Evaluation and Retraining of Driving Skills in Clients with Stroke

Évaluation et réentraînement des habiletés à la conduite automobile de clients ayant subi un accident vasculaire cérébral

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ABSTRACT

An important component of the rehabilitation of clients with stroke is a referral by treating clinicians to a driving evaluation service in order to determine fitness to drive. However, the validity of the evaluation procedure has not been well established. In addition, while clinicians offer therapy to help improve the level of function in many areas of daily life, few rehabilitation centres have attempted to assist clients to return to independent driving. This thesis is comprised of three manuscripts examining both the methods used to evaluate driving performance as well as the effectiveness of a novel training program on the driving success of clients with stroke.

The first study examined the ability of visual perceptual testing to predict on-road driving outcome. Individuals with stroke referred to a driving evaluation service over a 32-month period, and who completed both a battery of perceptual tests and an on-road driving evaluation were included in this historical cohort. Subjects who passed the on-road evaluation obtained better average scores on the majority of perceptual tests compared with those who failed. The Motor-Free Visual Perception Test (MVPT) was the most predictive test of on-road performance (positive predictive value = 86.1%; negative predictive value = 58.3%). The combination of tests resulting in the most predictive and parsimonious model included the MVPT and Trail Making B tests, such that those who scored poorly on both were 22 times more likely to fail the on-road evaluation. These findings suggest that a screening process is useful in identifying individuals who are not ready to undergo an on-road driving evaluation.

Visual processing skills, while critical for safe automobile driving, are known to diminish with age and are often seriously impaired following a stroke. The second area of research examined the effectiveness of training visual attention skills using the “Useful Field of View” (UFOV) in clients with stroke referred for driving evaluation. Initially, a pilot study was conducted to determine the test norms, variation in scores, and test-retest reliability of the UFOV evaluation. In addition,

this study assisted in the development of a training protocol and examined the feasibility of UFOV training in this clientele. The study results indicated substantial reduction in visual attention in 52 clients with stroke, with poorer scores occurring with increasing age. Test-retest reliability, tested on seven subjects, was moderate (ICC=0.70). Six subjects demonstrated improved performance on the UFOV following twenty sessions of training.

These findings assisted in the development of a randomized clinical trial designed to determine the effectiveness of a visual attention training program using the UFOV in improving the driving success rate in clients with stroke. Ninety-seven subjects referred to a driving evaluation service were randomized to either control or experimental treatment using stratified block randomization. Stratification was performed according to side of lesion (left or right hemisphere) and percentage reduction in UFOV (mild, moderate or severe). Subjects were tested by the research therapist using a battery of visual perceptual tests and the UFOV. Individuals in the experimental group received therapy using the UFOV, a new technology designed to retrain visual attention skills, including processing speed, divided attention and selective attention. Individuals randomized to the control group received therapy using commercially available software programs that target general visual perceptual skills. Subjects received training two to four times per week for a total of 20 sessions. Following completion of the intervention, subjects were tested using the visual perception test battery, the Test of Everyday Attention, and the standard on-road driving evaluation. All evaluations were conducted by an occupational therapist who was unaware of the subjects' group assignment.

Eighty-four subjects completed the outcome evaluation. The two groups were similar in terms of their medical, social and driving characteristics. There were no significant differences between the groups on any of the pre-training visual-perceptual tests or on UFOV testing. The experimental and control groups did not differ on any of the outcome measures. For those individuals with right-sided lesions, there was a non-significant increase in the rate of success on the on-road driving evaluation for those in the experimental group. In this subgroup, 52%

of those who received UFOV training passed the on-road driving test as compared to 29% in the control group. The study, however, did not have sufficient power to detect a clinically important effect size in this subgroup. While training using the UFOV was not effective in improving the proportion of individuals who passed the driving evaluation, preliminary analyses indicate that individuals with right hemisphere stroke may benefit from this type of training.

ABRÉGÉ

Une composante importante du processus de réadaptation des clients ayant subi un accident vasculaire cérébral (AVC) est la référence à un service d'évaluation de conduite automobile, dans le but de déterminer la capacité à conduire du client. Toutefois, la validité de la procédure d'évaluation actuellement utilisée n'a pas encore été déterminée. De plus, même si les cliniciens offrent des thérapies visant à optimiser le niveau de fonctionnement dans plusieurs domaines d'activités de la vie quotidienne, peu de centres de réadaptation ont jusqu'à maintenant tenté d'aider leurs clients à réapprendre à conduire de façon autonome. La présente thèse est constituée de trois articles portant sur les méthodes d'évaluation des performances de conduite ainsi que sur l'efficacité d'un nouveau programme d'entraînement à la conduite automobile pour les clients ayant subi un AVC.

La première étude examine la capacité des tests de perception visuelle à prédire les habiletés de conduite. Ont été inclus dans cette étude, les individus ayant subi un AVC référés à un service d'évaluation de conduite au cours d'une période de 32 mois et ayant complété une batterie de tests perceptuels ainsi qu'une évaluation de conduite. Les sujets ayant réussi l'évaluation sur route ont obtenu une meilleure côte moyenne dans la majorité des tests perceptuels en comparaison à ceux qui avaient échoué cette même évaluation. Le Motor-Free Visual Perception Test (MVPT) a démontré la meilleure qualité à prédire la performance au test sur route (valeur prédictive positive = 86.1%, valeur prédictive négative = 58.3%). En outre, la combinaison de tests formant le modèle optimal et ayant la meilleure valeur prédictive s'est avérée être le MVPT et le Trail Making B Test, puisque les sujets ayant obtenu un mauvais résultat à ces deux évaluations avaient vingt-deux fois plus de chances d'échouer à l'évaluation sur route. Ces résultats suggèrent qu'un processus de dépistage est utile afin d'identifier les individus qui ne sont pas prêts à subir une évaluation de conduite automobile.

Les habiletés de traitement d'information visuelle, reconnues pour leur importance dans une conduite automobile sécuritaire, diminuent avec l'âge et sont souvent affectées lors d'un AVC. Ainsi, la deuxième partie de la recherche s'est penchée sur l'efficacité d'un entraînement des habiletés d'attention visuelle, utilisant le 'Useful Field of View' (UFOV) chez des clients ayant subi un AVC référés pour une évaluation de conduite. Initialement, une étude pilote a été complétée afin de déterminer les normes du test, les variations dans les côtes et la fiabilité test-retest de l'évaluation UFOV. De plus, cette étude a permis de développer un protocole d'entraînement et d'examiner l'utilité du UFOV pour l'entraînement auprès de cette clientèle. Les résultats de l'étude ont indiqué une diminution significative de l'attention visuelle chez cinquante-deux clients ayant subi un AVC. De plus, les sujets les plus âgés ont obtenu les côtes les plus faibles. La fiabilité test-retest, calculée auprès de sept sujets, s'est averée modérée (ICC = 0,70). Finalement, six sujets ont démontré une amélioration au niveau de la performance au UFOV suite à vingt sessions d'entraînement.

Ces résultats sont venus supporter le développement d'un essai clinique randomisé pour déterminer l'efficacité d'un programme d'entraînement de l'attention visuelle utilisant le UFOV pour améliorer le taux de succès à la conduite automobile des clients ayant subi un AVC. Quatre-vingt-dix-sept sujets référés à un service d'évaluation de conduite ont été randomisés (blocs stratifiés) soit à un groupe de contrôle, soit à un groupe de traitement expérimental. La stratification a été accomplie selon le côté de la lésion du sujet (hémisphère gauche ou droit) et le pourcentage de réduction au UFOV (léger, modéré ou sévère). Les sujets ont été évalués par un thérapeute participant à la recherche à l'aide d'une batterie de tests de perception visuelle et du UFOV. Les individus appartenants au groupe expérimental ont reçu une thérapie utilisant le UFOV qui est une nouvelle technologie élaborée à des fins de réentraînement des habiletés d'attention visuelle, et qui inclu la vitesse de processus de l'information, l'attention partagée et l'attention sélective. Les sujets du groupe de contrôle ont reçu une thérapie utilisant un programme d'informatique disponible sur le marché et visant spécialement au réentraînement des habiletés de perception visuelle.

Tous les sujets ont reçu deux à quatre séances d'entraînement par semaine pour un total de vingt séances. Suite à l'intervention, les sujets ont été évalués à l'aide d'une batterie de tests de perception visuelle, le Test of Everyday Attention et l'évaluation de conduite sur route standard. Toutes les évaluations ont été effectuées par un ergothérapeute qui ne savais pas dans quel groupe les sujets avaient été assignés.

Quatre-vingt-quatre sujets ont complété l'évaluation finale. Les deux groupes étaient semblables quant à leurs caractéristiques médicales, sociales et de conduite automobile. Aucune différence significative entre les groupes n'a été notée dans les résultats obtenus aux tests de préentraînement visuel perceptuel et dans les résultats du test UFOV. Il n'y avait pas de différence significative au niveau des mesures de résultats entre le groupe experimental et de contrôle. Pour les individus ayant une lésion à l'hémisphère droit et faisant parti du groupe expérimental, on a noté une augmentation non significative dans le taux de succès à l'évaluation sur route. Dans ce sous-groupe, 52% de ceux appartenant au groupe expérimental ont réussi l'évaluation sur route comparé à 29% dans le groupe de contrôle. Par contre, la puissance de cette étude ne permettait pas de déceler un effet clinique important pour ce sous-groupe. Ainsi, même si l'entraînement à l'aide du UFOV ne s'est pas avéré efficace pour améliorer la proportion d'individus qui réussissaient leur évaluation de conduite, les analyses préliminaires indiquent que les individus ayant subi un AVC de l'hémisphère droit pourraient profiter de cet entraînement.

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Throughout the period of my Ph.D. candidacy, I received invaluable advice and assistance from the members of my supervisory committee. I wish to express my sincere gratitude to Dr. Nicol Korner-Bitensky for her keen sense of perspective and support, Dr. James Hanley for ensuring that I attended to and comprehended every detail of the data analysis, Dr. Jacques Gresset for his patience and guidance, and Dr. Joseph Carlton for his assistance with the important clinical issues. To each one, I express my sincerest gratitude, not only for their generous contribution of time, but also for their expertise and encouragement.

A special thank you to the participating occupational therapists, Catherine Rochon, Bruneau Brassard, Danièle Martineau, Maria McIntyre, Debbie Ryan, Julie Potvin, Rosie Coletti, and Heather Maxwell-Arnold, for conducting the evaluations and training sessions.

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To my late brother, Mark A Samuel, it is to you that I owe my academic interest and dedication. I express my deepest gratitude to my husband, Bruce, for his endless encouragement and support, and for always believing in me. To my children, Monty, Elan and Ariel, thanks for supporting me with your patience and your smiles.

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PREFACE

This thesis is organized in four chapters. Chapter 1 is an introduction to the topic under study. Chapter 2 is a review of the literature that covers the following related areas: the magnitude of the problem, specifically the frequency and importance of stroke; the clinical outcome of stroke with a focus on the impairments most related to automobile driving; the importance of driving for community reintegration; driving in the elderly, the disabled and individuals with stroke; evaluation of driving skills; and retraining of driving ability in the population with stroke.

Chapter 3 presents the three manuscripts that contain the studies comprising the thesis. The first paper is titled “Predicting ability to drive after stroke” and is the report of a study designed to establish the predictive validity of the routine perceptual-cognitive test battery in determining on-road driving performance. This study was published in the *Archives of Physical Medicine and Rehabilitation, volume 79, pages 753-750, 1998*. The second manuscript, “Use of the UFOV to evaluate and retrain visual attention skills in clients with stroke: a pilot study” presents the pilot work that was conducted to determine norms of the UFOV test for clients with stroke, as well as the feasibility and potential impact of UFOV training in these clients. This study has been submitted to the *American Journal of Occupational Therapy*. The final manuscript “Effectiveness of a visual attention retraining program on the driving performance of clients with stroke”, describes a randomized clinical trial conducted to determine the effectiveness of an intervention targeted specifically at the visual attention deficits common to stroke that are crucial for safe driving. This paper was submitted to the journal *Stroke* for review.

Finally, in Chapter 4, the findings are discussed, the study limitations are described, and the implications of these studies for clients with stroke and therapists involved in stroke rehabilitation are presented.

STATEMENT OF ORIGINALITY

To the best of my knowledge this thesis contains no material previously published or written by another person, except where references are made.

The impetus for conducting research in the area of driving evaluation and training came from Susan Sofer, an occupational therapist with a private clinical practice who is well known for her clinical expertise and extensive experience in driving evaluation. She has been an advocate for research to improve the status of clinical practice and knowledge in this area. Three of us, Susan Sofer, Nicol Korner-Bitensky, a researcher at the Jewish Rehabilitation Hospital, and I, together planned the studies reported in this thesis. My focus was on devising the research methodology used to conduct the studies. I was integrally responsible for the design of the studies; recruitment of subjects; hiring, training and supervising the clinicians; managing the data; planning and overseeing the data analyses; and documenting the work in these three manuscripts. Researchers and clinicians working in the area of driving evaluation, as well as the members of my thesis supervisory committee, contributed suggestions, comments and corrections on the research methodology and statistical methods that I used as well as on the documentation of my work.

The data for the study examining the perceptual-cognitive evaluation procedure were collected in the context of clinical practice at the Jewish Rehabilitation Hospital, prior to the inception of the study. In addition, the protocol for this study was prepared prior to my joining the team. Data for the studies examining the UFOV evaluation and retraining program were collected specifically for those studies.

This thesis represents an original contribution to the literature. This is the first time that these perceptual-cognitive tests, individually and in combination, were assessed for their predictive validity in clients with stroke. Also, this was the first randomized clinical trial that examined the effectiveness of an intervention targeted at improving driving performance in those with neurological impairments. The results of this work provide important information regarding the evaluation and training of driving skills in clients with stroke and highlight the need to continue to develop and systematically evaluate the measures and training methods used in this area of clinical practice.

CONTRIBUTIONS OF AUTHORS

The three manuscripts presented in this thesis discuss the results of work in the area of evaluation and retraining of driving skills in clients with stroke. In the first study examining the ability of perceptual testing to predict on-road performance, I was in responsible for compiling the data and planning and interpreting the data analysis. For the two studies which focused on UFOV training, I was primarily in charge of the design of the studies, supervising the treating therapists and the outcome evaluator, recruiting the study subjects, as well as for overseeing the data collection, managing the data entry, and planning and supervising the data analyses.

Susan Sofer, B.Sc. (O.T.), a clinician who has worked extensively in the area of driving evaluation, was responsible for the clinical aspects of the studies. She contributed the clinical information necessary to plan the study proposals, participated actively in planning the study procedures, and assisted in the development of the intervention protocol and the selection of measurement tools. She also assisted in the hiring and training of clinicians to carry out the evaluations and training sessions.

Nicol Korner-Bitensky, Ph.D. was a researcher at the Jewish Rehabilitation Hospital and a member of the thesis supervisory committee. She participated in the design of the studies, and offered theoretical and practical suggestions on many aspects of the conduct of the study, including recruitment, methodology and procedures. In addition, she was integrally involved in the writing of the first manuscript.

Isabelle Gelinas, Ph.D., researcher at the Jewish Rehabilitation Hospital, presented suggestions, primarily regarding the interpretation of the study results.

James Hanley, Ph.D., contributed to the data analyses, by offering suggestions for the conduct of the analyses and by clarifying the interpretation of the results.

Sharon Wood-Dauphinee, Ph.D., thesis supervisor, assisted in the design of the randomized clinical trial and offered advice on the conduct, execution and data analyses.

In addition, the authors for each of the studies participated in the interpretation of the study findings, assisted in developing the topics for the discussion of these findings, and commented on the final version of the manuscripts.

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1. INTRODUCTION

Driving a motor vehicle, which may have once been considered a luxury, is now an integral component of our lifestyle, facilitating our participation in all aspects of daily living and contributing to our quality of life. Following a stroke, the ability to perform functional activities, including driving an automobile, is frequently impaired due to the residual physical, cognitive, perceptual, language and behavioural deficits. The impact of reduced mobility within the community following a neurological insult is significant, in that those who stop driving have a higher frequency of depression (Legh-Smith et al., 1986) as well as an increased level of frustration and anger as a result of changes in personal roles and reduced participation in vocational and leisure activities (Davies Hallett et al., 1994).

After a stroke, only a small proportion of clients is referred to a driving evaluation service to determine fitness to drive. As there are no valid and reliable screening tools available to assist physicians in determining who requires evaluation, doctors in acute care facilities as well as those working in the community rarely refer clients for testing. In Canada, only those receiving rehabilitation services are likely to be evaluated for driving safety by an occupational therapist. For these individuals, therapists commonly administer a driving assessment in the final days of treatment by placing the client in an unfamiliar car, instructing them to follow a designated route, testing their performance and providing a recommendation regarding their "fitness to drive" to the Provincial Licensing Bureau. The most accurate method of determining the ability of an individual to resume driving is not known. At our centre, the evaluation of driving ability consists of two components: 1. a battery of perceptual-cognitive tests to evaluate specific skills, such as visual scanning, and selective and divided attention, and 2. an on-road driving evaluation. While these evaluation tools are selected according to our clinical understanding of the skills and behaviours necessary for safe driving, the validity of these evaluation procedures is not well known. These tests are time consuming, costly and stressful for the clients. Since driving is critical to their future independence, it is imperative that the measures that are used accurately determine fitness to drive.

In addition, individuals with stroke often have difficulty successfully completing these evaluations. This is not surprising, since driving is highly reliant on quick response time, visual attention, as well as complex perceptual and cognitive processing, functions that are often impaired following a stroke. At our centre, approximately 40-50% of clients with a stroke who are evaluated, pass the on-road evaluation and may continue to drive.

The primary objective of rehabilitation intervention is to enable clients with disabilities to reach their optimal physical, cognitive, and/or social level of function, as well as to enhance their quality of life and degree of participation in the community. Automobile driving can be an important contributing factor to successful community reintegration. While rehabilitation specialists provide interventions to clients with stroke to enable them to regain the highest possible level of functional independence in self-care, feeding, dressing and instrumental activities of daily living such as banking and shopping, one area in which clinicians have provided almost no assistance is in the retraining of driving skills. Few rehabilitation programs offer interventions targeted at improving driving ability and very little research has been conducted evaluating the effectiveness of the available methods of training driving following neurological impairment. To date, there are no known effective interventions to assist individuals with stroke to regain the necessary skills for driving.

In our society, the ability to drive is a privilege, not a right. The role of the rehabilitation specialist is to make sure that each client who can drive safely is given the opportunity to do so, while ensuring the safety of the client and others. Clinical approaches and research efforts must focus on developing and validating our methods of evaluating and retraining driving skills in clients with stroke. At the Jewish Rehabilitation Hospital where a large number of clients are evaluated annually to determine licensing status, we are well aware of the questionable quality of the assessment process and the lack of available training programs to improve driving skills. This project attempts to respond to these lacunae by addressing two principal objectives: to determine the predictive validity of a typical assessment battery and to develop and determine the effectiveness of an intervention program aimed at retraining certain skills commonly affected by stroke that are crucial for driving.

2. REVIEW OF THE LITERATURE

The review of the literature focuses on the following five areas: the magnitude of the problem; sequelae of stroke and their specific effects related to driving; driving performance in individuals with stroke and other disabling conditions; and the methods used to evaluate and retrain driving skills in individuals with disability.

2.1 MAGNITUDE OF THE PROBLEM

Stroke, or cerebrovascular accident (CVA), is defined by the World Health Organization (WHO) as an acute neurological dysfunction of vascular origin with a sudden (within seconds) or rapid (within hours) occurrence of symptoms and signs corresponding to the involvement of focal areas of the brain (WHO, 1989). By definition, neurological symptoms must persist for more than 24 hours for a stroke to be diagnosed (Sacco, 1995). A stroke may be caused by a cerebral infarction, due to a temporary or permanent occlusion of a feeding artery, or by a hemorrhage, caused by a rupture of an abnormal artery or arteriole (Sacco, 1995; WHO, 1989). Stroke caused by cerebral infarction accounts for approximately 65-80% of all stroke cases (D'Alessandro et al., 1992; Sacco, 1995). In Canada, the rate of cerebral infarction is higher than that of cerebral hemorrhage with ratios ranging from 3:1 to 20:1 depending on age and sex (Mayo et al., 1996).

2.1.1 Frequency of Stroke

Cerebrovascular disorders can occur at any age, in both males and females, and in all races. The incidence rate of first-ever stroke rises exponentially with increasing age from about 3 per 10,000 at 30 to 40 years of age to almost 300 per 10,000 in those aged 80 to 90 years (Bonita, 1992). Most strokes occur in individuals over 65 years of age, and with the aging of our population, the prevalence of stroke will undoubtedly increase (Helgason & Wolf, 1997; Sacco, 1995). The rate of stroke is higher in males and in African-Americans (Sacco, 1995). The known modifiable risk factors for stroke include hypertension, diabetes mellitus, cardiac disease, hypercholesterolemia, cigarette smoking, alcohol abuse, obesity, physical inactivity, and diet (Adams & Victor, 1993; Helgason & Wolf, 1997; Sacco, 1995; WHO, 1989).

Estimates of the incidence and prevalence of stroke vary according to whether a study was hospital or community based. Also, rates vary according to the diagnostic and data collection methods used, whether by clinical examination, computed tomography (CT) scan or at autopsy. The incidence of new cases of stroke in the United States has been estimated at 400,000 to 500,000 annually while the prevalence of stroke survivors has been estimated at 2 to 3 million individuals (Goldstein, 1990; Sacco, 1995). In Canada, stroke accounts for approximately 67,000 hospitalizations and 3.2 million hospital days per year (Petrasovits & Nair, 1994). The rate of hospitalization for cerebrovascular disease in 1996/1997 varied according to age and sex, ranging from 36/100,000 in women aged 35 to 44 years to 2,681/100,000 in women 85 years and older. For men, rates ranged from 35/100,000 in those aged 35 to 44 years to 3,273/100,000 in individuals 85 years and older (Canada, 2000b). The crude rates of hospitalization due to stroke in 1996 to 1997 for both men and women according to age are presented in the following tables.

Acute care hospitalizations for men by type of stroke and age, 1996/97 crude rates /100,000

Men	**35-44**	**45-54**	**55-64**	**65-74**	**75-84**	**85+**
All stroke	26	86	289	732	1612	2386
Subarachnoid hemorrhage	7	12	20	17	15	Not available
Intracerebral infarction	4	12	38	84	148	147
Cerebral infarction	13	58	219	600	1371	2108

Source: Hospital Morbidity database, Canadian Institute for Health Information

Acute care hospitalizations for women by type of stroke and age, 1996/97 crude rates /100,000

Women	35-44	45-54	55-64	65-74	75-84	85+
All stroke	25	66	167	469	1183	1996
Subarachnoid hemorrhage	11	22	24	26	27	20
Intracerebral infarction	3	9	20	53	103	136
Cerebral infarction	10	33	119	379	1028	1803

Source: Hospital Morbidity database, Canadian Institute for Health Information

The incidence rates for stroke have varied over the past several decades. In the 1970s and 1980s there was a consistent decrease in the rate of stroke attributed to modification of risk factors, such as improved control of hypertension (Truelsen et al., 1997), but this decline slowed or ended during the 1980s and 1990s (Canada, 2000b; D'Alessandro et al., 1992). This may be explained by the increase in use of CT scanning, thereby improving the detection of less severe strokes (Bonita, 1992; Brown et al., 1996). With the aging of the Canadian population, the total number of hospitalizations due to stroke has increased over the past 30 years in both men and women (Canada, 2000b). Mayo and colleagues (Mayo et al., 1996) examined the rate of stroke in the 10 Canadian provinces for the years 1982 to 1991. All individuals with stroke aged 15 years and over who were discharged from acute care hospitals were included. Over the study period, the rate of infarction decreased approximately 1% per year, while the rate for hemorrhagic stroke increased 44% for men and 34% for women. The rate of hospitalization in acute care hospitals in Quebec between 1981 and 1988 was examined according to age and type of stroke (Mayo et al., 1991). The rate of cerebral hemorrhage for men 50 years and over and for women 65 years and over increased over the study period. There was also an increase in the incidence rate for occlusion of the precerebral artery in those aged 65 years and over, while the rate decreased for those under 65 years of age. A significant reduction in the rate of occlusion of the cerebral artery was found for most age groups in both men and women.

The MONICA (Monitoring Trends and Determinants in Cardiovascular Disease) Project of the WHO, the largest epidemiological study of heart disease and stroke to date, studied cardiovascular disease in 35 defined populations in 21 countries over a 10 year period. The stroke component of the project encompassed 21 populations in 11 countries covering a total population of 2.9 million men and women aged 35 to 64 years, with seven registries extending their population to age 75 years (Bonita & Beaglehole, 1995; Thorvaldsen et al., 1995). Each stroke event was classified as either first or recurrent, and as fatal or nonfatal within 28 days. Death certificates as well as hospital admission and discharge diagnoses with ICD-8 or 9 (International Classification of Disease, edition eight or nine) codes of 430-434 and 436 were registered and cases managed outside of hospital were also ascertained. The age-standardized incidence rates for first stroke ranged from 101 to 285 per 100,000 in men, and from 47 to 198 per 100,000 in women. The median proportion of recurrent stroke was 20% (range 8-26%). Rates were consistently higher in men as compared to women with the ratio ranging from 1.2:1 to 2.4:1 (Thorvaldsen et al., 1995). The MONICA Project data for the years 1984-1990 were analyzed to examine trends in event rates over time. Stroke attack rates declined in 13 of the 17 study centres for men and in 15 centres for women, with the rates of decline ranging from 0.3 to 13.8% over the study period (Thorvaldsen et al., 1997). This decline in stroke incidence was also substantiated in a study conducted in Finland, which found a statistically significant decline in incidence between 1983 and 1992 (from 267 per 100,000 in 1983-1985 to 241 per 100,000 in 1990-1992 for men and from 150 to 129 per 100,000 in women over the study period) (Tuomilehto et al., 1996).

The MONICA project compared trends in stroke attack rates and case fatality rates between an Eastern (Novosibirsk, Siberia) and a Western (northern Sweden) country for individuals aged 35-69 years between 1987 to 1994 (Stegmayr et al., 2000). Findings indicated a large variation in the methodology and the quality of the data between the official registers. Stroke attack rates increased over the study period in both populations, ranging from 244 to 303 per 100,000 in Sweden and 430 to 660 per 100,000 in Siberia. There are difficulties, however, in accurately ascertaining and comparing the rates of stroke across different countries that may use different inclusion criteria (i.e. subarachnoid hemorrhage, transient ischemic attacks, silent infarcts detected by imaging), and may differ in the inclusion of only first ever or every stroke attack (Sudlow & Warlow, 1996).

In Rochester, Minnesota, the Rochester Epidemiology Project Medical Record Linkage System was used to identify all cases of stroke in the community from 1955 to 1989. The average annual age- and sex-adjusted incidence rates for 5-year periods were calculated. There was a decrease in the incidence rates for stroke through the 1970s (128 per 100,000 in 1975 to 1979 versus 205 per 100,000 in 1955 to 1959), while rates increased for all groups aged 54 years and older in both sexes during the 1980s (145 per 100,000) (Brown et al., 1996).

The decline in stroke incidence throughout the 1970s and in some cases into the 1980s occurred most specifically in the elderly (Derby et al., 2000; Truelsen et al., 1997). In Copenhagen, 19,698 subjects were examined at three points in time; 1976 to 1978, 1981 to 1983, and 1992 to 1994, to detect cases of first ever stroke. No change in incidence of stroke for subjects aged 45-64 years was found, but for those aged 65-84 years, there was a significant decline in incidence for men and a nonsignificant decline for women over time. In south-eastern New England, the rate of fatal strokes declined for both men and women with the trend attributable to reductions in those aged 65-74 years (Derby et al., 2000).

The prevalence of stroke in women in the Rochester Epidemiology Project remained stable over time with rates of 755 per 100,000 in 1955 to 1959 and 759 per 100,000 in 1985 to 1989. The prevalence for men, however, increased over the same period of time from 770 to 917 per 100,000 (Brown et al., 1996). Prevalence of stroke was estimated from two population-based studies in 1981 and 1991 in Auckland. The age-standardized rate was 833 per 100,00 population 15 years and older; 991 per 100,00 for men and 706 per 100,00 for women.

When those who made a complete recovery were excluded, the prevalence of those with some degree of impairment was estimated at 461 per 100,000 (Bonita, Solomon, & Broad, 1997).

2.1.2 Mortality

Stroke is the third leading cause of death, accounting for approximately 10-12% of all deaths in industrialized countries (Bonita, 1992; Helgason & Wolf, 1997). In Canada, stroke is the third leading cause of mortality (Petrasovits & Nair, 1994), accounting for 7.4% of all deaths (Canada, 2000c). The mortality rate in 1997 was 47.8 per 100,000 population; 52.8 per 100,000 for males and 43.9 per 100,000 for females (Canada, 2000a). The age-standardized mortality rates for cerebrovascular diseases from 1993-1997 ranged from 48-52/100,000 for males and females combined. According to the WHO 1996 World Health Statistics Annual, Canada had the lowest age-standardized mortality rate due to cerebrovascular disease of all countries studied (Canada, 2000b).

Canadian statistics report that the percentage of individuals with stroke discharged alive is approximately 82% and 85% for women and men, respectively, and that this rate is strongly associated with age (Petrasovits & Nair, 1994). Case-fatality rates, the proportion of events that are fatal within a specified period after an event, were reported by the MONICA study. Case-fatality rates for the first 28 days post-stroke ranged from 15 to 49% in men and 18 to 57% in women (mean 30%) and were consistently higher in women in almost all populations (Thorvaldsen et al., 1995). The reported case-fatality rates for ischemic stroke ranged from 24 to 31% at one month (D'Alessandro et al., 1992; Sacco, 1995) and 42% at one year post-stroke (Bonita, 1992), while the rates for hemorrhagic stroke were higher, ranging from 20-80% (Sacco, 1995). Survivors continue to have a 3 to 5 times greater risk of death and recurrent stroke is common (Bonita, 1992).

The rate of mortality due to stroke has been consistently decreasing over time (Bonita & Beaglehole, 1995). In Canada, since 1969, mortality has decreased in both men and women, reached a plateau in the 1990s, and has not changed significantly over the past 10 years (Canada, 2000b). From 1961 to 1991, the age adjusted Canadian mortality rate declined by 57% in men and 65% in women. Potential reasons for this decline include improvement in general health status, improved quality of acute care, increased access to health care, improved detection and control of high blood pressure, as well as a decline in the prevalence of risk factors such as smoking and fat consumption (Petrasovits & Nair, 1994).

In the United States, a 60% decline in stroke mortality occurred between 1960 and 1990 (Helgason & Wolf, 1997). Reduction in mortality occurred due to the decline in incidence of stroke as well as the improved rate of survival (Sacco, 1995). The population-based Northern Sweden MONICA study examined time trends in long-term survival following stroke in approximately 300,000 men and women with acute stroke from 1985-1994. The median follow up time was 4.7 years and all cases were followed for a minimum of one year. A gradual improvement in survival occurred over the study period (Peltonen et al., 1998). The Finnish MONICA study also reported a decrease in mortality from stroke over time (from 82 per 100,000 in 1983-1985 to 60 per 100,000 in 1990-1992 for men and 48 to 34 per 100,000 in women) (Tuomilehto et al., 1996). It has been suggested that an improved case-fatality rate rather than a decrease in the incidence rate is a more likely explanation for the decline in mortality due to stroke (Bonita, 1992).

In summary, there has been a decrease in the incidence of stroke over time, although more recently, this trend appears to be stabilizing. The use of CT scans for diagnostic purposes may have influenced the ending of this decline. In addition, mortality due to stroke has also declined over time. The aging of the population as well as improvements in the case-fatality rates due to stroke suggest that there will be a continued increase in the number of individuals living with the sequelae of stroke.

2.2 STROKE OUTCOME

2.2.1 Clinical Picture

The cardinal feature of stroke is the sudden onset of neurological symptoms (Sacco, 1995), resulting in a maximum deficit within minutes, or several hours at the longest (WHO, 1989). Symptoms most often stabilize during the following days, though deterioration may be seen in approximately 20-30% of cases (WHO, 1989). After the initial onset, the course of the illness may take one of the following forms: i. complete recovery in <24 hours, termed a transient ischemic attack (TIA); ii. complete recovery in >24 hours, termed a regressive ischemic neurological deficit (RIND); iii. partial recovery with persistent sequelae; iv. no recovery or continued worsening; or v. death. TIA and RIND usually refer to stroke of ischemic origin, while partial recovery, no recovery, or worsening are disease courses more often associated with a cerebral hemorrhage. A delayed worsening in the condition that occurs after the first 3-4 days, is most often the result of a hemorrhage (WHO, 1989).

The neurologic deficits reflect both the location and size of the infarct or hemorrhage (Adams & Victor, 1993). New imaging techniques, including computed tomography (CT) and magnetic resonance imaging (MRI), are necessary to identify the cerebral lesion and the affected vessels (Adams & Victor, 1993), as an unstructured clinical examination is insufficient to distinguish between the two causes of stroke (Ricci et al., 1994; Sacco, 1995). Hemiplegia is the classic sign of cerebrovascular disease, but there are many other manifestations including mental confusion, sensory impairments, aphasia, visual field deficits, diplopia, dysarthria, and perceptual and cognitive changes. (Macciocchi et al., 1998; Purvin, 1996; Ricci et al., 1994).

The different types of focal cerebral infarction and hemorrhage have been classified according to their etiology as well as their location and presenting deficits (Adams & Victor, 1993; Sacco, 1995; WHO, 1989) A summary of this information is presented in Appendix 1.

Medical complications after stroke are common. The charts of 607 consecutive stroke clients hospitalized in acute care were examined and 59% had experienced one or more recorded complications during the first 30 days post-stroke. The most common complicating factors included falls (22%), skin breaks (18%), urinary tract infections (16%), and respiratory infections (12%), as well as seizures, depression, confusion, and painful shoulders. Seizures and respiratory infections occurred early on, while other complications continued to present over the course of the study period. Complications were more common in those who were older, had a pre-stroke disability, and had urinary incontinence, while the presence of one or more complicating factors was associated with an increased risk of death (Davenport et al., 1996).

2.2.2 Impairment and Disability Associated with Stroke

Stroke is the leading cause of serious disability in the adult population (Helgason & Wolf, 1997; Petrasovits & Nair, 1994; Suchoff et al., 2000). The effects of the consequent changes in sensory, motor, perceptual, cognitive, psychological, and behavioural states are often devastating to the client as well as to their families (Suchoff et al., 2000). The aging of our communities as well as the success in reducing stroke mortality means that there will be an increase in the number of stroke survivors living with disabilities (Bonita, 1992). Providing services for survivors of stroke remains an important challenge for health care providers in Canada (Petrasovits & Nair, 1994).

Several studies have attempted to document the outcome of stroke survivors, however, making comparisons between them is often difficult. Studies differed considerably in their methodology, including subject selection criteria, classification of stroke (Millikan, 1996), source of the inclusion population (Segal & Whyte, 1997), and the timing and type of measurements used (Wood-Dauphinee et al., 1990). In addition, the burden of care directly due to stroke is difficult to measure due to the possible presence of other disabling and/or handicapping conditions prior to the stroke (Bonita, 1992).

Stroke sequelae include impairments in cognitive, motor, sensory, language, perceptual and/or behavioural functions and may result in physical and mental disability as well as difficulty adapting to previous social and occupational roles (WHO, 1989).

The proportion of clients with resultant mild to severe disability ranged from 62% to 90% depending on the type and timing of measurement (Cifu & Lorish, 1994; D'Alessandro et al., 1992). A population based study of clients admitted to hospital following a stroke in Valle d'Aosta, Italy examined level of disability using the Barthel Index. Results at one month after stroke indicated that 38% were fully independent, 34% partially dependent, and 29% totally dependent. A study examining outcome at 6 months following the initial insult, found that 48% had residual hemiparesis, 22% were unable to walk, 24-53% reported complete or partial dependence on Activities of Daily Living (ADL) scales, 12-18% were aphasic, and 32% were clinically depressed (Helgason & Wolf, 1997). A survey of 700 individuals who had sustained a stroke in the United Kingdom at a median time of 2 years post-stroke indicated that 33% reported impairment of thought processes, 27% reported difficulty speaking, and approximately two out of five experienced some impairment of movement. Only 25% made a full recovery. Functional disabilities were common with 29% having trouble washing their face and 41% unable to walk outside the house without difficulty. Instrumental activities of daily living (IADL) posed more of a challenge, with 69% reporting an inability to shop independently. Twenty seven percent of surveyed subjects needed continuous help and supervision, while 46% needed help at least once each day (Tennant et al., 1997).

The Copenhagen Stroke Study, a community-based prospective study, examined recovery following stroke for 1197 subjects from acute care admission until completion of rehabilitation or death. Severity of stroke was classified using the Scandinavian Neurological Stroke Scale (SSS) as very severe in 19% of clients, severe in 14%, moderate in 26%, and mild in 41%. Level of initial stroke severity was highly associated with functional outcome in survivors. A total of 64% were discharged home, 15% were discharged to nursing homes, and 21% died during their hospital stay (Jorgensen et al., 1995a).

In order to determine how well individuals with stroke fare in the community, the Heart and Stroke Foundation of Ontario carried out an analysis of the National Population Health Survey that studied Canadians 65 years and older (Hodgson, 1998). Of the 19,600 households surveyed, 319 (4%) individuals (or proxies) responded as having been affected by stroke. Results indicated a much higher rate of functional difficulties in those living with stroke. Sixty nine percent described their health as poor or fair (3 times greater than seniors without stroke), 87% experienced a restriction in their activities of everyday life (compared to 37% without stroke), 42% could not walk or required assistance to walk (compared to 10%), and 21% reported cognitive problems (compared to 11%).

