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Full Title: Development and Validation of a Vision and Night Driving Questionnaire

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Abstract

Purpose: Night-time driving difficulties are a common concern of older drivers and those with eye disease. This study aimed to develop and validate a questionnaire for assessing vision-related night driving difficulties in older drivers.

Methods: Items from existing vision-related quality of life questionnaires and driving studies were used to develop a questionnaire that was completed by 283 participants who reported visual difficulties for night driving (65.4% female, 50 to >80 years). The questionnaire included items relating to demographic and night driving characteristics (7 Items), general vision ratings (8 Items), vision-related night driving difficulties (11 items), and a single open question about specific night driving difficulties. The vision-related night driving difficulty items were analysed separately using Rasch analysis to form the vision and night driving questionnaire (VND-Q). Rasch analysis assessed validity and psychometric properties of the scale. Generalised linear regression models examined associations between VND-Q scores and age, gender, amount of night driving, self-rated vision, and eye conditions. Test-retest repeatability was assessed using intra-class correlation analysis and Bland-Altman methods of agreement for a subset of 30 participants.

Results: Rasch analysis indicated that a 9-item VND-Q scale was unidimensional, valid and reliable, and showed excellent discriminant ability (person separation index 3.04; person reliability 0.90). Targeting was better for those with greater self-reported night driving difficulties. Participants with self-reported bilateral eye conditions and worse self-reported general vision ratings had significantly more night driving difficulties with the VND-Q scale than individuals without eye conditions ($p=0.03$) and with better general vision ratings ($p<0.001$). Females reported more difficulties than males ($p<0.001$) and drove shorter distances at night per week which was also associated with greater difficulties ($p<0.001$). A repeatability coefficient (Rc) of 2.07 demonstrated excellent test-retest repeatability.

Conclusion: The 9-item VND-Q is a unidimensional and reliable questionnaire allowing quantification of the level of visual difficulties that older drivers report at night. The development of this questionnaire is an important step in providing a reliable and validated instrument for use to guide appropriate investigations, referrals, or interventions in clinical and research settings.

INTRODUCTION

Driving at night is more hazardous than driving during the day. There is a two to four times higher risk of a fatal accident[1] and up to seven times higher risk of a pedestrian fatality[2] for night driving, compared with daytime, after adjustment for distance traveled. Visual factors have been shown to contribute to this elevated night-time crash risk and it has been demonstrated that improved road lighting decreases night-time accidents and their severity.[2–5] Poor visibility has also been shown to be a particularly important factor in relation to night-time pedestrian fatalities.[2,4,5] Driving at night is perceived as one of the most challenging of all driving situations, with visual factors seemingly responsible, especially for older drivers.[6–9] Older drivers often report vision-related problems when driving at night, such as disability related to glare from oncoming headlights and difficulty reading road signs.[7,10–12] Some older drivers are so concerned about visual difficulties that they self-restrict their night-time driving,[7,10,11] and some cease night driving altogether.[8]

The low-luminance conditions evident on night-time roads present considerable visibility challenges for drivers.[7] Furthermore, the presence of glare from headlights and street lighting can cause visual disability through increased intraocular light scatter[13] as well as via neural processes, resulting in prolonged disability even after removal of the glare source.[14] Night-time driving conditions are particularly problematic for older drivers due to age-related pupil miosis,[15,16] increased crystalline lens opacities and light scatter,[17,18] and neuro-visual degenerations.[19] These changes can result in impaired contrast sensitivity, increased disability glare and delayed adaptation to fluctuating light levels.[20–22] In addition, age-related eye diseases, such as cataract, age-related macular degeneration (AMD), and glaucoma, can reduce night-time visual function, with cataracts resulting in reduced contrast sensitivity and increased disability glare,[23] and retinal diseases, such as AMD and glaucoma, resulting in reduced mesopic vision[24,25] and prolonged recovery after exposure to glare sources.[26,27]

Driving is important for maintaining older adults' independence and quality of life.[28,29] Therefore decisions regarding an older driver's capacity to drive at night must consider the balance between restricting night driving due to safety concerns and maintaining mobility and independence where possible. Around one third of adults aged 50 years or older report vision-related night driving difficulties,[7,30] and this proportion rises considerably in the presence of ocular diseases, such as cataracts.[31] The number of drivers who avoid driving at night also

increases significantly with age, with the most commonly reported reason being visual difficulties.[7,8] Self-reported and clinically measured reductions in visual function are associated with these older drivers' decisions to avoid night driving.[7,10,11,8]

The use of patient-reported outcome measures (PROM) is becoming increasingly important to support clinical decision making, as these measures capture perceptions from the patients' perspectives and provide functional and quality of life information.[32] For example, PROM relating to self-reported visual difficulties are used to guide referrals for cataract surgery[33] and to quantify changes in vision-related quality of life following interventions such as cataract[34,35] and refractive surgery.[36,37] There are a range of general vision-related quality-of-life (QOL) questionnaires, such as NEI-VFQ-25,[38] ADVS,[39] VAQ,[40] and CatQuest-9SF,[41] however these provide limited or no information specifically about night driving difficulties and are often designed for groups with particular visual impairments. For example, while the Low Luminance Questionnaire (LLQ)[12] is a comprehensive low light vision questionnaire which includes several night driving items, it was designed for adults with AMD and therefore is not targeted for the general older driving population who are likely to have better visual function. The Night Driving Comfort scale (DCS)[42] was designed for a general older driving population but includes items that relate to a range of physical, cognitive and sensory factors being non-specific to vision.

