APPLICABILITY OF A NEW DRIVING TRAINING PROTOCOL FOR POST-STROKE CLIENTS

Original clinical research

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ABSTRACT

Background—Very little is known about driving training techniques for post-stroke clients and there is a need to regroup the most efficient and feasible techniques to improve this important aspect of rehabilitation. Survey's results and a literature review recently highlighted the relevance of creating a new driving training protocol for subjects with stroke and cognitive limitations. The objectives of this research article are to present the development of a new driving protocol and show its applicability was tested in clinical context.

Methods—The 1st research design was a content validation to ensure the choice of the driving training methods and the elaboration of the training protocol in 9 levels. A pilot was done to pre-test its applicability (2nd research design). The setting of the research was in a Driving rehabilitation program in a rehab center. The participants involved were occupational therapist specialists (n=5) and post-stroke clients (n=5). On road re-evaluation was used, as well as off-road evaluations before and after the training protocol: Motor Free Visual Test, Trail Making Test, Useful Field Of View, Bells Test and Automatic Brake Reaction Timer.

Results—Adapted commentary driving and on-road training were perceived as being the most effective training methods. The protocol was feasible: training was completed in one month with 100% of participation. Three to seven training sessions (one hour) were needed to complete the 6 levels of adapted commentary driving and, to achieve the last 3 levels of the protocol, 4 behind-the-wheel training sessions were done.

Conclusion—This clinical protocol gives a better tool to rehabilitation specialists to train their post-stroke clients having cognitive limitations considering the specific and complex demands of the activity of driving.

Keywords—Mild cognitive impairment, motor vehicle, rehabilitation, on-road assessment

1. Introduction

For many individuals, driving provides access to the community where they can engage in everyday occupations such as shopping for groceries, getting a haircut, attending church, or meeting friends for coffee (Robertson, 2010). The percentage of people who resume driving post-stroke is low: or 30%; 39%, according to two different studies (Fisk, Owsley, & Pulley, 1997; Marshall et al., 2007). Driving is a complex task which implies visual, spatial, perceptual, and physical-based training. Depending on the brain area affected, strokes will affect differently each person. It is then important that these aspects are assessed before post-stroke clients resume driving. Resuming driving after a stroke has a positive impact on community integration (Griffen, Rapport, Bryer, & Scott, 2009) while people who cannot resume driving decrease their social activities and are more likely to be depressed (Legh-Smith, Wade, & Langton Hewer, 1986). However, few training programmes specifically designed for the population with stroke that focus on the requirements for driving have been tested (Gershkoff, & Finestone, 2009). It is important to train clients post-stroke using methods that target the complex demands of driving and to provide clinicians the tools to do it (Petzold et al., 2010). In this manuscript, the **research objectives** are to present the development of a driving training protocol for post-stroke clients with cognitive limitations and to test its applicability in clinical context.

2. Background

There is a variety of driving training techniques for clients after a stroke (Couture, Vincent, & Gelinas, 2012) but the literature is thin on the best technique to be used with post-stroke clients with cognitive limitations. According to a survey conducted among rehabilitation specialists (31 occupational therapists from 11 rehabilitation centres in the province of Quebec, Canada) about the methods and procedures they use, there was a need to develop a driving training protocol addressing this clientele (Couture et al, 2012).

Various authors have explored different driving training methods with the stroke population, such as the driving simulator (Akinwuntan et al. 2005), the Dynavision (Crotty & George, 2009), paper-and-pencil methods (Klonoff et al., 2010), the Useful Field of View (Ball & Owsley 1992; Mazer et al., 2003), video games (Belchior, 2007), training using a four-wheeled scooter (Kewman et al., 1985), computer software (Sivak, Hill, & Olson , 1984), commentary driving (Fillion, 2010) and on-road training (Jones, Giddens, & Croft, 1983; Quigley & DeLisa, 1983; Söderstrom, Pettersson, & Leppert, 2006). The effectiveness of these driving training methods is still unproven. Following a survey and a literature review (Couture et al, 2012), occupational therapists identified that using a driving simulator and a four-wheeled scooter would be pertinent but too difficult to transfer in all driving programs. It also appears that the modified commentary driving and the on-road training are methods that can be applied in a real driving environment and emerged as promising. In the literature on on-road training or commentary driving specifically for clients with stroke, we did not find any studies on the selection and gradation of learning levels. We found important to include graduated learning levels in our protocol because each learning level has clear and measurable objective which include cognitive assessments of their strategic and tactical ability of driving.

According to Marshall and colleagues (2007), gradation of learning levels in driving would make it easier for clinicians to identify strength and weaknesses of their patients.

