On-road driving behavior characteristics of patients with brain injury

（ドライブレコーダーからみた脳損傷者の実車運転における行動特徴）

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Contents

要旨

【背景と目的】

脳損傷者の運転行動の評価方法については，実車運転時の観察評価が妥当とされるが，評価者の主観に左右されやすいという欠点がある（Novack et al., 2006）．近年，ヒューマンエラーが関係するとみられる事故が多発することを背景として，国土交通省は映像記録型ドライブレコーダー（以下，ドライブレコーダー）による事故防止マニュアルを作成した．ドライブレコーダーとは，運転中の事故・ヒヤリハット場面を映像及び車体センサー情報として記録し専用解析ソフトを用いることで，事故・ヒヤリハット場面の統計分析，運転操作・車両挙動データから事故防止を目的とした教育等に役立てるものである．本研究ではドライブレコーダーを用い脳損傷者の運転行動特徴を客観的に明らかにすることを目的とした．

【方法】

（1）対象者

本研究では，医学的・法的に運転再開を許可された脳損傷者 26 名を対象とした．本研究における実車運転評価は，脳損傷者が安全に運転を再開するための実践的な支援として行われたため，比較対照群は一般健常者ではなく，日常的に模範運転を指導している教習指導員 26 名を年齢・性別をマッチングさせて設定した．

（2）実施手順

実車運転評価は，事前に定めた約 5 ㎞（所要時間約 15 分間）の市街地を走行した．脳損傷者が走行した後，教習指導員は同一車両を用いて同一コースを運転した．助手席に補助ブレーキが装備されたオートマチック式教習車両を使用し，脳損傷者が運転する際は，助手席に教習指導員が乗車し安全対策を講じた．車両にはドライブレコーダー（データテック社製　SR-Video®）をシュガーソケット部分，2 台の付属小型カメラをフロントガラス上部に設置した．運転中の車両挙動データを電子媒体に記録した．

（3）測定項目

① 注意挙動

ドライブレコーダーは走行中に閾値（前後加速度閾値：0.3G，旋回速度閾値：0.36 deg/sec）を越える急な速度・加速度の変化が発生した場合，注意挙動として自動検出した．注意挙動は，急ブレーキ，急カーブ，急アクセルの 3 種類であった．挙動発生時は，挙動の発生前後約 20 秒間の運転映像（前景・運転者）を付属小型カメラ 2 台が自動録画した．

② 運転診断ソフト（データテック社製　安全の達人II®）

アクセル，ブレーキ，停止，右左折，スムーズの計 5 項目を運転診断ソフトが自動的に点数化した（各 20 点，計 100 点，高得点は安全な運転であることを示す）．

③　Driving Assessment Scale（DAS）

運転中は2台のビデオカメラ（ソニー社製　Action Cam）で運転者および前景映像を記録した．研究者はビデオ映像を 2 回観察し，Driving Assessment Scale（DAS）（Novack et al., 2006）を採点した．DAS には，走行，進路変更，交差点・標識，駐車，運転態度，判断に関する全 23 項目の観察評価項目が設定されており，3 段階評定，合計46点満点で採点する（0点：常に～しばしば問題を生じる．1点：いくつかの場面で問題を生じる．2点：全ての場面で問題はない）．

（4）分析方法

脳損傷者の運転行動特徴を明らかにすることを目的に，注意挙動発生前後の自動録画映像を確認し，挙動の内容，挙動が発生した場面を観察評価した．運転診断ソフトの点数，DAS の点数を脳損傷者と教習指導員の 2 群間で比較した（Mann-Whitney U 検定）．統計解析は SPSS.ver25 を用い，有意水準は 0.05 未満とした．

【結果】

脳損傷者は全 12 件（8 名）の注意挙動が発生した．最も多く発生した挙動は急ブレーキであった（7 件，7 名）．挙動が発生した場面は，見通しの悪い一時停止交差点での右折場面（1 件），信号のある交差点での右折場面（3 件），信号のある交差点での左折場面（5件），片側二車線道路で駐車車両を追い越すための進路変更場面（3件）であった．教習指導員は 2 件の急ブレーキ挙動が発生したが，録画映像で挙動