While the majority of studies evaluating outcome following stroke ascertained subjects from hospital records, one study in the United Kingdom surveyed one hundred and fifty seven general practitioners and recruited 243 cases which were managed in the community and never admitted to hospital (Lincoln et al., 1998). In this sample of individuals with presumably very mild stroke, there was a significant reduction in ADL scores on the Barthel Index, with the most difficulty reported in advanced mobility, household tasks, and leisure activities. Twenty seven percent reported severe mobility impairment, 47% were unable to pronate and supinate their upper extremity, 18% were aphasic, and 53% had visual spatial problems. In addition, 26% were anxious and 13% were found to be depressed. While comparisons to age matched controls were not included, these findings suggest a significant unidentified disability due to stroke in this population of non-hospitalized individuals.

The exact prevalence of impairments and disabilities associated with stroke is difficult to summarize due to variations in the subjects, and the timing and methods of measurement. These studies, however, clearly indicate that individuals living in the community have a wide range of deficits and are typically restricted in their basic daily activities, especially in their Instrumental Activities of Daily Living.

2.2.3 Course of Recovery

Recovery after stroke is both spontaneous and adaptive. The majority of spontaneous or intrinsic recovery occurs within the first three months post-stroke and continues at a slower pace for at least six months, and possibly up to one year, with approximately 10% of individuals with moderate or severe stroke achieving a full recovery (Heitzner & Teasell, 1998). Adaptive recovery depends on clients' motivation and ability to learn, the support they receive from their family, as well as the quality and intensity of rehabilitation (Bonita et al., 1997; Kwakkel et al., 1997; Langhorne et al., 1996; Pak & Dombovy, 1994).

Recovery of impairments follows a sequential pattern. The initial stage is characterized by flaccidity, followed by the development of spasticity. Return of voluntary movement frequently occurs in a proximal to distal pattern, with increasing control of movement over time. The pace and pattern of recovery varies across clients, as does the point at which individuals plateau. Motor recovery usually reaches a plateau by about 3 months, with greater potential for later recovery in those with an intracerebral hemorrhage. The upper extremity is usually more involved and has less complete recovery than the lower extremity (Pak & Dombovy, 1994).

A pilot study tracking the outcomes of clients who received services in 31 rehabilitation programs across Canada in 1997/98 for a variety of diagnoses, found that those with stroke had an average of approximately 30% improvement in functional status, the largest gain of all diagnoses other than spinal cord injury (CIHI, 2000). Of the 79% of subjects in the Copenhagen Stroke Study who survived and completed rehabilitation, 80% reached their best ADL function within 6 weeks and 95% within 12.5 weeks. This study, however, was short-term and did not examine further improvement once adjustment following discharge took place (Jorgensen et al., 1995b).

Improvement in function continues over time even in clients with poor initial progress. A group of 47 clients with hemiparesis who were discharged from rehabilitation due to limited functional gains continued to receive rehabilitation interventions for up to 24 months post-stroke. Improvements were seen such that the mean Barthel Index increased 65% from 3 to 12 months post-stroke. In addition, while only 25% of subjects were rated as having achieved good functional independence on the Barthel (>70) at 6 months, this value improved to 79% at 12 months, and the percentage of clients walking independently increased over that time period from 18% to 74% (Dam et al., 1993).

Recovery of specific functions also occurs over time. Aphasia affects approximately 24% of those with stroke during the acute stage; while at 12 months, 12% have significant language impairment. Unilateral neglect after right cerebral infarction is reported to occur in 12-49% of clients, depending on the method of measurement used, with gross neglect resolving in the majority of clients by 8-12 weeks post-stroke. Complex visual-perceptual impairments may recover incompletely, with deficits often present at 1 year (Pak & Dombovy, 1994).

Recovery during the first weeks post-stroke is attributed, in part, to the resolution of edema and recovery of the surrounding ischemic penumbra. Other mechanisms of recovery involve dynamic functional and anatomical reorganization of the intact areas of the brain that assume a greater role in functions normally attributed to injured brain tissue (Pak & Dombovy, 1994). Following hemorrhagic lesions, the blood that entered the cerebral tissue resorbs slowly over a period of weeks and months, during which time symptoms and signs recede (Adams & Victor, 1993).

A multi-centre prospective study conducted in Europe included 327 persons with ischemic stroke and found that younger age, less severe initial stroke, and location of the lesion in the left hemisphere were associated with better recovery as measured by the Barthel Index (Macciocchi et al., 1998). A review of 33 studies of stroke outcome reported that consistent adverse prognostic indicators of function include previous stroke, older age, incontinence, and visual spatial deficits (Jongbloed, 1986).

The presence of cognitive impairments and neuropsychological deficits after stroke impacts on all areas of function and is a key determinant in the clients' level of disability irrespective of physical impairment. Disorders of unilateral neglect and other spatial perceptual deficits typically seen in right hemisphere lesions can interfere with the recovery of mobility and autonomy in self-care. Also, post-stroke depression is quite common and can interfere with functional capacity and the ability to maintain functional gains (Pak & Dombovy, 1994).

While age is an important factor in stroke recovery, there is evidence that even elderly clients with stroke improve in function following the initial insult (Kong et al., 1998). Kong and colleagues examined the outcome of 59 individuals with stroke aged 75 years and older who were admitted for inpatient rehabilitation and found improvements in function with 90% of subjects being discharged home. Results of the Copenhagen Stroke Study indicated that while age did not influence neurological outcome, it did have an independent effect on functional outcome, potentially indicative of a poor ability to compensate in older stroke survivors (Nakayama et al., 1994).

To examine potential changes in stroke outcome over calendar time, the Minnesota Heart Survey examined morbidity due to stroke over a 15-year period. The rate of reported symptoms and signs increased from 1970 to 1985, with the frequency of aphasia increasing from 13% to 22%, and visual field defects from 17 to 55% (McGovern et al., 1992). Improvements in measurement and hospital record keeping over this period of time may explain these changes.

Partial or complete resolution of disability occurs over time, but permanent deficits in activities of daily living and community life often occur following stroke. While individuals with stroke typically have a wide range of impairments, the cognitive and perceptual deficits, specifically those functions associated with visual attention, have the greatest impact on the ability to perform higher order and complex functional tasks such as driving, and these are discussed in greater detail.

2.2.4 Cognitive and Perceptual Impairment Following Stroke

Cognition refers to the ability of the brain to process, store, retrieve and manipulate information that it receives from the environment. Cognitive impairments of memory, attention, planning and organization, problem solving, abstract reasoning and judgement often occur following a stroke. Perception is the means through which an individual organizes and comes to understand information received by the senses (Simms, 1985). It involves the interpretation, integration and use of sensory stimuli into meaningful information. Visual processing is the active process of locating, extracting, and interpreting visual information from the environment using visual-perceptual skills (Suchoff et al., 2000). Perceptual dysfunction associated with stroke may include difficulties in depth perception, visual figure-ground differentiation, steriognosis (Brockmann Rubio & Van Deusen, 1995), spatial relations, motor planning, and body scheme (Alexander, 1994). These complex visual-perceptual deficits most often do not recover completely after stroke (Pak & Dombovy, 1994).

Several authors have attempted to describe the prevalence of cognitive and perceptual impairments commonly seen in clients with stroke. Variations in the definition of these functions, as well as differences in the subjects included, measures used, timing of evaluation and classification of impairment make it difficult to compare findings across studies. In one study, subjects had the most difficulty with right/left copying shapes, right/left copying words, and cube copying tasks (Marshall et al., 1997). Twenty-two subjects with stroke without unilateral neglect or aphasia as well as a convenience sample of 155 adults without disabilities were tested on the Test of Visual-Perceptual Skills. Subjects with stroke had significantly lower accuracy scores and greater mean total time scores compared to controls after controlling for age, gender and education (Su et al., 1995). In a descriptive study conducted by Edmans and Lincoln (Edmans & Lincoln, 1989), the cognitive and perceptual sequelae of stroke were examined in 150 clients using the Rivermead Perceptual Battery at 4 weeks post-stroke. Perceptual problems, defined as scoring two or more standard deviations below the mean on four or more subtests, were found in 114 subjects (76%) compared to only 4% in the normal population.

While some studies report that those with lesions of the right hemisphere demonstrate the most serious perceptual difficulties (Simms, 1985), others found no differences in the frequency of perceptual problems according to side of lesion (Jongbloed, 1986; Su et al., 1995; Titus et al., 1991; WHO, 1989). Titus and colleagues (Titus et al., 1991) determined that overall scores on a wide range of perceptual tests in 25 clients with stroke were significantly lower than the test norms. Interestingly, these differences occurred for individuals with both right- and left-sided lesions, suggesting that perceptual impairment is not only localized to the right hemisphere (Edmans & Lincoln, 1989). There is some evidence of right hemisphere advantage in spatial processing, though individuals with either right or left hemisphere lesions have difficulty with tasks that require more advanced levels of spatial information processing (De Haan & Newcombe, 1992). For example, in one study, there was no significant difference in the proportion of clients with right- (71%) and left- (81%) sided lesions who had perceptual impairments (Edmans & Lincoln, 1989).

The implications of deficits in visual-perceptual and cognitive processing for the performance of daily tasks were examined. In general, impairments in constructional praxis and visual discrimination (Titus et al., 1991) as well as deficits in visual scanning speed, and identification of visual stimuli in the affected hemifield are highly associated with poor performance in ADL functions (Warren, 1990). A study of 109 clients within the first two weeks of stroke found an association between both motor function as well as high-order perceptual skills such as spatial relations and figure-ground perception, and the ability to perform self-care tasks (Bernspang et al., 1987). Twenty-one subjects tested on the revised Kenny Self-Care Evaluation and on a cognitive skills assessment measuring time judgement, auditory attention, visual scanning, visual-spatial perception, digit span, verbal memory, abstract reasoning, and verbal comprehension determined that overall cognitive skill prior to the initiation of therapy was correlated to post-test ADL scores. The highest correlations were for auditory attention and visual-spatial perception (Tondat Carter et al., 1983).

2.2.4.1 Visual Attention and Stroke

Attentional skills are the critical fundamental components of many cognitive functions, such as learning, communication, and problem solving (Raskin & Mateer, 1994). Attention is often classified according to the source or modality of the information being processed, whether visual, auditory, somatosensory or memory; the distribution over time and space, either focused on a specific object or location or divided among a number of objects and events; or by the specific tasks that require specialized selection mechanisms, including orienting to particular stimuli, filtering and selecting objects based on specific attributes, searching, and expecting (Plude et al., 1994).

Attention is a multiple system with different components. The control of attention is critical in performing different types of tasks. Sustained attention requires vigilance when relevant tasks occur at a relatively slow rate over a prolonged period of time. Shared or divided attention is necessary when two or more unrelated tasks have to be carried out simultaneously; alternating attention occurs when attention is shifted from one concept to another within one set of stimuli. At times, attention must be suppressed and there are automatic processes that select schemata that are distracting to the requirements of a task (Stuss et al., 1995). Selective attention is the process of selecting portions of simultaneous sources of information either by enhancing the processing of some objects and/or by suppressing information from others (Rossi & Paradiso, 1995; Theeuwes, 1993). Optimal performance requires frequent shifts between fast, less demanding automatic processing and attentional control, which is slow and requires cognitive effort and concentration (Stuss et al., 1995).

All aspects of attention are important in the performance of self-care activities (Okkema, 1993). Sustained attention allows us to direct our efforts toward a self-care task until it is completed. Selective attention enables us to attend to activities performed in a distracting environment, while alternating attention is important when engaged in two activities or in a task with multiple simultaneous steps.

Visual attention refers to those attentional skills required to process visual stimuli. Visual information is distributed to a network of many separate specialized cortical areas. The geniculostriate and tectopulvinar pathways carry visual information from the eye to visual areas in the occipital lobe of the cortex. From these areas, information is carried to other visual areas in the temporal lobe via the occipitotemporal pathway and to the parietal lobe via the occipitoparietal pathway (Kinchla, 1992). The occipitotemporal system is involved in object recognition, size, colour and shape discrimination, orientation, and spatial frequency, through the categorization and analysis of associated object features, while the occipitoparietal system is involved in the perception of spatial relations between objects and the representation of stimulus locations (Duncan, 1993). The parietal lobe, particularly the right posterior parietal region, mediates both visual attention and the localization of objects in space and when damaged produces a visual spatial inattention or neglect (Suchoff et al., 2000).

Visual spatial inattention is defined as a reduction in the ability to respond to stimuli in the extra-personal space and includes both nonlateralized or scattered inattention as well as lateralized hemi-inattention (Chen Sea et al., 1993). Unilateral neglect or hemi-neglect also refers to the failure to report, respond, or orient to novel or meaningful stimuli, but is specific to stimuli presented to the side contralateral to the cerebral lesion. It is sometimes, but not always associated with accompanying visual field deficits (Zoltan, 1992b). Unilateral neglect typically affects the left side of the body and space. While clients may be able to intentionally shift their attention toward the affected side and to guide their eye and head movements to search for stimuli, when there is a competing stimulus in the preserved visual field, attention automatically shifts to this new stimulus (Arditi & Zihl, 2000).

Unilateral neglect of one's body and/or the environment is commonly seen following a stroke. The incidence of unilateral neglect in the acute stage is dependent upon the type of subjects sampled as well as the method used to determine neglect. The incidence of hemineglect, as measured by scores on a paper and pencil cancellation test, was evaluated in 602 participants in the Copenhagen Stroke Study. Forty two percent of those with right hemisphere lesions and 8% of clients with left-sided lesions were found to have a hemineglect. The presence of hemineglect was associated with the severity of stroke, and increased with increasing age. According to the results of CT scanning, those with hemineglect were more likely to have had a cerebral infarction (75% vs. 53%), a larger lesion size (52 mm vs. 30 mm), and cortical involvement (52% vs. 18%) (Pedersen et al., 1997). A second study of 146 clients with moderate stroke severity found that 47 (32%) had a visual neglect in the acute stage after stroke (Kalra et al., 1997).

While the degree of inattention or unilateral neglect is thought to decrease over time following a stroke, Marshall and colleagues determined that individuals still had a high incidence of hemi-inattention one year post-stroke (Marshall et al., 1997). Of 91 clients with apparent hemianopsia within 24 hours of onset of stroke, at one month, 28% only had a visual inattention, 43% had seemingly normal visual fields, and 29% remained unchanged (Barer et al., 1990).

The literature consistently reports an important impact of impairments in attention on the ability to function in daily life. Clients with attentional deficits are significantly more impaired in their ADL functioning compared to those free from attentional difficulties (Riddoch et al., 1995). Unilateral neglect most always results in an associated functional impairment and is one of the major impediments to functional recovery and rehabilitation success (Arditi & Zihl, 2000). For example, sixty four subjects with unilateral right hemisphere lesions were tested two to six months post-stroke on the Random Chinese Word Cancellation Test and were categorized as having either hemi-inattention (n=22), nonlateralized inattention (n=8), or normal attention (n=34). Self-care functioning for the three groups, as measured by the Klein-Bell ADL Scale, was compared and findings indicated that the group with hemi-inattention performed significantly more poorly than both the nonlateralized inattention and normal groups when controlling for somatosensory, motor and visual impairments (Chen Sea et al., 1993). Similarly, a study of 146 participants with stroke determined that of all subtests on the Rivermead Perceptual Assessment Battery only unilateral neglect was significantly associated with scores on the Barthel ADL Scale. Functional outcome was better in the group of clients without visual neglect as compared to those with unilateral neglect despite comparable motor recovery (Kalra et al., 1997).

The frequency of deficits in visual attention has been studied according to side of lesion. In one study, 190 subjects with stroke were tested on the Star Cancellation Task; 12/98 with left-sided lesions and 14/92 with right-sided lesions had a visual inattention. While the proportion of individuals with left and right hemisphere lesions did not differ in terms of the presence of visual inattention, the distribution of the resultant errors did differ between the groups. Those with right-sided stroke made omissions that increased from right to left such that the number of contralateral omissions were significantly greater than the number of ipsilateral omissions. The left-sided stroke group did not show a consistent variation across the field (Halligan et al., 1992).

This review has shown that the sequelae of stroke can manifest in a variety of ways, and while recovery following stroke does occur during the weeks and months following the insult, many individuals are left with mild to severe disability. Cognitive and perceptual dysfunction is common and has important implications for the ability to perform many functional tasks, specifically those that require more complex information processing. The impairments and disabilities associated with stroke impact upon the ability of individuals with stroke to reintegrate and function within the community.

2.2.5 Community Reintegration Following Stroke

Community integration refers to “some aspect of being part of the mainstream of family and community life; living independently; discharging the roles and responsibilities that are considered normal for someone of a specific age, gender, and culture; or being an active and contributing member of one’s social groups and of society as a whole” (Dijkers, 1999). It is difficult to accurately determine the deficit in community integration due to an illness or trauma, since community integration is unique to specific individual characteristics such as age, family and culture. The degree of impairment and disability, as well as social support and assistance, the physical environment, other specific skills and interests, and motivation together determine the ability to successfully reintegrate into the community (Dijkers, 1999). The measurement of community reintegration takes several forms including home and family roles and activities, other productive roles such as work, school, and volunteering, social networks, leisure activities, mobility, and economic self-sufficiency (Dijkers, 1999). Many of the measures that have been developed to assess community reintegration were derived from the concept of handicap described in the WHO International Classification of Impairment, Disability and Handicap (WHO, 1999). Handicap was defined as “a disadvantage for a given individual, resulting from an impairment or a disability, that limits or prevents the fulfilment of a role that is normal (depending on age, sex, and social and cultural factors) for that individual. Measures of community reintegration have included assessments of handicap, extended or instrumental activities of daily living, common household tasks, leisure activities, community mobility, and vocational activities.

The degree of difficulty reintegrating into the community associated with stroke is unclear. One population-based study of 639 6-year survivors of stroke conducted in Auckland, New Zealand, suggested that while stroke survivors were more likely to be dependent in functional tasks that require mobility and/or dexterity, they did not differ from their age and sex matched controls on measures of social functioning, mental health or bodily pain (Hackett et al., 2000). In contrast, a cross-sectional study examining the factors that contribute to the level of reintegration in stroke survivors at 3 months and one year post-stroke found that those with physical disability and depressive symptoms reported a greater degree of handicap on the Reintegration to Normal Living Index (Clarke et al., 1999). At one year post-stroke, physical disability, depressive symptoms, and impaired communication and cognition were significantly associated with increased level of handicap.

Studies conducted to examine community reintegration over time suggest that this outcome remains quite stable. A convenience sample of clients with moderate physical deficits and minimal cognitive impairment was divided according to the length of time post-discharge from rehabilitation; 28 clients were assessed less than 6 months and 17 were seen more than 6 months after discharge. While there were no significant differences between the groups on the overall Reintegration to Normal Living Index scores, those examined more than 6 months after stroke had lower scores for indoor mobility, self-care, personal relationships and handling of life events. The groups, however, were very small and those tested more than 6 months after discharge were younger (56 versus 63 years), and may have had different expectations of their community involvement (Béthoux et al., 1999). Similarly, twenty-five community dwelling stroke survivors were evaluated by telephone at 6 and 18 months post-stroke using the Craig Handicap Assessment and Reporting Technique (CHART). Scores on subscales measuring physical independence, mobility, occupation and social integration indicated no significant changes over the 12-month period (Segal & Whyte, 1997). Proxy assessment, however, indicated significant improvement on the social integration subscale as well as on the total test score.

A select group of clients with a first stroke at 60-85 years of age, who could communicate independently, and were free of severe cognitive impairment and aphasia, were interviewed between one and three years post-stroke to determine which factors were associated with quality of life (Kim et al., 1999). Only 50 of 433 individuals with stroke were eligible and completed the interview. Scores on the Functional Independence Measure (FIM), Frenchay Activities Index for IADL (FAI), Social Support Inventory for Stroke Survivors, Perceived Health Status, and Centre for Epidemiologic Studies Depression Scale were all statistically significantly correlated with their level of quality of life. Stepwise multiple regression analyses indicated that depression accounted for 32% of the variance in quality of life, while depression, marital status, social support, and functional status combined accounted for 60% of the variance. The results, however, cannot be generalized, due to the strict selection criteria used and the small proportion of eligible participants.

While only a few studies have examined the level of community reintegration in individuals with stroke, their results seem to indicate a reduction in social functioning, most likely associated with physical and other impairments. The specific contributions of these factors are difficult to determine, since the populations studied and the measurements used to integration into the community vary widely between studies.

2.3 DRIVING AND DISABILITY

2.3.1 Importance of Driving for Community Reintegration

In our society, driving an automobile is considered an important component of one's quality of life and sense of independence and competence (Persson, 1993). Driving enables adults to conduct their daily activities, accomplish productive endeavours, shop, go to medical appointments, participate in leisure activities, and facilitates socialization (Hunt, 1993; Korteling & Kaptein, 1996). This is especially true for the elderly and the disabled whose physical abilities may be diminished. With alternative methods of transportation difficult for the elderly to access (Rosenbloom, 1993), automobile driving enables this population to maintain mobility and independence within their community (Goode et al., 1998; Retchin & Anapolle, 1993; www.merck, 2000). The elderly who are unable to drive experience a loss of independence, a reduction in social activities, an increased reliance on family members for essential trips, and a higher rate of depression (Marottoli et al., 1997) as compared to those who continue to drive. Driving cessation may entail a loss of self-esteem and a change in the overall quality of life in the elderly (Stutts, 1998). The reduction in community involvement is evident in the finding that individuals aged 61–65 years old who have a driver’s license travel 100 times greater distance compared to those who do not drive (Rosenbloom, 1993). Since many elderly people rely on other elderly individuals to transport them, the loss of a driver’s license may have a negative impact on others as well (Rosenbloom, 1993).

For clients with stroke who have already had to face great changes in lifestyle and self esteem, driving is an integral component of successful community reintegration. Individuals who stop driving following the occurrence of a neurological impairment have a higher frequency of depression (39% for former drivers versus 7% for drivers) and a greater reduction in social activity than those who continue to drive (Legh-Smith et al., 1986). A qualitative study of three elderly individuals following a stroke found that the loss of driving ability directly altered their lifestyle, resulting in a reduction of freedom and independence, less access to community activities, and limited ability to socialize (Lister, 1999). Legh-Smith and colleagues (Legh-Smith et al., 1986) surveyed 433 individuals with stroke. Of the thirty nine percent who drove prior to the event, 42% had resumed driving. The primary reason for not returning to driving was the disability resulting from their stroke. Drivers achieved their prestroke level of activity while non-drivers showed considerable loss in activity as measured by the Frenchay Activities Index (FAI).

Driving an automobile has been clearly shown to affect community functioning, specifically in the elderly and in others with impairment in physical functioning. The serious and wide-ranging effects resulting from driving cessation means that it is imperative to have a clear understanding of the driving process. This will help ensure that those who are capable of safe driving are permitted to continue to drive (Korteling & Kaptein, 1996), while those that are known to be unsafe will be prevented from continuing to drive (Korner-Bitensky et al., 1994).

2.3.2 Models of Driving Performance

It has been estimated that 90 percent of the information input to the driver is visual (Simms, 1985). Therefore, the integrity of a person's visual-perceptual skills is crucial to competence on the road. To successfully drive a car, the driver needs to continually process new information and use it to make decisions.

Theorists have attempted to devise a comprehensive model of driving in order to accurately describe the driving task. To date, given the wide range of approaches used to describe driving, it is clear that no single model fully explains the driving task (Fox et al., 1998). Given the wide variety of driving situations and the complexity of the task, it is difficult to envision one comprehensive model of driving performance. Current knowledge about driving is limited because the available models have not been empirically tested and often have not been developed beyond conceptualization. However, a model that includes all critical aspects of driving is essential in order to develop effective and directed methods of evaluation and training of driving skills.

Earliest attempts at modelling the driving task focused on individual differences or traits, using accident involvement as the criterion for unsafe driving performance (Ranney, 1994). State record crash data provide standard information which does not rely on memory or the driver (Owsley, 1997). However, the use of accident occurrence as the measure of validity is problematic. These data do not include crashes where a police report is not completed. Many studies that have used state or provincial records are retrospective in nature, so that the direction of the association between specific functions or driving characteristics and automobile accidents is difficult to establish (Fox et al., 1998). This approach also assumes that these characteristics are highly reliable and do not change over time. However, stability of these factors over time is highly unlikely. For example, previous accident involvement will likely influence certain predictor characteristics such as driving behaviours. An additional difficulty with using accident rates as the criterion is that a traffic accident is a rare event (Fox et al., 1998), unless one is examining a very high-risk population using a very large sample over a long period of time. The poor reliability of accident data places the validity of these studies in question. State accident records are known to underestimate true accident frequency. A large study conducted by the Insurance Research Council in the United States in 1991 determined that on average only 40% of insurance claims appeared on the official state records, and the rate for individual states ranged from 1% to 71% (Council, 1991). Accidents may also not be a valid indicator of driving ability or road performance. The cause of accidents is multifactorial; not all errors result in an accident and not all accidents are a result of driver error (Fox et al., 1998).

Motivational models of driving performance were developed in the 1960s (Fuller, 1984). These models assume that driving is self-paced and controlled by the amount of risk a driver is willing to take (Ranney, 1994). These models focus on driving behaviour; what the driver actually does in a given situation (Fox et al., 1998; Fuller, 1984) rather than on the level of skill that the driver is capable of.

Information processing models focus on performance of the driving task, and attempt to determine the functions drivers must perform. They are represented as a sequence of stages, including perception, decision and response selection and the execution of the response (Ranney, 1994). The concept of automaticity has influenced the way the driving procedure is examined. Automaticity is fast, effortless processing which follows extended consistent practice (Schneider & Shiffrin, 1977). The concept of automaticity can even be applied to driving situations that are highly variable in nature. Automatic components of the task, such as braking and steering, can be developed despite the fact that precipitating situations differ. Automatic processing primarily involves perceptual processes, while cognitive and executive functions are implicated in controlled processing.

Simms (Simms, 1985) presented a perceptual-information processing model of the driving task. The perceptual-information processing model provided a framework within which the driving procedure could be understood. *Environmental information* includes road signs, other vehicles, pedestrians, and traffic lights. Assuming an adequate level of visual acuity and peripheral vision, visual-perceptual skills such as scanning, tracking and figure-ground discrimination determine the ease with which a driver notices objects in the cluttered periphery. Individuals use *attentional and perceptual mechanisms*, such as visual search, scanning, and figure-ground discrimination to determine the ease with which a driver can notice these objects. Impairment in these functions affects the efficiency of driver performance during the attention and perception components of the driving task, which in turn may affect the appropriateness of the subsequent decisions and actions on the road. *Logical analysis and decision making* provides the interpretation and assessment of the information following which a *response* must be made.

Galski developed the Cybernetic Model of Driving (Galski et al., 1992). This model includes aspects of the information processing and motivational models of driving. It was developed to assist in diagnosing the cause of driving problems identified by specific psychometric tests and behaviours. Driving is viewed as an integrated system of component mechanisms designed to process information and perform behaviours pertinent to safe driving. Each of the individual components interacts with each other.

The *General Driving Program* is a complex information processing mechanism that initiates and directs all driving related activities. *Dynamic memory* comprises all previous driving knowledge including road knowledge and operating principles. These operating principles occur in routine situations yet maintain the capacity to adapt to novel situations using additional information. The general driving program of an individual with a brain injury may have lost some or all of the driving memory, the capacity to build on driving experiences and/or the ability to apply learned information to familiar or new situations. The *Specific Driving Program* is a volitional program used to implement a particular driving plan, such as a specific destination and route, or precautions for specific weather and road conditions. Together the general and specific driving programs must direct four other systems: sensory input, calculation and construction co-processor, motor output, and resident diagnostic program. The general driving program requires *sensory input* from various sensory channels, including visual, auditory, proprioceptive and kinesthetic. All information is scanned rapidly by preattention analyzers and provides only global information about the driving environment and the operation of the vehicle. Routine driving occurs at this global level of analysis of sensory input. When situations arise that require more detailed information, the general driving program directs attention to the specific sensory channel for analysis. The *calculation and construction co-processor* aids in making sense of the rapidly changing sensory environment. It is at this level that the driver must calculate, integrate and co-ordinate the incoming information provided by scanning and directed attention. Types of environmental information include velocity, distance, spatial relationships and depth. The information is sent to the general driving program, integrates with previous driving experiences and then produces an action. The *motor output* is directed by the general driving program to physically manoeuvre the vehicle. It affects the action or actions required to handle a situation. Finally, the model includes a resident diagnostic program to assess the integrity and functioning of the entire system.

Galski and colleagues (Galski et al., 1993) attempted to validate this model by developing an assessment strategy based on the Cybernetic Model of Driving. They evaluated 106 subjects with stroke or traumatic brain injury to determine the ability of this large battery of tests to predict driving performance. Poor performance correctly identified 92% of the failures on the road evaluation.

<u>Hierarchical control models</u> describe driving as a multi-level system that includes activities at various levels of control. The hierarchy implies that decisions made at one level determine the cognitive requirements at a lower level. A model

explaining the levels of cognitive control required for driving was proposed (Michon, 1985). Michon describes three interdependent levels of decision making: strategic, tactical and operational. The *strategic level* is the general planning stage of a trip and includes determining the route, and planning the drive according to the weather, traffic, and one's personal condition. These decisions are not constrained by time. At the *tactical level*, control of the automobile, negotiation of common driving situations, making decisions in traffic and adjusting driving to current demands occur. These decisions take place in seconds. The *operational level* describes the immediate inputs, automatic action patterns, and instant reactions. This level of processing occurs within milliseconds. The hierarchy assumes a dynamic relationship between the three levels, with control switching from one level to another at the appropriate points in time. The driver allocates attention according to the immediate driving situation. While Michon's model has not been empirically tested, it has contributed to the conceptualization of the driving task and is used as a theoretical basis for much of the literature on driving involving individuals with brain impairment.

2.3.3 Skills Necessary for Driving

2.3.3.1 Medical and Optometric Requirements

Various licensing bodies as well as medical associations have published guidelines and/or regulations regarding driving for clients with a range of medical conditions. Published guidelines for physicians by the Canadian Medical Association (CMA, 1991) state that a client who has had a completed stroke should not be allowed to drive for at least one month from stroke onset. After this period, the client may drive if a thorough neurological assessment determines that the condition has stabilized with minimal loss of functional ability. When there is residual functional disability, a road test administered by a driving examiner is the best way of judging the client's ability to drive. A client who has had a stroke and resumes driving should remain under close medical supervision.

The Sociéte de l'assurance automobile de Québec (SAAQ, 1995) provides licensing restrictions and guidelines for individuals with disabilities and/or specific illnesses that require specialized adaptive equipment or monitoring. Specifically, for those with a neurological condition, the ability to drive depends on the gravity of the illness, the type of impairment it causes, and whether it is permanent, progressive or episodic. According to the SAAQ guidelines, neurological conditions resulting in *serious* disturbance of cognitive functions, alertness, consciousness, motor or sensory functions, equilibrium or co-ordination, are *essentially inconsistent* with driving a road vehicle. Disorders resulting in *slight* disturbance of these functions are *relatively inconsistent* with driving. The guidelines do not explain how to evaluate and classify these impairments. Driving makes great demands on the primary visual system and for this reason Provincial Licensing Agencies have created stringent criteria delineating fitness to drive based on the functioning of the primary visual system. In Quebec, the visual requirements to drive an automobile are clearly stated; a visual acuity of 6/12 in the better eye, and a visual field of 100 degree continuous binocular vision, including 30 degrees on each side of the vertical.

The regulations regarding driving eligibility are not specific enough for accurate decision making by health professionals. Information describing the specific skills and impairments associated with driving ability do exist in the literature. These skills focus on primary visual functions and on processing of visual information.

2.3.3.2 Vision

Driving is primarily a visual task (Higgins & Bailey, 2000) with an estimated 90-95% of the input to the driver being visual (Simms, 1985; Taylor, 1982). The demands made on the visual system during driving depend upon the complexity and dynamics of the environment and the criticality of the tasks being performed (Higgins & Bailey, 2000).

At the most fundamental level, orientation and mobility depend upon the primary visual functions; visual acuity, visual field, and contrast sensitivity. Visual acuity, while not clearly an important factor in predicting functional performance on mobility tasks, is most important for reading traffic signs. A reduction in visual field decreases the probability of detecting objects in the immediate environment. An individual with poor visual fields must move their eyes and head to scan their surroundings, especially in a complex environment. Contrast sensitivity, the ability to detect brightness and colour, must be sufficient for object detection and recognition (Higgins & Bailey, 2000).

Several studies have examined the association between these primary visual functions and driving performance and found that in general, the association between tests of vision and driving accidents is very weak (Goode et al., 1998; Gresset & Meyer, 1994b; Hills, 1980). Several statistically significant correlations between some measures of vision and accident records have been reported, but correlations were typically extremely low, less than r=0.1 (Burg, 1967), and accounted for less than 5% of the crash variance (Owsley & Ball, 1993).

Case-control studies have found that older drivers convicted of a traffic violation (Johansson et al., 1996) or involved in a road accident (Gresset & Meyer, 1994a; Gresset & Meyer, 1994b) were no more likely to have an impairment in visual acuity than matched controls. Johnson and Keltner (Johnson & Keltner, 1983) screened more than 8,000 drivers for visual field loss. Of those over 65 years of age, 13% exhibited a visual field deficit. The relationship between accident rate in the previous three years and visual field loss indicated that there was not an increased risk in those with a monocular field loss. Those with binocular visual field loss, however, were twice as likely to have been involved in a motor vehicle accident as compared to age and sex matched controls (Johnson & Keltner, 1983). Six subjects with hemianopsia had more difficulty on lane boundary crossings and increased variability in lane position on a driving simulator compared to seven older subjects with no visual field loss (Szlyk et al., 1993).

A large population-based study compared the visual limitations of 1400 male drivers in Quebec who had an accident during their 70th year with randomly selected controls. Relative risks for accidents, controlling for traffic conviction, mileage, time spent and frequency of driving during rush hours, indicated that drivers with minimal visual acuity (lower than 6/12) were not at an increased risk for accidents. However, there was a non-statistically significant increased risk of accidents in those with both minimal visual acuity and lack of binocularity when compared to those with normal vision (Gresset & Meyer, 1994a; Gresset & Meyer, 1994b).

A simulation of various visual impairments was conducted to examine the potential effects of cataract, and monocular and binocular visual restriction on specific driving functions. A closed-road circuit was used to examine peripheral awareness, manoeuvring, reversing, reaction time, road position, and the time to complete the course. In the 14 young adults who participated, peripheral awareness, driving time, and manoeuvring were significantly worse during the simulated cataract condition. Only peripheral and central reaction times were significantly longer for the field restriction condition (Wood & Troutbeck, 1994).

While the primary visual functions are typically evaluated to determine eligibility for driving, they are poorly associated with driving safety or performance (Shinar & Schieber, 1991). This is not because vision is unrelated to driving performance, but because these visual sensory functions do not in themselves reflect the complexity of the driving task (Ball & Owsley, 1992; Ball et al., 1993). Difficulties in driving result from the inability to attend and process visual information rather than only from a visual sensory deficit (Ball et al., 1993; Ball & Rebok, 1994).

2.3.3.3 Visual Processing

Driving requires the integrated use of higher visual functioning such as attention to both focal and secondary visual tasks, localizing a target amidst a visually cluttered environment, and speed of processing of the visual information (Ball et al., 1993; Owsley & Ball, 1993).

The demands of driving include navigating a vehicle in a visually cluttered environment and involve the simultaneous use of central and peripheral vision and the execution of both primary and secondary visual tasks. The examination of peripheral vision under more realistic conditions that incorporate the demands of a complex visual task may better predict driving performance (Ball et al., 1988).

Robinson and Winner (Robinson & Winner, 1998) use driving a car to illustrate the interaction between the various components of attention. While driving, we are constantly monitoring the environmental stimuli (anticipation), and quickly judge the stimuli as either relevant or irrelevant. We ignore the irrelevant stimuli (inhibition) while attending to the stimuli deemed as relevant (orientation). If a previous irrelevant stimulus becomes relevant, such as the car next to us drifting into our lane, our attentional system shifts the stimulus from an inhibited one to a stimulus that we orient to. Concurrently, we also maintain our attention to the task of driving. A normally functioning attentional system acts as the brain's information gatekeeper, allowing us to receive and integrate incoming information in a controlled manner. When brain injury damages one or more components of attention, the system no longer monitors and regulates information adequately.

Assuming a sufficient degree of visual acuity and peripheral vision, visual-perceptual skills such as scanning, tracking and figure-ground discrimination determine the ability to notice and react to objects in the visual field (Simms, 1985). Deficits in spatial relations, figure-ground, and depth perception will affect the driver's ability to identify the position of the car in relation to other cars, pedestrians and stationary objects, and will reduce an individual's ability to interpret angles, curves, crossroads and merging lanes. While these more complex visual processing skills are rarely tested during routine driving testing, they are important, as visual-perceptual errors are a major contributory factor to accidents (Hills, 1980).

The relationship between selective attention and driving ability has been examined in both normal and cognitively impaired subjects. Selective attention was significantly correlated with the number of accidents over the preceding five years in 75 normal subjects. In addition, while simple reaction time was not associated with accidents, complex reaction time, where subjects are required to detect and respond to various targets by either braking, or turning left or right, was significantly correlated with number of prior accidents (Mihal & Barrett, 1976). Measures of selective attention were predictive of on-road driving performance in 29 drivers with mild dementia, 49 with very mild dementia and 58 with no dementia, while controlling for the degree of cognitive impairment. Both the accuracy of the responses as well as the time to process the information were significant predictors of driving ability (Duchek et al., 1998). Persons with disorders of selective attention experience limitations in areas that require complex visual processing, such as driving, certain vocations and schooling (Delis et al., 1983).

The strong relationship between visual processing skills, specifically attention, and the complex functional task of driving, has led to the development of a more direct method of evaluating the ability to process complex visual information.

2.3.3.4 Useful Field of View

The functional visual field area in which information can be acquired and processed without eye and head movement has been termed useful field of view (UFOV) (Ball et al., 1988). UFOV is comprised of three visual attention skills; speed of processing visual information, divided attention, and selective attention. UFOV relies on both visual sensory and cognitive skills and provides a more global measure of visual functional status. Researchers have developed a measurement tool to map the area of UFOV. The evaluation assumes a normal visual field, and involves the detection, localization and identification of targets in the presence of complex visual backgrounds (Ball et al., 1990; Ball et al., 1988).

