and mental rotation. Sensory measures included visual acuity, contrast sensitivity, auditory thresholds, speech intelligibility and tactile sensitivity. Significant differences in contrast sensitivity was obtained as a function of age and pilot status. Also, young pilots (24-42 years) have greater tactile sensitivity than older pilots (64-88 years), and both non-pilot groups. In general, younger participants performed better on the assessments than the older subjects regardless of pilot status. Although, the mean differences between the young and older groups showed significance there was considerable overlap in the cognitive and sensory measures for the different age groups indicating that chronological age is not reliable predictor of performance.

Introduction

Americans over age 60 represent the fastest growing segment of the population. The pilot population is no exception. According to (GAMA, 2006), 19.5% of pilots are over the age of 60. Concerns have been raised regarding the potential safety impact of age-related changes in cognitive and sensory abilities on the flight skills of older pilots. Although insurance companies impose surcharges of up to 160% on general aviation (GA) pilots over age 60 (AOPA, 2005), there is no evidence that age related changes increase their crash risk. Research using non-pilot populations has documented a variety of age-related changes in cognitive and sensory abilities but it is unclear whether these findings generalized to older GA pilots. Older GA pilots may be in better overall health due to regular medical evaluations, which disqualify individuals demonstrating medical conditions or significant changes in sensory or cognitive abilities from licensure. Thus older pilots on average might be expected to show age-related declines of lesser magnitude than participants drawn from the general population.

Piloting relies on number of cognitive abilities including working memory, long term memory, recognition of auditory and display information, and visuo-spatial skills. Working memory may support retention of Air Traffic Control (ATC) information such as radio settings, heading and altitude information. The ability to identify ones aircraft registration or other information is a measure of recognition. Research suggests age related declines in both recall and recognition (Craik & Salthouse, 1992; Stevens, Cruz, Marks, & Lakatos, 1998). Spatial skills like those measured by a mental rotation task may support situational awareness or a pilot's awareness of the relationship between their aircraft, terrain and other traffic across time. Some evidence suggest pilots' perform better on mental rotation tasks than non-pilots (Dror, Kosslyn, & Waag, 1993).

According to the FAA Civil Aeromedical Institute (CAMI), the majority of restrictions on airmen's medicals are due to impaired vision (Nakagawara, Montgomery, & Wood, 2004). Age-related declines in vision occur for both near and far visual acuity and contrast sensitivity. Research suggests detectable far visual acuity and contrast sensitivity declines occur in the sixties and accelerate thereafter (Haegerstrom-Portnoy, Schneck, & Brabyn, 1999; Klein, Klein, & Lee, 1996). Current medical exams rely on visual acuity as a measure of visual function, however, research suggests that contrast sensitivity may be a better predictor of crash risk (Ginsburg, Evans, Sekuler, & Harp, 1982).

Auditory communication is an important component of piloting. Pilots rely on the auditory channel for navigation information as well as for detection of warnings and system health. Like vision, hearing shows age-related declines as well. Generally, hearing loss is modest for low frequency pure tones, but at higher frequencies the loss is much greater (Fleischer & Muller, 2005). It is suggested that the engine noise may increase hearing loss in pilots; however, experimental evidence shows similar declines at higher frequencies regardless of pilot status (Beringer & Harris Jr., 2005). Speech intelligibility assessments may show significant declines as a function of age, that may be considerably greater than that predicted by in changes in detection thresholds for pure tone (Pichora-Fuller, Schneider, & Daneman, 1997).

Tactile sensitivity provides an important cue in identifying and controlling knobs/switches on the instrument panel. Similar to the other senses, tactile sensitivity of the fingertips declines with age (Thornbury & Mistretta, 1981). We are not aware of any studies relating tactile sensitivity to flying performance.

The aim of this research was to compare the sensory and cognitive performance of young GA pilots, older GA pilots and aged matched non-pilots to determine if they differ significantly on measures of cognitive and sensory ability. The research addressed two specific questions: Do younger (age 24-42 years) and older pilots (age 64+ years) differ in their cognitive and sensory abilities and do older pilots (age 64+ years) and their age-matched (65+ years) controls show equivalent cognitive and sensory changes?