に至る過程を確認したところ，道路外からの強引な侵入車両を避けるための回避行動であり，運転エラーに起因する挙動ではなかった．運転診断ソフトでは，脳損傷者は教習指導員と比べて，有意にブレーキ，右左折の得点が低かった（p＜0.05）．DAS では，「走行中にゆっくりとブレーキを踏む（p＜0.05）」，「一時停止線で完全に停止する（p＜0.01）」，「進路変更時に視覚的に十分に確認する（p＜0.01）」，「交差点で歩行者を視覚的に十分に確認する（p＜0.01）」項目において，脳損傷者は有意に教習指導員よりも点数が低かった．

【結論】

交差点や進路変更の場面では，同時に多くの情報に注意し，迅速に状況判断して対処することが求められる．脳損傷者は，急ブレーキや急ハンドルで危険を回避することが特徴的であった．客観的な運転診断ソフトや映像を用いた観察評価は，脳損傷者の安全運転教育や，自己認識を深める一助としても活用することが期待できる．

本研究では，比較対象に一般健常者を含めていないため，行動特徴が障害に由来するものか，運転習慣によるものかは判別できない．今後の検討が必要である．

Abstract

Background/Aims: To clarify the characteristics of automobile driving performance in patients with brain injury, 26 patients (patient group) and 26 driving instructors (control group) were evaluated via an on-road driving assessment.

Methods: We evaluated on-road driving performance using an event data recorder, driving analysis software, and the video-based driving assessment scale (DAS). The number of unsafe driving events, the score on the driving analysis software, and the score on the DAS were then compared between the two groups.

Results: The patient group had 12 unsafe events (7 braking, 4 acceleration, 1 curving), but the instructors detected only two sudden braking to avoid a collision when another vehicle forcibly entered from outside the roadway. In the case of the driving analysis software, the patient group showed significantly lower scores for braking ($p < .05$) and steering wheel ($p < .05$) than did the control group. On the DAS, the patient group scored significantly lower for checking their blind spot during a lane change ($p < .01$) and being aware of pedestrians at an intersection ($p < .01$) than did the control group.

Conclusion: These objective video and g-force-generated on-road driving assessments may thus provide important information regarding driving and advice for patients with brain injury.

1. Introduction

Driving is a complex activity that involves simultaneous control of the lateral and longitudinal positions of a vehicle and requires the driver to estimate future situations from current information (Fox et al. 1998). Many people with brain injury desire to continue driving, but they experience sensory, motor, and cognitive changes that may limit their ability to drive safely. In particular, changes in reaction time, perceptual speed, and a variety of other cognitive skills may pose serious obstacles to safe driving (Novack et al. 2006).

Various tests, including cognitive functioning tests, simulators, and on-road driving assessments, are often used – sometimes in combination – to assess the driving behaviors of at-risk drivers (Willstrand et al. 2017). More specifically, cognitive functioning tests are used to obtain information on the patient's strengths and weaknesses to identify people who are not suitable for an on-road assessment (Duquette et al. 2010). The Stroke Drivers Screening Assessment (SDSA) was designed to assess whether stroke patients are fit to resume driving. The SDSA has correctly predicted the road performance of over 80% of stroke patients (Nouri and Lincoln 1993). Although simulator-based driving assessments are valid tools for screening at-risk drivers, they are not a valid alternative to on-road driving assessments (Eramudugolla et al. 2016). Research indicates that it is unlikely that any single test of functioning will be sensitive or specific enough to identify unsafe drivers during off-road assessments (Aksan et al. 2012). Nonetheless, on-road driving assessments are commonly regarded as the gold standard (Fox et al. 1998; Patomella et al. 2010). Previous studies have used a variety of approaches to assess brain-impaired drivers ranging from short, informal tests to a standardized course with predetermined maneuvers rated with explicit criteria (Fox et al. 1998). Whatever the approach, assessing driver fitness requires reliable and valid measures (Korteling and Kaptein 1996). Therefore, driving performance should be evaluated according to predefined and reliable criteria (Hunt 1997; Akinwuntan et al. 2003; Classen et al. 2017). However, on-road driving assessments are performed using dynamic and non-restricted spaces, over a longer distance, and with different speed limits, and these assessments are dependent on present traffic and the actions of other road users. Therefore, on-road driving assessments have greater potential for collisions (Akinwuntan et al. 2003).

