The Development of the Melbourne Low-Vision ADL Index: A Measure of Vision Disability

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Purpose. To develop a new test of activities of daily living (ADLs) appropriate for the low-vision population: the Melbourne Low-Vision ADL Index (MLVAI).

Methods. The MLVAI was designed as a desk-based clinical assessment, comprising 18 observed items on complex ADLs in part (a) and 9 questions on broad self-care ADLs in part (b). Each item was rated on a five-level descriptive scale from 0 to 4, based on independence, speed, and accuracy of performance. It was designed to be administered under standardized conditions with regard to the instructions, illumination, and working distances. The validity and reliability of the new MLVAI was determined for 122 subjects who were representative of the general low-vision population, in a cross-sectional study.

Results. Two items were found to be redundant and were eliminated from the test. Thus, the final test comprised 25 items, with 100 being the highest possible score. Cronbach's α indicated an internal reliability of 0.96, and an intraclass correlation coefficient indicated an overall reliability of 0.95. The SE of measurement was 4.5. According to Spearman's correlation coefficient, the test–retest reliability was 0.94 ($P < 0.001$), and the interpractitioner reliability for five different pairs of practitioners was 0.90 or higher ($P < 0.001$). With regard to validity, there was a moderately high correlation with vision impairment ($r = -0.68$, $P < 0.001$). Using Rasch analysis, content validity was also demonstrated by good separation indexes (4.70 and 9.88) and high reliability scores (0.96 and 0.99) for the person and items parameters, respectively. Separate calculation of indexes and reliability scores for parts (a) and (b) indicated high content validity and reliability of each part. However, the separation indexes and reliability scores were higher for part (a) than for part (b). The correlation coefficient for part (a) and part (b) was 0.68.

Conclusions. The MLVAI is a highly valid and reliable standardized test of ADL performance for the general low-vision population. It may be used to assess patients with low vision and has the potential to be used as a measure of low-vision rehabilitation outcomes. (*Invest Ophthalmol Vis Sci.* 2001;42: 1215–1225)

To provide appropriate rehabilitation programs to people with vision impairment, it is necessary to be able to assess their ability to perform activities of daily living (ADLs). Although many such tests have been highly developed and researched in other areas of rehabilitation, currently there is no ADL test that has gained wide acceptance in low-vision rehabilitation. A standardized, valid, and reliable test is needed.

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Approximately 50 ADL instruments have been developed for use in the aged and physically impaired and have been reviewed by several groups.[1–3] Generally, these instruments cover the basic self-care ADLs and do not cover the more complex ADLs (strictly referred to as instrumental ADLs or IADLs) relevant in low-vision rehabilitation. However, fewer than 15 disability or ADL instruments have been developed for use in low-vision rehabilitation. Some were developed to evaluate cataract surgery[4–7] and others to measure vision-related ADLs in the general elderly population,[8,9] to evaluate outcomes of low-vision programs,[10–12] and to study the relationship between vision and ADL performance.[13–18] Although some are applicable to the general low-vision population, many have unknown psychometric properties or do not cover adequately the relevant ADLs. Thus, existing instruments lack validity and demonstrated reliability for the low-vision population.

Therefore, the purpose of this study was to develop and to investigate the psychometric properties of a new ADL test appropriate for the low-vision population: the Melbourne Low-Vision ADL Index (MLVAI). The test was intended to be used primarily to measure ability to perform ADLs and secondarily to measure low-vision rehabilitation outcomes.

Methods

Selection of Items

A sample of ADL instruments from the scientific literature was used to select items for the MLVAI. First, we evaluated vision-related ADL instruments.[5,6,8–12,16,19–22] Second, we evaluated ADL instruments used to assess the aged,[23–33] because several instruments in this area have been extensively researched and have gained wide acceptance. Furthermore, the majority of the low-vision population in developed Western countries are elderly.[34–36]

We considered the frequency with which various ADLs appeared as items on these ADL instruments and whether they were consistent with research on the daily living problems reported by people with vision impairment.[37–39] From a pool of 75 potential items, the selection criteria were further refined as follows: importance in daily living, relevance in low-vision rehabilitation, and ability to distinguish between people with different amounts of vision impairment. Also our goal was, when possible, to select items for which performance could be observed, because observed performance is more verifiable than self-reported performance. Although no systematic studies have demonstrated that observed performance measures are better than self-report measures, the theoretical advantages are increased reliability and validity (patients without insight into their impairments may under- or overreport their ability[25]), greater sensitivity to change, and less influence of poor cognitive functioning, culture, language, and education.[40]

Of the final 27 items selected, 9 items were related to self-care ADLs and 18 to more complex IADLs (Table 1). Both self-care ADLs and complex IADLs were included to increase the range of ability that could be measured. Ability on each of the 18 IADL items was to be assessed by observing performance. Although it would be more accurate to also observe performance of the nine self-care ADL items, it would be highly time consuming and impractical. Therefore, ability on each of the nine self-care ADL items was assessed using a self-report questionnaire format.

Table 1. Items Selected for the Melbourne Low-Vision ADL Index

Observed Items	Questionnaire Items
Reading newspaper print	Eating
Reading newspaper headlines	Bathing
Reading a letter with typed print	Dressing
Using a telephone book	Grooming
Reading an account	Mobility
Reading a medicine label	Housework
Reading packet labels	Shopping
Recognizing faces	Preparing meals
Using a telephone	Managing medication
Writing a check	
Identifying coins	
Pouring	
Naming colors	
Buttoning a shirt	
Threading a sewing needle	
Telling the time: wrist watch	
Telling the time: wall clock	
Reading a digital display	

Selection of Assessment Scale

The assessment scale first considered was the time taken to perform each item. Performance time is an objective and reliable method, measured on a ratio scale. However, for the purposes of this test, there were two problems. The first was that simply measuring the time taken would not fully capture all the important aspects of ADL performance—for example, the number of errors or accuracy of performance. Although time taken and number of errors could be recorded separately, pilot studies showed that subjects made relatively few errors in performance, and this would result in a ceiling effect. The second problem in using performance time was that not all subjects were expected to be able to perform every item. Therefore, it would not be possible to record a performance time in all cases. Although this situation may be managed by assigning some arbitrary score, most statistical techniques are inappropriate for analyzing such results.

