

An Empirical Study of Occupation Aptitude for Urban Rail Transit Key Operation Post

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Abstract Introduced the professional feature of key positions and occupation aptitude in urban rail transit. Combined with urban rail transit key operation post, a general index of the key post occupation aptitude is established, question banks are designed to form a complete testing system, the structure, design ideology, effectiveness and other related aspects of which are analysed. The result shows that this system could help selecting the candidates who are suitable for the corresponding positions, and are expected to prevent possible human-factor accidents in urban and transit operation after special training.

Keywords Urban rail transit, Key operation post, Occupation aptitude

1. Introduction

The urban rail transit is an important component of the modern city traffic system, it is developing rapidly in China. Till the end of 2012 the total operating range had reached 2377km. [1] Safety is the lifeline of urban rail transit. The aims and principles of Urban rail transit operation management is to convey passengers efficiency and on time based on the safety operation and making the best use of the transport capacity. With the rapid development, recent years see a sharp increase in the number of passengers, and many newly built urban mass transit lines are being extended, the safety management of metro faces a grim station and great challenge.

The safety operation of metro is the focus of the society. The 12.22 accident of Shanghai metro line 1 in 2009, the subway train stagger direction accident of Shanghai metro line 10 in 2011 and the 9.27 accident of Shanghai metro line 10 in 2011, these all caused a great social sensation. There are many factors influencing the accidents, statistical analysis [2] about subway accidents of domestic and foreign in recent years showed that human, vehicles, track, power supply, signal and social disaster are principal factors in metro accidents. The psychological quality, emergency capability and staffs' treatment ability decide the treatment effect of the accident. It is helpful to understand the basic psychological situation, the psychological quality and personality that personnel possess through the occupation aptitude research to the key operation posts such as train drivers, operating dispatchers, station attendants, managers

and employees. It also contributes to choose more suitable candidates and maintain positive and healthy attitude of employees working in the same position for a long time in order to prevent or minimize accidents.

Based on the comprehensive research of literature and actual investigation, the paper include the following phases:

- (1) Define the professional feature of key positions and occupation aptitude in urban rail transit.
- (2) Construct the general index system of Occupation Aptitude for urban rail transit key operation post.
- (3) Design the test question bank that accord with the urban rail transit industry.
- (4) Test question bank and analyse the reliability and other related aspects of it.

2. The Professional Feature of Key Positions and Occupation Aptitude in Urban Rail Transit

The driving dispatcher, train driver and station attendant are the core positions that affect train operation safety in urban rail transit. Driving dispatcher is the core of the transport organization which take significant responsibilities such as train operation organization, improving the service quality of operations, ensure transportation safety, completing the passenger transportation plan and completing the passenger transportation plan. The train driver should be in charge of driving trains, completing the daily operation task, emergency management (including running extra trains, the troubleshooting tasks of main-line train and rescue mission), tilting train and other team work. Station attendants and the station operation organizers take charge of traffic safety, equipment operation management and instrument maintenance in the station.

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In China, aerospace and highway traffic areas all have adequate occupation aptitude test system and testing tool for key post. But the relevant research in urban rail transit is rather weak because urban rail transit is an emerging industry in China.

Side Wang in China railway academy of sciences took the related research about the psychological selection index of high-speed railway drivers. [3] Putting forward test evaluation methods including five pencil-and-paper tests which are Four number and calculation, range of attention, perceptual identification, digit symbol and curvilinear path; two attention quality tests which are 48 digital determine, black and white digital instrument method; 3 sport psychological tests which are psychomotor ability checks and so on.

Tianeng Zheng validated the applicability of five psychological pencil-and-paper test for filtrating railway drivers. [4] Occupation aptitude is a physical psychological quality characteristics that an employee must possess. It forms and develops on the basis of interaction between congenital factor and environment. Occupation aptitude test evaluates physical and psychological quality by a series of scientific evaluation method, to increase the vocational adaption, improve work efficiency and reduce accidents.

