Developing an Instrumental Activities of Daily Living Tool as Part of the Low Vision Assessment of Daily Activities Protocol

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Purpose. To determine the validity, reliability, and measurement characteristics using factor and Rasch analysis of the Very Low Vision Instrumental Activities of Daily Living (IADL-VLV) in persons with severe vision loss.

Methods. From an initial pool of 296 tasks, 25 were shortlisted after conducting a Delphi survey with persons designated legally blind. Using further input from occupational therapy and low-vision professionals, 11 activities were chosen to be pilot tested. Forty legally blind participants (better eye visual acuity < 20/200) underwent clinical assessments and functional tests as well as the 53 IADL tasks related to the 11 activities. The task pool was refined and condensed using factor and Rasch analysis.

Results. Based on iterative principal component analyses, tasks were grouped together into the following domains: reading signs/information access, signature placement, clothes sorting, shelf search, gesture recognition, clock reading, and table search. A final selection of 23 tasks yielded satisfactory measurement characteristics, differentiated between at least four different levels of IADL performance (person separation of 3.8), and had adequate task difficulty for the tested sample (person mean −0.61). In multivariate analyses, only visual acuity (VA) and percent of remaining visual field (VF) were associated with IADL performance.

Conclusions. Using a large item pool, participant, and expert input, as well as factor and Rasch analysis, we designed a valid and reliable assessment to measure vision-related IADL performance in persons with severe vision loss. This assessment tool can be used in clinical sight restoration trials.

Keywords: Activities of Daily Living, visual impairment, psychometric measurement, instrument development, retinitis pigmentosa

The ability to successfully perform instrumental activities of daily living (IADLs), such as operating household appliances, shopping, or reading signs, is a basic requirement for functional independence.[1–3] Many day-to-day tasks are vision-related, and several tools are available to capture vision-related IADL performance.[4–10] These are either based on self-report or on observed performance. Self-reported performance on selected IADLs is potentially distorted by a number of character traits (optimism versus pessimism, etc.), by a person's common practice (i.e., whether particular tasks are performed regularly and under which circumstances), and by other confounders such as depression, cognitive state, and general health or physical limitations.[11–14] Performance-based IADLs can potentially be distorted by any of these factors as well, but generally have been found to be more objective, reliable, and valid, and subject to less distortion when compared with self-report.[15] This is of particular importance when assessing a change in IADL performance over time, following an intervention, or rehabilitation. Both timed performance as well as accuracy, have been used to assess overall performance.[5,11]

To date, almost all available IADL instruments have been designed to capture performance in persons with mild to moderate vision impairment.[16] Thus, performance at either end of the vision spectrum—very good or very poor—is not well captured by most assessments due to floor and ceiling effects. With the promise of sight restoring treatments such as retinal prostheses, stem cells, or gene therapy on the horizon, it is important to develop outcome measures applicable to persons living with severe vision loss as neither visual acuity measurement nor measurement of IADLs using currently available instruments is appropriate in this group of patients.

Therefore, we developed a vision-related IADL assessment capturing time and accuracy for a set of observed tasks, the Very Low Vision Instrumental Activities of Daily Living (IADL-VLV) assessment, appropriate for persons with severe vision loss. This test battery is part of the Low Vision Assessment of Daily Activities (LoVADA), which is currently being developed as part of a comprehensive protocol for the Bionic Vision Australia retinal prosthesis project. The purpose of this study was to determine its validity, reliability and measurement characteristics using factor and Rasch analysis.

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Methods

The study was conducted between September 2012 and December 2013 at the Centre for Eye Research Australia, Royal Victorian Eye and Ear Hospital (RVEEH; Melbourne, Australia). Ethical approval was obtained from the Human Research and Ethics Committee at the RVEEH. All patients gave informed consent for study participation. The study adhered to the tenets of the Declaration of Helsinki.