There are currently no PROM for use in general older populations that specifically assess visual difficulties when driving at night. Therefore the aim of this study was to develop a PROM and to evaluate it using a large sample of older drivers who reported concerns about their vision for night driving. Development of the vision and night driving questionnaire (VND-Q) involved item selection and pilot testing, followed by Rasch analysis which is recognised as an effective approach for optimising the psychometric properties of PROM.[43]

METHODS

Recruitment

Drivers aged 50 years and older who reported low-luminance, glare or adaptation concerns about their vision for night driving were invited to participate via e-mails to patients of local Optometry and Ophthalmology practices, as well as through advertisements in local newsletters and radio. Participants were asked to complete either an online or paper-based questionnaire which was developed for this study. The questionnaire included items relating to demographics and night driving characteristics (7 Items), general vision ratings (8 Items),

vision-related night driving difficulties (11 items), and a single open question to describe any specific difficulties. Ethical approval of the study was obtained from the QUT Human Research Ethics Committee. The study adhered to the tenets of the Declaration of Helsinki.

Demographics and night driving characteristics

Demographic data collected included age category (in 10 year brackets), gender, and self-reported presence of eye conditions in either eye including: cataracts, cataract surgery, glaucoma, AMD, diabetic eye disease, or any other condition. Participants were also asked if they had previously reported their night-driving difficulties to an eye care professional. Items regarding night driving characteristics asked about the amount of night driving (average kilometres (km) per week in 25km increments), frequency of night driving avoidance, and whether spectacles were used for night driving.

General vision rating items

Participants rated their vision across several general situations, based on well-established questionnaires.[44,45] Ratings of general distance vision, day and night driving vision used a five category scale ranging from 'very poor' to 'excellent'. Ratings of vision under daylight, low-light, glare conditions, and difficulty adjusting from light to dark or from dark to light used a five category scale ranging from 'no difficulty' to 'extreme difficulty'.

Vision-related night-driving item generation

Table 1 outlines the 22 items that this study identified from existing vision-specific quality of life research and questionnaires.[12,39,40,46–52] Evaluation of the vision and driving research[14,42,53,54] also helped to derive an additional three items that were considered relevant but had not been used in existing questionnaires. These items assessed difficulty seeing low contrast objects such as pedestrians and animals, seeing hazards such as potholes and the road-side (curb) and, difficulty adjusting after exposure to oncoming headlight beams. The response scales of existing questionnaires had a range of response structures (from 2-7 options) and categories (difficulty, frequency and, level of agreement). Items for the new questionnaire were adjusted to have a common five-option scale of difficulty ranging from 'no difficulty' to 'extreme difficulty' as used in the LLQ.[12]

Table 1: Vision and night driving items from existing questionnaires (grouped by category)

Category	Item	Source

Vision Rating	How would you rate your ability to see clearly at night for safe driving?	(Molnar, Eby, et al. 2013)[47]
Headlights	When driving at night do you have difficulty with headlights from oncoming cars?	(Owsley et al. 2006)[12]
	How much is your driving disturbed by the lights of oncoming cars?	(Carta et al. 1998)[46]
	To what extent is your driving at night impaired by oncoming headlights?	(Prager et al. 2000)[45]
	How much are you hindered, limited or disabled by glare (dazzling light) when driving towards the sun or oncoming headlights?	(Lawrence et al. 1999)[48]
	How difficult do oncoming headlights or street lights make driving at night for you?	(Mangione et al. 1992)[36]
	I have trouble driving when there are headlights from oncoming cars in my field of view.	(Sloane et al. 1992)[37]
Low contrast	Do you have difficulty seeing dark-coloured cars while driving at night?	(Owsley et al. 2006)[12]
Signs	Do you have difficulty reading street signs when driving at night?	(Owsley et al. 2006)[12]
	Would you say that you read street signs at night with no/little/moderate/extreme difficulty?	(Mangione et al. 1992)[36]
	How confident are you driving at night, seeing street or exit signs with little warning?	(Myers et al. 2008)[39]
Moving objects	While driving at night, do you have difficulty judging the distance between you and other moving cars?	(Owsley et al. 2006)[12]
	While driving at night do you have difficulty judging the distance to your turn-off or exit?	(Owsley et al. 2006)[12]
	How difficult does seeing moving objects such as people or other cars make driving at night for you?	(Mangione et al. 1992)[36]
Peripheral vision	When driving at night, objects from the side unexpectedly appear or pop up in my field of view.	(Sloane et al. 1992)[37]
Poor weather	When driving at night in the rain, I have difficulty seeing the road because of headlights from oncoming cars.	(Sloane et al. 1992)[37]
	Do you get upset because you have difficulty seeing while driving in the rain?	(Owsley et al. 2006)[12]
	Have you limited driving in the rain because of difficulty seeing?	(Owsley et al. 2006)[12]
Dawn/dusk	Do you have difficulty seeing while driving at dawn or dusk because of glare?	(Owsley et al. 2006)[12]
Restriction	Do you limit your driving at night because of your vision?	(Owsley et al. 2006)[12]
	How much does your vision hinder, limit, or disable you in night-time driving?	(Lawrence et al. 1999)[48]
	To what extent, if at all, does your vision interfere with your ability to drive a car, by night?	(Pesudovs & Coster 1998)[44]