Considering all these promising training methods, the next sections present how we develop an adapted driving protocol for post-stroke patients with cognitive limitations (method 1) and how we managed a pilot test its applicability (method 2).

3. Research methods

The study was approved by the research ethics board of the *Institut de réadaptation en déficience physique de Québec* while three other rehabilitation centres agreed to recruit occupational therapists as participants (Project #MP-IRDPQ-08-135). All the participants signed a consent form. Two research designs were needed to answer the two research objectives, libelled as method 1 and 2.

3.1 Method 1- Focus group research design

For the **c**ontent development of a training protocol, a focus group research design was realised. Following the review of the literature on different training methods and the survey results previously published by Couture and colleagues (2012), a consultation of experts in driving rehabilitation was done regarding the four training methods reported as the most relevant. This consultation was also needed to assess the elaboration of a new training protocol that could be feasible in the public health system of Québec (graduate levels of learning according to the training methods, duration of the protocol, criteria of succeeding one level, etc.). Consultation was done through a focus group with occupational therapists specialized in driving rehabilitation.

Participants and recruitment– Four participants were recruited by the first author (MC) at a meeting of an occupational therapists driving group (n=57) from the *Association des établissements de réadaptation en déficience physique de Québec* (Quebec, Canada). A fifth participant was recruited later, through his programme manager that was present at the meeting. Selection criteria for the focus groups were: to have at least one year of experience in driving capability evaluation and/or training, including on the road; not have participated in the previous step of the research project, i.e. survey of the different training methods used in occupational therapists' practice.

Data collection and analysis – The focus group was held by videoconferencing and lasted 3 hours. First author (MC) was the animator and second author (CV), the co-animator. Four training methods were discussed (driving simulator, training using a four-wheeled scooter, commentary driving and on-road training), all of which are specifically used in driving programs or reproduce the complexity of the activity of driving in a moving environment. To develop a new training protocol for the target population, the focus group participants were asked to prioritise an approach that would be realistic in a rehabilitation centre and specify which methods to use and how they should be used (frequency, duration) as well as including the graduated training system. To include a component in the protocol, a consensus of 80% of the participants had to be reached. This meeting was recorded on DVD so that it could be referred to later in the study. After the focus group, first author writes a

preliminary version of the driving protocol, sent it to focus group experts for retroaction, and produces an experimental version of the protocol.

3.2 Method 2– Pilot test in clinic

A pilot test was realised with 5 subjects to assess their perceptual and cognitive scores before and after intervention (one month training period).

Participants and recruitment procedure – Participants were recruited from clients who had had a stroke and an unsafe driving performance because of perceptual-cognitive problems during their on-road assessment and training program at a rehabilitation centre. To be selected, participants had fulfil those criteria: to be at least 18 years of age, had failed their road test, had a current full driving license and had achieved an optimal level of independence allowing them to do activities of daily living (ADL) and instrumental activities of daily living (IADL). To be eligible, they also had to have the motor capabilities to drive a vehicle with automatic transmission, with the original accelerator or with the accelerator on the left or using a ball on the steering wheel. They had to be capable of self-criticism during their on-road experience, i.e., they had to be aware of their difficulties and had the necessary motivation to improve themselves. Also, during their on-road assessment, the referred clients also had to present an appropriate behaviour for driving, i.e. not be impulsive or aggressive. Clients with a diagnosis of mental health problems, hemianopsia, severe aphasia, or with a vision impairment that did not meet minimum driving requirements were excluded. All the participants signed the study consent form.

Intervention – The participants took part in training sessions indicated in the protocol. Application of the protocol implies that the participant and the occupational therapist worked through the training trying to go through each level. For example, at level 1, the occupational therapist is driving on pre-establish route; he expects that the participant sitting beside him in the front seat passenger, will point out all stop signs and traffic lights (not miss any) during a full 30-minute session. If expectations are met, level 2 will be tried, and so on until level 5. For the level 6 there is a change in the training method as the participant is now driving. The occupational therapist, sitting beside the participant, expects that the participant will make quick, appropriate decisions to change lanes safely in city and/or highway driving when sitting in the front passenger seat of a moving car, at least 5 consecutive times. The routes used for the modified commentary driving training were the same for all participants but differed from one level to the next. The routes used for the on-road training were different for each participant since some of the exercises required the participant to plan parts of the course.