Method

Participants. A total of forty-eight adults volunteered for the study. The participants were divided into four groups consisting of 11 males and 1 female that matches the ratio of males to females found in population of general aviation pilots. The age range of each of the four groups were as follows: young pilots (YP), range of 24-42 years old (M=33.6, SD=6.2); older pilots (OP) range of 64-88 years old (M=73.3, SD=7.6); the young and old non-pilot control groups were age matched to the pilot groups. Only pilots who had to hold a current pilot license and medical certificate and who primarily flew general aviation aircraft were recruited to participate.

All participants were informed of the experimental procedure, nature of the experiment, and signed a consent form approved by the IRB. To encourage participation, a monetary lottery was conducted as a gratuity for their time.

Assessment Description. Two cognitive assessments were given: the Wechsler Memory Scale and the Vandenberg Mental-Rotation Test (MRT), per the publisher's instructions. The Wechsler Logical Memory Test I and II (LMT I recall and LMTII recall), consisted of a recall and recognition (LMT Recognition) component of a verbalized story. A learning component (LMT Learn) was calculated between one of the stories read twice. The MRT is a spatial reasoning assessment containing 20 block drawings. Participants had to choose two of the four correct rotations for each drawing in a ten-minute time limit. Vision was assessed using far, near visual acuity charts and the Pelli-Robson contrast sensitivity chart. The Semmes-Weinstein Monofilament kit was used to determine tactile sensitivity of the fingers, palm and back of hand (SW Right and SW Left). Two auditory measures were used: thresholds of pure tones 500, 1000, 2000, 3000 and 4000 Hz and speech intelligibility.

Procedure. Two sessions were conducted. In the first session, cognitive, visual, and tactile measured were assessed while the second session consisted of the auditory testing. The vision testing was completed while participants wore their daily corrective lenses. Participants were examined during the auditory assessment with and without their hearing aids. Due to a 95% return rate of participants for the second session the auditory measures of pure tone thresholds and speech intelligibility were analyzed with a sample size of ten.

Results

The analysis was completed using a MANOVA to determine the differences between the four groups (YP, OP, YNP, and ONP) on the cognitive, visual and tactile assessments. Significant differences were found, Wilks' Lambda = .088, $F(30,103)=4.431$, $p<.001$. The multivariate η^2 was based on the Wilks' Lambda was $\eta^2 = .56$. One-way ANOVA and Tukey HSD post hoc (p<.005) tests were completed as follow-up statistics.

Statistically significance differences were found for far visual acuity [$F(3,44) = 6.77$, $p<.001$, $\eta^2 = .32$], near visual acuity [$F(3,44) = 4.56$, $p=.007$, $\eta^2 = .24$], and the two cognitive measures, LMTI Recall [$F(3,44) = 4.60$, $p=.008$, $\eta^2 = .23$] and LMTII Recall [$F(3,44) = 5.45$, $p=.003$, $\eta^2 = .27$]; however, during post hoc analysis the more rigorous alpha did not produce mean differences between the groups. The results for contrast sensitivity [$F(3,44) = 13.27$, $p<.001$, $\eta^2 = .48$] were significant, and post hoc analyses showed that younger participants performed better than older participants regardless of pilot status. The results for the mental rotation test were significant [$F(3,44) = 7.44$, $p<.001$, $\eta^2 = .34$] as were the results for the test of speech intelligibility [$F(3,44) = 7.27$, $p<.001$, $\eta^2 = .38$] , with follow-up analysis indicating that the YP group performed better than the ONP. The results of the tactile sensitivity measures of the right and left hands were also significant [$F(3,44) = 12.56$, $p<.001$, $\eta^2 = .46$] and [$F(3,44) = 22.76$, $p<.001$, $\eta^2 = .61$]. The post hoc analysis indicated that YP had greater tactile sensitivity than all other groups. The results for the LMT Learn and LMT Recognition were not statistically significant ($p>.05$). Shown in Figure 1 are the z-score group means for each measure.

