

The Development of a Driving Aptitude Test for Personnel Decisions

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Abstract—Business and government have a long history of using psychological aptitude tests for hiring, performance evaluation, and research. This paper reports the development of a Driving Aptitude Test (DAT) for selecting capable candidates with related sensorimotor abilities and aptitudes required for safe and quality driving. It was developed based on the various common perceptual and motor skills considered necessary for driving, such as mechanical knowledge, spatial analysis, emergency preparedness and handling ability as well as personality. This test may be useful as a predictor of the candidates' future job performance effectiveness.

Index Terms—Aptitude test, drivers, occupational test

I. INTRODUCTION

A. Aptitude Tests

Test of aptitude is defined as 'intended to measure cognitive or sensorimotor skills and abilities through psychometrically standardized or functionally structured samples of significant behaviours' [1]. An aptitude test serves as an assessment tool for measuring the latent learning capacity that a person has over and above the level that they have already achieved. They help determine what maximum we can expect from a person. Through measurement of the applicant's knowledge, skills, abilities, and personality which are the product of cumulative life experiences acquired over time, we can hopefully know the test taker's potential ability for learning and predict his or her future job performance [2].

B. The Application of Aptitude Tests

Aptitude tests can be classified into two categories according to the nature of the content. One is to test the general cognitive ability which we often refer to intelligence test; the other is to test the special ability, such as spatial visualization, verbal expression, mathematics, and music aptitudes [3]. A single aptitude test measures just one ability domain while a multiple aptitude battery provides scores in several distinctive ability areas.

Tests provides information about an individual's knowledge, skills, abilities and other characteristics that are useful for predicting school performance and personnel decisions, such as admission, hiring, placement, promotion, training, career counseling, and succession planning [4].

In education settings, administrators, teachers, school

psychologists, and career counselors use tests to make a variety of educational decisions, including admission, grading and career decisions. Career aptitude tests are given to high school students as vocational or career guidance to help them make reasonable career choices according to their personal traits and the needs of society [5]. Colleges and universities also use aptitude tests to predict the academic achievement of a candidate to facilitate admission decisions [6]. Examples like the Scholastic Aptitude test (SAT) and the Graduate Record Examination (GRE).

In organizational settings, human resource professionals and industrial/organizations psychologists use psychological tests to make decisions such as whom to hire for a particular position, what training individuals need, and what performance an individual will receive. Companies and governments use aptitude tests to determine whether an individual has the skills that are necessary to perform a particular job and whether the job and applicant are well matched. Aptitude tests can also be used to identify employee strengths and performance capabilities, opportunities for development, and ultimately to determine their training needs [2]. Professions make use of aptitude tests to see whether or not the applicant is suitable for the line of work required. Examples of aptitude tests used in professions include the Law School Admission Test (LSAT), which is designed to measure skills that are considered essential for success in law school. The UK Clinical Aptitude Test (UKCAT), which measures mental ability in four distinct domains (Quantitative Reasoning, Verbal Reasoning, Abstract Reasoning and Decision Analysis) was introduced in 2006 as an additional tool for the selection of medical students [7].

C. Tests for Assessing Special Occupational Aptitudes

Organizations begun to develop vocational aptitude tests for personnel selection during the 1940s[2]. The use of special aptitudes tests grew rapidly up to World War II and then accelerated due to the pressing need to select highly qualified candidates for very demanding and specialized jobs such as pilots, flight engineers, and navigators for the war effort [8].

The General Aptitude Test Battery (GATB) and the Armed Services Vocational Aptitude Battery (ASVAB) are two popular special aptitudes tests that are relevant to occupation [3]. In 1947, the General Aptitude Test Battery (GATB) was developed by the U.S. Department of Labour in response to the growing need for an instrument for use in occupational counseling. The GATB attempts to measure a wide range of aptitudes, from general intelligence to manual dexterity, including both verbal and task performance measures. The

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Armed Services Vocational Aptitude Battery (ASVAB), which is probably the most widely used test in existence in U.S., is administered annually to over a million individuals to determine qualifications for enlistment in the United States armed forces [9]. The ASVAB includes 10 subscales measuring coding speed, knowledge of general science, shop, automotive, and electronic information, as well as verbal and mathematical ability [10].