Phases of the Assessment Development

The study was conducted in two phases, starting with pooling items using existing ADL tools, and obtaining feedback on the importance of the items from 62 participants with severe vision loss (i.e., legally blind, <20/200 acuity in the better eye or <10° fields). Participants were interviewed and ranked a total of 296 items on a 3-step scale ("very important," "important," "not important"). Based on the ranking, the top 25 activities were selected. Out of these, a panel of experts (including ophthalmologists, optometrists, orthoptists, low-vision professionals, and occupational therapists) further refined the selection of activities to those that could be observed, standardized, and timed. A final set of 11 activities consisting of several tasks each was taken forward into the second phase of the study, in which the IADL tasks were pilot tested.

Participants of the Pilot Study

All participants were adults (≥18 years) and legally blind according to the Australian definition, which is based on either distance visual acuity (<20/200 in the better eye) or a visual field (VF) restriction (binocular VF of 10° or less) or both.

All participants underwent a complete clinical examination, including VF testing, and a battery of psychological tests, which contained an assessment of their cognitive function and a measure of depressive symptoms. Cognitive impairment and depression have been shown to influence performance on observed as well as self-reported tasks, with increasing cognitive impairment and depression leading to worsening performance.[12,13] Thus, we decided to control for these, using the Mini-Mental State Exam Second Edition Brief Version (MMSE-2 BV) and the Patient Health Questionnaire 9-items (PHQ-9).[17–19] For the PHQ-9, a cutoff of 10 and above to diagnose depression was used as suggested by a large meta-analysis.[17] Using the MMSE-2 BV, participants were deemed cognitively normal if they scored 13 or above, in accordance with the user's manual.[18]

Refraction was determined via autorefraction, followed by a monocular subjective refinement where possible. Best-corrected visual acuity (VA) was recorded both monocularly and binocularly, using a standard testing protocol. All patients were first tested on an Early Treatment of Diabetic Retinopathy Study (ETDRS) logMAR visual acuity chart at 4 m. As all patients had vision of equal to or worse than logMAR 1.0 (6/60) in their better eye, the next step was to repeat the ETDRS at 1 m. For patients that were unable to see the chart at this distance, acuity was measured using the Berkeley Rudimentary Vision Test (BRVT).[20]

Visual acuity was converted into logMAR for subsequent statistical analyses.

Remaining VF was detected using manual kinetic Goldmann perimetry,[21] with the V4e target size. Goldmann perimetry is the gold standard for assessment of fields in patients with severe retinitis pigmentosa (RP), and many participants' fixation did not permit for any other VF assessment. Field testing was completed by one experienced examiner, who measured each of the 24 meridians at least twice to check for consistency. The edges of any islands or scotomas were further probed with tangential movements to accurately map the remaining field. Unreliable field tests were defined as frequent fixation losses during testing and/or intermittent measures (i.e., where the edge of the island or scotoma was not repeatable on the second measure) and were excluded from analysis. Percentage of remaining field was quantified as described previously.[22] In brief, the hard copy Goldmann fields were scanned into ImageJ software (http://imagej.nih.gov/ij/; provided in the public domain by the National Institutes of Health, Bethesda, MD, USA). The percentage of field seen was determined by comparing the field seen to the total possible field area. For the purposes of this study, the total VF remaining included both central field (within 10° from fixation) and peripheral islands.

IADL-VLV Tasks

The tasks chosen for this pilot study included table and shelf searches of cutlery and crockery items, clock face and symbol recognition, signature placement, drink pouring, clothes sorting, and the understanding of hand gestures. A full list of all activities and tasks can be found in the appendix (Supplementary Material, all tasks summarized in Table 1). All tasks were scored as to completion and accuracy on a four-step scale (3 = task completed accurately on first attempt, 2 = task completed inaccurately in 1–2 attempts, 1 = task completed inaccurately in more than 2 attempts, 0 = task not completed). Four rating categories were chosen as this number is highly reproducible and allows for sufficient discrimination between the categories.[23,24] In addition, all tasks were timed until completion or until the participant gave up. In this pilot study, participants were allowed up to three attempts to complete a task. Criteria for inaccuracy are listed for every task in the Supplementary Material.

Statistical Analyses

The data entry and management was performed using the OpenClinica open source software, version 3.1 (OpenClinica LLC and collaborators, Waltham, MA, USA). Data analysis was carried out with the SPSS statistical software (Version 19.0; SPSS Science, Chicago, IL, USA) and the Winsteps software (version 3.68; Chicago, IL, USA). We used factor analysis (SPSS) and Rasch analysis (Winsteps) to explore factor loading and item performance and fit, respectively.