Through the research of occupation aptitude for urban rail transit key operation post, rail transit operation enterprise could scientifically select and reasonably use qualified operators to achieve the goal of "Competency-position fit" with the different professional characteristics of different jobs, determine the evaluation criteria and index scientifically, evaluate job seekers' level of career adaptability through testing them. Furthermore personnel dynamic management provides scientific basis for making effective professional training plan by testing and evaluating the operators on regular and building dynamic database of Occupation Aptitude. [5]

3. The Construction of General Index System of Occupation Aptitude for Urban Rail Transit Key Operation Post

Setting the job selection index of pilot, motorist, high-speed train driver and ships driver usually adopts literature analysis method, analogy method, Delphi method, event scene analysis method, etc. Through using these methods mentioned above, it is easy to generalize accurate selection indicator of key position about urban rail transit employees. Through the analysis of relevant research literature and behavioural event interview or questionnaire investigation to the corresponding professionals or experts in the field about the key positions, the work content and requirements, it suggests that the peculiarity strongly linked to operation safety of key position in urban rail transit is mainly psychological quality dimension and it can be used as

a selection basis. Moreover the cognitive processing quality and individual differences are the most important aspects of psychological quality.

Cognitive processing is a psychological process that related to information processing of individual, the speed of processing information, quality (accuracy) were used as the measure indices. [6] And the test to the employees in the urban rail transit key operation post should focus on the image analysis judgment ability, thinking ability, attentional concentration, spatial orientation ability etc.

Analysis and judgement capability is to analyse, distinguish things, to observe and study alone, it is usually tested by graphics etc. [6]

The image thinking ability is to solve problem with audio-visual image and representation, its characteristic is specific iconicity and it's usually tested through graphics speculated which is similar with mental rotation test. [6]

Attention is mainly viewed as the psychological tendencies and the quality of being intent and concentrated. Take driving train for example, it plays a decisive role in traffic safety that whether driver can focus on working during driving. It can be tested through wrong character verification. [6]

Spatial orientation reflects individual mastery of the spatial relationship between itself and the external object. It is usually tested by direction anticipation. [6]

Personality reflects the individual stable attitude to the objective reality and the corresponding habituation behaviour. [6] Different personality individual facing the same stimulus will exist a certain differences in reaction speed, strength, etc. According to the principles of competency-position fit, there will be the emphasis on different characters of competent person in different occupation post on the base of professional characteristics and a sound personality. [7] The personality characteristics related to the urban rail transit key post can be summarized as decisiveness, sensitivity, social boldness, wisdom, stability, persistence, independence, self-discipline, tension, etc. It's on the basis of classic personality test scale and the research conclusion to the driver's personality structure characteristics of the aviation, navigation and other fields.

The general evaluation index system of urban rail transit key post (Figure 1) can be structured by reviewing and summarizing the important aspect in the dimensions above. [8]

This index system contains some single abilities such as attention quality, thought, memory, attitude, emotion, personality quality and so on which embodies work ability that urban rail transit operation post must possess. For example whether the train driver could take notice of train operation state such as the locomotive calibration, the surroundings and all kinds of signal information in due time; whether station attendant could maintain attention for a long time and whether the driving dispatcher could keep greater attention span.