We next considered having practitioners assign a performance-rating score. Using this method, it would be possible to assess combined aspects of performance and to deal with inability to perform an item. Furthermore, we considered it important to use the same scale for the questionnaire items and the observed performance items, which would be feasible using practitioner ratings. The disadvantages are that the method is variable, and two practitioners may make different decisions about how several aspects of performance should be combined to assign a rating. However, providing standardized descriptive criteria for each rating level is thought to reduce the variability of practitioner judgments. Thus, a five-level adjectival Likert-type rating scale was selected. It ranged from 0 to 4 and was used for all items. Standardized descriptive criteria were assigned to each level, based on the speed, accuracy, and independence with which a subject was able to perform the item. The general form of the rating scale is presented in Table 2. We also chose to have the practitioner, when applicable, measure performance time for each item. The purpose of this was to facilitate accurate judgments regarding the speed of performance. The total score for the MLVAI was derived by summing the rating for each item. Thus, the maximum possible total score was 108.

Production of Items

Details of the design and production of the items for the MLVAI are provided in the Appendix. The original test is given in Haymes thesis,[41] (available from Baillieu Library, University of Melbourne, Vic 3010, Australia, and can be viewed at http://www.optometry.unimelb.edu.au/dept/99research/SAHLV/SAHLV.html). Briefly, all items were as realistic as possible. Many of them were paper-based ADLs. Any original documents used to produce paper-based items were computerized and printed to allow standardization and reproduction in the long term. All instructions, items, and score sheets were put into an A4-sized ring binder, which was stored in a portable plastic container along with the objects required for some of the items.

Administration of the Test

Standardized instructions were given for every item. All the observed items were to be performed at 25 cm, using habitual spectacles, except for recognizing faces and telling the time using a wall clock, which were to be performed at 1 m. The use of low-vision devices was not allowed, so that disability could be determined as defined by the World Health Organization: the subject's inability to perform the activity in the manner considered normal for human being.[42] The test was administered under standard illumination conditions of 240 lux, as recommended in the *Australian Standard*, section 1680.1,[43] for moderately difficult indoor tasks. Pilot studies conducted in eight normal subjects with simulated vision impairment[44] indicated that the test would take approximately 20 minutes.

Subjects

We recruited 126 subjects with impaired vision from several sources: the Vision Australia Foundation Kooyong Low-Vision Clinic, the Macular Vision Loss Support Society of Australia, and Retina Australia. The criteria for inclusion were: more than 18 years of age, any type of ocular disease, stable vision impairment (over the previous 12 months), and ability to speak and read English. Subjects were excluded if they had total blindness, cognitive impairment, physical impairment, or hearing impairment so that they were not able to manage a conversation in a quiet room. All the subjects had been to a low-vision rehabilitation clinic in the past. Informed consent to participate was obtained, and the research was approved by The University of Melbourne Human Research Ethics Committee. The study was conducted in accordance with the tenets of the Declaration of Helsinki.

Test Administrators

Four practitioners were recruited to administer the MLVAI: one optometrist, one occupational therapist, and two orthoptists at the Kooyong Low-Vision Clinic. A further 15 occupational therapists were recruited from regional clinics to score the video-recorded performances of two subjects.

Table 2. General Rating Scale for the Melbourne Low-Vision ADL Index

	Descriptive Criteria
Observed Items	
0	Very unsatisfactory: subject unable to complete task/item
1	Unsatisfactory: subject attempted the item, but was unable to complete it independently
2	Borderline: subject completed the item very slowly, or with many errors, or a combination of both
3	Satisfactory: subject completed the item moderately slowly, or with some errors, or a combination of both
4	Very satisfactory: subject completed the item quickly and efficiently, without errors
Questionnaire Items	
0	Very unsatisfactory: subject reported complete inability to perform task/item
1	Unsatisfactory: subject reported ability to perform the item, but only with a great deal of help
2	Borderline: subject reported ability to perform the item, but required some help
3	Satisfactory: subject reported ability to perform the item without help, but slowly or with some difficulty
4	Very satisfactory: subject reported ability to perform the item independently, quickly, and efficiently

Demographics and Vision Measures

The following demographics were recorded: age, gender, and ocular disorder (from clinical records or confirmed by examination). Binocular distance visual acuity was measured using a Bailey–Lovie log minimum angle of resolution (logMAR) chart[45] and scored using the per-letter method.[46] In addition, the binocular visual field was assessed, using the Goldmann perimeter (III-4e target). Using the distance visual acuity and visual field measures obtained, the level of vision impairment was then categorized according to Johnston's table of vision impairment,[47] which is based on the World Health Organization[42] classification of vision impairment. Each of the seven categories may be assigned based on visual acuity or visual fields. Subjects were categorized according to the worse of these two results.

Procedure

In the main study, all subjects were administered the MLVAI on two occasions. On one occasion the original version, already described, was administered. On the other occasion, an alternative version was administered. The purpose of the alternative version was to minimize the practice effect when a subject repeated the test.[48] The alternative version was constructed by making minor alterations to the original, while keeping the alternative items similar in structure and intention to the original items.

Testing took place over two sessions at the Kooyong Low-Vision Clinic. The presentation order of the original and alternative versions of the MLVAI was randomized. In the first session, one version of the MLVAI was administered, demographics were recorded, and distance visual acuity was measured. In the second session, the other version of the MLVAI was administered, the binocular visual field was assessed, and distance visual acuity was remeasured to ensure that there had been no sudden vision loss. The median duration between the two sessions was 2 weeks, with the interquartile range being between 1.5 and 3 weeks.

Although the optometrist administered both versions of the MLVAI to approximately half of the subjects, the three additional practitioners were involved in administering the test to the remainder of the subjects. By using all four practitioners for the remainder of the subjects, the results of six different pairs of practitioners could be compared. The order in which each one of a pair of practitioners administered the MLVAI to subjects was randomized. Each pair of practitioners tested between 6 and 16 subjects.

In the minor study, one male subject and one female subject with age-related macular degeneration were selected from the group. The male subject was aged 82 years, with binocular distance visual acuity of 6/30 (20/100), and the female subject was aged 79 years, with binocular distance visual acuity of 6/15 (20/50). One practitioner administered the MLVAI to each subject and recorded the sessions on videotape. The 15 practitioners previously described were asked to view the videotape and rate the performance of each subject. The purpose was to determine the interpractitioner reliability using a larger group of practitioners.