In essence, factor analysis is used to describe variability of unobserved/unmeasured variables (so called "factors") using observed, correlated variables. Using these joint variations in response allows reduction of the number of interdependent, observed variables using linear combinations of the potential factors plus error terms. It differs from principal component analysis (PCA) employed by Rasch analysis, and to date it is unclear which method is more appropriate in selecting tasks or items in instrument development.[25,26]

In brief, Rasch analysis is used to assess how well a measure captures the measured underlying construct or trait. There is a long history of using Rasch analysis in questionnaire or test development, using unobserved or self-reported ratings. However, there are also a large number of studies which use Rasch analysis to develop and evaluate assessments using observed measures, in particular when measuring competence in activities of daily living in occupational therapy or in the assessment of IADL performance and its relation to vision as reported for example by Spaeth and colleagues.[9,27–30] Using self-ratings and observer ratings to assess an underlying construct that can only be approximated but never truly be measured, such as quality of life or competence in activities of daily living, is essentially the same in both scenarios, thus Rasch analysis can be used to assess the instrument's measurement characteristics.

Rasch analysis mathematically describes the interaction between respondents and test items and applies a strict model which the pattern of participants' responses should satisfy.[31–34] Rasch analysis provides greater insight into the psychometric properties of the instrument compared with traditional methods based on classical test theory. Several techniques are available to determine how well items fit the latent trait being measured; how well the items discriminate between the respondents; and how well item difficulty targets person ability (i.e., level of visual functioning).[35] During Rasch analysis, scores that approximate interval-level measurement (person measures [PM], expressed in log of the odds units, or logits) are estimated from raw ordinal data. We used Rasch analysis to explore unidimensionality in two ways. First, by testing how well each item 'fits' or 'misfits' the underlying trait through an 'infit' mean square standardized residuals (MNSQ) statistic.[36] A value of 0.7 to 1.3 is considered acceptable, while lower or higher values may indicate redundancy or unacceptable variation in the responses, respectively. Second, the items were tested for local independence using PCA, which means that they are not related except for the fact that they measure the same trait, with as little overlap between items as possible. The PCA of residuals for the first factor should exceed 50% and the first contrast of residuals should be less than 2.5 eigenvalues.[36]

Principal component analysis in Rasch analysis differs in that it assesses the residuals (i.e., the unexplained part [or variance] rather than the explained part of the data). Residuals are assessed as to whether they differ from a random normal distribution, which would be expected if they were just measurement noise. Furthermore, the noise associated with one item should be independent of the noise associated with another item. If PCA detects a residual factor in the unexplained data, that is, a nonrandom distribution or a correlation of residuals between items, the Rasch model assumes multidimensionality and the scale should be reassessed as to whether it needs to be split into subscales.

Descriptive statistical analyses were performed to characterize the participants' sociodemographic, clinical, and IADL-VLV data. As we aimed to retain only vision-related tasks, the associations between IADL-VLV scores and vision were explored using multivariate logistic regression, controlling for participant characteristics.

Results

Participant Characteristics

A total of 40 participants were included. All were legally blind due to a rod–cone dystrophy, with the majority having autosomal recessive retinitis pigmentosa (>80%). Mean age was 53 years, and 53% of the sample was male (Table 2). The mean binocular VA was 2.3 LogMAR, which is in the range of hand movement vision and 70% of the sample had less than 10% of VF remaining (Table 2). Using the MMSE, no participant was cognitively impaired. Based on the PHQ-9 scores, five participants were depressed with scores greater than or equal to 10. These patients were referred for treatment of their depression outside of the study.

Psychometric Evaluation of the IADL-VLV

Using factor analysis, one main factor that explained 80.31% of variance was extracted for all 11 summary tasks (each consisting of 4–8 tasks) indicating robust measurement of IADL performance with the chosen tasks (Table 1 lists all summary tasks and subtasks). Using all 53 single tasks, factor analysis extracted five factors with eigenvalues of two or more, indicating as many as five independent subscales. The first factor explained 57% of variance, indicating that a number of tasks split into different summary tasks as intended, but also that a number of tasks could be omitted and the assessment shortened. Using the component matrix, almost all tasks had a loading of greater than or equal to 0.5 onto the first factor, providing little information on further task selection. Based on this, factor analysis was not felt to aid in selection of tasks and assessing single task performance, and we assessed further measurement characteristics using Rasch analysis.

