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Improving Driving-Ability after Stroke

A scoping review of interventions within occupational therapy

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Review Article

Improving Driving-Ability after Stroke: A scoping review of interventions within occupational therapy.

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Abstract

Stroke is a leading cause of disability in the world and cognitive impairments post stroke are common. Driving is an occupation of great importance to many individuals and enables participation in society but due to cognition deficits after stroke it can be a difficult task to perform adequately. The aim of this study was to review and map interventions used to improve driving ability after stroke within occupational therapy practice. A literature search was conducted using Arksey and O'Malley's six-stage framework [1], and a search was made in four different databases. Seven articles were found and used for further analysing. Results showed two main categories of interventions. Task-specific training consisting of either simulator-based training or behind the wheel training in real traffic, and training of raw cognitive functions focused on driving related abilities. Both interventions overall showed improvement of driving ability, with task specific training being somewhat superior. Considering the easy implementation possibilities, cognitive training with specific focus on driving skills could be used in current occupational therapy practices. Larger studies might prove task-specific training to be much more superior which can then motivate more simulator-based intervention possibilities. Future studies could also focus on improving self-awareness as a factor.

Key words: cognitive training, driving ability, simulator-based training, occupational therapy, task-specific training.

Word count: 5099

Introduction

Driving is an important occupation within the western culture, leading to independence and participation in society [2], which can be seen to promote occupational performance and health [3,4] However, due to cognitive deficits after stroke it can be a difficult task to perform adequately [5].

Stroke is one of the leading causes of disability worldwide [6]. With an aging population and advances in medicine leading to a decline of deaths due to stroke, cognitive impairments post stroke are increasing [7]. Cognitive impairments after stroke are common with a prevalence of up to 80% of all stroke patients [8], many of whom can be overlooked in the post stroke follow ups [9]. When looking at global cognitive functions in a longitudinal systematic review the majority of studies reported a decline in function for stroke patients, and standardized testing and continuous follow ups are needed [7].

In our daily lives, during our daily activities, you are constantly being exposed to a large amount of sensory information and because of the brains limited resources an effective way of structuring this information is necessary to be able to handle the environment you are in [10].

Cognition is an umbrella term for all mental processes in the brain requiring us to process information and using knowledge. All our daily activities require cognitive functions, just to be able to make a simple phone call you need to use perception, memory, motor planning and sustained attention. When faced with a brain damage impairment of cognitive function can often be the main obstacle in the performance of these activities [11].

Driving is one complex activity which requires a large amount of functions, both interaction of cognitive skills but also multisensory perception as well as motor abilities [12]. Different types of attention are required to maintain safe driving. Reacting to unpredictable events, ignore distractions and react to potential dangerous stimuli, and to keep focused on the driving task are examples of required attention in driving [13,14]. Studies have shown that attentional problems are a primary cause of risk within older drivers [15].

Executive function such as planning, making decisions and mental flexibility, as well as memory is also linked to a complex task such as driving [16]. Visou-spatial abilities can relate to the ability to estimate distances between cars, or other cues such as traffic lights in the environment [17]

Driving as an occupation

Within occupational therapy, the main focus and interest are the daily occupations of clients. Occupation is a broad term, and can be used for everything that individuals either need or want to participate in [18], and includes everything from self-care to productivity activities to leisure activities [19]. Driving can be assumed to be one of those activities, as it is important in many people's lives and a big part of the western culture as it can promote feelings of competence and social inclusion [2]. Being able to participate in the activities important to the individual is of great importance for a person's well-being [3], and promotes occupational performance and the health of the individual [4].

Occupational performance is a complex process, requiring the use of the individual's skills organized into appropriate patterns within the environment and task that is to be performed [20]. When one part of this process is changed, it leads to changes of the performance and the results. Performance capacity is dependent on both cognitive and physical abilities, and the abilities are trained every time we perform an activity [3]. Therefore a person's ability to perform everyday activities can be greatly impacted by perceptual and cognitive impairment [21], one of them being the ability to drive which many wish to resume after stroke [22]. Research shows that individuals with less ability to perform the activities wanted are less likely to be satisfied with their health compared to individuals being more active within their wanted occupations [23].