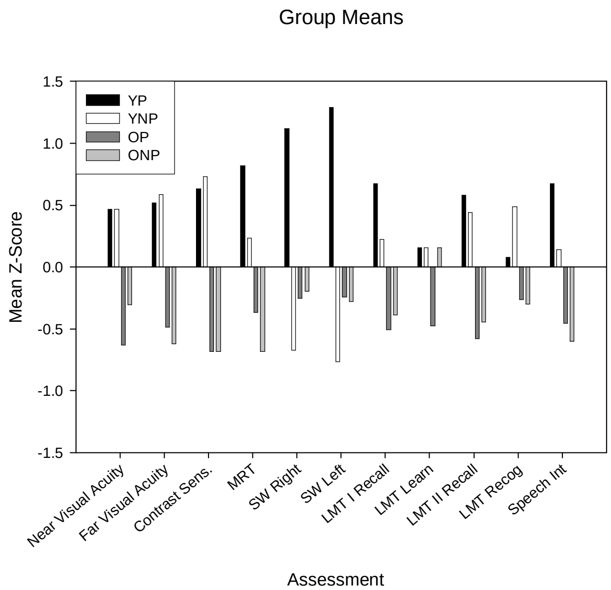

Figure 1. Standardized Means of Assessments

The pure tone auditory thresholds are shown in Figure 2. The data shows a decline with age, with higher frequencies (i.e. 3000 Hz and 4000 Hz) showing a greater decline.

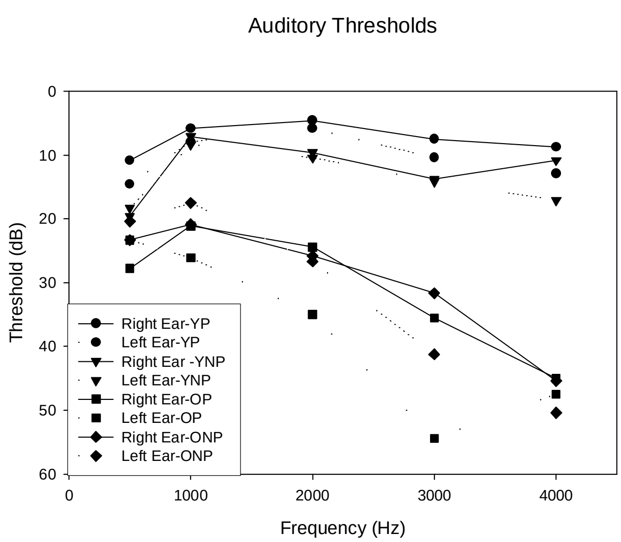

Figure 2. Auditory Threshold Analysis

Figure 3 shows the data for several of the tests. The older groups exhibit some cognitive and sensory declines; however the charts also show considerable overlap in the scores of the young and older participants.

Discussion

The research addressed two specific questions: Do younger (age 24-42 years) and older pilots (age 64+ years) differ in their cognitive and sensory abilities and do older pilots (age 64+ years) and their age-matched (65+ years) controls show equivalent cognitive and sensory changes? We hypothesized that younger and older pilot would perform similarly and older pilots would perform better than their age-matched cohorts from the general population, due to the required medical evaluations and flight reviews that would eliminate those with cognitive or sensory impairments. The results show younger participants perform better than the older participants and the older pilots perform similarly to older non-pilots

No significant age-related differences on measures of learning or recognition ability were obtained. Significant differences were found for the recall and the mental rotation tasks. These results show that the age related changes in cognitive skills were typically modest in magnitude and that older pilots and non-pilots show similar patterns of aging. It is possible that larger effects might be observed on other unmeasured cognitive skills especially under dual tasks conditions that are more typical of piloting.