A large number of tasks demonstrated either a floor or a ceiling effect (27 of 53 tasks [49%], and 2 of 53 tasks [4%], respectively). All tasks were retained at this stage, however, in order to allow for optimal task selection based on an iteration of PCA.

Using all tasks, PCA indicated severe multidimensionality (eigenvalue for first contrast 7.1), and a number of misfitting tasks, of which the majority (4 of 5) had an infitMNSQ less than 0.5, indicating redundancy (Table 3). Based on this, all tasks related to table search using a black background (tasks 4.1–4.4) and clock reading using a black background (tasks 8.1–8.4) were omitted. Based on several iterated PCAs, the single tasks grouped together as follows; reading symbols /information, signature placement, clothes sorting, shelf search, gestures, clock reading, and table search. A number of the tasks were omitted from every subscale based on misfit or insufficient loading onto the component. The tasks related to drink pouring neither contributed to measurement on any of the identified factors, nor did they group together as a separate factor, and were omitted. Drink pouring was also a task that showed a strong ceiling effect, with most subjects able to complete the task with ease. Based on these omissions, the measurement properties improved as depicted in Table 3 (IADL-VLV V2, items as listed in Table 1).

However, the following tasks misfit considerably: 3.4 and 3.5, the two most difficult items of the multiple item shelf search. Removing these would result in the retention of only two tasks, which is too few items for a valid subscale. Adding task 3.1 (omitted due to insufficient loading onto the subscale) would provide a sufficient number of tasks, but lead to considerable misfit of items 3.2 and 3.4. Based on this, the whole subscale shelf search (single and multiple items) was omitted. This led to an improvement in person separation, and a considerable improvement in the eigenvalue and the variance (72%–78%) of the first contrast, supporting the omission of the shelf search items (IADL-VLV V3, Table 3). The final scale reflects the results of the factor analysis, with approximately 80% of variance explained, and five identified components (eigenvalue of 4.7). An overview of final items is provided in Table 1 (asterisks). The person separation of 3.8 indicates that the assessment is able to differentiate between at least four different levels of IADL performance, and the person mean close to zero (–0.61) indicates adequacy of task difficulty for the tested sample. In summary, the 23 final tasks are related to table search, recognition of symbols, clock reading, signature placement, clothes sorting, and recognition of hand gestures.

Association of the IADL-VLV Scores With Participant Characteristics

We used multinomial logistic regression and general linear regression to assess the association of task score and task time with VA and VF, respectively, for all single tasks. Using accuracy as an outcome measure, all tasks were associated with VA and

Table 1. Overview of IADL Tasks, Their Rasch Subscale Loading, Floor and Ceiling Effects, Association With VA and VF, and Selection of Final Items

