Development of the Korean stroke drivers' screening assessment: A Pilot Study for adapting road sign recognition subtest

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Abstract

Driving is an important activity of daily living affected by the motor and cognitive deficits after stroke. However, there are no standard practices of generally accepted and valid screening tools for stroke patients in Korea. Thus, This paper presents the development progress of an adapted version of the Stroke Drivers' Screening Assessment (SDSA), which is a set of cognitive tests to evaluate fitness to drive in stroke patients. We adapted the original United Kingdom (UK) version of the SDSA to make it suitable for use in Korea by replacing all UK-specific traffic situations and road signs with their Korean equivalents. In order to apply the pass/fail SDSA equations of the original UK version of the SDSA, the road sign recognition subtest of K-SDSA was carefully investigated with healthy older drivers and revised the road scenarios to match with their UK peers' scores. Final validity of the pass/fail SDSA equations were conducted by comparing the stroke patients' driving performance in a driving simulator.

Keywords: Screening Assessment, Driving Rehabilitation, Stroke Patients, Rehabilitation Program

Introduction

For a person with disability who has difficulty to access public transportation, driving a car is an essential ability for the independent living and securement of mobility rights. Loss of driving ability is associated with a poorer quality of life [1-3] and return to driving facilitates community reintegration [4].

However, a driver with cognitive impairment may produce an increased risk of crashes. McGwin et al. reported that drivers who crashed were more likely to have had a stroke compared with drivers not involved in crashes [5]. But, most of these individuals resume driving without any formal evaluation of their driving ability because there is no appropriate driving assessment method for stroke patients in South Korea.

The Stroke Drivers' Screening Assessment (SDSA) battery, which was developed in the United Kingdom, has been reported as predictive of the driving performance of stroke patients [6, 7], and its validity in measuring attention and executive abilities to be critical for driving has been demonstrated [8].

The SDSA has been adapted for use in Nordic countries with moderate (62%) [9] to moderately high accuracy (78%,) [10] in predicting driving performance for stroke patients and in the US with high accuracy, i.e. 100% for stroke and 82% for Parkinson disease [11]. However, the SDSA battery has not been adapted in South Korea because traffic rules and road signs are different between the UK and Korea.

The aim in this study was to investigate the potential for predicting driving performance of Korean stroke patients using the SDSA and modify the SDSA battery to make it suitable for use in Korea.

Stroke Drivers Screening Assessment

Stroke Drivers Screening Assessment Overview

The Stroke Drivers Screening Assessment (SDSA) was developed as part of a research program on driving skills after stroke at the University of Nottingham [12]. The SDSA consists of four test components i.e., Dot Cancellation for assessing concentration, Square Matrix Direction and Square Matrix Compass for visuospatial capacity, and Road Sign Recognition for non-verbal reasoning ability. Each task is conducted the following procedure.

Dot Cancellation

There are 625 groups of dots arranged in 25 rows. Some of the groups have 3, 4, or 5 dots on a paper. Participants are instructed to cross out all groups of only 4 dots in a maximum of 15 minutes.

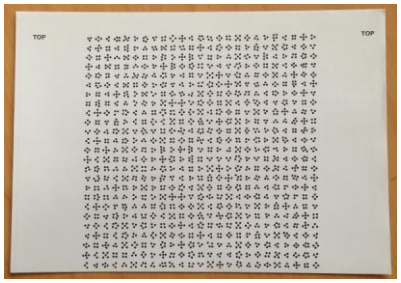


Figure 1. Dot cancellation

Park, M., Son, J., and Shin, H., " Development of the Korean stroke drivers' screening assessment: A Pilot Study for adapting road sign recognition subtest", The Japanese Journal of Ergonomics, Vol. 49, pp. 463-466, 2013.

Square Matrix Direction

This test involves correctly placing 16 cards, each of which contains 2 vehicles traveling in different directions, into 16 squares arranged in a 4 by 4 matrix in a maximum of 5 minutes (see Figure 2).