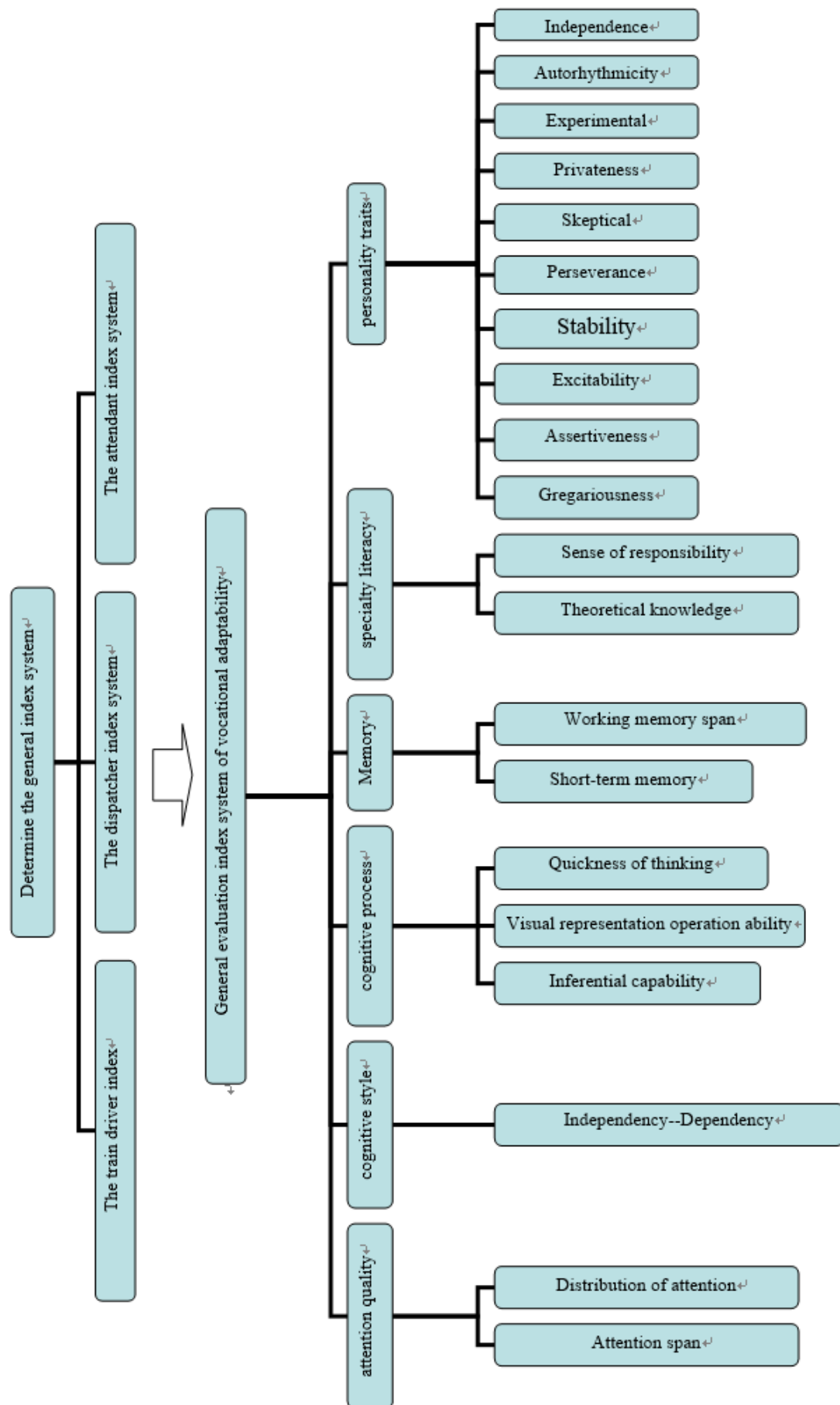


Figure 1. General adaptive testing evaluation index system

4. Around the General Evaluation Index System, Design the Test Question Bank that Accord with the Urban Rail Transit Industry

Table 1. Urban rail transit test architecture form

Number		Expected test quantity	Scheduled time	Test point
Part One	1	10~20	5min	Attentiveness
	2	12~24	5min	Attentiveness
	3	20~40	5min	Thinking
	4	9~18	5min	Cognitive Process
	5	4~8	5min	Memory
	6	10~20	5min	Memory
Part Two	7	40	8min	Professional Test
	8	30	8min	Responsibility
	9	110	14min	Personality Test

According to the evaluation index system model, the test stem was designed combined with the urban rail transit

industry background, rapid calculation, pattern recognition, 16 PF tests, rail transportation, speaking skills and safety knowledge .Test is shown in table 1.

4.1. Design Attention Quality Quiz

Currently the attention test of transportation industry operators is primary focused on two aspects: the attention span and attention distribution ability (See table 2). Researches show that the accident proneness operator is significantly lower than security drivers on the aspect of attention span and attention distribution ability.

4.2. Design Professional Test

The test is centre on the basic knowledge of instrument display, operation panel and rail transit, combined with urban rail transit industry background, the work environment and operating requirements of the following three jobs: dispatcher, train driver and the station attendant. (See table 3).