Owsley and colleagues (Owsley et al., 1991) have shown that while primary visual functions such as visual acuity and visual field are associated with UFOV, the presence of good primary visual status is not necessarily indicative of normal UFOV. For example, 50% of elderly individuals were found to have good visual function but poor UFOV (Owsley et al., 1991). The ability to localize a target embedded within distracters is partly dependent upon primary visual functions but primarily dependent upon attentional skills (Owsley et al., 1995).

The ability to process information within this functional visual field remains stable throughout early and middle adulthood and is then progressively reduced in the elderly (Ball et al., 1988). Older adults who were free of impairments in visual acuity, performed more poorly on complex visual attention tasks (Ball et al., 1990; Ball et al., 1993). They were able to localize objects presented in their peripheral field with 100% accuracy at all eccentricities evaluated (degrees of visual field:

10º, 20º, 30º). However, some participants required longer stimulus durations to achieve this level of performance, indicating a reduced speed of visual processing. When a central object was added to the task, localization of the targets furthest in the periphery could no longer be accomplished, indicating a reduction in UFOV. Increasing the stimulus duration enabled subjects to regain 100% accuracy in the dual task situation. The addition of distracters also impaired the localization performance of some subjects such that the most eccentric targets could no longer be detected. Increasing the duration of presentation of the target sometimes reversed this. UFOV is dynamic, as it is a function of the duration of target presentation, the level of complexity of the central task, and the salience of the peripheral object (Ball et al., 1990; Ball et al., 1993).

Tests of UFOV contribute important information related to driving ability over and above the standard visual examination. In a study examining the association between motor vehicle accidents within the previous five years and visual function, cognitive function, and visual attention, Owsley and associates (Owsley et al., 1991) found that UFOV was the most predictive measure. Fifty-three drivers, 57-83 years of age, were tested on measures of visual acuity, contrast sensitivity, disability glare, colour discrimination, visual field sensitivity, useful field of view and mental status. While eye health and visual sensory function were not related to crashes, UFOV and mental status were the best predictors of vehicle accidents accounting for 20% of the variance for accidents and 29% of the variance for accidents at a traffic intersection. This is not surprising considering that driving through an intersection places heavy requirements on peripheral visual fields and awareness of peripheral objects. Those with a reduced UFOV were 4.2 times more likely to have incurred one or more crashes and 15.6 times more likely to have had an accident at a roadway intersection.

A larger study was subsequently conducted to validate these findings (Ball et al., 1993). Two hundred and ninety four subjects involved in 364 at-fault crashes were selected from the population of all licensed drivers aged 55 years and older living in Jefferson County, Alabama. Subjects were stratified according to age and crash frequency for the previous 5-year period. State records provided information regarding at-fault crashes, including both the number and the circumstances surrounding each crash. Eye health, central vision and peripheral vision had only minimal association with crash frequency, accounting for only 5% of the variance. Correlation analyses indicated that the variable most strongly associated with crashes was UFOV with a correlation of r=0.52. This relationship between crash frequency and UFOV was consistent across all tested age groups (55-64, 65-74, >74 years) and for those with both good and poor mental status. The average number of crashes increased with increasing scores on the UFOV and ranged from approximately 0.2 for those with 10 percent reduction in UFOV to 2.5 for those with 90 percent reduction. Using a cutoff point in UFOV of 40% reduction, the sensitivity of UFOV in identifying those with at-fault crashes was 89% and the specificity of identifying those with no crashes was 81%. The odds ratio was also calculated, indicating that individuals with a reduction in UFOV greater than 40% were six times more likely to have incurred an at-fault crash than those with minimal or no reduction. An analysis of the data indicated that restriction in UFOV was a statistically significant predictor of injurious as well as non-injurious crashes. The risk of injurious crashes increased with impairment (OR=4.2 with UFOV reduction of 23-40%; OR=13.6 with 41-60% reduction; and OR=17.2 for reduction of greater than 60%).

A similar retrospective population-based study was designed to “predict” reported at-fault crashes in the previous 5 years for adults aged 55 years and older, and included a battery of neurocognitive tests in addition to the UFOV (Goode et al., 1998). Two hundred and thirty nine subjects were tested out of 1342 persons contacted. Tests included the Mattis Organic Mental Syndrome Screening Examination (MOMSSE), Trail Making Test A and B, Wechsler Memory Scale, Rey-Osterrieth Complex Figure Test, and UFOV. One hundred and fifteen subjects were classified as safe drivers (0 at-fault crashes) and 124 as having been involved in one or more at-fault crashes in the previous five years. Results indicated that while the traditional tests significantly differentiated between those who did and did not have a previous crash, the addition of the UFOV scores to the model improved sensitivity of identifying crashers from 57.3% to 76.6% and the specificity of detecting non-crashers from 60.0% to 78.3%. The UFOV alone also significantly distinguished between the two groups. These “prediction” studies were conducted retrospectively, examining the ability of measures to predict previous events. The direction of the association is impossible to determine. In addition, state accident reports may be an underestimate of the number of crashes, however it is unlikely that the reporting rate differed according to level of UFOV functioning. If differential reporting did occur, the poorer functioning group would have been most likely to report fewer crashes.

Subsequently, a prospective study followed 294 older drivers for three years to determine the visual characteristics associated with future crash involvement. Results of Cox proportional hazards modelling determined that impaired UFOV was the only factor significantly associated with time to crashes. Those with reductions of 40% or greater were 2.2 times more likely to be involved in a crash over the subsequent three years. While this prospective study is an improvement over the previous retrospective studies, performance on the independent variables, measured only at the start of the study, may not have remained stable over the three year period (Owsley et al., 1998a).

2.3.4 Driving Performance in the Elderly

In the United States, more than 13% of all drivers are over the age of 65 years (www.merck, 2000), and with the projected increase in elderly drivers, the proportion of older drivers will rise to 25% by the year 2024 (Owsley, 1997; Retchin & Anapolle, 1993), and to 39% by the year 2050 (Council, 1989). In Canada, a review of the issues surrounding the older driver conducted by Statistics Canada included data from the 1996/97 National Population Health Survey (NPHS), the 1991 Survey of Aging and Independence, and Transport Canada (Millar, 1999). In 1996/97, Canadians 65 years and older numbered 3.4 million and represented 12% of the Canadian population. By the year 2016, elderly drivers are projected to number 5.9 million, almost 16% of the population. This increase is not only due to the increasing age of the population, but also to the increase in the number of women drivers (Retchin & Anapolle, 1993) and the greater proportion of healthy elderly.

In Canada, 59% of the elderly aged 65 years and over held a driver's license, with percentages ranging from 71% for those 65 to 69 years to 23% for those 85 years and older. Drivers were more frequently men, and rates increased with increasing household income and level of education. Seventy two percent of the elderly who possessed a driver's license reported driving three or more times per week. Elderly drivers were more likely to be seriously injured or to die in a motor vehicle collision with a motor vehicle traffic accident mortality rate of 27.2 per 100,000 compared to 16.4 per 100,000 for all drivers (Millar, 1999). These findings, however, may be overestimates of the true population numbers since the data recorded all those with driver's licenses and did not exclude those who were not driving.

Individuals over 60 years of age who stopped driving were more likely to be older, female and non-white, and to have diabetes. They were less functionally independent in terms of mobility, self-care, and instrumental activities of daily living, and had lower cognitive scores on the Mini-Mental State Examination (MMSE) (Gallo et al., 1999). Elderly women with physical impairments were more likely to stop driving as compared to their unimpaired counterparts (Forrest et al., 1997). The 19% of the 1769 women who had stopped driving reported more fractures, stroke, myocardial infarction, visual and hearing impairment, and memory deficit as well as scored lower on the Mini-Mental State Examination.

Elderly drivers usually drive safely, most likely because driving patterns are learned and become automatic with experience. However, due to changes in their participation in life activities as well as the functional changes associated with aging, elderly drivers often alter their driving habits. They tend to drive more slowly and cautiously, for shorter distances, less frequently at night or during rush hour, and generally take fewer risks (Retchin & Anapolle, 1993). However, they do have the highest collision rate per mile compared to all other age groups except those 24 years and under. These rates begin to rise after age 70, and escalate after age 80 (Owsley, 1997; Retchin & Anapolle, 1993; www.merck, 2000).

The literature suggests that older drivers modify their driving habits in response to the changes associated with aging. However, this self-regulated change in driving behaviour may not be sufficient to adequately reduce crash risk (Ball et al., 1998). Carr and colleagues (Carr et al., 1992) examined the effects of age on driving performance. Forty drivers aged 18-35 years and 20 healthy drivers over age 65 years were tested on the Miller Road Test. Groups did not differ on the total score. The elderly group performed more poorly on the item ‘signalling failures’ and scored better on ‘speeding violations’ and ‘steering errors’. There were no differences between the groups on errors of turning or stopping. The road test measures the physical aspects of driving, such as using the left foot on the brake and hesitating too long, but does not evaluate scanning the environment, attention, or driving behaviours.

Studies have attempted to identify risk factors associated with unsafe driving in the elderly. While there is no standard screening measure for those at risk for driving impairment, visual processing deficits and cognitive impairments are independently related to vehicle crashes in the elderly (Ball et al., 1993; Retchin & Anapolle, 1993). Medication usage, including benzodiazepines (Hemmelgarn et al., 1997), opioid analgesics, and sedatives increases the risk of crashes (Ray et al., 1993) (Sims et al., 2000).

A case-control study examined the medical and functional factors associated with vehicle crashes in a population-based sample of individuals aged 55 years and over. Cases were 99 older drivers who experienced one to seven state recorded at-fault crashes in the six years preceding the study. Controls were 75 drivers who were not involved in an at-fault crash during that period. Driving exposure did not differ between the cases and controls. In univariate logistic regression models, crash involvement was significantly associated with black race, difficulty reaching, not using a beta-blocker or diuretic, positive urinary opiates, falling, and poor UFOV performance. The multivariate model that best differentiated the cases from controls included race, UFOV scores, falling, and not using a beta-blocker. This study, while population-based and well controlled, included an outcome that occurred prior to determination of exposure potentially producing a reverse causality bias (Sims et al., 1998).

A subsequent prospective study including 174 individuals aged 55 years and older examined the relationship between crash occurrence and medical and functional factors. A history of stroke or transient ischemic attack was significantly associated with crashes in the subsequent 5 years with a relative risk of 2.71. Difficulties with physical abilities such as walking, grip strength, reaching, and getting in and out of bed, the ability to perform functional tasks, as well as visual impairments were not associated with an increased rate of automobile crashes in the elderly. However, poor UFOV results were significantly associated with increased crash rate with a relative risk of 1.87 (Sims et al., 2000).

The elderly make up a significant group of drivers. While many alter their driving behaviours, those with functional difficulties are more likely to exhibit unsafe driving performance. In this group, measures of visual processing were most highly associated with involvement in automobile crashes.

2.3.5 Driving Performance in Clients with Stroke and Other Disabling Conditions

While individuals with disabilities often experience physical, cognitive and/or behavioural changes that render them unsafe to drive, the legal procedures to deal with this issue are inconsistent and poorly enforced. In a survey of licensing bureau clerks and supervisors in all 50 states in the United States (Pidikiti & Novack, 1991), the information provided regarding the reporting of individuals with disabilities was found to be inconsistent. According to the U.S. Department of Transportation National Highway Safety Administration Driving Licensing Law Annotated, only 15 states authorize physicians and other specialists to report clients with disabilities that would affect driving ability, and for only seven is reporting mandatory.

Due to the ambiguous information available to professionals responsible for the care of those with disabilities, these clients are poorly guided regarding driving. In fact, a questionnaire completed by 290 stroke survivors between three months and six years post-stroke, found that only 52% received any advice about driving, 33% from a physician and 27% from a family member. Eighty seven percent of respondents did not receive a driving evaluation. Eight percent completed a test of vision, and only 5% were tested on the road. Of those driving after stroke, only 11.5% had been tested on the road (Fisk et al., 1997).

There is no clear association between medical or disabling conditions and driving safety. In a case control study of over 4,000 subjects in Quebec, elderly drivers with impairments or chronic medical conditions, such as heart disease, diabetes, hearing impairments, and amputation were found not to be at increased risk for road accidents resulting in property damage or bodily harm. A small non-significant increase in risk, however, was found for individuals with paralysis (Gresset & Meyer, 1994a).

Changes in medical status, including macular degeneration, retinal hemorrhage, stroke, Parkinson’s Disease, and syncope, as well as deficits in ADL, were significantly associated with a decision to stop driving in 276 drivers in Florida (Campbell et al., 1993). In addition, two hundred and seventy nine individuals with cataract were more likely to drive slower than the general flow of the traffic, and to drive fewer days and fewer miles per week. These individuals reported more difficulty with driving alone, making left turns across traffic, driving in the rain, on interstates, in high traffic, and at night (Owsley et al., 1999).

A review of a random sample of over 350 clients with a broad range of diagnoses who were tested at the Driver Rehabilitation Services at Bloorview MacMillan Centre in Toronto over a 25 year period found that only 40% of clients were deemed safe drivers based upon their first evaluation. The reasons for an unsafe result included requiring additional practice (40%), visual/perceptual deficits (36%), medical condition (15%), bad driving habits (3%), psychological impairments (4%), and motor deficits (2%) (Klavora et al., 2000b).

2.3.5.1 Cognitive Impairment

The driving behaviours of older drivers with cognitive impairments indicate a clear trend toward reduced driving exposure in those with lower levels of cognitive and visual function. These individuals drive fewer miles annually and avoid high-risk driving situations, such as driving after dark, during rush hour, in heavy traffic, on highways, during poor weather conditions and alone (Campbell et al., 1993; Stutts, 1998). Cushman (Cushman, 1996; Cushman & Cogliandro, 1997) compared self-reported driving behaviours between 91 community volunteers over aged 55 with 32 clients with early Alzheimer's Disease. Subjects were classified as meeting or not meeting the standards for driving according to their road knowledge, response time, vision, neuropsychological test results, UFOV scores, and a rating of pass or fail on an on-road driving evaluation. There was a significant difference in the reported annual mileage between those who met and those who did not meet driving standards, with those who did not meet criteria, driving approximately one third the number of miles.

2.3.5.2 Neurological Conditions

In a highly cited review of the literature regarding driving following brain injury, van Zomeren and colleagues (van Zomeren et al., 1987) reported that approximately half of all clients with brain injury maintained their driver's license, though not all were driving. Overall, the driving records of clients with a wide range of neurological conditions do not indicate an increase in accidents, however, specific subgroups may be at increased risk.

Due to the ability to compensate for motor deficits by using physical adaptations, these deficits are of little concern in returning to driving (van Zomeren et al., 1987). In fact, in one study, the driving performance of individuals with spinal cord injury, who have severe motor deficits without cognitive or perceptual impairment, did not differ from matched controls (Sivak et al., 1981).

Residual impairments such as decreased speed of cognitive processing, attentional problems, decreased efficiency of motor performance (Ranney, 1994; Stuss et al., 1995), and poor visual scanning, spatial perception, orientation, and tracking (van Zomeren et al., 1987), may have an important negative impact upon the ability to drive safely. This can be seen in a study comparing a group of clients with traumatic brain injury (n=16) or subarachnoid hemorrhage (n=13), two to six years post-injury, to a control group, matched for age, sex, education and driving experience. Groups were compared using tests of visual-motor perception and cognitive functions, measures requiring information processing, executive functions and planning, as well as on a driving simulator and on an on-road evaluation. Evaluators, however, were aware of the results of the psychological tests and the simulator evaluation. The control group performed better than the brain injured group on all neuropsychological tests except reaction time. On the simulator, the groups differed on tests of complex reaction time, time to collision in unpredictable situations and on the distracting task, but did not differ in predictable situations. On the on-road test, the group with brain injury had poorer attention and behaviour in traffic (planning and adjusting to rules and other road users), but did not differ on speed, manoeuvring, and lateral position, tasks relying on automated functions (Lundqvist et al., 1997).

2.3.5.3 Stroke

The proportion of individuals who return to driving following stroke ranges from approximately 30 to 75 percent, depending upon the method of survey used and the type of subjects included (Fisk et al., 1997; Lings & Jensen, 1991). In a select group of subjects with no complicating factors following their stroke, Lings and Jensen found that 72% of those with right-sided lesions and 79% of those with left-sided lesion were still driving. Simms (Simms, 1985) studied a more heterogeneous sample and found a lower proportion of drivers, 50% with left stroke and 54% with right stroke.

Several studies have described the behaviours of drivers with stroke. Thirty percent of 290 stroke survivors referred to psychology services at a rehabilitation centre who were driving prior to their stroke, were still driving three to six months after stroke. Only one third of drivers reported driving six to seven days per week. Those who were driving had higher FIM discharge scores compared to nondrivers (Fisk et al., 1997). Katz and colleagues reported on a convenience sample of individuals with various brain injuries, including eight with stroke, who successfully completed the driving evaluation and were deemed safe drivers, They were individually matched to a control group of friends or relatives. There were no statistically significant differences in driving behaviours, including the number of days per week driven, the total miles per week, conditions avoided, traffic violations, or damages and injuries, between the two groups. This very small study included and combined all types of brain injury, such that the results for stroke clients alone were impossible to determine (Katz et al., 1990).

Studies investigating the ability to drive safely after stroke resulted in contradictory findings. Koepsell and colleagues designed a study to determine the risk of accidents according to specific medical conditions (Koepsell et al., 1994). They conducted a population based case-control study of 234 persons over aged 65 who received medical care for injuries sustained during a motor vehicle collision. While there was an increased risk of injuries in those with coronary heart disease and diabetes, the estimated relative risk for those with stroke was 0.8 (95% CI = 0.2-2.5), indicating that those with stroke were no more likely to sustain an injurious collision compared to age and sex-matched controls. However, these results cannot be considered conclusive since the prevalence of stroke in this group was extremely small (1.7% in the cases and 2.2% in controls). In addition, while those with coronary heart disease and diabetes may not change their driving status following diagnosis, those with stroke, especially those more severely affected, are less likely to maintain their driver's license, or to be driving.

The driving records for almost 2,000 clients with stroke were compared to a sample of non-hospitalized individuals. Subjects were frequency-matched for age, gender and zip code. After controlling for age, gender, and the occurrence of a crash or traffic citation during the 12 months proceeding the stroke or the reference date, there was no increase in the risk of a crash in the 12 months following hospitalization among the group with stroke. In addition, this group was slightly less likely to have received a citation for a moving violation. While the results suggest that those with stroke are no more likely to incur a crash or traffic violation following a stroke, in the absence of a measure of driving exposure, it is difficult to make this conclusion (Haselkorn et al., 1998).

In contrast, a study conducted by Sims and colleagues (Sims et al., 2000) found that a history of stroke or transient ischemic attack was significantly associated with crashes. This group examined the relationship between crash occurrence and several medical conditions in a population-based sample of individuals aged 55 years and older living in Jefferson County, Alabama. One hundred and seventy four subjects, stratified according to previous crash frequency, completed medical, functional, visual and cognitive evaluations. The results of Cox proportional hazards modelling indicated that those who had a stroke or TIA had an increase in automobile crashes in the subsequent 5 years, with a relative risk of 2.71.

While it is not clear whether drivers with stroke are at increased risk for crashes, studies have shown that driving performance is often impaired. Wilson and Smith (Wilson & Smith, 1983) investigated the driving performance of 11 stroke clients on a driving course and found they scored more poorly compared to controls on the majority of the tested items. They noted problems in entering and leaving highways, a lack of awareness of other potentially interacting vehicles and difficulty in dealing with sudden events. Results of a principal component analysis suggested that the impairments were related to visual scanning and co-ordination of separate visual scans, attention to a secondary task, response to an emergency situation, joining and interacting with traffic, and the ability to perform left-sided tasks. Although this study suggests that there are significant deficits in the driving ability of those with stroke, the comparability of the selected control group is questionable. The only information provided about the 19 controls is that 11 were aged 46 to 65 years and 8 were 18 to 26 years of age.

Simms (Simms, 1985) evaluated 104 subjects with stroke using a battery of perceptual-cognitive tests. Those with right-sided lesions had the greatest impairments in perception, while those with left-sided lesions had more difficulty following directions and performed slowly rather than inaccurately on the perceptual tasks. One year later, a subgroup of 37 subjects who were driving reported no accidents involving major property damage or personal injury. Forty one percent, however, reported minor driving incidents.

Lings and Jensen compared individuals with stroke to controls on their performance in a simulated car (Lings & Jensen, 1991). Forty six subjects with right-sided stroke, 67 with left-sided stroke, and 109 controls were measured for grip strength, force, direction and speed of turning the steering wheel, reaction times on the pedal and steering wheel, and choice reaction times. Reaction times were increased, especially in those with ride-sided lesions, while those with left-sided lesions committed more errors of direction. In addition, clients with right-sided strokes failed the evaluation more frequently (van Zomeren et al., 1987).

While elderly clients, and specifically those with stroke, appear to have some impairment in their performance of the driving task, the impact of these deficits is not very clear. Studies have indicated that these individuals tend to modify their exposure to the more difficult driving situations. However, studies comparing driving risk typically have not included measures of exposure. While there has been little investigation of the ability to drive following a stroke, those studies that did evaluate driving performance found that clients have difficulty exploring their environment and responding quickly. While both those with left and right-sided lesions have difficulty with the driving task, the type of difficulties that each group exhibits seems to differ. Given that there are concerns regarding the ability to drive safely following stroke, it is essential to accurately distinguish safe from unsafe driving.

2.4 EVALUATION OF DRIVING PERFORMANCE

The long-lasting impairments associated with stroke make it imperative to accurately assess the driving ability of these clients and identify their level of safety (Korteling & Kaptein, 1996). Rehabilitation professionals are frequently asked to evaluate and render an opinion about the driving ability or potential of those with physical disabilities, but standard procedures for evaluating fitness to drive do not exist (Monga, 1997). Typically the evaluation consists of several components, including a medical and visual examination, an evaluation of the fundamental perceptual and cognitive skills necessary during driving, and a functional on-road driving evaluation on a closed course or in real traffic. The medical assessment administered by a physician includes a general physical examination, focusing on any medical conditions that may impact upon driving, as well as a more detailed ophthalmologic examination of eye health, visual acuity and peripheral vision. The assessment of fundamental perceptual and cognitive skills is typically accomplished using a battery of standardized and/or home-grown paper and pencil tests and often computer-based perceptual assessments. The evaluation then proceeds to the testing of driving performance, either in a simulator, on a closed driving course or on the road (Hunt, 1993). The perceptual-cognitive testing and the driving evaluation are typically administered by an occupational therapist, in conjunction with other clinical team members. Clearly, it is important to accurately measure driving safety, so that those clients with neurological impairments that do not significantly impact on performance may continue to drive, and that those who are no longer able to drive safely are prevented from driving. In addition, the majority of clients who sustain an acute neurological event do not receive formal rehabilitation services and it is often the family physician who is responsible for discussing the issue of driving with them (Korner-Bitensky et al., 1990). There is obviously a need for a screening tool that can be used by physicians to precisely identify clients who are safe drivers, those who are unable to resume driving, and those who require further testing.

The measurement of driving ability is not a unique construct, but includes several different components, utilizing different methods of ascertainment. These include examining driving records or self-report of crash involvement and driving infractions as a measure of safety, evaluating the fundamental skills required for driving, and measuring functional driving behaviour using either a driving simulator or an on-road evaluation (Goode et al., 1998).

2.4.1 Evaluation of Driving Safety

The examination of state driving records to ascertain automobile crash and/or driving infraction data has been used as a measure of driving safety. Others have also focused on the number and severity of crashes and/or infractions but measured using self-report. These methods, however, are likely to result in biased estimates as individuals tend to underreport these occurrences (Owsley, 1997). When using crash and infraction data to evaluate driving safety, it is necessary to include an estimate of driving exposure, including whether one is driving, as well as the distance and under what circumstances (Owsley, 1997).

2.4.2 Evaluation of Fundamental Driving Skills

There is agreement that visual-perception and cognition are important basic skills necessary for driving and that their evaluation is important in the driving assessment process. The specific testing procedures that provide the most useful information, however, are not clearly defined. Clinicians working in driving evaluation programs are looking for a method to screen a person's ability to resume driving using an off-road perceptual-cognitive assessment (Klavora et al., 2000a). A review of driving evaluation procedures for individuals with stroke indicated that the following areas of visual-perception and cognition should be tested: visual attention, unilateral visual neglect, visual scanning, spatial awareness, motor planning, topographical orientation, problem solving, simple and complex visual reaction time, and visual-motor co-ordination (Cumbo-Misheck, 1993; Klavora et al., 2000a). A recently conducted survey of North American driving programs indicated that the two most commonly used perceptual tests are the Motor-Free Visual Perception Test (MVPT) and Trail Making Test A and B (Korner-Bitensky et al., 1998), but many other testing procedures are currently in use as well.

Sivak and colleagues (Sivak et al., 1981) administered 12 perceptual-cognitive tests, five driving tasks in a closed-course, and an evaluation of in-traffic driving to clients with stroke (n=16), traumatic brain injury (n=7), spinal cord injury (n=8) and to normal controls (n=10). Subjects with brain damage performed significantly worse than the controls on both the perceptual-cognitive tests and the closed course driving test. The measures with the highest correlation with driving performance in those with brain injury were the Picture Completion subtest of the Wechsler Adult Intelligence Scale (r=0.72), stereo depth (r=0.52), and Picture Arrangement (r=0.46).

Seventy-two subjects with stroke and seven coronary infarct controls were studied (Sundet et al., 1995). A stepwise multiple regression analysis was performed to determine the contribution of both subject characteristics and neuropsychological test results to the decision by the professional team as to whether or not a subject should drive. Trail Making B was the most predictive variable.

Galski and colleagues (Galski et al., 1990) examined the internal validity and predictive validity of the predriving evaluations developed at the Kessler Institute for Rehabilitation in New Jersey. The evaluation procedure consisted of physical and neuropsychological tests, including tests of attention, concentration, reaction time, memory, visual acuity and visual-spatial skills. The driving evaluations for a combined sample of 14 subjects with traumatic brain injury and 23 clients with stroke were examined retrospectively. Results indicated that the predriver items were not predictive of the behind-the-wheel evaluation. Using their Cybernetic Model of Driving as a conceptual framework, the authors tested 22 individuals with traumatic brain injury and 13 with stroke using a battery of psychometric tests specifically selected to measure the abilities described in the model (Galski et al., 1992). Skills were scored as either pass or fail and were ranked according to importance. Together, the seven neuropsychological tests, an evaluation on a driving simulator, and measures of behaviour explained 93% of the on-road outcome. A larger study of 58 subjects with traumatic brain injury and 58 with stroke found that the sensitivity of the neuropsychological testing in predicting driving failure was 71% and the specificity of driving success was 87%. These results were improved to 82% and 91% respectively when measures of behaviour were included in the model (Galski et al., 1993). The importance of behaviour in those with stroke was not examined separately.

Nouri and colleagues (Nouri et al., 1987) created a screening assessment of perceptual and cognitive ability for clients with stroke wishing to return to driving. An assessment battery was administered to forty subjects more than six weeks post-stroke and each scale was graded as good, average, borderline or below standard. Those rated as good or average were considered as having passed the cognitive assessment while those obtaining borderline and below standard grades were categorized as having failed. A driving instructor and an occupational therapist who were unaware of the cognitive assessment results conducted an on-road test. Discriminant function analyses indicated the combination of tests that together predicted driving performance: Dot Cancellation, Rey Figure Testing, What Else is in the Square, Pursuit Rotor, Token Test, Recognition Memory Test, Cube Copying, and Hazard Recognition. The tests that were most highly associated with driving performance were those requiring complex reasoning skills, visual attention, concentration, spatial abilities, visual scanning, and eye-hand co-ordination while vision, visual field, and reaction time were unrelated. This cognitive battery was validated on 40 stroke clients to determine whether the rating of pass and fail on the driving test could be predicted. The equation including three tests, Dot Cancellation, What Else is in the Square?, and Road Sign Recognition, best predicted driving grade and correctly classified 82.2% of one sample of subjects and 79.4% of a second sample (Nouri & Lincoln, 1992). The predictive value of the cognitive test battery was compared to that of the advice of each subject's physician regarding his or her fitness to drive. Subjects were first tested on the road and graded as either having passed or failed the driving test. Twenty-seven subjects were then tested on the screening test, while 25 asked their physicians' advice. The screening assessment correctly predicted the road performance of 81% of clients while physicians correctly predicted 56%. The latter may have occurred by chance, since there were two possible outcomes, pass and fail (Nouri & Lincoln, 1993).

The Cognitive Behavioral Driver's Inventory (CBDI) was constructed to assess the prerequisite skills for driving. A mixed group of 94 subjects with neurological deficits, including those with right cerebrovascular lesion (n=32), left cerebrovascular lesion (n=25), traumatic brain injury (n=20), spinal cord injury (n=6) and other neurological impairment (n=11) was evaluated on the CBDI and a road test. The test battery was composed of several tests from Bracey's Cognitive Rehabilitation Programs, including measures of attention, concentration, reaction time, dynamic cognitive processing, decision making, visual discrimination, and divided attention, as well as the WAIS-R Picture Completion and Digit Symbol subtests, brake reaction time, and vision. Global performance was defined as the average of the item scores. There was a significant difference in scores between those who passed the road test and those who either failed or were not tested due to extremely poor performance on the CBDI (Engumet al., 1988a). A short form of the CBDI was created including the 10 items with the highest correlation to the total score. (Engum et al., 1988b).

Engum and colleagues (Engum et al., 1990) examined the ability of the CBDI to discriminate between those with brain injury whose cognitive impairments precluded them from driving, those with brain injury allowed to resume driving, and normal control subjects. Pass/fail status was determined by the psychologists' clinical interpretation of the CBDI results and the clients' performance on the road test. The CBDI was administered to 215 rehabilitation clients, including 59 with left-sided stroke, 58 with right-sided stroke, 63 with traumatic brain injury, 9 with spinal cord injury, and 26 with other neurological conditions. Those that passed the driving test performed significantly better, on average, on all items on the CBDI compared to those who failed. Klavora and colleagues (Klavora et al., 2000a) compared the predictive validity of the CBDI to that of the Dynavision Performance Assessment Battery, a measure of visual scanning ability. Subjects were at least six months post-stroke and had been diagnosed with visual scanning or visual attention problems. However, only 56 of 471 eligible clients agreed to participate. Scoring well on either the CBDI or the Dynavision was significantly associated with a higher probability of passing the on-road evaluation, while scoring well on both these tests was highly associated with driving outcome (OR=43.93). The specific selection criteria and the low participation rate, however, make the results difficult to generalize

The results of these studies, while clearly indicating a relationship between perceptual-cognitive test results and driving assessment outcome, are difficult to apply to the clinical situation where clinicians are attempting to predict individual client's ability to return to driving. Some studies included only a limited number of subjects (Nouri et al., 1987; Sivak et al., 1981). Others studied a mixed sample of clients with a variety of diagnoses making it impossible to determine the results specific to only those clients with stroke (Engum et al., 1988a; Galski et al., 1992; Sivak et al., 1981). In several studies, statistical comparisons of the many measures may have produced significant correlations by chance (Engum et al., 1988a; Galski et al., 1992; Sivak et al., 1981). Some authors examined a battery of perceptual tests, and reported either the predictive ability of tests separately (Galski et al., 1992) or for the total test battery (Engum et al., 1988a; Sivak et al., 1981), but did not provide the model that resulted in the best combination of tests for clinical use.

2.4.3 Evaluation of Driving

The evaluation of on-road driving performance is regarded as the direct measure of driving ability (Lundqvist et al., 1997). Driving behaviour is typically assessed using a functional evaluation of on-road performance where the examiner, most often an occupational therapist and/or a driving instructor, observes a client driving along a predetermined route, and makes judgements about certain manoeuvres. The advantage of this method is that it directly evaluates the functional task of driving. In order to use the on-road evaluation as an objective measure of driving performance, relevant component manoeuvres must be identified and accurately quantified (Owsley, 1997).

2.4.3.1 Driving Simulator

Simulated driving tasks allow the evaluation of driving skills in a safe environment. Technology has improved and simulators are more interactive and can more realistically simulate many aspects of the driving task. The driving simulator has been used as an assessment tool, typically prior to the on-road evaluation, to help evaluators document the clients' difficulties with specific aspects of driving (Quigley & DeLisa, 1983). Decisions that can be aided by a simulator include determining whether the client is a candidate to operate a car with or without adaptations (Cimolino & Balkovec, 1988), whether they require additional training, or if there are deficiencies that rule out driving (Monga, 1997). Simulators may also be used to evaluate hazard perception and the ability to use defensive driving skills, abilities that would be dangerous to assess on a road test (Quigley & DeLisa, 1983).

While few studies have systematically examined the relationship between evaluation on a simulator and on-road testing (Owsley, 1997), findings to date indicate little correlation between the two measures (Monga, 1997; Owsley, 1997). Fitness-to-drive as assessed by a driving simulator was compared to results obtained following on-road testing in 38 subjects with stroke. Results indicated poor association between the two measures (Kappa=0.29) (Nouri & Tinson, 1988). For clients with stroke, a simulator may not be a useful tool, as these individuals prefer to be evaluated in a real and familiar car (Quigley & DeLisa, 1983).

Only one study found a relationship between a driving simulator and driving safety. Thirty-eight elderly individuals who participated in a driving simulation study were contacted to determine driving status three years later. Those who were classified as high-risk on the driving simulator reported 47 crashes per 1,000,000 miles driven as compared to 6 crashes per 1,000,000 miles for the low-risk group. While these values suggest a strong increase in crashes in those who performed poorly on the simulator, findings were based on individuals self-report of crashes, a measure known to be biased (Cox & Taylor, 1999).

2.4.3.2 Closed Driving Course

Evaluators have tested driving skills on a closed driving course prior to on-road testing. Closed course evaluations are used to test basic car manoeuvring skills, such as driving around cones and braking (Fox et al., 1998). These tests typically measure skill performance, number of errors, and the time taken to complete the course, while free of traffic and other common distracters (Fox et al., 1998). A closed-course may not adequately reflect the real driving situation, but it is thought to provide information to help determine whether a client meets the minimum standards of competence for an on-road evaluation (Fox et al., 1998). However, Galski and colleagues determined that the closed-course portion of their evaluation yielded little information about the driving behaviours observed on a road test (Galski et al., 1992; Galski et al., 1993; Galski et al., 1990).

2.4.3.3 On-road Evaluations

Behind the wheel evaluations are most likely the best way to ascertain whether a client is a safe driver, however, they are expensive and time-consuming to conduct (Monga, 1997), require expensive equipment and specially trained evaluators, and carry a high liability (Klavora et al., 2000a; Monga, 1997). They are typically used as the criterion measure against which other types of evaluation procedures have been validated (Kewman et al., 1985; Sivak et al., 1984a; Sivak et al., 1981). On-road evaluations, routinely performed in most driving evaluation centres, are typically checklists of driving behaviours used to assist in the determination of a pass or fail. Most studies include two individuals in the car so that the driving instructor, seated beside the driver, concentrates on maintaining safety and giving directions to the driver, while the therapist or rater is seated in the back of the car and can observe the clients' scanning and manoeuvres (Fox et al., 1998).

Typically, a standardized route is used to test city and highway driving and includes lights, stop signs, merges and other driving situations. More recent reports of driving evaluations (Fox et al., 1992; Galski et al., 1993) have included not only items examining the operation of the vehicle, but also aspects of the clients' behaviour in traffic (Fox et al., 1998). While the methods of administration of the evaluations are often well described, the criteria for scoring the individual items and for deriving the final rating of a pass or fail is not well defined. Wilson and Smith used a 5-point scale to rate each item (Wilson & Smith, 1983), while most others used a 2-point scale, dichotomizing performance as safe versus unsafe, or correct versus incorrect (Galski et al., 1993; Nouri et al., 1987). Scoring subjects on non-standardized routes is of questionable validity since each subject does not experience the same opportunities for error (Fox et al., 1998), although controlling for all experiences on the road is impossible to maintain due to changes in weather conditions, traffic and other obstacles. In the absence of a strong criterion measure, standardized administration and scoring criteria is necessary for a highly valid on-road test (Fox et al., 1998).

Recent literature discusses the following road tests: Miller Road Test (Carr et al., 1992), Performance-Based Driving Evaluation (Odenheimer et al., 1994), Washington University Road Test (Hunt et al., 1997), DriveABLE Road Test

(Dobbs, 1997), and Cognitive Behavioral Driver's Inventory (Engum et al., 1988a).

The Miller Road Test (Carr et al., 1992) is a standardized road test designed by the School Bus and Traffic Safety Section of the Department of Motor Vehicles in North Carolina and was used in a study of the effect of age on driving ability (Carr et al., 1992). This measure rates clients' skills in 19 areas, including checking the vehicle, starting the vehicle, intersections, turns, and speed control. Scoring is weighted so that points are given according to the severity of error. There was no information provided on the methodology used to develop the items, the determination of the weighting scale, nor its psychometric properties. In addition, there were no reports of this evaluation tool being used with clients with disabilities.

The Performance-Based Driving Evaluation (Odenheimer et al., 1994) was developed on a select group of 30 licensed drivers over 60 years of age. Six of the subjects had been diagnosed with dementia. The items were selected by experts in driving evaluation and were included in a closed-course and an on-road course. The driving instructor gave a global score rating the driver on a 4-point scale ranging from 0 (unsafe under any circumstances) to 3 (competent under any circumstances). Two research raters also scored seven closed-course tasks and 68 in-traffic tasks as either pass or fail. The tasks included turns, merges, responses to traffic signals and signs, driving straight, and complex manoeuvres. Inter-rater reliability of the two raters for the in-traffic course was r=0.74. Validity of the measure was also examined in several ways. A correlation of r=0.74 was found between the global score (an ordinal scale) and the in-traffic score. Construct validity was tested against the Mini Mental State Evaluation, traffic sign recognition, visual and verbal memory, Trail Making Test part A, and simple and complex reaction time tasks. All tests, other than the simple reaction time task, were significantly correlated with in-traffic scores.