Main outcomes measures – Before and after the training, the perceptual-cognitive functions of all the participants were evaluated using standardized measures (Motor Free Visual Test, Trail Making Test, Useful Field Of View, Bells Test and Automatic Brake Reaction Timer), the first three of which have been shown to be good indicators of on-road performance (Galski, Bruno, & Ehle, 1992; Myers et al, 2000).. Brake reaction time was also evaluated before training and at least one month later. At the end of the training, the participant was referred to the occupational therapist in the driving evaluation and training program

at a rehabilitation centre for an on-road reevaluation (main outcome measure). The occupational therapist who did the on-road reevaluation was different from the one who did the training with the research protocol.

To verify the feasibility, the number of sessions completed and the participants' attendance rate were noted. Also, all of the participants were questioned about the helpfulness of the protocol and their satisfaction with its duration and the methods used.

Perceptual-cognitive tests – The Motor Free Visual Test (MVPT) provides a brief assessment of visual perceptual skills, without involving motor skills (Colarusso & Hammill, 1972). The test consists of 36 multiple choice tests and evaluates the following aspects: spatial relationships, visual discrimination, figure-ground perception, visual closure and visual memory. The duration of the visual perception process is also noted. Standards are available for individuals between 18 and 80 years of age (Bouska & Kwatny, 1982). The Trail Making Test, parts A and B, is used to measure attention, mental flexibility and information processing speed (Strauss, Sherman, & Spreen, 2006). Part A of the test requires the participant to connect in sequential order 25 numbers randomly scattered on a sheet, and in part B the participant alternately connects numbers and letters. The test must be completed as quickly as possible and the time taken is used to compare the participant to available age- and education-related norms. The Useful Field Of View (UFOV) test developed by Ball, Beard, Roencker, Miller and Griggs (1988) measures central vision, information processing speed and visual, divided and selective attention (Mazer et al., 2003). This test is administered on a computer and scored with software, and is used as a measure for screening for driving skills. The test includes three parts (Ball & Owsley, 1992). In the first subtest, the participant must identify a target in the centre of the screen. In the second subtest, the participant must simultaneously locate a central target and a peripheral target. The third part of the test is identical to the second, except for the addition of distractors (Mazer et al., 2003). The software generates a score indicating the risk of a driving accident (Ball & Owsley, 1992). The Bells Test is a cancellation task that produces a quantitative and qualitative evaluation of visual neglect (Gauthier, Dehaut, & Joannette, 1989). It also allows for the approximate observation of the visual search strategy and better exploration of the clinical signs of spatial attention deficits. The total number of bells and the time taken to complete the task are compiled. However, there are no norms for this test and few metrological studies have been done. The Automatic Brake Reaction Timer (Model 95-01, Safety Products Division of YR Products) measures simple brake reaction time. Gender- and age-based (16 to 76 years) norms are available. No validity or reliability studies were found in the literature, apart from a study by Dickerson and colleagues (2008) with the RT-2S Brake Reaction Time Tester, which is similar to the Automatic Brake Reaction Timer.

Road test – The road test covered a 20-km route designed to evaluate different aspects of driving (such as left turn on green without priority, lane changes, four-way or two-way stops, lane narrowing, one way, parking manoeuvres, yield, etc.). The first part of the test took place mainly in light-traffic low-speed (30, 50 km/h) residential areas and the second on boulevards, divided highways and motorways with medium to high traffic

density and speed (30, 50, 100 km/h). During the test observations were noted based on Michon's model (Michon, 1985), the mistakes that occurred and their seriousness. The observations are described according to three interdependent and hierarchical levels of decision-making: strategic, tactical and operational (Michon, 1985). At the strategic level, the participant's ability to plan and self-criticize was observed. There were no time constraints on decisions at this level (Ranney, 1994). At the tactical level, decisions were made based on the immediate driving environment. For example, the driver had to change lanes, turn, enter an intersection, etc. (Ranney, 1994). The operational level concerned the handling of the vehicle's main controls such as acceleration and braking (Ranney, 1994). At the end of the test, after the participant had left, the occupational therapist discussed the observations made with the driving instructor and, if necessary, verified certain situations that occurred. The occupational therapist then determined if the participant drove safely (passed) or not (fail) based on the type and seriousness of the mistakes. For example, if an unsafe situation occurred that required the driving instructor to intervene for safety reasons, the driving was considered unsafe. The other mistakes noted and their seriousness were evaluated based on their impact on safety.

Data analysis – To determine if there has been a significant improvement or deterioration on the perceptual-cognitive tests and reaction time, the scores were compared with the norms for the tests, before and after the training. An improvement in on-road performance was defined as passing the road test. Finally, descriptive analyses were done to assess the feasibility of the protocol.

