

Study on Mental Attributes of Aged Test Pilots

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Abstract Mental ability will decline by ageing while the experience accumulating. It is important to study the mental attributes of aged test pilots in order to maximum professional span and ensure flight safety. Methods A total of 35 experts including test pilots and aircraft design engineers were interviewed on the issues of the mental ability of aged test pilots through completing a questionnaire about the issue. A battery of mental ability test and 16PF were used to examine 37 test pilots who were divided into three age groups (age above 45 year, $n = 16$) and control group (age below 45 year, $n = 21$). Results Most important mental attributes of older test pilots were related to professional spirits, flying expertise (judgment) and personality. The firstly aging abilities were cognition and psychomotor ones. Scores of Detecting special graph, Distinguishing direction and Distracted listening were lower than those of control group ($P < 0.05$), which were negatively correlated to age ($r = -0.335, -0.411, -0.409, P < 0.05$). Conclusion Mental abilities related to reaction speed decline earlier. Although the expertise may compensate for the decline, routine aptitude test will benefit the increasing need for test pilot and aviation safety.

Keywords Test pilot · Aging · Mental attribute

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1 Introduction

Mental ability and human performance will decline after the peak age, but the change pattern of different type ability varies. In aviation occupation, an air carrier flight pilot must retire from pilot job upon reaching their 60th birthday, commonly referred to as the Age 60 Rule [1], which was implemented by the Federal Aviation Administration (FAA) in 1959. Since then, the relationship between pilot age, piloting performance, and safety has inspired much debate and many questions.

Pilot incapacitation and performance factor are the most important concerns. Age-related decline in the pilot ability includes rapidly reaction, resisting fatigue, applying experience and judgement in emergency situations [2]. But in November, 2006, the International Civil Aviation Organization (ICAO) revised the maximum age for pilots from age 60 to age 65, and the United States followed in December 13, 2007 [3]. This may spire the concerns of aviation safety and expertise compensation in aged pilots. Although retired age of test pilot for fighter is far lower than 65, it is important to study the mental attributes of them because the high demand of fighter flying.

According to fluid and crystallized intelligence theory, originally identified by Cattell [4], fluid intelligence is the capacity to reason and solve problems, independent of any knowledge from the past. It typically peaks in young adulthood and then steadily declines. This decline may be related to local atrophy of the brain in the right cerebellum [5]. Crystallized intelligence is the ability to use skills, knowledge, and experience. This improves gradually with age, and stays relatively stable across most of adulthood, and then begins to decline after age 60, even age 80 [6].

Many researcher concerns about aged pilots ability since it is a high cognition demand job. Wu et al. [7] used seven cognitive test to investigate the age difference in the basic cognitive ability of fighter pilots and its influence upon flying training. The results show that pilot cognitive ability of the age 26–28 was higher than younger and older age groups. The age difference were significant between age groups, but did not influence upon flying performance. Hardy [8] also pointed out that there was only weak evidence that age-related differences in cognition influence pilot performance. But Yesavage [9] revealed that pilot performance on several flight tasks declined significantly with age. Quinn Kennedy [10] also found that older pilots' (41+ year) decision making ability and flight control performance were lower than younger pilots, but expertise could attenuated an age-related decline in flight control.

Flight skills, expertise and, special knowledge are essential to test pilots. Most test pilots became mature after their age 40. So it is important to study the age effect on their cognition. In this study, subject matter experts (SMEs) and psychological test were combined to study mental attributes among aged test pilots.

2 Subjects and Methods

2.1 Subjects

A total of 35 subject matter experts were investigated, including test pilots (TP), and aircraft design engineer (ADE).

There were 37 flying qualified test pilots, 35–56 year of age, who completed the study. All pilots were sub grouped into two age ranges: 45–53, 35–45, named older group and control group respectively. There were 16 older group members (average age 47.94 year) and 21 control ones (average age 41.43 year).

The experimental protocol was approved by the Beihang University Human Ethics Committee. All subjects signed informed consent to attend the experiment and their rights to withdraw at any time.

2.2 Tools

2.2.1 Mental Attributes Questionnaire of Aged Test Pilots

We compiled a questionnaire of 29 mental attributes that were essential to test pilot according to literature and test flying work context and job activities. The subject was asked to evaluate the importance of each item with 1–5 scale. The test pilots were asked to identify the top 10 mental attributes which were most important to old test pilot and top 10 which were most influence by age (Table 1).

2.2.2 Psychological Test

A test battery for measurement of mental attributes of fighter pilots developed by Wu [11]. The test battery include Sixteen personality Factor (16PF), Detecting special graph (DSG), Comparing simulated scales (CSS), Distinguishing direction (DD), Dual task (DT), Distracted listening (DL). According to the according to literature and test flying work context and job activities, Growth capacity (GC) and Innovation ability (IA) in 16PF were adopted in the study.

The test was completed on Lenovo Y460 notebook computer with 15 in. LED screen resolution of which was set at 1024 × 768.

