CHAPTER 3

Mobility Scooter Driving Ability In Visually Impaired Individuals

A version of this chapter has previously been published as Cordes, C., Heutink, J., Brookhuis, K.A., Brouwer, W.H., Melis-Dankers, B.J.M. (2018). Mobility scooter driving ability in visually impaired individuals. Disability and Rehabilitation, 40(12), 1372-1378
Abstract

Goal of this study was to investigate how well visually impaired individuals can learn to use mobility scooters and which parts of the driving task deserve special attention. For this purpose, a mobility scooter driving skill test was developed to compare driving skills (e.g., reverse driving, turning) between 48 visually impaired (very low visual acuity = 14, low visual acuity = 10, peripheral field defects = 11, combination of visual impairments = 13) and 37 normal-sighted controls without any prior experience with mobility scooters. Performance on this test was rated on a 3-point scale. Furthermore, the number of extra repetitions on the different elements were noted. Results showed that visually impaired participants were able to gain sufficient driving skills to be able to use mobility scooters. Participants with visual field defects combined with low visual acuity showed most problems learning different skills and needed more training. Reverse driving and stopping seemed to be most difficult. Concluding, the present findings suggest that visually impaired individuals are able to learn to drive mobility scooters. Mobility scooter allocators should be aware that these individuals might need more training on certain elements of the driving task.
Introduction

Mobility scooters are powered mobility devices that can enhance independent mobility in individuals with motor problems (Schepers, 2007). In Europe, Great Britain and the Netherlands are the leading countries with approximately 200,000 – 300,000 mobility scooter users. Mobility scooters have been shown to increase activities, community participation, and independent living of users, thereby preventing negative consequences of restricted mobility (Auger et al., 2008; Edwards & McCluskey, 2010). They are especially important for medium distances (1.0 – 7.5km) in daily life, for example to visit family and friends, to keep a doctor’s appointment, or to go shopping (Schepers, 2007).

Since mobility scooters are mainly used by elderly people, most users are likely to have more than just one health issue. Comorbid disorders other than motor impairment can influence the safe use of mobility scooters, and, depending on the seriousness of the comorbidity, they can even prevent individuals from driving them. Since the occurrence of visual impairment increases with age, visual impairment is a common comorbidity amongst elderly mobility scooter users. Visual impairment has been shown to influence the safe use of motor vehicles in fast traffic (e.g., cars). Therefore, legal standards of vision for driving have been introduced for the use of cars (visual acuity > 0.5, visual field > 120°), but in contrast, there are no such regulations for the use of mobility scooters in most countries. A driving licence is neither required. The absence of legal standards of vision for driving visual regulations for mobility scooters has advantages, since these vehicles are meant to support and optimise independent mobility (Letts et al., 1998). Not being able to use their mobility scooter might be detrimental for affected individuals (Oxley & Whelan, 2008), since restricted mobility is related to a lower quality of life (Carp, 1988; Ragland et al., 2005; Williams & Willmott, 2012). A disadvantage of the absence of standards of vision for driving a mobility scooter is that individuals with a visual impairment or professionals advising them may be uncertain about the question whether it is safe to participate in traffic. This uncertainty may lead to a dilemma for professionals: Advising or perhaps training the use of a mobility scooter for a visually impaired individual at the risk of decreasing traffic safety, or advising against the use of a mobility scooter at the risk of unnecessarily limiting a visually impaired individual’s independent mobility. For this reason it is important to study mobility scooter driving safety in visually impaired individuals.
When investigating driving safety, it is important to distinguish three concepts: fitness-to-drive, driving ability, and driving behaviour. Fitness-to-drive is defined as the medical requirements to learn and execute the driving task (e.g., visual, cognitive, or motor abilities). Low visual acuity, for example, can hinder drivers to read traffic sign; a paresis in one arm has consequences for steering a vehicle. Driving ability refers to the declarative and procedural knowledge of driving (e.g., operation of vehicle); in other words, a typical driving test for novice drivers focuses particularly on these elements to determine how well the driving task has been learned (Selander, 2012). Driving behaviour describes how a driver chooses to behave in a certain traffic situation (e.g., keeping or exceeding maximum speed, driving slower in busy traffic). Especially in mobility scooters, driving ability needs to be assessed in inexperienced drivers before deciding on the role of fitness-to-drive on driving safety. For people with impairments, failing to assess driving ability increases the risk of attributing difficulties to the impairment rather than to an underdeveloped driving ability and puts these people at disadvantage. Particularly the counterintuitive operation in mobility scooters (releasing the forward lever instead of actively pressing a lever to brake) makes training and assessment of driving ability necessary. This line of thought is illustrated by Schepers (2007), who reported that the main reasons for accidents in the Netherlands are precariously high speeds when driving around corners or mistakes in operation of the mobility scooters. These examples describe failures in driving ability or driving behaviour rather than inadequate fitness-to-drive. Accordingly, Nitz (2008) showed that more than half of the healthy novice mobility scooter drivers participating in her study had difficulties with at least one item, but improved after a number of training sessions.

