Driving Aptitude Test (DAT): A New Set of Aptitude Tests for Occupational Drivers

[1]Alan H.S. Chan and K. Chen

***Abstract*—Aptitude tests have been widely used in business and government for hiring, performance evaluation, and research. There are many kinds of aptitude assessments some of which test special abilities in very demanding and specialized tasks and occupations, such as pilots, flight engineers, and navigators. But many of the aptitude tests currently in use are out of date and there is no specific test for occupational drivers. This paper reports the development of a Driving Aptitude Test (DAT) to meet this need.**

***Index Terms*—Aptitude test, occupational drivers**

I. Introduction

A. Aptitude Tests

Business and government have a long history of using psychological aptitude tests for hiring, performance evaluation, and research. Test of aptitude is 'intended to measure cognitive or sensorimotor skills and abilities through psychometrically standardized or functionally structured samples of significant behaviors' [1]. An aptitude test is an assessment tool for measuring the latent learning capacity that a person has over and above the level that they have already achieved. 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].

According to the nature of the content, aptitude tests can be classified into two categories: one is the general cognitive ability type of test which we often refer to intelligence; the other is the special ability test, 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.

B. The Application of Aptitude Tests

Schools, business, and government agencies often use aptitude tests to predict performance or success, or to estimate the extent to which an individual will profit from a specified course of training. 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. Colleges and universities also use aptitude tests, like the Scholastic Aptitude test (SAT) and the Graduate Record Examination (GRE), to predict the academic achievement of a candidate to facilitate admission decisions. 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; and the Commission on Graduates of Foreign Nursing Schools (CGFNS) which is required by a majority of U.S. State Boards of Nursing and is used to predict success on the National Council Licensure Examination-Registered Nurse examination (NCLEX-RN).

C. Tests for Assessing Special Occupational Aptitudes

During the 1940s, large-scale programs were developed to design vocational aptitude tests for personnel selection and prediction of how successful a person would be for an occupation [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 [4]. Generally, the tests were for the psychomotor, mechanical, clerical, artistic and psychological aptitudes demanded for various occupational domains.

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 for use in making employment selection decisions in government agencies [2]. GATB attempts to measure a wide range of aptitudes, from general intelligence to manual dexterity, including both verbal and task performance measures. The Armed Services Vocational Aptitude Battery (ASVAB), which is probably the most widely used test in existence, is administered annually to over a million individuals to determine qualifications for enlistment in the United States armed forces [3].

Outside the military, clerical workers represent the most tested occupational category. The Minnesota Clerical Test

[1] The authors are with City University of Hong Kong, Hong Kong. (*corresponding author – Alan H.S.Chan, phone: 2788 8439; E-mail: alan.chan@cityu.edu.hk; K. Chen, E-mail: kechen2@student.cityu.edu.hk).

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and Differential Aptitude Test are tests that measure a highly specific clerical function. They are especially useful in assessing clerical competence, such as speed, accuracy, and grammar [5]. The Bennett Mechanical Comprehension Test and the Revised Minnesota Paper Form Board Test are two popular measures of mechanical ability. 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 [6]. The Accounting Orientation Test has shown some promise in measuring accounting skills. 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 [7]. 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 [8].

D. Need for Aptitude Test for Drivers

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. 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 need 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. Kaplan [5] noted that 'the individual will not take the test as seriously if most of the items represent items no longer found in a modern workplace'.

It is thought by some that, if only the fittest and strongest participants are employed, the possibility and rate of work related injuries would be reduced [8]. Inoue [9] 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.

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 [10]. 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 [10, 11]. The ability to understand and use mechanical devices is critical for professional drivers. 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. Mechanical aptitude is the ability to understand mechanical principles, devices, and tools, and some aspects of everyday physics. 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. Individuals with poor spatial ability are more likely to become confused and lost than those with higher spatial abilities. Driving requires the ability to read maps, recognize terrain, and be aware of one's direction. Moreover, for professional drivers, the potential capacity to handle emergencies such as accidents and a good service attitude are also desirable. 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 test to provide an aid to transportation companies for the selection and recruitment of prospective drivers. The purpose of the assessment is 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. 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 was 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. 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.

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C. Content and Scales

The kinds of knowledge and abilities to be measured in the DAT are:

1) 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.

2) Spatial ability

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 think about folding paper patterns into solid shapes and some ask to think about blocks hidden by other blocks.

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.

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. 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

The total score of subscale A to R was calculate by adding the scores from the subscale A to R. The scores ranged from 0 to 371 which indicated the total ability of mechanical, spatial and emergency preparedness and handling. The score of subscale S is from 0 to 200, and was classified into five ratings which indicated the applicant's stress level and risk of being in a crash. According to the scores (0-100) in section T, the respondents were classified into three groups of high, middle and low rank. The higher rank indicated a better service attitude.

E. Administration of the DAT Tables

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. A cut off scoring point can be determined for selection of drivers. A composite score will be compiled for the whole test. 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.