Analysis

First, the results were analyzed using classic test theory to allow comparison with other instruments, in that most vision-related ADL instruments to date have been developed using classic test theory. The data were double entered into a spreadsheet (Excel ver. 6.0; Microsoft, Redmond, WA) and analyzed with statistical analysis software (Minitab for Windows, ver. 12.0; Minitab, University Park, PA). Both parametric and nonparametric statistical methods were used to analyze the data. In every instance, there was little difference between the results. Mostly the results using nonparametric statistical methods are reported, because the distributions of several of the variables measured were not strictly normal. However, some parametric statistics are reported on the assumption that they are relatively insensitive to departures from normality.

Table 3. Causes of Vision Impairment

	Examples	Subjects (*n*)
Central vision loss	AMD; macular dystrophy; retinal vein occlusion; optic atrophy	85
Peripheral vision loss	Retinitis pigmentosa; glaucoma; diabetic retinopathy	20
Combined causes	AMD and glaucoma; AMD and cataract	15
Media opacities only	Cataract; keratoconus	4
Uncertain		2

AMD, age-related macular degeneration.

Second, the results were analyzed using item-response theory (IRT). Most ADL instruments have been developed using classic test theory,[49] but it has several shortcomings. The main ones are that the results are dependent on the sample of subjects tested, that every item is assumed to have the same difficulty, and that the ordinal ratings used produce an interval scale. IRT is a powerful statistical tool that overcomes these problems and has gained wide acceptance in the development of educational and psychological instruments.[50] Recently, Massof[51] advocated its use in the development of vision disability measures and Turano et al.[52] applied it to a low-vision mobility measure. IRT assumes that there is an unobserved (latent) continuous dimension of ability (θ) and that each person can be placed along this dimension at a point that reflects the extent of his or her ability. IRT estimates item characteristic curves for each item that show the probability of a positive response on a specific item as a function of ability (θ).[53] The shape of the curve for each item is determined by two item parameters β_i and α_i. Parameter β_i represents the item difficulty, and α_i represents the item discriminating ability of item *i*. Formally, the proportion of people who have amount of the ability who answer item *i* correctly is given as:

$$P_i(\theta) = \frac{e^{\alpha_i(\theta-\beta_i)}}{1 + e^{\alpha_i(\theta-\beta_i)}}$$

In the simplest model of IRT, termed the one-parameter logistic model or Rasch model, all the items are assumed to have equal discriminating ability (α_i). Thus, the important parameters are person ability and item difficulty. Each of these parameters may be transformed to an interval scale using the logarithm of the odds ratio (log-odds), where the mean value is 0 and the SD 1. The units on the log-odds scale are called logits. (See Hambleton et al.[53] for a detailed description of IRT and Massof[51] for a description of using the Rasch model to develop a vision disabilty measure.) We used another statistical analysis program (Bigsteps, ver. 2.82; Mesa Press, Chicago, IL) to perform a Rasch analysis on the data.

Results

Subject Characteristics

The 126 subjects recruited for the main study were aged between 20 and 89 years, and just over half the subjects (75 of 126) were women. The mean (±SD) age was 70 ± 16 years. The causes of vision impairment are given in Table 3. Binocular distance visual acuity for the subjects ranged from 6/6 (0.0 logMAR) to 6/300 (1.7 logMAR), although distance visual acuity could not be measured for two subjects. The mean (±SD) binocular distance visual acuity was 0.9 ± 0.5 logMAR. Visual field defects varied from a full central scotoma, to peripheral constriction to 2°. Four subjects did not return for the second experimental session because of illness. Thus, the final number of subjects who completed all tests was 122.

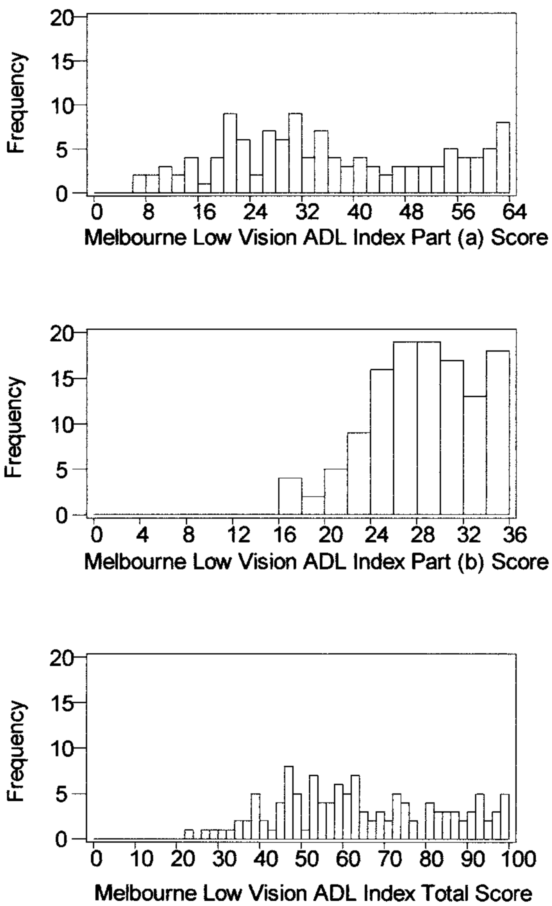

FIGURE 1. Distribution of part (a) score (observed items), part (b) score (questionnaire items), and total score on the Melbourne Low-Vision ADL Index for 122 subjects with impaired vision.

Internal Reliability and Item Redundancy

The distribution of scores for three items—identifying color, telling the time using a digital display, and buttoning a shirt—were highly skewed, indicating they may be too easy and did not add much discriminative value to the test. The results were the most skewed for identifying color.

We further analyzed the data to determine whether these items should be eliminated from the test using item-total correlations and Cronbach's α. The basis of both these tests is the correlations between items and the correlation between each item and the total test score. None of the item–total correlations obtained were less than 0.20, which is the usual cutoff criterion for indicating that items should be eliminated from a test.[49] However, the lowest item–total correlation of 0.24 was obtained for the shirt item, giving support to eliminating it from the test. The other approach, which also indicates the internal reliability of a test, is to calculate Cronbach's α, which can be calculated eliminating one item at a time. If α significantly increases, that item should be discarded from the test.[49] The elimination of any one item did not make any difference to the Cronbachs's α. Cronbach's α was 0.96 for the full 27-item MLVAI.