When comparing gaps in occupations before and after acquired brain injury in one study transportation (not only driving) was found to differ significantly with 99% of participants engaging in the occupation before and only 76% after [24]. Which also proves the hinder not being able to drive can be for stroke patients. Many stroke patients are not fit to drive. In a study with 104 participants with stroke it was found that the majority (61%) were judged as not immediately suitable for driving [5].

More than 60% of trips taken by older adults are made alone, and a loss of a driver's license is effecting mobility, sense of independence as well as quality of life [25]. It has been found that general health and well-being may be directly affected by inability to continue driving, leaving an increased risk of depression and social isolation [26]. Proving the importance of driving in many older adults' daily lives.

Medical requirements of driving

Driving comes with many responsibilities as accidents and unfitness to drive can have lethal consequences. Older people are statistically at higher risk of dying in a traffic accident [27].

The laws concerning driving and resuming to drive after stroke varies between countries, and in some countries there is no obligation put on physicians to report patients who are not medically fit to drive [2]. In the Swedish '*driving license law'* (körkortslagen) it states that any injury, disease or other medical condition that might affect your ability to drive has to be examined with regards to traffic safety, and physicians are obliged to report to the *Swedish Transport Agency* (Transportstyerelsen) if found that a patient is unfit to drive [28].

Driving ability and occupational therapy

Occupational therapists are internationally known as professionals within healthcare to be responsible for drivers screening and assessments, typically performing cognitive assessments before making decision about engaging in an on-road observation [16].

A Swedish survey sent to occupational therapists throughout the country indicates that the majority of respondents perform some assessments of driving ability, however, the methods used varied a great deal. Ranging from more general types of ADL assessments to basic cognitive screening assessments to more task specific assessments of the driving skill. Tests most performed are focusing predominantly on measuring attention, executive functions, as well as visuo-spatial functions [17]. Relating to aspects needed while driving. Research show difficulties in predicting ones driving ability and the tests correlations with on-road performance, indicating that the decision of fitness to drive shouldn't rely on one stand-alone test [29]. In general, tests of visuospatial functions are greatly correlated with on-road driving performance among drivers with brain damage [5,17,30].

Task specific tests with on-road assessments are sometimes used in combination with other assessments, which often make it possible to determine if cognitive impairments can be compensated for by the driver's experience [31].

Occupational therapists who include driving as an everyday activity in their assessments can within the healthcare provide a unique perspective of the issue that driving experts alone can't. Considering the complex cognitive demands of driving as well as the medical requirements for holding a license, appropriate assessments are necessary and developing official guidelines for occupational therapists should be put to focus [31].

A core concept within occupational therapy practice is to enable clients to participate in occupations meaningful to the individual [32]. Being able to drive is found to be important for many people in the western culture and being able to continue driving can be related to

quality of life, feeling of competence, and general well-being [2,26], and has been shown to be experienced as a big gap for patients comparing their lives before and after brain injury [24]. Leading to an interest for occupational therapists to work towards enabling driving as an activity for people post brain injury, within official regulations and safety requirements. Continued research is needed in the field of finding a accurate assessment method, but also to look into the possibilty to retrain important functions needed to be able to perform the activity in a safe way. Therefore, the aim of this study was to review and map interventions used to improve driving ability after stroke within occupational therapy practice.

Methods

To review and map available research within the subject a scoping study method was used. A scoping review is preferably used to summarize evidence within the chosen field and differs from a systematic review in the way that the quality of the studies are not taken into consideration and therefore can be a useful method within disciplines where RCT studies are not yet conducted, such as rehabilitation science [33]. Scoping reviews are most commonly used to show an overview of existing knowledge within the field, regardless of the quality. Therefore a formal methodological assessment is usually not made [34].

Arksey and O'Malley's [1] six-stage framework was used to structure the process of the study. It consists of: 1- identifying the research question, 2- identifying relevant studies, 3- study selection, 4-charting the data, 5- summarizing and reporting results, and 6- consultation. Last stage is optional and has not been used within this study.