Recently, advances in sensor computer technologies have provided a method to automatically collect detailed and objective information on driver performance (Eby et al. 2012). For example, g-force-generated video event recording technology can effectively detect unsafe driving events such as unsafe speed, not scanning at intersections, and judgment errors in general older adults and in those with cognitive impairments (Ott et al. 2017). However, this objective and advanced assessment method is rarely used in patients with brain injury. Instead, on-road driving assessments with these patients are often performed to determine whether they pass or fail.

Objective measures need to be used for evaluation to assist patients in safely restarting driving and in deciding whether to stop driving (Fox et al. 1998). Thus, the purpose of the present study is to clarify the characteristics of on-road driving behaviors in patients with brain injury by combining the evaluation method of video recording and g-force-generated event recording.

2. Method

This study was approved by all relevant research ethics committee review boards and was conducted in accordance with all applicable laws and guidelines. All participants provided written and informed consent and did not receive financial incentives for participating.

2.1. Research Design

We applied a cross-sectional analytical observational research design to compare the driving behavior of patients with brain injury with that of driving instructors. Sample sizes were calculated using G*power software (two tails, $d = 0.8$, α err prob = .05, 1-β = 0.8), resulting in a sample size of 26 per group (Faul et al. 2007). Thus, 26 patients with brain injury who were age- and gender-matched with 26 driving instructors – all of whom possessed a valid driver's license – participated in our study.

2.2. Participants

The patients were recruited from a rehabilitation hospital and selected based on the following criteria. Inclusion criteria required that participants 1) be diagnosed with cerebrovascular accident, traumatic brain injury, or brain disease; 2) had passed a driving simulator test that was conducted in the hospital and were permitted to drive by a doctor; and 3) had driven a car at least once a week before onset. Exclusion criteria required that participants 1) have motor paralysis, 2) have difficulty with walking, 3) be dependent on care for basic activities of daily living, and 4) have a history of epileptic seizures within the past two years. The patients consisted of 23 men and three women, and the average age was 45.3 years ± 9.8 (Table 1). The diagnoses of the patients were as follows: brain hemorrhage (n=11), brain infarction (n=6), traumatic brain injury (n=5), hypoxic encephalopathy (n=2), brain tumor (n=1), and encephalitis (n=1). The average period after onset was 25.2 months ± 18.4.

Driving instructors were recruited from a driving school. Their inclusion criteria were as follows: 1) have more than three years' experience, 2) drive a car at least once a week, and 3) have had no accidents or violations in the past year. Driving instructors were excluded if they scored below 27 on the Mini Mental State Examination (MMSE) (Folstein et al. 1975). The driving instructors consisted of 23 men and three women, and the average age was 41.9 years ± 9.4. All instructors met the participation criteria.

2.3. Procedure

First, we provided a questionnaire to the patients that consisted of the following: age, sex, number of years with a driver's license, number of traffic accidents and violations, purpose of driving (e.g., commuting, shopping, work, leisure time), and average driving per day and distance (km) per week at the rehabilitation center. The number of traffic accidents and violations refers to the number of times during the entire period from the acquisition of a driver's license to the date of the research. Afterward, we conducted the MMSE (Folstein et al. 1975) and the Trail Making Test (TMT) (Reitan 1958) at the rehabilitation hospital. We then met with the driving instructors, explained the research contents with written materials, and invited those who age- and gender-matched the patients to participate. We administered the same questionnaire, the MMSE, and the TMT to the instructors and confirmed that the instructors met the participation criteria. Finally, the on-road driving assessment was completed under good weather conditions on a weekday afternoon.