These findings supported the elimination of the shirt item from the test. Moreover, this item was not practicable, because it was awkward for subjects to put on a shirt over existing clothing. We also chose to eliminate the color identification item from the final score because, of all the items, the rating distribution for this item was the most highly skewed, indicating it was adding little discriminative value to the test. Furthermore, this item correlated perfectly with the digital display item, suggesting that both items were unnecessary. The final selection of just 25 items achieved a balance between making the test short and clinically useful and retaining enough items to maintain reliability. An additional advantage was that the final test comprising 25 items, each scored out of a possible 4, produced a convenient possible total test score of 100. Cronbach's α was unchanged for the 25-item test. Henceforth, the results reported pertain to the reduced 25-item MLVAI.

Descriptive Statistics

The total raw score for the MLVAI ranged from 23 to 100. The mean ($\pm$SD) total raw score was 63.9 $\pm$ 19.5 of 100. The distributions of part (a) observed items, part (b) questionnaire items, and the total raw score are shown in Figure 1.

Reliability

The overall reliability of the MLVAI was determined by calculating an intraclass correlation coefficient for the test–retest data (n = 122). This is the ratio of true variance between subjects to the sum of subject variance and measurement error.[49] The intraclass correlation coefficient was 0.95. The SE of measurement[49] was 4.5.

We examined plots of the MLVAI test against retest for the total raw scores, the raw scores on parts (a) and (b), and the individual test items. We then computed Spearman correlation coefficients. All test–retest correlation coefficients ranged from $r_s = 0.47$ to 0.91 ($P < 0.001$). The test–retest Spearman correlation coefficient for total score was $r_s = 0.94$ ($P < 0.001$; Fig. 2).

To determine the interpractitioner reliability, the Spearman correlation coefficients and plots of total raw score for each pair of practitioners were analyzed. All the correlation coefficients were high ($r_s \geq 0.90$, $P < 0.001$), except for one pair of practitioners who administered the test to only six subjects ($r_s = 0.68$, $P = 0.14$). For the minor study involving 15 practitioners who scored two different subjects with impaired vision on the MLVAI by observing a video recording, we obtained an intraclass correlation coefficient of 0.97.

Validity

For the MLVAI to be valid, we would expect a significant correlation between test score and level of vision impairment.

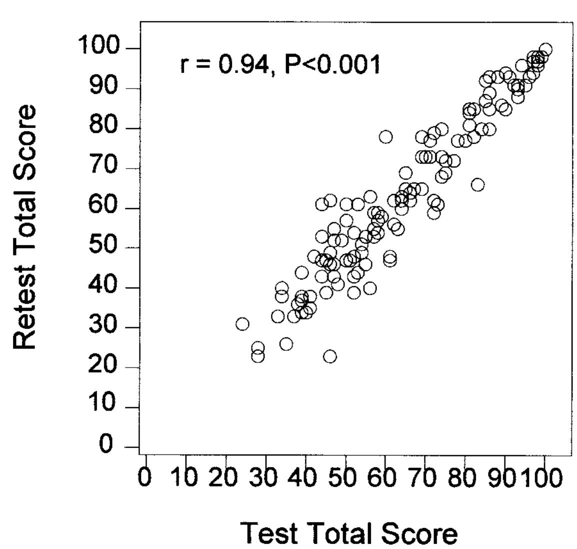

FIGURE 2. Test–retest reliability of the Melbourne Low-Vision ADL Index total score for 122 subjects with impaired vision.

TABLE 4. Factors for the Melbourne Low-Vision ADL Index

Factor 1 (Variance = 21.9%)		Factor 2 (Variance = 20.5%)		Factor 3 (Variance = 18.6%)	
Item	**Communality**	**Item**	**Communality**	**Item**	**Communality**
Headlines	0.81	Newsprint	0.94	Meals	0.65
Packet labels	0.80	Telephone book	0.84	Housework	0.65
Digital clock	0.58	Medicine label	0.90	Eating	0.56
Accounting	0.79	Typed letter	0.90	Medication	0.48
Wall clock	0.60	Needle threading	0.66	Shopping	0.61
Check	0.70			Dressing	0.34
Wrist watch	0.62			Mobility	0.37
Faces	0.60			Bathing	0.25
Pouring	0.55			Coins	0.52
Telephone	0.48			Grooming	0.17

This table represents the order in which items contribute to factors. The items with higher loadings, not necessarily higher communalities, are nearer the top of the column.

The Spearman correlation coefficient for test score and level of vision impairment (visual acuity on a logMAR scale or visual field loss on a log degrees scale, as described in the Methods section) was $r_s = -0.68$ ($P < 0.001$). Similarly, we might expect a difference between the scores of those with central vision impairment and those with peripheral vision impairment. There is strong clinical opinion and some scientific evidence that people with central vision impairment perform more poorly in general ADLs than people with peripheral vision impairment.[54] Indeed, a two-tailed Mann–Whitney test showed a statistically significant difference between the two groups (difference between median scores = −15.0, Wilcoxon statistic = 3662.5, $P = 0.02$ adjusted for ties).

Factor analysis was used to explore the theoretical factors (groups of correlated items) underlying the MLVAI and to provide further evidence of the construct validity of the test. Principal-components extraction was used in an initial run to evaluate the assumptions and limitations of factor analysis and to estimate the number of factors from eigenvalues. The first four eigenvalues were 12.55, 2.35, 1.43, and 1.16, respectively, with remaining eigenvalues less than 1.0. This indicated that there was one main factor underlying the MLVAI that explained 50% of the variance in results and that three to four factors yielded the best solution. In subsequent factor analyses, using the maximum likelihood method of extraction with orthogonal varimax rotation, the solution was evaluated specifying three and four factors. Three factors yielded the most interpretable solution (Table 4). Factor one contained items that were moderately difficult visually. Factor two contained items that were visually difficult, high-spatial-frequency, low-contrast tasks. The first two factors essentially combined to form part (a), the observed items of the MLVAI. Factor three, containing items related to self-care that were visually easy tasks, formed part (b), the questionnaire items. The rotated factor loadings, communalities, and loading plots indicated the items were well defined by this factor solution. Using a loading cut point of 0.45, as suggested by Tabachnick and Fidell,[55] all the items except grooming (item b7) loaded on to a factor.

Rasch Analysis

Factor analysis showed the first eigenvalue was relatively large compared with the second, suggesting that the items were approximately dominated by one factor. Thus, the results meet the underlying assumption of Rasch analysis that the items should be unidimensional.

Table 5 shows the 25 items in order from the most to the least visual ability required to perform the item. If the item logit is positive, the required visual ability for that item is higher than the mean required visual ability of all the items, and the reverse is true if the item logit is negative. Thus, the most difficult item was reading the telephone book, whereas the easiest item was bathing.