Identifying the research question

Research questions as well as inclusion and exclusion criteria (Table 1) were formed guided by PCC (population, concept, context), as advised by Peters et al. [34]. What interventions intended to improve driving ability after stroke are presented in literature? For this thesis the *population* of interest are adults with cognitive impairments after stroke who wishes to resume driving. The *concept* that is being looked at is interventions used towards the goal of being able to drive with all needed legal criteria fulfilled. All interventions should be performed within the *context* of an occupational therapy setting or be able to relate to the occupational therapy setting.

[Insert Table 2]

Identifying relevant studies

Inclusion and exclusion criteria were formed within the PCC model. For studies to be included in the review its participants needed to be adults and had a stroke with cognitive impairments. The studies also needed to focus on interventions aiming to retrain driving ability in a stroke rehabilitation setting to be included. Studies with other population or aims were excluded for this review. Limits were also put regarding language, publication date, and availability. Texts needed to be available to obtain in full-text from open access or via Jönköping University, be written in English and be published 2005 or later to be included in the review. All included articles should also be scientifically written and published in a peer-reviewed scientific journal. Gray literature are often helpful within review studies, as much possible data aren't commercially published or reviewed, however it can also provide a challenge within the systematic search as it exists in many different formats [35], therefore it was excluded in this study.

Only electronic databases were used in the search, as well as reference lists from already identified relevant articles. Search was conducted in databases PubMed, AMED, PsychInfo and CINAHL. Different trial searches were made to try out the combination of search words and search strings leading to the decision of a wider search not to miss out of result of interest. The trial search also revealed the appropriate search words and MeSH terms frequently used in appropriate literature.

Search words used ended up being "Automobile driving" AND "Stroke", combined with "training" OR "learning" OR "rehabilitation" to make sure the article was focused on the training aspects as the trial search revealed many articles provided on the topic were related to assessments. The same search words and combination of them were used within all the databases.

[Insert Table 2]

Study selection

The literature search (Table 1) was made during spring of 2021. Selection was made first based on title, then abstract and then full text. All reference lists of already identified articles were then manually screened. Inclusion and exclusion criteria were applied within all stages of selection process. The selection process is presented in Figure 1.

[Insert Figure 1]

Charting the data

Data from selected articles were summarized and extracted as shown in Table 2. The Arksey and O'Malley [1] structure was used where authors, intervention type, study population, aims, methodology, outcome measures and important results are visible.

Summarizing and reporting results

The last stage was summarizing and reporting the results. An overview was conducted with key information from the studies. Two main categories of interventions related to the research question were found and used as a starting point for presenting the results. The research question was always in focus while reporting the results.

[Insert Table 3]

Ethical considerations

All the data used for this research have already been published and ethically approved. A conscious attempt was made to make sure the data was presented as transparently and as true to the original as possible. As the search and analysis was made by the author alone it is also of great importance to consider how that influences the results of the study. Bias can occur in

any stage of the research process and can mean that one result outcome is favoured over another [36]. Previous experiences from the author might interfere with the interpretation of the results [37]. In this case the author has experience with the field of assessing driving ability after stroke within work environment, but not with specific driving ability training programs which this thesis is about. A throughout understanding of how bias could influence the work is of importance before starting any study [36], and this was considered and reflected upon within all stages of current thesis.

Results

After process of screening collected data, seven studies remained, which looked at interventions aimed to improve driving ability. The most commonly used method of interventions was driving-simulator training [38–42]. Methods focused on cognitive aspects included Dynavision training [43], non-simulator based cognitive training [40,41], and training aimed to improve visual attention and processing skills [39] as well as behind-the-wheel training in a real life setting [44]. Driving simulator training was in some studies used as the primary intervention in the experimental group, with other types of cognitive training being the control group intervention [38,40,41]. Results is divided into two categories of interventions: task specific training, and cognitive functions training.

Overview of the studies can be seen in Table 3. Number of participants in the studies varied between 26 up to 83 for the interventions. Studies made in Europe, and more specifically in Belgium are overrepresented within the results [38–41].

Task specific training

Two different types of task specific training were used in the studies. Behind-the-wheel training in a real car setting with actual driving lessons was used as intervention in one study [44], however the most common task-specific intervention method used was simulator training [38–42].

