

Evaluating Multi-dimensional Abilities of Bus Drivers

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Abstract. As professional drivers typically were driving more time on the road than general drivers, the relationship between age and multi-dimensional driving abilities of bus drivers should be of concern to transportation officials tasked with improving workplace safety. This study examined the multi-dimensional abilities of bus drivers through their responses to a self-assessment questionnaire and on tests of hand-eye coordination, balance ability and hand grip strength. Among sixteen participants recruited from an urban bus company, gender and age significantly correlated with self-rating evaluation, hand-eye coordination tests and grip strength capabilities. Recommended of this study were conducted the self-rating evaluation, hand-eye coordination, balance ability and hand grip strength in the process of licensing exams test to assess driving qualification, renew driving license particularly. Bus drivers should also regularly take these ability tests to assess their driving quality and ability. In this way, an employer can accurately assess drivers' multi-dimensional abilities and verify whether they meet the demands of their jobs.

Keywords: Psychological assessment · Occupational drivers · Driving abilities · Safety management · Aging

1 Introduction

Driving is the primary mode of transportation in many countries and the driving ability is intimately associated with health-related quality of life [1]. Further, driving is one of the most complex tasks that humans perform on a regular basis, placing significant demands on sensory, perceptual, cognitive, and motor capabilities. However, age-related declines in these capabilities negatively affect driving performance [2]. Several eye diseases that including glaucoma have been associated with increased risk for motor vehicle accidents [3]. With an aging population, it is estimated that over 58 million people will have open angle glaucoma by the year 2020. Although it is clear that vision is essential for driving, it is not clear what vision skills and tests are actually more closely related to the ability of driving safely [4]. Gentzler and Smither [5] have

developed test batteries to identify at-risk older drivers. Wood et al. [6] reported that age-related changes in sensory abilities, such as visual impairment, can potentially influence the ability to perform visual tasks and simultaneous dual tasks not directly related to vision. Indices of unsafe driving performance, including increased crash risk and impaired on-road driving performance, have been reported in older drivers with cataracts and in those drivers with reductions in specific visual functions including visual fields, motion sensitivity, contrast sensitivity and visual attention [7].

In Taiwan, in addition to measurements of cognitive abilities and motor skills, a physical examination is required when drivers apply for an occupational license, and it includes an evaluation of visual abilities (visual acuity, visual field, and night vision), heart functioning and blood pressure. Drivers younger than 60 years are required to retake the physical examination every three years to maintain license validity while those 60 years and older need to be re-examined every year. However, cognitive abilities and motor skills of professional drivers are not re-examined as part of the license renewal process in either age group.

Gentzler and Smither [5] have used various criteria to assess driving performance, including (1) the selective and divided attention abilities, processing speed, memory, accuracy, reaction time as cognitive functions; (2) the range of motion, strength in the extremities such as the foot, mobility as physical functions and (3) static visual acuity, contrast sensitivity, visual field, visuospatial ability, dynamic acuity, useful field of view as visual function. Professional drivers were usually driving more time on the road than general drivers. The purpose of the present study was to examine the multi-dimensional abilities of professional bus drivers using self-assessment tests, hand-eye coordination tests and grip strength and balance ability test. In addition, the study wanted to establish appropriate assessment mechanisms to promote safer driving and, thus, safer roadways.

2 Methods

2.1 Participants

This study recruited sixteen bus drivers that including 10 males and 6 females from an urban bus company in Taipei city. The mean age of the male drivers was 46 years old, the mean height was 170.5 ± 6.5 cm, and the mean weight was 73.9 ± 8.8 kg. The mean age of the female drivers was 43 years old, the mean height was 159.5 ± 2.1 cm, and the mean weight was 63.9 ± 10.4 kg.

2.2 Self-rating Questionnaires

The self-rating form is designed to help driver examine driving ability to keep driving safety from American Automobile Association Foundation for Traffic Safety (version 2010). The self-rating tool provides facts and suggestions for safe driving. Although the questionnaire was designed for people over the age of 65, it is important to recognize all driver limitations and to be aware of everything a driver can do to be safe on the road.