Figure 3 shows the distribution of the person-ability logits. A positive-ability logit indicates higher ability, and a negative-ability logit indicates less ability. The mean (±SD) of the distribution was 0.91 ± 1.60 logits, indicating that the visual ability of subjects in this sample was more than the mean required visual ability.

The infit and outfit statistics in Table 5 indicate the construct validity. The outfit statistic is sensitive to unexpected behavior by subjects on items far from the subject's ability level. The mean-square (MNSQ) outfit statistic is expected to be 1.0. Values substantially less than 1.0 indicate dependency in the data; values substantially more than 1.0 indicate the presence of unexpected outliers. The infit is an information-weighted fit statistic, which is more sensitive to unexpected behavior affecting ratings to items near the subject's ability level. As for the outfit statistic, the MNSQ infit statistic is expected to be 1.0. Values substantially below 1.0 indicate dependency in the data, and values substantially above 1.0 indicate noise. For both the outfit and infit statistic, the Z_{STD} is the MNSQ normalized to approximate a theoretical mean 0.0 and 1.0 SD. Z_{STD} values greater than 2.0 indicate the MNSQ exceeds the model's expectation by more than 2 SDs. From Table 5, the infit statistic for needle threading and face recognition indicates noise in the data. For needle threading, noise may be due to the possibility that the item is tapping a different process, because a high level of fine motor skill is also required. For face recognition, noise may be due to the possibility that, although two famous faces were used, some subjects could see the faces but were not familiar with the faces. Table 5 also shows that the most misfitting items were reading a typed letter, reading an account, shopping, reading packet labels, and pouring. The MNSQ infit statistics for these items were more than 3 SDs below the expected value of 1.0, indicating they may be dependent on a cofactor. With regard to the subjects, 29 subjects had ability MNSQ infit and outfit values outside the model's expectations by more than 2 SDs (Fig. 4).

The separation indexes (a measure of how broadly the parameters are distributed across the visual ability dimension) and reliability values for both person-ability and item-difficulty parameters are given at the bottom of Table 5. Content validity is indicated by the high separation indexes, and the precision of the measures is indicated by the high-reliability values.

To further investigate the differences evident in the score distributions for part (a) and part (b) (Fig. 1), and the findings

Table 5. Results of Rasch Analysis (All Items)

Item Difficulty

Item	Description	Item Logit	Error	Infit MNSQ	Infit Z_{STD}	Outfit MNSQ	Outfit Z_{STD}	Point Biserial Correlation
a6	Telephone book	2.48	0.13	1.10	0.6	0.85	−0.7	0.75
a12	Needle threading	2.42	0.13	1.74	3.9	1.47	1.9	0.68
a7	Newsprint	2.19	0.12	0.85	−1.0	0.74	−1.5	0.79
a8	Medicine label	1.59	0.11	1.11	0.8	0.95	−0.3	0.80
a11	Typed letter	1.39	0.11	0.61	−3.5	0.59	−3.2	0.86
a3	Accounting	0.56	0.11	0.62	−3.6	0.73	−2.1	0.84
a10	Faces	0.52	0.11	1.44	3.1	1.30	1.9	0.75
a2	Writing	0.49	0.11	0.78	−1.9	0.87	−0.9	0.79
b1	Shopping	0.32	0.11	0.65	−3.2	0.87	−0.9	0.72
a4	Wrist watch	0.23	0.11	0.93	−0.6	0.99	0.0	0.72
a15	Wall clock	0.04	0.11	1.03	0.2	1.14	0.8	0.71
b3	Housework	−0.05	0.11	1.11	0.8	1.56	2.9	0.50
a17	Coins	−0.14	0.11	0.70	−2.5	0.90	−0.6	0.69
b8	Mobility	−0.24	0.12	0.91	−0.6	1.28	1.5	0.52
a16	Packet labels	−0.28	0.12	0.49	−4.6	0.47	−3.7	0.84
a13	Headlines	−0.34	0.12	0.69	−2.4	0.64	−2.3	0.80
a14	Pouring	−0.34	0.12	0.58	−3.5	0.72	−1.7	0.70
a5	Telephone	−0.63	0.12	0.87	−0.9	0.93	−0.3	0.64
b2	Meal preparation	−0.74	0.13	0.73	−2.0	0.79	−1.1	0.62
b4	Medication	−1.15	0.14	0.88	−0.8	0.89	−0.5	0.55
b7	Grooming	−1.27	0.14	1.11	0.6	1.74	2.4	0.31
a9	Digital clock	−1.56	0.15	1.29	1.6	0.96	−0.1	0.62
b5	Eating	−1.56	0.15	0.67	−2.3	1.02	0.1	0.56
b6	Dressing	−1.60	0.16	1.00	0.0	1.39	1.2	0.42
b9	Bathing	−2.35	0.19	1.29	1.6	1.66	1.3	0.34

Global Fit Statistics for the Person Ability and Item Difficulty Parameters

Measure	Separation Index	Reliability	Average Infit	Average Outfit	Model Measurement Error	SD
Person ability	4.70	0.96	0.98	1.02	0.30	0.13
Item difficulty	9.88	0.99	0.93	1.02	0.12	0.02

The results are calculated for $n = 121$, because one subject had a perfect score, and perfect scores do not enter a Rasch analysis.[53]

of factor analysis (Table 4), Rasch analysis was also performed separately for parts (a) and (b).

The mean person ability for part (a) was 0.44 ± 1.93 logits and for part (b) was 2.73 ± 1.71 logits. This indicates that the ability of the subjects in this sample was more than the required ability, particularly for part (b). The most misfitting items for part (a) were as mentioned earlier, except that pouring was not a misfitting item and reading newspaper headlines was a misfitting item in this separate analysis. The only misfitting item for part (b) was eating. The separation indexes and reliability values are given in Table 6 and were higher for part (a) than for part (b). The correlation between the two parts was analyzed by calculating a Pearson correlation coefficient for the person-ability measures. The correlation between parts (a) and (b) was 0.68 ($P < 0.001$). Also, the correlation coefficient for each part and visual acuity (logMAR) and the test–retest correlation coefficient for each part was calculated (Table 6).