In Söderström et al. study, 15 stroke patients who had previously failed a driving assessment were offered driving lessons for up to 12 hours in total, as well as a 2-hour lesson in traffic theory. After intervention period, 87% of them passed the on-road test. No significant changes were seen in the neuropsychological tests performed pre- and post interventions amongst the individuals after the intervention period, except for the variable of traffic knowledge [44]. In Akinwuntan et al. study an improvement was found both on on-road driving

as well as neuropsychological tests. In the study a comparison was made between one group receiving task specific training in the form of simulator-based training, and another group receiving driving related cognitive task training. Both groups received a total of 15 hours of training spread out over a period of five weeks. More participants from the simulator-based training group improved from "unfit to dive" to "fit to drive" compared to the cognitive training group, however the difference was not significant, and the cognitive group also improved. One significant difference was found, in advantage for simulator training group, in the "road sign recongnition test" [38]. A similar study was performed by Devos et al., also comparing 15 hours of simulator training with 15 hours cognitive training in their study and its effect on on-road assessment amongst stroke patients. Although both groups improved their driving ability after intervention period, the simulator training group did improve significantly more [40]. These advantages for simulator training over cognitive training were seen 6-months post intervention as well but had however faded at a 5-year follow up. More people from the simulator based training group passed the driving assessment compared to the cognitive training group, but the difference was not significant [41].

Simulator training was seen to improve braking time to avoid collision in Hitosugi et al. study, and a significant improvement of stroke patients reaction time was measured from pre to post training. The authors argue that the majority of the participants in their study would be assessed as being able to return to driving after simulator-based training [42].

Akinwuntan et al. [39] also studied the effects of simulator-based training versus cognitive training on UFOV (Useful field of view) test performance. UFOV being a test of visual attention designed to indicate likelihood of crashes, and often used in assessments of driving ability. All participants, both in the simulator-based training group (n=33) and in the cognitive training group (n=36) received 15 hours of training in total spread over 3 weeks. All participants got regular hospital rehabilitation as well. The simulator-based training group practiced driving skills, as well as specific simulator-based assignments aimed to improve visual attention and speed of processing skills. The cognitive group received similar training, outside of a simulator, focused on visual attention, and planning decision making, and executive reasoning skills. Assessments were made before, after, and again 3 months later. No significant difference was seen between the methods, however significant within group improvement from pre to post training was seen for both methods [39].

Cognitive functions training

As already presented above, cognitive training was often used as the control intervention to simulator training and improvements in the outcome measures were seen, however not as much as for simulator training [38,40,41].

In Devos et al. study [40] the participants in the cognitive training group played different commercially available games that involved specific cognitive skills related to driving, such as problem-solving, visuospatial abilities, non-verbal memory, planning ability, and decision making. Some of the games were traffic related and some were not. They were also provided with a route-finding task were participants needed to draw on paper and find the most efficient routes to assigned places. Participants in the cognitive training group improved on overall outcome measures, however compared to the simulator-based training group the improvement dropped significantly more on the 6-months follow up. Despite that, no significant difference between the groups were found in the five-year follow-up study [40,41].

Participants of Akinwuntan's study [38] received similar cognitive training tasks, such as route finding, memory training, and forming different patterns using tiles, as well as using cards with different traffic situations to train recognition of traffic signs. Participants in this group did improve their results in many of the outcome measures from pre- to post intervention and 12 out of 26 participants who were assessed as *unfit to drive* before intervention climbed up one step to *temporarily unfit to drive* at the post measure, showing the improvement [38].

Another of the studies looked more specifically at attention, visual scanning, and processing speed, which are important skills for driving, and aimed to evaluate the effectiveness of Dynavision which aspires to retrain these specific functions. The authors recruited 26 stroke patients that were randomly and equally placed in either dynavision training group or put on a waiting list, receiving no intervention. Dynavision training was performed according to manual, 3 times per week for six weeks. No significant difference was seen between the intervention group and the non-intervention group when tested on on-road driving six weeks later. However, although not statistically significant, a higher proportion of people in the intervention group passed (10/13 compared to 6/13 in the non-intervention group). Significant differences could be seen on secondary outcome test that specifically measured visual scanning ability, response, and reaction time [43].