The measures of visual function show that near and far visual acuity did not differ across the four groups; however, younger participants had better contrast sensitivity than the older participants. Evaluation of contrast sensitivity is currently not a part of the required medical exams. Some driving studies have reported an association between contrast sensitivity and crash risk however these studies typically involve participants with clinically significant eye disease (Owsley, 1994; Owsley et al., 1998).

The results for auditory thresholds were generally similar to those observed for vision. The older participants had higher auditory thresholds than the young participants regardless of pilot status. One limitation of audiometric thresholds is that they are a poor predictor of the difficulties individuals experience understanding spoken language in noisy conditions. We found that younger pilots performed better than the older non-pilots but they did not differ

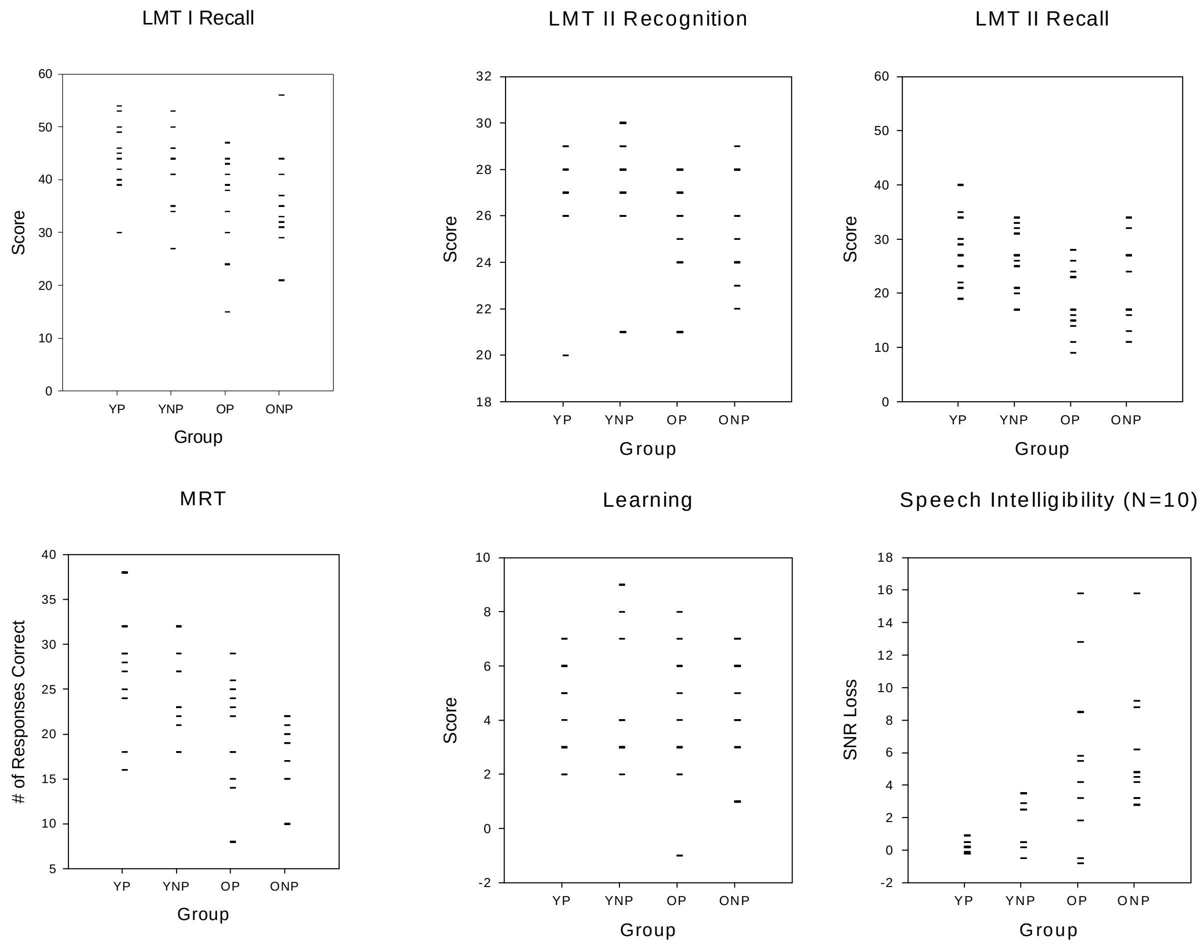

Figure 3. Range of Data for Various Measures

from the older pilots on the measure of speech intelligibility. One explanation for this finding is that the older pilots may have greater experience using top-down processes to interpret spoken language in noisy conditions.