The Washington University Road Test (Hunt et al., 1997) was designed for clients with early dementia using information about the driving behaviours associated with higher rates of motor vehicle crashes. A standard car is used on the 9.6 km course. Subjects are first rated as either having passed or failed seven basic motor vehicle operational tasks on a closed-course. On the road portion of the test, subjects are scored on a 3-point scale, ranging from moderate to severe impairment to no impairment. Ratings occur at predetermined locations along the route and evaluate left turns, stops, lane maintenance, speed, traffic awareness, merging, concentration, lane changes, traffic signs, comprehension of directions, attention to task, awareness of their driving affecting others, judgement, and the need for safety manoeuvres by the instructor. Standardized scoring criteria are available for each item. The total score ranges from 0-108. In addition, a global subjective rating of safe, marginal or unsafe driving performance is assigned. Interrater reliability testing between 3 raters on 10 road tests resulted in a Kappa of 0.85-0.96, depending on the raters. Also, test-retest reliability was assessed on 63 subjects one month later, with a reported Kappa of 0.53 for the overall rating.

The DriveABLE (Dobbs, 1997) was developed using a group of 115 cognitively impaired elderly subjects. The driving course consists of 37 manoeuvres over a route that takes approximately 40 minutes to complete. Errors were determined by distinguishing common errors seen in the general population from errors that are relevant for safety, and each error is recorded along with a measure of its severity, either low, moderate, or high risk. Errors are categorized according to the type of mistake made; position, stopping, speed, aggressive/overcautious, confusion/overcaution or observation.

The Cognitive Behavioral Driver's Inventory (Engum et al., 1988a) is an assessment that includes a cognitive perceptual battery as well as an on-road component. The road test uses a standard course and the subject is graded on control operations, such as buckling seatbelts, and other variables, including hostility, confusion, inattention, judgement, and problem solving. Each item along the route is rated as "well executed" or "not well executed" and an overall subjective rating of pass or fail is provided.

It is difficult to standardize a measure of driving due to the many inherent differences in climatic conditions, the amount of traffic, or the complexity of the driving situations that arise for individual subjects. While the pass or fail on a standard driving route is the common way for determining driving performance, it remains problematic, even in the assessment of the general public. In addition, the specific applicability of the available measures to those with different diagnoses, such as stroke, has not been shown.

While there is clearly no agreed upon and accurate approach to measuring driving ability, researchers consistently focus on similar fundamental skills and driving functions. In addition, clinicians and researchers are focusing attention on implementing relevant treatments in order to improve driving function in the elderly as well as in clients with stroke.

2.5 TRAINING OF DRIVING PERFORMANCE

2.5.1 Stroke Rehabilitation

Co-ordinated stroke care is known to improve long-term functional outcome, but the scientific evidence documenting the value of specific rehabilitation interventions is limited (Cifu & Stewart, 1999; Johansson, 2000; Miyai et al., 1998; Ottenbacher & Jannell, 1993). In general, comparisons between different methods of treatment in current use have failed to show that any particular stroke rehabilitation strategy is superior to another (de Pedro-Cuesta et al., 1992; Johansson, 2000). The overall effectiveness of rehabilitation interventions is difficult to summarize since many studies include only those clients with a reasonable chance of success (van Zomeren et al., 1987), treatment settings differ, samples are heterogeneous, stroke severity is not controlled, and there are differences in the type, quantity and quality of the interventions.

In individuals with stroke, therapeutic interventions for perceptual and cognitive deficits have focused on either improving the actual impairments associated with the condition or compensating for the resultant deficits. The functional approach focuses on the repetitive practice of daily living tasks while adapting the environment and developing compensatory strategies to improve independence in meeting basic needs. This approach treats the symptom rather than the cause of the problem (Zoltan, 1992a). Generalization to other skills or contexts is not expected (Raskin & Mateer, 1994). Remedial or transfer of training approaches target the remediation of deficits in specific cognitive areas, such as attention, concentration, motor planning, visual spatial processing, as well as higher order functions such as planning, reasoning and problem solving (Raskin & Mateer, 1994). Exercises are performed repeatedly and are most commonly used in the earliest stages of rehabilitation. This approach assumes the presence of neural plasticity, such that neurological functioning can be modified by sensory input, experiences, and learning (Johansson, 2000), and is based on the theory that repetitive practice of tasks results in improvement that carries over into similar tasks and ultimately to daily function (Zoltan, 1992a).

The ability to generalize skills to novel tasks and situations remains unclear. It is thought that clients are able to learn specific responses but are less capable of learning general strategies applicable to new situations (Antonucci et al., 1995). For example, the effects of rehabilitation of hemi-inattention appear to be task specific and show little generalization (van Zomeren & Brouwer, 1994).

Several studies investigating the effectiveness of intervention targeted at perceptual and cognitive dysfunction found some improvements with training. In three randomized clinical trials, training of overall deficits appeared to have a positive impact on performance. Training of scanning ability in 57 clients with right hemisphere lesions improved performance in academic skills, cancellation tasks, and other related tasks (Weinberg et al., 1977). Seventy-seven clients with right-sided lesions received either a visual-perceptual remediation program (n=48) consisting of scanning training, somatosensory awareness, and complex visual-perception training or control intervention (n=29). While those in the experimental group improved in single target cancellation and spatial tasks, these benefits did not generalize to performance on other tasks (Gordon et al., 1985). Finally, the effectiveness of three weeks of intervention focusing on training of visual scanning, visual spatial perception, and time judgement was compared to traditional therapy in 33 stroke clients (Tondat Carter et al., 1983). Results indicated improvements following treatment as well as generalization to areas of function and personal care.

Specific training for unilateral neglect, including visual scanning reading, and copying training, was compared to general cognitive intervention in 20 clients with right hemisphere lesions and unilateral neglect. Those that received eight weeks of treatment performed significantly better on related tasks, such as the Letter Cancellation Test and the Sentence Reading Test (Antonucci et al., 1995).

Computers provide an efficient and motivating medium for cognitive rehabilitation activities (Finlayson, 1990). While no large treatment studies have compared computer-assisted therapy to conventional programs, reports indicate that computer–assisted therapy is motivating for clients with poor attention. Computers offer consistent and reliable presentation of stimuli and objective collection of data (Robinson & Winner, 1998), flexibility of perceptual variables during treatment, immediate feedback of performance, and repetition (Efferson, 1995). While computers may be used to treat specific impairments, they do not require the many perceptual, vestibular and motor responses typical of more complex daily functional tasks (Efferson, 1995).

In an uncontrolled case study of three clients with visual neglect following stroke, subjects were treated with specialized computer software to remediate basic perceptual and cognitive skills. These subjects showed consistent improvement from pre- to post-test scores on letter cancellation and line bisection tasks (Paul, 1996). A second study followed fourteen subjects with visual neglect for four weeks as a baseline, followed by four weeks of treatment. Training consisted of computer perceptual games, and paper and pencil tasks. Subjects improved on all measures of attention and behaviour over both the baseline and the treatment periods, indicating that natural recovery may be responsible for much of the improved performance after stroke (Fanthome et al., 1995).

Two small randomized trials did not find benefits specific to computerized retraining. Twenty subjects, matched for age, sex and degree of impairment, were assigned to receive either six hours of training using Bracy's visual-spatial software package or routine hospital therapy. There were no significant improvements in performance on the Barthel Index, Modified Motor Assessment Scale, WAIS-R (Wechsler Adult Intelligence Scale-revised) Block Design, and remote memory, measures not directly related to the type of training provided (Hajek et al., 1993).

Robertson and colleagues (Robertson et al., 1990) randomized 36 clients with unilateral neglect to receive 14 sessions of either scanning training on a touch-screen computer, or computer activities not targeted at improving this neuropsychological function, such as word games. Results indicated no significant differences between the two groups on any of the variables tested.

While these studies have examined the effectiveness of treating impairments known to be associated with automobile driving, there are relatively few studies that have examined the benefits of intervention directed at improving driving ability directly. The reported studies explored interventions designed to treat either the fundamental visual-perceptual and cognitive deficits or driving skills, using either a driving simulator, small motorized vehicle, or full scale on-road training.

2.5.2 Training of Fundamental Driving Skills

To examine the effectiveness of perceptual and cognitive training, investigators have studied the use of paper and pencil tasks, as well as the use of specialized computerized training tools. Sivak provided eight subjects with acquired brain damage eight to ten hours of individualized perceptual-cognitive training using paper and pencil exercises, designed to improve visual scanning, directed eye movements, spatial perception and discrimination, figure-ground differentiation, visual imagery, attentional capacity and general problem solving. Results of perceptual testing reflected improved scores in 47 of the 59 tests. Driving performance was evaluated using an on-road driving test. Subjects were evaluated on their execution of 166 predetermined actions divided into five categories: leaving a safe gap when merging into traffic, position at stop sign, yield sign or traffic signal, making necessary observations, staying safely in lane, and speed. There was a significant increase in the pre- to post-training driving score. However, a control group was not studied, making it impossible to determine whether these improvements can be attributed to the training program (Sivak et al., 1984a).

2.5.2.1 Dynavision

Klavora and colleagues studied the use of the Dynavision, a large wall-mounted board containing 64 buttons, designed to evaluate and retrain visual scanning, visual attention in focal and peripheral fields, and visual-motor reactions and co-ordination (Klavora et al., 1994; Klavora et al., 1995a; Klavora et al.,1995b; Klavora et al., 1995c). This team of researchers tested the effectiveness of training using the Dynavision on psychomotor ability and on-road driving performance. Ten subjects with stroke, with marked visual and attentional impairment who were judged unsafe to drive, participated in six weeks of individualized training. After training, six of the 10 subjects were judged safe to drive. Since the study did not include control subjects and the evaluations were not conducted blindly, it is impossible to judge the validity of these results.

2.5.2.2 Useful Field of View

The UFOV evaluation tool, known to be a strong predictor of driving safety, can also be used to retrain visual attention skills. Ball and colleagues (Ball et al., 1988) evaluated the effect of intervention using the UFOV on driving performance. Treatment consisted of five sessions of training processing speed, divided attention and selective attention. Twenty-four subjects, eight 22-33 years of age, eight 40-49 years and eight 60-75 years were included in the study. Training produced a general improvement in performance on the UFOV for all ages and at all areas of the visual field, such that after training the middle aged group performed similar to the young group prior to training and the oldest group performed similarly to the middle aged group before training. In addition, these improvements in performance persisted over a six-month period. This same group of researchers recently conducted a randomized clinical trial (Roenker et al., personal communication) evaluating the effectiveness of UFOV training on driving performance in older adults with decreased attentional skills (≥30 percent reduction on the UFOV). Subjects participated in either a UFOV training program (n=49) or a driving simulator training program (n=25). The duration of training for both groups was approximately four to five hours. A third group of 25 elderly subjects with no loss of attentional skills served as a comparison group. Pre- and post-tests included the simple and choice reaction time test, the Doron driving simulator, and an on-road driving evaluation. Specific driving behaviours were rated on a 3-point scale by two independent evaluators. In addition, the raters provided a global rating of driving, ranging from 1- very unsafe to 6-very competent. After training, the UFOV group obtained significantly improved UFOV scores and choice reaction time scores. Both groups that received training improved on the driving evaluation, with the UFOV trained group demonstrating fewer dangerous maneuvers, while those that received simulator training improving on three driving performance measures; turning, positioning safely at stops, and signalling.

2.5.3 Training of Driving

2.5.3.1 Driving Simulator

Training on a driving simulator has been used in clinical driving programs (Cimolino & Balkovec, 1988; Szeto et al., 1982). The simulator may provide clients an opportunity to analyze and practice driving situations under a variety of conditions, allowing repetition and review of each situation (Kumar et al., 1991). The effectiveness of simulator training in improving on-road performance, however, has not been established. In addition, the feasibility of using a driving simulator in clients with disabilities has been questioned. In a group of clients with a variety of diagnoses, 13 of 167 subjects were unable to complete training due to physical or emotional discomfort (Kent et al., 1979).

Twenty-one subjects over age 55 were randomly assigned to receive either simulator training on the Doron Simulator, viewing of simulator films, or no training. On-road evaluation results were higher in those trained using the simulator, however, no details of the training program were provided (Jacobs et al., 1997). Cimolino and Balkovec reported on the use of a driving simulator in their driving evaluation and training program for disabled adolescent new drivers and adults with stroke. While the details of the training were not provided, the authors report a large increase in driving simulator scores for the adolescent population, with very little change noted for the group with stroke. (Cimolino & Balkovec, 1988).

2.5.3.2 Small-Scale Vehicle (SSV)

A small-scale vehicle for retraining driving skills has been suggested, with potential benefits including lower price and operating costs, adaptability to left- and right-handed clients, and the ability to regain skills away from public thoroughfares (Hale et al., 1987). Kewman and colleagues used a small motorized vehicle to retrain 13 clients with severe head injury on seven driving-related exercises. They were compared to 11 head-injury clients who received experience with the electric vehicle but no specific training. An additional control group consisted of high school students. Experimental exercises were designed to train the attentional and visual-motor skills required for driving. Subjects were tested by a blind evaluator using a standardized on-road driving test. The program resulted in improved driving performance for those in the experimental group as compared to control subjects with head injury, but scores were lower than those obtained by the non-brain injured controls (Kewman et al., 1985).

2.5.3.3 In-Car Training

The benefits of in-car training for those with disabilities have not been carefully assessed (Jones et al., 1983). Quigley and DeLisa selected disabled clients who did not perform well on the driving evaluation to receive in-car training and classroom instruction. Driving training began in a parking lot and proceeded to residential streets to teach turns, intersection procedures, lane changes and parking. After successfully completing the program, clients were tested at the Department of Motor Vehicles. Results indicated that 74% of 23 subjects with left-sided lesions and 52% of 27 subjects with right-sided lesions passed the evaluation. However, the effectiveness of this type of training program cannot be determined since the training procedures were not standardized and were poorly defined, and no comparison group was included (Quigley & DeLisa, 1983).

The studies on training are so varied in their approaches and in the rigor of methodology that it is difficult to conclude that one or the other retraining strategy is the appropriate direction to follow. The literature review has summarized our knowledge to-date regarding the deficits associated with stroke and their impact on daily functioning. Clearly, the ability to attend and process visual information is crucial to safe driving. In addition, training of visual processing skills in the elderly, using the UFOV, suggests the potential for this tool in the treatment of attention following stroke.

The ability to accurately measure driving performance is critical to providing decisions about return to driving that is fair to both the client and society as a whole. In addition, valid measures are necessary to accurately measure treatment effectiveness. This thesis begins to address these two important issues; driving evaluation and training of skills in clients with stroke.

3. METHODOLOGY AND RESULTS

3.1 Predicting Ability to Drive After Stroke

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3.1.1 ABSTRACT

Objective: To determine the ability of perceptual testing to predict on-road driving outcome in subjects with stroke.

Study Design: Historical cohort study of 84 individuals with stroke who completed both the perceptual testing and the on-road driving evaluation conducted in a driving evaluation service.

Measures: Perceptual tests, such as the Motor-Free Visual Perception Test (MVPT) and Trail Making B test, and an on-road driving evaluation. Based on driving behaviours, a pass or fail outcome was determined by the examiners.

Results: Subjects who passed the on-road evaluation had better average scores on the majority of perceptual tests compared with those who failed. The MVPT was the most predictive of on-road performance (positive predictive value = 86.1%; negative predictive value = 58.3%). The combination of tests resulting in the most predictive and parsimonious model was the MVPT plus Trail Making B, such that those who scored poorly on both were 22 times more likely to fail the on-road evaluation.

Conclusion: A screening process is useful in identifying persons who are not ready to undergo an on-road driving evaluation.

3.1.2 INTRODUCTION

Driving a motor vehicle is an integral component of modern life. A neurologic event such as a stroke affects driving ability, thus necessitating the evaluation of fitness to drive. This evaluation procedure and the subsequent recommendations to the driver's licensing agency are often the responsibility of rehabilitation clinicians, yet there are no specified guidelines regarding the appropriate assessment tools on which to base these recommendations.

Safe driving is dependent on the integration of complex visual processing skills. It has been estimated that 90% of informational input to the driver is visual.[1] Assuming an adequate degree of visual acuity and peripheral vision, visual-perceptual skills such as scanning, tracking and figure-ground discrimination determine the ability to notice and react to objects in the visual field.[1] Thus, complex visual-perception and attention skills are the major requirements for driving that are frequently effected by stroke.

Several groups of researchers have examined the relation between perceptual functioning and driving ability in individuals with various conditions. Engum and colleagues[2] tested 94 subjects, including individuals with stroke, traumatic brain injury, spinal cord injury, and other diagnoses, to develop a cognitive behavioural driver's inventory that included 27 tests of perception, cognition and attention. Significant group differences were found between those who passed and those who failed the driving test.[2-4]

Sivak and colleagues[5] examined the performance of 31 individuals with stroke, head injury, and spinal cord injury and 10 control subjects in a series of 12 perceptual-cognitive tests. The results of many of the individual tests significantly correlated with the outcome of a driving evaluation, suggesting an association between neuropsychological test performance and driving ability. The highest correlation for clients with stroke and head injury combined was on the Picture Completion subtest of the Wechsler Adult Intelligence Scale ($r = 0.72$).

Galski and colleagues[6] examined the ability of a predriving evaluation, consisting of 21 physical and neuropsychological tests, to predict driving performance.

Thirty-five individuals with stroke and traumatic brain injury were evaluated on a driving simulator and on a battery of tests measuring the processing of sensory input. On-road driving performance was significantly correlated with several of the psychological and physical tests; however, the names of the tests were not specified by the authors. In a subsequent study using this test battery, 106 subjects with stroke and head injury were evaluated.[7] The authors reported that the sensitivity of correctly identifying driving failure was 71%, while the specificity of identifying a passing score was 87%. Although the authors present sensitivity and specificity analyses, it would have been important to indicate the positive and negative predictive values of the perceptual test scores. The sensitivity/specificity analyses provide information on the proportion of subjects who passed the driving test who received a high score on the perceptual test and the proportion who failed the driving test who received a low score on the perceptual test. What is crucial in this area of study is an understanding of the ability of the perceptual test results to predict on-road driving performance; hence, the need to calculate predictive values.

In the only research focusing exclusively on clients with stroke, Nouri and colleagues[8] tested 39 individuals on a battery of 13 tests that measure perception, cognition and vision. Twenty-three separate test results were obtained. Nine of the 23 scores discriminated between three possible outcomes on the on-road test, pass, borderline, and fail. When Nouri and Lincoln,[9] the authors attempted to substantiate these findings on a second group of 40 subjects, the model was not validated. In a further attempt to verify the model, a random sample of half of the combined group of 79 subjects was selected and discriminant equations predicting pass and fail were calculated. The equations included three tests- Dot Cancellation, What Else is in the Square?, and Road Sign Recognition- that together correctly predicted the pass/fail outcome of 82.2% of individuals.

The results of these studies, while clearly indicating an association between perceptual/cognitive test results and driving assessment outcome, are difficult to apply to the clinical situation in which clinicians are attempting to predict each client's ability to return to driving. Some studies have been plagued by a limited number of subjects.[5,8] Others have included combinations of clients from varying diagnostic groups even though it is well known that there are substantial differences in their sequelae.[2,5,6] For example, a young individual with a head injury may have a very different set of impairments that affect driving potential compared with an elderly individual who has sustained a stroke. In a number of studies, statistical comparisons of numerous tools potentially lead to significant correlations by chance.[2,5,6] Some authors examined a battery of perceptual tests and reported the predictive ability of individual tests separately[6] or for the battery as a whole,[2,5] but did not provide information on the statistical model that resulted in the best combination of tests for clinical use. In addition, the test batteries often consisted of an unreasonably large number of tests that in some instances are restricted to use by psychologists and thus are not available to clinicians from other health care backgrounds who are commonly involved in the assessment of driving.

Before initiating this study, an extensive survey was conducted to identify the tools that are most commonly used by clinicians to assess the perceptual skills necessary for driving.[10] All Canadian rehabilitation centres known to have adult clients were contacted to identify whether they saw individuals with stroke and head injury and, if so, whether a driving evaluation process existed. Twenty-three centres, representing all 10 provinces, responded as having a mechanism to conduct a driving evaluation. In most centres, perceptual assessment took anywhere from 30 to 60 minutes. A recently conducted survey[11] of North American driving programs indicated that the two most commonly used perceptual tests are the Motor-Free Visual Perception Test (MVPT)[12] and Trail Making A and B.[13] Administering perceptual and cognitive tests is costly, time consuming, and stressful for the client, and their value to the driving assessment process is not well understood. Indeed, we were informed that in most evaluation centres, regardless of the test results, most clients go on to perform an on-road driving evaluation. The question arises as to the value of an extensive battery if it is not used to screen out those who are unfit to proceed to the road test.

Thus, this study was designed to determine the ability of these commonly used perceptual tests, alone or in combination, to predict driving performance of clients with stroke. Specifically, the goal was to identify the combination of perceptual tests that was most predictive of a pass or fail on an on-road driving evaluation.

3.1.3 METHODS

3.1.3.1 SUBJECTS

To assemble the historical cohort, we reviewed the charts of all 92 clients with stroke referred to the Driving Evaluation Service at the Jewish Rehabilitation Hospital (JRH), a McGill University- affiliated hospital in Montreal, Canada, between July 1992 and February 1995. Commonly, referrals to the service are made if one or more treating clinicians are concerned regarding the motor, perceptual, or cognitive functioning of their client. Although the majority of referrals were for individuals receiving inpatient rehabilitation services at the JRH, on rare occasions referrals came from other rehabilitation centres, acute care hospitals, and private physicians. Clients with medical conditions that legally preclude them from driving, including visual homonymous hemianopsia, a primary visual impairment inadequately improved by corrective lenses, Class IV cardiac status, and uncontrolled seizures, were not eligible. All 84 subjects who had completed a battery of perceptual tests and an on-road driving evaluation were included in the analyses.

3.1.3.2 MEASURES

The perceptual tests and the on-road driving evaluation tools are described below. All perceptual tests were administered by an occupational therapist who instructed the clients to work as quickly and as accurately as possible. The test battery took approximately 90 minutes to complete. The resultant scores and the time taken to complete each of the tests were recorded. The on-road evaluation was administered within one week following completion of the perceptual testing, and took approximately one hour.

3.1.3.2.1 Perceptual Tests

The Complex Reaction Timer[14] consists of a steering wheel, a brake pedal, a gas pedal, and a panel display of lights. Fifteen light stimuli are presented in random order and at random intervals. The subject is required to respond to the different stimuli by either braking, or turning the steering wheel to the right or left. The timer starts whenever a stimulus light comes on and stops as soon as the appropriate response is performed. The response times to 15 stimuli are recorded. A maximum score of 500 was set. Each subject completed three trials on the reaction timer.

The MVPT[12] is a standardized measure of visual-perceptual skills in five areas: spatial relations, visual discrimination, figure-ground discrimination, visual closure, and visual memory. A maximum score of 36 indicates no errors. The time required to complete each item is noted and the average time per item is calculated. As part of the driving evaluation, a change in response is acceptable before the examiner turns the page to the next item. Normative data are available for adults aged 18 to 80 years.

The Single Letter Cancellation Test[15] is a test of visual scanning and visual attention ability. It consists of a paper with 6 lines of 52 letters per line. The stimulus letter H is presented 105 times. The client is asked to put a line through each letter H found on the page. The number of omissions is recorded. Normative data have been published according to age and gender, based on testing of 341 individuals with lesions of the right hemisphere. The test-retest reliability calculated on 31 subjects was good ($r = 0.63$).[16]

The Double Letter Cancellation Test[15] is similar to the single letter task, but requires the subject to cancel both letters C and E. Again, omissions are calculated. Normative data are also available for this test. The test-retest reliability calculated on 31 subjects was reported as $r = 0.62$.[16]

The Money Road Map Test of Direction Sense[17] is a test of right/left directional orientation. As the examiner traces the path on the test sheet with a pencil, the subject must indicate whether a right or left turn was taken. The score is expressed as the number of incorrect responses.

Trail Making Test A and B[13] are tests of visual conceptual and visual-motor tracking. They are given in two parts. In part A subjects are required to connect the numbers 1 to 25 in consecutive order. In part B, the test sheet contains the numbers 1 to 13 and the letters A to L. Subjects must alternate between the series of letters and numbers connecting number 1 to letter A to number 2 to letter B and so on. Subjects are told to complete each task as quickly and as accurately as possible without lifting the pencil from the paper. In cases where the client is not comfortable with the alphabet sequence, the alphabet is written on a sheet of paper for them to follow. For the purpose of driver evaluation, the therapist does not intervene during the test administration. The total number of errors is recorded. The reliability as measured by a coefficient of concordance was high in part A ($r = 0.78$) and good on part B ($r = 0.67$).[18]

The Bells Test[19] is a complex test of selective attention and visual scanning. The test sheet contains 35 bells embedded within 264 distracters. Subjects are asked to circle each bell that they see. The score is the total number of bells circled and the time it took to complete the task.

The Charron Test[20] evaluates visual attention processing. Subjects must discriminate between similar pairs of objects or numbers. There are 19 pairs of objects and 37 pairs of numbers. Subjects are asked to place a check mark next to each pair that is not identical. The total number of omissions and commissions is recorded.

3.1.3.2.2 On-Road Driving Evaluation

The on-road driving evaluation is based on the standard test procedure used by the provincial licensing board in Quebec, Canada. The on-road driving evaluation is conducted by the same occupational therapist who administers the perceptual tests along with an experienced driving school instructor who is unaware of the results of the perceptual testing. For those with physical impairments, the vehicle is equipped with adaptations such as a spinner knob, and a left accelerator. Clients are oriented to the car and to the adaptations. The instructor provides specific instructions to the client while directing them on a standard route. The evaluation route begins on quiet streets and then proceeds to busy boulevards and highways. If a client makes repeated critical errors, he or she is asked to pull the car to the side of the road and the instructor and therapist provide verbal feedback and recommendations regarding driving performance. The driving evaluation then continues.

Routinely, a 43 item assessment form (see Appendix) is completed during the on-road evaluation, enabling the occupational therapist to document the clients' strengths and weaknesses. The form includes four sections that cover use of controls, manoeuvring, specific driving skills, such as visual exploration and response to traffic signals, and general driving skills that include decision-making, planning, and tolerance. Once the evaluation is completed, the therapist and driving school instructor review the client's driving behaviours, knowledge, application of driving regulations, and ability to manoeuvre the vehicle safely. Based on this assessment, they determine whether the client has passed or failed.

3.1.3.3 PROCEDURE

The medical charts of all eligible subjects were reviewed and the results from both the perceptual tests and the on-road driving evaluation were extracted. Demographic information, including date of birth, gender, and diagnosis were recorded from the medical chart.

3.1.3.4 DATA ANALYSIS

As a first step in the analyses, individuals were classified according to their on-road evaluation outcome, either pass or fail. Descriptive statistics were then generated, with t tests used to compare the group means on the nine perceptual tests according to this dichotomy. The impact of outliers was also assessed. Reaction time was assessed three times for each client and the analyses were conducted with the scores of the three trials separately as well as with the average of the three scores. The eight other tests each resulted in a score and in the time (in seconds) required to complete the task.

To determine how each perceptual test was able to predict pass or fail on the driving evaluation, 2 X 2 tables were created, where the two dichotomized outcomes were Driving Outcome (Fail or Pass) and Perceptual Score (Bad or Good) (figure 1). To identify the cutoff score on each perceptual test, different cutoff values were analyzed until the one that yielded the best positive predictive value was found. Because it is most important to identify individuals who will fail an on-road driving evaluation to prevent needless on-road testing, a high positive predictive value is desirable. Positive and negative predictive values were calculated for each perceptual test. Specifically, the positive predictive value (a/a+b) was the proportion of individuals with a poor perceptual score (a+b), who failed the on-road driving evaluation. Negative predictive value (d/c+d) was the proportion with a good perceptual score (c+d) who passed the driving test.

Logistic regression analysis was performed to determine the combination of perceptual tests and client characteristics that best predicted the dichotomous outcome (pass or fail) on the driving evaluation. The logistic model is in the form of:

$$\log (p/1\text{-}p) = (\beta_o + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_i x_i)$$

where p was identified as the probability of failure. For the analysis, age was categorized as <50, 51 to 70 and >70 years. For each perceptual test, a dichotomous variable was created using the cutoff value that had been found to result in the highest positive predictive value. First, univariate models were generated. Combinations of perceptual tests were then included in the model according to the univariate results, and those that significantly improved the model were retained. In addition, because individuals with stroke are known to experience very different sequelae according to side of lesion, logistic regression models were created separately for those with right and left-sided lesions.

3.1.4 RESULTS

Ninety-two individuals with stroke were referred to the driving service during the study period. Of these, 84 were tested on both the perceptual battery and the on-road driving evaluation. The eight subjects who were not tested on the road all had perceptual test scores that indicated severe perceptual impairment, which the therapist deemed to be incompatible with on-road driving. These individuals were encouraged not to take the on-road evaluation.

Subject characteristics for the entire group and according to pass (n = 33) and fail (n = 51) on the on-road evaluation are presented in table 1. The average age was 61 years. Individuals were tested approximately 4.5 months after the onset of stroke: in Montreal at the time of study, the average length of stay in the acute care setting for individuals discharged to rehabilitation was 44 days, and the average length of stay in the rehabilitation setting was approximately 75 days. Thus, most individuals were tested around the time of discharge from inpatient treatment. When those who passed were compared to those who failed on age, time since stroke, side of lesion, and gender, only age was significantly different, with those who passed being, on average, younger than those who failed.

Average scores on perceptual testing for those who passed and failed the on-road evaluation are presented in table 2. On most of the tests, there were significant differences in perceptual test scores and time to complete the tests between groups, with better perceptual functioning and quicker test completion for those who passed. Removal of outliers did not affect these findings.

The results of analyses conducted to determine how the individual test scores predicted pass or fail on the on-road driving evaluation are presented in table 3. Missing data occurred since not all subjects were capable of completing all the tests. The positive predictive values ranged from 65% to 86%. The negative predictive values were considerably lower, ranging from 43% to 58%. These results indicate that, overall, the perceptual tests performed better as predictors of those who failed than of those who passed.

For the group as a whole, the MVPT was the test with both the highest positive and negative predictive values. The positive predictive value of the MVPT indicated that of the 36 subjects who received a poor score (<30), 31 (86.1%) failed the driving evaluation. Of the 48 subjects who received a score >30, only 28 passed the driving test, resulting in a negative predictive value of 58%. Figure 2 further illustrates the relation between pass/fail and the individual MVPT scores. As the raw data revealed some interesting differences in perceptual test performance according to side of lesion, further analyses were performed investigating the predictive value of the MVPT scores according to left and right hemisphere lesions in those with unilateral lesions (n=83). The positive predictive value of the MVPT for the group with right hemisphere lesions was 94% and for the group with left hemisphere lesions, 80%. The positive predictive values of the Trail Making B test for the group with right and left hemisphere lesions was 82% and 88%, respectively.

The univariate logistic models generated for each perceptual test and subject characteristic indicated that age, Reaction Time 1, MVPT score, Money Road Map, and Trail Making B were significantly associated with outcome on the on-road test (table 4). The greatest odds of failing was predicted by the MVPT, such that those who scored <30 were 8.7 times more likely to fail the on-road evaluation than those who scored >30.

To assess the additional contribution of the time taken to complete each test, both the time and score were entered into the logistic model. In addition, the interaction between score and time was examined. In none of the models did the time variable contribute over and above the model including only the score.

When logistic regression models were created using the variables identified as important from the univariate procedure, the combination of tests that led to the most predictive and parsimonious model included the MVPT and the Trail Making B test (table 5). While the p value for the variable Trail Making B was 0.053, resulting in a confidence interval for the odds ratio that includes one, this test was retained in the model because it was deemed to have clinical importance in the driving assessment of individuals with stroke. The data lend support for this judgement in that subjects who performed poorly on both the MVPT and Trail Making B tests were 22 times more likely to fail the on-road evaluation as compared with those who performed well on both tests.

Further regression analysis explored pass or fail outcome according to side of lesion (table 6). For the 45 subjects with left hemisphere lesions, the model that best predicted driving outcome included the Trail Making B test, such that those who performed poorly (3 or more errors) on this test were 11 times more likely to fail the driving test, compared with those who performed well (fewer than 3 errors). For the 38 individuals with right hemisphere lesions, the model that best predicted outcome included only the MVPT. Of these subjects, there was a 15 times greater risk of failure for those who scored poorly (<30) on the MVPT as compared with those who scored high (>30).

3.1.5 DISCUSSION

The findings of this study suggest that there are clients with stroke who are clearly not capable of successfully completing an on-road evaluation when tested at one point in time during their recovery. As a group, those who failed the on-road driving evaluation performed more poorly on most perceptual tests as compared with those who passed the on-road evaluation. When each variable was examined separately, several were predictive of on-road driving performance, including age, Reaction Time 1, MVPT, Money Road Map, and Trail Making B, with the MVPT showing the highest predictive ability. The strong contribution of the MVPT is understandable considering that it taps a number of perceptual skills, including visual discrimination, spatial relations, and figure-ground discrimination, thus combining skills that are assessed on some of the other tests individually.

For the group as a whole, the logistic model that best explained on-road driving outcome while being the most parsimonious included the MVPT and Trail Making B tests. Trail Making B is a difficult task that assesses multiple conceptual tracking, sequencing and alternating divided attention. Reaction time was also an important variable that approached but did not reach significance. While reaction time was assessed three times, Reaction Time 1 scores were the most predictive, probably because this test best reflects how a client reacts to a new situation, and thus it taxes skills that are similar to those required during driving.

Some tests did not differentiate between those who passed and those who failed the driving evaluation and for the most part these were tests on which the vast majority of subjects performed well. Both the double letter cancellation and Trail Making A tests were too easy for this clientele, resulting in a ceiling effect.

3.1.5.1 THE MVPT

Poor performance on the MVPT was found to be highly predictive of failure on the driving evaluation. The clinical implications of this finding are that a cutoff of <30 on the MVPT can indicate, with a fair degree of certainty, failure on the on-road evaluation. The MVPT is a standardized test widely used by clinicians in the assessment of individuals with stroke. Two important points must be made regarding how the MVPT is administered when used to screen individuals for on-road testing readiness. Since the time of this study, a new version of the MVPT has been developed.[22] This version does not require the client to work in the horizontal field. Rather, the response options are presented vertically on the page. This is an important difference in that it eliminates the ability to assess unilateral visual neglect, a deficit that is known to seriously affect driving performance. Thus, it is important that clinicians involved in driving evaluation use the 1982 version of the MVPT. The second point is that MVPT age-specific norms are available, making it possible to adjust an individual's score according to his or her age. In this study, it was decided to use the total unadjusted score, because driving requires a certain level of function, regardless of age.

The MVPT score was not highly predictive of a pass, such that even at the highest possible MVPT scores, half of the subjects passed and half failed the on-road evaluation. Driving, while depending heavily on perceptual skills, also requires judgement, and behavioural and cognitive skills that are not assessed by the perceptual tests used in this study.

3.1.5.2 SIDE OF LESION

Although the side of lesion did not significantly predict driving outcome, the study results indicate that the ability of certain perceptual tests to predict pass or fail on the driving test may differ according to side of lesion. For subjects with right hemisphere lesions, the MVPT, which tests five areas of visual-perception, was the best predictor of driving outcome. This finding is consistent with the expectation that serious perceptual impairments commonly found with right-sided lesions would be associated with on-road failure. The most predictive and parsimonious model for subjects with left hemisphere lesions included only the

Trail Making B test. This test evaluates cognitive abilities, including alternating attention and sequencing. Because perceptual deficits are not generally the predominant impairment associated with left hemisphere lesions, it is possible that in the absence of perceptual deficits, cognitive processes are important indicators of driving ability. However, the logistic models for those with left and right hemisphere lesions separately were calculated on small sample sizes. Other tests that were not statistically significant may have important clinical significance in the evaluation of driving performance for those with left and right hemisphere lesions.

3.1.5.3 TIME SINCE STROKE

In this study, individuals underwent assessment at various times after stroke. Some of the variability in time was attributable to the severity of the stroke and its sequelae, which, when severe, required a sufficient degree of resolution before the driving evaluation. Most often, clients were anxious to resume driving, and the assessment was planned to coincide with their discharge home from rehabilitation. This study suggests that the severity of the stroke and the timing of the driving evaluation are potentially associated with driving performance. It will be important to identify indicators of readiness so that clients are tested only when they have recovered to a level that provides them a realistic opportunity of passing the driving assessment.

3.1.5.4 LIMITATIONS OF THE STUDY

The therapist who conducted the on-road driving evaluations had performed the perceptual tests and was therefore not blind to the perceptual status of the client. It was thought unreasonable for a therapist to conduct the on-road evaluation without knowledge of the subject's perceptual deficits. Thus, the therapist could seek circumstances that taxed an individual's potentially weak driving behaviours and observe how he or she adapted to them. However, determination of the pass/fail status of the client was made jointly by the therapist and professional driving school instructor, the latter being blind to the perceptual status of the client. In addition, the idea for the study occurred after all of the data had been collected, potentially reducing the likelihood of misclassification bias.

The passing of an on-road driving evaluation, although a reasonable criterion, is problematic in that there are no known standardized methods of administration and scoring. When such a dilemma arises, the best one can do is look at the reliability of the measure. The inter-rater reliability of the on-road driving evaluation has recently been examined as a forerunner to a randomized clinical trial on driving and stroke. Five clients with varying degrees of perceptual impairment completed the one-hour on-road driving evaluation while being observed by two experienced occupational therapists who independently rated driving performance. For all five individuals the determination of pass or fail by the two independent raters was identical.