Outside the military, tests are used by a variety of professionals for many different purposes in a number of different settings. The Minnesota Clerical Test and the General Clerical Test are tests that measure a highly specific clerical function. They are especially useful in assessing clerical, numerical and verbal abilities needed for routine clerical activities [11]. The Bennett Mechanical Comprehension Test and the Revised Minnesota Paper Form Board Test are two popular measures of mechanical ability [12], [13]. They are most appropriately used for jobs in industries such as manufacturing, production, energy, and utilities, and in occupations such as automotive mechanic, engineer, installation, maintenance, repair, skilled trade, technical sales, transportation trade, and equipment operator [14]. The PC-based WOMBAT(TM) test is used as a selection device for pilots and air traffic controllers, and it is a good predictor of situational awareness ability, which is an underlying ability associated with exceptional piloting skill [15]. The New South Wales Fire Brigade recently introduced a pre-employment assessment test as the basis for selecting the most suitable fire-fighters, with the aim of reducing the risk of work related injuries by only selecting employees best able to perform job tasks [16].

D. Need for Aptitude Test for Drivers

It is well known that the persons' attributes and vocational interests differ in measurable ways with differences having a bearing on the potential for successful performance on many jobs. Among the different types of aptitude tests, the most common type is the intelligent quotient (IQ) test, which purports to measure high-level cognitive ability. However, IQ tests have been overused in personnel selection process and are found to be only suitable for jobs requiring high-level cognitive activity or learning ability [17]. It is obvious that such abilities are less important to successful job performance of a vehicle driving task. Moreover, tests for jobs such as, secretary, engineer, accountant, fire-fighter, and military personnel, have been developed, but there is no special aptitude test available for occupational driver selection. Different careers and occupations require different abilities and skills for successful job performance. The tests for fire-fighters, secretaries or engineers apparently cannot identify the critical performance requirements of the drivers' job. Also, although the forenamed special aptitude tests have good reliability and validity, and have been widely used, a problem is that with rapidly changing times and the advent of high technology, some items in these tests may be out of date.

It is thought by some that, if only the fittest and strongest applicants are employed, the possibility and rate of work related injuries would be reduced [16], [18]. An UK online fleet driver assessment, which aims to pre-test driver

behavioral attributes, knowledge of driving regulations and perceptions of hazards has been found to be effective to identify, target and reduce occupational road safety risks [20]. Inoue [19] suggested that psychological aptitude tests for drivers can help to establish a safer transportation environment and carried out a set of aptitude tests on 1,484 train operation staff with a wide age range of 18 to 63. The results of analysis of the correspondence between the aptitude test results and the staff members' history of railway accidents or transport disruption showed that the accident experience was negatively related to the number of correct answers of the tests. It was concluded that the aptitude tests should be used as an effective tool for personnel selection and assessment with the objective of preventing accidents caused by human error.

E. Driving Task Analysis

The match between the car drivers' capabilities and the demands of the actual driving task determines the outcome in terms of a more or less safe driving behaviour [18]. Driving is a very complex task which requires the execution of driving behaviour whilst always being alert to the driving environment. It is a process of interaction between the driver, the vehicle and the environment [21]. The professional driver needs a variety of different kinds of skills to successfully perform the task of driving. Excluding the purely intellectual skills involved in driving from consideration, the task components vary along a continuum from those with mainly perceptual demands, like monitoring road traffic conditions and fare payments, evaluating the headways in car-following situations, to task components with substantial motor demands like operation of control devices for starting and stopping of cars, pressing of buttons for giving alarms, and operating of other devices for opening and closing of doors [21], [22].

The preliminary task analysis of drivers conducted in this study helps identifying the critical performance requirements of the drivers' job and suggests the types of knowledge, skills, and abilities that might be important to effective performance on the job. These attributes in turn suggest the selection tests that are likely to be good measures of target personal characteristics. Four aptitudes - mechanical aptitude, spatial aptitude, emergency preparedness and handling ability and personality are identified. Mechanical aptitude is the ability to understand mechanical principles, devices, and tools, and some aspects of everyday physics [23]. Simple hand tools such as spanners and wrenches, as well as more complex systems such as pumps and internal combustion engines are standard tools for various professional drivers. The ability to understand and use mechanical devices is critical for professional drivers. Spatial ability is also very important for drivers, as this refers to cognitive and perceptual abilities with space and shapes and can be defined as the ability to visualize in three dimensions [24]. Driving requires the ability to read maps, recognize terrain, and be aware of one's direction. Individuals with poor spatial ability are more likely to become confused and lost than those with higher spatial abilities.

Moreover, for professional drivers, the potential capacity to handle emergencies such as accidents and a good service

attitude are also desirable. The level of emergency preparedness and handling ability will directly influence the severity of passenger casualties and vehicle damage in an accident. Most accidents can be directly attributed to human factors [19], [25]. Apart from driving skill, driving style is the other important human components in driving [25]. Driving style refers to the ways drivers choose to drive or drive habitually, which is influenced by motives, attitudes, personality traits, and lifestyle. Also, a good service attitude is needed by people who work in service industries.