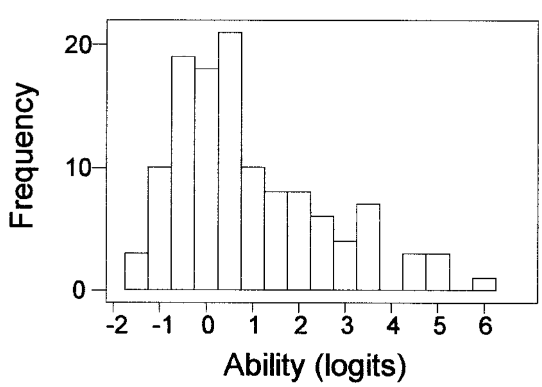

Figure 3. Distribution of person ability (logits) for the 25-item Melbourne Low-Vision ADL Index, determined using Rasch analysis for 121 subjects with impaired vision.

Discussion

Subject Characteristics

In comparison with epidemiologic studies,[34–36] the sample was representative of the general low-vision population in Western countries.

Melbourne Low-Vision ADL Index Characteristics

The distribution of total raw scores was wide (range, 23–100). However, although the scores for part (a), the observed items, were distributed across the possible range from 0 to 64, the scores for part (b), the basic self-care questionnaire items, were

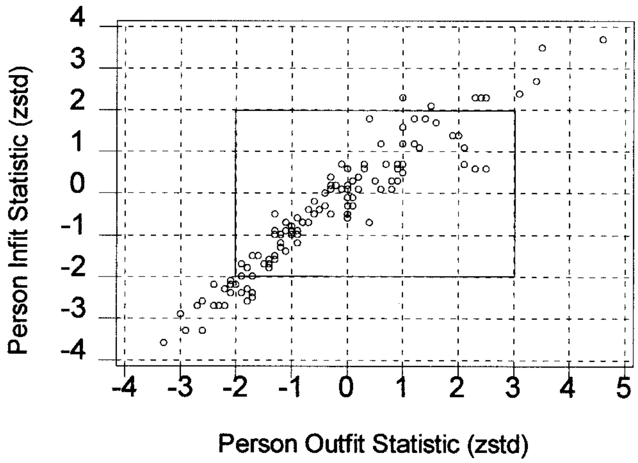

FIGURE 4. Person infit and outfit statistics (Z_{STD}) for the 25-item Melbourne Low-Vision ADL Index, determined using Rasch analysis for 121 subjects with impaired vision. The data outside the central box (*continuous line*) indicate person infit and outfit statistics outside the model's expectation by more than 2 SDs.

skewed toward the high end of the range 0 to 36. This indicates part (b) may not discriminate well between those at the high end—that is, those with better vision.

Furthermore, factor analysis (Table 4) and Rasch analyses (Tables 5, 6) also indicated a difference between performance of part (a) complex IADLs and self-report of part (b) basic self-care ADLs. These findings may have been obtained for three reasons. One is the ceiling effect seen in the distribution of part (b) scores, which resulted in lower correlations, separation indexes, and reliability for part (b) than for part (a). The second reason is that there is a difference between how the items were assessed: performance-based practitioner rating versus self-report questionnaire. Indeed, the correlation obtained between parts (a) and (b) was moderate ($r = 0.68$). Thus, as in other studies,[56,57] performance-based and self-report measures did not entirely agree. The third reason for the difference in part (a) and part (b) findings may be because the self-report items were less difficult and thus required less visual ability than the performance-based items. In fact, the order of the item-difficulty measures supports this suggestion. Complex IADLs, such as reading, recognizing faces, and telling the time, were more difficult for the majority of subjects with impaired vision than were the basic self-care ADLs, such as grooming, eating, dressing, and bathing. This agrees with anecdotal clinical findings, the formal survey findings of Genensky et al.,[37] the focus group study by Mangione et al.,[58] and the findings of Szlyk et al.[54] Thus, for the majority of persons with vision impairment, complex IADLs should be targeted in low-vision rehabilitation.

Reliability

The overall reliability of the MLVAI was high, as indicated by the intraclass correlation coefficient and Rasch analysis reliability values. The SE of measurement indicates that 68% of the time, the true score will lie within ±4.5 points of the obtained score. Given that the test score is of a possible 100 and the subjective element in functional measures, this is reasonable. This is further supported by Rasch analysis. The Rasch analysis person-ability and item-difficulty parameters also had high reliability values (0.96 and 0.99, respectively). However, when considered separately, there was a difference between the reliability value for part (a) and part (b). Although the person-ability reliability values for each part were both high, the reliability of part (a) was higher than that for part (b) (0.95 and 0.86, respectively).

Although the correlation coefficients for five of six different pairs of practitioners indicated a high interpractitioner reliability, the correlation for one pair of practitioners was moderate. However, the results are difficult to generalize, because the number of subjects seen by each pair of practitioners was small. An additional study involving more practitioners, but fewer subjects, indicated a higher interpractitioner reliability. However, again, the interpretation of the results of this minor study are limited, because there were only two subjects. We suggest further investigation of the interpractitioner reliability of the MLVAI.

TABLE 6. Results of Rasch Analysis for Part (a) and Part (b)

Analysis Results

Measure	Separation Index	Reliability	Average Infit	Average Outfit	Model Measurement Error	SD
Part (a)						
Person ability	4.56	0.95	0.98	1.00	0.38	0.14
Item difficulty	10.36	0.99	0.95	1.00	0.13	0.01
Part (b)						
Person ability	2.50	0.86	0.98	1.07	0.64	0.15
Item difficulty	7.53	0.98	1.01	1.11	0.17	0.02

Correlations

	Visual Acuity* (Pearson r)	Test–Retest Item-Difficulty Measures (Intraclass r)	Test–Retest Person-Ability Measures (Intraclass r)
Part (a)	−0.80	0.99	0.94
Part (b)	−0.49	0.98	0.81

The results are calculated for $n = 120$ and $n = 115$, because two subjects had a perfect score for part (a), and seven subjects had a perfect score for part (b). Perfect scores do not enter a Rasch analysis.[53]

* Expressed in logMAR.

The few similar instruments that have gained some acceptance in low-vision ADL assessment and that report reliability coefficients are the Activities of Daily Vision Scale,[5,59] the VF-14,[6,60] and the Visual Disability Assessment.[7] The Cronbach's α coefficients for these instruments vary from 0.85 to 0.94, compared with 0.96 for the MLVAI. The high Cronbach's α obtained for the MLVAI may indicate some redundancy of items, which is supported by the Rasch analysis. The test–retest reliability coefficients for the Activities of Daily Vision Scale,[5,59] VF-14,[6,60] and the Visual Disability Assessment[7] vary from 0.79 to 0.98, compared with 0.95 for the MLVAI, and the interpractitioner reliability coefficients vary from 0.94 to 0.97, compared with 0.97 for the MLVAI. Thus, the reliability of the MLVAI is generally higher than for other similar low-vision functional instruments. Moreover, the test–retest and interpractitioner reliability of the MLVAI is higher than that of the Older American Resource Services Questionnaire,[26] a well-accepted ADL measure used in gerontology.

