■ORIGINAL ARTICLE

# Neurobehavioral Impairment Scale of the A-ONE J: Rasch Analysis and Concurrent Validation

Yasuhiro Higashi[1, 2], Shinichi Takabatake[3], Asako Matsubara[4], Koji Nishikawa[5], Toshikatsu Kaneda[1, 2], Kazuyo Nakaoka[6], Yuta Somei[2], and Guðrún Árnadóttir[7, 8]

[1] Faculty of Health Sciences, Morinomiya University of Medical Sciences
[2] Department of Rehabilitation, Kansai Rehabilitation Hospital
[3] Faculty of Health Sciences, Kyoto Tachibana University
[4] Department of Rehabilitation, Hiroshima City Rehabilitation Hospital
[5] Department of Rehabilitation, Kanazawa Kobu Memorial Hospital
[6] Graduate School of Rehabilitation Science, Osaka Metropolitan University
[7] Department of Occupational Therapy, Landspítali, The National University Hospital of Iceland
[8] Faculty of Medicine, University of Iceland

**Abstract: Background:** The ADL-focused Occupation-based Neurobehavioral Evaluation (A-ONE) is used to evaluate both performance of ADL tasks and neurobehavioral impairments (NBIs) that interfere with ADL performance of clients with neurological disorders. Its Japanese translation is referred to as A-ONE J. This study examined the psychometric properties of the Neurobehavioral Impairment (NB) Scale of A-ONE J for persons with cerebral vascular accident (CVA).

**Methods:** Rasch analysis was performed on NB scale data from 185 participants with CVA, as well as from right CVA (RCVA) and left CVA (LCVA) data separately. The values of the obtained Rasch indicators were compared with results from previous A-ONE studies.

**Results:** Unidimensionality was obtained for 55 item CVA scale for the entire group as well as for 55 item RCVA scale and 53 item LCVA scale. Separation reliability for item and person calibrations was high for all three scales. Most comparisons of Rasch indicators concurrently met set criteria.

**Conclusion:** The psychometric properties of the NB scale of A-ONE J were determined. The obtained unidimensionality of the NB scale items for Japanese people with CVA provides an opportunity for quantitative measurement of a wide range of NBIs interfering with their ADL performance.

Keywords: activities of daily living, assessment, cerebral vascular accident, occupational therapy, outcome

(*Asian J Occup Ther* **19**: 30−37, 2023)

## Introduction

One of the most common types of evaluation used by occupational therapists to evaluate patients who have had a cerebral vascular accident (CVA) is that of activities of daily living (ADL) [1–3]. In the ADL evaluation, it would be of benefit to assess not only ADL performance, but also impairments, such as motor, sensory, cognitive, and perceptual impairments that limit performance of the ADL. Evaluation of these impairments is usually performed separately from ADL assessment [1]. However, deficit specific tests of neurological functions and neuropsychological test batteries intended to evaluate presence of impairments do not reflect the impact of the impairments on occupational performance such as ADL performance. Further, such tests have been reported to present with low to moderate ecological validity [4]. Thus, the importance of assessing neurobehavioral impairments (NBIs), which interfere with ADL performances in natural contexts, has gained support in the rehabilitation literature [5].

Received: 25 April 2022, Accepted: 28 September 2022
Corresponding to: Yasuhiro Higashi, Faculty of Health Sciences, Morinomiya University of Medical Sciences, 1-26-16, Nankokita, Suminoe, Osaka, 559-8611, Japan
e-mail: yasuhiro_higashi@morinomiya-u.ac.jp

The ADL-focused Occupation-based Neurobehavioral Evaluation (A-ONE) was the first instrument developed in the field of occupational therapy to assess the impact of NBIs on occupational performances. It was further the only assessment providing opportunity to evaluate a wide range of NBIs that interfere with ADL performance in naturalistic contexts [6].

The A-ONE is an ADL instrument developed by an Icelandic occupational therapist, Guðrún Árnadóttir in 1990 [1]. By administering this tool, occupational therapists can identify the level of clients' ADL ability and NBIs that interfere with ADL performances through naturalistic ADL observation. When NBIs are identified by use of the A-ONE, clinical reasoning and neurological knowledge are applied. The A-ONE comprises two scales representing two different hypothetical constructs. Both scales, i.e., the Functional Independence scale (FI scale) and the Neurobehavioral Impairment scale (NB scale), were developed as criterion-referenced ordinal rating scales [1, 7, 8].