The assessment of aptitude is particularly important for drivers, which contributes to the transportation safety and security. At present there are insufficient tools effective for driver aptitude measurement. Based on previous aptitude tests, the Driving Aptitude Test described here was developed for transportation companies to select qualified professional drivers.

II. DRIVING APTITUDE TEST (DAT)

A. Purpose

The purpose of this study is to develop an aptitude assessment battery to provide an aid to transportation companies for the selection and recruitment of prospective drivers. The Driver Aptitude Test (DAT) is designed to measure aptitudes, qualities and traits essential for occupational drivers, and was developed based on the various common perceptual and motor skills considered necessary for the task of driving. It may also be useful as a predictor of the candidates' future job performance effectiveness.

B. Description

The DAT is a paper and pencil, multiple-choice format group test. It has been shown that the scores on this type of paper-and-pencil aptitude tests can be used to provide reasonably accurate predictions of job performance on driving tasks and help identifying persons with high potential for success as quality drivers [26]. Most of the aptitude tests in current use are multiple-choice tests with questions having either four or five options.

The Driving Aptitude Test (DAT) may help to determine whether an applicant has the necessary skills and abilities to perform the job, and to ensure a reasonable match between the individual and job. With reference to some common aptitude and personality tests, the DAT is basically a power test with generous time limits and consists of 20 subscales, which includes 344 questions testing knowledge and abilities, and 40 questions examining the patterns of thoughts, feeling and behaviour that help to predict how the respondents are likely to act or react under different circumstances. The language of the DAT is Chinese. The test users may randomly select a combination of questions from the prepared battery for use.

C. Content and Scales

The DAT measures a complex set of abilities composed of four primary facets or constructs:

1) Mechanical concepts

Six subscales (Reading Scales, Fundamental Arithmetic, Tool Knowledge, Interpreting Symbols, Mechanical

Knowledge, and Mechanical Insight) are used to assess the mechanical concepts. Questions in this category are set to measure the aptitude for or ability to learn about how things work. They measure knowledge of some widely known and understood mechanical and scientific concepts. Questions consist of simple diagrams about practical and everyday situations like gears, pulleys, hand tools, control devices, gravity, and basic electricity. Candidates usually have to figure out what is happening in the picture and what will happen. To some extent, one would expect that extensive experience with machines and tools would improve performance on this test.

2) Spatial ability

Measures of spatial abilities include 11 subscales: Eye Hand Coordination, Reading Maps, Visual Comparison, Line Following, Series Reasoning, Hidden Figures, Block Counting, Rotated Blocks, Understanding Patterns, Matching Pieces and Parts, and Spatial Analysis. Questions in this category are set to measure the ability of candidates to think about how flat (2D) and solid (3D) objects can be flipped, rotated, assembled, turned over, folded, and dismantled. For example, some questions ask the candidates to mental rotation of shapes, solving mazes, imagining the folding and unfolding of sheets of paper, and finding hidden figures. Some questions are based on maps. Drivers are expected to be able to figure out the shortest routes to make jobs easier and faster.

3) Emergency preparedness and handling ability

Questions in this category are set to measure the ability of the candidates to prepare and handle emergency situations arising from various types of hypothetical road accidents. The types of emergencies include passenger fall or illness, vehicle breakdown, vehicle collision, vehicle fire, and vehicle rollover. The applicants must demonstrate that they can recognize and avoid various risks. Through answers to these questions, we can assess the test taker's ability to stay calm and prevent injury or loss of life in a traffic accident.

4) Personality test

This set of test is basically for assessing and evaluating personality. The respondents will be asked to answer true or false questions or indicate their preference choices amongst a set of items but there are no right or wrong answers. Two subscales, Safety Attitude and Customer Service Attitude, are included in this category. Questions will be set to measure traits like tolerance, confidence, anger proneness, stress coping abilities, willingness to obey directives, and attitudes related to customers. The personality measure score will be used for providing supplementary information for screening out highly undesirable potential employees.

The above mentioned knowledge and abilities are assessed by 20 subscales. The name and feature of each subscale is presented in Table 1. Twenty sample questions for the twenty subscales are shown in Appendix 1.

D. Scores

A composite score will be compiled for the whole test. Except section S (Personality Analysis - Safety Attitude) and section T (Personality Analysis - Service Attitude), all questions carry equal marks. The total score of section A to R is calculated by adding the scores from the subscale A to R.