A small pilot study was conducted involving older drivers who reported night driving difficulties and were recruited through research personnel and their friends in the School of Optometry and Vision Science at QUT (n=35; 15 female, 20 male; median age 60-70yrs category). The pilot study included the identified vision-related night driving items, combining items where content was overlapping to result in a total of 12 items. Open questions were also included in the pilot questionnaire to provide feedback and to identify any specific night driving difficulties that were present. The pilot data did not identify any issues with understanding of the items except that peripheral vision at night was poorly understood by several of the participants and thus was not included in the final selection of items. No respondents reported night driving difficulties that were in addition to the original item selection. One respondent reported difficulty distinguishing between the options of 'a little' and 'some difficulty' but the five category scale was retained given that Rasch analysis would assess any potential issues with categories. Table 2 shows the final selection of the eleven vision and night driving difficulty items that were analysed using Rasch analysis to develop the vision and night driving questionnaire (VND-Q).

Rasch analysis

The VND-Q was developed using Rasch analysis using Winsteps (Version 3.73, www.winsteps.com)[55] and the Andrich rating scale model.[56] The use of Rasch analysis enabled formation of a linear interval scale, in logits, of person abilities and item difficulties. This contrasts classical test theory which assumes equal interval steps between response categories and equal emphasis on each item. In the Rasch model for this study, an individual with poor ability had more vision-related night driving difficulty and a more positive or higher logit value. Correspondingly, an item of less difficulty was rated with a higher logit score than a more difficult item.

Table 2: Item structure, content and response scales for the 11 item questionnaire. All items used a five option difficulty scale: no difficulty, a little difficulty, moderate difficulty, a lot of difficulty, extreme difficulty.

	Item
How much difficulty do you have or would you have with the following night driving tasks:	
Item 1	Seeing dark coloured cars when driving at night
Item 2	Seeing pedestrians or animals on the road side when driving at night
Item 3	Seeing the curb or potholes in the road when driving at night
Item 4	Reading street signs when driving at night
Item 5	Seeing the road because of oncoming headlights when driving at night

Item 6	Seeing because of glare when driving at dusk or dawn
Item 7	Seeing because of glare from headlights of oncoming cars when driving at night
Item 8	Adjusting after passing headlights from oncoming cars when driving at night
Item 9	Judging the distance to your turnoff or exit while driving at night
Item 10	Judging the distance between you and other moving cars while driving at night
Item 11	Seeing the road in rain or poor weather when driving at night

Open question about specific difficulties

A single open question was also included for participants to describe their vision-related night driving difficulties in their own words. The responses were categorised into broad themes by a single reviewer.

Psychometric properties of the VND –Q

Rating scale and reliability: Response category ratings were examined to determine if thresholds were ordered. Disordered thresholds indicate response options that are either underused, have unclear definitions or are difficult to discriminate from adjacent response options.[41,57] Reliability of the scale for discriminating between high and low abilities was assessed using the Person Separation Index (PSI) and Person Reliability (PR) coefficients, where values greater than 2.0 or 0.8, respectively, indicate acceptable reliability and discrimination capability.[41]

Unidimensionality and item fit: Item fit statistics (mean square infit and outfit) were assessed to identify items that contributed appropriately to the Rasch model, where values less than 0.7 suggest item redundancy and over 1.3 indicates excessive measurement noise.[57] Unidimensionality was assessed using principal component analysis (PCA), where the first factor should explain at least 60% of the variance and the proportion of unexplained variance of the first contrast should be less than 5%.[43]

Targeting: The person-item map was inspected to investigate targeting of the questionnaire, where less than a 1.0 logit difference between the mean item difficulty and mean person ability indicates a good match between items and the study population. Differential Item Functioning (DIF) was assessed to ensure that the underlying trait was measured uniformly across subgroups such as gender, age and ocular pathology status. A DIF contrast greater than 1.0 logit indicates the presence of interpretation bias, with differential response patterns across subgroups.[58]

Questionnaire construct validity

The association between VND-Q Rasch scores and age, gender and amount of night driving was examined using generalised regression models, in unadjusted models and models adjusting for each other variable. Construct validity was investigated by analysing the associations between VND-Q Rasch scores and measures of self-reported visual function (presence of eye conditions and general vision ratings), where it was hypothesised that the presence of bilateral eye conditions and poorer general vision ratings would relate to greater vision-related night driving difficulties. Generalised linear regression analyses were conducted separately for each of these vision variables, as well as for prior reporting to an eye-care practitioner, in unadjusted models and models adjusting for age, gender and amount of night driving as covariates. Statistical analyses were performed using SPSS version 21.0 (SPSS, http://www-01.ibm.com/software/au/analytics/spss/) and p values <0.05 were used to indicate statistical significance. Residuals of the regression models were assessed to confirm the model assumptions of normality, linearity and homoscedasticity.