The original purpose of the A-ONE was not to measure the clients' ability by using total scores, but to set goals and plan interventions by using the descriptive information obtained from the ordinal rating scales [1]. Ordinal scale scores cannot be used to generate total scores as if they were measures based on interval scores [8, 9]. To avoid misuse of ordinal scores, Rasch analysis based on modern measurement theory, has been used in rehabilitation medicine to examine the properties of existing ordinal-level instruments and validate their measurement potential. Application of Rasch analysis thus provides a potential for converting the total score to measures [10]. Consequently, Rasch analysis was applied in several studies to examine the potential for using both the FI and the NB scales of the original A-ONE as outcome measures. The results of those studies revealed that the ordinal scale scores of both FI [1, 8, 14] and NB scale items could be converted to valid measures [1, 5, 11, 12]. Four of these publications include reviews of the psychometric properties of the NB scale of the A-ONE for persons diagnosed with CVA. These include a CVA-NBI scale [1, 12], as well as two additional scales, one for persons with RCVA and the other persons with LCVA [1, 5, 11,].

Rasch analysis is used to estimate an individual's ability to assess the difficulty of items expressed in log odds units (logits) on a single continuous scale. The term unidimensionality refers to the concept that the items included on the scale comprise a single construct. Unidimensionality of items needs to be examined before constructing a measure [10, 11]. It is also possible to use Rasch analysis to examine whether the hierarchical order of scale items represents sequential item difficulty [10].

For validating the measurement potential of a scale unidimensionality can be examined by different types of analyses. Goodness-of-fit analyses is used to evaluate fit of all people and items, to the Rasch model. It includes evaluation of infit mean-square (MnSq), outfit MnSq, as well as standardized z (Zstd) values, indicating the degree of matching between actual and expected responses [10]. Principal component analysis (PCA) of Rasch based residuals is another type of possible analysis of unidimensionality used to examine the assumption that all data can be explained by the latent measure. This is different from PCA in classical test theory, which is a correlation model to identify factors in the scale [11, 13].

Finally, in Rasch analysis the person and item reliability need to be explored. The person reliability index represents the reproducibility of the ordering of the individual's ability logit score if the same sample of persons were given another set of parallel items. The item reliability index shows the repeatability of the ordering of items along a path when the items are given to another sample of the same size that behaves in the same way [10].

In Japan, the Japanese A-ONE study group translated the Japanese version of the A-ONE (A-ONE J) from the original A-ONE items and definitions, simultaneously addressing cultural differences [14]. This process is described under Instrumentation. Subsequently, we examined the psychometric properties of the FI scale of the A-ONE J by using Rasch analysis [12]. However, the NB scale of the A-ONE J has not yet been examined by application of Rasch analysis. The purpose of the present study was thus to examine the psychometric properties of the NB scale of the A-ONE J for people with CVA and to confirm whether a total score can be generated as an outcome measure for that diagnostic group. An additional purpose was to qualitatively compare the obtained Rasch indicators of the study to previous results from the original Rasch analyses of the NB scale of the A-ONE.

## Methods

*Participants*

This was a multicenter study conducted between October 2015 and June 2019. The participants were recruited from nine different acute and rehabilitation hospitals in Japan to which the A-ONE-trained occupational therapists belonged. Each participant or their family gave informed written consent before participating in this study. The study was approved by the School of Comprehensive Rehabilitation Osaka Prefecture Univer-

**Table 1** Demographic Information of Participants.

| | ALL (n = 185) | RCVA (n = 87) | LCVA (n = 76) | BCVA (n = 22) |
|---|---|---|---|---|
| Age (years) | | | | |
| M | 71.8 | 72.2 | 71.9 | 69.8 |
| SD | 12.5 | 12.6 | 12.8 | 11.6 |
| Range | 39–96 | 41–96 | 39–93 | 46–87 |
| Sex | | | | |
| Male | 116 | 58 | 44 | 14 |
| Female | 69 | 29 | 32 | 8 |
| Diagnosis | | | | |
| Infarction | 110 | 54 | 42 | 14 |
| Hemorrhage | 75 | 33 | 34 | 8 |
| Days after onset | | | | |
| M | 77.3 | 80.1 | 68.5 | 96.5 |
| SD | 55.4 | 58.9 | 49.8 | 56.1 |
| Range | 2–298 | 2–298 | 4–215 | 25–187 |

ALL = all participants; RCVA = participants with right cerebral vascular accident; LCVA = participants with left cerebral vascular accident; BCVA= participants with bilateral cerebral vascular accident.

sity (approval number: 2016–209) as well as the Research Ethics Committees of each participating hospital.

