The Testing Research on Basic Cognitive Ability's Influence Factors in Special Vehicle Crewman

Qun Wang, Fang Xie, Sijuan Zheng, Zhongliang Wei and Qianxiang Zhou

Abstract In order to investigate the factors that affect a certain type of special vehicle crewman's basic cognitive ability, this paper starts from the basic connotation of basic cognitive ability, to determine the test content that affects the cognitive ability including depth perception, spatial perception, sound/light simple reaction time, attention span, attention focus ability, etc. About 107 subjects participate in the static environment test, the variance analysis method is used to deal with test results. The analysis result shows that: the crewman's basic cognitive ability is greatly influenced by individual operating mode and external environmental factors, while different ages, educational background, and region have no obvious effect on the basic cognitive ability in the crewman. These conclusions have a certain reference value for the design of this special vehicle.

Keywords Special vehicle · Cognitive ability · Mental resources · Ability test

1 Introduction

At present, the technical development of special vehicle has changed from mechanization to informatization and this has made the amount of information received by the crewmen in a geometric growth, but the basic cognitive ability of human is limited. Therefore, in the ergonomic research of special vehicle, it is necessary to study the task characteristics and basic cognitive ability characteristics of crewman, analyze the influence factors, coordinate the relationship between crewman and

Q. Wang (✉) · F. Xie · S. Zheng · Z. Wei
China North Vehicle Research Institute, Huaishuling No. 4 Court, Fengtai District, Beijing 100072, China
e-mail: buaawq1988@163.com

Q. Zhou
School of Biological Science and Medical Engineering, Beihang University, No. 37, Xueyuan Road, Haidian District, Beijing 100191, China

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vehicle, balance the division of tasks of crewman and vehicle for use and reasonably allocate man-vehicle functions to ensure the successful completion of tasks [1].

According to the Multi Resources Theory of Wickens [2, 3], the process of completing the task by people can be considered as a process of using their own abilities. People decompose useful ability resources from information input, information processing, and information output and these abilities can be divided into visual ability, hearing ability, and other basic cognitive abilities. This paper starts from mental resources of crewman to combine main operating tasks of vehicle crewman for obtaining main basic cognitive ability need. Analyze its influence factors through experimental test to provide data support for man-machine interface design of the vehicle.

2 Test Methods and Steps

2.1 Subjects

The subjects are 107 crewmen aged from 20 to 25 with 5 driving years. They respectively come from Hebei, Shanghai, Anhui, Fujian, Jiangsu, Shandong, Zhejiang, Guangxi, Guangdong, Henan, Hubei, Gansu, Shanxi, Shanxi, Sichuan, and such 19 provinces and cities. Visual acuity or corrected visual acuity is above 1.0. There is no color blindness and color amblyopia. They are right-handed people and all know and agree on the test content before the test.

2.2 Test Content Design

(1) Because this measurement content is basic cognitive ability of crewman, the test on crewman is only conducted in the static environment and there is no test on vehicle in the driving state;
(2) All basic cognitive ability tests are conducted in the daytime and there is no ability test at night;
(3) All subjects have accepted physical examination and their physical conditions and intelligence are normal. Routine examination is not required, including color vision, height, and weight and so on.

In conclusion, the test content is related to the basic abilities of vision, perception, memory, attention thinking, and imagination of crewman. Test items are ultimately identified as: depth perception, spatial perception, sound/light simple reaction time, attention span, attention focus ability.

Table 1 Test equipment and function

No.	Equipment's name	Equipment's function
1	Depth perception tester	Test the visual perception ability and judgment ability of the distant objects
2	Space perception tester	Test the crewman reaction ability When face the complex information task load
3	Sound/light simple reaction time tester	Test the ability to respond to sound and light stimulation
4	Attention span tester	Test focus breadth on the target and work efficiency
5	Attention focus ability tester	Test the ability of continuous attention to the target object

2.3 Test Equipment and Methods

(1) Preparation of test equipment

Test equipment is expressed in the following Table 1.

(2) Test methods

In order to reduce the contingency of test results, every subject is tested for three times and the mean value of measurement results are used as the final result of the measurement. Combined with data processing, analyze various factors that affect the crewman's basic cognitive ability.

3 Test Results and Analysis

3.1 Normal Distribution Test

Through the verification, the kurtosis coefficient and asymmetry coefficient of five parameters are less than 1, so the sampled data of five cognitive parameters conform to the normal distribution [4], and the statistical results are expressed in the following Table 2.