Items 1–13 were scored as ‘always or almost always,’ ‘sometimes,’ or ‘never or almost never’ and questions 14 and 15 were scored as ‘none,’ ‘one or two,’ or ‘three or more’. Subjects checked the box next to each appropriate response. The questionnaires were scored by (1) writing the check mark totals recorded in the squares on the question form in the square to the right; (2) writing the check mark totals recorded in the triangle on the question form in the square to the right; (3) multiplying the number in the square by 5; (4) multiplying the number in the triangle by 3; and (5) adding the results of steps 3 and 4 together. Lower scores (0–15) indicate safer drivers and scores ranging from 16 to 34 indicate that the driver is engaging in some practices that need improvement to ensure safety. Scores higher than 35 mean the driver is engaging in too many unsafe driving practices and should stop driving.

2.3 Hand-Eye Coordination Test

The hand-eye coordination test comprised the dynamic stability test and the electrical-mirror tracer test. During the dynamic stability test, a stabilimeter (TKK 1211, Takei Scientific Instruments Co., Ltd., Niigata city, Japan) attached to the arm of the participant is used to monitor stability as the subject traces a groove on a panel with a stylus in a specified period of time (Fig. 1 left). When the stylus makes contact with the edge of the groove, a buzzer is sounded. The paths of the tracer include linear paths, curved paths, and square paths.

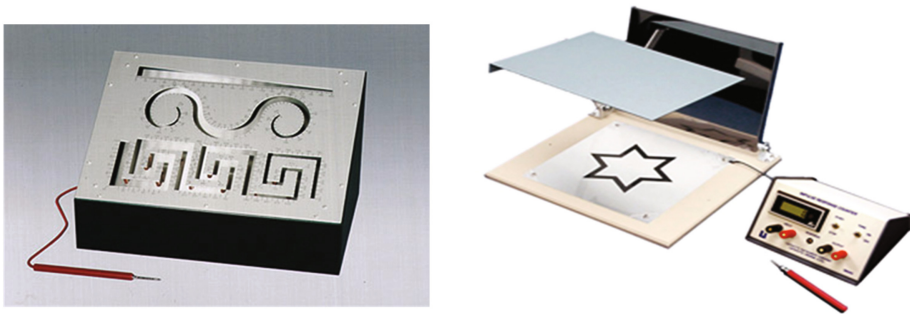


Fig. 1. Dynamic stability test and auto-scoring mirror tracing test

The mirror tracing apparatus is a standard psychology laboratory instrument that has been used in a variety of experimental studies (Model 58042A, Lafayette Instrument Co., Indiana, USA). The subject’s task is to trace, by looking in a mirror, a pattern which is on the board. The subject has to trace between the lines with an electric pencil without touching the sides of the star. Errors are tallied by counting the number of times the subject touches the lines. In addition, total time required to trace the complete pattern is recorded (Fig. 1 right).

2.4 Grip Strength and Balance Ability Test

Maximum grip strength across a 50 mm span was measured using a digital grip-strength dynamometer (TKK 5401, Takei Scientific Instruments Co., Ltd., Niigata city, Japan). Measurements ranged from 5.0–100 kg and the minimum measurement unit was 0.1 kg (accuracy, ± 2.0 kg). Each measurement continued for approximately 3 s, or until the participant could no longer resist while standing with forearm straight down. The participants rested at least 60 s between trials, and the highest value of three strength measurements was considered to be the subject's maximum strength.

The balance ability test was conducted with both eyes closed while standing on one foot (left foot and right foot were tested separately). The time it took to touch the floor with the other foot was recorded. A standing time greater than one minute was considered to indicate good balance ability.