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

F. Future work for validation

Although DAT is well developed, the prospective validation process is yet to be done. Some methods are proposed for validating the Driver Aptitude Test.

First, the relationship between the test score and safety indices needs to be examined. The safety indices could be the number of accidents or transport disruptions, work injuries and 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 category [12]. 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

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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.

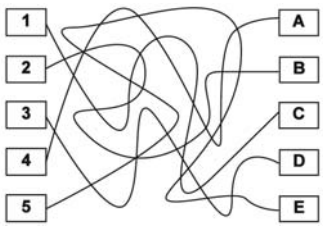
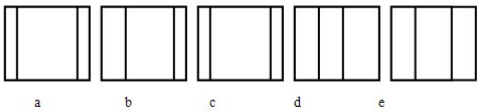
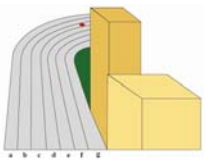
If the test is valid, the accident index should have a negative relationship with the test score, and the difference in the accident indexes of the three groups should be significant by the chi-square test. According to the score, we can predict the performance of the driver.

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 higher 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.

APPENDIX

APPENDIX 1. TWENTY SAMPLE QUESTIONS FOR THE TWENTY SUBSCALES.

Scales	Sample Questions
A	If you are driving vehicle and unfortunately involved in a traffic accident, which of the following should not be done? A. Take care of the injured, and warn other motorists. B. Turn on the hazard warning lights. In the evening, use the headlamps lighting the scene. C. Stop the vehicle if there were casualties or vehicle or property damage. D. If there were no deaths, injuries or no serious damage, the vehicle should be moved to a nearby safe place. E. Because there were no injuries, you can speed up to quickly left the scene.
B	What is the speed shown in the right picture? A. 90 kilometres / hour B. 90 miles / hour C. 95 kilometres / hour D. 95 miles / hour E. 100 kilometres / hour 
C	In the following picture, which letter on the right is connected to number 3? 
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	10000 meters is equivalent to: A. 0.1 kilometres B. 1 kilometres C. 5 kilometres D. 10 kilometres E. 100 kilometres
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, b B. a, c C. b, d D. b, e E. d, e
H	The traffic sign on the right means: A. No buses or coaches B. No goods vehicles C. No motor vehicles D. No mini-buses (public light buses) E. No Green minibuses 
I	In the following map, the Oval is on which line?  A. b B. c C. d D. e E. f

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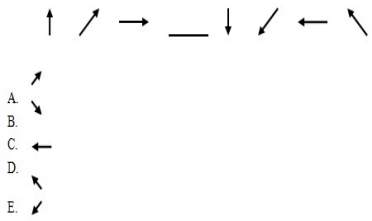
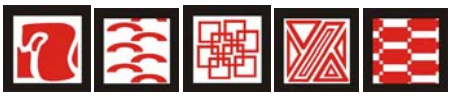
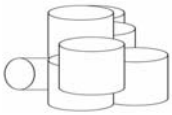
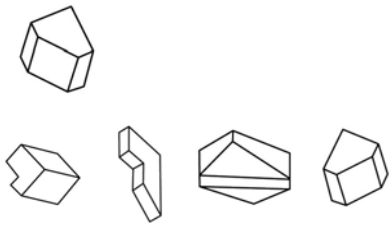
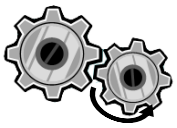
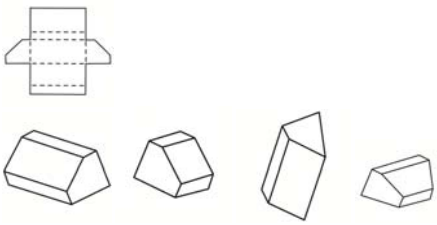
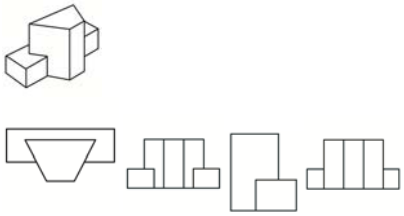
J	Please choose a right picture on the lines: 
K	 Which picture shown below hides the above picture?  A B C D E
L	How many cylinders are there in the figure?  A. 6 B. 7 C. 8 D. 9 E. 10
M	Which figure is exactly the same as the above one?  A B C D
N	What is the basic principle of car seat belts? A. Inertia B. Momentum C. Centripetal force D. Simple harmonic motion E. Newton's Third Law
O	If the pinion gear turns as shown, in what directions will the large gear turns?  A. Clockwise B. Counter clockwise C. None of the above
P	Which shape can you make form the following pattern?  A B C D

Q	Which one of the five traffic signs can you make from theses three pieces?  A B C D E
R	Which of the plan graphs can not be expressed by the above space graph?  A B C D
S	In the following options, which is the most effective way to reduce traffic accidents? 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.
T	If you find two passengers are arguing about a sear, you will: 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.

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