Validity

The empiric development of the MLVAI implies that its content is valid. Furthermore, several results obtained provide evidence of construct validity. First, there was a moderately high, statistically significant correlation between MLVAI score and level of vision impairment. As expected, the correlation between visual acuity and part (a) complex IADLs was higher than the correlation between visual acuity and part (b) basic self-care ADLs ($r = -0.80$, $P < 0.001$; and $r = -0.49$, $P < 0.001$, respectively). Second, exploratory factor analysis showed that there was one main factor underlying the MLVAI, suggesting that the test is tapping one underlying theme: the ability to perform ADLs. Furthermore, factor analysis showed that the results could best be interpreted by three sensible underlying factors. Finally, Rasch analysis yielded high separation indexes for the person-ability and item-difficulty measures. However, the difference between parts (a) and (b) was again evident, with the separation index indicating greater content validity for part (a) than for part (b).

Because all results indicate a difference between part (a) and part (b), the total score for the MLVAI should be interpreted with caution. We suggest that it would be clearest to consider the scores for part (a) and part (b) separately. Although all results indicate that part (a) has higher content validity and reliability than part (b), we consider the results for each part of the test to be acceptable.

Suggested Changes

Notwithstanding the fact that we demonstrated the MLVAI to be highly reliable and valid in its present state, we suggest changes that may further improve the test. To enhance reliability, we suggest determining the normal time taken to perform each observed item for a group of age-matched subjects with normal vision. With the use of this information, the objectivity of the scale could be enhanced by assigning an appropriate range of times to each rating level.

Also, Rasch analysis indicated that some items may be redundant, and in future the test may be improved by eliminating those items. However, at this stage we caution against this, because the accuracy of the item-difficulty parameters depends on the sample size,[49,53] which in this study was relatively small for using Rasch analysis. Further investigation is warranted.

Future Studies

In future, we plan to investigate further the validity of the MLVAI by administering it to a sample size of more than 500 to determine more accurately the item parameters using item response theory. This will enable us to refine the content of the existing test and to identify gaps in the item logit distribution that should be filled with new items. Also, additional validation of the MLVAI should be undertaken by determining its correlation with other ADL performance instruments, such as the Activities of Daily Vision Scale[5] and the VF-14.[6] Also, its responsiveness to clinically important changes should be investigated.

Clinical Applications

There are several potential applications for the MLVAI, the first being to gather standardized baseline information when people enter rehabilitation programs. The majority of persons with vision impairment will have greatest difficulty with part (a), complex IADLs. Some will have sufficiently severe vision impairment to decrease their performance of part (b), basic self-care ADLs. Part (b) is likely to become more important in future, because a substantial increase in the number of elderly people with severe vision impairment is estimated.[61] A second application for the MLVAI is to guide planning the most appropriate programs. In most cases this will be the rehabilitation of complex IADL performance. However, when difficulty in self-care ADLs is indicated on part (b) items, such activities are likely to take precedence in the rehabilitation plan because of their fundamental importance in daily living. Third, depending on the program implemented for a particular person, each part of the MLVAI has the potential to be used to monitor change in function and to evaluate the outcomes of low-vision rehabilitation.

Recently, there has been a great effort to develop quality-of-life questionnaires as outcome measures of low-vision rehabilitation programs. We believe that more objective disability measures, such as the new Melbourne Low-Vision ADL Index, should be in place first. Although such a disability measure neither gives a total representation of the person with impaired vision nor a total representation of the outcomes achieved in low-vision rehabilitation programs, we consider that it should be an integral part of outcome measurement.

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Appendix

Part A: Observed Items

Many of the detailed items were produced by scanning the originals. In all these cases, the originals were scanned using a flatbed scanner (Studioscan IIsi; AGFA, Nunawading, Victoria, Australia). The resulting images were manipulated using image management software (PhotoShop, ver. 3.0.5; Adobe, San Jose, CA,) in the Center Internationale d'Eclairage (CIE) L*a*b mode, on a gamma-corrected monitor (AppleVision 1710; Apple Computer, Cupertino, CA). They were then converted to the CMYK mode and printed on a color laser printer (model 12/660 PS; Apple Computer). Although some of the simpler items were generated using other computer software programs, they were printed on the same laser printer used for the items produced by scanning the originals.

Item a1: Naming Colors. Red-, green-, blue-, and yellow-colored cards (13.5 × 16.4 cm) were generated in the image management software (PhotoShop; Adobe).

Item a2: Writing a Bank Check. A unique bank check, based on real-world examples, was produced by computer (Word, ver. 6.0; Microsoft). The font used for the bank title was dark red 16-point Geneva (height of capital letters, 4 mm). The font used for the words "Pay", "or bearer", "the sum of," and

"/19" was black 8-point Geneva (height of capital letters, 2 mm). The lines were dark gray and 0.25-point (0.1 mm). The font used for the "$" sign was bold black 18-point Geneva (height, 6 mm), and the line forming the box for writing the numerical form of the amount was 20% gray and 2-point (0.5 mm). The task was for the subject to write the check to the company "Gas Works" for $163.55 and to date and sign the check using a blue medium ballpoint pen.

Item a3: Reading an Account. The account selected was based on a local utility company account. The original was scanned and then manipulated to modify the original company name, the due date, and the amount, by using the image management software (PhotoShop; Adobe). The height of the solid blue capital letters in the company name was 10 mm, and the height of the black numerals in the amount and the due date was 5 mm. The task was for the subject to read the company name (Gas Works), amount ($163.55), and due date (09 Jul 1997).

Item a4: Telling Time Using a Wrist Watch. A wrist watch of moderate visual difficulty was selected, and the image was produced using image creation software (MacDraw Pro, ver. 1.5; Claris, Santa Clara, CA). The font used was bold black Arial, (height of numerals, 1.5 mm). The hour hand was 5 mm long, and the minute hand was 6 mm long. Both hands were 2-point (0.5 mm). The diameter of the clock face on the A4-sized white card was 20 mm. The task was for the subject to read the time of 10:20.

Item a5: Using a Telephone. An Australian-manufactured standard telephone (Touchfone 200; Telstra, Melbourne, Australia) was used. The keys were gray with off-white numbers. The keys measured 17 × 11 mm and the numbers measured 6 mm height × 5 mm width. The task was for the subject to attempt to call 9470 1263.