Ten therapists and their attending physicians selected participants for inclusion based on (a) the presence of cognitive or perceptual dysfunction as a result of CVA, as revealed by a medical examination, and (b) the person's medical readiness for an ADL evaluation. Individuals who were not medically stable or not able to perform any ADL task were excluded.

The total number of participants who were selected according to above criteria was 185. Eighty-seven were diagnosed with right CVA (RCVA), 76 with left CVA (LCVA), and 22 with bilateral CVA. The CVA resulted from infarction in 110 participants and from hemorrhage in 75. The mean time from the onset of stroke was 77.3 days. Detailed participant demographic information is presented in Table 1. A sample size of at least 30 was required in each diagnostic group for Rasch analysis, as this number would be sufficient to provide a 95% confidence interval for the stability of the estimated item difficulty calibrations within an absolute value of 1.0 logit [11, 15, 16].

*Instrumentation*

The A-ONE is commonly used for adults that have acquired central nervous system dysfunction. As noted earlier, the A-ONE comprises two scales, the FI scale and the NB scale. The FI scale consists of 20 ADL items in four domains: dressing (D), grooming and hygiene (G), transfer and mobility (T), feeding (F) and two communication (C) items. A rating scale with categories ranging from 0 to 4 is used to score the observed level of assistance needed. The NB scale is used to evaluate the impact of NBIs that interfere with ADL task performance. It contains two subscales, the Neurobehavioral Specific Impairment subscale (NBSIS) comprised of 46 rating scale items, with scores ranging from 0 to 4 (0 = absence of errors, 4 = maximum physical assistance to overcome errors), and the Neurobehavioral Pervasive Impairment subscale (NBPIS), comprised of 31 dichotomous items. The NBSIS items are evaluated for each ADL domain (e.g., D-motor apraxia, G-motor apraxia, T-motor apraxia, F-motor apraxia). It is scored based on the type of assistance required to overcome the performance errors (NBI) during ADL performance. The NBPIS items are evaluated only once, based on errors observed in at least one ADL task. The A-ONE manual contains conceptual and operational definitions of all items and detailed criteria for scoring. To use A-ONE in clinical practice and research, a five-day training course where therapists practice clinical reasoning and differentiation of impairments is required. [5, 8, 11, 14]. Further information on A-ONE training courses for occupational therapists can be obtained from https://www.a-one.is/.

All the items of both the FI and NB Scales of the A-ONE J had been translated to Japanese, as well as all the conceptual and operational definitions of the neurobehavioral terms. The details of the translation process were described in a previous study [14]. Two changes were made to the FI scale of the original A-ONE to accommodate Japanese culture. The item "Wash face and upper body" was simplified to "Wash face and hands" and the item "Use knife to cut and spread" was changed to "Use chopsticks to manipulate and carry food." As the impact of NB items on the A-ONE is scored based on task performance on the FI scale, this change may potentially affect the NB scores in the grooming and hygiene domain as well as in the feeding domain. There were no other item changes made from the original A-ONE.

*Procedures*

At each hospital, the therapists who had completed the 5-day A-ONE training course evaluated the participants according to the standardized procedure described in the manual. The raw scores were analyzed using the WINSTEPS Rasch computer software program (Version 4.5.0) [17]. In line with the preceding Rasch studies of the NB scale of the A-ONE [1, 5, 11], the five-level rating scale of the NBSIS items was dichotomized prior to data analysis such that 0 = absent and 1 to 4 = present. Dichotomization was used so that all items would be scored consistent with the current scoring of the NBPIS items. For item inclusion, we used 55 items which were the same items as used for Rasch analysis in the previous studies [1, 5]. The 55 items are listed in Table 2.

