

A Preliminary Study on the Relationship between Cognitive Ability Tests Scores and Resilience of Flight Students

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Abstract: To investigate the possibility of auxiliary evaluation of flight students' resilience by making use of cognitive ability tasks, and to provide competence evaluation reference for flight students' selection and training. 709 flight students were tested by computer-based cognitive ability tests with tablets, including visual matrix comparison task and corresponding variant task, the Resilience Scale for Chinese Adolescent and several basic cognitive tasks. We compared differences in various indicators of tasks among flight students and analyzed whether students' performance in stress scenarios has something to do with their resilience. There were significant differences in various indicators between visual matrix comparison task (daily context) and corresponding variant task (stress context) ($P < 0.01$). Stress resistance scores of flight students was positively correlated with positive cognition scores (one dimension of resilience) ($P < 0.05$). The stress situation triggered by cognitive tasks can help to evaluate flight students' resilience to a certain extent so that it could provide scientific evidence and feedback for screening, selecting and training flight students.

1. Introduction

With the rapid improvement of aircraft automation, the requirements for pilots' information processing, memory, attention, and logical thinking have also increased. As a monitor and decision-maker of human machine system, pilots are responsible for a large amount of information processes from sensory input to decision output. Cognitive function closely related to flight is the basic psychological ability that pilots must possess [1-2]. Therefore, it is vital to evaluate the cognitive abilities of flight cadets during selection and training.

With the vigorous development of civil aviation industry, the daily flight tasks of pilots have increased, and pilots may encounter unexpected emergency events during flight missions, such as aircraft mechanical failures, sudden changes in bad weather, and on-board medical emergencies. After a sudden emergency, pilots may experience corresponding stress reactions that can lead to severe physical exhaustion and a decrease in psychological resources, and may even lead to physical

and mental health problems. Therefore, it is also important to evaluate the psychological resilience of flight cadets during selection and training [3].

Currently, most measurements of psychological resilience are scales, such as CD-RISC (a translated and revised resilience scale), the revised Adolescent Resilience Scale (HKRA) based on the dynamic model of psychological resilience, and the Psychological Resilience Scale developed for the youth population in China through interviews based on the process model of psychological resilience [4]. However, traditional measurement scales are relatively high on surface validity, participants can infer the intentions of researchers and may be affected by factors such as social desirability. If a tool can be found to indirectly measure psychological resilience with low surface validity, then the ability evaluation of flying students will be more stable and accurate. Given the above needs, this study aims to assess the cognitive ability and psychological resilience of flight cadets in the selection and training stages, trying to measure the cognitive ability of flight cadets through classical cognitive tasks and variations of these tasks, and provide some references for evaluating the psychological resilience level of flight cadets through changes in performance between cognitive tasks.

2. Experiment

2.1. Participants

We selected 709 participants from the flight cadet group, all participants were male, ranging in age from 19.42 to 28.25 years old, with an average age of 22.39 years old. All participants had normal vision and passed the physical examination.

2.2. Methods

Part of the cognitive tests are adopted from the "Aviation Staff Psychological Testing Platform" (developed by the Aviation Psychology Laboratory of the Civil Aviation Medical Research Institute of China). Participants were required to complete visual matrix comparison tasks and variation tasks, the psychological resilience scale, and some simple basic cognitive tasks designed to reduce practice effect of performance on a tablet.

In the visual matrix comparison task, participants were required to compare the two matrices randomly presented on the tablet each time and press the button as soon as possible to ensure accuracy. The visual matrix comparison variant task requires participants to compare the two matrices randomly presented on the tablet within a short fixed time period, and press the button as soon as possible to ensure accuracy. These two cognitive tasks measure the subjects' perceptual speed ability, including perceptual speed and efficiency.

We use the Adolescent Psychological Resilience Scale [5], a total of 27 questions were designed and analyzed by a second-order five-factor structure. Five dimensions including goal focus, interpersonal assistance, family support, emotional control and positive cognition were obtained through the scale. And there were two higher-order factors, namely human power and supportive power, which measures the individual's effective coping and adaptive ability when encounter loss, difficulty, or adversity. This scale has good reliability and validity.

The analysis indicators of the visual matrix comparison task and the variant task include the number of correct answers, accuracy, reaction time, and efficiency, which reflect the subjects' perceptual speed ability. The changes of the same analysis indicators on these two tasks measure the subjects' perceptual speed ability induced by limited time pressure situations, which is a reflection of individual ability of stress resistance. The analysis indicators of the Psychological Resilience Scale include scores of each dimension, as well as scores of human power and supportive power factors,

which is the embodiment of individual resilience from adversity.

2.3. Procedure

All participants completed the tasks by a tablet device with unified parameters in a relatively quiet, well lit and ventilated psychological assessment room. Each task consists of three stages: guidance, practice test and formal test. The participants can only enter the formal testing stage to complete the task after fully understanding the guidance and practicing correctly.