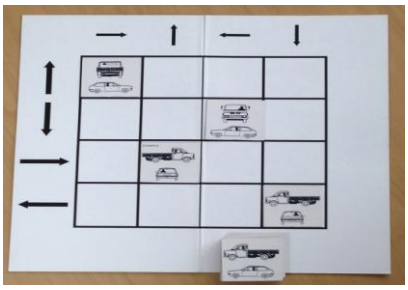


Figure 2. Square matrix direction

Square Matrix Compass

This test requests to place 16 cards out of 29 rotary cards, each of which contains 2 vehicles traveling in and out an roundabout in 8 directions (see Figure 3), into 16 squares arranged in a 4 by 4 matrix in a maximum of 5 minutes.

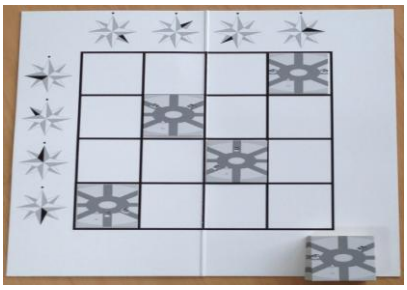


Figure 3. Square matrix compass

Road Sign Recognition

In this test, a stroke patient is asked to match the best road sign from a selection of 19 road signs to 12 traffic situations, e.g., railroad crossing, construction zone, etc. (see Figure 4), in a maximum time of 3 minutes.

Figure 4. Road sign recognition

Adaptation to Korean Traffic Conditions

There are large differences between Korean and UK traffic environments. Two countries have opposite driving directions, i.e. right handed for UK and left handed for Korea. Thus, the position of the driver behind the wheel was changed from right to left in the square matrix direction cards as shown in Figure 5.

There is no change in the Dot cancellation test and the Square Matrix Compass test. However, many road signs and traffic situations were changed in the Road Sign Recognition test. Examples of a UK road sign and its Korea equivalent are shown in Figure 6. All changes were done in consultation with one of the developers of the original SDSA and Korean experts in traffic and road signs. Prior to implementation, the modified version of the SDSA was pilot tested with 5 healthy older drivers in Korea.

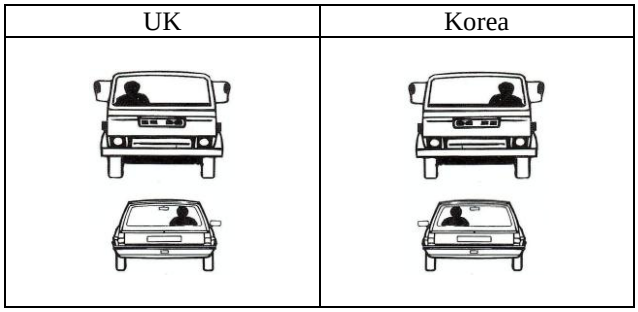


Figure 5. Comparison of the UK and Korean vehicle cards of Square Matrix Direction

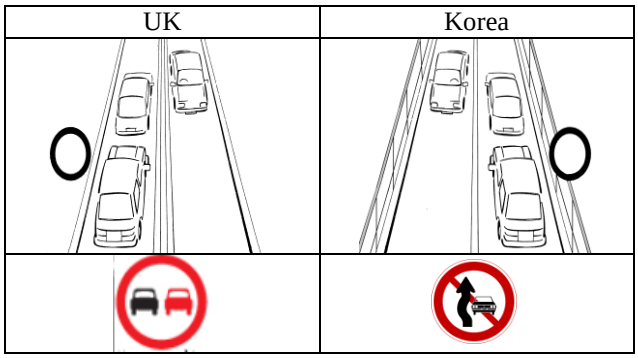


Figure 6. Comparison of the UK and Korean road scenario and sign in Sign Recognition Test

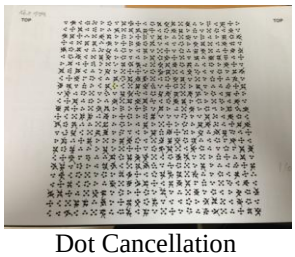
Method

Participants

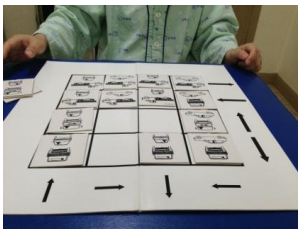
To conduct a pilot study with the Korean SDSA, 7 participants with stroke were recruited from the Kang Hospital at Daegu city, South Korea. All participants met the following inclusion criteria: had a stroke, drove before stroke, drove on average more than 3 years and scored 24 points or greater on the mini mental status exam.