**Table 2** Retained Scale Items for the Rasch Analysis

| Item | | | | | | |
|---|---|---|---|---|---|---|
| Motor apraxia | D | G | T | F | | |
| Ideational apraxia | D | G | T | F | | |
| Unilateral body neglect | D | G | T | F | | |
| Spatial relations | D | G | T | F | | |
| Unilateral spatial neglect | D | G | T | F | | |
| Motoric | D | G | T | F | | |
| Organization and sequencing | D | G | T | F | | |
| Perseveration | D | G | T | F | C | |
| Topographical disorientation | | | T | | | |
| Sensory aphasia | | | | | C | |
| Anomia | | | | | C | |
| Paraphasia | | | | | C | |
| Dysarthria | | | | | C | |
| Expressive aphasia | | | | | C | |
| Lability | | | | | | P |
| Apathy | | | | | | P |
| Depression | | | | | | P |
| Irritability | | | | | | P |
| Frustration | | | | | | P |
| Restlessness | | | | | | P |
| Insight | | | | | | P |
| Judgment | | | | | | P |
| Confusion | | | | | | P |
| Attention | | | | | | P |
| Distraction | | | | | | P |
| Initiative | | | | | | P |
| Motivation | | | | | | P |
| Performance Latency | | | | | | P |
| Working memory | | | | | | P |
| Confabulation | | | | | | P |
| Number of items | | | 55 | | | |

Item domains: D = dressing, G = grooming and hygiene, T = transfers and mobility, F = feeding, C = communication. P = Pervasive scale items.

We then proceeded to analyze the data using the simple Rasch model for dichotomous data. The analysis progressed in two phases. In the first phase, we examined the psychometric properties of a total CVA scale including all the CVA participants. We examined unidimensionality by means of goodness of fit and omitted items one at a time until all items demonstrated acceptable goodness of fit. In accord with the preceding studies [1, 5, 11], fit statistics of MnSq > 1.4 associated with Zstd > 2.0 were taken as an indication of an item misfit. We decided to remove the items based on infit MnSq and infit Zstd values. Infit statistics are an information-weighted indicator of misfit. Outfit statistics are not weighted and are relatively sensitive to the impact of out-of-range scores (individual performance away from the item's location). Abnormal infit statistics usually cause more concern than do large outfit statistics [10]. As in the previous study, we only used infit statistics in the present study [14]. In the second phase, we divided participants into those with RCVA and those with LCVA and analyzed these subgroups separately in accord with the preceding study [5]. As noted before, for applying Rasch analysis, at least 30 participants are required [11, 15, 16], therefore, data for participants with bilateral CVA were not analyzed, due to the small number of participants in this group. For RCVA and LCVA we examined, by the same methods as the first phase, the psychometric properties using simple Rasch analyses.

*Data Analysis*

*Structural Validity and Reliability*

*Unidimensionality.*

Unidimensionality was examined by goodness-of-fit analyses based on the Rasch model and PCA of Rasch based residuals [13]. When applied to the NB scale of the A-ONE J, in accord with the Rasch analysis of the original NB scale of the A-ONE in the previous study [5, 11], the Rasch model was based on the following two assertions. First, the more neurobehaviorally disabled a participant is, the more profound errors (NBIs) will be scored as present; second, errors that emerge with mild NBIs are more likely to be scored as present for all participants than are those that emerge only with severe NBIs.

First, unidimensionality was examined by the goodness-of-fit analyses with above mentioned criteria. We also evaluated unidimensionality by means of PCA of Rasch based residuals by using the five-level quality criteria described by Fisher [18], to determine whether additional factors were likely to be present. According to the criteria, the proportion of unexplained variance accounted for by the first contrast (the largest secondary dimension) needs to be less than 15% to be classified as "fair" [18]. The variance explained by the measures in a PCA of Rasch based residuals has further been used for evaluating unidimensionality in the past [18]. The criterion for the proportion of the variance explained by the measures was more than 50%. However, this criterion was revised because the variance explained by the measures changes with the targeting of the items on the persons. Thus, at present, there is no published set range of values useful for assessing scale functioning [18]. Therefore, in terms of PCA of Rasch based residuals, we applied only the part of the criteria referring to the proportion of unexplained variance accounted for by the first contrast.