Table 2. Attention quality test project example

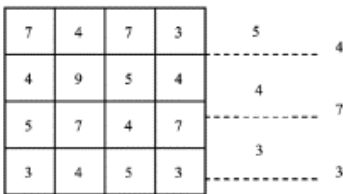


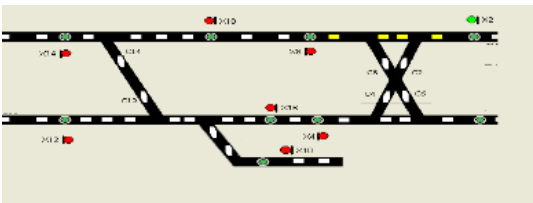
A. Attention span	B. Attention distribution ability
<p>The test objectives: attention span The number of test subjects: 20 questions Test time: 5 minutes The test object: on-the-job personnel of urban rail transit Test score: every question one point Example: Using their own attention span form for testing. Each page has 18 large squares, each big box contains 16 Numbers. There are three Numbers after each big box on the right side of the dotted line. Find the number of digit which is the same with the figures next to the big box on the right side of the dotted line(For example if there are five 4, write five in article 1 on the dotted line in parentheses),in turn, do it, quit until hear "stop" password. This test last for 5min, get one point for each correct point.</p>	<p>The test objective: the allocation of attention The number of test subjects: 24 questions Test time: 5 minutes The test object: on-the-job personnel of urban rail transit Test score: every question one point Example: Test the distribution of attention and transfer capability. According to the principle of "stroop" effect. Present a certain colour of Chinese characters to the participants. Present Chinese character literal with the same or different colour with its meaning. It asks for subjects to judge whether every character's meaning is consistent with the literal colour in a certain period of time. Mark "√" in the beside parentheses if they are consistent, mark "×" if they are not consistent. Get one point for each correct answer.</p>
	

Table 3. The example of professional test project

A. Instrument Display	B. Panel to identify
<p>The test objectives: The instrument quality of train driver The test object: The on-the-job personnel of urban rail transit. Test scoring: Every question one point.</p>	<p>The test objectives: The instrument quality of station attendant The test object: The on-the-job personnel of urban rail transit. Test scoring: Every question one point.</p>
<p>The picture shows:</p> <p>A. Voltmeter B. Ampere meter C. Pressure gauge D. Frequency table</p> 	<p>This diagram shows the red signal, display for the green signal, the direction is all toward the right, there are red signal toward the left.</p> 

5. Question Bank Test

The three positions of Shanghai ShenTong metro group co., Ltd were tested in three tranches, including train dispatchers, train drivers and station attendants. As the result of the test, there are 420 person-times effective tests. Based on the results, the reliability and validity of question bank would be carried on.

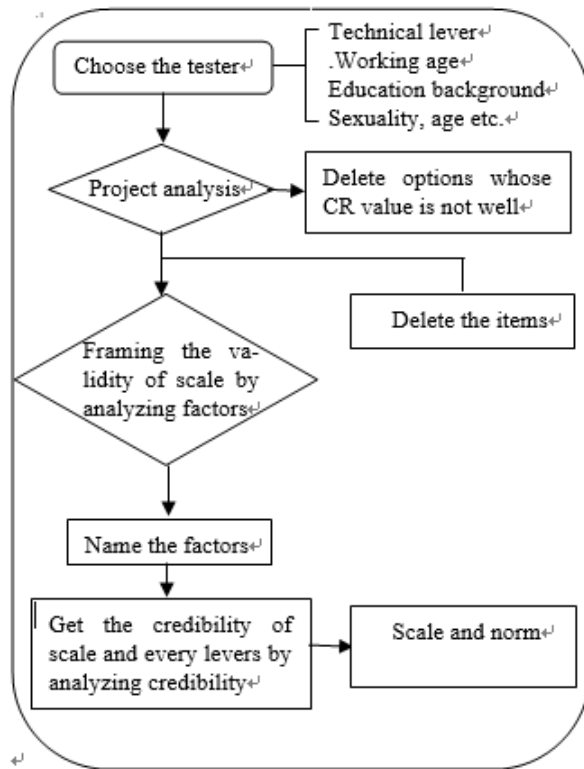


Figure 2. The procedure of tests

Based on the technical grade classification of the examiners, representative samples was chosen according to working years, educational background, working experiences, professional skills and so on. The main way to test would be paper-and-pencil test, and the test time should be 60 minutes. The specific process of the test is shown in figure 2.

The emphasis of the test analysis is topic 1-6 in the first part and topic 1-2 in the second part. The topic 3 in the second part is not analysed because of the reference of the Cattell 16 personality factors test, of which all aspects are already very mature.

5.1. The Project Analysis

The project analysis is based on the testing result, carried on every questions (projects) of the test and aiming to evaluate and filter questions. The analysis index is consist of the difficulty and discrimination of programs. The discrimination is the ability of questions to make a distinction between participants on different levers, which means the discriminability of questions. The higher level of discrimination, the more effective to make a distinction between different participants, the higher valuation of the

question to be used.

It can be realized by using SPSS software and adopting Independent Samples Test. (in table 4).