Procedure

The experiment was conducted in a quiet room and administered in a one session. Following informed consent and completion of a questionnaire, participants began the sequential experiments for about 30 minutes (see Figure 7): Dot Cancellation (Max. 15 min.), Square Matrix Direction (Max. 5 min.), Square Matrix Compass (Max. 5 min.), and Road Sign Recognition (Max. 3 min.).



Dot Cancellation



Square Matrix Direction

Square Matrix Compass

Road Sign Recognition

Figure 7. SDSA test procedure with a stroke patient

Assessment Method

The pass (1) and fail (2) equations of the original SDSA are:

(Dot Cancellation Test time*0.012) + (Dot Cancellation Test false positive*0.216) + (Square Matrices Direction*0.409) + (Road Sign Recognition*1.168) – 13.79 (1)

(Dot Cancellation Test time*0.017) + (Dot Cancellation Test time false positive*0.035) + (Square Matrices Direction *0.185) + (Road Sign Recognition *0.813) – 10.042 (2)

The participant is predicted to pass when the "Pass" score of a participant is higher than the "Fail" score and vice versa. The predicted results from the SDSA equations were compared with each stroke participant's simulator-based driving performance to evaluate their driving ability.

Results

Prior to start the main experiments with the stroke patients; preliminary experiments were conducted with Korean healthy elderly participants using an adapted version of SDSA. As shown in Table 1, the Korean healthy older group was relatively younger that their peers in the UK. Comparing the performance of SDSA, the Korean healthy elderly group was faster but less accurate than their UK peers in the dot cancellation test. In the square matrices directions and the square matrices compass, the healthy older participants in Korea had slightly lower performance than the UK older group. The scores of the road recognition test in the Korean healthy older drivers are also slightly lower than the UK peers. However, the overall performance of the Korean stroke patients was superior to the UK patients, because this study included mild stroke patients only.

As shown in Table 2, the Korean version of SDSA (K-SDSA) predicted stroke participants' driving ability with 71.4% accuracy (sensitivity = 66.7%, specificity = 75%) when comparing with the simulator-based performance. Although the K-SDSA had given wrong prediction for two participants, it showed similar accuracy to the other countries that had adopted the original SDSA.

Discussion

The stroke cohort had no apparent impairment as assessed by the MMSE (participated more than 24 point), but four of seven failed in the SDSA test. However, one of the participants with cognitive deficits passed in the simulator-based driving performance

Table 1. Comparison of UK and Korea SDSA

	UK				Korea			
	Healthy elderly		Patients with Stroke		Healthy elderly		Patients with Stroke	
	Median	IQR	Median	IQR	Median	IQR	Median	IQR
Age	67	64-72	73	66.5-76.0	61	59-61	47	47-57
# of years driving	45	40-50	50	41-57	30	24-35	20	15-20
SDSA								
Dot Cancellation								
- Time	407	347-504	504	418-715	372	348-353	489	462-611
- Errors	7	5-5	23	8-36	20	20-22	12	8-33
- False positives	0	0-0	0	0-1	0	0-0	0	0-2
Square Matrices Directions	32	32-32	13	7.0-24.5	28	20-28	30	20-32
Square Matrices Compass	27	20-30	10	4.5-14.5	26	20-27	21	14-21
Road Sign Recognition	7	6-10	3	1.5-5.0	6	5-8	5	3-5

Table 2. Stroke patients` SDSA and simulator driving Performance (n=7)