				Binocular VA, logMAR				Remaining VF in %			
				Score		Time		Score		Time	
Tasks	Final Selection	Rasch Loading Onto a Subscale	Floor/Ceiling Effect	Cox Pseudo-R^2	P	R^2	P	Cox Pseudo-R^2	P	R^2	P
Task 1 – Table search (white background)											
Task 1.1 Placemat	Selected	Yes		0.497	**<0.001**	0.002	0.777	0.328	**0.001**	0.094	0.055
Task 1.2 Dinner plate	Selected	Yes	Yes	0.614	**<0.001**	0.023	0.355	0.375	**<0.001**	0.111	**0.035**
Task 1.3 Coffee mug	Selected	Yes	Yes	0.600	**<0.001**	0.034	0.257	0.540	**<0.001**	0.122	**0.027**
Task 1.4 Dinner fork	Selected	Yes		0.636	**<0.001**	0.025	0.334	0.333	**0.001**	0.115	**0.033**
Task 2 – Shelf search single items											
Task 2.1 Shelf search cereal		No	Yes	0.493	**<0.001**	0.030	0.285	0.305	**0.002**	0.083	0.071
Task 2.2 Shelf search cola bottle		No	Yes	0.460	**<0.001**	0.071	0.097	0.328	**0.001**	0.139	0.018
Task 2.3 Shelf search tomato soup		No		0.540	**<0.001**	0.006	0.643	0.304	**0.002**	0.060	0.126
Task 2.4 Shelf search tea box		No		0.543	**<0.001**	0.021	0.369	0.234	**0.014**	0.061	0.123
Task 2.5 Shelf search curry powder		No		0.285	**0.004**	0.004	0.682	0.177	0.051	0.047	0.180
Task 3 – Shelf search multiple items											
Task 3.1 Shelf search multiple tasks cereal		No	Yes	0.403	**<0.001**	No time recorded for task 3		0.304	**0.001**	No time recorded for task 3	
Task 3.2 Shelf search multiple tasks cola bottle		Yes, but omitted	Yes	0.340	**0.001**			0.218	**0.020**		
Task 3.3 Shelf search multiple tasks tomato soup		Yes, but omitted	Yes	0.373	**<0.001**			0.230	**0.005**		
Task 3.4 Shelf search multiple tasks tea box		Yes, but omitted		0.257	**0.003**			0.178	**0.022**		
Task 3.5 Shelf search multiple tasks curry powder		Yes, but omitted	Yes	0.550	**<0.001**			0.371	**<0.001**		
Task 4 – Table search (black background)											
Task 4.1 Placemat		No		0.647	**<0.001**	0.001	0.891	0.391	**<0.001**	0.083	0.072
Task 4.2 Dinner plate (black)		No	Yes	0.567	**<0.001**	0.138	**0.018**	0.373	**<0.001**	0.072	0.094
Task 4.3 Coffee mug (black)		No	Yes	0.644	**<0.001**	0.071	0.097	0.555	**<0.001**	0.094	0.054
Task 4.4 Dinner fork (black)		No		0.639	**<0.001**	0.032	0.356	0.385	**<0.001**	0.101	**0.045**
Task 5 – Clock reading (white background)											
Task 5.1 Clock 9.00		No		0.445	**<0.001**	0.008	0.559	0.215	**0.003**	0.085	0.079
Task 5.2 Clock 3.30	Selected	Yes	Yes	0.584	**<0.001**	0.90	0.071	0.436	**<0.001**	0.136	**0.025**
Task 5.3 Clock 12.15	Selected	Yes		0.659	**<0.001**	0.180	**0.009**	0.347	**0.001**	0.125	**0.032**
Task 5.4 Clock 9.30	Selected	Yes		0.635	**<0.001**	0.141	**0.022**	0.485	**<0.001**	0.126	**0.031**