5.2. The Analysis of Credibility

The credibility means the consistency, stability and dependability of the tests' result. It usually can be represented by internal consistency (the coefficient of internal consistency is α). [9] The higher the reliability coefficient is, the more consistent, stable and dependable the tests' result is. The analysis of credibility on every questions is carried on through SPSS. (It is shown in table 5, 6 and 7)

Table 4. The program analysis of attention quality

A. attention span—Read the table	B. attention allocation—discriminate colours
There are 20 questions in the item. Through the project analysis, a third tests has nice identify degrees ($P < 0.05$). The identify is better in question 6,7,8,9,10,11,13,15,16,17 and 18, and passable in question 2,5,14 and 20.	There are 24 groups, in which there are 5 true or false questions for matching the meaning and colours. There are 120 matching judgments in total. Through the project analysis, two third tests has nice identify degrees ($P < 0.05$). The identify is better in question 2,3,4,5,6,7,8,9, 10,11,12,13,14,15,16,17,18,19,2 2,31 and 41, and passable in question 2,20 and 21.

Table 5. The original results of reliability analysis in attention quality—attention span

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.9292438	0.933714021	60

Table 6. the original results of reliability analysis in attention quality—attention allocation

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.9827639	0.983854237	120

Table 7. Reliability analysis in attention quality

A. attention span—Read the table	B. attention allocation—discriminate colours
After the reliability analysis, all questions have a high reliability because of high coefficient of internal consistency, which of 60 programs is 0.929.	After the reliability analysis, all questions have a high reliability because of high coefficient of internal consistency, which of 120 programs is 0.982.

Through three times tests and analysis, our team revised the questions three times, which have low level aptitude discrimination in assessment tests for the urban rail transit key post. Also improved the way of questions presentation, enhanced the relevancy between the item content and employees' working environment. And place particular emphasis on inspecting the mastery degree of professional knowledge related to positions and form a relatively complete test system.

At the same time of testing questions, the author also analyses the relationship between working age and each individual ability, and the difference on tests among staffs on different positions and education backgrounds.

5.3. The Analysis of Other Related Aspects---The Correlation Analysis of Seniority and Each Test Module

Through the interactive analysis of three factors: the length of service, education and jobs, it can be sure that jobs have significant effect on employees test scores in the overall test combined with the correlation between seniority and the employee's scoring of spatial cognition, short-term memory, attention span, etc. The length of service only has fixed impact on employees' attention distribution and the agility of thinking (see Table 8).

5.4. The Analysis of Other Related Aspects---Post Degree Difference Analysis

Through the single factor analysis of variance, there is difference in scores between different jobs in the first part of the module and the difference is significant, $F=5.288$, $P=0.000<0.05$; It is proved preliminarily that there exists difference between jobs in different modules, even the

workers of different jobs do the same test. In another word, the average scores of different test modules varies with different types of work.

6. Conclusions

6.1. Research Achievement

With the development of rail transit, the pressure of staff in key operation post is growing. It's easy to have a negative psychological impact on person because of the tension, monotonous and mechanical work environment. To enhance the level of urban rail transit operation quality and service, improve the work performance of staff in key position, it is necessary to understand their adaptive situation according to scientific analysis of objective data. The general index system and question bank of occupation aptitude for urban rail transit key operation post is a complete test system, it contains a variety of patterns combined with simplified, pattern recognition, 16 pf tests, the general knowledge of rail transportation, operative skills and safety knowledge. It can help to choose more suitable candidates to prevent or minimize accidents.

Table 8. The correlation between seniority and the scoring of spatial cognition, short-term memory and attention span