4. Results

4.1 Participants' profile (focus group)

The five focus group participants had an average of 22.4 years of experience as occupational therapists and 10.8 years of experience in assessing driving capabilities. They were between 30 and 55 years of age and four of them were women. All had a bachelor's degree, and one also had a master's degree and a graduate certificate in assessing driving capabilities. Top of table 1 presents the detailed profile of the occupational therapists recruited for the focus group.

Table 1. Profile of the occupational therapists recruited for the focus group (n=5)

Occupational therapists	n (%)
Women / Men	4 (80) / 1 (20)
Age group	
30-39	1 (20)
40-49	3 (60)
50-55	1 (20)
Education	
Bachelor's	4 (80)
Master's + Certificate in assessing driving capabilities	1 (20)
Years of experience: mean (range)	22.4 (15-33)
Years of experience in assessing driving capabilities	10.8

4.2 Selected training methods

Following intense discussion, two were selected, namely modified commentary driving and on-road training. Those methods were chosen because they are realised in real context of driving (on road), which implies that, after training; participant can easily transfer what he learns in reality.

The **modified commentary driving method** is based on the commentary driving techniques described by Corriveau (1997) and Corriveau and Benard (2008). Corriveau (1997) maintains that the three elements involved in this method are identification, anticipation and action. Thus the driver must identify elements relevant to his/her driving, anticipate what other drivers will do, describe how he/she plans to react and describe the actions he/she takes (Corriveau, 1997). When using the modified commentary driving method, the main difference is that the occupational therapist or driving instructor drives the vehicle while the trainee sits in the front passenger seat. It requires the participant to comment out loud on the elements and events in the environment according to a structured hierarchy (Fillion, 2010). The participant must first identify fixed objects (traffic signs), then moving objects (vehicles, pedestrians), anticipate different situations and make appropriate decisions. The **on-road training method** implies that the participant drives the vehicle and is accompanied by a driving instructor or sometimes an occupational therapist. Studies that explored on-road training found that participants showed improvement after the training. Söderstrom et al. (2006) reported that 6 to 12 hours of on-road training with a driving instructor (preceded by 2 hours of theory) raised the success rate on the driving test from 50% to 85% (13/15 participants who received training). In a retrospective study, Quigley and DeLisa (1983) reported that, of 50 participants who received on-road training, 52% (14/27) with a right hemisphere stroke passed the driving test after between 8 and 13 training sessions, compared to 74% (17/23) of participants with a left hemisphere stroke, who needed between 6 and 8 training sessions. Finally, in their driving assessment programme, Jones et al., (1983) reported that 9 of 91 participants who had had a stroke were referred to occupational therapy for on-road training after failing the test and that 8 passed the test after the training. However, there are no studies on safe behaviours and compensatory mechanisms such as preventive driving (Söderstrom et al., 2006).

The first method will encourage the participant to show his perceptual and discriminative abilities in different road situations, but as a passenger, and the second method will encourage the participant in taking real driving decisions and safety manoeuvring. The driving simulator and scooter-based training were rejected partly because of practical considerations in a clinical setting in Quebec. Only 2 rehabilitation driving programs are equipped with simulators and only one, with the scooter, on a possibility of 12 programs in Québec, Canada.

4.3 The training protocol - Learning levels in the training.

The training protocol developed following the focus group is based on the two methods mentioned above and includes 9 learning levels designed to develop and/or compensate for the necessary functional driving skills. The levels were based on the conceptual model of Marshall and colleagues (2007), which in turn was based on models developed by Michon (1985) and

Galski, Bruno and Ehle (1992). Each learning level includes suggested exercises and a quantifiable, measurable objective. To pass each level the stated objective must be achieved. The Appendix contains the detailed objectives for the different levels. The training protocol is designed to allow participants to progress at their own pace. For example, some participants will spend more time on one level while others might complete more than one level in a 60 minutes session. The therapist ensures that the participant has passed a level before going onto the next, with one exception: namely, that even if a participant does not pass all of the levels in modified commentary driving, he/she could still receive on-road training.

The first 6 levels of the protocol use the modified commentary driving method. Figure 1 presents the main elements that the participant must see or analyse in order to attain the objectives in the first six learning levels. The gradation of the training levels takes into account the complexity of the cognitive skills required; for example, level 1 mainly requires visual perception (indicating stop signs and traffic lights) while level 6 requires decision-making, including the integration of the skills from the previous levels (e.g. making decisions when changing lanes requires the participant to pay attention, see the environment clearly and be able to anticipate what other drivers will do). The tasks get increasingly complex from one level to the next following the progression based on Fillion's modified commentary driving approach (Fillion, 2010). At the start of the training, the basic principles of visual exploration are taught; then the task requirements intensify to develop visual perception (levels 1 and 2), divided attention (level 3), anticipation (level 4) and decision-making (levels 5 and 6). If the participant reaches a plateau and does not show any improvement over 3 consecutive sessions, the clinician will stop the commentary driving portion of the training but the client may still receive on-road training to verify if that person could to drive without having to tell what he perceives.