2.3 Statistical Analysis

The IBM SPSS statistical software package 20.0 was used for data analysis, all test data were expressed as Mean ± SD ($\bar{x} \pm s$). Pearson correlation test and t-test was

Table 1 Mental attributes questionnaire of aged test pilots

No.	Mental attributes	Importance evaluation (1–5)	Top 10 important	Top 10 age declined
1	Interesting in test flying			
2	Curiosity			
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28	Harmonious interpersonal relationship			
29	Sense of discipline			

used for statistical analyses. An alpha-level of 0.05 was used as threshold for significance.

3 Results

3.1 Survey on Mental Attributes of Aged Test Pilots

Top 5 most important mental attributes evaluated by ACG are 80% (4/5) similar to those of TP. Top 5 most important mental attributes evaluated by TP are 80% (4/5) similar to those selected by TP. Top 5 mental attributes which are influenced by age are different to those most important ones except agility of thinking Table 2.

3.2 Psychological Test Results

DSG, DD, DL scores of elder group are significantly higher than those of control group ($P = 0.008, 0.008, 0.020$) Table 3. There are negative correlation between

Table 2 Mental attributes of aged test pilots

No.	Top 5 evaluated by ACG	Top 5 evaluated by TP	Top 5 selected by TP	Top 5 influenced by TP
1	Decisiveness	Rigorous	Interesting in test flying	Agility of arms and legs
2	Interesting in test flying	Interesting in test flying	Decisiveness	Long memory
3	Judgment complicated situation	Decisiveness	Agility of thinking	Agility of thinking
4	Divided attention	Divided attention	Divided attention	Perception ability
5	Space orientation	Judgment complicated situation	Rigorous	Curiosity

Table 3 Comparative of mental attributes of test pilots between two groups

	Older group (N = 16)		Control group (N = 21)		t	P value
	M	SD	M	SD		
DSG	5.06	2.86	8.43	4.43	2.797	0.008**
CSS	13.06	5.08	16.19	4.76	1.907	0.066
DD	6.31	5.50	12.19	7.14	2.829	0.008**
DT	71.09	41.70	86.64	35.70	1.195	0.242
DL	30.81	6.08	35.38	4.81	2.473	0.020**
GC	22.80	4.66	25.89	3.95	1.253	0.249
IA	78.80	5.26	80.78	5.04	0.684	0.513

Note *P < 0.05; **P < 0.05

Table 4 Correlation between age and mental attributes of test pilots (r)

	DSG	CSS	DD	DT	DL	GC	AI
Age	-0.335*	-0.323	-0.411*	-0.208	-0.409*	-0.269	-0.286

Note *P < 0.05; ** P < 0.05

age and mental attribute test. The correlation between age and DSG, DD, DL test are significant ($r = -0.335, -0.411, -0.409$) Table 4.

4 Discussion

The essential mental attributes of pilots including excellent ability of perception, memory, thinking, attention, psychomotor and personality character. With the development of aviation technology, automation gradually replaced many traditional piloting skills such as stick and rudder control. But test pilots still need the skills since the automation is not always on work. They must understand the inner work of the increasingly complicated aviation system besides piloting. The occupation character distinguish the mental attribute from traditional pilot [12]. The USAF have set the special TP requirement of flying ability, technical ability and professional competence [13]. But the study on mental attributes of test pilots is rare.

In our survey, the most important mental attributes of older test pilots are related to professional spirits, flying expertise (judgment) and personality. The psychomotor abilities which rely on neural system function, are less important and would decline early with aging.

The psychological test results is accordance with the survey results. The older test pilots' cognition and perception ability decline as aging since three sub test scores are lower than younger group. There are no significant difference between two group in personality test. Dual task test is more complex than other tests, and is

done on a simulated radar interface which is similar to pilot work activity, so is not sensitive to aging effect and can be compensated by expertise.

Many studies [14] on general pilots' aging and cognition ability or simulation flight performance found that the relationship between increased age and decreased flight performance was significant. But other factors are also important for the older pilots' performance [15]. Expertise may attenuate an age-related flight control decline [16] and that expertise effects were most evident in the accuracy of executing aviation communications [17], but many performance may not benefit from experience.

In our study, many test pilots' cognition and psychomotor ability is above the average level of younger groups. The individual difference is evident. Many older test pilots between 45 and 56 years feel the cognition ability decline themselves. Although they thought that can be compensated by expertise and have no crisis for safety, it is never too late to be careful. David [18] examined the effect of age on aircraft pilots' cognition with a variety of neuropsychological tests. The results show that age was significantly related to test performance except immediate verbal recall or recognition. 95% scores lower than 2SD occurred in pilots over age 40 which may also mean a gradual cognition decline. Individual difference was an important factor for flying requirements of aged pilots. Tsang [19] reviewed psychological literature about age effects on four cognitive abilities essential to pilot performance and also concluded that 40 is the declining age. Pilots over age 40 should be evaluated by ability tests annually.

With the development of aviation industry, there are increasing demands for test pilots, either in general or military aviation. The occupation character determines that the test flying expertise is important to be a qualified test pilot. Routine aptitude tests will benefit the need for test pilots and aviation safety.

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