TABLE 1. Continued

Tasks	Final Selection	Rasch Loading Onto a Subscale	Floor/Ceiling Effect	Binocular VA, logMAR: Score Cox Pseudo-R^2	Binocular VA, logMAR: Score P	Binocular VA, logMAR: Time R^2	Binocular VA, logMAR: Time P	Remaining VF in %: Score Cox Pseudo-R^2	Remaining VF in %: Score P	Remaining VF in %: Time R^2	Remaining VF in %: Time P
Task 6 – Sign recognition											
Task 6.1 Sign "Information"		No		0.695	**<0.001**	0.042	0.223	0.385	**<0.001**	0.051	0.179
Task 6.2 Sign "Right arrow"	Selected	Yes	Yes	0.603	**<0.001**	0.189	**0.007**	0.322	**0.002**	0.124	**0.033**
Task 6.3 Sign "First aid/ cross"	Selected	Yes	Yes	0.527	**<0.001**	0.127	**0.033**	0.296	**0.005**	0.118	**0.040**
Task 6.4 Sign "Steps"	Selected	Yes	Yes	0.627	**<0.001**	0.097	0.065	0.343	**0.002**	0.201	**0.006**
Task 6.5 Sign "Wheelchair"		No	Yes	0.504	**<0.001**	0.001	0.826	0.267	**0.004**	0.035	0.272
Task 6.6 Sign "Down arrow"	Selected	Yes	Yes	0.612	**<0.001**	0.260	**0.002**	0.288	**0.002**	0.173	**0.012**
Task 6.7 Sign "Man"	Selected	Yes	Yes	0.609	**<0.001**	0.208	**0.005**	0.348	**0.002**	0.094	0.068
Task 6.8 Sign "Coffee/cup"	Selected	Yes	Yes	0.664	**<0.001**	0.146	**0.022**	0.396	**<0.001**	0.132	**0.029**
Task 7 – Signature placement											
Task 7.1 Signature small	Selected	Yes		0.605	**<0.001**	0.069	0.102	0.326	**0.001**	0.127	**0.024**
Task 7.2 Signature X-large		No	Yes	0.384	**<0.001**	0.047	0.178	0.282	**0.001**	0.058	0.133
Task 7.3 Signature large	Selected	Yes	Yes	0.413	**<0.001**	0.189	**0.005**	0.227	**0.016**	0.032	0.267
Task 7.4 Signature medium	Selected	Yes		0.583	**<0.001**	0.243	**0.001**	0.218	**0.020**	0.165	**0.009**
Task 8 – Clock reading (black background)											
Task 8.1 Clock 3.00 (black)		No		0.485	**<0.001**	0.058	0.146	0.329	**0.002**	0.164	**0.012**
Task 8.2 5.45 Clock (black)		No		0.635	**<0.001**	0.088	0.070	0.362	**0.001**	0.086	0.073
Task 8.3 Clock 8.15 (black)		No		0.587	**<0.001**	0.055	0.155	0.305	**0.003**	0.138	**0.021**
Task 8.4 Clock 10.10 (black)		No		0.560	**<0.001**	0.109	**0.043**	0.306	**0.001**	0.100	0.053
Task 9 – Drink pouring											
Task 9.1 Drink pouring kettle fingerdip		No	Yes	0.021	0.648	0.024	0.340	0.018	0.694	0.065	0.112
Task 9.2 Drink pouring kettle handle		No	Yes	0.182	**0.045**	0.30	0.289	0.299	**0.003**	0.074	0.089
Task 9.3 Drink pouring jug fingerdip		No	Yes	0.045	0.401	0.038	0.227	0.124	0.071	0.097	**0.050**
Task 9.4 Drink pouring jug handle		No	Yes	0.119	0.079	0.023	0.353	0.103	0.114	0.132	**0.021**
Task 10 – Clothes sorting											
Task 10.1 Singlets B&W	Selected	Yes	Yes	0.385	<0.001	0.159	0.011	0.209	**0.009**	0.136	**0.019**
Task 10.2 Singlets B, W&G	Selected	Yes	Yes	0.529	<0.001	0.289	<0.001	0.358	**0.001**	0.215	**0.003**
Task 10.3 Socks B&W		No	Yes	0.407	**<0.001**	0.396	**<0.001**	0.372	**<0.001**	0.176	**0.007**
Task 10.4 Socks B, W&G	Selected	Yes		0.569	**<0.001**	0.282	**<0.001**	0.355	**0.001**	0.199	**0.004**
Task 10.5 Hankies L&D		No	Yes	0.595	**<0.001**	0.377	**<0.001**	0.414	**<0.001**	0.237	**0.001**
Task 10.6 Hankies L, D, P	Selected	Yes		0.623	**<0.001**	0.357	**<0.001**	0.238	**0.012**	0.249	**0.001**

TABLE 1. Continued

Tasks	Final Selection	Rasch Loading Onto a Subscale	Floor/Ceiling Effect	Binocular VA, logMAR				Remaining VF in %			
				Score		Time		Score		Time	
				Cox Pseudo-R^2	*P*	R^2	*P*	Cox Pseudo-R^2	*P*	R^2	*P*
Task 11 – Recognition of gestures											
Task 11.1 Gesture "quiet"	Selected	Yes	Yes	0.539	**<0.001**	No time recorded for task 11		0.359	**0.001**	No time recorded for task 11	
Task 11.2 Gesture "pointing"		No		0.548	**<0.001**			0.412	**<0.001**		
Task 11.3 Gesture "waving"		No		0.544	**<0.001**			0.293	**0.004**		
Task 11.4 Gesture "beckoning"	Selected	Yes		0.394	**<0.001**			0.430	**<0.001**		
Task 11.5 Gesture "stop"	selected	Yes		0.455	**<0.001**			0.318	**0.002**		

Bolded *P* values indicate statistical significance. B, black; W, white; G, grey; L, light; D, dark; P, pattern.