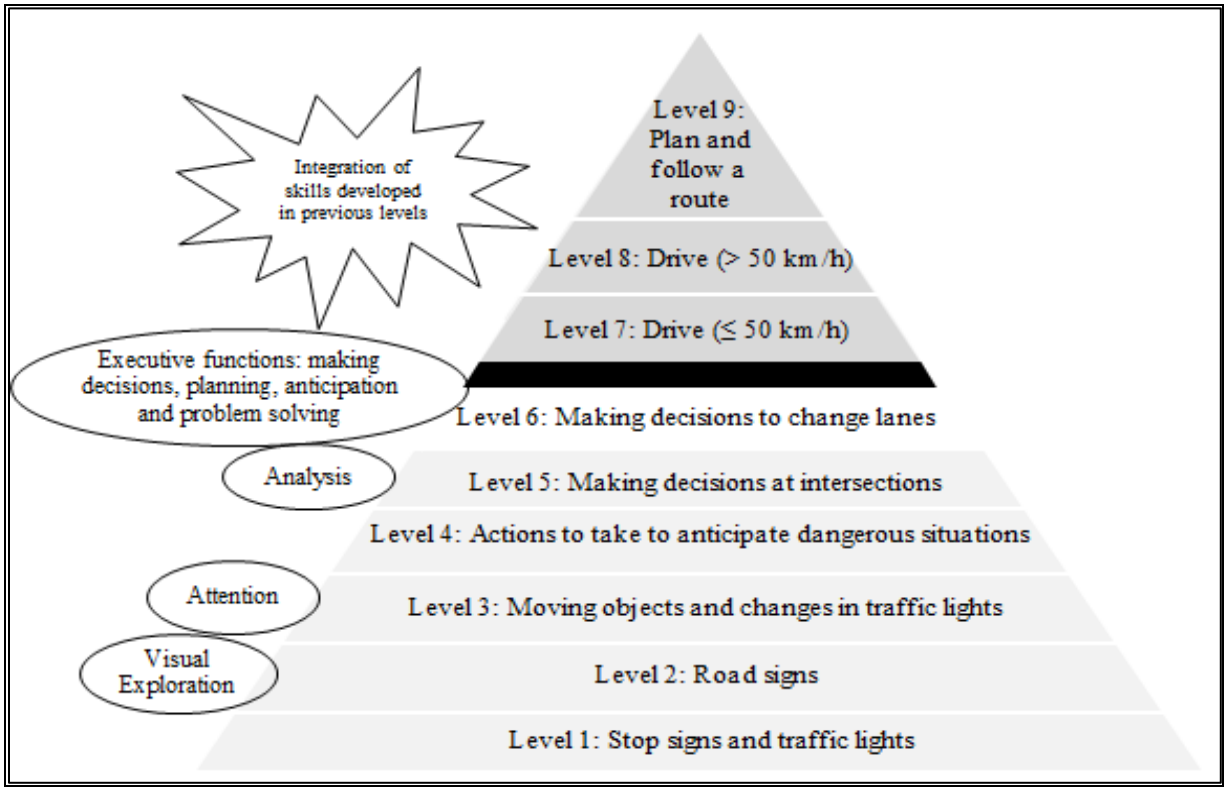

Figure 1. Progression in driving training levels and skills developed

Levels 7 to 9 of the protocol done in the on-road training are also progressive (see figure 1). According to the proposed graduation, the participant must not display any unsafe driving behaviours when driving in areas where the speed is up to 50 km/h (level 7), before going onto the next level (level 8) where the speed is higher (50 km/h and over). For the final level (level 9), which integrates the requirements of the two previous levels, the participant is asked to plan and follow a route, all the while reacting appropriately to unforeseen situations. Exercises are also proposed to facilitate the integration of the skills developed during the modified commentary driving portion of the training. There is also a gradation in each of the on-road training levels since the sessions take place first in areas with less traffic and information (number of signs, complexity of the environment such as one-way streets, yields, etc.) and then in increasingly complex environments. Also, during the on-road training, if the participant stops showing improvement and remains at the same level for 3 sessions or if the performance is clearly not safe, the training will stop. The occupational therapists consulted agreed that there should be 2 or 3 training sessions per week and that they should last no more than 60 minutes. The total number of training sessions for a participant, including both training methods, is 15 (including a maximum of 4 on-road training sessions as a driver). Finally, to facilitate data collection during the training, an observation grid covering all the levels is used. Following this phase, the protocol moved onto the first assessment step, which was to verify its applicability with a small group of participants and collect information for the development of a larger study to measure its effectiveness.