Questionnaire repeatability

A subset of participants (n=30) repeated the questionnaire after a 2-3 week interval to evaluate reliability and repeatability of the questionnaire. Intra-class correlation analysis was used to determine the test-retest reliability of the VND-Q using a single-measures, two-way approach. The 95% repeatability coefficient (R_c) was calculated using the standard deviation of the differences between repeated measures and multiplying by 2.[59] A Bland-Altman plot showed the distribution of data within 95% confidence limits and any patterns of differences between questionnaire scores at time 1 and 2.[60]

RESULTS

Respondent characteristics

A total of 288 completed questionnaires were submitted, of which 283 (98%) reported some vision-related night driving difficulty and were included in the analysis. Most responses were obtained via the online format (88%) and the remaining responses were paper-based (12%). There was no missing data except for from eight participants who did not respond to the question about whether they had reported their difficulties to an eye-care practitioner. The demographic and night driving characteristics of the respondents are shown in Table 3.

Table 3: Demographic and driving characteristics of respondents.

	Response category	n (%)
Age group (yrs)	50-59	104 (37)
	60-69	94 (33)
	70-79	72 (25)
	80 and older	13 (5)
Gender	Male	98 (35)
	Female	185 (65)
Eye condition	None	196 (69)
	Cataract	39 (14)
	AMD	23 (8)
	Glaucoma	16 (6)
	Diabetic eye disease	9 (3)
Previous report to eye-care practitioner	Yes	147 (54)
	No	128 (46)
Amount of night driving (km)[a]	0-24	153 (54)
	25-49	80 (28)
	50-74	19 (7)
	75-100	14 (5)
	100 or more	17 (6)
Night driving avoidance (because of vision)	None	160 (57)
	A little	44 (15)
	Some	26 (9)
	A lot	34 (12)
	All of the time	19 (7)

a: in a typical week over the past month

Figure 1 shows the distribution of self-ratings of general vision. The majority of respondents (81%) rated their general distance vision as good to excellent, with similar results for ratings of vision for day driving (97%). Fewer participants reported good to excellent vision for night driving (61%). High ratings of difficulty with glare and low-light were more frequent, with 59% of respondents reporting moderate or greater difficulties with glare and 35% reporting similar difficulty under low-light, compared to only 4% who reported moderate or greater difficulty under daylight conditions. Adaptation difficulties were also common with 45% of respondents reporting moderate or greater difficulty when adapting from dark to light conditions and 33% reporting this level for adapting from light to dark conditions.

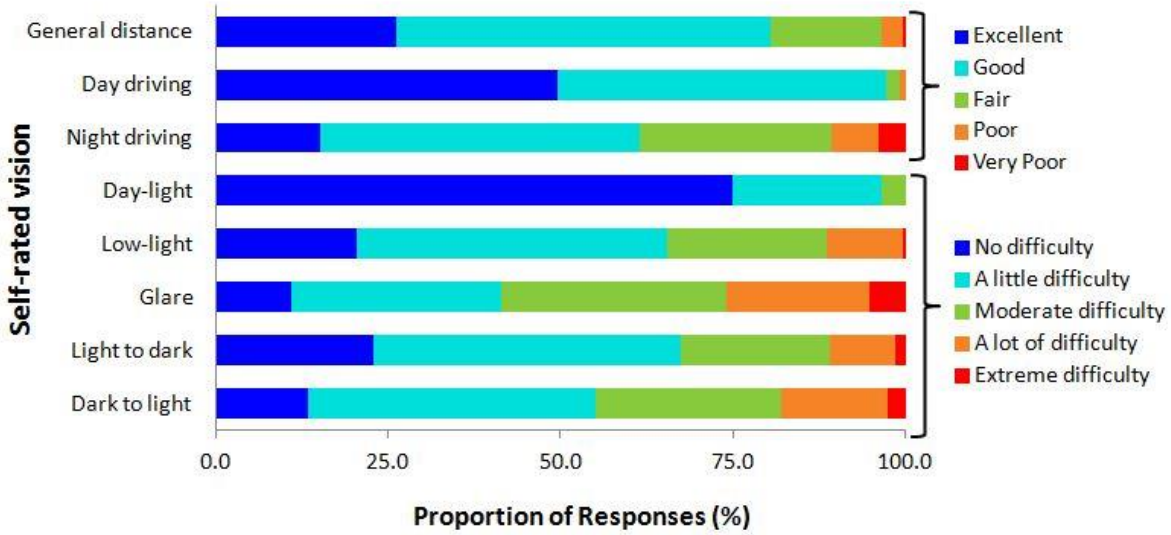

Figure 1: Self-rated general vision and difficulty in different lighting conditions.

Psychometric properties of the VND-Q

Rating scale and item fit: No disordered thresholds were evident, so the five category response scale was retained. Inspection of the infit mean square revealed one initial misfitting item, number 3, which was removed. The second Rasch iteration revealed a further misfitting item, number 7, which was also removed. The misfitting items ('seeing the curb and potholes' and 'glare from oncoming headlights') showed item redundancy (<0.7 mean square infit), given the ceiling effect where most participants reported high levels of difficulty regardless of the extent of underlying night driving difficulties. The remaining nine items showed fit statistics within the acceptable range (between 0.7 and 1.3, Table 4). The least difficult item was 'judging the distance between you and other moving cars while driving at night' (item 10), and the most difficult item was 'difficulty seeing the road in rain or poor weather when driving at night' (item 11).