Table 2 The normal distribution test consequence of cognitive parameters

Statistics	Depth perception	Spatial perception	Acousto-optic response		Attention span	Attention focusing
			Optic-response	Acousto-response		
Asymmetry coefficient	0.726	0.961	0.514	0.870	−0.265	−0.658
Kurtosis coefficient	−0.186	0.945	0.054	0.236	−0.622	0.054

3.2 *Statistical Analysis of Test Data*

The specific analysis of the data of each test project is conducted below:

3.2.1 Depth Perception

Depth perception is the perception of people for object distance. This test mainly uses Three Needle Test of Haime Hertz and data analysis by SPSS and judges the threshold of depth perception of subjects under different conditions to get the differences of depth perception. The accuracy of binocular depth perception is better than that of monocular depth perception in general [5]. Experimenter records error value of subject moving from variation stimulus to the standard stimulus from different positions (nearest, near 5, far 5, farthest).

As shown in Figs. 1 and 2, number nearest, near 5, far 5, and farthest in the measurement of binocular depth perception as 1, 2, 3, and 4, respectively. Then conduct one-way analysis of variance. Through four ways of multiple comparisons, there are not significant differences ($P > 0.05$). So in the experiment, the starting position of variation to stimulate has no obvious effect on the depth perception of people.

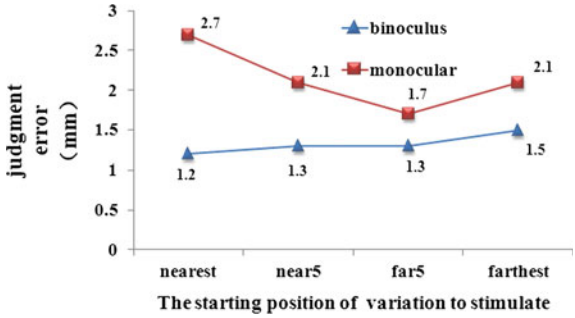

Fig. 1 The comparison of eyes judgment error at different starting position

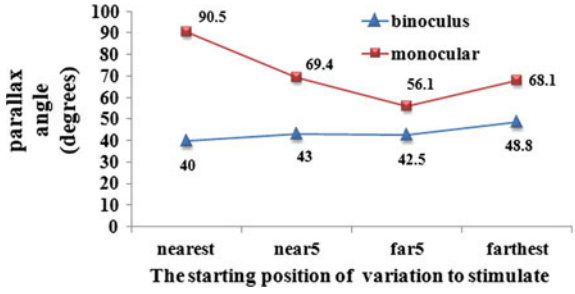

Fig. 2 The comparison of single—eyes angle difference at different starting position

3.2.2 Spatial Perception

The test is mainly used for studying the spatial structure features of stimulus and determining and distinguishing the reaction time of complex graphics. This test designed three different graphics in total, respectively block, bar, and irregular shape. Each graphic appears in two different spatial positions 1 and 2. Spatial perception can be used to evaluate the crewman's reaction ability when facing complex information task load.

The spatial perception parameters calculated with recorded values in the experiment are expressed in the following Table 3.

From the calculation results in Table 4, we can see that compared with block, bar and irregular graphics, the spatial perception ability to block is the highest, followed by bar, and the lowest is irregular shape. When the same graphic appears in the different spatial positions 1 and 2, we can find that the spatial perception ability to the same graphic in the feature 2 is better than that in the feature 1, which is related to the complexity of spatial positions.

3.2.3 Sound/Light Simple Reaction Time

Figure 3 shows the statistical results of different factors. Comparing the data and from the acousto-optic tasks at the same time, we can see that people's response to light is faster than that to sound. Moreover, in three voices, people's recognition capability to high pitch is the fastest, followed by bass and then alto voice. This may be because that alto voice is between high pitch and bass and is easily confused, so it is difficult to distinguish alto voice. Due to the distribution of attention,

Table 3 The calculation results of spatial perception parameter

Pattern type	Mean value	Standard deviation	Maximum	Minimum
Block 1	1.4	0.6	3.0	0.6
Bar 1	1.5	0.5	3.1	0.7
Irregular 1	2.2	0.6	3.6	1.2
Block 2	1.4	0.4	2.6	0.7
Bar 2	1.3	0.3	2.1	0.8
Irregular 2	2.1	0.7	3.6	0.8

Table 4 The calculation consequence of attention span parameters

State	Mean value	Standard deviation	Maximum	Minimum
Non-interfering	8.3	1.8	12.0	4.5
Noise	8.6	1.6	12.0	4.5
Audio	8.5	1.7	12.0	4.5

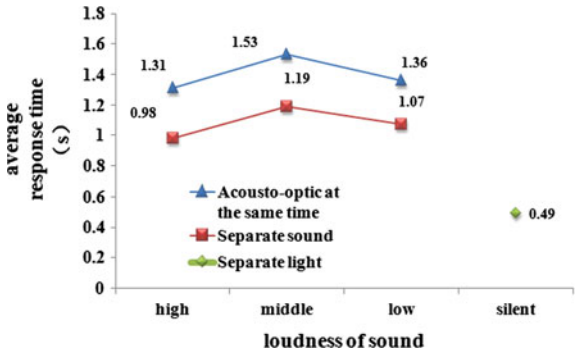

Fig. 3 The data comparison

people's reaction ability to voice or light in the dual task is significantly lower than that in the single task ($P < 0.05$).