Finally, the tests of tactile sensitivity revealed that young pilots performed better than any of the other three groups. Surprisingly little is known about tactile sensitivity, and its contribution to flying performance. How changes in tactile sensitivity affect flight performance remain to be identified.

Our results show that pilots experience similar age related changes in sensory and cognitive skills as non-pilots and that the observed age related changes are modest. These results also show that there is considerable overlap in the performance of the different age groups demonstrating that age based restrictions unfairly discriminate against older pilots.

References

AOPA. (2005). Older Pilots an Insurance Risk? AOPA Launches Aging Pilot Study to Find Out. Retrieved March 17, 2005, 2005, from http://www.aopa.org/whatsnew/newsitems/2005/050317aging.html

Beringer, D. B., & Harris Jr., H. C. (2005). *Baseline Hearing Thresholds Between Pilots and Non-Pilots and the Effects of Engine Noise*. Retrieved. from.

Craik, F. I. M., & Salthouse, T. A. (Eds.). (1992). *The Handbook of Aging and Cognition* (1 ed.). Hillsdale, New Jersey: Lawrence Erlbaum Associates, Publishers.

Dror, I. E., Kosslyn, S. M., & Waag, W. L. (1993). Visual-Spatial Abilities of Pilots. *Journal of Applied Psychology*, *78*(5), 763-773.

Fleischer, G., & Muller, R. (2005). *On the Relation Between Exposure to Sound and Auditory Performance.* Paper presented at the SAE 2005 Noise and Vibration Conference and Exhibition, Grand Traverse, MI.

GAMA. (2006). *General Aviation Statistical Databook 2005*. Washington, D.C.: GAMA.

Ginsburg, A. P., Evans, D. W., Sekuler, R., & Harp, S. (1982). Contrast Sensitivity Predicts Pilots' Performance in Aircraft Simulators. *American Journal of Optometry and Physiological Optics, 59*, 105-109.

Haegerstrom-Portnoy, G., Schneck, M. E., & Brabyn, J. A. (1999). Seeing into Old Age: Vision Function Beyond Acuity. *Optometry and Vision Science, 76*(3), 141-158.

Klein, R., Klein, B. E. K., & Lee, K. E. (1996). Changes in Visual Acuity in a Population: The Beaver Dam Eye Study. *Ophthalmology, 103*(8), 1169-1178.

Nakagawara, V. B., Montgomery, R. W., & Wood, K. J. (2004). *Demographics and Vision Restrictions in Civilian Pilots: Clinical Implications*. DOT/FAA/AM-04/6.

Owsley, C. (1994). Vision and Driving in the Elderly. *Optometry and Vision Science, 71*(12), 727-735.

Owsley, C., Ball, K., McGwin, G., Sloane, M. E., Roenker, D. L., White, M. F., et al. (1998). Visual Processing Impairment and Risk of Motor Vehicle Crash Among Older Adults. *Journal of American Medical Association, 279*(12), 1083-1088.

Pichora-Fuller, M. K., Schneider, B. A., & Daneman, M. (1997). How Young and Old Adults Listen to and Remember Speech in Noise. *The Journal of the Acoustical Society of America 97*(1), 593-608.

Stevens, J. C., Cruz, L. A., Marks, L. E., & Lakatos, S. (1998). A Multimodal Assessment of Sensory Thresholds in Aging. *The Journal of Gerontology, 53B*(4), 263-272.

Thornbury, J. M., & Mistretta, C. M. (1981). Tactile Sensitivity as a Function of Age. *Journal of Gerontology, 36*(1), 34-39.