The score ranges from 0 to 371, which indicate the total ability of mechanical, spatial and emergency preparedness and handling.

Regarding the Personality Test, assessment scores for the choices will be compiled to provide information about the traits and qualities of respondents with regard to particular measures. The score of subscale S is from 0 to 200, and is classified into five ratings. The lower rating indicates a lower stress level and risk of being in a crash. According to the scores (0-100) in section T, the respondents are classified into three groups of high, middle and low rank. The higher rank indicates a better service attitude. Candidates with a low score would need to consider whether they would be an asset to a service business.

TABLE I. THE SUBSCALES INCLUDED IN THE DAT

Subscales	Description
A. Emergency and Handling	test the ability to stay calm and prevent injury or loss of life in a traffic accident
B. Reading Scales	test the ability to read precise values from analog and digital displays
C. Eye Hand Coordination	this test includes letter symbol coding, inspection tests, examining objects, and mazes
D. Reading Maps	test ability to imagine a 3D situation on a 2D piece of paper.
E. Fundamental Arithmetic	test basic math skills needed on the job
F. Tool Knowledge	tests recognition of and usage of common tools
G. Visual Comparison	candidates are presented with a number of similar objects and asked to decide which of the different similar objects are identical
H. Interpreting Symbols	test ability to discover a relationship, recurring pattern, or continuing pattern in a symbol series
I. Line Following	similar to following wires, pipe, or tubes in some industrial problems, candidates are asked to follow lines from one place to another on a diagram
J. Series Reasoning	test ability to reason in a series or sequence of numbers, which may entail addition, subtraction, etc.
K. Hidden Figures	test ability to find given geometric shapes inside more elaborate and complicated figures
L. Block Counting	test the ability to count lots of blocks that can or cannot be seen
M. Rotated Blocks	test ability to mentally spin a 3D figure around and envision what it will look like from a new angle
N. Mechanical Knowledge	test general mechanical aptitude
O. Mechanical Insight	test ability to make calculations involving tools and mechanical equipment
P. Understanding Patterns	test ability to transform objects in 2D into 3D and vice versa
Q. Matching Pieces and Parts	test ability to mentally flip flop, turn, and piece together shapes
R. Spatial Analysis	test ability to take several separate spatial views and mentally combine them into a 3D solid
S. Safety Attitude	test personality of safety attitude, stress and risk level
T. Customer Service Attitude	test attitudes related to customers

E. Administration of the DAT

The battery is designed for ease in group administration, in settings such as classroom. All information was self-reported. Candidates are given a time limit for answering the questions in the DAT. It is thought that most candidates are able to finish the questions within the time limit. All the answers should be marked on the Answer Sheet, which can be scored by hand or machine. Test takers are told that they may only

mark one answer to each question. Two or more answers will score no marks.

A cut off scoring point can be determined for selection of drivers. A person having composite score above the cut off point will be considered eligible for selection to a driving position. Regarding the Personality Test, although it does not have pass or fail scores, assessment scores for the choices made by the respondents will be compiled to provide information about the traits and qualities of respondents with regard to particular measures.

F. Future work for validation

The aim of test is to assign numbers (i.e., test score) to individuals so that some attributions of the individual are faithfully reflected by some properties of the number assigned. Statistics can be used to describe test core. The validity of test cores is critically important in determining whether a test can provide good measurement.

Tests are used to make decisions. It is important that the test measures what they say they are measuring. Although DAT is well developed, the prospective validation process is yet to be done. Some methods are proposed for validating the Driver Aptitude Test [27].

First, the relationship between the test score and safety indices needs to be examined. The DAT is supposed to be able to predict the drivers' future job performance. The safety indices could be the number of accidents, transport disruptions, and work injuries, or rating estimates from supervisors on such factors as ability and personality. One possible way to approach validation is to divide the participates into three groups of high, middle and low rank according to their total scores, and to create an almost equal number of members in each group [20]. Then, calculate the Accident Index (AI) in each group using the computation formula (1):

$$AI = \frac{a_x \div a}{n_x \div n} \times 100 \quad (1)$$

Where a_x = the number of people in group x who have caused accidents, a = the total number of people who have caused accidents, n_x = the number of people in group x, and n = the total number of people.

If the test is valid, the Accident Index (AI) should have a negative relationship with the test score. Moreover, the difference in the Accident Index (AI) between the three groups should be significant by the chi-square test. According to the test score, we can predict the performance of the driver.