Another concern regarding the on-road test is its correlation with driving safety. We are currently addressing this issue by asking all clients who are tested in our service to provide written consent, enabling us to gain access to their driving record through the licensing bureau. In future studies it will be possible to examine the driving safety of individuals with stroke who do resume driving.

3.1.6 CONCLUSION

Driving is an important part of every day life. When a driver's license is revoked, the impact on the individual's life is often dramatic. Work, social activities and daily movement in the community may all be affected. Considering the seriousness of the decision, it is astonishing that health professionals have little training in driving assessment and have no standard rules for what domains must be assessed, either as prerequisites for on-road testing, or during the on-road evaluation itself. Most clinicians depend on their clinical judgement in making decisions regarding a client's fitness to drive. However, clinical judgement alone is not sufficient. The use of standardized perceptual-cognitive tools provides important information indicating whether a client has recovered sufficiently to be tested on the road or whether the test should be delayed. Furthermore, perceptual-cognitive test results help guide the therapist as to which skills require specific examination during an on-road driving evaluation.

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Figure 1. The 2 X 2 table for evaluating the predictive value of the perceptual tests.

		Driving Outcome	
		Fail	Pass
Perceptual Score	Bad	a	b
	Good	c	d

Figure 2. Number of subjects who passed and failed the on-road driving test according to their MVPT score.

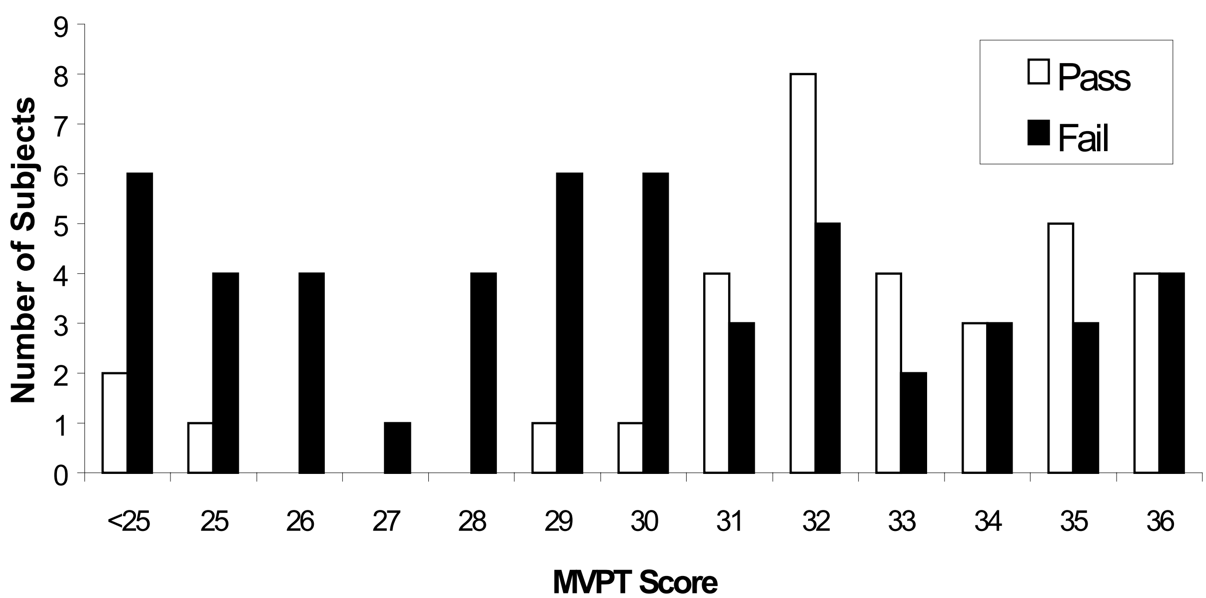

Table 1. Subject characteristics according to pass and fail on the on-road driving evaluation

	All subjects (n=84)	Pass (n=33)	Fail (n=51)
Age (years)			
Mean (SD)	60.8 (11.9)	56.8 (12.1)	63.4 (11.2)
Range	27 - 84	27 - 73	29 - 84
Time since stroke (months)			
Mean (SD)	10.4 (15.8)	9.1 (17.3)	11.3 (14.8)
Median	4.8	4.1	7.0
Range	1.0 - 96.0	1.4 - 96.0	1.0 - 84.0
Side of lesion (n (%))			
Left	45 (53.6%)	20 (60.6%)	25 (49.0%)
Right	38 (45.2%)	12 (36.4%)	26 (51.0%)
Bilateral	1 (1.2%)	1 (3.0%)	0 (0.0%)
Gender (n (%))			
Male	63 (75%)	27 (81.8%)	36 (70.6%)
Female	21 (25%)	6 (18.2%)	15 (29.4%)

Table 2. Results of *t*-tests comparing mean perceptual test scores and times of completion according to pass and fail on the on-road driving evaluation

	Pass (n=33)	**Fail** (n=51)	***p* value**
Reeaction Time 1	121.1 (55.2)	169.6 (107.7)	.01
Reaction Time 2	94.2 (46.3)	120.0 (85.7)	.09
Reaction Time 3	81.3 (26.9)	93.3 (41.8)	.13
Reaction Time average	99.1 (35.5)	130.6 (76.5)	.02
MVPT score	32.0 (4.1)	29.2 (4.7)	.005
MVPT time (sec)	4.6 (2.0)	5.8 (2.4)	.01
Single Cancellation (no. errors)	2.5 (5.1)	6.6 (13.0)	.05
Single Cancellation time (sec)	113.0 (31.0)	131.6 (46.6)	.03
Double Cancellation (no. errors)	5.1 (5.5)	6.2 (7.9)	.44
Double Cancellation time (sec)	170.9 (64.1)	197.3 (73.8)	.09
Road Map (no. errors)	4.5 (4.9)	6.7 (5.6)	.06
Road Map time (sec)	97.5 (27.2)	119.8 (45.4)	.007
Trail Making A (no. errors)	0.1 (0.4)	0.3 (0.8)	.15
Trail Making A time (sec)	53.0 (29.9)	68.2 (38.9)	.05
Trail Making B (no. errors)	1.2 (1.9)	5.3 (7.0)	.0002
Trail Making B time (sec)	137.0 (64.4)	187.4 (77.3)	.003
Bells (no. errors)	1.7 (1.9)	3.4 (7.7)	.14
Bells time (sec)	188.7 (54.5)	213.4 (73.7)	.08
Charron (no. errors)	3.9 (4.3)	5.4 (5.9)	.19
Charron time (sec)	288.1 (93.0)	361.3 (120.8)	.003

Table 3. Positive and negative predictive values for the perceptual tests

Test (Cutoff Value)	Positive Predictive Value	Negative Predictive Value
MVPT (>30 points)	86.1% (31/36)	58.3% (28/48)
Trail Making B (<3 errors)	85.2% (23/27)	48.1% (25/52)
Trail Making A (<1 errors)	80.0% (8/10)	41.9% (31/74)
Single Cancellation (<5 errors)	78.9% (15/19)	44.6% (29/65)
Bells (<4 errors)	77.8% (14/18)	43.9% (29/66)
Reaction Time 1 (<118 points)	74.4% (29/39)	56.1% (23/41)
Charron (<5 errors)	72.4% (21/29)	45.5% (25/55)
Road Map (<4 errors)	72.1% (31/43)	52.6% (20/38)
Double Cancellation (<5 errors)	64.9% (24/37)	42.6% (20/47)

Numbers in parentheses in positive predictive value column show the number of true positives per number of subjects who failed perceptual test; in negative predictive value column, number of true negatives per number of subjects who passed perceptual test.

Table 4. Univariate logistic regression models for pass/fail on the on-road driving evaluation

Variable (Cutoff Value)	Driving Outcome			
	Estimated Coefficient	Standard Error	Odds Ratio	95% Confidence Interval
Age (years)				
≤ 50		Reference	category	
51 – 70	1.20	0.62	3.33	0.98 - 11.32
> 70	1.86	0.75	6.40	1.47 - 27.84
Side of lesion	0.55	0.46	1.73	0.70 - 4.27
Gender	0.63	0.55	1.87	0.64 - 5.47
Reaction Time 1 (score) (< 118, ≥ 118)	1.11	0.47	3.03	1.20 - 7.66
MVPT (score) (≤ 30, > 30)	2.16	0.56	8.68	2.87 - 26.21
Single Cancellation (errors) (< 5, ≥ 5)	1.11	0.62	3.02	0.90 - 10.10
Double Cancellation (errors) (< 5, ≥ 5)	0.31	0.45	1.37	0.56 - 3.33
Road Map (errors) (< 4, ≥ 4)	1.00	0.46	2.71	1.10 - 6.70
Trail Making A (errors) (< 1, ≥ 1)	1.06	0.82	2.88	0.57 - 2.68
Trail Making B (errors) (< 3, ≥ 3)	1.78	0.60	5.96	1.83 - 19.42
Bells (errors) (< 4, ≥ 4)	1.01	0.62	2.74	0.82 - 9.23
Charron (errors) (< 5, ≥ 5)	0.78	0.50	2.19	0.83 - 5.78

Table 5. Logistic regression model for pass/fail on the on-road driving evaluation

Variable	Driving Outcome			
	Estimated Coefficient	Standard Error	Odds Ratio	Confidence Interval
MVPT ($\leq$ 30, > 30)	1.85	0.58	6.36	2.04 - 19.82
Trail Making B (< 3, $\geq$ 3)	1.26	0.65	3.53	0.99 - 12.60
Constant	-0.55	0.32		

n = 84; X^2 = 22.42; p = 0.0001

Table 6. Logistic Regression Models for Pass/Fail on the On-Road Driving Evaluation According to Side of Lesion

Variable	Driving Outcome			
	Estimated Coefficient	Standard Error	Odds Ratio	Confidence Interval
LEFT STROKE				
Trail Making B (< 3, $\geq$ 3)	2.44	0.85	11.47	2.17 - 60.70
Constant	-0.49	0.38		
RIGHT STROKE				
MVPT ($\leq$ 30, > 30)	2.71	1.12	15.03	1.67 - 134.99
Constant	-6.83×10^{-17}	0.43		

Left Stroke: n = 45; X^2 = 14.73; p = 0.0006

Right Stroke: n = 36; X^2 = 9.42; p = 0.0021

APPENDIX

JEWISH REHABILITATION HOSPITAL ROAD EVALUATION FORM

Date:________________________File:__________________________
Name:_______________________Permit No.:____________________
Class:_______ Conditions:_____________________________________
( ) automatic ( ) standard

5-Adequate and secure
4-Adequate after correction
3-Acceptable but still makes errors
2-Requires training / re-evaluation
1-Unable

DESCRIPTION	SCORE	COMMENTS
Use of controls:		
Start the motor		
Use: signal indicators hazard indicator windshield wipers		
Control the steering wheel: without adaptation with adaptation		
Use: gear shift brake pedal gas pedal hand control left accelerator		
Manoeuvres:		
Go in reverse		
Parallel parking		
Drive straight		
Turn right		
Turn left		
Signal your intentions		
Follow the road		
Lane changes and passing		
Positioning car in the lane		
Leave adequate space between cars		
Stops at intersections		
Enter/exit traffic		
Highway driving: enter/pass/exit		
Adjust speed as needed		
General performance		
Specific Skills:		
Visual exploration		
Blind spots		
Interpreting road signs		
Observe law and regulations		
Adjust to adverse conditions		
Ability to anticipate		
Reaction time		
General Skills:		
Decision making: vision/analysis/decision		
Ability to learn		
Visual-perception		
Planning ability		
Attention/concentration		
Tolerance to effort (mental/physical)		
Behaviour		
Self correction		

Comment(s): ____
Adaptations: ____
Translated 12/97 Signature:_____________________________________

3.2 Use of the UFOV to Evaluate and Retrain Visual Attention Skills in Clients with Stroke: A Pilot Study

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The previous study examined the ability of commonly used perceptual-cognitive measures to predict on-road driving outcome. Findings from this study contribute important information for improving the accuracy of the driving evaluation procedure for clients with stroke. The measurement tools used in this area of rehabilitation are often not standardized and frequently their psychometric properties are unknown. This study determined that overall, the measures used in our rehabilitation centre and in many centres across Canada, are predictive of driving performance. Specifically, the combination of two measures, the ones with the best known reliability and validity, have been found to together accurately predict failure on a driving evaluation. The conduct and validity of the results of a study of treatment effectiveness is dependent upon the selected measurement tools. The results of this first study enhance our understanding of the psychometric quality of the measures used in the typical driving evaluation procedure.

In addition, the study findings provide additional theoretical information, improving our comprehension of the association between specific visual processing impairments following stroke and driving ability. The study analyses and results indicate that visual-perceptual processing, specifically complex or higher level visual-perceptual tasks, are highly associated with on-road driving. These findings assist in the selection and development of a treatment program to target related impairments. The treatment under investigation in the following two studies uses a newly designed computer software to train specific visual attention processing skills.

3.2.1 ABSTRACT

Objective: The objective of this pilot study was to examine the use of a visual attention analyzer in the evaluation and retraining of useful field of view (UFOV) in clients with stroke.

Study Design: Fifty-two clients with stroke, referred to a Driving Evaluation Service, were evaluated using the UFOV. The UFOV assesses three aspects of visual attention: processing speed, divided attention and selective attention. Seven subjects were retested to determine the test-retest reliability of the UFOV. Six subjects participated in the development of a training protocol and participated in a 20-session visual attention retraining program.

Results: UFOV scores indicate substantial reduction in visual attention in clients after stroke, with older subjects performing the most poorly. Test-retest reliability was moderate (ICC=0.70). Mean UFOV scores significantly improved following retraining.

Conclusion: Although UFOV scores indicate poor visual attention skills in individuals with stroke, preliminary information suggests that UFOV scores significantly improve with training.

3.2.2 INTRODUCTION

Driving a motor vehicle, although frequently an integral component of a person's reintegration into the community, is a highly complex functional skill that is often affected by the wide range of sequelae following a cerebral vascular accident (stroke). Occupational therapists are often involved in evaluating clients' abilities to drive following a stroke. Accuracy in the measurement of driving safety is critical to ensure that clients who are safe are not prevented from maintaining their independent mode of transportation, as well as to prevent those who are unsafe drivers from posing a danger to themselves and others. However, there is no known measure available to occupational therapists, which enables them to accurately assess the skills required for safe driving.

Although occupational therapists focus on improving the skills that their clients require to engage in the highest possible level of occupational performance, few driving evaluation programs for people with disabilities include any retraining of driving skills. Given the importance placed on returning to driving, and our focus on training functional activities, it is important and appropriate that we develop effective driving retraining programs to assist our clients achieve a higher level of independence and improved quality of life.

Automobile driving is a routinely performed complex activity, with an estimated 90% of the informational input to the driver being visual (Simms, 1985). Licensing board evaluations typically include the sensory testing of vision. However, the association between scores on tests of primary visual functions and driving accidents appears to be weak (Gresset & Meyer, 1994; Hills, 1980). Evidence suggests that visual acuity and peripheral field sensitivity do not adequately reflect the complexity of the driving task (Ball & Owsley, 1992; Ball et al., 1990). The demands of driving include navigating a vehicle within a visual environment cluttered with distracters and involve the simultaneous use of central and peripheral vision (Ball & Owsley, 1992). These visual processing skills are among those necessary for safe driving, as visual-perceptual errors are known to be a major contributory factor to automobile accidents (Hills, 1980). These complex visual processing skills, however, are rarely formally tested by licensing agencies during routine driving evaluation.

As a complement to the measurement of primary visual functions, there are now efforts to examine the importance of higher order visual attention skills on driving performance (Ball et al., 1993). A visual attention analyzer has been developed to map an individual's functional visual field, or useful field of view. Useful field of view is the area of the visual field in which visual information can be acquired and processed without eye and head movement (Ball et al., 1988). The visual attention analyzer developed by Ball and associates is referred to as the UFOV. The UFOV is a large screened computer that uses specialized software to evaluate three aspects of visual attention- visual processing speed, divided attention and selective attention.

A study examining performance on the UFOV in a group of healthy elderly people indicated a decline in processing speed and in divided and selective attention with increasing age (Ball et al., 1988; Goode et al., 1998; Owsley & Ball, 1993). In addition, poor performance on the UFOV, as indicated by a large percent reduction in the useful field of view area, was associated with a high rate of traffic accidents. In a retrospective study examining the driving records of 53 elderly subjects, those with reduction in the area of useful field of view of 40% or more had a rate of prior accidents four times greater than those who performed well on the UFOV (Owsley et al., 1991). In addition, they experienced a 15 times greater number of accidents at roadway intersections (Owsley et al., 1991).

Scores on the UFOV, measured as the percentage reduction in visual attention skills as compared to a healthy young population, have been shown to differentiate between drivers with and without a previous injurious crash (Owsley et al., 1998b). Smaller percent reduction scores indicate better performance. Those with UFOV scores indicating 23-40% reduction were 4.2 times more likely to have been involved in an injurious crash as compared to those with better scores. The odds ratios (OR) for traffic accidents were higher for those with greater impairments of 41-60% (OR=13.6) and >60% (OR=17.2) reduction (Owsley et al., 1998b). This same team of researchers conducted a prospective study to examine the association between UFOV scores and subsequent driving performance. Those with poor UFOV scores ($\geq$40% reduction) were 2.2 times more likely to be involved in a crash over the subsequent three years as compared to those with UFOV scores of <40% reduction (Owsley et al., 1998a). Although the results clearly suggest an association between performance on the UFOV and driving ability, the researchers measured visual attention only once, and did not consider that changes in visual attention in this population may have occurred over the three-year follow-up.

The use of the UFOV in the retraining of visual attention skills in elderly subjects has shown encouraging results. A study examining the effectiveness of training 24 elderly subjects on the UFOV indicated a marked improvement in useful field of view following retraining; the improvement was retained over a six-month period. These highly significant gains occurred in all age subgroups (Ball et al., 1988). Additionally, in a study using a randomized controlled trial, the effectiveness of training on the UFOV was compared to simulator training in 77 high-risk elderly subjects. In addition, all subjects were compared to a low-risk untreated control group. Those in the UFOV group exhibited significantly fewer risky driving behaviours than subjects in the other groups during an on-road driving test and improved reaction time during complex visual tasks. A limitation was that the group treated on the simulator received only two hours of training as compared to an average of 4.5 hours received by the UFOV group. This discrepancy may have contributed to the improved outcome for the UFOV group (Roenker et al., personal communication 2000).

The results of these studies with elderly subjects indicate a positive association between driving performance and test scores on the UFOV. In addition, there is evidence that retraining using the UFOV is effective in improving visual attention skills in an elderly population. These findings may have important implications for clients with stroke who have serious impairments in visual processing speed and ability and who wish to resume driving. Thus, the global objective of this pilot study was to examine the use of the UFOV visual attention analyzer in the evaluation and retraining of visual attention skills in clients with stroke. The specific objectives were to: (1) determine the distribution of scores on the UFOV in a sample of clients with stroke, (2) determine the test-retest reliability of scores on the UFOV, and (3) identify change in performance on the UFOV following a 20 session training program. The information resulting from this study assisted in developing the methodology for a randomized clinical trial being conducted to evaluate the effectiveness of a UFOV training program for clients with stroke.

3.2.3 MATERIALS AND METHODS

3.2.3.1 SUBJECTS

All clients referred to the Driving Evaluation Service at the Jewish Rehabilitation Hospital (JRH), Quebec, Canada for driving evaluations following a stroke were eligible for inclusion in the study. Individuals with medical conditions that precluded them from driving, including homonymous hemianopsia, primary visual impairment that does not meet the licensing bureau's criteria, class IV cardiac status, and seizures were not eligible. Other exclusion criteria included a Functional Independence Measure (FIM) (Hamilton et al., 1987) comprehension score of less than five indicating an inability to comprehend simple verbal instructions, impaired cognition as determined by a score of less than six on the Pfeiffer cognitive test (Pfeiffer, 1975), and severe perceptual or motor impairments deemed incompatible with driving by the inter-disciplinary stroke team. All eligible subjects who were referred to the service over an 18-month period and who agreed to participate were included in the study. One hundred and forty four potential subjects who were admitted to the JRH and who were driving prior to their stroke were examined for eligibility. Eighty-seven of those were deemed ineligible to participate. Five eligible subjects refused to participate. Fifty-two subjects were eligible and consented to participate. Subject ranged in age from 36 - 82 years (mean = 65.2 years; SD = 11.3). Seventy five percent of the subjects were male. Subjects were evenly divided according to side of lesion. The average time since stroke at the time of evaluation was approximately 2 months (69 days), ranging from 35 to 194 days. Forty-eight (92%) of the subjects were inpatients at the Jewish Rehabilitation Hospital and four were recruited as outpatients. Mean score on the FIM was 115.8 (SD = 9.9).

3.2.3.2 TESTING PROCEDURE

Assessment of useful field of view was performed on all subjects using the UFOV visual attention analyzer (Model 3000, Visual Resources Inc., 1733 Campus Plaza, suite 15, Bowling Green, KY 42101). The UFOV is a specially designed software program that presents visual stimuli onto a large computer monitor. As stated previously, this tool tests three components of visual attention- processing speed, divided attention and selective attention. The evaluations were conducted by an occupational therapist in a darkened room free of distraction. While not formally validated in a French Canadian sample, a scripted set of instructions was presented to each participant in either English or French. The therapist first described and then demonstrated each task using two examples presented on the screen. The subject was then presented with four practice trials, which were similar to the actual test items but were presented on the screen for a longer duration. The demonstration and/or practice trials were repeated until the therapist was certain that the subject understood the procedures.

The first task, processing speed, requires the identification of a centrally located object, either a car or a truck, presented in a white box on the computer monitor. The subject must indicate what he or she saw, either a car or truck, by touching the appropriate image on the screen after each trial. The duration of presentation of the object is gradually decreased until the subject can no longer identify which of the two objects was presented. The duration of presentation decreases from 250 to 12.5 msec.

The divided attention task requires subjects to identify the centrally presented target and to locate a simultaneously presented peripheral target. Subjects perform the central and peripheral tasks concurrently. The peripheral target appears unpredictably at one of 24 locations representing all combinations of eccentricity (10°, 20°, 30° visual angle) and direction (4 cardinal and 4 oblique). Divided attention is tested at exposure durations ranging from 240 to 40 msec.

The final and most complex task is the evaluation of selective attention. This subtest provides a measure of distractibility by having subjects perform the same task as in the divided attention task, with the addition of distracters in the field.

White triangles are presented throughout the screen to evaluate the subject's ability to differentiate the peripheral target from the distracters.

The score for each of the three subtests is automatically calculated by the computer as the percentage reduction from the maximum area of useful field of view. Each subtest score ranges from 0-30% reduction. The total percentage loss of UFOV is a composite of the 3 subtests and can range from 0-90% reduction. The time taken to complete the test is also recorded.

3.2.3.3 STUDY PROCEDURE

Distribution of UFOV Scores- This was a descriptive study examining the performance of visual attention tasks in 52 clients following stroke. The charts of all clients with stroke who were referred to the Driving Evaluation Service were examined for eligibility. For those eligible to participate, the study occupational therapist approached the client to explain the purpose and procedures of the study. Upon receiving written informed consent, a convenient time for evaluation on the UFOV was arranged. During testing, to ensure that all subjects viewed the stimuli in the same manner, their foreheads and chins were positioned against a metal rest with their eyes positioned at the midlevel of the screen. The evaluation was conducted using a uniform method of administration.

Test-retest Reliability- The first seven subjects who agreed to participate were selected for the test-retest reliability phase of the study. These seven individuals completed the UFOV evaluation twice within a two-day period.

UFOV Training- The first six participants who agreed to participate in the training program, completed 20 training sessions and were then reassessed on the UFOV to identify changes in performance following training. Training on the UFOV consisted of manipulating several parameters that enabled practice sessions to be offered at a level of difficulty appropriate to the individual subjects. For example, the therapist was able to vary the colour of the peripheral target. White is the most difficult target to see, while other more distinct colours such as blue, red, green and yellow were used to reduce the level of difficulty of the task. The distracters were either presented using a dim or normal setting. The dim setting was used to reduce the degree of distraction and thus facilitate the task.

The duration of presentation on the screen ranged from 40 to 400 msec with processing of the shorter durations requiring greater visual attention ability. The eccentricity of presentation of the peripheral target could be set at 10°, 20°, or 30°. Targets presented at greater eccentricities were located more peripherally and required a higher level of ability. In addition, extra training to either the right, left, top or bottom of the screen was provided according to the participants' specific needs.

During the training sessions, these six participants assisted in the development of the training protocol. Criteria for selecting the training parameters were developed based upon the training program described in an earlier study with elderly drivers (Ball et al., 1988). The standard training protocol was developed according to the subjects' performance during the training sessions. Subjects began training on one of the three modules available, either processing speed, divided attention, or selective attention, according to the results of initial testing. For example, the training began with the processing speed task when total test scores indicated UFOV reduction of >80% or when the threshold duration was >20 msec (i.e. subjects achieved 75% accuracy with a duration exposure of >20 msec). When an individual scored between 40-80% reduction, training started with the divided attention task. Those with scores of <40% reduction began training with the most complex task, selective attention. A standardized method of progressing through the training program was devised. All clients began at the slowest speed and at the smallest eccentricity. Eccentricity was increased from 10° to 20° to 30° and duration of presentation was then reduced from 400 to 40 msec as the client correctly identified 75% or more of the presentations. When the client reached a level where he or she was no longer capable of accomplishing the task, the peripheral target was changed to a colour (progressing from little to greater contrast) and training progressed until duration of presentation was decreased two levels (80 mscec). If the client was unable to respond correctly to 75% of the presentations with the colour target at these faster presentations, the distracters were then set to dim to decrease the demands of the task. Once subjects were capable of accomplishing this task with the colour peripheral targets, they then returned to the previous level of training. An experienced occupational therapist manipulated the parameters of presentation and completed detailed reports of each training session. These reports contained information about the specific parameters that were selected during each trial and the subjects' successes and failures.

3.2.3.4 DATA ANALYSIS

Descriptive statistics were used to present the distribution of scores on the UFOV in our sample of subjects with stroke. One way analyses of variance and t-tests were used to examine potential differences according to important subject characteristics, including age, gender, and side of lesion. Pearson's product moment correlations were calculated to examine the association between UFOV scores and the subjects' clinical characteristics. To determine the test-retest reliability of scores on the UFOV, intraclass correlation analysis was performed using the SAS (SAS, 1996) procedure, proc varcomp. This computer program computes the variance components in a general linear model. Paired t-tests were employed to determine any significant differences between pre- and post-training scores. The SAS statistical program was used for all analyses (SAS, 1996).

3.2.4 RESULTS

Distribution of UFOV Scores- Scores obtained on the UFOV for the entire group are presented in Table 1 and Figure 1. The mean percentage reduction in UFOV in this sample of subjects was 39.5%. Twenty-five (48%) subjects obtained total scores over 40% reduction, indicating a clinically significant reduction in visual attention. Examination of the subtest scores demonstrates that visual attention performance diminished as the complexity and demands of the task increased. High scores on the selective attention subtest indicate serious difficulty in the performance of this complex task in our sample. In addition, the wide range of scores (12.5 - 90% reduction) indicates a large variation in visual attention performance within this stroke population.

Table 2 presents the distribution of scores on the UFOV according to age, side of lesion and gender. The results of testing using one way analysis of variance indicated that scores differed according to age ($F_{3.48} = 3.21$, $p = 0.03$). Post-hoc testing using Scheffe's multiple-comparison procedure indicated that individuals aged less than or equal to 54 years performed significantly better than those 65 years and older. No statistically significant differences in scores according to side of lesion ($p = 0.79$) or gender ($p = 0.34$) were seen. Pearson product moment correlation analysis indicated that there was no significant association between percentage reduction in UFOV and FIM scores ($r = -0.16$; $p = 0.26$) or time since stroke ($r = -0.02$; $p = 0.90$).

Test-retest Reliability- The seven subjects in the test-retest reliability component of the study were slightly older than the group as a whole (mean age = 73.3 years), 5 were female and 4 had a left sided-lesion. Of the seven subjects, the scores improved over the two testing sessions for four, declined for two and stayed the same for one. The magnitude of change varied from an improvement of 20% reduction to a decline of 17.5% reduction. The intra-class correlation coefficient (ICC) was 0.70 (lower limit of the confidence interval=0.19).

UFOV Training- The six subjects who participated in the training were slightly younger than the whole group (mean age = 60 years), had equal numbers of males and females, and 5 of the 6 had a left-sided lesion. Their pre- and post-training scores are presented in Figure 2. The mean initial total UFOV score indicated a reduction of 36.3% (range 22.5-45%) as compared to a mean post-training total score of 6.3% reduction (range 0-17.5%). Three of the six subjects achieved a score of 0.0% loss. Paired t-tests indicated a highly significant difference between pre- and post-training scores ($p<0.0001$). Subjects improved on all three subtests, processing speed ($p=0.09$), divided attention ($p=0.009$), and selective attention ($p<0.0001$). All six subjects obtained a post-training score of 0% reduction on both the processing speed and divided attention tasks.

3.2.5 DISCUSSION

The results of this pilot study examining the use of the UFOV in a group of clients with stroke undergoing rehabilitation indicate a wide range of performance.

Overall, a significant decline in the three aspects of visual attention abilities measured by the UFOV was found in this sample. Although norms for a similar aged population without stroke are not available, the distribution of scores found in our sample is similar to that seen in another study of 294 individuals aged 65 to 85 years (Ball et al., 1993). Ball and colleagues determined that 43% of their elderly group obtained scores greater than 40% reduction on the UFOV, while 38% of the subjects with stroke evaluated in this study scored higher than 40% reduction. As the age distribution of their sample (Ball & Rebok, 1994) is much older than for this sample and scores on the UFOV are known to decline with increasing age, it is difficult to speculate on the actual relationship of the scores to the visual attention sequelae of stroke.

It was anticipated that subjects with right-sided lesions would demonstrate poorer performance on the visual attention tasks due to the known visual-perceptual deficits associated with this diagnosis. However, there were no differences in scores on the UFOV according to side of lesion. This finding may be due to the fact that individuals with severe deficits in perception were excluded from the study, potentially increasing the overall level of performance of this study sample. Although some studies (Barer et al., 1990; van Ravensberg et al., 1984) have reported higher proportions of subjects with perceptual impairments following right-sided lesions than left, Marshall and colleagues (Marshall et al., 1997) also found no differences in performance between these two groups on a visual divided attention task. It is possible that completion of the tasks on the UFOV requires a combination of skills, such as attention and concentration, skills affected by both left and right-sided lesions.

An understanding of the test-retest reliability of the UFOV is important for the interpretation of repeated testing results. An intra-class correlation coefficient of 0.70 indicates a moderate level of reliability over repeated testing. However, the small sample size results in an extremely large confidence interval for this value. Several client factors may affect the consistency of performance. The status of clients in the early stages following a stroke may be changing, and their medical status may be unstable. The UFOV evaluation is quite complex and learning of the tasks with repeated measurement may affect subsequent performance. Indeed, of the seven subjects, four performed better during the second test session.

The standardized training program was developed while working with six subjects and appears to be a feasible method of retraining visual attention in the stroke population. Methods of training were attempted and revised according to the subjects' responses. While the systematic training progression was successfully used with these six clients, not all scenarios could be foreseen and there may be future instances where the program cannot be carried out as planned.

The six clients who participated in the training program all showed marked improvement in their performance on the UFOV. In the absence of a control group, it is not known whether this improvement would be similar in an untreated group. Although the results of test-retest reliability did not indicate a strong learning effect over the two evaluation sessions, clearly, the use of the UFOV as a measure of outcome may reflect a training effect rather than a significant change in the level of attention. Whether this improvement is associated with an improved ability to perform functional tasks requiring high levels of attention, such as driving, is still not known.

The results of this study indicate that clients with stroke who were undergoing rehabilitation exhibited substantial loss in visual processing skills as measured using the UFOV. While the association between UFOV scores and functional driving performance in the elderly has been clearly demonstrated, this relationship has not yet been examined in clients with stroke. In addition, highly significant improvement in UFOV scores was demonstrated following training on the UFOV. While these preliminary results suggest that the UFOV may be a useful tool to assist occupational therapists in the treatment of impairments in attention, the impact of this approach to training on the performance of functional tasks is not yet known. Because this study did not include a control group, it is uncertain as to whether this positive change represents improved visual attention or isolated learning of the UFOV tasks. Further study must be conducted to determine whether the improved UFOV scores translate into enhanced functional performance in activities highly dependent on visual attention such as automobile driving. These findings formed the basis for an ongoing randomized clinical trial examining the impact of retraining visual attention skills using the UFOV on on-road driving performance in clients with stroke.

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Table 1. Scores on the Useful Field of View (UFOV) (% reduction)

	n	Maximum Score	Mean (SD)	Median	Range
UFOV total (% reduction)	52	90	39.5 (19.5)	35	12.5 - 90
processing speed	52	30	3.8 (7.3)	0	0 - 30
divided attention	52	30	10.8 (10.2)	7.5	0 - 30
selective attention	52	30	24.9 (6.6)	30	7.5 - 30
Test time (minutes)	50	n/a	22.0 (7.2)	20.5	4.2 - 47.5

Table 2. Useful Field of View scores (% reduction) (mean and standard deviation) according to age, side of lesion, and gender

	n	UFOV Score
Age (years) *		
≤ 54	8	21.9 (9.9)
55-64	12	39.8 (21.0)
65-74	21	42.1 (18.9)
≥75	11	46.8 (18.5)
Gender		
male	39	40.6 (21.4)
female	13	36.0 (12.1)
Side of lesion		
left	26	38.8 (20.3)
right	26	40.2 (19.0)

*$F_{3,48} = 3.21$; $p = 0.03$

(Significant differences: ≤ 54 vs. 65-74 and ≤ 54 vs. ≥75)

Figure 1. Distribution of total scores on the Useful Field of View (UFOV)
Note: Low scores indicate better performance.

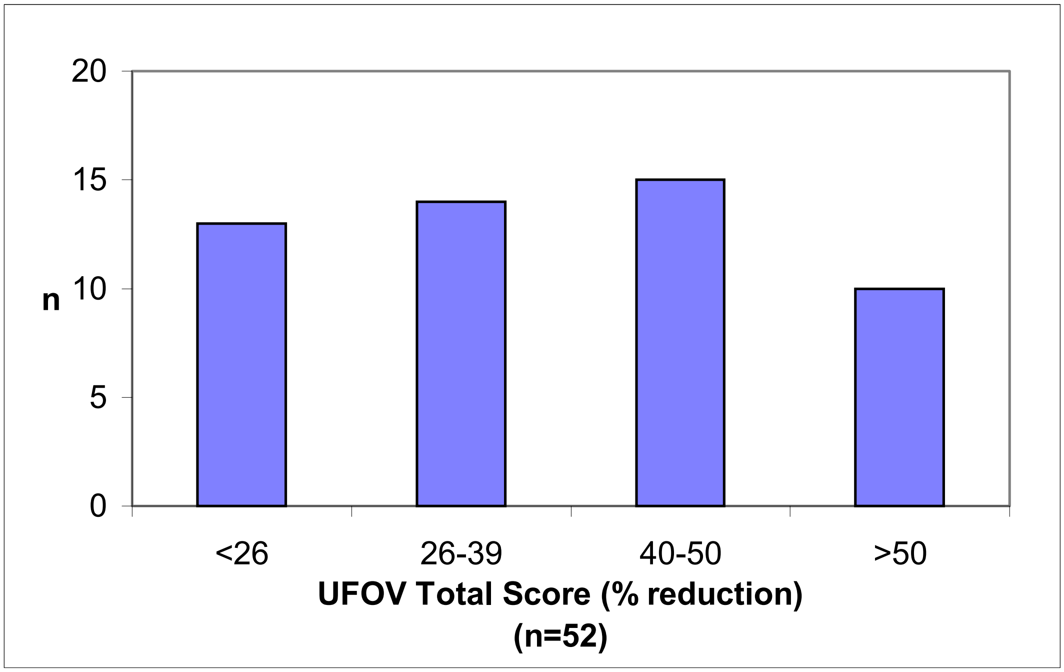
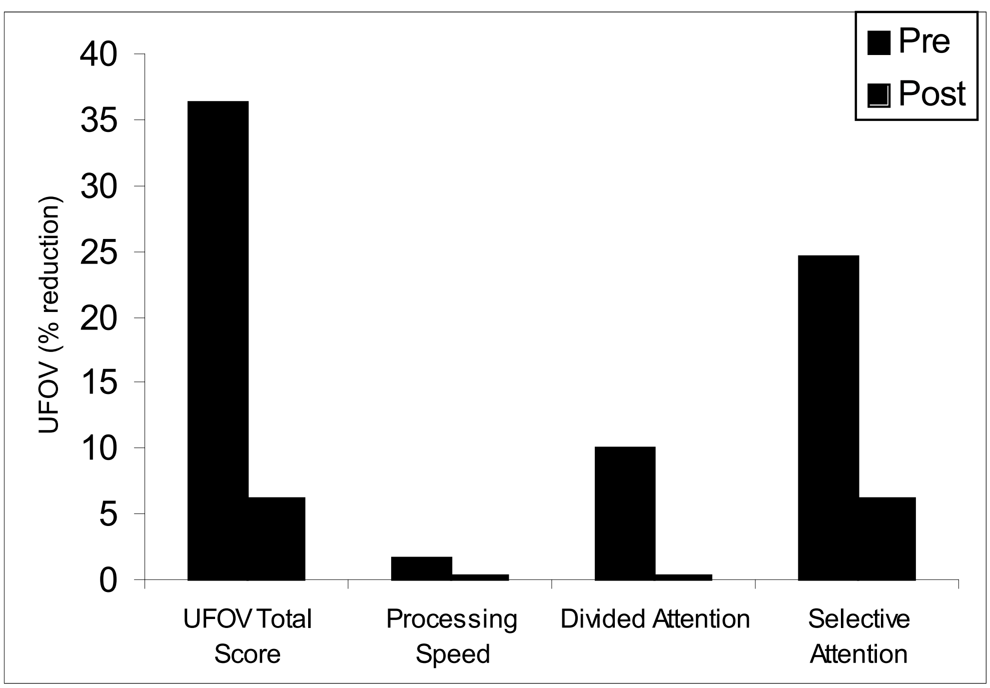


Figure 2. Pre- and post-training Useful Field of View scores (n=6)
Note: Low scores indicate better performance.