Discussion

Results of this review showed that two main categories of interventions for improving driving ability were presented within the literature. Task specific training focusing on actual driving,

and cognitive training that aimed to focus on improving the raw cognitive functions needed for driving. Many of the studies compared the two methods to each other with varied results. Devos et al [40] presented a significant difference favourable for the simulator-based training compared to cognitive training on on-road driving ability, although similar previous study was unable to show the same [38]. A significant difference between the methods were seen six months post intervention but had disappeared at the five-year follow up [41]. No significant difference could be seen between the two categories of interventions in results on the UFOV measure either [39]. Simulator-based training did show significant improvement on braking and reaction time [42], and 87% of participants who had previously failed on-road assessment passed after taking driving lessons, although showing no significant difference on neuropsychological tests [44].

Although many of the studies failed to provide a significant difference between the two intervention methods when compared with one another, results of Söderström et al. study [44], which showed good results on on-road assessment after intervention but no difference in neuropsychological tests, shows the complexity of the activity. Due to its complexity it cannot always be linked to raw cognitive functions [44], and therefore also training raw cognitive functions might not have that much of a carryover effect to the actual activity compared to training the direct functional skills [40]. Crotty and George study [43] was unique in the way that they compared training of cognitive skills compared to no training at all, which showed no significant difference in the on-road assessment. Once again confirming the difficulty of transferability of cognitive training to practical scenarios [eg. 45]. To keep in mind is that the study was a small one (n=26), and a higher proportion of the intervention group did pass, but the difference was not significant [43]. With that said, results still did show improvement on on-road driving ability using just driving related cognitive training such as route finding, visuospatial abilities, planning ability and decision making [38,40,41], but not quite as much as the simulator training did. Devos et al. also showed in their five-year follow up study that the differences found immediately after interventions, as well as at six months post intervention, between simulator training and cognitive training could no longer be seen after five years [41]. Leading one to also want to investigate the cost-efficient part of these interventions. Simulator based training, or real driving training comes with a higher cost as well as other requirements [46,47] and can be difficult to motivate within the health care system.

Söderström et al. did in their study [44] conclude that a major important factor when it comes to successfully driving after stroke is a person’s awareness of their difficulties. Stating

that the cognitive impairments alone cannot predict a person's driving ability but rather how they deal with it. This is supported by other studies as well. In Patomella et al. study [48] it became obvious that there can be a large discrepancy between how the patient performed in driving tests and how they experienced it themselves. All participants in the study believed they had performed the driving well and safe, as well as being convinced they would pass a future retest although failing this one. This also leading to the participants questioning the competence of staff as well as feeling unjustly treated in the test situation [48]. Showing how complex both driving ability is, measuring it, as well as involving the patient in it, and take into consideration the law regulating it. Driving can often be an activity taken for granted, and when being questioned and stopped from driving although yet perceiving oneself to be a competent driver could often be a crisis and lead to occupational deprivation [48]. None of the studies included in this review had focused interventions on improving people's awareness, but this could be an interesting factor to take into consideration when working with driving rehabilitation, no matter what intervention is used. When being aware of one's cognitive deficits it is more likely to use compensatory strategies amongst people with brain injury [49,50], which could also mean being able to drive without affecting driving safety. If succeeding in making the patient aware the decision of not driving might not be as difficult to accept, as well as for improving driving ability it can be assumed to be of great importance to understand ones starting position.

Whether interventions on improving driving ability focuses on the raw cognitive functions or is task specific and focuses on driving either in simulator or in real traffic, it is important to have knowledge of what is being improved. Although this review is focused on interventions for improving driving ability it does go hand in hand with assessments of driving ability. On-road assessments are considered to be the 'real' measure for driving ability [51], however within health care it is more often measured with a number of neuropsychological tests [31]. Being that no neuropsychological tests can 100% predict driving ability it is also important to reflect upon if interventions used in rehabilitation are improving results of the tests or actual driving ability. Cognitive training focused on driving skills is however easy to implement in many rehabilitation settings and occupational therapy practices, without any large costs, and the intervention could still be supported based on these results. Most authors although did conclude that it is difficult to train raw cognitive functions and have it transfer to the complex task of driving. Larger studies might be able to statistically prove the difference between the methods that many of these studies failed to do, which also would more strongly motivate to offer task specific training with simulators in rehabilitation settings. Research

regarding self-awareness and interventions on improving it could also be interesting to look at and its effect on driving ability.