4.4 Participants' profile (pilot test in clinic)

Three women and two men with stroke assessed in the driving evaluation and training programme who met the inclusion criteria agreed to participate in the study. Their ages ranged from 32 to 62 years and the time post-stroke before beginning the training varied from 5 to 16 months. Three had brain injuries in the left hemisphere, and two in the right. The main characteristics of the participants recruited for the applicability of the protocol phase are presented in the bottom of table 2. Only one of the participants required adapted equipment to be added to the vehicle (note 2 in table 2).

Table 2. Participants recruited for the applicability of the protocol phase (n=5)[4]

n	*Age (years)*	Sex	*Type of injury*	*Vehicle modifications*	*Time since stroke (months)*	*Education*
#1	33	F	L stroke[1]	Accelerator on the left, ball[2]	10	Secondary
#2	62	F	L stroke	No	5	Post-secondary
#3	60	M	R stroke[3]	No	12	Post-secondary
#4	60	F	L meningioma removed	No	16	Secondary
#5	32	M	R stroke	No	5	Post-secondary

Note 1: L = Left ; Note 2: Knob on the steering wheel with integrated switches; Note 3: R = Right
Note 4: Participants had fulfil those criteria: to be at least 18 years of age, had failed their road test, had a current full driving license and had achieved an optimal level of independence allowing them to do activities of daily living (ADL) and instrumental activities of daily living (IADL). They also had to have the motor capabilities to drive a vehicle with automatic transmission, with the original accelerator or with the accelerator on the left or using a ball on the steering wheel. They had to be capable of self-criticism during their on-road experience, i.e., they had to be aware of their difficulties and had the necessary motivation to improve themselves. Also, during their on-road assessment, the referred clients also had to present an appropriate behaviour for driving, i.e. not be impulsive or aggressive. Clients with a diagnosis of mental health problems, hemianopsia, severe aphasia, or with a vision impairment that did not meet minimum driving requirements were excluded.

4.5 Applicability of the protocol

The five participants completed the training process within one month, apart from one participant who had health problems during the process and did not complete post assessments. The

Table 3. *Results for the pilot test in clinic and applicability of the driving protocol*

Variable on the perceptual-cognitive tests	*Participants*				
	1	2	3	4	5
Useful Field of View [UFOV] (category)					
Before the training	1	1	1	1	1
After the training	1	1	1	1	1
Motor Visual Perception Test [MVPT] (/36)					
Before the training	36	36	36	35	33*
After the training	36	36	n/d	36	35
Motor Visual Perception Test [MVPT] (seconds)					
Before the training	3.0	5.2	6.2*	3.9	2.4
After the training	1.2	4.3	n/a	3.8	1.9
Trail Making Test A [TMT-A] (seconds)					
Before the training	27	27	23	28	24
After the training	19	33	n/a	24	16
Trail Making Test B [TMT-B] (seconds)					
Before the training	58	88*	73	64	64
After the training	74*	82*	n/a	47	43
Bells Test (result)					
Before the training	35	35	35	35	34
After the training	33	35	n/a	35	35
Bells Test (seconds)					
Before the training	162	240	347*	173	80
After the training	178	163	n/a	115	105
Automatic Brake Reaction Timer [ABRT]					
Before the training	n/a	0.35	0.44	0.53*	0.43*
After the training	n/a	0.35	n/a	0.50	0.38
Number of sessions completed					
Modified commentary driving sessions	7	5	3	3	4
On-road sessions	4	4	4	4	4
Total of sessions	11	9	7	7	9
Last level completed /9	8	7	8	7	9
Result on the road test	Unsafe	Unsafe	n.c.[1]	Safe	Safe

*Result below the norm

Note 1: not completed. Participant #3 could not do the on-road test because of the onset of serious health problems.

participants' attendance at the training sessions was 100%. It took them between 3 and 7 sessions to complete the six commentary driving levels. Thereafter, they

all needed the maximum of four hours initially scheduled for the on-road training. Only one participant attained the objectives of all nine learning levels. Table 3 details the number of sessions required for each training method and the results on the road test. Two of the participants showed safe driving at the road test (level 7 and level 8 completed) and the occupational therapist made a positive recommendation to the *Société de l'assurance automobile du Québec* (provincial motor vehicle bureau) to issue a valid license to these two individuals. In addition, following the training process, all of the participants said the new training protocol was helpful and that they were satisfied with the training methods and duration of the training protocol.