TABLE 2. Participant Characteristics, $n = 40$

Characteristics	Mean ± SD or *n*, %
Age	53 ± 16
Age category	
55+	21 (52.5%)
<55	19 (47.5%)
Sex	
Male	21 (52.5%)
Female	19 (47.5%)
Binocular VA, logMAR	2.3 ± 1.0
VA code	
>2.0 logMAR	19 (47.5%)
≤2.0 logMAR	21 (52.5%)
% VF Remaining	11.8 ± 20.4
% VF	
0–10%	28 (70.0%)
>10%	12 (30.0%)
MMSE	15.3 ± 0.88
PHQ-9	3.45 ± 4.84

VA, visual acuity; VF, visual field; logMAR, logarithm of the minimum angle of resolution; MMSE, mini-mental state exam; PHQ-9, Patient Health Questionnaire 9-items.

VF except the drink pouring items, which showed no association (Table 1). This lent further support to our decision to omit all drink pouring tasks. Associations were less consistent for the obtained time scores (61% associated with VA and 87% associated with VF; Table 1).

Rasch analysis was used to generate person measures for the IADL-VLV V3 (mean −0.61 logits, ±2.49 logits SD). There was no difference by age group or sex in the IADL performance scores. Persons with worse VA or less remaining VF scored considerably lower ($P < 0.001$ and $P = 0.001$, respectively). In a generalized linear model, only VA and percentage of remaining VF were associated with PM IADL-VLV, not age or sex, controlling for depression and cognitive impairment (Table 4).

DISCUSSION

Using a large item pool, participant and expert input, factor, and Rasch analysis, we designed a valid and reliable performance-based assessment of IADLs for persons living with severe vision loss, the IADL-VLV. This instrument can differentiate between at least four different levels of IADL performance or ability, and is well targeted to the assessed sample, with the final set of tasks being neither too difficult nor too easy. We established face validity of the overall assessment by involving participant as well as expert input. Instrumental Activities of Daily Living performance measured by the IADL-VLV is associated with both VA and remaining VF, which is further evidence of the assessment's validity. Further larger studies are needed to explore the tool's measurement properties in more detail, including reproducibility as well as further validation of the instrument.

The need for an ADL test battery for persons with severe vision loss has become urgent over the past few years, with the commencement of clinical trials for vision restoration techniques, such as stem cells, gene therapy, and retinal prostheses. While these techniques are still in their infancy, the vision gains are expected to remain small for the medium term, and hence outcomes must be measured on a scale not previously required.[37] The IADL-VLV provides a tool which can accurately

Table 3. The Fit Parameters of the IADL-VLV Assessment Compared to the Rasch Model

Parameters	Rasch Model	IADL-VLV All Tasks	IADL-VLV V2	IADL-VLV V3
Item No.		All	1.1–1.4, 3.2–3.5, 5.2–5.4, 6.2–6.4, 6.6–6.8, 7.1, 7.3–7.4, 10.1–10.2, 10.4, 10.6, 11.1, 11.4–11.5	1.1–1.4, 5.2–5.4, 6.2–6.4, 6.6–6.8, 7.1, 7.3–7.4, 10.1–10.2, 10.4, 10.6, 11.1, 11.4–11.5
Number of misfitting items	0	5	2	0
Person separation (PSI)	>2.0	5.38	3.53	3.78
Person reliability (PR)	>0.8	0.97	0.93	0.93
Person mean	0	−0.81	−0.66	−0.61
Principal Components Analysis (PCA; Eigenvalue for first contrast)	<2.5	7.1	5.6	4.7
Variance by the first factor	50%–60%	70.7%	71.6%	77.5%

discriminate performance in persons with severe vision loss (<6/60), and it is hoped that this test battery, as part of the larger LoVADA protocol, will be able to be implemented in vision restoration clinical trials. Despite the observed floor effect in the accuracy score, items were retained at this stage of instrument development as a further differentiation between participants is possible by their time scores. Timing as well as scoring allowed for sufficient differentiation between all participants. All retained items were associated with binocular VA and a considerable number were also associated with percentage of remaining VF, which reflects results for other vision-related IADL assessments reported by Spaeth and colleagues.[38,39]