Item a6: Using a Telephone Book. A page from the telephone book[62] was reproduced, with permission from the Telstra Corporation. The original page was scanned into the computer and printed. The height of the numerals in the telephone number was 2 mm. The task was for the subject to search for "I & C Brewer of 5 Darling Street, Oakleigh" and report their telephone number (9470 1263).

Item a7: Reading Newspaper Print. A newspaper article that was simple to read for the general population and of sufficient length to establish reading fluency, was selected. The original article, with 87 words and a Flesch[63] reading-ease score of 65, was scanned and printed. The height of the capital letters in the main body of the text was 2 mm. The task was for the subject to read the given section of the *Herald Sun* newspaper article entitled "There's No Place Like Home."[64]

Item a8: Reading a Medicine Label. The original medicine label was reproduced by computer (Word; Microsoft). The font used for the name of the medication and dosage was 12-point dark gray bold Arial, (height of capital letters, 3 mm). The font for the instructions was 10-point dark gray bold-italic Arial Narrow (height of capital letters, 2.5 mm). The font used for the number of repeat prescriptions and date was 10-point light gray bold Arial Narrow. The task was for the subject to read the name of the medication (amoxil or amoxycillin), the dosage, and the instructions (one capsule, three times daily, or every 8 hours).

Item a9: Reading a Digital Display. A large and bold display was selected, and the image reproduced by computer (Word; Microsoft). The font used for the digital display was 64-point white Bookman Old Style, (height of numerals, 16 mm), against a black background measuring 92 × 56 mm. The task was for the subject to read the time of 12:58.

Item a10: Recognizing Faces. Various scientific techniques have been established for such a task.[65–67] However, a more expeditious and convenient task was required for inclusion in the multi-item MLVAI. Therefore, we chose to have the subject simply recognize and name a famous person whose face appeared in a photograph at a distance of 1 m. An image of Princess Diana on the cover of *Diana, Her Life in Photographs*[68] and an image of President Bill Clinton from *Presidents and First Ladies of the United States*[69] was photocopied and enlarged on a color laser photocopier (resolution, 400 dots per inch; Fuji–Xerox; North Ryde, New South Wales, Australia). The final life-sized image of the head of Princess Diana measured approximately 190 mm in height and that of President Clinton measured 200 mm in height.

Item a11: Reading a Typed Letter. A letter used by the Victorian College of Optometry to advise patients that they have an appointment was selected for this item. The original was copied into a computer (Word; Microsoft). The font used for the name of the organization was 18-point bold black Times (height of the capital letters, 4 mm), and the address was 11-point Times (height of the capital letters, 3 mm). The font of the appointment time and date was 10-point black Courier (height of the capital letters, 2 mm). The font of the text included in and below a red information box, was 12-point Times (height of the capital letters, 3 mm). The task was for the subject to find and read the name and address of the place of appointment, the date and time of the appointment, and the two health cards to bring to the appointment.

Item a12: Threading a Sewing Needle. A medium-sized embroidery-crewel needle size 5 with a 4-mm-long eye (model 65115; Lincraft, Melbourne, Australia), and 100% polyester white (color 800) thread (CA02776; Gütermann, Gutach, Germany) were used. A pale-blue A4-sized card was chosen to provide a standard contrasting background for all subjects.

Item a13: Reading Newspaper Headlines. Two newspaper headlines that were simple to read and contained words of varying length were selected. The headlines were five and six words long with Flesch[63] reading ease scores of 83 and 102, respectively. The originals were scanned and printed. The height of the capital letters was 15 mm. The task was for the subject to read both headlines: "Help to End the Food Nightmare"[70] and "Police Hunt for Armed Robbers."[71]

Item a14: Pouring. The subject was required to pour water from a 2-l semitransparent jug into a 350-ml clear plastic cup, to within approximately 1 cm of the top of the cup. An opaque white plastic tray was used as the standard background.

Item a15: Telling Time Using a Wall Clock. An image of a real wall clock was reproduced using image creation software (MacDraw Pro; Claris). The font used for the display was bold black 96-point Times New Roman (height of the numerals, 22 mm). The hour hand was 50 mm long, the minute hand was 60 mm long, and the second hand was 70 mm long. The hour and minute hands were 6-point (2.5 mm) and the second hand was 1-point (0.25 mm). The overall diameter of the clock face was 187 mm on a white A4-sized card. The task was for the subject to read the time of 1:35.

Item a16: Reading Packet Labels. A variety of common Melbourne grocery products were chosen. The six original packet labels were scanned. The height of the capital letters varied from 7 mm for the type of soup on the soup label to 25 mm for the height of the type of cereal on the cereal label. The task was for the subject to give the type and name of the products: bran cereal (Sultana Bran; Kelloggs, Pagewood, NSW), toothpaste (Colgate–Palmolive, New York, NY), soup (Creamy Chicken and Vegetables; Continental, Epping, NSW), bandages (BandAid; Johnson & Johnson, New Brunswick, NJ), and biscuits (Savoy-Arnotts, Homebush, NSW).

Item a17: Identifying Coins. Two of each Australian coin were selected: $2, $1, 20¢, 10¢, and 5¢. The date on the coins varied from 1977 to 1996. A pale-blue A4 card was used as a standard background. The task was for subjects to retrieve $3.55 from the pile of coins.

Item a18: Buttoning a Shirt. A plain white cotton shirt with white buttons was selected. To avoid disadvantaging the opposite gender, a male shirt with the buttons on the right and a female shirt with the buttons on the left were used.

Part B: Questionnaire Items

The questionnaire section of the MLVAI was based on 9 of the 14 items in the ADL subtest of the Duke University Older Americans Resources and Services Multidimensional Functional Assessment Questionnaire (OARS MFAQ).[26]

Item b1: Shopping. Can you go shopping for groceries or clothes. . .

Item b2: Preparing Meals. Can you prepare your own meals. . .

Item b3: Managing Housework. Can you do your housework. . .

Item b4: Managing Medication. Can you take your own medicine. . .

Item b5: Eating. Can you eat. . .

Item b6: Dressing. Can you dress and undress yourself. . .

Item b7: Grooming. Can you take care of your own appearance—e.g., shaving, hair, make-up. . .

Item b8: Mobility. Can you walk outdoors. . .

Item b9: Bathing. Can you take a bath or shower. . .

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