Unidimensionality and reliability: Unidimensionality of the 9-item scale was confirmed using PCA, where the first factor explained 69 percent of the variance and the eigenvalue of the second component was 1.7. The 9-item VND-Q demonstrated excellent discriminant ability, with a person separation index of 3.04 and PR coefficient of 0.90. Table 5 shows a comparison of parameters for the final 9-item version of the questionnaire and the expected Rasch model requirements. Overall, the fit statistics of the nine item VND-Q and the principal component analysis indicate that the scale was unidimensional, valid and reliable.

Table 4: Item fit statistics and item difficulty of the 9-item VND-Q ordered by most to least difficult.

	Item total correlation	Mean square		Item difficulty (SE)
		Infit	Outfit	
Item 11	0.79	0.97	0.94	-1.56 (0.10)
Item 5	0.82	0.9	0.89	-1.37 (0.10)
Item 4	0.72	1.27	1.27	-0.70 (0.10)
Item 6	0.79	0.98	0.95	-0.67 (0.10)
Item 8	0.81	1.02	1.03	-0.01 (0.10)
Item 2	0.81	0.8	0.79	0.33 (0.11)
Item 1	0.81	0.79	0.83	0.51 (0.11)
Item 9	0.75	1.19	1.03	1.37 (0.12)
Item 10	0.76	1.24	0.9	2.08 (0.12)

Targeting: Inspection of the person-item map (Figure 2) showed a 2.07 logit difference between person and item difficulty means. While there was an adequate spread of item difficulties, targeting of the 9-item VND-Q appeared to be more appropriate for drivers with moderate to high levels of difficulties than those with only lower levels. There was no notable DIF for age group, gender, amount of night driving, or eye conditions (Table 5), with all less than 1.0 logit difference between category means.

Table 5: Fit parameters of the VND-Q scale with Rasch model requirements.

Parameter	9-Item VND-Q	Rasch model requirements
Disordered thresholds	No	No
Number of misfitting items	0	0
Person Separation Index	3.04	>2
Person reliability	0.9	>0.8
Difference between person and item means (logit)	2.07	<1.0
Variance by first factor (%)	69	>60
PCA (eigenvalue for 1st contrast)	1.9	< 2.4
Differential Item Functioning (logit)[a]		
Age group (<60, ≥60yrs)	<1.0	<1.0
Gender	<1.0	<1.0
Amount of night driving (<25, ≥25 km/wk)	<1.0	<1.0
Ocular pathology (nil, pathology)	<1.0	<1.0