We installed an event data recorder (SR-Video by Datatec Co., Ltd. Tokyo) in the lighter socket of a standard sedan-type test vehicle (Toyota Crown, Aichi) with automatic transmission and dual brake pedals. When conducting an on-road driving assessment, it is difficult for the evaluator to maintain concentration at all times while also paying attention to the safety of the subjects (Akinwuntan et al. 2003). Therefore, we installed two video cameras (Action Cam, Sony Corporation, Tokyo) on the top of the windshield, and the angles were set to record the foreground and the driver's face and hand operation. We set the standardized in-traffic route in residential and urban areas with a 5.0 km length, approximately 15 minutes in duration, which included straight drives, right and left turns, and lane changes. There were universities, large-scale general hospitals, and subway stations along the driving course. Parked vehicles were always parked on the two-lane roads in front of the hospital and subway station. After being introduced to the vehicle, the patient practiced driving in the driving school to get used to operating the vehicle. The assessment began with the patient in the driver's seat, the driving instructor in the front passenger's seat, and the evaluator in the rear seat in a position that allowed full view of the actions of the driver. The instructor guided the patient and was responsible for safety management while the patient was driving.

To assess the patient's inherent driving characteristics, the instructor did not provide specific advice except when there was risk of an accident or road violation. After the patient drove, the driving instructor drove the same route as the patient in the same vehicle. The evaluator, who is an occupational therapist with 12 years of driving evaluation experience, sat in the rear seat and evaluated the driving behaviors using a Driving Assessment Scale (DAS) (Novack et al. 2006). To ensure reliability, the same evaluator scored the DAS while viewing the recorded driving video.

2.4. Equipment and Measurements

Event Data Recorder. The event data recorder automatically detected changes in speed, acceleration, and angular velocity exceeding the predefined default value, which were categorized as jerky events. For event detection, the default value (0.3 G longitudinal acceleration and 0.36 deg/sec turning speed) recommended by the apparatus was used. Jerky events were defined as the following three types of behaviors: braking, acceleration, and rough curving. The three types of events and the total number of events were used as indicators of unsafe driving behavior.

Driving analysis software. The driving analysis software (Anzenno Tatsujin Ⅱ™ by Datatec Co., Ltd. Tokyo) has mainly been used for the safety management of occupational drivers such as those driving trucks, buses, and taxis; there is no reported use for the evaluation of driving behavior of brain-injured persons. This software automatically scored five items: 1) braking, 2) stopping, 3) steering wheel, 4) right/left turn, and 5) smoothness. A braking score was used as an indicator of the softness and slowness of braking while driving. Software automatically scored the driver based on the speed at braking, deceleration, acceleration, and braking speed. A stopping score was used as an indicator of the softness and slowness of braking when stopping. The software automatically scored the driver based on the speed at braking, deceleration, acceleration, and time required to stop the vehicle. A steering wheel score was used as an indicator of steering wheel smoothness and slowness at curves and intersections. The software automatically scored the driver based on driving speed, azimuthal angular velocity, and steering wheel turning speed. A right/left turn score was used as an index of safety confirmation at intersections. The software automatically scored the driver based on the speed (deceleration/acceleration) before entering the intersection as well as the speed (deceleration/acceleration) at the intersection. A smoothness score was used as an indicator of driving stability. The software automatically scored the driver based on changes in acceleration in the longitudinal and lateral directions during driving.

Each item could be scored up to 20 points, for a total of 100 points, with high scores indicating safe driving behaviors.

Driving assessment scale (DAS). We used a DAS – identical to the one used for the Washington University Road Test – to evaluate subjects' driving behavior. Research indicates that this assessment is reliable (Hunt et al., 1997). It consists of 25 items related to driving, including lane changes, intersections, parking, driving attitude, judgement, and support. Each item is rated (0, 1, or 2) based on whether the person encountered consistent difficulty with the behavior (and was therefore considered unsafe: 0), exhibited difficulty on some occasions but not others (considered marginal; 1), or performed the behavior without problems in all instances (considered safe; 2). A total score is then derived, ranging from 0 to 50, with high scores indicating safe driving.

Mini Mental State Examination (MMSE). The MMSE is a cognitive impairment screening tool, for which scores range from 0 to 30. Scores between 20 and 25 are regarded as inconclusive with patients requiring further assessment, and scores above 26 are suggested to imply that patients have a sufficient level of cognitive function (Folstein et al. 1975; Schanke and Sundet 2000).

Trail Making Test (TMT). The TMT is a test of attention and visual motor tracking. The TMT consists of parts A and B, and the score represents the time to complete each task (Reitan 1958). TMT-A and TMT-B scores are reported to be useful in predicting whether a person with a brain injury can drive (Mazer et al. 1998).