2.4. Statistic analysis

We use SPSS 26.0 statistical software to enter and organize data. Paired sample t-tests were used to analyze the data of flight students on the two perceptual speed tasks, t value is computed by equation (1), and S is the standard error and n is the sample size.

$$t = \frac{(\bar{x} - \bar{y})}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \quad (1)$$

Pearson correlation analysis was used to analyze the relationship between perceptual speed tasks and psychological resilience. Linear regression analysis was used to predict the psychological resilience of flight students. $P < 0.05$ was considered statistically significant, r value is computed by equation (2), and estimates the covariance and standard deviation of the sample.

$$r = \frac{\sum_{i=1}^n (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^n (X_i - \bar{X})^2} \sqrt{\sum_{i=1}^n (Y_i - \bar{Y})^2}} \quad (2)$$

3. Result

3.1. The cognitive ability of flight students in different situations

709 flight cadets completed cognitive ability tasks, and the descriptive results of various indicators for visual matrix comparison and variant tasks are shown in Table 1 and 2.

Table 1 Descriptive statistics of raw scores for pilot cadets in visual matrix comparison task, M (SD)

Material level	Visual Matrix Comparison Task		
	Accuracy	Reaction Time	efficiency
same	0.98 (0.03)	2.64 (0.79)	0.012 (0.004)
different	0.96 (0.05)	1.94 (0.40)	0.027 (0.005)

Table 2 Descriptive statistics of raw scores for pilot cadets in visual variant task, M (SD)

Material level	Visual Variant Task		
	Accuracy	Reaction Time	efficiency
same	0.91 (0.07)	1.70 (0.20)	0.015 (0.003)
different	0.86 (0.09)	1.52 (0.17)	0.029 (0.005)

3.2. Comparison of cognitive ability of flight cadets in different situations

The accuracy of flight students in the pressure situation (0.89 ± 0.06) was lower than that in the daily situation (0.97 ± 0.03), and the difference was statistically significant ($t = 34.44$, $P < 0.01$). Similarly, there were statistically significant differences in reaction time and efficiency between the

two situations ($t=36.63$, $P<0.01$; $t=117.77$, $P<0.01$). Furthermore, within each level of the matrix materials (same matrix level and different matrix levels), there were statistically significant differences in accuracy ($t=27.97$, $P<0.01$; $t=27.99$, $P<0.01$), and reaction time between the two situations ($t=35.48$, $P<0.01$; $t=36.30$, $P<0.01$) (Fig.1).

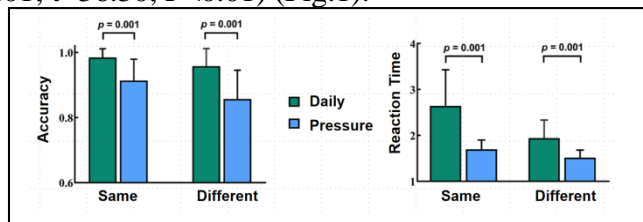


Figure 1. Different scores for different matrix material levels in visual matrix comparison and variant tasks

3.3. The relationship between flight cadets' ability to withstand pressure and psychological resilience

The results showed that there was a significant positive correlation ($r=0.1$, $P<0.05$) between the average efficiency change of flight students between the two situations and the positive cognitive dimension scores of the psychological resilience scale. Furthermore, there was also a significant positive correlation ($r=0.1$, $P<0.05$) between the residual standard scores calculated from the regression equation and the positive cognitive dimension score of the psychological resilience scale, indicating that the stronger the flight cadet's ability to withstand pressure in visual matrix comparison tasks, the better their positive cognition (Figure 2).

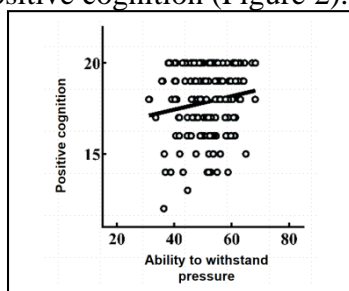


Figure 2. Relationship between pressure resistance and positive cognition of pilot cadets

The score of stress resistance reflected in the cognitive task was taken as the independent variable and the score of positive cognition was taken as the dependent variable for regression analysis. The final regression equation was $Y=16.55+0.024X$. This indicates that flight cadets' ability to withstand pressure in visual matrix comparison tasks can predict positive cognition.