a: DIF across all items for the dichotomized groupings

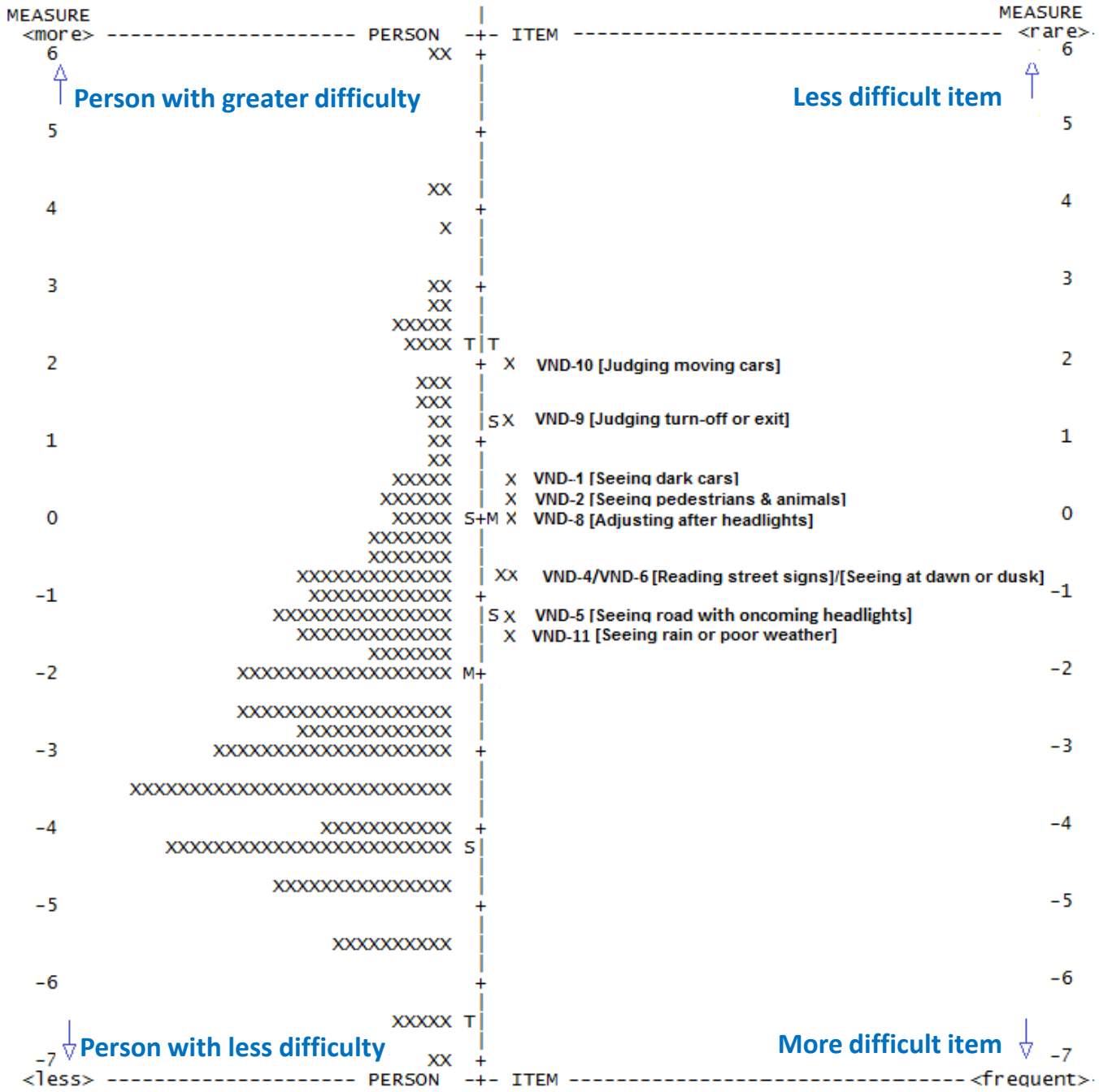

Figure 2: Person-Item map showing targeting of the nine item VND-Q and separation of the person and item means (M). The person-item map shows less difficult items and persons with higher amounts of the latent trait (more night vision difficulties) at the top of the map and the most difficult items together with persons with lower amounts of the latent trait at the bottom of the map.

<u>Questionnaire construct validity</u>

The mean (±SD) VND-Q score for respondents was -2.07 ± 2.34 logits, corresponding to a mean score of 19 out of a maximum 45 points. In the multivariate regression models including age, gender and night driving exposure (**Error! Reference source not found.**), age was not

significantly associated with vision-related night driving difficulties (p=0.45). Multivariate analyses also showed that female respondents reported significantly more vision-related night driving difficulties than males (regression coefficient=0.90 p=0.002) and respondents who reported less night driving exposure (<25 km per week) also had more vision-related night driving difficulties (regression coefficient=-1.05, p<0.001). In addition, those who had previously reported their night driving difficulties to an eye care practitioner indicated more vision-related night driving difficulties (regression coefficient=0.95 p<0.001). These findings also did not differ in the unadjusted analyses (**Error! Reference source not found.**).

Construct validity was supported whereby respondents who self-reported bilateral eye disease had significantly greater vision-related night driving difficulties for both univariate and multivariate models, compared to those who reported no eye disease; although, there were no significant differences between those with unilateral eye conditions and no eye disease (**Error! Reference source not found.**). Respondents with better self-rated general distance vision (good to excellent) and less difficulty under low-light and glare (little to no difficulty) had significantly less vision-related night driving difficulties for univariate and multivariate regression models (**Error! Reference source not found.**).

Table 6: Demographic and self-reported vision univariate and multivariate regression outcomes with VND-Q as the dependent variable.

Variable	n (%)	Mean logit score (95% CI) for reference group[ab]	Unadjusted Analysis		Adjusted analysis[c]	
			Regression coefficient (95% CI)	p-value	Regression coefficient (95% CI)	p-value
Total sample	283 (100%)	-2.07 ± 2.34 (SD)				
Demographic variables						
Age						
<60 (reference)	179 (63.3%)	-1.87 (-2.32 to -1.43)				
≥60	104 (36.7 %)		-0.32 (-0.88 to 0.25)	0.27	-0.21 (-0.76 to 0.34)	0.45
Gender						
Male (reference)	98 (34.5%)	-2.85 (-3.30 to -2.40)				
Female	185 (65.4%)		**1.19 (0.64 to 1.75)**	**<0.001**	**0.90 (0.33 to 1.47)**	**0.002**
Amount of night driving (km/week)						
< 25km (reference)	152 (54.1%)	-1.51(-1.87 to -1.16)				
≥25km	129 (45.9%)		**-1.22 (-1.75 to -0.69)**	**<0.001**	**-1.05 (-1.58 to -0.51)**	**<0.001**
Self-reported vision variables						
Eye disease						
None (reference)	196 (69.2%)	-2.25 (-2.57 to -1.92)				
Unilateral condition	41 (14.5%)		0.30 (-0.49 to 1.08)	0.50	0.36 (-0.76 to 1.48)	0.53
Bilateral conditions	46 (16.3%)		**0.80 (0.06 to 1.55)**	**0.030**	**0.76 (0.05 to 1.47)**	**0.040**
General distance vision						
Good to Excellent (reference)	227 (80.2%)	-2.32 (-2.62 to -2.03)				
Fair to Very Poor	56 (19.8%)		**1.27 (0.60 to 1.93)**	**<0.001**	**1.23 (0.58 to 1.88)**	**<0.001**
Difficulty in low-light						
A little to no difficulty (reference)	185 (65.4%)	-2.75 (-3.06 to -2.44)				
Moderate to extreme difficulty	98 (34.6%)		**1.96 (1.44 to 2.49)**	**<0.001**	**1.79 (1.29 to 2.30)**	**<0.001**
Self-reported difficulty with glare						
A little to no difficulty (reference)	117 (58.7%)	-3.41 (-3.78 to -3.04)				
Moderate to extreme difficulty	166 (41.3%)		**2.28 (1.80 to 2.77)**	**<0.001**	**2.12 (1.65 to 2.59)**	**<0.001**
Reported to practitioner						
No (reference)	128 (46.5%)	-2.55 (-2.95 to -2.15)				
Yes	147 (53.5%)		**0.91 (0.36 to 1.46)**	**<0.001**	**0.95 (0.43 to 1.47)**	**<0.001**

a: more negative scores represent less vision-related night driving difficulties
b: based on unadjusted models
c: models include age, gender and night driving exposure

Categorisation of open question responses

Table 7 summarises the broad themes identified in the open question responses which were completed by 100 (35%) respondents. The predominant problem identified was glare from oncoming headlights, followed by vision in poor lighting when driving at night. Importantly, no additional content areas were identified, which provides evidence that the VND-Q items reflect the predominant visual difficulties experienced by older drivers at night. Although difficulties with night driving in unfamiliar areas and on highways were reported, these situations were infrequent and were situation specific and therefore not necessarily relevant to all drivers.