2.5. Data Analysis

We saved the driving data onto an SD card (Datatec Co., Ltd. Tokyo) and used an event data recorder and driving analysis software. We analyzed the data using SPSS version 24 (IBM corporation, 2016), and the significance level was set at $p < .05$. To compare patients with driving instructors, *t*- tests or Mann-Whitney *U*-tests were conducted.

2.6. Research Ethics

This study was approved by the ethical committee of the Graduate School of Medicine, Nagoya University (reference number: 16-609), the institutional review board of Nagoya City Rehabilitation Agency (approval day: December 20, 2017), and the Chubu Nippon driving school (approval day: January 27, 2017). All participants provided written informed consent.

2.7. Declaration of Conflicting Interests

The author(s) declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

3. Results

Based on the questionnaire on the purpose of driving, 21 patients used cars for commuting, and 16 patients used cars while working. Thus, for the patients, driving was highly related to work. The average number of traffic violations reported by patients was 3.1 ± 2.7, which was significantly higher than those of the instructors ($U = 145.0$, $p < .01$). Patients drove significantly less frequently per week than instructors ($U = 246.5$, $p < .05$). There were no significant differences regarding the period of time holding a driver's license, number of traffic accidents, or driving distance per week. The patients had significantly slower TMT-B scores than the instructors ($U = 199.0$, $p < .05$). For the MMSE and TMT-A, there were no significant differences between groups (Table 1).

The event data recorder detected 12 events in total (for eight patients). The most frequent events were braking-related (seven events; seven patients). Six patients had only one event; however, two patients had three events. The events were found at four scenes: 1) turning right at an intersection with bad visibility, 2) turning right at an intersection with a signal, 3) turning left at an intersection with a signal, and 4) changing lanes to overtake a parked vehicle (Table 2). A braking event was detected on all occasions. In scene 3, many events were detected (braking = 2; curving = 3). On the other hand, for the instructors, two sudden braking events were detected, but as confirmed by the video, these were deliberate actions to avoid a collision when another vehicle forcibly invaded from outside the roadway.

According to the driving analysis software, patients scored significantly lower in braking ($U = 229.5$, $p < .05$) and steering wheel use ($U = 220.5$, $p < .05$) than instructors (Table 3). In DAS, patients scored significantly lower than instructors in braking smoothly ($U = 260.0$, $p < .05$) and stops completely at the stop sign ($U = 130.0$, $p < .01$) when driving, signals properly ($U = 91.0$, $p < .01$) and checks blind spot ($U = 104.0$, $p < .01$) during lane changes, is aware of pedestrians ($U = 221.0$, $p < .01$) and visually scans at appropriate times ($U = 208.0$, $p < .01$) at intersections, and total points ($U = 0.0$, $p < .01$) (Table 4).

4. Discussion

For patients with brain injury, many unsafe events were detected by the event data recorder. The most frequent unsafe event was sudden braking, which was detected at intersections and during lane changes. A braking event means that a strong backward acceleration has occurred, and it can be seen that the patient stepped heavily on the brake while driving at an intersection or during a lane change. Furthermore, according to the driving analysis software, patients exhibited significantly lower braking and steering wheel scores than instructors. While driving, the patients stepped down strongly on the brake pedal and swung the steering wheel quickly and heavily. The effectiveness of video feedback interventions to improve driving behavior has been shown in previous research (Ott et al. 2017; McGehee et al. 2008).

The novelty of this study is that the driving behavior of patients with brain injury was clarified objectively by combining event data recorder and driving analysis software.

Regarding the Driving Assessment Scale, patients had difficulty using smooth braking and did not completely stop at stop signs. The patients were late in activating the turn signal when changing lanes, and they did not sufficiently confirm their blind spot. At the intersection, the patients had difficulty visually scanning the pedestrians and surrounding conditions at the appropriate times. To pass a forward parked vehicle, it is necessary to instantaneously determine surrounding conditions, such as the position of other vehicles, and change lanes at an appropriate time while considering traveling speed. Additionally, when turning at an intersection, it is necessary to attend to multiple types of information, such as other vehicles, pedestrians, and signal changes. In situations in which multiple kinds of information – such as lane changes and intersections – need to be processed quickly, patients appeared to avoid accidents with sudden braking or steering to compensate for their delayed response, supporting previous research (Schultheis et al. 2009). Regarding on-road driving assessments, for patients with brain injury, it is useful to include intersections and lane changes on the test route, as recommended in prior research (Patomella et al. 2010).