	Driving Performance pass/fail	
SDSA pass/fail	Fail, n(%)	Pass, n(%)
Fail, n(%)	3 (42.9%)	1 (14.3%)
Pass, n(%)	1 (14.3%)	2 (28.6%)

evaluation. Though the small sample sizes make it difficult to interpret the results precisely, the results suggest that the participants had only very mild attention and executive function impairments for which they adequately compensated during simulated driving. Three stroke participants also failed the simulator evaluation and SDSA. However, one stroke participant passed the SDSA assessment but failed the simulator-based evaluation. We can speculate that this participant did not adjust well to the driving simulator or only physical harm not cognition damage.

This is the first attempt to adapt the SDSA for use with a Korea-based population. Preliminary findings demonstrated that the K-SDSA may have the potential to accurately predict driving ability after stroke. The small sample size is a major limitation of this preliminary study. Thus, the predictive accuracy of the K-SDSA in this study should be considered as an indication of the potential usefulness of the SDSA. For the future study, larger studies are needed to better assess the predictive accuracy and validity of the K-SDSA.

Acknowledgments

This research was supported in part by Daegu Gyeongbuk Institute of Science and Technology (DGIST) Research Program of the Ministry of Science, ICT and Future Planning (MSIP) (Project No. 13-S-01), and Establishment Program of Industrial Original Technological Base of the Ministry of Trade, Industry and Energy (MOTIE) (Project No. M0000009).

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References

[1] Legh-Smith J., Wade D.T. and Langton HR.:Driving after a stroke. Journal of the Royal Society of Medicine, 79:200–203, 1986

[2] Marottoli R.A., de Leon C.F., Glass T.A. et al.: Consequences of driving cessation: decreased out-of-home activity levels. Journals of Gerontology – Series B Psychological Sciences and Social Sciences, 55: S334–S340, 2000

[3] Novack T.A., Labbe D., Grote M. et al.:Return to driving within 5 years of moderate severe traumatic brain injury. Brain Injury, 24: 464–471, 2010

[4] Rapport L.J., Bryer R.C. and Hanks R.A.: Driving and Community Integration After Traumatic Brain Injury. Archives of Physical Medicine and Rehabilitation, 89: 922–930, 2008

[5] McGwin G., Sims R.V., Pulley L.V. and Roseman, J.M.:Relations among chronic medical conditions, medications, and automobile crashes in the elderly: a populationbased case–control study. American Journal of Epidemiology, 152: 424–431, 2000

[6] Nouri F.M. and Lincoln N.B.: Predicting driving performance after stroke, British Medical Journal, 307: 482-483, 1993

[7] Devos H., Akinwuntan A.E., Nieuwboer A., Truijen S., De Weerdt W.:A systematic review and meta-analysis on predictors of fitness to drive after stroke. Neurology, In Press, 76(8): 747-56, 2010

[8] George S. and Crotty M.: Establishing criterion validity of the Useful Field of View assessment and Stroke Drivers' Screening Assessment: comparison to the results of on-road assessment, American Journal of Occupational Therapy, 64: 114-122, 2010

[9] Selander H., Johansson K., Lundberg C., Falkmer, T.: The Nordic stroke driver screening assessment as predictor for the outcome of an on-road test, Scandinavian Journal of Occupational Therapy, 17(1): 10-17, 2010

[10] Lundberg C., Caneman G., Samuelsson S., Hakamies-Blomqvist L., Almkvist O.: The assessment of fitness to drive after a stroke: The Nordic Stroke Driver Screening Assessment, Scandinavian Journal of Psychology, 44: 23-30, 2003

[11] Akinwuntan AE., Gantt D., Gibson G., Kimmons K., Ross V., Rosen P., Wachtel J.,: The United States Version of the Stroke Drivers' Screening Assessment Battery: A Report of Preliminary Findings, 241-247, 2011

[12] Lincoln N.B., Radford K.A., Nouri F.M.: Stroke Drivers` Screening Assessment Revised Manual, University of Nottingham, UK, 2010