4.6 Results from perceptual-cognitive and reaction time tests assessments.

Table 4 shows that participants obtained results within or above the norms, before and after the on-road training on the MVPT, UFOV, Bells Test and Automatic Brake Reaction Timer. The pre- and post-training results on the majority of the perceptual-cognitive tests showed some changes in the participants. In fact, all of the participants improved their performance on the Trail Making Test A results as a percentile compared to the norms for people in the same age group. However, on the Trail Making Test B, two of the participants who had an unsafe driving performance also obtained results below the norms on this test. The results on this test showed an improvement in 3 participants and a decline in one participant.

Table 4. Number of sessions completed and results on the road test

Participant	*# modified commentary driving sessions*	*# on-road sessions*	*Total # of sessions*	*Last level completed /9*	*Result on the road test*
1	7	4	11	8	Unsafe
2	5	4	9	7	Unsafe
3	3	4	7	8	Not completed[1]
4	3	4	7	7	Safe
5	4	4	8	9	Safe

Note 1: Participant #3 could not do the on-road test because of the onset of serious health problems.

5. *Discussion*

A driving training protocol was developed for a population with stroke presenting perceptual-cognitive deficits and its applicability in a clinical setting was pretested. The protocol should be applied at the end of the process of training perceptual-cognitive capacities. The driving training protocol developed proposes two innovations. First, it incorporates two methods that gradually meet the requirements for the activity of driving and adapting to variable external factors, including traffic, road conditions and the weather. Second, the protocol developed makes it possible to observe the participant's progress using pre-established clear and measurable objectives for the nine target performance levels.

The training protocol proved to be applicable in a clinical setting in a relatively short period of time (1 month per participant) and using methods that are easy to apply in a driving programme. Also, all of the participants thought the new training protocol was helpful and the attendance rate was 100%. The participants also expressed their satisfaction with the selected training methods. The duration of the training protocol was also considered reasonable for all of the participants since 4 of them completed the requisite sessions in only 4 weeks. It is important to note that all participants needed the maximum of 4 hours of on-road training although they did not necessarily complete all 9 levels of the protocol.

A larger sample is needed to confirm that the number of on-road sessions is not enough to pass the road test. However, to determine the number of on-road sessions we have also to take into account the possible plateau effect of participants. For example, although one participant decided to take 2 additional hours at his own expense before doing the on-road reevaluation, he still failed the road test because of a continuing decline in visual exploration, information processing speed, analytical difficulties and executive function problems. It is possible that this participant reached a plateau in his capacities related to the tactical level, according to Marshall's model, which is why extra sessions did not improve his driving abilities.

A larger sample is also essential to determine to explain the performance variability of participants. It was found that not all of the participants who passed the on-road test completed the last training level and, conversely, that one participant who passed level 8 (safe motorway driving) failed the driving test. The inconsistent on-road performance phenomenon must be explored by a follow-up study with more participants and a control group. A follow-up study would also make it possible to test the impact of adapted equipment on participants' performance.

As part of this applicability experiment, we were able to learn and adapt the protocol for a later utilization. For example, the final level (ninth) is already covered in the two preceding levels and could be eliminated. Also, the objectives used to pass the levels should be defined in more details to facilitate their use. Modifications will also be made to the proposed exercises and to the grid to make the protocol easier for clinicians to administer.

Although the MVPT, Trail Making A and B and UFOV tests have all been studied (Mazer et al, 1998) and been shown to be good indicators of on-road performance, it was the results on the Trail Making B that corroborated more with the results obtained during the road test. The two participants that had an unsafe performance on the road test also had results below the norms on the Trail Making B, which is consistent with other studies showing that this test is sensitive enough to predict results on the driving test (Classen et al., 2008; Marshall et al., 2007).

Although the MVPT and UFOV showed some predictive value in the literature, four of the five participants in our study obtained results within the norms for these tests yet two of them failed the driving test. No perceptual problems were found in these participants during the driving tests, which could explain the normal results on the MVPT. At this stage, we cannot correlate these tests to the on-road performance but a later study can certainly address the multiple

variables (e.g. lesion site and severity) that can affect results of this new protocol.

We are aware of the study limitations. Although the objective of this preliminary study was to examine the applicability and not the effectiveness of this protocol, the results with the participants showed the applicability of the protocol in just one rehabilitation centre in one public health care system where clients do not have to pay for on-road lessons. A future study with an experimental design (sample representative of the population and a control group) is needed to demonstrate if the training protocol developed here is really effective in improving driving capacities.