In the public literature, no study has yet investigated driving ability in visually impaired individuals in mobility scooters. Due to their impairment, visually impaired individuals might need more training or specifically directed training; yet, there is no widely accepted approach in how to test and train mobility scooter driving ability in these individuals. Therefore, we performed an extensive experiment looking at different factors that are related to the driving safety of visually impaired individuals in mobility scooters. The present study specifically focussed on the driving ability by assessing how well visually impaired individuals are able to learn to use mobility scooters compared to a group of normal-sighted controls. To measure driving ability, a driving skill test that included a short instruction and
training of several driving skills was used. Furthermore, it was investigated which elements parts of the driving task deserve special attention in further training.

A number of studies have shown that anxiety can impact performance in mobility tasks (Fairclough, Tattersall, & Houston, 2006; Welsh, 2010; Wilson, Smith, Chattington, Ford, & Marple-Horvat, 2006). Especially visually impaired people are often reported to experience more anxiety than normal-sighted people in corresponding age groups (Zijlstra, Ballemands, & Kempen, 2012) which includes responding with distress and fear in (unknown) mobility situations (Welsh, 2010; Zijlstra et al., 2012). Previous driving experience in motor vehicles and experienced anxiety were therefore taken into account to explore the potential influence of these factors on driving performance.

Methods

Participants

Forty-eight visually impaired participants and 37 healthy controls took part in the experiment. Participants were divided into 5 different groups as described in Chapter 2, resulting in 14 participants with very low visual acuity, 10 participants

<table>
<thead>
<tr>
<th>Table 3.1. Participants’ characteristics</th>
<th>Visually impaired participants (n = 48)</th>
<th>Normal-sighted controls (n = 37)</th>
<th>Test statistic (df)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>17</td>
<td>14</td>
<td>t (83) = 0.236</td>
<td>0.814</td>
</tr>
<tr>
<td>Male</td>
<td>31</td>
<td>23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (mean year ± SD)</td>
<td>61 (± 7.7)</td>
<td>61 (± 6.0)</td>
<td>t (83) = 0.236</td>
<td>0.814</td>
</tr>
<tr>
<td>Distribution of educational level</td>
<td>0/2/0/3/14/22/7a</td>
<td>0/0/0/0/13/20/4</td>
<td>χ² (4) = 4.604</td>
<td>0.330</td>
</tr>
<tr>
<td>MMSEb (mean ± SD)</td>
<td>28.06 (± 1.72)</td>
<td>28.43 (± 1.39)</td>
<td>U = 797.5</td>
<td>0.412</td>
</tr>
<tr>
<td>Driving experience (mean year ± SD)</td>
<td>25 (± 14)</td>
<td>38 (± 10)</td>
<td>U = 357.5</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

a (1) Less than six years of primary education. (2) Finished six years primary education. (3) Six years primary education and less than two years of low level secondary education. (4) Four years of low level secondary education. (5) Four years of average level secondary education. (6) Five years of high level secondary education. (7) University degree.

b Mini Mental Status Examination, a screening tool for general cognitive functioning. A score below 24 indicates cognitive impairment.
with low visual acuity, 11 participants with peripheral field defects, 13 participants with a combination of visual impairments, and 27 normal-sighted controls. Visually impaired participants did not significantly differ from normal-sighted controls with regard to age, level of education (Spek & Velderman, 2013), and general cognitive functioning (Table 3.1). Normal-sighted controls had more driving experience with motorised vehicles than visually impaired participants. The experiment was approved by the Ethical Committee Psychology of the University of Groningen, the Netherlands, according to the Declaration of Helsinki. All participants provided written informed consent.

**Mobility scooter driving skill test**

The driving skill test took place in a relatively quiet part of the UMCG using the mobility scooter described in Chapter 2 and lasted approximately 15 minutes. It consisted of 15 elements that were based on the official national mobility scooter course developed by “Blijf Veilig Mobiel [Staying Mobile Safely]” (Van Baalen & Boerwinkel, 2011), a governmental supported national community of interest aiming for safe mobility in the Netherlands. It included elements such as driving straight ahead, reversing, accelerating, or stopping on time (Table 3.2). The elements “stopping”, “reversing around a corner”, and “driving through a narrow opening” were practiced more than once since these elements were described as challenging by mobility scooter experts. The internal consistency of the test as we created it was acceptable ($\alpha = 0.77$). All participants received a detailed explanation on the operation of the mobility scooter before they started the driving skill test. The participants were accompanied by an instructor and a trained research assistant who acted as an observer. For safety purposes, the instructor was equipped with a remote control to be able to stop the mobility scooter at any time.