3.3 EFFECTIVENESS OF A VISUAL ATTENTION RETRAINING PROGRAM ON THE DRIVING PERFORMANCE OF CLIENTS WITH STROKE

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Submitted to: Stroke

The results of the pilot study indicated that there is a significant reduction in visual attention skills in those with stroke, such that many of these clients score below the level known to be associated with poor driving performance. In addition, an examination of the test-retest reliability of the UFOV suggested that results on this measure are moderately stable over time.

Information from this pilot study was directly used in determining the methodology for the randomized clinical trial reported in the following manuscript. The distribution of scores obtained by the pilot sample assisted in determining the cutoff values for stratification according to severity of visual attention impairment. Piloting of the treatment procedures enabled us to develop the criteria for initiating and carrying out the intervention on the UFOV. While we were unable to determine potential change in on-road performance following training since the pilot study did not include a driving evaluation, we did detect substantial improvements in UFOV scores following training. These findings led us to design a study to determine whether these changes in UFOV scores would generalize to improvements in functional tasks such as driving.

3.3.1 ABSTRACT

Background and Purpose: While driving is important in the reintegration to the community for clients following a stroke, few rehabilitation programs for clients with neurological impairments include driving retraining. This study evaluates the effectiveness of a visual attention retraining program using the UFOV (Useful Field of View) as compared to a traditional visual-perception treatment program on the driving performance of clients with stroke.

Methods: A randomized clinical trial was conducted. Ninety-seven individuals with stroke referred for driving evaluation were randomized to receive 20 sessions of either UFOV training of visual processing speed, divided attention and selective attention, or traditional computerized perceptual training. Stratification was performed according to side of lesion (left or right hemisphere) and percentage reduction in useful field of view (mild, moderate or severe). Following training, subjects were evaluated using visual-perception tests, the Test of Everyday Attention, and the standard on-road driving evaluation. An occupational therapist blind to group assignment conducted all evaluations.

Results: Eighty-four subjects completed the outcome evaluation. There were no significant differences between groups on any of the outcome measures. There was, however, almost a two-fold increase (52% versus 29%) in the rate of success on the on-road driving evaluation following UFOV training for subjects with right-sided lesions.

Conclusions: While rehabilitation targeting visual attention skills was not significantly more beneficial than traditional perceptual training in improving outcome on a driving evaluation, study results suggest a potential improvement for subjects with right-sided lesions.

3.3.2 INTRODUCTION

Stroke is a major disabling condition often associated with long term physical, cognitive and psychological sequelae.[1-3] While rehabilitation specialists provide intervention to enable clients with stroke to regain the necessary skills to return to the community,[4-7] little therapeutic intervention in the area of driving retraining is offered. In Canada, rehabilitation professionals commonly assess driving competence in the final days of treatment and provide a recommendation regarding fitness to drive to the Licensing Board. While driving at one time may have been considered a luxury, it is now an integral component of our lifestyle, necessary for most vocations and highly desirable for maintaining quality of life. Indeed, individuals who stop driving exhibit symptoms of depression,[8] report feelings of loneliness and immobility,[9] and exhibit an increased level of frustration and anger as a result of vocational, leisure and personal role changes.[10]

Automobile driving is a complex activity, with an estimated 90% of the informational input to the driver being visual.[11] While licensing boards typically evaluate visual acuity and peripheral field sensitivity, the association between these primary visual functions and driving accidents is weak.[12-14] These functions do not adequately reflect the complexity of the driving task,[15,16] which requires the integrated processing of higher visual functioning abilities.[15] Deficits in visual processing occur with increasing age,[17,18] and more specifically, in individuals with a stroke.[19-21] Following a stroke, clients exhibit poor visual scanning, visual attention and spatial relations, impairments specifically associated with poor performance on driving evaluations.[22-24] In addition, visual-perceptual errors are known to be a major contributory factor to automobile accidents.[13,25]

As a compliment to the measurement of primary visual functions, researchers have recently developed a measure of visual processing skills, and have examined the impact of deficits in these abilities on driving performance.[26] A visual attention analyzer, referred to as the UFOV, is used to map an individual's functional visual field, or useful field of view (UFOV). UFOV is the area in which visual information can be acquired and processed without eye and head movement.[17] The UFOV is a large screened computer that uses specialized software to evaluate and retrain three aspects of visual attention, visual processing speed, divided attention and selective attention. Poor scores on the UFOV ($\geq$40% reduction in the area in which visual information can be processed), are associated with an increase in the number of roadway accidents,[25,27,28] including a 15 times greater number of accidents at roadway intersections.[27]

While the reduced autonomy associated with cancelling one's driver's license has been established,[29] there have been few studies examining the effectiveness of retraining driving skills in either the elderly or disabled populations. A variety of driving retraining approaches, including the use of visual-perceptual training,[30-32] computerized training,[17,33-35] driving training on a simulator,[36-41] training using small motorized vehicles,[42] as well as full scale on-road training,[43-45] have been investigated. The results of these investigations are difficult to interpret since many were case studies or had extremely small sample sizes, did not include control groups, used outcome measures that were subjective, and failed to conduct evaluations blindly.

The UFOV, used to assess the visual attention skills required for automobile driving, has also been employed to retrain these skills in the elderly. Ball and colleagues[17] evaluated the effectiveness of retraining using the UFOV on twenty-four healthy subjects, aged 22 to 75 years. Subjects were randomly assigned to receive visual attention training on the UFOV with either full or partial distracters. Following the five training sessions, all subjects made significantly fewer errors on the UFOV evaluation and maintained this improvement at a six-month follow-up. A recently completed randomized controlled trial examined the effectiveness of UFOV training on driving performance in the elderly. Results indicated that the 49 subjects with decreased visual attention skills, who received 4.5 hours of UFOV training, exhibited significantly fewer risky driving behaviours during an on-road driving test and demonstrated improved reaction time during complex visual tasks compared to those who received simulator training. However, the simulator trained group received fewer hours of training, and the outcome evaluators were not always blind to the treatment received.(D. Roenker, personal communication, 1999)

The published studies examining the effectiveness of retraining driving skills vary in their approaches and in methodological rigor, making it difficult to conclude that one or another retraining strategy is most beneficial. Of all reported training methods, the UFOV is the only approach that specifically targets the underlying visual attention skills necessary for driving, skills that are commonly impaired in clients with stroke. In addition, preliminary work examining the effectiveness of training elderly individuals with impaired visual processing abilities suggested that training impacts upon driving performance.[17,33] It was the intent of this study to determine whether these benefits would also apply to those with impaired visual attention following a stroke. The objective of this study was to evaluate the effectiveness of a visual attention retraining program using the UFOV compared to traditional visual-perception treatment on the driving performance of clients with stroke as indicated by a pass or fail on the on-road driving evaluation.

3.3.3 MATERIALS AND METHODS

3.3.3.1 STUDY DESIGN AND SETTING

A randomized clinical trial was conducted to examine the effectiveness of UFOV training compared to traditional therapy on the driving success rate of clients with stroke. The study was conducted at the Jewish Rehabilitation Hospital (JRH), a 120 bed McGill University affiliated rehabilitation hospital located in Laval, Quebec. The JRH provides inpatient and outpatient rehabilitation services for adults living on the island of Montreal and surrounding regions. Approximately 250 clients are admitted for rehabilitation each year following a stroke. They are admitted an average of 23.6 days following the onset of stroke and receive inpatient care for a mean of 43 days.

3.3.3.2 SUBJECTS

Study subjects were recruited from all inpatients and outpatients with stroke referred to the Driving Evaluation Service at the JRH, as well as from other acute care and rehabilitation centres in the Montreal area. Individuals were eligible for inclusion if they presented with a hemispheric stroke that occurred within the previous six months, were licensed to drive prior to the referent stroke, drove in the six months prior to the stroke, and wanted to return to driving. Individuals with a repeat stroke were included if they met all other requirements. Exclusion criteria included meeting the medical prerequisites for driving as indicated by the Canadian Medical Association,[46] the absence of visual homonymous hemianopsia, primary visual impairment inadequately improved with corrective lenses, Class IV cardiac status, and seizure activity within the previous year. In addition, clients with a bilateral lesion, cerebellar or brainstem stroke, severe cognitive deficit as indicated by a score of less than 6 on the Pfeiffer Short Portable Mental Status Questionnaire,[47] severe perceptual, comprehension or motor deficit as determined by the treating medical team, or an inability to communicate in English or French, were excluded. Eligible subjects were included in the study if they were willing to participate in the 20-session program, were available during daytime hours, and agreed to sign an informed consent form.

3.3.3.3 STUDY PROCEDURE

The medical charts of all clients admitted to the JRH with a stroke, all outpatients referred to the Driving Evaluation Service, and all referrals to the study by outside referral sources, were evaluated by the research therapist to identify those individuals potentially eligible for the study. Those who met preliminary inclusion and exclusion criteria were approached by the research therapist, either in person or by telephone. Their driving history was elicited using a brief series of questions (appendix 4) and if they were deemed eligible, the details of the study were described to them. Those who agreed to participate were asked to sign an informed consent form. Subjects were informed that the results of their evaluations would be sent to the provincial licensing bureau, the department that would make the final determination of licensure. Prior to commencing recruitment, the study was approved by the Research Ethics Committee at the JRH.

Individuals were randomized to either the experimental or control group using a stratified block design. Subjects were stratified according to side of lesion (left or right hemisphere) and severity of visual processing dysfunction (mild, moderate or severe) as determined by the results of pre- testing on the UFOV. Those who received a score of $\leq$25% reduction in useful field of view were classified as having mild impairment, those with scores between 26 and 50% reduction as moderate impairment, and individuals with >50% reduction as severe impairment. Subjects were randomly assigned to groups using a separate computer-generated table of random numbers for each stratum, with blocks of six used to ensure that a similar number of subjects was allocated to the experimental and control groups.

Two occupational therapists were initially trained by the principal investigators to conduct the pre-test evaluation and all training sessions. An additional four therapists were trained over the course of the study to replace those who left. Throughout the study, the occupational therapist who trained subjects in the experimental group also trained those in the control group.

All subjects completed a pre-test evaluation, consisting of a battery of visual-perceptual evaluations and testing on the UFOV. A questionnaire requesting information about socio-demographic characteristics, medical and functional status, driving history and the importance of driving was also administered. Subjects randomized to the experimental group received a visual information processing training program using the UFOV, while those in the control group received visual-perceptual retraining using commercially available computer software on the same large screen computer. All training sessions were conducted by the therapist in a dark, distraction-free environment. In addition, all subjects, regardless of group allocation, received four sessions of physical retraining on the Baltimore Therapeutic Equipment (BTE) work simulator. The simulation of turning the steering wheel and pressing the gas and break pedals was provided to ensure that clients did not perform poorly on the on-road driving test due to difficulty with the necessary motor skills or unfamiliarity with the adaptive equipment. Both groups of subjects received a total of 20 sessions, at a rate of 2-4 treatment sessions per week. The duration of each session ranged from 30 to 60 minutes, according to each individual's needs and tolerance.

The interventions were conducted in the JRH Research Centre, separate from the common treatment areas of the hospital, to prevent the awareness of treatment assignment by the clinical therapists. Taxi service was provided to those individuals with no other means of transportation. Subjects who did not attend at least 75% of their sessions were consider to have received incomplete therapy and were coded as non-compliant but were retained in the analysis.

As soon as possible following completion of the intervention, each subject returned for two post-test evaluation sessions. During the first session, subjects were reassessed by an independent occupational therapist who was blind to the subjects' treatment group, on the same battery of visual-perceptual evaluations received prior to treatment, as well as on the Test of Everyday Attention (TEA). The on-road driving evaluation and the UFOV test were administered at the second testing session. Both the driving school instructor who directed the evaluation and the occupational therapist who evaluated the on-road driving performance remained blinded to the intervention received by the subjects. Subjects and evaluators were asked to refrain from discussing the treatment received. In addition, the on-road driving evaluation was always performed prior to testing on the UFOV, to prevent the evaluator from observing the subjects' performance on the UFOV, which may have indicated the training the client received. All subjects and the evaluator were asked to document the intervention they believed was received, either traditional or experimental. The co-ordinator of the driving evaluation service at the JRH, an occupational therapist certified by the Association of Driving Educators for the Disabled (ADED) trained the evaluator for the on-road evaluation. The testing procedures and the specific pass/fail criteria were reviewed and demonstrated on the road, and to ensure consistency, the evaluators then independently scored several evaluations and discussed any discrepancies that occurred.

One additional component of the study was to compare the results with those of a historical cohort. Thus, the charts of individuals with a hemispheric stroke assessed for driving at the JRH during the 35-month period prior to initiation of this study were examined. The results of this historical cohort on the on-road driving evaluation were compared to those received for the current study cohort, to determine whether training, regardless of group assignment, resulted in improved driving success in clients with stroke.

3.3.3.4 MEASURES

3.3.3.4.1 Useful Field of View

Testing of visual attention ability, both before and after the administration of the intervention program, was conducted using the UFOV (Visual Resources, Inc., Bowling Green, KY). The UFOV is a software program presented on a large touch-screen computer that measures three aspects of visual attention; speed of visual processing, divided attention and selected attention (figure 1). Standardized instructions are presented in either English or French. For each task, the therapist demonstrates the procedure using the two examples presented on the screen and the subject then completes four practice trials. The demonstration and/or practice trials are repeated until the therapist is certain that the subject understands the task.

Processing speed: This task requires the subject to identify a centrally located object, either a car or a truck, presented in a white box on the computer monitor. The subject must respond by touching the appropriate image on the screen after each trial. The duration of presentation of the object is gradually decreased from 250 to 12.5 msec until the subject can no longer identify with 75% accuracy, which of the two objects was presented.

Divided attention: Subjects must identify the centrally presented object and concurrently locate a simultaneously presented peripheral target which appears unpredictably at any one of 24 locations representing all combinations of eccentricity (10°, 20°, 30° of visual angle) and direction (4 cardinal and 4 oblique axes). Divided attention is tested at decreasing exposure durations, ranging from 240 to 40 msec.

Selective attention: The task is similar to the divided attention task, with the addition of distracters in the peripheral field. White triangles are presented throughout the screen, and subjects must identify the central target and determine the location of the peripheral target embedded within the distracters. Figure 1 illustrates the selective attention task.

The score for each of the three subtests is calculated as a percentage reduction in UFOV, and ranges from 0-30% reduction. The total percentage loss of UFOV is a composite of the 3 subtests and ranges from 0-90% reduction. In the literature, a cutoff of 40% reduction on the composite score has been used to differentiate between good and poor visual attention ability.[27] The time taken to complete the test is also recorded.

Prior to the initiation of this clinical trial, the test-retest reliability of the UFOV was established. Seven subjects were tested twice within two days, and the intraclass correlation coefficient for the total UFOV score was ICC = 0.70.[48]

3.3.3.4.2 <u>Visual Perception</u>

A battery of visual-perceptual tests, known to assess the skills necessary for driving, was administered prior to the initiation of treatment and again following the completion of the intervention program. Collectively, the tests provide information on overall visual-perceptual skills including visual scanning ability, reaction time to visual stimuli, figure ground discrimination, spatial relations, visual memory, visual processing time and direction sense. Both the score and the time taken to complete each test were recorded.

The Complex Reaction Timer[49] consists of a steering wheel, a brake pedal, a gas pedal, and a panel display of lights. Fifteen light stimuli are presented in random order and at random intervals and subjects are required to respond by either braking, or turning the steering wheel to the right or left. The timer begins whenever a light flashes and stops when the appropriate response is performed. The response time to 15 stimuli is recorded, with a maximum value of 500. Each subject completes three trials.

The Motor-Free Visual Perception Test (MVPT)[50] is a standardized measure of five aspects of visual-perception: spatial relations, visual discrimination, figure-ground discrimination, visual closure and visual memory. A maximum score of 36 indicates no errors, and the average time to complete the items is calculated. Normative data are available for adults aged 18-80 years.

The Single Letter Cancellation Test[51] is a test of visual scanning and visual attention ability. It consists of a paper with 6 lines of 52 letters per line, with the stimulus letter H presented 105 times. The client is asked to put a line through each letter H, and the number of omissions and wrong letters cancelled are recorded. Normative data for individuals with right hemisphere lesions have been published. Test-retest reliability calculated on 31 subjects was good (r = 0.63).[52]

The Double Letter Cancellation Test[51] is similar to the single letter task, but requires the subject to cancel both letters C and E. Again, the number of errors is recorded. Normative data are available and the test-retest reliability was r = 0.62.[52]

The Money Road Map Test of Direction Sense[53] is a test of right/left directional orientation. As the examiner traces the path on the test sheet with his pencil, the subject must indicate whether a right or left turn was taken. The score is expressed as the number of incorrect responses.

Trail Making Test A and B[54] are tests of visual-motor tracking and alternating attention. In part A, subjects are required to connect numbers 1 to 25 in consecutive order. In part B, the test sheet contains the numbers 1 to 13 and the letters A to L. Subjects must alternate between the series of letters and numbers by connecting number 1 to letter A to number 2 to letter B and so on. In cases where the client is not comfortable with the alphabet sequence, the alphabet is written on a sheet of paper for them to follow. Contrary to the usual method of administering the test, for the purpose of this study, the therapist did not intervene when the client made an error during the test, rather recorded the total number of errors upon completion. Reliability was found to be high for part A (r=0.78) and good for part B (r= 0.67).[55]

The Bells Test[56] is a complex test for visual neglect, selective attention and visual scanning. The test sheet contains 35 bells embedded within 264 distracters and subjects are asked to circle each of the bells. The score is the total number of bells that are missed.

The Charron Test[57] evaluates visual attention processing. Subjects must discriminate between similar pairs of objects or numbers, by placing a check mark next to each pair that is not identical. The total number of errors is recorded.

3.3.3.4.3 Test of Everyday Attention

The Test of Everyday Attention (TEA)[58] is a norm-referenced test of visual and auditory attention during everyday activities. The tasks were designed to evaluate selective attention, sustained attention, attentional switching, and divided attention. The test is composed of eight subtests: Map Search, Elevator Counting, Elevator Counting with Distraction, Visual Elevator, Elevator Counting with Reversal, Telephone Search, Telephone Search While Counting and Lottery. The final subtest, lottery, was not used since the accompanying audiotape has not been translated into French. There are three comparable versions of the test, so those individuals using version A during their regular therapy were tested using version B for the purposes of this study. The score for each item is converted to a scaled score and a percentile ranking. Norms are available for individuals aged 18-80 years. Test-retest reliability was assessed using versions A and B with healthy individuals and those with stroke, and correlation coefficients varied from 0.59 to 0.86 for the healthy group, and with one exception (0.41), 0.77 to 0.90 for the group with stroke. The validity of the TEA was assessed for clients with stroke[58] and significant correlations between many of the items on the TEA and the Barthel Index,[59] the Extended Activities of Daily Living Scale[60] and the Rating Scale of Attentional Behaviour[61] were found.

3.3.3.4.4 On-Road Driving Evaluation

The on-road driving evaluation, the primary outcome measure for this study, was carried out by occupational therapists experienced in conducting driving evaluations in the province of Quebec. For subjects with physical impairments, the vehicle is equipped with adaptations such as a spinner knob, and a left accelerator. Clients are oriented to the car and to the adaptations. The instructor then provides standard instructions to the clients as he directs them on a standard route. The evaluation route begins on quiet streets and then proceeds to busy boulevards and highways. Right turns, left turns, parallel parking, stop signs, traffic lights, and merging into traffic are among the manoeuvres negotiated. If a client makes repeated critical errors, he/she is asked to park the car on the side of the road and the instructor and therapist provide verbal feedback and recommendations regarding driving performance. The duration of the on-road evaluation is approximately one hour.

A 43-item assessment form is completed during the on-road evaluation, enabling the occupational therapist to document the clients' strengths and weaknesses. The form includes four sections that document use of controls, manoeuvring, specific driving skills, such as visual exploration and response to traffic signals, and general driving skills, including decision making, planning and tolerance. Each item is scored on a 5-point scale; 5 indicating normal performance, 4 normal after correction by instructor, 3 fair performance, 2 poor performance, and 1 unable to perform. Once the evaluation is complete, the therapist and driving school instructor review the clients' driving behaviours, knowledge, application of driving regulations and ability to manoeuvre the vehicle safely, and determine whether the client has *passed*, *failed* or requires driving *lessons*. In addition, the average scores obtained for each of the four subsections are summed to provide a measure of driving performance ranging from 4 to 20 points. Prior to commencing the study, the inter-rater reliability of the on-road driving evaluation was examined. The co-ordinator of the Driving Service and the outcome evaluator independently rated five on-road evaluations, and the inter-rater reliability of the *pass*, *fail* or *lessons* rating was 100%.

3.3.3.4.5 <u>Potential Confounding Variables</u>

Medical information, including side of lesion, type of stroke, medications, presence of comorbid conditions as measured by the Comorbidity Questionnaire[62], visual acuity, and Esterman[63] functional binocular visual field area were collected from the medical charts. A detailed questionnaire was administered to document socio-demographic factors, functional and rehabilitation status and driving history. Socio-demographic information included gender, age, and language used during training. The Functional Independence Measure (FIM) at discharge from hospital was collected from the medical chart as an indicator of level of functional independence. For outpatients, the study therapist administered the FIM during the first week of training. Participation in additional occupational therapy or physical therapy programs was also recorded. Information was collected on the number of years of driving experience, reasons subjects had driven prior to their stroke, frequency of driving per week and the subjects' personal assessment of driving competence and importance.

3.3.3.5 INTERVENTIONS

3.3.3.5.1 Experimental Intervention

Individuals in the experimental group underwent a 20-session training program[48] using the UFOV, a software program designed to train three distinct visual attention skills: speed of processing of visual information, divided attention, and selective attention. The training program closely resembles the tasks used in the UFOV evaluation, with the specific parameters of presentation controlled by the treating therapist. The therapist can select the duration of presentation of the targets on the screen. The target can remain on the screen from 40 to 400 msec, with shorter durations requiring a higher level of visual attention ability. For the divided attention and selective attention tasks, the therapist may select the colour of the peripheral target. White is the most difficult target to see, while more distinct colours such as blue, green, red and yellow may be chosen to enable the client to more easily process the presence of the peripheral target. In addition, the location of presentation is set at 10°, 20°, or 30° eccentricity. Targets presented at greater eccentricities are located further in the periphery and thus, are more difficult to process visually. For the selective attention task, the therapist can select to have either normal or dim distracters.

The standard training protocol was designed according to the subjects' performance during the pre-test evaluation. Subjects began training on one of the three modules available, either processing speed, divided attention, or selective attention. Training began with the processing speed task when test scores indicated UFOV reduction of >80% or when the threshold duration was >20 msec (i.e. subjects achieved 75% accuracy with a duration exposure of >20 msec). When an individual scored between 40-80% reduction, training started with the divided attention task. Those with <40% reduction or better on the UFOV total score began training with the most complex task, selective attention.

A standardized method of progressing through the training program was devised. All clients began at the slowest speed and at the smallest eccentricity. Eccentricity was increased from 10° to 20° to 30° and duration of presentation was then reduced from 400 to 40 msec as the client correctly identified 75% or more of the presentations. When the client reached a level where he or she was no longer capable of accomplishing the task, the peripheral target was changed to a colour (progressing from little to greater contrast) and training progressed until duration of presentation was decreased two levels (80 mscec). If the client was unable to respond correctly to 75% of the presentations with the colour target at these faster presentations, the distracters were then set to dim to decrease the demands of the task. Once subjects were capable of accomplishing this task with the colour peripheral targets, they returned to the previous level of training.

3.3.3.5.2 <u>Control Intervention</u>

The control group also underwent a 20-session training program conducted using the same touch screen computer, so that the screen size and touch screen feature remained constant across the two intervention groups. The training proceeded using commercially available software programs commonly used by occupational therapists to retrain perceptual and cognitive functions in neurologically impaired clients. The four programs, Tetris, Mastermind, Othello, and Jigsaw Puzzle, were selected so that they targeted perceptual and cognitive skills, but did not include the element of speed of visual processing. Performance on these tasks requires perceptual abilities such as spatial relations and orientation, figure ground discrimination, visual search, visual attention, visual processing speed, concentration and problem solving abilities. The therapist initially selected the simplest level of each program, then explained and demonstrated the task. He or she assisted the client to accomplish the task by providing verbal suggestions and teaching appropriate problem-solving strategies. For each task, the therapist increased the level of complexity as performance improved.

3.3.3.6 SAMPLE SIZE

A review of the charts of individuals with stroke assessed at the JRH Driving Evaluation Service during the 35-month period prior to initiation of this study, indicated that 40% successfully completed the on-road driving evaluation. With a sample size of n=94, it would be possible to detect an increase in the proportion of success in the experimental group to 70% with a power of 85% and an alpha of .05 using a two-tailed test. We attempted to recruit as close to 100 subjects as possible, to allow for dropouts and non-compliance. Retention and compliance were expected to be high, as driving is an area of functioning that, in our experience, is highly important to our clients.

3.3.3.7 DATA ANALYSIS

The primary research question was whether individuals with stroke who participated in a visual attention retraining program have improved success in passing an on-road driving evaluation as compared to subjects who received traditional visual-perceptual training. Background information, including medical status, socio-demographic factors, functional status, rehabilitation involvement and driving experience were examined by group to determine the comparability of the experimental and control clients. In addition, the pre-test UFOV and perceptual test scores were examined for potential differences between the groups as well as to determine whether the treatment received by subjects in the two groups differed according to the frequency and duration of sessions.

The visual-perception and TEA post-test results were compared by group using t-tests. To determine whether there was an improvement in the proportion of individuals passing the on-road test following training on the UFOV, the results of the on-road driving evaluation were compared using Chi-square analyses. Subjects were classified as having passed or failed the on-road evaluation, with those recommended for driving lessons grouped with those who failed since they did not meet the standards for a pass at the time of evaluation. In addition, t-tests were used to compare the scores on the on-road driving evaluation to determine whether those who received experimental intervention exhibited better driving performance.

Logistic regression analyses were conducted to analyze the impact of the driving retraining program on the success rate on the on-road evaluation. The primary independent variable was group allocation. Other factors included were side of lesion, type of stroke, time since stroke, gender, age, severity of initial visual attention impairment, pre-test visual-perception scores, previous driving experience, FIM, and frequency of other rehabilitation services received. The variables were examined in a series of univariate models and all those meeting a probability criteria of $p<0.1$ were retained and included in the multi-variate analyses. A correlation matrix was examined to determine the presence of collinearity. In addition, multivariate linear regression analyses were conducted to determine whether the group that received UFOV training received significantly higher scores on their on- road driving evaluation while controlling for the medical, social and driving factors.

The primary statistical analysis was conducted as an intention to treat analysis and included all randomized subjects who completed the on-road driving evaluation. Secondary analyses were done by excluding those who did not comply with the training program.

The rate of pass and fail for the study cohort was compared to that obtained for the historical cohort using Chi-square analyses.

3.3.4 RESULTS

A total of 707 clients were reviewed for eligibility. They include all clients admitted to the JRH with a diagnosis of stroke as well as outpatients referred to the Driving

Evaluation Service. Of these, 350 were driving prior to stroke and 357 were non-drivers. The drivers were more likely to be male (74% versus 28%), younger (67.4 versus 75.4 years) and have a longer length of stay in rehabilitation (49.2 versus 43.9 days). All drivers were examined for eligibility; 122 (34.9%) were deemed eligible to participate and one client died prior to determination of eligibility. Of these, ninety-seven (79.5%) agreed to participate in the study. Ninety two percent of those who refused to participate were male. The distribution of drivers and non-drivers and of those drivers who were and were not included in the study is presented in figure 2. The reasons for ineligibility and for refusing to participate in the study are listed in table 1.

The socio-demographic, medical, functional, and driving characteristics of the study participants according to their group assignment are presented in table 2. The two groups did not differ clinically on any of the variables related to personal characteristics, medical condition or rehabilitation involvement other than the time of evaluation post-stroke. Subjects in the experimental group, however, were tested longer after their stroke for both pre- and post-test evaluations, compared to those in control group. Also, the two groups did not differ on their personal assessment of driving competence and importance, the frequency and the reasons subjects had driven prior to their stroke, and their driving experience.

The pre-test UFOV and visual-perception scores revealed no differences between the groups on any of the test scores or time taken to complete the tasks. The scores obtained according to group are presented in tables 3 and 4.

The average number of treatment sessions received by the two groups did not differ significantly {experimental: 17.5 (sd=5.3) n=47; control: 18.1 (sd=5.0) n= 50; p=0.534}. However, the duration of each session differed significantly with the experimental group receiving treatment for an average of 34.1 (sd=6.7) minutes per session and the control group receiving an average of 43.8 (sd=8.0) minutes per session (p< 0.0001).

Those considered compliant with the training program, defined as completing 75% or more of the training sessions, were compared to those who were non-compliant. The proportions of non-compliant subjects did not differ significantly between the groups. The rate of non-compliance in the experimental group was 17.0% as compared to 12.0% in the control group. The reasons for non-compliance in the experimental group were: became medically unfit to drive (1), unmotivated (3), illness (1), decided not to drive (1), moved (1), and deceased (1). The reasons for non-compliance in the control group were: became medically unfit to drive (1), unmotivated (3), illness (1), and deceased (1).

Of the 97 subjects who participated in the study, 84 completed the outcome evaluation, 41 in the experimental group and 43 in the control group. Subjects dropped out for the following reasons: became medically unfit to drive (3), decided not to return to driving (5), moved (1), unable to drive due to legal infractions (1), and deceased (3). In addition to the 84 who were tested, two subjects were tested on the visual-perception tests and the Test of Everyday Attention, but failed to complete the on-road evaluation.

Post-test results indicated that the proportion of subjects who passed and failed the on-road evaluation did not differ by group (table 5). Similarly, when only subjects who complied with the intervention were included in the analysis, no significant differences between the groups on any of the outcome measures were found. In addition, there were no differences between the groups on any of the visual-perception tests (table 6) or TEA subtests (table 7). The results of testing on the UFOV following the completion of the training program indicate highly significant differences between the groups, with the group receiving intensive training on the UFOV obtaining significantly better scores (38% versus 13% reduction). When UFOV scores were categorized according to suggested cutoff score, 19 of those in the experimental group who initially received scores of ≥40% reduction improved into the <40% reduction category while in the control group, 10 improved, and 3 performed more poorly.

Secondary analyses were also conducted to examine the effectiveness of the intervention by strata. While there were no statistically significant differences in on-road success between the experimental and control groups for subjects with left- or right-sided lesions, the group with right-sided lesions who received experimental intervention were almost twice as likely to pass the on-road evaluation (52.4% versus 28.6%) as compared to those in the control group (table 8). Stratified analyses for those with mild, moderate, and severe visual attention impairment (table 9) found no significant differences in performance between experimental and control interventions.

The mean scores on the on-road evaluation did not significantly differ according to group (experimental group: 15.4 (sd=3.0); control group: 15.0 (sd=2.6); p=0.59). Moreover, there were no differences between groups on any of the four subsections. Stratified analysis according to side of lesion and severity of impairment resulted in no differences between groups.

The results of univariate logistic regression models indicated that passing the on-road driving evaluation was significantly associated with younger age, and better performance on the FIM, UFOV, reaction time, double cancellation, Charron, and MVPT score and time. Results of multiple linear regression analyses using the on-road driving scores as the outcome indicated that these same factors were also associated with on-road driving performance, such that those who were younger and scored better on these tests of perception and attention were more likely to obtain higher on-road driving scores.

The proportion of individuals who passed the driving test in this cohort (30/84; 36%) was compared to the results obtained from the historical cohort (30/76; 39%), and no significant difference in the rate of success following either intervention program was found.

When questioned regarding the treatment received, subjects answered correctly 30% of the time and did not know in 50% of the cases. The outcome evaluator correctly identified the treatment received 79% of the time. However, there was no difference in the rate of passing for those thought to be in the control or experimental groups.

3.3.5 DISCUSSION

As the length of survival following stroke improves and rehabilitation professionals treat increasing numbers of individuals with stroke, it is crucial to investigate the methods of retraining skills that enable individuals to resume as normal a lifestyle as possible. This study was the first to systematically evaluate the effectiveness of an intervention targeted at retraining the visual attention skills necessary for driving. While the results indicate that the specialized retraining provided by the UFOV was not more effective in improving the driving ability of individuals with stroke as compared to traditional perceptual training, the trends revealed in this study provide a basis upon which to develop more effective methods of driver retraining. It is important to examine the results of both the positive and negative trials as they impact upon the design of future trials.[64]

There are several theoretical and methodological factors that may help explain these overall negative findings. The two interventions under investigation were very similar in nature, and were provided in the same setting with the same frequency and intensity. It is possible that they were equally beneficial in improving attentional and perceptual skills. While the pass rate for this study cohort did not significantly differ from that received by the historical cohort, the two cohorts may be inherently different. The fact that clients are currently admitted for and discharged earlier from rehabilitation services than in the earlier cohort may have contributed to these similar findings.

While co-ordinated stroke care is known to improve long-term functional outcome, scientific evidence documenting the value of specific rehabilitation interventions is limited.[65] Overall, differences in the effectiveness of specific rehabilitation procedures or programs compared to conventional or traditional interventions have not been found.[66] The results of this study are consistent with outcomes for randomized clinical trials evaluating interventions in stroke rehabilitation.

Therapeutic interventions for individuals with stroke focus on either improving the actual impairments or compensating for the resultant deficits. Remedial approaches are most commonly used in the earliest stages of rehabilitation and assume the presence of neural plasticity such that neurological functioning can be modified by sensory input, experiences, and learning.[65] Theoretically, repetitive practice of perceptual tasks results in improvement that carries over into similar perceptual tasks and ultimately to daily function. However, the efficacy of this approach remains controversial.[67] For example, the effects of rehabilitation of hemi-inattention appear to be specific and show little generalization.[68] Subjects are able to learn specific responses but less able to learn general strategies applicable to new situations.[69]

There is no conclusive evidence for the treatment of hemi-inattention. While several studies have found a positive impact for treatment focused on unilateral attention deficits,[69,70,71,72] others have resulted in negative findings.[73,74,75] Studies were typically conducted with small sample sizes, and using poorly controlled methodology.

It is common for impairments in attention to occur following stroke,[68] but the association between specific attention tasks and driving performance is not known. Damage to the right hemisphere often produces visual processing dysfunction, specifically in locating, extracting and interpreting visual information from the environment. These deficits affect attention, speed of processing, and other perceptual skills, and can be disabling.[76] While UFOV intervention focuses on these areas of impairment, the study included all clients with stroke, not only those known to have these deficits. In addition, while drivers, especially experienced ones, can make up for slow information processing and other attention deficits, compensation may be limited. Also, other sensory, visual and perceptual deficits may have contributed to the study results.

With a negative trial it is important to examine the possibility of a type II error, that a difference was not found when one in fact existed. A larger then expected number of withdrawals from the study occurred, decreasing the power of the study to detect a 30-percentage point difference to 82%. In addition, the study did not have the power to detect differences in performance for the individual strata. In fact, a trend of improved success in subjects with right hemisphere lesions was found. This finding is consistent with our understanding of hemispheric differences, since individuals with right hemisphere lesions are known to have impairment in the higher order processing of visual information.[76] According to Oxman and Guyatt[77] this study fulfils the following criteria for subgroup analyses:

the magnitude of the difference, while not statistically significant, is clinically important; the hypothesis of this subgroup difference was proposed a priori and was the primary subgroup analysis proposed; and the differences in outcome were from comparisons within a single study.

Difficulties in implementing the study protocol as designed may have impacted upon the outcome of the study. Subjects were asked to participate in the intervention sessions four times per week for five weeks. However, many of the subjects who attended as outpatients were unable to maintain this frequency, and attended only twice per week. While this problem occurred similarly in both groups, it is important to consider the difficulty experienced by elderly clients with stroke to participate in an intensive outpatient rehabilitation program. In addition, the duration of the sessions for those who received visual-perception training was slightly longer than that received by those who received the visual attention intervention. Clinically, this discrepancy may be explained by the fact that the control intervention consisted of four different perceptual activities requiring additional time for set-up and instruction and that UFOV training places high demands on attention and concentration, causing the subjects to fatigue more quickly.

The use of the on-road driving evaluation as the primary outcome measure for the study may also be problematic since it is difficult to standardize the conditions of the assessment. Differences in climatic conditions, the density of traffic, or the complexity of the driving situations incurred for individual subjects may have increased the variability in the outcome measure.

While the study did not have sufficient power to detect statistically significant differences between the intervention groups, examination of the results indicate potential clinically important results. Eleven of 21 (52%) of individuals with a right-sided lesion who received visual attention training passed the driving evaluation compared to only six of 21 (29%) in the control group. The type of impairments commonly found in those with right-hemisphere stroke can help explain the positive effect of treatment found in this subgroup. Impairments in perceptual and attention functioning, abilities targeted by the UFOV intervention, are commonly seen in those with right-sided lesions.[76] Stroke is known to be a multi-dimensional disorder and it is not surprising that a specific treatment may best benefit a specific subgroup. A larger study focusing on this subgroup would be necessary to definitively determine the effectiveness of UFOV training on this subgroup, while other impairments may need to be targeted to successfully treat those with left-sided lesions.

While studies examining the use of UFOV training in an elderly population produced positive results,[17,33] these findings were not replicated with a neurologically impaired population. While the intervention may improve performance in elderly clients with slowed functioning, there may not be a similar effect in individuals with neurological impairment.

This randomized clinical trial is a first step in addressing the challenge of developing effective and practical driving interventions for individuals with neurological impairments. The importance placed by many of our clients with reduced mobility on returning to independent driving encourages rehabilitation clinicians and researchers to develop more beneficial interventions.