6. Conclusion

The research objectives were achieved since this article has described the development of a driving training protocol for clients post-stroke, including adapted commentary driving and on-road training. This article has also exposed the applicability (100% feasibility) of this protocol in clinics since it was demonstrated with a small sample of participants. Training was based on 9 learning levels designed to develop and/or compensate for the necessary functional driving skills. Three to seven training sessions (one hour) were needed to complete the 6 levels of adapted commentary driving and, to achieve the last 3 levels of the protocol, 4 behind-the-wheel training sessions were done. It is essential to continue research in this field of occupational therapy practice to verify the effectiveness of the training protocol with clients with stroke and also test its effectiveness with other populations presenting cognitive deficits, such as those with traumatic brain injury.

ACKNOWLEDGEMENTS

We wish to thank the *Direction de l'enseignement et du soutien scientifique* of the *Institut de réadaptation en déficience physique de Québec*, which provided financial support to carry out this project, and the *Centre interdisciplinaire de recherche en réadaptation et intégration sociale* (CIRRIS) for support in translating this article. We also thank the occupational therapists who participated in the project and their respective institutions: *Institut de réadaptation en déficience physique de Québec*, *Centre de réadaptation Estrie*, *Centre de réadaptation Lucie-Bruneau*, *Centre en déficience physique Chaudière-Appalaches* and *Centre de réadaptation Constance-Lethbridge*. Also, the *Ordre des ergothérapeutes du Québec* awarded the Anne-Lang-Étienne scholarship to carry out this project as part of the first author's master's program. Finally, the authors would like to thank Dr Frederic Dumont for his help for the manuscript revision.

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APPENDIX

Detailed explanation of the training levels

Level 1

Objective: The participant will see all stop signs and traffic lights (not miss any) when sitting in the **front passenger seat** of a moving car during a full 30-minute session.

Level 2

Objective: The participant will see the following road signs: stop signs, no entry, yield, speed limits, school zone, compulsory and forbidden manoeuvres, one way and warning signs (danger or road work) as well as all traffic lights when sitting in the **front passenger seat** of a moving car.

To move onto the next level the participant must identify 95% of the above signs over a period of at least 30 minutes.

Level 3

Objective: The participant will see important elements in the environment such as the road signs listed in objective 2. The participant must also identify moving objects that may pose an increased safety risk (for example, pedestrians, cyclists, children playing ball on the sidewalk, vehicles entering the road from a laneway) as well as changes in traffic lights when sitting in the **front passenger seat** of a moving car.

To move onto the next level the participant must identify 95% of the above signs over a period of at least 30 minutes.

Level 4

Objective: The participant will see important elements in the environment such as road signs, changes in traffic lights and moving objects that pose a risk to his/her safety. The participant will identify all dangers in the environment by anticipating the risk to his/her safety when sitting in the **front passenger seat** of a moving car.

To move onto the next level the participant must not miss anything in the situation that poses a risk to his/her or others' safety (e.g. not see a child running into the road after a ball, a change in traffic lights, etc.) over a period of at least 30 consecutive minutes.

Level 5

Objective: The participant will see and analyze signs at intersections and make quick, appropriate decisions in each of the following situations at least 3 times for each situation:

4-way stops

2-way stops or 1-way stop

Left turn at traffic lights on arrow or flashing green

Left turn at traffic lights against traffic

Yield

To move onto the next level the participant must make the correct decisions in each of the above situations, 3 consecutive times.

Level 6

Objective: The participant will make quick, appropriate decisions to change lanes safely in city and/or highway driving when sitting in the front passenger seat of a moving car, at least 5 consecutive times.

Level 7

Objective: The participant will control the vehicle **as the driver,** following all the road signs, identifying all important elements in the environment and planning his/her actions so as to react appropriately to dangers in the environment, in low speed zones ($\leq$50 km/hr).

To move onto the next level the participant must not make any major mistakes that could create a risk to his/her or others' safety while driving for at least 30 minutes.

Level 8

Objective: The participant will control the vehicle **as the driver,** following all the road signs, identifying all important elements in the environment and planning his/her actions so as to react appropriately to dangers in the environment, in higher speed zones (≤50 km/hr). *To move onto the next level the participant must not make any major mistakes that could create a risk to his/her or others' safety while driving for at least 30 minutes.*

Level 9

Objective: The participant will plan and follow a 30-minute route **(as the driver)**, paying attention to stimuli in the environment and reacting appropriately to dangers.

To pass this level, the participant must not make any significant or major mistakes that could create a risk to his/her or others' safety while driving for at least 30 minutes.