**Evaluation**

The observer rated performance on each element of driving skill test on a 3-point scale (Van Baalen & Boerwinkel, 2011), representing good (1), satisfactory (2) and insufficient (3) performance (Table 3.2). For each individual, ratings of the first attempt were added to sum-scores representing overall performance. Sum-scores could range from 15 (best) to 45 (worst). During the training, the instructor was blind for the assistant’s evaluation. Extra practice of an element was given if the instructor was not convinced that performance was sufficient to continue to an on-road driving test at a later stage of this experiment or if the participant indicated
## Table 3.2. Elements and evaluation of the driving skill test (adopted and adapted from Van Baalen and Boerwinkel, published by Veilig Verkeer Nederland, 2011)

<table>
<thead>
<tr>
<th>Element</th>
<th>Content</th>
<th>Evaluation</th>
</tr>
</thead>
</table>
| Explanation operation    | Participants were asked to repeat the explanation they got concerning throttle and dashboard | **Good:** The participant is able to independently describe the functions on the dashboard and knows how to use them  
**Satisfactory:** The participant knows the most important functions on the dashboard and how to use them appropriately  
**Insufficient:** The participant cannot remember the functions on the dashboard and how to use them in an appropriate manner |
| Driving straight ahead   | Driving straight ahead through a wide corridor.                         | **Good:** The participant is able to drive straight ahead in a controlled manner  
**Satisfactory:** The participant is able to drive straight ahead mostly in a controlled manner  
**Insufficient:** The participant is swaying and not able to drive straight ahead |
| Accelerating             | Controlling the amount and fluency of gathering speed                   | **Good:** The participant is able to accelerate/decelerate gradually and controlled  
**Satisfactory:** Accelerating and decelerating is safe, but sometimes jerky  
**Insufficient:** The participant accelerates/decelerates too fast and not controlled |
| Stopping (4x)            | 4 markings on the ground indicated stopping. Participants were asked to stop directly in front of the markings. | **Good:** The participant is able to stop in a safe and controlled manner in front of the markings  
**Satisfactory:** The participant is able to stop in a safe manner, but performs the stop abrupt and does not halt exactly in front of the marking  
**Insufficient:** The participant is not able to stop in a safe manner and halts way before or after the marking |
| Driving in a circle (2x) | Driving around a circular obstacle in a hallway (clockwise and anticlockwise) | **Good:** The participant is able to drive properly in a circle, oversees the situation, and can adjust the speed  
**Satisfactory:** The participant has difficulties driving in a circle, but still performs the task safely  
**Insufficient:** The participant is not able to drive safely in a circle |
to feel insecure about that particular element/skill. The number of repetitions on each element were registered by the observer.

**STAI**

Participants were asked to fill in the State Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1993) to determine their level of anxiety during
the mobility scooter drive. This inventory consists of two parts: the Trait-Anxiety scale, to assess how people generally feel, and the State-Anxiety scale, to measure how people feel at a particular moment. Both parts of the STAI consist of 20 items that are scored on a 4-point scale. Scores can range from 20 to 40, with higher scores representing more anxiety. Participants of the present study completed the Trait-Anxiety Scale at home, whereas the State-Anxiety Scale was filled in after the mobility scooter drive.

**Statistical analysis**

The Statistical Package for the Social Sciences (SPSS, Inc., Chicago, IL, version 22) was used for data analysis. Driving ability was operationalised as the sum-scores of the first attempt (overall performance) and the number of repetitions. The correlation between these two variables was moderate (r = 0.459, p < 0.001), showing only partial overlap. Therefore, the variables were analysed independently. The overall performance was calculated by summing up the score of the different elements and was then compared between the different groups. Post-hoc comparisons were only executed between normal-sighted controls and the 4 groups of visually impaired individuals. Since the assumptions for parametric tests were not met, non-parametric tests (Kruskal Wallis, Mann-Whitney U) were executed to investigate differences between groups. The significance level was pre-set at \( \alpha = 0.05 \). To keep a conservative approach towards driving safety, we decided not to correct for type I error for multiple comparisons. In addition to the overall performance, the need of additional repetitions was compared between the five groups using a chi-square statistic and the number of repetitions per element were explored.