Table 7: Open-question responses regarding vision-related night driving difficulties.

Night Driving Difficulties	Number of comments
Problems with oncoming headlight glare, halos or starbursts, seeing lane markings	71
Concerns about visibility in poor lighting, difficulty seeing pedestrians, animals, curb, road lane markings	25
Avoidance of night driving	24
Discomfort, aching, pain, anxiety, related to night driving	21
Difficulty seeing in poor weather	15
Prolonged time to regain vision after headlights	12
Concerns about clarity of vision, difficulty reading signs	10
Difficulty driving at night in unfamiliar surroundings because of vision	6
Problems judging distance to turnoff because of vision	5
Problems judging distance to other vehicles because of vision	5
Difficulty with vision when driving on highways at night	3

Questionnaire repeatability

The two-way, single-measure ICC for test–retest reliability was 0.89 (95% CI, 0.78–0.95). The repeatability coefficient, R_c=2.07, demonstrated excellent repeatability of the VND-Q score. The Bland-Altman plot showed the data to be distributed within the 95% limits of agreement (LOA) and there was a negligible mean elevation of Rasch score upon retesting (mean difference ± 95% LOA = 0.27 ± 2.03 logit) (Figure 3).

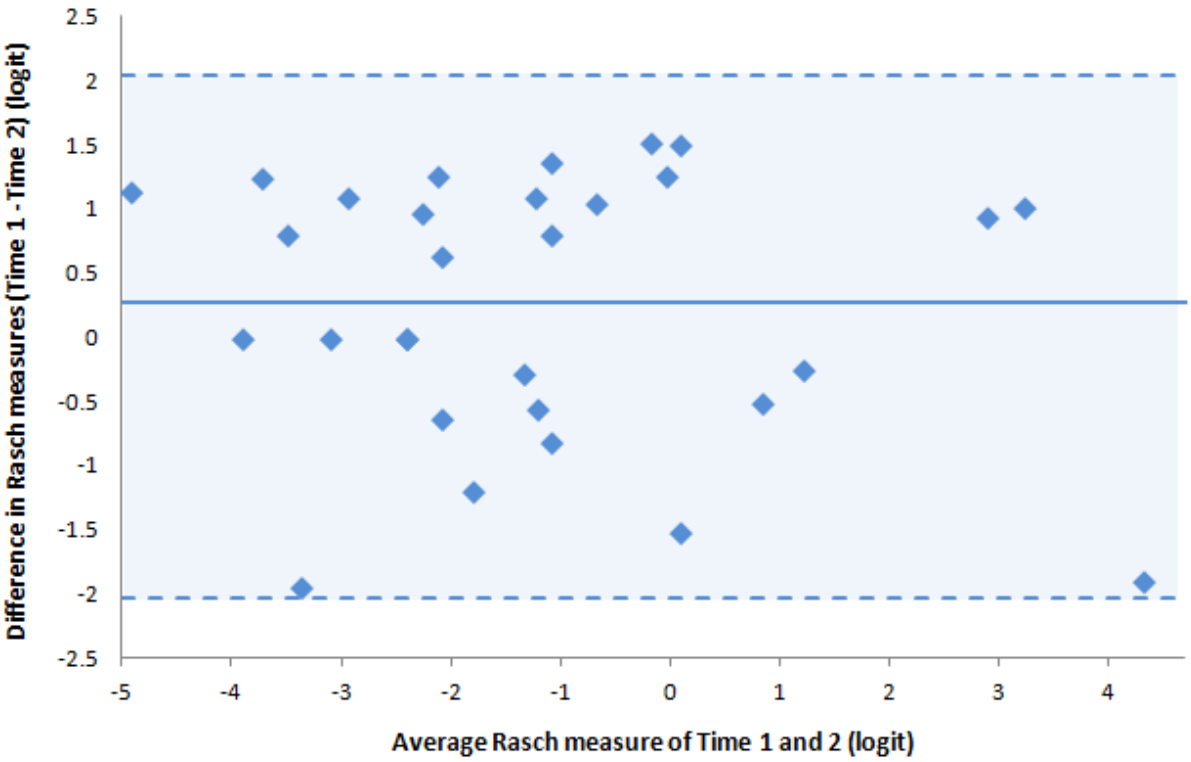

Figure 3: Bland-Altman plot of VND-Q Rasch scores for test-retest at time 1 and time 2 (n=30).

DISCUSSION

This study describes the development of a vision and night driving difficulties questionnaire (VND-Q), which comprised a nine-item, unidimensional, interval-level scale for use in a general population of older drivers. The psychometric properties of the questionnaire were established using Rasch analysis to inform item selection and to validate the questionnaire in a large sample of older drivers who experienced varying degrees of night driving difficulties.