2.5 Experimental Procedures

The study was approved by the Research Ethics Committee of the researcher's institution. Subjects participated in the experiments after providing informed consent with respect to the investigative procedures. First, subjects need to rate their driving ability by self-rating questionnaires. Further, hand-eye coordination test involved the dynamic stability test and auto-scoring mirror tracing test. Finally, grip strength and balance ability test were conducted. A minimum rest period of 5 min or more, if required, was provided between trials. During the rest periods, participants were asked to stay seated, relaxed and to remain silent.

2.6 Data Analysis

A randomized complete design with between-subject factors (age and gender) was used in this study. In addition, age could be divided into three groups, i.e. younger groups (<30 years old) middle groups (31–54 years old) and older groups (more than 55 years old). Further, multivariate analysis of variance (MANOVA) was utilized to identify significant differences between conditions for AAA self-rating questionnaire, hand-eye coordination test and grip strength and balance ability test. Statistical significance was set at a probability level of 0.05.

3 Results

3.1 The Self-rating Analysis

The mean scores of AAA self-rating form among gender and age showed in Table 1. Mean scores of self-rating is higher in male drivers (26.8) than in female drivers (12.8). From interpretation of score denoted that the lower score (0 to 15) is the safer driver, and female drivers are fine status. Furthermore, Table 2 revealed the decision condition of drivers' ability based AAA self-rating form. There are five and four male drivers in caution and unsafe condition and three female drivers in caution condition, respectively. Drivers are engaging in some practices that need improvement to ensure safety.

These drivers should be re-education for driving safety. There are 33% male drivers really upset affecting their driving, and less half male drivers always get eye exams and check the medications affecting their driving ability. Administrative staff should be noticed the drivers beginning to experience some natural age-related changes and drivers adjust their driving habits to keep driving safely. Checking visual ability regularly and consulting for taking medications or drugs could be provided in company.

Table 1. The mean scores of AAA self-rating form among gender and age

Variables		Mean	Standard deviation	Min	Max
Gender	Male	26.8	15.6	5	60
	Female	12.8	9.5	0	27
Age	<30	32.5	7.7	27	38
	31–54	24.0	18.1	3	70
	>55	11.0	9.8	0	22

Table 2. Meaning of scores based on self-rating form among gender and age

			Gender		Age		
Levels	Scores	Decision	Male	Female	≤ 30	31–54	≥ 55
Level 1 safe driving	0 to15	Qualified	2	4	0	4	2
Level 2 caution	16 to 34	Unqualified	5	3	1	5	2
Level 3 unsafe driving	35 and over	Unqualified	4	0	1	3	0

3.2 Hand-Eye Coordination Tests, Balance Ability and Hand Grip Strength

Table 3 shows the results of the hand-eye coordination, balance ability, and hand grip strength tests by gender and age. The results of MANOVA showed that the gender effects had found (Pillai’s trace = 0.97, $F(12, 1) = 13.2$, $p < 0.05$, partial $\eta^2 = 0.96$) on 0.95 of statistical power ($\alpha = 0.05$, two-tail). Female drivers needed more time to accomplish tracing tasks. In contrast, male drivers made more mistakes than female drivers while tracing circular ($F(1, 12) = 7.35$, $p < 0.05$) and square paths using the left hand ($F(1, 12) = 5.2$, $p < 0.05$). For the electrical mirror tracer test, female drivers made a greater number of mistakes and took longer to accomplish these tasks than male drivers ($F(1, 12) = 6.76$, $p < 0.05$). Balance ability on either foot did not differ significantly between genders. However, hand grip strength differed significantly between genders ($F(1, 12) = 21.66$, $p < 0.001$).