Results of this review showed improvement in driving ability using both intervention methods. Although limited results, this could be a guide in helping people after stroke being able to eventually get back to driving. Encouraging participation in meaningful activities important for a persons well-being [3]. Performance capacity is greatly dependent on cognitive and physical abilities [3], and if able to improve those abilites it would mean a positive change in occupational performance. People with less abilities to perform wanted activities are less satisfied with their health [23], once again showing the issues importance within occupational therapy and health care. The inability to drive has been shown to lead to an increased risk of depression and social isolation [26].

Methodological considerations

When conducting any study, it is of importance to consider the quality of it, which can be looked at from a trustworthiness perspective. Within this concept the terms *credibility, dependability, conformability, transferability,* and *authenticity* are used [52]. Elo et al have compiled a checklist for evaluating the trustworthiness of all the different phases of a study.

Method of choice for this study was to conduct a scoping review, which is relevant in regards to aim. The data received did address relevant information in relation to aim, which is important for the studys' *credibility* [52]. Self-awareness during the whole process of collection and coding is also important for *credibility* [52]. This study was made alone, and search words and databases chosen could be affected by bias which could also lead to intervention methods already suspected by the author and other methods missing out. However, the same intervention methods seem to be used amongst different countries as well as throughout a wide spread of years, which is good from a *dependability* perspective [52]. To help structure this review Arksey and O'Malleys' [1] framework was used, with the last stage of consulting experts taken out. The last step would've been a valuable improvement of the work and especially could've provided an opinion on the interventions found and how they are used within today's occupational therapy practice. Having someone to discuss with can often be positive for *conformability,* to make sure the results presented were accurate to the original [52].

Inexperience in researchers could also affect *authenticity,* and lead to a simplified presentation of the results found [52], once again showing benefits of having a consulting expert. *Transferability* refers to whether the results presented can be transferred to other settings [52], in this case the issue of driving ability and its complexity as well as intervention methods found could easily be transferred to other groups than stroke survivors as well. Similar methods of intervention could probably be used, therefore the results could be considered to have good transferability.

When setting the limitations of this thesis it was first considered to use references from the last ten years to make sure to use the latest evidence regarding the issue, however this was found to be too narrow while doing trial searches in the beginning and the decision was made to expand it. All the articles used for this review were published more than ten years ago which could be considered old in the field of research. This is a limitation of this review, that no newer references could be found, and more recent research would have been beneficial. This might be due to search terms or databases used but could also be due to lack of research within the subject. The author has experience with the issue of assessing driving ability after stroke, and years of experience of working with patients with stroke within different neurological rehabilitations centers in Sweden, where the question of driving and training process multiple times have been brought up both by patients, but also amongst health care staff. Showing that although the literature presented in research terms could be seen as old, it seems as if the issue and the implementation in everyday stroke rehabilitation is accurate and relevant. Having a within the field expert would however be beneficial to discuss this with. Including gray literature within the subject could also be beneficial.

Conclusion

The overall conclusion and findings of these studies is that driving ability is a very complex activity, requiring many different cognitive functions. Both methods of interventions did show improvement of driving ability, with task specific training being somewhat superior although often failed to provide a significant difference compared to cognitive training.

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Declaration of Interest

The author reports there are no competing interests to declare.

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Table 1. Overview of base for research question according to PCC model.

Population	Concept	Context
Adults with a previously obtained driving license with cognitive impairments due to stroke and will to resume driving	Interventions with the goal to improve driving ability.	Within occupational therapy/rehabilitation settings.

Table 2. Search history

Database	Number of hits	Screened abstract	Full Text assessed	Included
PubMed	135	31	10	4
AMED	32	9	1	0
CINAHL	100	15	3	1
PsychINFO	62	10	3	2

Table 3. Overview of the included studies.