The unsafe events – detected with the event data recorder – were based on changes in vehicle speed, acceleration, and azimuth velocity. Therefore, when evaluating driving ability using the event data recorder, comprehensive driving characteristics such as the distance to the preceding vehicle, lateral position in the lane, timing for signaling, and driving attitude cannot be measured. Instead, to comprehensively evaluate driving behavior, it is important to incorporate observational evaluation. In conventional on-road driving assessments, it is common for evaluators to sit in the rear seat and score while observing the driver, but there are problems with this approach, for example, ensuring the safety of the driver and the fact that the evaluator may have difficulty concentrating for long periods of time (Akinwuntan et al. 2003). By recording a video while driving and assessing the video afterward, it is possible to accurately score driving behavior. However, it is difficult to evaluate the driver's concentration, attitude, and communication with other vehicles when only using video evaluations. Thus, to increase the reliability of on-road driving assessments, it is desirable for evaluators to be positioned in the rear seat and to provide a final driving score after viewing the recorded video. Findings resulting from this study will contribute to developing useful driving evaluations and interventions based on patient characteristics.

A limitation in the present study is that general healthy subjects were not included in the comparison group; thus, it is difficult to determine whether patients' characteristics were derived from illness or from their driving habits. In the future, researchers should consider using general healthy subjects in the comparison group.

5. Conclusion

We evaluated on-road driving behaviors using video and g-force-generated event recording to clarify the characteristics of driving behaviors in patients with brain injury. The results indicate that on-road driving assessment using objective video and event recording could assist with driving education, self-monitoring, and judgement regarding when to cease driving.

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Tables

Table 1. Characteristics of participants

	Mean (SD), Range		Inferential statistics
	Patients (n = 26)	Instructors (n = 26)	
Age in years	45.3 (9.8), 26-59	41.9 (9.4), 24-57	U = 258.0 (p = 0.15)
Males, n (%)	23 (88.4)	23 (88.4)	p = 0.67
Driving experience (years)	25.9 (10.3), 6-41	23.5 (9.2), 6-39	t = -0.85 (p = 0.40)
Traffic accidents (number of times)	1.0 (1.1), 0-3	0.7 (1.0), 0-4	U = 253.0 (p = 0.15)
Traffic violations (number of times)	3.1 (2.7), 0-10	0.7 (1.1), 0-3	U = 145.0 (p = 0.00) **
Driving frequency (days per week)	6.0 (1.4), 2-7	6.7 (0.8), 3-7	U = 246.5 (p = 0.04) *
Driving distance (kilometers per week)	268.3 (504.9), 10-2500	107.4 (108.4), 10-400	U = 268.5 (p = 0.29)
MMSE (total score)	29.3 (1.3), 26-30	29.7 (0.6), 28-30	U = 301.0 (p = 0.35)

TMT-A (second)	38.9 (14.7), 21-81	32.1 (8.4), 16-48	*U* = 240.5 (p = 0.08)
TMT-B (second)	73.5 (23.0), 43-146	58.4 (11.2), 38-81	*U* = 199.0 (p = 0.01) *

*$p < 0.05$; **$p < 0.01$ (Mann–Whitney *U*-test)

MMSE: Mini Mental State Examination, TMT: Trail Making Test

The number of traffic accidents and violations refers to the number of times during the entire period from the acquisition of a driver's license to the date of the research.