**Additional analysis**

The maximum number of years of driving experience in a motor vehicles (car, motorcycle, moped, etc.) was noted and correlated with the overall performance. In addition to that, years of driving experience was compared between participants who needed extra repetitions and participants who did not need extra repetition using the Mann-Whitney-U test. Concerning the measurement of anxiety, both the score on the Trait and the State Anxiety Scale were compared between visually impaired participants and normal-sighted controls using Mann-Whitney-U tests. The State-Anxiety Scale was further correlated with the overall performance on the driving skill test, and the level of anxiety was compared between participants who needed extra repetitions and participants who did not need extra repetition. For
this purpose, a Mann-Whitney-U test was used.

Results

**Overall performance on mobility scooter driving skill test**

Comparison of all five groups did not yield a statistically significant difference between the groups ($H(4) = 8.01, p = 0.091$). Post-hoc tests showed that individuals with a combination of visual impairments performed worse than normal-sighted controls. Participants with peripheral field defects performed slightly, but not significantly, worse than normal-sighted controls. Individuals with (very) low visual acuity did not differ significantly from normal-sighted controls. Effect sizes were small to medium (Table 3.3).

<table>
<thead>
<tr>
<th></th>
<th>Very low visual acuity</th>
<th>Low visual acuity</th>
<th>Peripheral field defect</th>
<th>Combination</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>14</td>
<td>10</td>
<td>11</td>
<td>13</td>
<td>37</td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>18.29 (2.64)</td>
<td>18.20 (3.36)</td>
<td>20.73 (5.14)</td>
<td>21.08 (4.94)</td>
<td>18.03 (3.13)</td>
</tr>
<tr>
<td>Median</td>
<td>18.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>17.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>20.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>19.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>17.0&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Post-hoc&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Mann-Whitney-U</td>
<td>225.0</td>
<td>183.0</td>
<td>133.5</td>
<td>132.5</td>
</tr>
<tr>
<td>P</td>
<td>0.969</td>
<td>0.467</td>
<td>0.083</td>
<td>0.016</td>
<td></td>
</tr>
<tr>
<td>r</td>
<td>-0.10</td>
<td>-0.01</td>
<td>-0.25</td>
<td>-0.34</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Kruskal Wallis: $H(4) = 8.01, p = 0.091$

<sup>b</sup>controls versus respective group with visual impairment

**Repetitions**

An explorative analysis showed that individuals with a combination of visual impairments needed most repetitions on the elements of the driving skill test, followed by individuals with peripheral field defects and individuals with a low visual acuity (Figure 3.1). Comparison of the five groups revealed a significant difference ($\chi^2 (4) = 10.79, p = 0.029$). Post-hoc analysis showed that more participants with combined visual impairments and less normal-sighted participants have to repeat certain elements of the practice drive than expected (Table 3.4).

Explorative analysis of the different elements of the driving skill test appeared to show that driving backwards, driving backwards around the corner, and stopping
seemed to be the most difficult elements (Table 3.5). Participants with combined visual impairments needed most repetitions on these elements.

Additional analyses

Driving experience was not associated with the overall performance on the driving skill test within the group of visually impaired participants ($r = -0.045$, $p = 0.760$). There is no statistically significant difference in the years of driving experience between visually impaired participants who do (Median = 25.0) or do not (Median = 25.0) need extra repetitions on the driving instruction ($U = 215.5$, $p = 0.205$). The effect size was small ($r = -0.18$).
STAI

Visually impaired participants (M = 35.53, SD = 8.14) experienced significantly more general anxiety compared to normal-sighted controls (M = 31.05, SD = 5.74; U = 585.5, p = 0.010, r = -0.28). Visually impaired participants showed somewhat more anxiety after the mobility scooter drive, however, this difference was not significant.
Slow motorised traffic and vision

\(M_{\text{visimp}} = 28.11, \text{SD}_{\text{visimp}} = 7.19; M_{\text{contr}} = 25.14, \text{SD}_{\text{contr}} = 4.70; U = 659.0, p = 0.084, r = -0.18\). Comparison of the experienced anxiety after the driving skill test (STAI State) between visually impaired participants who needed extra repetitions (Median = 30.0) and those who did not need extra repetition (Median = 24.0), resulted in a significant difference (\(U = 171.0, p = 0.038, r = -0.30\)). Visually impaired participants in need of more repetitions experienced more anxiety after the driving skill test. However, visually impaired participants who needed more repetitions were not significantly more anxious in general (STAI Trait, \(\text{Median}_{\text{rep}} = 36.0; \text{Median}_{\text{Norep}} = 36.0; U = 255.5, p = 0.820, r = 0.03\)) Furthermore, worse overall performance was associated with elevated anxiety after the mobility scooter drive (\(r = 0.244, p = 0.026\)), but not with anxiety in general.