Authors, **Year of Publication, Origin**	**Title**	**Keywords**	**Aim** and Intervention	**Participants**	**Key findings**
Devos et al (2009), Belgium	*Comparison of the effect of two driving retraining programs on On-Road performance after stroke*	*Stroke; Rehabilitation; Automobile driving; Driving simulator*	To examine the specific carryover effect of driving skills of a com- prehensive training program in a driving simulator when compared with a cognitive training program. RCT. Simulator training group vs cognitive training group. Outcome measure: On-Road + Neuropsychological tests.	n=83 with stroke	Overall improvement, more improvement in the driving simulator group. Most perceived differences were observed in 6 months post stroke.
Akinwuntan (2005), Belgium	*Effect of simulator training on driving after stroke*	Simulator training; drivin g; stroke; neuro logically impaired persons; driving ability	To investigate the effect of simulator-based training on driving after stroke. RCT, simulator training group vs cognitive training group. Outcome measure: On-Road + Neuropsychological tests.	n=83 with stroke	Experimental group significantly improved in most variables. Control subjects significantly improved their performance in many variables. Road signs were only significantly better after simulator training. Greater amount of positive transfer of learning when a skill is trained in a similar context to which is performed.

Devos et al (2010), Belgium	*Effect of simulator training on fitness to drive after stroke: A 5 year follow up of a randomized controlled trial*	automobile driving, stroke, randomized controlled trial	The authors' primary aim was to determine the effect of simulator versus cognitive rehabilitation therapy on fitness-to-drive at 5 years poststroke. A second aim was to investigate differences in clinical characteristics between stroke survivors who resumed and stopped driving. RCT. Follow-up study from previous study. 5-years. Simulator training vs cognitive training.	n=44 with stroke	60% of simulator group passed the fitness to drive,48% of the cognitive group passed the fitness to drive
Söderström et al (2006), Sweden	*Prediction of driving ability after stroke and the effect of behind-the-wheel training*	Stroke, neuropsychological tests, driving, training	The aim of the study was to examine the predictive value of a neuropsychological test battery relating to an on-the-road driving evaluation and to determine whether patients who failed the driving test could improve their driving through behind-the-wheel training. RCT. People with stroke compared to healthy controls, after receiving driving lessons.	n=34 with stroke and n=20 healthy controls.	Patients performed significantly less well compared with matched in the cognitive tests. About 50% both in stroke group and in control group failed the driving test. 15 stroke patients received driving practice at driving schools. As well as traffic theory lesson of 2 h. 13 of them (87%) passed the road test after the training period. No significant improvements were made in the cognitive tests except for the Traffic theory knowledge test, which had improved. Both groups mainly failed within areas related to attentional functions.

Akinwuntan (2010), Belgium	*Retraining moderately impaired stroke survivors in driving related visual attention skills*	Divided attention, driving simulation, selective attention, speed of processing, stroke, rehabilitation	Aim to investigate the effects of 2 training programs on performance on the Useful Field of Vision (UFOV). RCT. Simulator based training (driving+cognition - specific scenarios) vs non-simulator based cognitive training.	n=69 with stroke	UFOV was used as outcome measure. Measured before, after and after 3 months post training. No significant different between the groups, however significant within group improvements for all UFOV parameters. Improvements were retained after 3 months
Crotty (2009), Australia	*Retraining visual processing skills to improve driving ability after stroke*	Automobile driving, brain injuries, cerebrovascular accident, randomized clinical trial, rehabilitation	To evaluate the effectiveness of retraining using the Dynavision on driving performance of people with stroke. RCT. Dynavision training vs no training. Outcome measure: On-Road driving ability + other attention skills.	n=26 with stroke, referred for driving assessment.	More participants in the experimental group passed compared to the control group, although not significant. Significant difference in second outcome measure.
Hitosugi et al (2011), Japan	*Support for stroke patiens in resumption of driving: patient survey and driving simulator trial*	Automobile driving, rehabilitation, stroke, support, training	To investigate stroke patients perceived support and information given in medical care regarding driving after stroke, as well as investigating the effect of simulator training. Questionnaire to participants with stroke having received driving simulator training vs healthy controls.	n=24 with stroke, n=20 healthy controls.	Simulator training: increased ability to perform braking and an improvement in driving ability. With most likely to pass an on-road test.