Second, we can divide the subjects into accident involvement and no-accident involvement groups and then compare the total test scores between the two groups. The mean score of the accident group should be lower than the no-accident group, and the difference is significant by the T-test. If this is the case, then the test can be used to assist selection of drivers so as to minimize the risks of danger related to driving and contribute to improved safety.

Third, performance on the test should be able to discriminate professional drivers from a control group of non-drivers. The mean score of the professional drivers should be higher than the non-drivers, and the difference

should be significant by T-test. If so, then the DAT may be used for personnel selection in order to identifying persons with high potential to become successful as quality drivers.

III. CONCLUSION

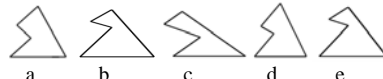
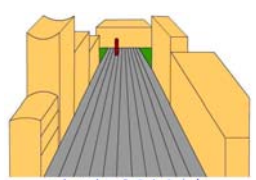

The present research aimed to design a driving aptitude battery for vocational selection in transportation companies. The DAT is a battery of 21 subscales, which measures mechanical aptitude, spatial aptitude, emergency preparedness and handling ability as well as personality.

The primary use of the DAT is as a selection tool for occupational drivers on the basis of the test scores. Test scores are aids for decision makers; they are not the only basis for personnel decisions. Hogan noted that ‘although they can be useful, people, not tests, make the final personnel decisions’ [4]. The decision makers may use a variety of other evaluations and assessments to reach conclusion. Tests are only parts of the process that contributes to the employment decisions.

APPENDIX

APPENDIX 1. TWENTY SAMPLE QUESTIONS FOR THE TWENTY SUBSCALES.

Scales	Sample Questions
A	When you are involved in an accident, which of the following behavior is correct? A. Stay calm. B. Ensure the casualty's safety. C. Call the police. D. Using warning signs to remind the cars behind. E. All of the above
B	The scale in the fuel contents gauge is A. 100% B. 90% C. 50% D. 30% E. 20%
C	In the maze, where is the exit? A. A B. B C. C D. D E. E
D	According to the following map, Model House Estate is on the east of a building, and on its south is Cheong Lee. Then what is the name of this building?

	A. MLC Millennia Plaza B. Lok's Industrial Building C. Stan Hope House D. Harbour Plaza E. Tung Kin
E	1/4 is equivalent to: A. 10% B. 25% C. 40% D. 50% E. 70%
F	The tool shown in the right would most likely be used to: A. Storage of drinking water B. Clean cars C. Decorate D. Fight fire E. Storage of sand
G	In the following options, find the two choices that are exactly the same (Note: the pattern can not be rotated).  A. a, c B. b, d C. e, d D. b, e E. c, d
H	The traffic sign on the right means: A. Silent zone B. No goods vehicles C. Use of horn D. No mini-buses (public light buses) E. No Green minibuses
I	In the following map, the Cylinder is on line  A. b B. c C. d D. e E. f
J	Which numbers should be in the vacant positions? 10 3 9 5 8 7 7 9 6 ___ ___ A. 11, 5 B. 10, 5 C. 10, 4 D. 11, 6 E. 12, 4
K	 Which picture shown below hides the above picture?

	<p style="text-align: center;">A B C D E</p>
L	<p>How many cylinders are there in the figure?</p> <p>A. 9 B. 10 C. 11 D. 12 E. 13</p>
M	<p>Which block is different from others?</p> <p style="text-align: center;">A B C D E</p>
N	<p>In physics, what is the unit for force measurement?</p> <p>A. Hess B. Newton C. Volt D. Joule E. Pascal</p>
O	<p>Which block is the heaviest?</p> <p>A. a B. b C. c D. b and c</p>
P	<p>Which shape can you make form the following pattern?</p> <p style="text-align: center;">A B C D</p>
Q	<p>Which one is the missing part of the picture in the left?</p> <p style="text-align: center;">A B C D E</p>
R	<p>Which of the plan graphs cannot be expressed by the above space graph?</p> <p style="text-align: center;">A B C D</p>
S	<p>In the following options, which is the most effective way to reduce traffic accidents?</p>

	<p>A. There are better safety facilities in road works, such as wider straight road, clearly safety signs. B. Design a more advanced car, for example: a more effective braking system, or tires with stronger traction C. Strengthen penalties for violations. D. To make drivers aware of the high cost caused by accidents.</p>
T	<p>If you find two passengers are arguing about a sear, you will:</p> <p>A. Ignoring, because it is their business. B. If circumstances permitted, will see if their disputes can be resolved, and try to flatten their emotions. C. Will know the whole story and do judgment.</p>

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