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Table 1. Explanations for non-eligibility and refusal to participate

	n
Total Not Eligible	**227**
team decision of ‘medically unfit to drive’	126
does not want to resume driving	8
bilateral stroke	17
seizures	8
other neurological condition (ie. MS)	2
no French/English	4
severe perceptual, cognitive, and/or comprehension impairment	16
visual impairment	13
too difficult to come for treatment	11
discharged before eligibility known	21
uncooperative in hospital	1
Deceased	**1**
Total Refused	**25**
wanted an evaluation right away	12
he/she does not think needs training	13

Table 2. Comparison of sociodemographic and medical factors by group at start of trial

	Experimental (n=47)	**Control (n=50)**
Age (mean (SD))	65.5 (11.4)	66.5 (8.9)
Gender (n)		
male	35 (74.5%)	35 (70.0%)
female	12 (25.5%)	15 (30.0%)
Language of Training (n)		
French	33 (70.2%)	34 (68.0%)
English	14 (29.8%)	16 (32.0%)
Type of Stroke (n)*		
lacunar infarction	22 (50.0%)	30 (60.0%)
cortical infarction	9 (20.5%)	14 (28.0%)
vertebrobasilar infarction	1 (2.3%)	1 (2.0%)
subarachnoid hemorrhage	2 (4.6%)	0 (0.0%)
intracerebral hemorrhage	10 (22.7%)	5 (10.0%)
Side of Lesion (n)		
left	22 (46.8%)	25 (50.0%)
right	25 (53.2%)	25 (50.0%)
Previous Stroke (n)	6 (12.8%)	5 (10.0%)
Medication (n)		
antidepressants	7 (14.9%)	8 (16.0%)
benzodiazepines	10 (21.3%)	7 (14.0%)
hypoglycemics	9 (19.2%)	15 (30.0%)
opiods	0 (0%)	1 (2.0%)
Visual Acuity-right* (mean (SD))	6/12.7 (6/16.7)	6/11.6 (6/13.1)

Visual Acuity-left* (mean (SD))	6/11.1 (6/10.8)	6/9.7 (6/5.5)
Visual Field Area* (mean (SD))	84.0% (7.7)	83.9% (9.8)
Comorbidity Score	3.7 (1.3)	4.0 (1.5)
Severity of Visual Attention (n)		
mild	13 (27.6%)	14 (28.0%)
moderate	24 (51.1%)	27 (54.0%)
severe	10 (21.3%)	9 (18.0%)
FIM* (mean (SD))	114.9 (10.4)	116.9 (6.2)
Pfeiffer Cognitive Score (mean (SD))	8.8 (1.0)	8.9 (1.0)
Occupational Therapy (sessions per week) (mean (SD))	2.9 (2.1)	3.6 (1.9)
Physical Therapy (sessions per week) (mean (SD))	2.6 (2.2)	3.3 (2.1)
Days in Acute Care* (mean (SD))	26.2 (16.8)	25.0 (16.9)
Days in Rehabilitation* (mean (SD))	54.8 (24.5)	50.3 (23.2)
Time since stroke to pre-test evaluation* (days) (mean (SD))	91.2 (51.8)	66.7 (28.2)

* number of subjects varies due to incomplete data

Table 3. Comparison of pre-test visual-perception scores by group

	Experimental n=47	Control n=50
Reaction Time 1* (mean (SD))	161.0 (129.3)	116.2 (62.8)
Reaction Time 2* (mean (SD))	108.2 (85.0)	82.2 (27.8)
Reaction Time 3* (mean (SD))	88.3 (77.9)	73.3 (22.6)
MVPT Score (mean (SD))	31.1 (4.0)	30.7 (4.2)
MVPT Score Norm (mean (SD))	-1.0 (2.6)	-1.3 (2.8)
MVPT Time (mean (SD))	6.9 (3.6)	5.9 (2.3)
MVPT Time Norm (mean (SD))	-1.7 (2.9)	-0.8 (1.6)
Single Cancellation (mean errors (SD))	3.0 (5.2)	3.2 (5.5)
Single Cancellation (mean sec (SD))	163.6 (59.9)	152.7 (47.2)
Double Cancellation (mean errors (SD))	6.7 (5.5)	6.8 (5.9)
Double Cancellation (mean sec (SD))	213.5 (98.4)	196.9 (62.6)
Road Map (mean errors (SD))	8.2 (5.7)	7.5 (5.6)
Road Map (mean sec (SD))	114.4 (52.3)	111.8 (42.7)
Trail A (mean errors (SD))	0.2 (0.6)	0.4 (1.0)
Trail A (mean sec (SD))	67.5 (3.9)	67.7 (36.0)
Trail B (mean errors (SD))	3.5 (5.0)	3.3 (4.0)
Trail B* (mean sec (SD))	207.2 (147.0)	207.2 (116.3)
Bells (mean errors (SD))	2.4 (2.3)	2.7 (2.8)
Bells (mean sec (SD))	213.4 (71.1)	199.8 (65.1)
Charron* (mean errors (SD))	4.7 (4.4)	5.0 (4.9)
Charron* (mean sec (SD))	388.0 (187.4)	366.9 (130.9)

* number of subjects varies due to incomplete data

Table 4. Comparison of pre-test UFOV scores (% reduction in useful field of view) by group

	Experimental n=47	Control n=50
Total (mean (SD))	38.4 (19.0)	38.8 (16.4)
Processing Speed (mean (SD))	4.9 (8.0)	3.1 (5.8)
Divided Attention (mean (SD))	9.6 (8.5)	10.0 (9.8)
Selective Attention (mean (SD))	23.8 (7.0)	25.8 (4.9)

Table 5. Comparison of post-test on-road driving evaluation results by group

	Experimental n=41	Control n=43
Pass	16 (39.0%)	14 (32.6%)
Fail	25 (61.0%)	29 (67.4%)

Pass versus fail (including lessons): $X^2 = 0.38$; df = 1; p = 0.54

Table 6. Comparison of post-test visual-perception scores by group

	Experimental n=41	Control n=45	p-value
Reaction Time 1 (mean (SD))*	61.3 (15.7)	90.7 (92.1)	.14
Reaction Time 2 (mean (SD))*	62.2 (30.3)	59.3 (12.7)	.68
Reaction Time 3 (mean (SD))*	56.9 (8.2)	57.9 (13.8)	.76
MVPT Score (mean (SD))	30.5 (3.9)	30.2 (4.9)	.75
MVPT Score norm (mean (SD))	-1.4 (3.2)	-1.8 (3.5)	.67
MVPT Time (mean (SD))	5.0 (1.8)	4.9 (1.6)	.66
MVPT Time norm (mean (SD))	-0.22 (1.1)	-0.07 (0.7)	.43
Single Cancellation (mean errors (SD))	4.9 (14.6)	4.1 (9.0)	.77
Single Cancellation (mean sec (SD))	140.2 (40.1)	141.6 (41.4)	.88
Double Cancellation (mean errors (SD))	5.2 (4.8)	5.1 (6.7)	.96
Double Cancellation (mean sec (SD))	176.3 (53.5)	182.6 (50.7)	.58
Road Map (mean errors (SD))	7.6 (5.0)	7.5 (5.7)	.96
Road Map (mean sec (SD))	110.1 (42.2)	119.3 (48.9)	.36
Trail A (mean errors (SD))	0.1 (0.3)	0.4 (1.3)	.25
Trail A (mean sec (SD))	49.4 (16.1)	57.3 (27.6)	.11
Trail B (mean errors (SD))	1.7 (2.9)	1.5 (2.3)	.70
Trail B (mean sec (SD))	139.9 (66.0)	161.6 (81.2)	.19
Bells (mean errors (SD))	1.7 (1.6)	1.5 (1.7)	.65
Bells (mean sec (SD))	164.2 (56.1)	172.0 (55.5)	.52
Charron (mean errors (SD))	4.4 (4.4)	4.5 (4.2)	.93
Charron (mean sec (SD))	335.6 (116.4)	343.4 (139.6)	.78

Table 7. Comparison of post -test Test of Everyday Attention (TEA) standard scores by group

	Experimental n=40	Control n=44	p-value
Map Search (1 minute)	6.7 (3.0)	7.0 (3.2)	.63
Map Search (2 minutes)	7.4 (2.1)	7.2 (2.5)	.69
Elevator Counting	1.2 (0.5)	1.3 (0.5)	.30
Elevator Counting with Distraction	8.4 (2.8)	8.9 (3.2)	.45
Visual Elevator	8.8 (3.8)	9.0 (4.1)	.76
Visual Elevator (Timing)	7.9 (3.1)	7.8 (4.6)	.92
Elevator Counting with Reversal	7.9 (2.6)	7.3 (2.5)	.29
Telephone Search	7.1 (2.3)	6.7 (2.4)	.45
Telephone Search While Counting	9.2 (3.7)	9.0 (4.0)	.85

Table 8. Comparison of post-test on-road driving evaluation results by group according to side of lesion

	Experimental n=41	**Control n=43**
LEFT STROKE (N=42)		
Pass	5 (25.0%)	8 (36.4%)
Fail	15 (75.0%)	14 (63.6%)
RIGHT STROKE (N=42)		
Pass	11 (52.4%)	6 (28.6%)
Fail	10 (47.7%)	15 (71.5%)

LEFT STROKE:

Pass versus Fail (including lessons): $X^2 = 0.63$; df = 1; p = 0.43

RIGHT STROKE:

Pass versus Fail (including lessons): $X^2 = 2.47$; df=1; p=0.12

Table 9. Comparison of post-test on-road driving evaluation results by group according to severity of impairment in Useful Field of View

	Experimental n=41	**Control** n=43
MILD (N=25)		
Pass	8 (66.7%)	6 (46.2%)
Fail	4 (33.3%)	7 (53.9%)
MODERATE (n=45)		
Pass	7 (31.8%)	5 (21.7%)
Fail	15 (68.2%)	18 (79.2%)
SEVERE (N=14)		
Pass	1 (14.3%)	3 (42.9%)
Fail	6 (85.7%)	4 (57.1%)

MILD STROKE:

Pass versus Fail (including lessons): $X^2 = 1.066$; df = 1; p = 0.302

MODERATE STROKE:

Pass / Fail (including lessons): $X^2 = 0.584$; df = 1; p = 0.445

SEVERE STROKE:

Pass / Fail (including lessons): $X^2 = 1.400$; df = 1; p = 0.237

Figure 1: UFOV Evaluation of Selective Attention

A. The UFOV visual attention analyzer

B. Presentation of selective attention task

C. Response to central task

D. Response to peripheral task

Figure 2: Selection of Study Cohort

Records Reviewed

(Clients admitted to JRH with a diagnosis of stroke + outpatients referred from Driving Evaluation Service)

707

↙ ↘

Drivers **Nondrivers**

350 **357**

↙ ↓ ↘

Eligible **Died** **Not Eligible**

122 **1** **227**

↙ ↘

Accepted **Refused**

97 **25**

4. SUMMARY AND CONCLUSIONS

The results of the studies presented in the three preceding manuscripts provide important information for both clinicians and researchers working toward accurate evaluation and effective retraining of driving performance in clients with stroke. This section summarizes and discusses the main findings from these studies.

4.1 STATE OF KNOWLEDGE

The large volume of literature discussing driving in individuals with disabilities indicates a strong desire on the part of clinicians and researchers to improve the services provided to these clients. However, it is extremely difficult to draw many conclusions from these studies due to the many inconsistencies between them as well as the poor quality of study designs. The definitions of concepts such as visual processing, visual attention, and hemineglect differ considerably between studies; subject selection criteria are inconsistent; and the timing of measurement as well as the tools used to evaluate outcome vary (Bowen, McKenna, & Tallis, 1999). In fact, in the review of the literature, assumptions have been made that authors were referring to similar constructs based on similar definitions and/or measurement tools. The constructs may be more dissimilar than could be distinguished from accompanying descriptions, making it extremely difficult to judge the main findings from the literature.

In addition, the information in the area of driving and the disabled comes primarily from clinical descriptions and poorly controlled studies, often case series. Overall, studies included small, heterogeneous samples that combined diagnoses, potentially masking results specific to one or more subgroups. Since individuals may be disabled due to a wide range of impairments, there is a need for the design of well-controlled studies incorporating more homogeneous groups.

4.2 EVALUATION OF DRIVING

The first study presented in this thesis focused on the assessment procedure used in driving evaluation. This study was designed to address the predictive validity of perceptual-cognitive testing in clients with stroke. The primary objective was to determine the ability of commonly used perceptual tests to predict driving performance in such clients. This study used a more homogeneous population compared to previously conducted studies, and not only determined the predictive validity of each measure individually, but also used multivariate modelling to determine the combination of tests most predictive of on-road performance. The primary study finding, that the MVPT and Trail Making B tests together were the most predictive of on-road performance, indicates that higher order processing skills, specifically those that measure speed of processing, are most closely associated with actual driving performance. Identifying the combination of tests most useful in predicting driving, may assist clinicians to reduce redundancy in the testing procedure and to more efficiently screen for those who are likely to pass or fail the driving test.

The primary limitation in the methodology used to conduct this study was that the same therapist who conducted the on-road driving evaluation also administered the battery of perceptual tests. While it would have been preferable to administer the outcome measures blindly, in clinical practice, it is very difficult for the outcome evaluator to be unaware of the results of the perceptual testing. This information is typically used by the therapist during the on-road evaluation to ensure that the functional impact of known deficits is adequately examined. However, since the conception of the question for this study occurred after the completion of data collection, the potential for measurement bias is reduced.

The functional evaluation of driving is extremely complex and the development of standardized and valid measurement tools to test on-road driving performance has been difficult. Many of the approaches used appear to be testing similar constructs in similar ways, but the lack of accurate measurement tools has affected the quality of the research in this area. Research in the area of driving evaluation and retraining is hindered by the absence of a common criterion, whether it is performance during the driving task, driving safety, or knowledge, as well as by the complexity and subjectivity inherent in the evaluation of driving. A fairly recent publication presented preliminary results of the development of a new driving evaluation tool (Dobbs, 1997). This measure was developed by systematically examining driving errors, and differentiating acceptable errors from those that are indicative of declining *driving competence*. Initial validation studies have demonstrated the ability of the measure to detect errors and to discriminate between known groups, such as individuals with and without cognitive decline. This new research will hopefully provide researchers and clinicians with a criterion measure against which driving performance can be evaluated.

4.3 DRIVING TRAINING

Both the pilot study as well as the randomized clinical trial presented in the second and third manuscripts examine a novel method of treating the underlying impairments known to affect driving performance. The results of the pilot work, specifying the range of scores on the UFOV for clients with stroke and indicating that training on the UFOV is feasible in this population, provided information necessary for the design of the randomized trial. While it was our intention to address the impact of stroke on UFOV test results, we were unable to compare the results to norms, as these data were not available according to age.

Conducting a randomized clinical trial in the field of rehabilitation of clients with stroke, while considered to provide the highest level of evidence regarding treatment effectiveness, is fraught with difficulties related to subject selection and participation, provision of standardized treatments, subject compliance with the treatment protocol, and the outcome assessment. These potential difficulties have important implications for both the internal validity as well as the external validity, or generalizability, of the study results.

While the study included only subjects with stroke, this is a heterogeneous group, differing according to the size and location of the lesion as well as in the resultant impairments. The residual deficits as well as age, gender, pre-morbid health, and social situation may have an independent effect on the outcome of interest and may be differentially associated with treatment effectiveness. Also, as stroke survivors spontaneously recover over time due to the plasticity of the nervous system and other concurrent interventions, it is very difficult to distinguish the relative contribution of the rehabilitation procedure under investigation from these factors (Riddoch et al., 1995).

The generalizability of the study results is dependent upon the subject selection criteria employed as well as the sources for subject recruitment. Only clients who were drivers and who the treating rehabilitation team considered sufficiently safe to be evaluated on the road were eligible to participate. Many potential subjects were considered ineligible for a variety of medical, functional and other reasons. In addition, the recruitment strategies enabled us to primarily include only those clients who were receiving rehabilitation services, and did not include those who were discharged either home or to long-term care directly from acute care following their stroke. Individuals not referred for rehabilitation are typically the most mildly or the most severely affected and are rarely referred for driving evaluation services. These subject restrictions limit the generalizability of the study results to those who would typically be sent for a driving evaluation, those with moderate impairments due to a stroke who are receiving rehabilitation services.

Due to the restrictive criteria for eligibility as well as the demands of the training program, the recruitment process was extremely time-consuming and tedious. The presence or absence of the many selection criteria needed to be verified and a referral from the clinical team was necessary prior to determining eligibility status.

Given the high motivation of most drivers to return to driving following discharge from hospital, there were relatively few individuals who refused to participate. Potential subjects refused for two primary reasons; several did not want to delay their driving evaluation, and others felt that they did not require additional training. Those who refused to participate were more likely to be male and had a significantly shorter length of stay in a rehabilitation hospital compared to those who agreed to participate. These differences need to be taken into consideration when generalizing the results to the defined population.

There were major difficulties in maintaining the subjects in the study until its completion. Participation required a large commitment in terms of time and energy for clients who were generally elderly and physically disabled. Transportation for training sessions and evaluations was a major obstacle. Results indicate that the only difference between those who withdrew and those who completed the study was that males were more likely to withdraw from the study.

In the field of rehabilitation, interventions cannot be standardized for all individuals in the study. Treatment is always individualized to the needs of each client, since the focus is on improving specific skills or functions. Further, treatment is adjusted to the changing needs and abilities of individuals in order to maximize benefits. Clearly, the clinician who is providing the interventions and making clinical decisions cannot be blinded to the intervention, as is often the case in drug trials. To reduce the variation across treating personnel as well as to improve the consistency of each clinician's intervention, the results and experiences from the pilot study were used to develop standardized criteria for the training program, specifically outlining how treatment should commence and how training should proceed based on the changing performance of each subject.

In many areas of neurological rehabilitation, the ability to generalize training of individual skills to functional tasks has not been well established. In this study, training on the UFOV produced great improvements in UFOV scores with no change in functional ability.

Another condition of treatment that must be considered when designing a clinical trial in this field, is the most beneficial intensity of the intervention. Two systematic reviews (Kwakkel et al., 1997) (Langhorne et al., 1996) were conducted to synthesize the studies evaluating effectiveness of increased intensity of physical therapy interventions. While the interventions evaluated in these trials and the types of outcome measures employed were quite heterogeneous, overall, there is some evidence that intensive interventions are associated with improvements in function and in neuromuscular status, but that these effects may be transient (Langhorne et al., 1996). While we attempted to provide intensive intervention (four 45-minute sessions per week) in our clinical trial, this was difficult to implement. Many study participants, especially those who were involved as outpatients, were unable to attend at that frequency and/or to tolerate the full treatment time.

A major concern in conducting outcome evaluations in rehabilitation is detection bias, a systematic difference in the outcome dependent upon the treatment received. In this randomized trial, outcome evaluations were conducted blindly to ensure that the evaluation results remained unbiased. Given that the assessments used in these studies are reliant on the observation of behaviour and functional tasks, ensuring blinded evaluations is most critical in reducing bias. Several measures were implemented to ensure that the outcome evaluator was unaware of the interventions received. We selected a therapist who did not work at the hospital and came to the Research Centre only to conduct the evaluations. Prior to the evaluation, all subjects and the evaluator were asked not to discuss the treatment that they received. In addition, the perceptual-cognitive evaluations and the on-road test were administered prior to conducting the final UFOV assessment, since we felt that the evaluator would be able to detect who received experimental training according to their skill in using the UFOV. Subjects and the evaluator responded to a question asking what treatment they thought had been provided, either the traditional or the experimental intervention. The evaluator was trained to complete this question prior to conducting the UFOV testing, but upon completion of the study, we discovered that this was not followed and that this question was completed after testing was finished. By comparing the success and failure rates of the on-road evaluations for those whom the evaluator thought were in the control and experimental groups, we determined that the evaluator's rating of group assignment did not influence outcome.

The results of the clinical trial did not yield statistically significant differences between the groups. One explanation for not being able to reject the null hypothesis is a potential Type II error, that the null hypothesis was not rejected when in fact the null hypothesis was false. In other words, there was a failure to find a significant difference when in fact a difference truly existed. A treatment that is effective will often fail to yield significant results simply because sample size in inadequate (Freiman, Chalmers, Smith, & Kuebler, 1978) and our sample size of 84 completed subjects may not have been sufficient to detect differences between the groups. A retrospective analysis indicated that with this number of subjects, we only had a power of 81% to detect an increase in success from 40% to 70%.

Also related to the issue of power is the intended difference in outcome that one would like to detect. We chose to use a difference in outcome of 30%, however, we had no framework upon which to make this decision. When the trial was developed in 1994, emphasis was not being placed on estimating the minimal clinically important difference (MCID). The MCID is defined as the smallest difference in measured health status in the domain of interest which clients perceive as beneficial and which would mandate, in the absence of troublesome side effects and excessive cost, a change in the client's management (Jaeschke, Singer, & Guyatt, 1989). It has only been in the last few years that this concept has received broader discussion and different methods of estimating MCID have been developed (Jaeschke et al., 1989; Redelmeier, Guyatt, & Goldstein, 1996; Stratford et al., 1996). While the best method for determining MCID is controversial, studies using a variety of outcome measures are resulting in fairly consistent findings. The application of a methodology to determine clinically significant differences will be extremely useful in selecting measures that are sensitive to change, in planning new clinical trials, determining the appropriate sample size, and in interpreting the outcomes of trials. While the current investigations of MCID have all been conducted on continuous measures, had the relevant information for differences in proportions been known when we were designing the study, it may have directed us toward a larger sample size.

In this trial, there is an important concern that the impact of treatment may not have been detected because the control group received intervention that was not sufficiently different from that of the experimental group. Both groups received the same number of sessions, by the same occupational therapists, using the same large touch-screen computer. While the interventions differed in that the experimental training consisted of software targeted at specific quick visual processing abilities and the control group received traditional perceptual training, the similarities between them may have prevented the detection of clinical and statistical differences. Since we did not include a placebo group, we were only able to conclude that specific visual attention computerized training was not superior to traditional computerized training, but were unable to determine whether this type of training is better than no intervention.

The one finding that merits further discussion is that the subgroup of subjects with right hemisphere lesions who received UFOV intervention had a higher rate of on-road driving success. Oxman (Oxman & Guyatt, 1992) presented guidelines for determining the credibility of subgroup analyses: 1. The magnitude of the difference is clinically important. In our study there was an increase of 24 percentage points in the success rate for this subgroup. 2. The difference is statistically significant. This was not the case in the current study. 3. The hypothesis preceded the analysis. Side of lesion was used during stratification, prior to the commencement of the study. 4. The subgroup analysis was one of a small number of hypotheses tested. Only the subgroups divided according to side of lesion and severity of impairment were analyzed. 5. Subgroup differences resulted from comparisons within (not between) studies. This was true in this study. 6. Results are consistent across studies. This information is not currently available. 7. There is indirect evidence that supports the hypothesized difference. There is biological and clinical evidence from experimental and non-experimental studies supporting the notion that those with right hemisphere lesions benefit from visual attention training (Antonucci et al., 1995; Gordon et al., 1985; Weinberg et al., 1977). Right hemisphere lesions are often associated with attentional deficits, in particular unilateral neglect, and one review of the topic stated that clients with deficits in attention are significantly more functionally impaired (Riddoch et al., 1995). These findings provide sufficient support to continue the investigation of UFOV training in those with lesions of the right hemisphere.

When attempting to address the issue of rehabilitation effectiveness, there remain many unknown factors that may have important implications. The population that would best benefit and the intensity of rehabilitation likely to be most effective in reducing disability is not clearly understood. The variability of rehabilitation practices, the time interval between onset of stroke and commencement of treatment, as well as the type and duration of treatment must be carefully examined. Also, measurement of outcome must become more standardized to improve our ability to interpret and apply study results clinically (Dombovy, Sandok, & Basford, 1986).

While the overall results of the study examining treatment effectiveness did not indicate that UFOV training was superior to traditional perceptual training, these findings do have an important impact on clinical practice as well as future research. Currently, the methods for training visual-perception and attention are selected by each individual therapist. The results of clinical trials, including those with negative findings (Goldstein et al., 1999), can help direct the development of new intervention strategies, and may provide important practical information for evaluating these novel procedures. In fact, it is imperative to carefully examine the effectiveness of new methods of intervention prior to them becoming established in clinical practice, when it is still ethical to conduct a clinical trial.

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APPENDICES

APPENDIX 1

Location of Lesion and Presenting Deficits (adapted from: Adams & Victor, 1993)

Location of Lesion	Common Deficits
Carotid artery region	
i. middle cerebral artery ischemic stroke	•contralateral sensory and motor weakness or hemiparesis of the face and arm •lower limb involved to a lesser degree •visual functions may be impaired; homonymous hemianopsia or unilateral visual neglect •aphasia when the dominant cerebral hemisphere is affected
ii. anterior cerebral artery ischemic stroke	•sensory motor monoparesis of lower limb or hemiparesis predominately affecting the lower limb with proximal upper limb involvement •urinary incontinence
Vertebrobasilar artery region	
i. posterior cerebral artery ischemic stroke	•homonymous hemianopsia (unilateral visual field loss) or quadrinopsisa (unilateral field loss in the upper half of visual field) •hemisensory abnormalities
ii. posterior fossa (involvement of the brainstem and cerebellum)	•combination of cranial nerve or cerebellar dysfunction on one side •sensory or motor dysfunction contralateral side
iii. cerebellar infarction	•hemiataxia •hypotonia •loss of balance •intense nystagmus and vertigo

Lacunar syndromes (involve the small blood vessels)	•pure motor, resulting in mild to moderate hemiparesis involving the face, arm and leg •or pure unilateral sensory disturbances •or a combination of cerebellar incoordination and motor deficit on the same side of the body
Intracerebral hemorrhage (result of hypertensive bleed, rupture of a saccular aneurysm, vascular malformation, or associated with a bleeding disorder)	•not possible to distinguish a cerebral hemorrhage from a cerebral infarction on clinical grounds alone •headache and/or nausea and vomiting during the first hours of onset •persistent disturbance of consciousness •proportional motor and sensory deficits of the face, leg, and arm is suggestive of a deep hemispheric hemorrhage

APPENDIX 2

CONSENT FORM: PILOT STUDY

The Occupational Therapy and Research Departments at the Jewish Rehabilitation Hospital are examining methods of retraining people who have had a stroke to return to driving.

We are asking you to participate in a preliminary study that will look at a new method of testing an important perceptual skill, visual attention. This method uses computer programs to test your ability to attend and locate objects in your visual field. During the test, you will be asked to press a button to respond to what you see on the screen. The session will last approximately 30 minutes and will be directed by an Occupational Therapist. This test will be given in addition to any other evaluations and treatment you receive at the hospital.

CONFIDENTIALITY
The results of the visual attention test will remain confidential. Your name will not be identified in any publications or presentations of the study.

CONSENT
You can be assured that the information you have received about this project is accurate and complete. We would like you to participate. However, your participation is completely voluntary. The type and quality of your regular treatment will not be effected by your decision. If you decide to participate and later change your mind, you may withdraw from the study at any time.

If you have any questions about this project, please call Susan Sofer at 688-9550 Ext. 221 or Barbara Mazer at 688-9550 Ext. 442

Your signature indicates that you have read this form, that you understand the purpose of the research and that this project may not have direct benefit for you and that you agree to participate.

______________________________ Signature of Participant	__________________ Date
______________________________ Signature of Witness	__________________ Date

FORMULAIRE DE CONSENTEMENT: ÉTUDE PILOT

Le service d'ergothérapie et le département de recherche de l'Hôpital Juif de Réadaptation s'intéressent aux méthodes de rééducation pouvant favoriser un retour à la conduite automobile chez les gens qui ont eu un accident cérébro-vasculaire.

Nous demandons votre participation à cette étude préliminaire qui examine une nouvelle méthode d'évaluer l'attention visuelle. On utilisera un ordinateur pour évaluer votre attention et vos réponses lorsque des images d'objets apparaîtront dans votre champs visuel. Durant le test, vous devrez répondre en pressant sur un bouton. La session durera 30 minutes et sera menée par une ou un ergothérapeute. Cette évaluation vient s'ajouter aux traitements habituels que vous recevez à l'hôpital.

CONFIDENTIALITÉ

Les résultats de l'évaluation de l'attention visuelle seront confidentiels. Votre nom ne paraîtra jamais dans une publication quelconque portant sur les résultats de cette étude.

CONSENTEMENT

Soyez assuré que les informations que vous avez reçues sur ce projet de recherche sont précises et complètes. Il n'y pas de côut associé à votre participation à ce programme. Votre participation à ce programme est volontaire. Votre décision n'affectera pas le type et la qualité des thérapies que vous recevez à l'hôpital. Si vous décidez de participer au projet, vous pouvez à tout instant retirer votre participation.

Si vous avez des questions concernant ce projet, veuillez s'il vous plaît contacter Susan Sofer au 688-9550 poste 221 ou Barbara Mazer au 688-9550 poste 442.

Votre signature indique que vous avez lu ce formulaire, que vous comprenez le but de cette recherche et que cette recherche peu ou non être bénéfique, et que vous acceptez de participer à l'étude.

______________________________ ______________________
Signature du Participant Date

______________________________ ______________________
Signature du Témoin Date

CONSENT FORM: PILOT STUDY - RELIABILITY

The Occupational Therapy Department and the Research Department at the Jewish Rehabilitation Hospital are examining methods of retraining people who have had a stroke to return to driving.

We are asking you to participate in a preliminary study that will look at the consistency of a new method of testing an important perceptual skill, visual attention. This part of the study will examine the scores obtained during two separate sessions. The test uses computer programs to examine your ability to attend and locate objects in your visual field. During the test, you will be asked to press a button to respond to what you see on the screen. Each session will last approximately 30 minutes and will be directed by an occupational therapist. This test will be given in addition to any other evaluations and treatment you receive at the hospital.

There are no known risks associated with this evaluation.

CONFIDENTIALITY

The results of the visual attention test will remain confidential. Your name will not be identified in any publications or presentations of the study.

CONSENT

You can be assured that the information you have received about this project is accurate and complete. We would like you to participate. However, your participation is completely voluntary. The type and quality of your regular treatment will not be affected by your decision. If you decide to participate and later change your mind, you may withdraw from the study at any time.

If you have any questions about this project, please call Danièle Martineau at Extension 539, Susan Sofer at Extension 221 or Barbara Mazer at Extension 442.

Your signature indicates that you have read this form, that you understand the purpose of the research, that this project may or may not have direct benefit to you, and that you agree to participate.

______________________________	____________________
Signature of Participant	Date
______________________________	____________________
Signature of Witness	Date

FORMULAIRE DE CONSENTEMENT: ÉTUDE PILOTE - FIABILITÉ

Le service d'ergothérapie et le département de recherche de l'Hôpital Juif de Réadaptation s'intéressent aux méthodes de rééducation pouvant favoriser un retour à la conduite automobile chez les gens qui ont eu un accident cérébro-vasculaire.

Nous demandons votre participation à cette étude préliminaire qui examine la fiabilité d'une nouvelle méthode d'évaluer l'attention visuelle. Dans cette partie de l'étude, on examinera les résultats de deux sessions différentes. On utilisera un ordinateur pour évaluer votre attention et vos réponses lorsque des images d'objets apparaîtront dans votre champ visuel. Durant le test, vous devrez répondre à ce que vous verrai sur l'écran en pressant sur un bouton. Chaque session durera 30 minutes et sera menée par une ou un ergothérapeute. Cette évaluation vient s'ajouter aux traîtements habituels que vous recevez à l'hôpital. Il n'y a aucun risque connu associé à ce traîtement.

CONFIDENTIALITÉ

Les résultats de l'évaluation de l'attention visuelle seront confidentiels. Votre nom ne paraîtra jamais dans une publication ou présentation quelconque portant sur les résultats de cette étude.

CONSENTEMENT

Soyez assuré que les informations que vous avez reçues sur ce projet de recherche sont précises et complètes. Nous aimerions que vous participiez. Cependant votre participation à ce programme est volontaire. Votre décision n'affectera pas le type et la qualité des thérapies que vous recevez à l'hôpital. Si vous décidez de participer au projet, et que plus tard vous changez d'idée, vous pouvez à tout instant retirer votre participation.

Si vous avez des questions concernant ce projet, veuillez s'il vous plaît contacter Danièle Martineau au local 539, Susan Sofer au local 221 ou Barbara Mazer au local 442.

Votre signature indique que vous avez lu ce formulaire, que vous comprenez le but de cette recherche et que cette recherche peut être ou non bénéfique, et que vous acceptez de participer à l'étude.

________________________________ ____________________

Signature du participant Date

________________________________ ____________________

Signature du témoin Date

CONSENT FORM: PILOT STUDY - TRAINING

The Occupational Therapy and Research Departments at the Jewish Rehabilitation Hospital are examining methods of retraining people who have had a stroke to return to driving.

We are asking you to participate in a preliminary study that will look at a new method of training an important driving skill, visual attention. This method uses computer programs to train you to attend and locate objects in your visual field. You will receive training 4 times per week for 5 weeks, for a total of 20 sessions. Each session will last approximately 30-45 minutes and will be directed by an Occupational Therapist. These sessions will be given in addition to any other evaluations and treatment you receive at the hospital.
There are no known risks associated with this treatment.

CONFIDENTIALITY
The results of the visual attention test will remain confidential. Your name will not be identified in any publications or presentations of the study.

CONSENT
You can be assured that the information you have received about this project is accurate and complete. We would like you to participate. However, your participation is completely voluntary. Your decision will not effect the type or quality of your regular treatment. If you decide to participate and later change your mind, you may withdraw from the study at any time.

If you have any questions about this project, please call Susan Sofer at 688-9550 Ext. 221 or Barbara Mazer at 688-9550 Ext. 442.

Your signature indicates that you have read this form, that you understand the purpose of the research and that this project may not have direct benefit for you, and that you agree to participate.

____________________________ __________________
Signature of Participant Date

____________________________ __________________
Signature of Witness Date

FORMULAIRE DE CONSENTEMENT: ÉTUDE PILOTE - RÉENTRAINEMENT

Le service d'ergothérapie et le département de recherche de l'Hôpital Juif de Réadaptation s'intéressent aux méthodes de rééducation pouvant favoriser un retour à la conduite automobile chez les gens qui ont eu un accident cérébro-vasculaire.

Nous demandons votre participation à cette étude préliminaire qui examine une nouvelle méthod pour entraîner à être attentif et à repérer les objets qui sont dans votre champ visuel. Le programme durera 5 semaines. Il y aura 4 sessions par semaine pour un total de 20 sessions. Chaque session durera de 30 à 45 minutes et sera menée par une ou un ergothérapeute. Ces sessions viendront s'ajouter aux traitements habituels que vous recevez à l'hôpital.
Il n'y a aucun risque connu associé à ce traîtement.

CONFIDENTIALITÉ
Les résultats de l'évaluation de l'attention visuelle seront confidentiels. Votre nom ne paraîtra jamais dans une publication quelconque portant sur les résultats de cette étude.

CONSENTEMENT
Soyez assuré que les informations que vous avez reçues sur ce projet de recherche sont précises et complètes. Il n'y a pas de coût associé à votre participation à ce programme. Votre participation à ce programme est volontaire. Votre décision n'affectera pas le type de thérapie ainsi que la qualité des thérapies que vous recevez à l'hôpital. Si vous décidez de participer au projet, vous pouvez à tout instant retirer votre participation.

Si vous avez des questions concernant ce projet, veuillez s'il vous plaît contacter Susan Sofer au 688-9550 poste 221 ou Barbara Mazer au 688-9550 poste 442.
Votre signature indique que vous avez lu ce formulaire, que vous comprenez le but de cette recherche et que cette recherche peut ou non être bénéfique, et que vous acceptez de participer à l'étude.

____________________________________ ____________________
Signature du participant Date

____________________________________ ____________________
Signature du témoin Date

RANDOMIZED CLINICAL TRIAL
CONSENT FORM

The Occupational Therapy Department and the Research Department at the Jewish Rehabilitation Hospital are examining methods of retraining people who have had a stroke to return to driving.

We are asking you to participate in a study that will look at the effectiveness of two different driving retraining programs. One uses computer programs to train you to attend and locate objects in your visual field. The other trains general visual-perceptual abilities. You will receive only one of the retraining programs and you will not know beforehand which one it will be. Each program consists of 4 sessions per week for 5 weeks, for a total of 20 sessions. Each session will last approximately 30-45 minutes and will be directed by an Occupational Therapist. These sessions will be given in addition to any regular therapy you may be receiving. You will also be asked to complete tests of visual attention and visual-perception both on the computer and with paper and pencil tasks. These tests will be given both before and after the retraining program. At the end of the program, you will receive the standard on-road driving evaluation. There are no known risks associated with either retraining program nor any of the evaluations.

CONFIDENTIALITY

The results of the final perceptual testing and the on-road driving evaluation will be sent to La Société de l'Assurance Automobile du Québec, as is the standard procedure for all individuals evaluated for driving at the Jewish Rehabilitation Hospital. Your name will not be identified in any publications or presentations of the study.

CONSENT

You can be assured that the information you have received about this project is accurate and complete. This program will be provided to you at no additional cost.

We would like you to participate. However, your participation is completely voluntary. Your decision will not effect the type and quality of your regular treatment or your driving evaluation. If you decide to participate and later change your mind, you may withdraw from the study at any time.

If you have any questions about this project, please call Barbara Mazer at 450-688-9550 Ext. 526.

Your signature indicates that you have read this form, that you understand the purpose of the research, that this project may or may not have direct benefit to you, and that you agree to participate.

______________________________	____________________
Signature of Participant	Date
______________________________	____________________
Signature of Witness	Date

ESSAI CLINIQUE RANDOMISÉ
FORMULE DE CONSENTEMENT

Le département d'ergothérapie et le département de recherche de l'Hôpital juif de réadaptation s'intéressent aux méthodes de rééducation pouvant favoriser un retour à la conduite automobile chez les gens qui ont eu un accident cérébrovasculaire.

