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16. Abstract Fifty general aviation pilots (average age 49; range 40-73) completed a questionnaire concerning cockpit visual problems. The results of the questionnaire indicated that proper interpretation of the airspeed indicator and the altimeter required the best visual acuity (48 and 39 percent of the respondents respectively). However, 33 percent reported the attitude indicator, an instrument with relatively few numerals or markings, required optimum visual acuity. Thirty-seven percent of the pilots reported that the engine instruments, usually smaller scale, are difficult to read. Light reflected from instrument cover plates caused visual problems for 32 percent of the pilots, with most difficulty occurring during daylight hours. Forty-eight percent of the pilots reported a delay in focusing from outside the cockpit to the charts and instruments, while 6 percent reported a delay of focusing from inside to outside the cockpit. More instrument readability problems were evident while flying at night than during dusk or daylight. The effects of decreasing focusing power, altered dark adaptation, and need for more lighting are discussed with respect to the older pilot. Recommendations are made to investigate the effects of instrument lighting, vision standards, and instrument design and location with respect to the limitations of the aging visual system.					
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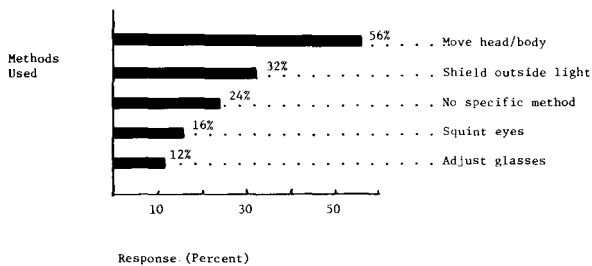


from outside the cockpit to charts and 17 percent had noticed an increase in focusing time from outside to the instruments. Few pilots (6 percent) reported a delay in focusing from maps or instruments to outside the aircraft.

Frequency of Problems. When the pilots were asked if they had noted any difficulty in reading aircraft instruments, 56 percent reported none, 38 percent said "occasionally," and 6 percent reported frequent visual problems. When questioned as to when the instruments are most difficult to read, 48 percent indicated "nighttime," 28 percent said "dawn and dusk," 22 percent replied "never difficult," and 6 percent reported "equally difficult at all times." Of the 16 pilots reporting visual difficulty from reflective glare off the instrument cover plates, 69 percent indicated more problems during the day while 31 percent had more problems at night.

Individual Solutions. Table 3 lists the subjects' responses concerning various methods used to improve the readability of the cockpit instruments.

TABLE 3.
Methods Used by Pilots
to Improve Instrument Readability



When asked what specific steps were taken to reduce reflections from the glass cover plates, 43 percent stated they employed head movements and 26 percent shielded the instruments; the remaining subjects gave no response.

Of 44 pilots responding to the question concerning the level of instrument brightness preferred during night flying, 66 percent preferred the medium intensity level, 23 percent liked the brightest level, and 16 percent preferred the dim level. Thirty percent of those responding stated they occasionally used a flashlight to read the instruments when flying at night. When asked

to recommend changes to improve the readability of aircraft instruments, 36 percent recommended lighting changes, 28 percent indicated changes in the dial design, and 30 percent said no changes were needed.

Miscellaneous Data. Prescription spectacle lenses were worn by 68 percent of the subjects while flying. Of those wearing glasses, 67 percent wore bifocal lenses, 27 percent wore trifocal lenses, and 7 percent wore half-eye reading glasses. When viewing the instruments, 65 percent of those wearing bifocal lenses used the bifocal (lower) portion rather than the distance portion of the lens. Sixty-two percent of the trifocal wearers used the trifocal (middle) portion of the lens to view the instruments. Of those pilots wearing glasses, 44 percent carried an extra pair while flying.

Information from the Aeromedical Certification Branch showed that 32 percent of all pilots are required to wear glasses while flying. An additional 8.2 percent of the pilots must have glasses (usually the reading type) available while flying. Although the information was not available, the percentage of pilots wearing glasses would be expected to increase with age.

In response to the question concerning the color of instrument lighting available, 52 percent of the subjects stated they flew aircraft equipped with red panel lighting, 24 percent said white lighting, while 22 percent said selectable red or white lighting.

IV. Discussion.

Because of the limited pilot population surveyed ($N=50$) and the large number of ocular refractive and instrumentation variables, no statistical correlations could be made between the visual measurements and questionnaire data. However, in a laboratory study now in progress at the FAA Civil Aeromedical Institute, visual acuity of older subjects will be determined through the distance and near portions of their spectacle lenses at 51, 76, and 102 cm during photopic viewing conditions. The questionnaire data, however, indicate several common instrument-readability problems among older pilots. Although not investigated in this study, many of the same problems may also occur among younger pilots when flying under similar conditions.

The results of the questionnaire indicate that aircraft instruments with many numerals and markings (airspeed indicator and altimeter) require optimum visual acuity for proper interpretation. However, one-third of the pilots reported that an instrument with few numerals or markings (attitude indicator) required optimum visual acuity for proper interpretation. The apparent dichotomy of opinions indicates that interpretative difficulties associated with dial design may influence the pilot's opinions. In addition, we believe that the pilot's training and experience influence his opinion about the instruments that require optimum vision for correct dial interpretation.

The readability for electro-optical displays (cathode ray, light-emitting diode, etc.) was not covered in the questionnaire. Because of increasing use of these displays in aircraft instruments, further research is recommended in this area with respect to older pilots.

To isolate visual performance from the pilots' subjective judgment, we recommend a study to evaluate readability of aircraft instruments under various visual acuity levels and flying conditions. Information concerning the visual, cognitive, and design aspects of instrument readability is found in several sources.^{16, 17, 18}

Another visual problem noted by one-third of the pilots was reflective glare from the glass plates covering the panel instruments. Reflective glare is presumed to occur without respect to the pilot's age or visual status. At least two aspects of cover plate reflections require further investigation. First, research should be conducted to quantitate visual impairment caused by reflections during various flight conditions. Second, we need data on the effectiveness of shielding, lighting, polarizing, and/or convexing the glass cover plates.

Instrument-readability problems caused by oblique observation angles (parallax) also merit investigation as to their significance and possible remedies by design modification.

Nearly half the respondents indicated that instrument readability was a problem when flying at night. We believe that further research is necessary concerning the effects of instrument lighting intensity, spectral color of lighting, dial markings, hypoxia, fatigue, and drugs with respect to night vision in older pilots. Several papers direct attention to the visual problems of presbyopic pilots.^{19, 20, 21}

The trifocal portion of a spectacle lens is designed to improve visual acuity at the intermediate (instrument panel) range. The necessity for trifocal lenses increases with age and is considered essential to provide good intermediate vision for those with less than 2.00 D of accommodation. Data show that individuals 53 years of age or older have less than 2.00 D of accommodation and may benefit from trifocal lenses, especially under dim luminance conditions.^{4, 5} However, of the 14 pilots more than 53 years of age surveyed in our study, only two pilots wore trifocal lenses. Harper and Kidera also reported that many senior pilots flying large commercial aircraft do not wear trifocal lenses.²⁰ They stated that natural human reluctance to wearing multifocal lenses and unawareness of reduced intermediate visual acuity were contributing factors.

This survey revealed several potential visual problems common to older general aviation pilots. We feel that these visual problems merit further attention with respect to medical standards, accident statistics, human factors, and cockpit design.

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