The VND-Q is the first questionnaire designed to specifically investigate vision-related night driving difficulties. Importantly, it was developed for use in a general older population, rather than for those with specific eye diseases and is therefore highly applicable and relevant for the ageing driving population. The VND-Q covers a range of driving tasks and includes items that vary in difficulty from easier tasks, such as judging the distance to other moving cars, through to more difficult tasks, such as driving in poor weather at night. An excel conversion table for the VND-Q is available through online supplementary content.

The construct validity of the VND-Q was supported in the present study, where respondents with poorer self-reported general vision in low-light and with glare had more vision-related night driving difficulties. Notably, respondents who self-reported bilateral eye conditions had more difficulties, which provides additional support of construct validity of the VND-Q, given that conditions such as glaucoma[61], AMD[24,62] and cataract[63,64] are known to impair mesopic vision and increase glare sensitivity. However, the majority of respondents did not self-report any eye disease (69%), therefore the ability to generalise these results for glaucoma, age-related macular degeneration and cataract populations is limited.

Higher levels of vision-related night driving difficulty for female participants concurs with previous findings, where females reported higher levels of discomfort and difficulty when driving at night compared to males.[65,66] Our findings also showed that a larger proportion of the males drove more at night than females (>25 km: 62% vs 39%, respectively); greater exposure to night driving may improve males' night driving confidence[67] as well as decrease the perception of discomfort associated with night-driving.[65] Among all respondents, VND-Q scores were significantly lower for those who reported driving more at night than those who had less exposure. Correspondingly, females also reported more night-driving avoidance than males. This concurs with previous research, where females are less likely to drive at night than males,[8] who tend to attribute more importance to their driving status and stop only when physical health has declined substantially.[8,65]

A key strength of the current study was the use of Rasch analysis to develop an interval measure of vision-related night driving difficulties, without the category spacing assumption inherent in classical test theory.[68] The Rasch generated questionnaire demonstrated unidimensionality, confirming a consistent underlying latent trait, and demonstrated well-ordered thresholds. According to published criteria-based recommendations for Rasch analysed vision-related PROMs[69], the properties of the VND-Q would be considered to be high quality (grade A) in areas of item identification, response categories, dimensionality, measurement precision, item fit statistics, concurrent validity, test-rest reliability and known group validity. Item selection, differential item functioning and targeting would be considered medium quality (grade B). Overall the quality assessment of the VND-Q, according to these recommendations, supports the validity of this PROM.

There are, however, some limitations of the study that should be considered when interpreting the results. Construct validity was evaluated using self-reported vision and eye

conditions; further evaluation is ongoing through exploration of how self-reported night driving difficulties as assessed by the VND-Q relate to clinical measures of visual function and real-world night driving performance. The current study was not powered to detect differences in night driving difficulties between subgroups of eye conditions, and future work with larger samples of older adults with age-related eye diseases should be undertaken. A larger sample size to confirm the repeatability of the VND-Q is also required and future research would be useful to determine the VND-Q responsiveness to potential treatment options, such as cataract surgery, contact lens, or IOL options, to improve the capacity of older adults to drive at night.

Targeting of the VND-Q was sub-optimal to our study population, which indicates that it may be more applicable to older drivers with greater levels of vision-related night driving difficulties, such as those with specific eye conditions likely to impact on visual function at night. The inclusion of more difficult night-driving items to improve the targeting of the questionnaire would be difficult, as it already includes challenging driving tasks (driving in poor weather at night). Based on these considerations, targeting of the VND-Q was considered satisfactory for a general population of older drivers who have night driving concerns. Testing the VND-Q in a population with eye disease is an important aspect to consider, although it is likely that many individuals with greater visual impairment due to eye disease may have restricted their night-time driving or avoid it altogether[11] given that night driving has been shown as one of the first visual tasks to be restricted due to eye disease.

The VND-Q can provide important and relevant information to clinicians, particularly when combined with clinical vision data, to inform clinical decisions such as referral for cataract surgery or potentially for license renewal assessments. Our findings show that around half of the participants had reported their difficulties to an eye-care practitioner, even though all reported some degree of vision-related difficulties with night-driving. While individuals with greater night driving difficulties were more likely to have reported their concerns, the VND-Q could help clinicians identify older drivers who may be more hesitant to report their difficulties to eye-care providers, potentially due to concerns about losing their licence. In a research setting, the VND-Q could be combined with other established driving questionnaires, such as the Driving Habits Questionnaire,[31] to provide comprehensive self-reported driver information regarding driving habits self-rated driving ability and vision-related night driving difficulties.

In conclusion, this study developed and validated a 9-item VND-Q to quantify the degree of vision-related night driving difficulties of older drivers, using a well-established Rasch analysis protocol to confirm its unidimensionality and reliability for use in clinical and research settings. The development of the VND-Q is an important step in providing a reliable and validated instrument to assist clinicians and researchers in better understanding and tailoring treatment options for older drivers reporting vision-related night driving difficulties. Vision testing is primarily conducted under photopic light levels, which do not reflect the level of visual ability under low luminance or glare conditions, therefore questionnaires such as the VND-Q may provide important information for the detection of difficulties that older drivers experience in low-light conditions, in the presence of glare sources and when adapting to changing in light levels.

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