Nous demandons votre participation à cette étude qui examine l'efficacité de deux différents programmes de rééducation à la conduite automobile. Dans le premier programme, on utilisera un ordinateur pour vous entraîner à être attentif et à repérer les objets qui sont dans votre champs visuel. Le deuxième programme vous permettra d'entraîner vos habiletés de perception visuelle en général. Vous ne recevrez qu'un seul des deux programmes et le choix du programme ne vous sera pas divulgué à l'avance. Chaque programme durera 5 semaines. Il y aura 4 sessions par semaine pour un total de 20 sessions. Chaque session durera 30-45 minutes et sera menée par une ou un ergothérapeute. Ces sessions viendront s'ajouter aux traitements habituels que vous recevez à l'hôpital. Nous vous demanderons de compléter une série de tests d'attention visuelle et de perception visuelle à l'ordinateur ou avec papier et crayon. Les tests seront faits à deux occasions: (1) avant votre participation au programme et (2) à la fin du programme. Vous recevrez aussi une évaluation de la conduite automobile standardisée à la fin du programme. Il n'y a aucun risque connu associé à ce traitement.

CONFIDENTIALITÉ

Les résultats du test perceptuel et de l'évaluation sur la route seront envoyés à la Société de l'assurance automobile du Québec. Ceci est une procédure standard de l'Hôpital juif de réadaptation. Votre nom ne paraîtra jamais dans une publication quelconque portant sur les résultats de cette étude.

CONSENTEMENT

Soyez assuré que les informations que vous avez reçues sur ce projet de recherche sont précises et complètes. Il n'y a pas de coûts associés à votre participation à ce programme. Bien que nous aimerions obtenir votre participation à ce programme, celle-ci est volontaire. Votre décision n'affectera ni le type, ni la qualité des thérapies pas plus que l'évaluation de conduite. Si vous décidez de participer au projet, vous pouvez à tout instant retirer votre participation.

Si vous avez des questions concernant ce projet, veuillez s'il vous plaît contacter Barbara Mazer au 450-688-9550 poste 526.

Votre signature indique que vous avez lu cette formule, que vous comprenez le but de cette recherche, que vous pouvez ou non en retirer un bénéfice direct, et que vous acceptez d'y participer.

Signature du Participant	Date
Signature du Témoin	Date

APPENDIX 3

TRAINING MATERIALS

UFOV

Visual Attention Analyzer

Model 3000

Visual Resources Inc.
1733 Campus Plaza, Suite 15
Bowling Green, KY 42101
(502) 842-5965

DRIVING RETRAINING RESEARCH PROJECT
TRAINING GUIDELINES
VISUAL ATTENTION (UFOV)

Selection of the parameters for each training block should be chosen according to the following guidelines.

Task Selection
The task to begin training is selected according to the following:

Processing Speed for clients with extreme reductions (>80%) in useful field of view or with threshold duration scores of >20 msec.
Train this skill only if there is a reduction in the processing speed test score.
Practice should continue until a threshold duration of 20 or less is achieved.
Training of divided attention can begin before 20 msec is achieved.

Divided Attention for clients with reductions between 40% and 80% or a threshold duration of <20 msec.
Train this skill only if there is a reduction in the divided attention test score.

Selective Attention for clients with reductions of <40% and 0% reduction in divided attention.

Center Task
Select visual.
Identify center target.

Peripheral Target
Select car.

Colour: blue, red, green - easier
Yellow - intermediate
White - most difficult

Distracter (for selective attention)
Dim - easier
Normal - more difficult

Duration
Begin with Level 10 (400 msec) and work down to Level 1 (40 msec).

Eccentricity
Begin with 10 degrees. When the proportion correct exceeds 75% (12/16), increase eccentricity to 20 degrees. When the proportion correct exceeds 75% at 20 degrees, increase eccentricity to 23 degrees.

<u>Extra training</u>
Chose either left, right, top or bottom when test results indicate a definite reduction in attention in one quadrant. Otherwise choose full.

Modifications to the training program should be made according to the following guidelines.

<u>Divided Attention</u>

Training of divided attention begins at <u>Duration 10</u> (400 msec) using a <u>white car</u> at <u>10 degrees eccentricity</u>. Progress from 10 to 20 to 30 degrees eccentricity at this duration. If client obtains at least 75% correct (12 or more out of 16 trials) continue increasing eccentricity and then decreasing duration.

When the client reaches a level at which he/she cannot score at least 75% correct and/or makes 2 or more center errors, change the peripheral target to a <u>colour target</u>, progressing from the an *easy* to an *intermediate* colour (as stated above). Work with the colour target until duration is decreased 2 levels (i.e. from 8 to 6). Return to a white target at the original duration. Repeat procedure if necessary.

<u>Selective Attention</u>

Begin training selective attention when client is scoring 75% on divided attention at duration 7. Start at <u>Duration 10</u> using a <u>white car</u> at <u>10 degrees eccentricity</u>. Progress to 20 and then 30 degrees eccentricity at this duration. If the client obtains at least 75% correct, continue increasing eccentricity and decreasing duration.

When the client reaches a level at which he/she cannot score at least 75% correct and /or makes 2 or more center errors, change the peripheral target to a <u>colour target</u> progressing from the an *easy* to an *intermediate* colour (as stated above). Work with the colour target until duration is decreased 2 levels. Return to a white target at the original duration. Repeat procedure if necessary.

If the client cannot achieve 75% correct using a colour target, use a white car and <u>dim</u> the distracters, and proceed in the same way.

DRIVING RETRAINING RESEARCH PROJECT
TRAINING GUIDELINES
PERCEPTION

When C:\> is on large screen and you want to use the UFOV, type:
C:\>1 <enter>

To open GAMES when C:\> is on large screen, type:
C:\> cd games <enter>
C:\GAMES> name of game <enter>

To go from UFOV testing or training to GAMES, you must get C:\> to the large screen. To do this type:
C:\> mode co80 <enter>
C:\> now appears on large screen.

To see directory of all the game files, when in GAMES, type:
C:\GAMES> dir *.exe/p

To reset the computer when you get stuck, press CTRL, ALT, DEL, all at the same time.

GAME INSTRUCTIONS

JIGSAW PUZZLE

C:\GAMES > JIG <enter>

When game appears, touch screen anywhere. At * images, chose a puzzle by touching the screen.
Select level: kids / novice / medium / expert / master.
Press start. You will see a picture on the screen. Touch the screen to scramble the pieces. Touch the screen to stop.
Select a puzzle piece by touching it, then touch the position where you want it to go.
When the puzzle is complete, record the level, number of moves, number of views and grade.
Then touch the screen to return to the menu. Chose another puzzle or touch quit.
You may press ESC to leave the game.

Address: Alive Software $15
P.O. Box 4004
Santa Clara, CA. 95054

MASTERMIND

C:\GAMES > MASTER <enter>

Select Sound - on / off
Level - 1 / 2 / 3
Boxes - 5
Pieces - 5
Multiple - Off / On

Once the selections are made you must exit the game to make any changes. Press O.K.

Rules: Mastermind is a challenging game of logic and deduction. The playing board consists of 5 empty boxes that the player fills from a selection of 5 pieces of fruit. This can be done with or without multiple pieces of the same kind of fruit and with any one of three levels of answer reporting. The object of the game is to guess what piece of fruit goes in which position.

Reporting Levels:

Level 1: Mastermind will display the correctly guessed pieces of fruit in their guessed positions and will display the number of fruit in their correct position in front of the answer boxes. Level 1 will also highlight the fruit that was in the correct box.

Level 2: Mastermind will display (in random order) which pieces of fruit were guessed correctly. It will also show the number of fruit placed in the correct position in front of the answer boxes.

Level 3: Mastermind will display a happy face marker for each correctly guessed piece of fruit. It will also show the number of fruit placed in the correct position in front of the answer boxes.

When all five selections are correct, record the level, multiple on or off, and number of moves.

Address: Expert Source Code Inc. $12.00
P.O. Box 180519
Casselberrry, Florida
32718-0519

<u>OTHELLO</u>

C:\GAMES> OTHELLO <enter>

You need to wait several seconds before you see the first question: “Do you need instructions?” Use arrow keys to select NO and press enter.

This is not a touch screen game, you must use the arrow keys to move the orange box to the square you select.

Select: Mode of play - 1
Do you want to be black - yes / no
Level - 1(easy) / 2(moderate) / 3(difficult)

Rules: The object of Othello is to have more stones at the end of the game than does your opponent. In this game black always goes first. If you play against the computer you can chose to be black (you go first) or to be white (the computer goes first). The board consists of 64 spaces. The game begins with each player having 2 stones, set up in the center of the board. To take your turn you move the box cursor to the space that you want to put your next stone, and press enter. To move the cursor, use the key pad, including pg up, pg dn, end, and home. Other keys are F1 - help; F2 - sound; F3 - hint; F4 - level; F5 - quit.

You only get a turn if you have a legal move. A legal move is one which places a stone adjacent to another stone and surrounds one or more of the opponent’s stones. To surround an opponent you must place your stone to form a line connecting one or more enemy stones to another of your stones. Only stones that are adjacent form a line. You capture all enemy stones in the line bounded by your current move and your first adjacent stone in that line. The game continues until all spaces are filled or neither player has a move. If one player can’t move, the other may go again. If you have a move you must make it. The block of colour at the top left-hand corner shows whose turn it is. The bars of colour below that show the state of the game. The green bar represents empty spaces.

When the game is complete record <u>level</u>, subject’s <u>colour</u> (black or white), <u>number of black stones</u> and <u>number of white stones</u>.

TETRIS

C:\GAMES > FRAC <enter>

Select level (speed): 1-9 (select 1)
layers: 0-8 (select 0)
<enter>
Wait until the colour screen is complete. Game will begin immediately

Rules: The object of this game is very simple- to pack the falling blocks as efficiently as possible. Move and rotate the blocks by using the numeric keypad like this:

	↑8	
4←	5	→6
	↓2	

Drop them with INS, DEL or SPACE. ENTER increases the speed. If you dislike beeps, press 'B". You get more points the faster you are. Every filled layer gives an extra bonus.

When the game is over, record the level, score, and bonus.
Press any key to continue.
Press <enter>
Do you want to play again? (y/n)

Address: Max Shapiro $10
Beckombergav 5/2415
S-16153 Bromma
Sweden

DRIVING RETRAINING RESEARCH PROJECT

PHYSICAL RETRAINING PROGRAM

The physical retraining for both the visual attention and visual-perception group will proceed as follows:

- to be administered during the last 4 retraining sessions
- take approximately 15 minutes
- consist of training using the (a) Reaction timer, and (b) the B.T.E. Simulator using tool #802 and 131.

REACTION TIMER

The subject will have three (3) trials on the Reaction Timer using his/her RLE. For those subjects whose RLE are affected, also train the LLE.

The procedure is exactly the same as that used during the initial evaluation.

BTE

Attachment #131 is used to simulate the turning of a steering wheel.

Attachment #802 with the flat pedal attached to the lateral handle is used to simulate pressing on a foot pedal in a car.

The procedure for using the B.T.E. is as follows:

- ensure that date (6 digits) and time (4 digits) have been entered into the machine
- adjust the height of the exercise head
- set RATCHET position
- set TORQUE
- begin exercise
- continue exercise for each attachment for a total of 180 seconds

<u>Steering</u> #131

Subjects should be comfortably seated on a chair without armrests.

Set **MANUAL MODE**

Set **DYNAMIC**

Adjust the exercise head so that it is positioned at #4 as indicated on right side of exercise head. The height of the exercise head should be adjusted such that the subject's shoulders are relaxed and elbows are flexed to approximately 115 degrees.

RATCHET position should be set to "**OFF**".

TORQUE should be set to **18**.

MOVEMENTS should be small alternating clockwise and counterclockwise for 1000 degrees. After approximately 1000 degrees, the steering wheel should be turned approximately 360 degrees using hands (cross over style). For those subjects with the functional use of only one hand, the wheel should be turned with one hand using the spinner knob. Repeat this pattern for 180 seconds, then press END TEST.

Steering #131

Adjust the exercise head so that it is positioned at a height of just less than 27 inches as indicated on the B.T.E. pedestal and at #3 normal position.

RATCHET position should be set to "**CW**" when using **RLE**, and "**CCW**" when using **LLE**. Train the LLE when the subject's right side is affected.

TORQUE should be set to **72**.

MOVEMENTS should be from the "stopper" (#001) [placed in the exercise head at location #6 for RLE and #7 for LLE] to a point where the subject extends his/her knee as far away from the chair as possible. This should be repeated for 180 seconds.

APPENDIX 4: EVALUATION MATERIALS

DRIVING RETRAINING RESEARCH PROJECT
BACKGROUND INFORMATION

Study Number____________ Inpatient ☐ Outpatient ☐
Hospital Number__________ Strata________
Date ____________________ Group________

GENERAL INFORMATION

Date of Birth: ____/____/____ (y m d)

Date of Stroke: ____/____/____ (y m d)

Date of Admission (inpt): ____/____/____ (y m d)

Date of Discharge (inpt): ____/____/____ (y m d)

Date of Initial Evaluation: ____/____/____ (y m d)

Date of Final Training: ____/____/____ (y m d)

Length of Hospitalization: acute: _______days
rehabilitation _______days

Gender:	Male ☐	Female ☐	
Languages Spoken:	French ☐	English ☐	Other ☐
Diagnosis:	L-CVA ☐	R-CVA ☐	
Previous Stroke:	No ☐	Yes ☐	
Side:	L-CVA ☐	R-CVA ☐	

Prior to your stroke, which hand did you use for the majority of your daily activities?
Avant votre ACV quelle main utilisiez-vous pour faire la plupart de vos activités quotidiennes?

Left ☐ Right ☐

MEDICAL STATUS

Comorbidity Questionnaire: score ☐
subject score ☐

Medications (initial session) ______________________________

Medications (final session) ______________________________

Initial Presentation

Type of stroke:
- subarachnoid hemorrhage ☐
- intra-cerebral hemorrhage ☐
- other intra-cranial hemorrhage ☐
- occlusion of precerebral artery ☐
- occlusion of cerebral artery ☐

Location:______________________________

Visual System: Acuity______________
Visual Fields________

FUNCTION

Pfeiffer Cognitive Score : ☐

FIM score ☐

Date of FIM: ____/____/____
y m d

REHABILITATION THERAPY

Number of sessions per week:
- Occupational Therapy ☐
- Psychology ☐
- Physical Therapy ☐

DRIVING HISTORY

How many years have you been driving? ☐
Depuis combien d'années conduisez-vous?

At what age did you start driving? ☐
A quel âge avez-vous commencé à conduire?

In the month before your stroke, were you driving? Yes ☐ No ☐
Un mois avant votre ACV, conduisiez-vous?

If not, when did you last drive? ____/____/____
Si non, quand avez-vous conduit pour la dernière fois? y m d

Prior to your stroke, how many days per week did you drive?
Avant votre ACV, combien de jours par semaine conduisiez-vous?

5-7 ☐ 3-4 ☐ 1-2 ☐ <1 ☐

Before your stroke did you drive to go to :
Avant votre ACV conduisiez-vous pour aller:

	Yes	No	—
Work	☐	☐	Au travail
School	☐	☐	A l'école
Shopping	☐	☐	Magasiner
Recreation/leisure	☐	☐	A vos activités de loisirs
Other	☐	☐	Autres
Total	☐	☐	Total

How important is it to you to resume driving?
Est-ce que c'est important pour vous de recommencer à conduire?

Extremely	☐	☐	Enormement
Quite a bit	☐	☐	Beacoup
Moderately	☐	☐	Moyennement
Slightly	☐	☐	Un peu
Not at all	☐	☐	Pas de tout

If you drove today do you think you would be:
Si vous deviez conduire aujourd'hui,croyez- vous que vous seriez:

A very good driver	☐	Un très bon conducteur
A good driver	☐	Un bon conducteur
Not a good driver	☐	Pas un bon conducteur

JEWISH REHABILITATION HOSPITAL ROAD EVALUATION FORM

5-Adequate and secure
4-Adequate after correction
3-Acceptable but makes errors
2-Requires training & re-evaluation
1-Unable

Date:______________________ File:______________________________
Name:______________________ Permit No.:_________________________
Class:______ Conditions:______________________________________
( ) automatic ( ) standard

DESCRIPTION	SCORE	COMMENTS
Use of controls:		
Start the motor		
Use: signal indicators hazard indicator windshield wipers		
Control the steering wheel: without adaptation with adaptation		
Use: gear shift brake pedal gas pedal hand control left accelerator		
Manoeuvres:		
Go in reverse		
Parallel parking		
Drive straight		
Turn right		
Turn left		
Signal your intentions		
Follow the road		
Lane changes and passing		
Positioning car in the lane		
Leave adequate space between cars		
Stops at intersections		
Enter/exit traffic		
Highway driving: enter/pass/exit		
Adjust speed as needed		
General performance		
Specific Skills:		
Visual exploration		
Blind spots		
Interpreting road signs		
Observe law and regulations		
Adjust to adverse conditions		
Ability to anticipate		
Reaction time		
General Skills:		
Decision making: vision/analysis/decision		
Ability to learn		
Visual-perception		
Planning ability		
Attention/concentration		
Tolerance to effort (mental/physical)		
Behaviour		
Self correction		

Comment(s): _________
Adaptations: _________
Translated 12/97 Signature:____

UFOV (USEFUL FIELD OF VIEW)

DIRECTIONS FOR TEST ADMINISTRATION

N.B. *****Position the eyes at the level of the center of the screen. Chin must remain in chin rest and forehead must be against the top of the bar.
*****Glasses may or may not be worn. (should be worn if they are normally worn for driving)
*****Remind subjects that it is common for most people to feel that they are not doing well and that they may in fact be doing very well. Repeat that mistakes are common and expected.
*****Encourage guessing.

Turn on UFOV by pressing switch up (light on switch is always on). Switch on monitor and printer. After several messages 'UFOV' will appear on the screen.

To scan the options, use the <u>Tab</u> key.
To make a selection press <u>Enter.</u>

Select <u>TRAINING/SCREENING</u> option.
Select <u>NEW CLIENT</u> option.

Enter Biographical Data:

1. First name
2. Last name
3. SSN - 9 digit study number
4. Birthdate (MMDDYY)

Verify data and press <u>Y</u>.
Select <u>STANDARD SCREENING PROTOCOL</u>.
Select <u>FULL SCORE</u>.
Select <u>YES</u> for a hard copy of the results.
Select <u>YES</u> for a detailed error printout.
(To return to program while in DOS, type EXIT.)

Slide keyboard back in and close cover

ORIENTATION

You are going to be asked to do different tasks. For every task I'll show you what to do and then you'll have a chance to practice.
Don't get worried when you can't find what you're supposed to see. We will be looking for the point at which you are unable to answer the questions correctly. Everyone reaches this point.

TEST I

DEMONSTRATION
Press the red box on the screen.

Sit forward and place your chin in the chin rest until I tell you to sit back and relax. Notice the white box in the center of the screen. Keep your eyes focused on what is in the center of the box.
You will need to respond as to what you see in the center of the box. It will be either a car or a truck. This is what our car looks like.

Press Proceed.

To respond you should touch the screen like this (demonstrate using index finger)
Make sure to touch the screen using only the tip of your finger.
This is what our truck looks like.
Everytime you see the white box (Press proceed) **this busy picture will flash on the screen. Ignore it, and focus only on what was in the box.**
Now please touch either the car or the truck to indicate what you just saw in the white box.
Are you comfortable with touching the screen?

If response is "YES", proceed to the next instruction.
If response is "NO", say the following: "**Would you prefer telling me your answer and I could touch the screen for you?"** (proceed)

Now you'll have a chance to practice this 4 times.
Remember to focus on what you see in the center of the white box. It will flash very quickly.

PRACTICE
Press the red box.

What was inside the white box?

Repeat the question after each trial, if necessary.

After practice session when Options appear on the screen say: **You can take as much time as you need to answer but as soon as you answer the next white box will flash on the screen.**
Do you want to practice some more?
Once we start the white box will flash quicker and quicker. Everyone reaches a point where they can no longer see what's on the screen.
Are you ready?

TEST
Press more practice or begin test.

Press the red box.

Proceed with test 1.

TEST II

Now you are going to see something a little different, again the most important thing is that you keep your eyes focused in the center of the white box.
This task will be like the one you just did but I'm going to add something to it.

DEMONSTRATION
Press the red box.

First you will have to identify whether you saw the car or truck in the white box. Notice, there is a car somewhere else on the screen outside of the white box. You are going to touch the screen where you saw the car.

Press Proceed.

What was inside the box?
Now, touch the line on the screen that indicates where you saw the car that was presented outside of the white box. Do not touch the red area.

(2nd demo)
It is most important that you identify what you saw in the white box.

Press Proceed.

What was inside the white box?
On which line did you see the car outside of the white box?

Repeat the questions after each trial, if necessary.

PRACTICE
Press the red box.
After practice session, when options appear on the screen say: **Do you want to practice some more or are you ready to begin?**

Press more practice or begin test.

The section will get harder and harder. Everyone reaches a point where they can no longer see what's on the screen.

Are you ready?

TEST
Press the red box.
Proceed with test 2.
Press the red box to begin the next set of trials, if necessary.

TEST III

This is the last and hardest task. It is like the last one, but there will also be clutter on the screen.

DEMONSTRATION

Press the red box.

First you will have to identify whether you saw a car or truck in the white box. Then you will have to touch the line to indicate where you saw the car that was outside of the box.
You may find it more difficult to notice where this car is because of all the clutter.

Press Proceed.

What was inside the box?
Now, touch the line on the screen that indicates where you saw the car that was outside of the white box.
Remember that it is most important to focus on what is in the white box.

(2nd demo)
Press Proceed.
Repeat the questions after each trial, if necessary.

What was inside the white box?
On which line did you see the car outside of the white box?

PRACTICE

Press the red box.
Repeat the questions after each trial, if necessary.
After practice session when options appear on the screen say: **Do you want to practice some more or are you ready to begin?**

Press more practice or begin test.

The section will get harder and harder. Everyone reaches a point where they can no longer see what's on the screen.
Are you ready?

TEST

Press the red box.
Proceed with test 3.
Press red box to begin next set of trials if necessary.

UFOV (USEFUL FIELD OF VIEW)

DIRECTIVES POUR L'ADMINISTRATION DU TEST

N.B. *Position the eyes at the level of the center of the screen. Chin must remain in chin rest and forehead must be against the top of the bar.
*Glasses may or may not be worn. (should be worn if they are normally worn for driving)
*Remind subjects that it is common for most people to feel that they are not doing well and that they may in fact be doing very well. Repeat that mistakes are common and expected.
*Encourage guessing.

Turn on UFOV by pressing switch up (light on switch is always on). Switch on monitor and printer. After several messages 'UFOV' will appear on the screen.

To scan the options, use the Tab key.
To make a selection press Enter.

Select TRAINING/SCREENING option.
Select NEW CLIENT option.

Enter Biographical Data:

1. First name
2. Last name
3. SSN - 9 digit study number
4. Birthdate (MMDDYY)

Verify data and press Y.
Select STANDARD SCREENING PROTOCOL.
Select FULL SCORE.
Select YES for a hard copy of the results.
Select YES for a detailed error printout.
(To return to program while in DOS, type EXIT.)

Slide keyboard back in and close cover

ORIENTATION

Nous allons vous demander de faire différentes tâches. Pour chaque tâche, je vais vous montrer ce qu'il faut faire et vous aurez alors une chance de pratiquer. Ne vous inquiétez pas lorsque vous ne pouvez trouver ce que vous devez voir. Nous voulons trouver le niveau auquel vous n'êtes plus capable de répondre correctement aux questions. Tout le monde atteint ce niveau.

TEST I

DÉMONSTRATION
Press the red box on the screen.

Asseyez-vous en avant sur la chaise et placez votre menton sur le porte-menton jusqu'au moment ou je vous indiquerai de vous rasseoir et de vous reposer.
Notez la boite blanche au centre de l'écran. Maintenez votre concentration sur ce qu'il y a au centre de la boite.
Vous devrez répondre en indiquant ce que vous voyez au centre de la boite. Ce sera soit une auto ou un camion. Voici a quoi ressemble une auto.

Press <u>Proceed</u>.

Pour répondre vous devez toucher l'écran comme ceci (demonstrate using index finger).
Assurez-vous de toucher l'écran en utilisant uniquement le bout du doigt.
Voici a quoi ressemble le camion.
A chaque fois que vous voyez la boite blanche (Press <u>proceed</u>) **cet écran très chargé apparaîtra rapidement tout de suite après. Ignorez-le et concentrez-vous seulement sur ce qui était dans la boite.**
Maintenant touchez soit l'auto ou le camion pour indiquer lequel vous venez tout juste de voir dans la boite blanche.
Êtes-vous à l'aise pour toucher l'écran?

If response is "YES", proceed to the next instruction.
If response is "NO", say the following: **"Préfériez-vous me dire votre réponse et que je touche l'écran pour vous?"** (proceed)

Vous allez maintenant avoir la chance de pratiquer ceci 4 fois.
Souvenez-vous de vous concentrer sur ce que vous voyez au centre de la boite blanche. Ca va apparaître très rapidement.

<u>PRACTICE</u>
Press the <u>red box</u>.

Qu'y avait-il a l'intérieur de la boite blanche?

Repeat the question after each trial, if necessary.

After practice session when Options appear on the screen say: **Vous pouvez prendre tout votre temps pour répondre mais aussitôt que vous aurez répondu, la prochaine boite blanche apparaîtra sur l'écran.**
Voulez-vous pratiquer davantage?
Une fois que nous allons commencer, la boite blanche apparaîtra de plus en plus rapidement. Tout le monde atteint un niveau ou ils ne peuvent plus voir ce qu'il y a à l'écran.
Êtes-vous prêt?

TEST II

Maintenant vous allez voir quelque chose d'un peu différent. Encore une fois, le plus important est de vous concentrer sur le centre de la boite blanche.
Cette tâche sera similaire à celle que vous venez juste de faire mais je vais y ajouter quelque chose de nouveau.

DEMONSTRATION
Press the red box.

Premièrement vous devrez identifier si vous avez vu une auto ou un camion dans la boite blanche.
Remarquez qu'il y a une auto ailleurs sur l'écran à l'extérieur de la boite blanche.
Vous allez toucher l'écran où vous avez vu l'auto.

Press Proceed.

Qu'y avait-il à l'intérieur de la boite?
Maintenant touchez la ligne sur l'écran qui correspond à où vous avez vu l'auto qui était présentée à l'extérieur de la boite blanche. Ne toucher pas la section rouge.

(2nd demo)
Il est très important que vous identifier ce que vous avez vu dans la boite blanche.

Press Proceed.

Qu'y avait-il dans la boite blanche?
Sur quelle ligne avez-vous vu l'auto à l'extérieur de la boite blanche?

Repeat the questions after each trial, if necessary.

PRACTICE
Press the red box.
After practice session, when options appear on the screen say: **Voulez-vous pratiquer davantage ou êtes-vous prêt à commencer?**

Press more practice or begin test.

Cette tâche deviendra de plus en plus difficile. Tout le monde atteint un niveau ou ils ne peuvent plus voir ce qu'il y a sur l'écran.
Êtes-vous prêt?

TEST III

Cette tâche est la dernière et la plus difficile. Elle est similaire à la dernière sauf qu'en plus l'écran sera encombré.

DÉMONSTRATION
Press the red box.

Premièrement vous devrez identifier si vous avez vu une auto ou un camion dans la boite blanche.
Ensuite vous devrez toucher la ligne afin d'indiquer où vous avez vu la voiture qui était à l'extérieur de la boite.
Vous pouvez trouver l'auto plus difficile à localiser à cause de l'encombrement sur l'écran.

Press Proceed.

Qu'y avait-il à l'intérieur de la boite?
Maintenant touchez la ligne sur l'écran qui indique où vous avez vu l'auto qui était à l'extérieur de la boite blanche.
Souvenez-vous qu'il est très important de se concentrer sur ce qui est à l'intérieur de la boite blanche.

(2nd demo)
Press Proceed.
Repeat the questions after each trial, if necessary.

Qu'y avait-il à l'intérieur de la boite blanche?
Sur quelle ligne avez-vous vu l'auto à l'extérieur de la boite blanche?

PRACTICE
Press the red box.
Repeat the questions after each trial, if necessary.
After practice session when options appear on the screen say: **Voulez-vous pratiquer davantage ou êtes-vous prêt à commencer?**
Press more practice or begin test.

Cette tâche deviendra de plus en plus difficile. Tout le monde atteint un niveau ou ils ne peuvent plus voir ce qu'il y a sur l'écran.
Êtes-vous prêt?

DRIVING RETRAINING RESEARCH PROJECT

PERCEPTUAL TESTING INSTRUCTIONS

Reaction Timer

Here is the gas, and the brake is higher up.*(INDICATE*)

When I turn the machine on and you press on the gas, the green light will light up. You have to pay attention *(INDICATE)* to the lights for your instructions.

If the red light lights up, you have to move your foot from the gas, press on the brake hard enough so that the light turns off. Once the red light is off you go back to the gas. If the orange light on the right hand side lights up, you have to turn the steering wheel to the right, enough so that the light turns off. If the orange light on the left-hand side lights up, turn the steering wheel to the left, enough so that the light turns off. You don't have to press on the brake when you are turning the steering wheel. It's different than a car.

It is important that you react to the lights as quickly as you can, because there is a clock on the side *(INDICATE)* that keeps track of the time that it takes you to react. We will be doing it a few times so you will have a chance to get used to the machine. <u>1ST trial</u>.

***Go**.*

<u>2nd trial</u>. Now we will do it again. Now that you that you know how the machine works, I want you to try and do it a little quicker.

Go.

<u>3rd trial</u>

***Go**.*

Prior to doing the paper and pencil tests the following instructions should be given:

The rest of the tests that we are going to do are timed. It is important that you work as quickly as you can, but also pay attention not to make too many mistakes. In other words, both speed and accuracy are important. I am going to give you the test results when we meet again next time.

MVPT

Place the book directly in front of the client.

For this test, I am going to be the one to turn the pages *(example)*. Can you tell me how many objects you see on the page?

Then go to directions on scoring sheet.

On the examples, show the correct response. Repeat directions if the subject does not seem to comprehend. If unable to do the task, go to the next section.

Single Letter Cancellation

You are going to have to do some writing. I am going to place this in front of you. What you have to do is look at the letters, and every time you find the letter **H** you have to cross it out. I want you to cross out all the **H**'s you can find as quickly as you can. ***Go.***

Stop clock and remove test when scanning is complete.

Double Letter Cancellation

Now we are going to do something that is similar to the last test but a little more difficult. This time what you have to do is look for the letter **C** and **E** and every time you find the letter C and the letter E, you have to cross it out. Cross out all the **C**'s and **E**'s that you can find as quickly as possible.

Go.

Money Road Map

Here we are going to pretend that you are a car. I am going to show you your route. For example, if we start here (*use red pen, show example)* you are going straight, you come to a corner and you have to turn. Is that a left or right turn? *(continue with example).*

If you have difficulty speaking, you can show me with your hand, left or right, whatever you are more comfortable with.

Now we are going to do the same thing. I am going to time it. And we will start from here. *(Indicate)*

Subjects cannot use their finger to follow the path. Subjects cannot move or turn their bodies on their chair.

Trial Making A

Here we have numbers. What you have to do is attach the numbers in the proper order. For example, we attach the first number to the second, third, fourth. Can you complete the example for me? That's right. Now you can do the same thing. There will be more numbers.

You are going to start with number one and attach the numbers as quickly as you can.

Go.

Trial Making B

This test is similar but a little more difficult to the one you just did. Here we have both numbers and letters. What you have to do is alternate number, letter, number, letter, but you have to keep the correct sequence. For example, you would attach the first number to the first letter, second number, second letter. Complete the example.

That's right. *(Test sheet)* You are going to do the same thing. There will just be more numbers and more letters. Do it as quickly as you can, starting with number one. ***Go.***

Bell's Test

In a moment, *(show sample sheet)* I am going to give you a page that has the same objects as these except that they are smaller and there are more of them. What you have to do is every time you find a bell you have to circle it. The object is to find all the bells and circle them as quickly as you can *(position test sheet).* Wait until I say start, I am going to give you the red pen to use so it will be easier for you to see what you have already found.

Go.

(If subject has not found all the Bells, allow for a single verbal cue).

Are you sure you found them all?

Wait until subject stops scanning, to a maximum of 6 minutes.

Charron Test

What you have to do is look at what there is on either side of the lines *(indicate).* If what you see is the same, you do nothing. If the two drawings or numbers in each pair are different, you make a check mark *(demonstrate)* on the line. Do that as quickly as you can. ***Go.***

DRIVING RETRAINING RESEARCH PROJECT

PERCEPTUAL TESTING INSTRUCTIONS - FRANÇAIS

Reaction Timer

Voici l'accélérateur, le frein est un peu plus haut. *(INDICATE)*

Lorsque je vais allumer la machine et que vous allez peser sur l'accélérateur, la lumière verte va s'allumer. Vous devez observer les lumières attentivement. *(INDICATE).* Elles vont vous indiquer ce que vous devez faire.

Lorsque la lumière rouge s'allume, vous devez retirer votre pied de l'accélérateur et freiner suffisamment pour que la lumière s'éteigne. Lorsque la lumière rouge s'éteind, vous devez retourner à l'accélérateur.

Si la lumière orange s'allume sur le côté droit, vous devez tourner le volant vers la droite, suffisamment pour que la lumière s'éteigne. Si la lumière orange s'allume sur le côté gauche, vous devez tourner le volant vers la gauche, suffisamment pour que la lumière s'éteigne. Vous n'avez pas à freiner lorsque vous tourner le volant. Ce n'est pas comme une voiture.

Il est important que vous réagissiez aussi rapidement que possible aux lumières parce qu'il y a une horloge sur le côté *(INDICATE)* qui enregistre le temps qu'il vous prend pour réagir. Nous allons pratiquer plusieurs fois . Vous allez avoir la chance de vous familiariser avec la machine.

1ST trial.

***Go*.**

2nd trial. Nous allons maintenant le refaire. Puisque vous savez maintenant comment fonctionne la machine, essayez réagir un peu plus vite.

Go.

3rd trial

***Go*.**

Prior to administering the paper and pencil tests the following instructions should be given:

Les tests que nous allons faire maintenant vont être chronométrés. Vous devez travailler le plus rapidement possible mais aussi porter attention à ne pas faire trop d'erreurs. En d'autres mots, la vitesse et la précision sont importantes. La prochaine fois que nous allons nous revoir, je vais vous donner les résultats des tests.

MVPT

Place the book directly in front of the client.

Pour ce test, c'est moi qui vais tourner les pages (example). Pouvez-vous me dire combien d'objets il y a sur cette page?

Then go to directions on scoring sheet.

On the examples, show the correct response. Repeat directions if the subject does not seem to comprehend. If unable to do the task, go to the next section.

Single Letter Cancellation

Je vais placer cette feuille devant vous. Vous devez regarder ces lettres et chaque fois que vous trouver la lettre **H** vous devez la barrer. Vous devez barrer tous les **H** que vous allez trouver le plus vite possible.

Go.

Stop clock and remove test when scanning is complete.

Double Letter Cancellation

Maintenant nous allons faire quelque chose semblable au test précédant mais un peu plus difficile. Vous devez trouver les lettres **C** et E et chaque fois que vous trouvez les lettres C et E ,vous devez les barrer. Barrer tous les C et E que vous pouvez trouver, le plus vite possible.

Go.

Money Road Map

Nous allons maintenant supposer que vous êtes une voiture et je vais vous montrer votre route. Par exemple, nous commençons ici, *(use red pen, show*

example) vous allez tout droit, vous arrivez à une intersection et vous devez tourner. Devez-vous tourner à droite ou à gauche?
(continue with example)
Si vous avez de la difficulté à vous exprimer, vous pouvez m'indiquer le chemin avec votre main gauche ou droite, celle avec qui vous êtes le plus confortable.
Nous allons maintenant faire la même chose . Je vais vous chronométrer. Nous allons commencer ici. *(Indicate)*
Subjects cannot use their finger to follow the path. Subjects cannot move or turn their bodies on their chair.

Trial Making A

Maintenant nous avons des chiffres. Vous devez relier les chiffres dans le bon ordre. Par exemple, on relie le chiffre 1 au deuxième, troisième, quatrième... Pouvez-vous compléter cet exemple? C'est bien. Maintenant vous allez faire la même chose mais il y aura plus de chiffres.
Commencez par le numéro 1 et continuer à relier les chiffres, le plus vite possible.
Go.

Trial Making B

Ce test est semblable au test précédant mais il est un peu plus difficile. Nous avons ici des chiffres et des lettres. Vous devez relier les chiffres et les lettres en alternant chiffre-lettre-chiffre toujours en gardant la bonne séquence. Par exemple, on relie le chiffre 1 à la première lettre, le chiffre 2 à la deuxième lettre. Pouvez-vous completer l'exemple.?
C'est bien *(Test Sheet).* Vous allez maintenant faire la même chose sauf qu'il y a plus de chiffres et de lettres. Commencez par le chiffre 1 et continuer le plus vite possible.
Go.

Bell's Test

Dans un instant *(show sample sheet)* je vais vous donner une autre feuille avec les mêmes objets que ceux-ci sauf qu'ils seront plus petits et plus nombreux. A chaque fois que vous voyez une cloche, vous devez l'encercler. Le but de ce test est d'encercler toutes les cloches trouvées, le plus vite possible *(position test sheet).* Attendez avant de commencer. Vous allez utiliser ce crayon rouge pour vous aider à voir les cloches que vous trouvez.

Go.

(If subject has not found all the Bells, allow for a single verbal cue).

Êtes-vous certain d'avoir trouvé toutes les cloches?

Wait until subject stops scanning, to a maximum of 6 minutes.

Charron Test

Vous devez regarder ce qu'il y a de chaque côte de ces lignes *(indicate)*. Si ce vous voyez est identique, ne faites rien. Si les deux dessins ou nombres dans chaque paire sont différents, cochez, (*demonstrate*) la ligne pointillée. Travailler le plus vite possible.

Go.