		Seniority	The total scores of watch reading	The total scores of character recognition	The total scores of numerical calculation	The total scores of graphics judgment	The scores of character translation	The scores of spatial operators
Seniority	Pearson correlation significance(bilateral) N	1 660	-.045 .249 660	-.210** .000 600	-.099* .016 581	-.041 .319 587	.028 .506 586	-.033 .433 583
The total scores of watch reading	Pearson correlation significance(bilateral) N	-0.45 .249 660	1 919	.365** .000 853	.546** .000 825	.444** .000 838	.281** .000 837	.155** .000 833
The total scores of character recognition	Pearson correlation significance(bilateral) N	-.210** .000 600	.365** .000 853	1 853	.509** .000 825	.426** .000 838	.163** .000 837	.221** .000 833
The total scores of numerical calculation	Pearson correlation significance(bilateral) N	-.099* .016 581	.546** .000 825	.509** .000 825	1 825	.710** .000 825	.231** .000 824	.119** .001 820
The total scores of graphics judgment	Pearson correlation significance(bilateral) N	-.041 .319 587	.444** .000 838	.426** .000 838	.710** .000 825	1 838	.294** .000 837	.127** .000 833
The scores of character translation	Pearson correlation significance(bilateral) N	.028 .506 586	.281** .000 837	.163** .000 837	.231** .000 824	.294** .000 837	1 837	.281** .000 833
The scores of spatial operators	Pearson correlation significance(bilateral) N	-.033 .433 583	.155** .000 833	.221** .000 833	.119** .001 820	.127** .000 833	.281** .000 833	1 833

**remarkably correlative at Level. 01(bilateral)

*remarkably correlative at Level0. 05(bilateral)

Table 9. The correlation between seniority and the score of spatial cognition, short-term memory, attention span, etc

Effect		Value	F	Hypothesis df	Error df	Sig.	Eta-Squared
Intercept	Pillai tracking	.616	126.884 ^a	6.000	475.000	.000	.616
	The Lambda Wilks	.384	126.884 ^a	6.000	475.000	.000	.616
	Hotelling tracking	1.603	126.884 ^a	6.000	475.000	.000	.616
	Roy's biggest root	1.603	126.884 ^a	6.000	475.000	.000	.616
Education background	Pillai tracking	.031	.841	18.000	1431.000	.653	.010
	The Lambda Wilks	.969	.839	18.000	1343.988	.655	.010
	Hotelling tracking	.032	.837	18.000	1421.000	.658	.010
	Roy's biggest root	.015	1.201 ^b	6.000	477.000	.304	.015
Position	Pillai tracking	.043	1.723	12.000	952.000	.057	.021
	The Lambda Wilks	.958	1.731 ^a	12.000	950.000	.046	.021
	Hotelling tracking	.044	1.738	12.000	948.000	.054	.022
	Roy's biggest root	.039	3.113 ^b	6.000	476.000	.005	.038
Seniority	Pillai tracking	.423	1.399	156.000	2880.000	.001	.070
	The Lambda Wilks	.643	1.400	156.000	2794.653	.001	.071
	Hotelling tracking	.462	1.401	156.000	2840.000	.001	.071
	Roy's biggest root	.145	2.681 ^b	26.000	480.000	.000	.127
Education background * Position	Pillai tracking	.048	1.303	18.000	1431.000	.176	.016
	The Lambda Wilks	.952	1.303	18.000	1343.988	.176	.016
	Hotelling tracking	.049	1.302	18.000	1421.000	.177	.016
	Roy's biggest root	.029	2.272 ^b	6.000	477.000	.036	.028
Education background * Seniority	Pillai tracking	.472	1.322	186.000	2880.000	.003	.079
	The Lambda Wilks	.609	1.046	186.000	2813.341	.381	.079
	Hotelling tracking	.523	1.332	186.000	2840.000	.002	.080
	Roy's biggest root	.166	2.569 ^b	31.000	480.000	.000	.142
Position * Seniority	Pillai tracking	.128	1.042	60.000	2880.000	.388	.021
	The Lambda Wilks	.878	1.327	60.000	2493.728	.003	.021
	Hotelling tracking	.133	1.049	60.000	2840.000	.375	.022
	Roy's biggest root	.062	2.967 ^b	10.000	480.000	.001	.058
Education background * Position * Seniority	Pillai tracking	.219	1.135	96.000	2880.000	.177	.036
	The Lambda Wilks	.799	1.139	96.000	2697.921	.172	.037
	Hotelling tracking	.232	1.141	96.000	2840.000	.167	.037
	Roy's biggest root	.088	2.649 ^b	16.000	480.000	.001	.081

6.2. Research Prospect

Control training cost of human resources to some extent by using the occupation aptitude test system; train, educate and manage the key operation post staff according to the test result to prevent accident.

Form a scientific testing tool which possess discrimination and be credible according to the research. It lays the foundation of developing software about individual or comprehensive ability training and simulation facility in traffic safety training field for urban rail transit.

The research is applied to human resource selection in

Shanghai ShenTong metro group co., Ltd. Meanwhile provide a reference to the national urban rail transit industry.

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