There were no significant differences in number of mistakes made while tracing straight, circular and square paths. However, elderly drivers spent more effort to accomplish these tasks. In contrast, younger drivers made more mistakes than older drivers in tracing the square path. Drivers required more time to accomplish mirror tracings for both hands with incrementally advancing age. There was no significant

Table 3. Results of hand-eye coordination tests, balance ability and hand grip strength among gender and age

Tests	Variables		Gender		Age		
			Male	Female	≤ 30	31–54	≥ 55
Dynamic stability tests	Straight path	Right hand mistakes	2.1	0.9	2.3	1.6	1.5
		Left hand mistakes	2.1	1.3	2.5	1.8	1.6
		Right hand time	4.6	6.6	2.5	5.7	5.6
		Left hand time	3.4	4.3	2.2	3.3	5.7
	Circular path	Right hand mistakes	3.9	2.4	2.3	3.2	4.3
		Left hand mistakes	5.2	1.8	7.0	3.1	5.1
		Right hand time	4.6	6.4	2.8	5.1	6.7
		Left hand time	5.1	4.5	3.2	4.4	6.8
	Square path	Right hand mistakes	7.5	4.0	7.5	6.3	5.5
		Left hand mistakes	11.2	7.3	17.0	8.7	9.3
		Right hand time	16.5	18.4	11.1	16.8	21.1
		Left hand time	19.3	16.4	14.5	16.1	26.2
Electrical-mirror tracer		Right hand mistakes	42.3	56.7	50.8	36.4	75.9
		Left hand mistakes	26.8	77.8	27.8	47.0	47.3
		Right hand time	94.5	140.4	71.1	102.4	153.4
		Left hand time	62.8	132.7	33.8	98.3	84.6
Balance ability		Right foot	14.7	15.0	14.1	14.0	17.6
		Left foot	11.6	14.3	12.2	13.5	13.5
Hand grip strength		Right hand (kg)	33.3	21.2	32.5	28.0	30.0
		Left hand (kg)	38.0	23.0	36.0	31.8	33.5

difference between men and women in accomplishing the circular tracing tasks. In contrast, the time to accomplish the task increased with age. There were no significant differences in balance ability or hand grip strength between age groups.

4 Discussion

Driving is one of the most complex tasks that humans perform on a regular basis, placing significant demands on sensation, perceptual, cognitive, and motor capabilities. However, age-related declines in these capabilities negatively affect driving performance. This study examined multi-dimensional abilities for professional bus drivers. Self-rating of driver behavior is the first tool for evaluation of driving performance. The study applied the AAA self-rating evaluation to examine the performance of urban bus drivers. This simple self-rating form was easily completed by the drivers and showed

the condition of the driver relative to driving safety. Results of the analysis showed that male bus drivers had markedly higher unsafe scores than female drivers.

Gender and age are significantly associated with the capabilities of hand-eye coordination, balance ability and hand grip strength. Although typically a male occupation, bus driving is undergoing a process of feminization [8]. Thus, buses are not only providing the service of transportation, but also need to be comfortable and safe for both passengers and driver. Tse et al. [9] consolidated the key research on the occupational health of urban bus drivers since the 1950s. Stressors for bus drivers include poor cabin ergonomics, rotating shift patterns and inflexible running times. Greater attention to salient moderating and mediating variables in the stressor–strain relationship is featuring in more recent research. Based on our results, this study suggest that professional driving license testing should consider the different among gender and age of the drivers and should set different visual ability assessment criteria for each group.

5 Conclusion

Recommended of this study were conducted the self-rating evaluation, hand-eye coordination, balance ability and hand grip strength in the process of licensing exams test to assess driving qualification, renew driving license particularly. Bus drivers should also regularly take these ability tests to assess their driving quality and ability. In this way, an employer can accurately assess drivers' multi-dimensional abilities and verify whether they meet the demands of their jobs. On the other hand, some assistant facilities should be provided. For example, power-assisted steering wheel for female drivers, camera or blind area detection alarm for elderly drivers.

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Advances in Smart Vehicular Technology,
Transportation, Communication and Applications
Proceedings of the First International Conference on
Smart Vehicular Technology, Transportation,
Communication and Applications, November 6-8, 2017,
Kaohsiung, Taiwan
Pan, J.-S.; Wu, T.-Y.; Zhao, Y.; Jain, L.C. (Eds.)
2018, XV, 404 p. 16 illus., 10 illus. in color., Hardcover
ISBN: 978-3-319-70729-7