Performance-based measures have been shown to reflect a person's current functional ability, and to capture change over time with better accuracy than self-report.[40] Self-report tends to yield a higher functional ability compared with the actual observed ability, particularly in the elderly.[41] Similarly, IADL difficulties have been found to be more strongly associated with vision and a change in vision compared with difficulties with basic ADLs (essential life skills such as feeding and dressing oneself),[42] making IADLs the better choice to assess vision-related functional ability over time or following an intervention. Against this background, the IADL-VLV fits, for example, the assessment criteria stipulated by the US Food and Drug Administration (FDA) that evaluation of retinal prostheses should include functional vision (i.e., IADL/ADL assessment) and quality of life measures.[43,44]

As this is a cross-sectional sample, it is impossible to say whether a score or timing the activity is a better way to assess change over time or following an intervention. Both outcomes (scores and time) are associated with VA and VF in our cross-sectional sample. Owsley and colleagues[5] showed that timing IADLs is a valid outcome measure for vision-related tasks, and is independent of other functional and health problems or advanced age. Cognitive function is uniquely associated with timed IADLS[11] and further studies using the IADL-VLV will need to control for this. Which outcome (score versus time) is the more sensitive to small changes cannot be established based on our current data. Thus, both outcome measures will be retained for now, and this question will be addressed in future larger scale studies.

Table 4. Factors Associated With Person Measure of the Overall IADL Accuracy Score in a Generalized Linear Model

Parameter	B	95% Confidence Interval Lower	95% Confidence Interval Upper	*P*
Sex				
Male	−0.051	−0.76	0.65	0.887
Female (reference)	0			
Age	−0.003	−0.03	0.02	0.822
VA	1.823	1.43	2.22	0.000
% of remaining VF	−0.026	−0.05	−0.01	0.009

IADL, instrumental activities of daily living; PM, person measures; VA, visual acuity; VF, visual field.

All items related to the shelf search tasks were omitted as they did not contribute to the overall measurement of IADL performance. This is likely due to combining too many different aspects, such as identifying the item by size, grabbing the item, and then securely transferring the item to a table next to the shelf into one task. These are too many components for just a single task, which created considerable noise in the data from these tasks. Similarly, all tasks related to drink pouring had to be omitted as not only did the tasks not perform adequately in terms of their measurement, but none of them were related to any measures of vision either. With drink pouring, it seems that tactile input, sound and proprioception may determine performance of these tasks much more than visual function. Thus, they are inappropriate to be used in a vision-related IADL assessment.

Strengths of this study include the incorporation of input from persons who were legally blind, occupational therapists, and low-vision professionals, which is a shortcoming of many other existing IADL scales.[45] Furthermore, we used modern psychometric techniques to comprehensively evaluate the IADL-VLV's measurement properties, and based our final selection of items on this as well as the association with measures of visual function in our sample. Despite the sample having severe vision impairment, performance of the tasks was associated with visual function, highlighting reliability and validity of the vision-related IADL-VLV. The assessed sample was characterized in great detail, including a full clinical workup, psychological assessment, and functional vision testing which, unlike other studies, allowed us to control for cognitive function and depression as well as relevant clinical parameters. Our study is limited by its relatively small sample size, and further studies are needed to evaluate the assessment in more detail, including in people with different causes of vision loss. The testing time required for the reduced test is between 0.5 to 1 hour, and further studies will not only validate the battery of test items further but also refine them to reduce the overall time needed. The results cannot be generalized to a population with less visual impairment.

In conclusion, the final set of items constitute a valid and reliable assessment to measure vision-related IADL performance in persons with severe vision loss, and final scores are associated with both VA and remaining VF which makes this assessment likely to be sensitive to change in visual function over time or following an intervention. However, further studies are needed to confirm this.

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