Table 2. Number of jerky events in 26 patients

Number of events	Scene 1	Scene 2	Scene 3	Scene 4	Total
Braking	1	2	2	2	7
Acceleration	0	0	0	1	1
Curving	0	1	3	0	4
Sum of events	1	3	5	3	12

Scene 1: Turning right at an intersection with bad visibility

Scene 2: Turning right at an intersection with signal

Scene 3: Turning left at an intersection with signal

Scene 4: Changing lanes to overtake a parked vehicle

Table 3. Comparison of the driving analysis software

	Mean (SD)		Inferential statistics
Driving scores	Patients (n = 26)	Instructors (n = 26)	*U, p/t, p*
Braking	16.9 (4.0)	19.0 (1.8)	$U = 229.5$, $p = 0.03^{*}$
Stopping	17.1 (4.1)	18.7 (2.3)	$U = 294.0$, $p = 0.39$
Steering wheel	16.5 (3.6)	18.5 (2.3)	$U = 220.5$, $p = 0.02^{*}$
Right/left turn	19.5 (0.9)	19.3 (2.3)	$U = 294.0$, $p = 0.29$
Smoothness	9.9 (5.5)	10.2 (4.0)	$U = 321.5$, $p = 0.77$
Total score	79.8 (13.1)	85.7 (7.9)	$t = 1.97$, $p = 0.06$

* $p < 0.05$ (Mann–Whitney U-test)

Table 4. Driving assessment scale by video recording

		Mean (SD)		Inferential statistics
		Patients (n = 26)	Instructors (n = 26)	U, p/t, p
Driving	1. Accelerates smoothly	1.77 (0.51)	2.00 (0.00)	$U = 273.0$, $p = 0.05$
	2. Maintains speed	1.77 (0.58)	2.00 (0.00)	$U = 286.0$, $p = 0.11$
	3. Stays in lane	1.96 (0.20)	2.00 (0.00)	$U = 325.0$, $p = 1.00$
	4. Follows at a safe distance	1.88 (0.33)	2.00 (0.00)	$U = 299.0$, $p = 0.24$
	5. Brakes smoothly	1.73 (0.53)	2.00 (0.00)	$U = 260.0$, $p = 0.02^{*}$
	6. Stops completely at the stop sign	1.00 (0.89)	2.00 (0.00)	$U = 130.0$, $p = 0.00^{**}$
Lane change	7. Signals properly during lane change	1.15 (0.61)	2.00 (0.00)	$U = 91.0$, $p = 0.00^{**}$
	8. Checks blind spot during lane change	1.27 (0.53)	2.00 (0.00)	$U = 104.0$, $p = 0.00^{**}$
	9. Maintains speed during lane change	1.88 (0.43)	2.00 (0.00)	$U = 312.0$, $p = 0.49$
Intersectio	10. Attends to traffic signs	1.96 (0.20)	2.00 (0.00)	$U = 325.0$, $p = 1.00$

n	11. Uses turn signals	1.96 (0.20)	2.00 (0.00)	$U = 325.0$, $p = 1.00$
	12. Aware of pedestrians	1.65 (0.49)	2.00 (0.00)	$U = 221.0$, $p = 0.00^{**}$
	13. Positions appropriately when stopped	2.00 (0.00)	2.00 (0.00)	$U = 338.0$, $p = 1.00$
	14. Interprets traffic signals	1.92 (0.27)	2.00 (0.00)	$U = 312.0$, $p = 0.49$
	15. Visually scans at appropriate times	1.62 (0.50)	2.00 (0.00)	$U = 208.0$, $p = 0.00^{**}$
Parking	16. Backing up over a distance 100 feet	1.96 (0.20)	2.00 (0.00)	$U = 325.0$, $p = 1.00$
	17. Parks in designated spaces	1.96 (0.20)	2.00 (0.00)	$U = 325.0$, $p =1.00$
Attitude	18. Yields right-of-way	1.96 (0.20)	2.00 (0.00)	$U = 325.0$, $p =1.00$
	19. Other drivers irritated	2.00 (0.00)	2.00 (0.00)	$U = 338.0$, $p = 1.00$
	20. Visually scans	1.96 (0.20)	2.00 (0.00)	$U = 325.0$, $p = 1.00$
	21. Distractibility	2.00 (0.00)	2.00 (0.00)	$U = 338.0$, $p = 1.00$
Judgement	22. Follows instructions	1.96 (0.20)	2.00 (0.00)	$U = 325.0$, $p = 1.00$
	23. Uses good judgement	1.88 (0.33)	2.00 (0.00)	$U = 299.0$, $p = 0.24$
Total		41.23 (3.55)	46.0 (0.00)	$U = 0.00$, $p = 0.00^{**}$

* $p < 0.05$; ** $p < 0.01$ (Mann–Whitney *U*-test)

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