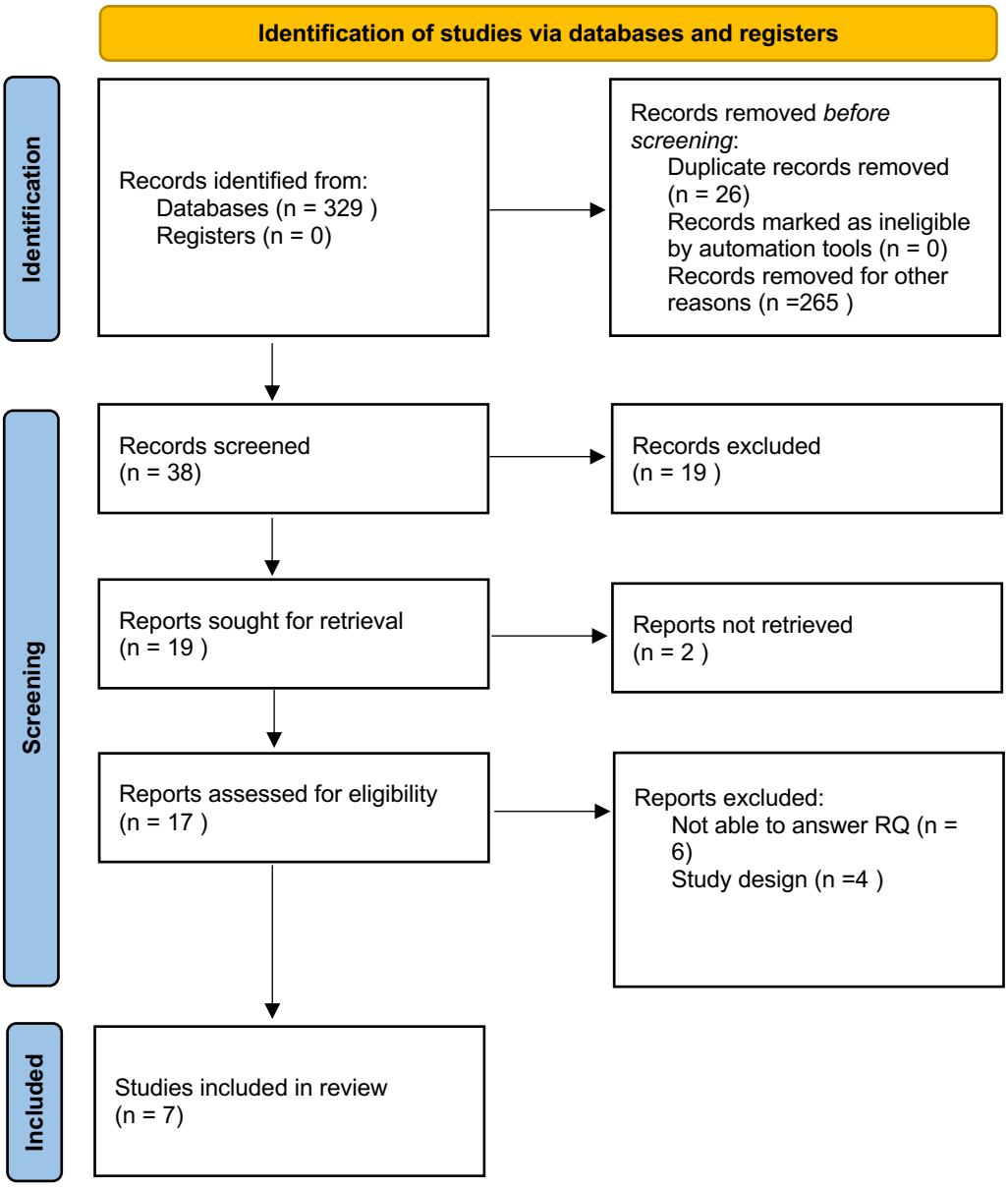

Figure 1. Overview of data selection process.

Clinical implications:

- Cognitive training focused on driving related task can help improve driving ability and can easily be implemented within the rehabilitation facilities.
- Considering the importance of driving as an occupation work could preferably be put towards trying to improve possibilities towards enabling task specific training either using a simulator or with corporation with driving schools
- Interventions aimed to increase self-awareness should be focused on when it comes to cognitive impairments and driving ability.