3.2.4 Attention Span

Attention span is also called attention range. It refers to the number of objects that people can notice clearly at the same time. The statistical results of attention span data of subjects in the conditions of noninterfering, noise, and audio are expressed in the following Table 4.

Analyze the attention span values in the different working conditions (noninterfering, noise and audio) through one-way variance and then obtain that $P > 0.05$, namely, three conditions have no significant effect on the attention span.

3.2.5 Attention Focus

Attention focus ability can be used to evaluate crewman's ability to pay continuous attention to the target object. In the test, the subjects are divided into three groups and tested according to circle, triangle, and square. Taking environmental state (whether interference or not) and pattern turn (clockwise/anticlockwise) as independent variables, conduct two-way analysis of variance. The statistical results are suggested in the following Table 5.

Table 5 The calculation consequence of Attention parameters (non-interfering + clockwise)

Combination of the independent variables	Mean value	Standard deviation	Maximum	Minimum
Non-interfering + clockwise	0.663	0.14	0.923	0.203
Non-interfering + anticlockwise	0.653	0.150	0.910	0.185
Interference + clockwise	0.653	0.150	0.910	0.185
Interference + anticlockwise	0.671	0.174	0.959	0.180

From the results of two-way analysis of variance, the main effect of environmental state and pattern turn on the attention focus ability is not significant ($P > 0.05$) and their interaction effect is not significant either ($P > 0.05$). In a similar way, the data of attention focus on triangle and square are processed and the same results are obtained. However, from Table 5, people's attention focus ability to the patterns turning anticlockwise is poorer than that to the patterns turning clockwise, which may be related to their daily living habits. Meanwhile, in the noninterfering situation, compared with the condition of interference, it is easier for people to focus.

3.3 *Different Ages, Educational Background, and Regions' Influence on Various Cognitive Parameters*

Conduct one-way analysis of variance of different ages (20–21, 21–22, 22–23, 24–25), educational background (junior high school, technical secondary school, senior high school and professional high school, junior college, and undergraduate course), and regions' (North of China, East of China, Central of China, South of China, Southwest of China, Northwest of China, Northeast of China) influence on various cognitive parameters of subjects. The significant analysis results are expressed in the following Table 6.

From the above results, we can know that besides the significant differences in light reaction ability between subjects with different educational background ($P < 0.05$), other different ages, educational background and regions have no significant effect on various cognitive parameters of subjects, so it can be considered that there is no significant difference in cognitive ability of subjects with different ages, educational background, and regions.

Table 6 The significant analysis consequence of different ages, educational background, and regional's influence on various cognitive parameters

Cognitive parameters	Depth perception ability	Spatial perception ability	Sound/light simple reaction time		Attention span ability	Attention focus ability
			Light reaction	Sound reaction		
Participants attribute						
Age	0.909	0.831	0.497	0.410	0.266	0.547
Education background	0.533	0.275	**0.004** (**<0.05**)	0.053	0.487	0.244
Region	0.098	0.830	0.141	0.647	0.7	0.498

4 Conclusions

This paper collected five cognitive parameters data of 107 people through test methods and obtained the following conclusions through the analysis and discussion of these data:

(1) The starting point of variance to stimulate has no significant effect on people's depth perception;
(2) The crewman's light reaction is faster than sound reaction. And it is found that in three voices, crewman's recognition capability to high pitch is the fastest, followed by bass and then alto voice.
(3) The crewman's spatial perception ability to block is highest, followed by bar, and then irregular shape. Due to the different positions, the complexity of the same graphic is different and the spatial perception ability will be different;
(4) The attention focus on tracking different shapes of patterns of crewmen is different and will be affected by the turning of patterns;
(5) The influence of different ages, educational background, and regions on crewman's various cognitive parameters is not obvious.

The above conclusions have a certain reference value for the design of this special vehicle.

Crewman's basic cognitive ability characteristics have important effect on observation, judgment, decision-making, coordination, and other tasks in the process of control and their influence factors shall be considered in the preliminary stage of vehicle design, so as to more fully play the role of man-vehicle operation efficiency of special vehicle.

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