**Discussion**

Goal of the present study was to investigate mobility scooter driving ability in visually impaired individuals and to identify elements of the driving task that need special attention in visually impaired people. We showed that both visually impaired individuals and normal-sighted controls were able to learn to use mobility scooters without any prior experience and after getting only a short instruction. Visually impaired individuals needed more attention and training with certain elements depending on their impairment; specifically participants with a combination of visual impairments showed difficulties and needed more time to acquire sufficient driving ability. Reversing seemed to be a difficult element amongst all participants, but especially for participants with combined visual impairment. This observation is comparable to the results of Nitz (2008), who described reversing in mobility scooters as one of the most difficult tasks. One reason why reversing is in particular difficult for participants with visual field defects could be that the restricted visual field makes it especially difficult to see the visual scene behind them. Another difficult element appeared to be stopping on time. Rather than related to visual impairment, this difficulty was based on the operation of the scooter. Since the mobility scooter could not actively be stopped, it was difficult to judge when the vehicle came to a halt. Problems with stopping thus seemed to be mainly dependent on the degree of driving ability, whereas difficulties with reversing appeared to depend both on driving ability and visual impairment.

Although we could observe variation in performance between the participants, we cannot predict someone’s driving ability solely from type or severity of one’s
visual impairment. There was only one participant (visual acuity ≈ 0.03, VFS < 12) who was not able to master the majority of the elements (e.g., unable to drive straight ahead, constantly bumping into walls). His visual impairment prevented him to walk independently without a human guide which could be an indication that he could not drive mobility scooters independently either. The common belief that people with visual impairments in general cannot learn to drive a mobility scooter is therefore challenged. On the contrary, to purely measure fitness-to-drive, one has to show sufficient driving ability, otherwise an impairment (which often does not have much scope to improve) could be wrongly seen as the reason for poor driving performance, whereas insufficient driving ability (which can be trained easily) is the underlying cause. Sufficient driving ability is thus a basic requirement to be able to participate safely in traffic. However, fitness-to-drive and driving behaviour play a role in safe traffic participation and should be investigated as well. Therefore, we cannot predict how visually impaired individuals actually perform in on-road traffic situations and give advice to mobility scooter allocators solely based on this experiment.

Other individual differences might explain the variance in performance. Contrary to our expectations, visually impaired individuals with more driving experience in other motor vehicles did not instantly perform better on the mobility scooter driving skill test. Manoeuvring a mobility scooter seems to be different from driving other vehicles and might not affect how well individuals can learn to drive mobility scooters (Nitz, 2008). With regard to the anxiety experienced, it was shown that visually impaired individuals who performed worse on the driving skill test experienced more anxiety than visually impaired individuals who performed better. Previous research has shown that anxiety can influence performance (Fairclough et al., 2006; Welsh, 2010; Wilson et al., 2006; Zijlstra et al., 2012). In the present study though, it is not entirely clear whether anxiety lead to worse performance on the mobility scooter driving skill test or whether worse driving performance evoked more feelings of anxiety. Apart from driving experience and anxiety, factors such as age, personality, or compensation strategies might play a role and should be further investigated in future studies.

A number of limitations of our study should be noted. First, due to our small group size, we were not able to statistically explore differences between the groups in more detail. The sample size could also be an explanation for the fact that not all explored differences were statistically significant. Second, the shortened and
partially adapted version of the official mobility scooter course in the Netherlands (Van Baalen & Boerwinkel, 2011) has not been formally validated. The overall good performance could be a sign of a ceiling effect and might have decreased the true difference between visually impaired and normal-sighted participants. Constructing a more complex driving ability test might increase differences between the two groups. Third, the age range in our study is limited. Younger or older individuals with visual impairment could have less or more difficulties acquiring driving ability due to better or worse cognitive functioning.

This study is the first step to explore mobility scooter driving safety in visually impaired individuals. We showed that visually impaired people are able to learn driving mobility scooters, however, we cannot make predictions about on-road driving safety yet. Allocators of mobility scooters should bear in mind though that a visual impairment does not necessarily mean that driving skills cannot be acquired. Novice mobility scooter users with visual impairment were able to manoeuvre the scooters as well as normal-sighted controls when training was increased. Especially stopping and reversing are skills that need more attention. To be able to confidently make recommendations about mobility scooter allocation, future research needs to explore how individuals with visual impairment perform in real-life situation.