4. Discussion

With the continuous evolvement of aircraft, the requirements for pilot capabilities and resource management are also constantly increasing. In the past two decades, the screening of cognitive ability has become an increasingly important part of psychological selection for pilots in Europe and America, while mental health screening is also crucial. However, in addition to interviews, the screening methods and tools are mostly questionnaires with high surface validity and are easily influenced by attitude of participants [6]. So this study attempts to investigate whether measuring an individual's cognitive ability can also have a certain reference value for evaluating their mental health level by manipulating the relevant parameters of cognitive tasks. Domestic and foreign

research literatures are also concerned about the relationship between cognitive ability and mental health. Researchers used the scale and the implicit association test (IAT) to screen out children with psychological resilience and those lacking psychological resilience. They measured children's social abilities through explicit self-awareness and implicit self-awareness, and measured actual social abilities from multiple perspectives of the two information sources [7-8]. Some studies have also found that poor cognitive ability in early adulthood is a risk factor for common mental health problems many years later [9], and research results even show that mild cognitive impairment in preschool children is related to mental health problems in adulthood [10]. Meanwhile, the results of this study indicate that the performance of flight cadets in visual matrix comparison tasks in a limited period of time reflects their stress resistance and psychological resilience. It is still possible to assess the mental health level of flying students through the cognitive tasks based on the test forms and research results.

In this study, researchers adopted visual matrix comparison tasks to investigate the perceptual speed dimension of cognitive ability of flight cadets, while the visual sequence comparison task was commonly used in most previous studies. The visual sequence comparison task is a sub-test of Cogscreen-AE test system which is widely used for selecting and evaluating pilots' cognitive abilities. The study used visual sequence comparison tasks as the experimental paradigm and found that individuals who were able to correctly perceive stimuli in a shorter period of time exhibited better situational awareness [11]. After applying the visual sequence comparison task in the test system, a recent study found that there was no significant change in cognitive performance of navy pilots before and after flight, indicating that the test is a very effective and stable tool [12]. However, the stimulus materials (matrix graph) used in this study is more complex and comprehensive than letters and numbers, which can better induce participants' stress resistance when completing variant tasks [13]. In the aviation field, there are many studies focused on the impact of different difficult cognitive tasks on pilots. Researchers used different cognitive tasks to induce brain fatigue of high-performance fighter pilots, and observed the changes in average cerebral blood flow velocity of pilots through transcranial Doppler ultrasound [14]. The results showed that continuous arithmetic tasks do not lead to changes in average blood flow velocity, while continuous operational tasks significantly reduce the average blood flow velocity. We know that individuals will experience time pressure under time constraints. Time pressure describes a subjective perception that an individual has insufficient or even a lack of time. Initially, researchers regarded time pressure as a negative stressor and proved that time pressure has a negative impact on individual health and cognitive activities [15-17]. In recent years, some scholars tend to point out that time pressure will not only negatively influence on individuals, but also positively promote individuals [18-19]. However, changes in individuals' information processing performance of cognitive tasks cannot be simply understood as individuals' ability to withstand pressure. There are many hypotheses and mechanisms, and the two concepts are not exactly identical [20]. In the future, how to extract more precisely the topics and content of interest from cognitive processing performance changes will require further exploration.

We found that cadets' performance in cognitive tasks was only positively correlated with the positive cognitive dimension of the psychological resilience scale. This suggests that the stronger the cadets' ability to resist pressure in tasks, the better their positive cognition. A large number of studies have confirmed that individuals with good psychological resilience have stronger anti-pressure ability when encountering adversity and other situations [21]. From the perspective of evolutionary psychology, the adaptor formed in the evolutionary process of psychological resilience is a kind of "self-protection instinct" in the face of survival difficulties. It can improve the probability and quality of human survival to a certain extent, in the form of better adaptation to survival dilemmas [22], and a certain degree of development. However, we did not find a correlation between cadets'

performance of cognitive tasks and other dimensions of the resilience scale (goal focus, emotional control, family support, and interpersonal assistance). The possible reasons are that there is no significant correlation between resistance of the subjects in the task and the above dimensions, or the above dimensions explain the degree of stress resistance weakly. From the perspective of the scale structure, the family support and interpersonal assistance dimensions were only the second highest level factor (only 19% of the variance) to the positive cognition dimension which is the individual level. The family support and interpersonal assistance dimensions belong to the support system.

Previous studies have indicated that there are differences in psychological resilience among groups of different ages. Researchers used meta-analyses to explore the relationship between psychological resilience and well-being in older adults, and have shown that the relationship between psychological resilience and well-being is influenced by age [23]. Some studies also suggest that psychological resilience during adolescence is not influenced by age, but there are gender differences [24]. In this study, we conducted Pearson correlation analysis between age and individual stress resistance scores, as well as positive cognitive dimension scores in order to exclude the possible impact of age on individual stress resistance and psychological resilience. The results showed that there was no significant correlation between them ($P>0.05$). This indicates that the stress resistance of flight cadets is not related to positive cognition and age, which is similar to previous studies.

With the continuous progress of aviation industry, the selection and training of civil aviation pilots has entered a period of development, and how to use test tools to more accurately describe the ability of pilots has become a very important aspect. This study attempts to measure the cognitive ability of flight cadets by using classical cognitive tests and variant tasks to assist in assessing their psychological resilience. But there are also individual differences. The research results provide some references for the update of evaluation tools. In future studies, it is necessary to further explore the relationship between various aspects of perceived speed ability and psychological resilience, and determine more effective assessment tools to provide scientific basis for pilot selection and training.

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