*Reliability*

Both person and item reliability were analyzed. The relevant indicator is the reliability of these separation indexes, which indicates the degree of confidence in the reproducibility of these estimates [10]. The value of the coefficient varies from 0 to 1 (a value greater than 0.8 is considered good and that greater than 0.9 is considered very good) [18].

Finally, the obtained values of psychometric properties of the present study were compared with the findings of the original Rasch analyses indicators of the A-ONE NB scale. Several such analyses have been performed, exploring both combined diagnostic samples (CVA and dementia) as well as subgroups of those samples [1, 5]. Qualitative comparisons with the A-ONE NB scale were restricted to the CVA, RCVA and LCVA scales. The comparisons took aim of Fishers [18] quality criteria.

## Results

***Phase one: CVA scale***

*Unidimensionality*

All the items of the CVA scale fitted the Rasch model. This finding indicates that there were no misfit items detected on the CVA scale. PCA of Rasch based residuals revealed that 45.9% of the variance could be explained by the Rasch dimension. Unexplained variance was 5.9%, which met the unidimensional criteria (Table 3). Item calibration values for all participants are presented in Table 4.

*Reliability*

The person separation index was 2.31, and the person reliability coefficient was 0.84. The item separation index was 6.03, and the item reliability coefficient was 0.97.

***Phase two: RCVA and LCVA scales***

*Unidimensionality*

For RCVA, in the goodness-of-fit analysis, all the items fitted the Rasch model. This finding indicates that there were no misfit items detected on the RCVA scale. PCA of Rasch based residuals revealed that 52.7% of the variance could be explained by the Rasch dimension. Unexplained variance was 7.1%, which met the unidimensional criteria (Table 3).

For LCVA, in the goodness-of-fit analysis, two items “Dysarthria” and “Paraphasia” did not fit the Rasch model and therefore these items were omitted. After omitting these items, all the items of the LCVA scale fitted the Rasch model. This finding indicates that there were no misfit items detected on the LCVA scale. PCA of Rasch based residuals revealed that 50.9% of the variance could be explained by the Rasch dimension. Unexplained variance was 5.3%, and it satisfied the unidimensional criteria (Table 3). Item calibration values for RCVA and LCVA hierarchies are presented in Table 4.

**Table 3** Values of Principal Components Analysis (PCA)

| | ALL | RCVA | LCVA |
|---|---|---|---|
| PCA: Rasch factor | 45.9% | 52.7% | 50.9% |
| PCA: First contrast | 5.9% | 7.1% | 5.3% |

ALL = all participants; RCVA = participants with right cerebral vascular accident; LCVA = participants with left cerebral vascular accident.

*Reliability*

For RCVA, the person separation index was 2.52, and the target person reliability coefficient was 0.91. The item separation index was 3.21, and the item reliability coefficient was 0.91.

For LCVA, the person separation index was 2.38, and the target person reliability coefficient was 0.91. The item separation index was 3.19, and the item reliability coefficient was 0.91.

*Comparison with the original A-ONE results*

The Rasch indicators resulting from this study of the A-ONE J were compared with results from Rasch analyses of the original A-ONE. Before the qualitative comparison of Rasch indicators, results from all the studies were interpreted according to Fisher’s quality criteria [18]. Table 5 summarizes comparisons of the results for all three scales.

## Discussion

In this study, we confirmed by use of Rasch analyses the presence of unidimensionality for the NB scale of the A-ONE J when evaluating persons with CVA. On the A-ONE J CVA scale and RCVA scale all 55 items were retained in the analysis, and all but two items formed the 53 items LCVA scale. In other words, the NBIs that interfered with ADL performance can be arranged in a unidimensional hierarchy on the A-ONE J, finding that had been obtained previously in Rasch analyses studies of the original A-ONE [1, 5]. The reason for why the original RCVA and LCVA scales have fewer items (51 and 42 respectively) relates to use of more stringent criteria in previous studies. This includes that no item misfit was allowed resulting in item deletion. It also applied to the variance explained by the measures (Rasch factor < 60%) in the previous studies [5, 11], in accord with accepted statistical rules of the time, as opposed to use of no value criteria for the Rasch factor in the present study, this being based on Fisher’s revised criteria [18]. The results of PCA of Rasch based residuals for the CVA scale, as well as for the RCVA and LCVA scales of the A-ONE J satisfied the unidimensional criteria.

We succeeded in constructing a valid and reliable

**Table 4** Item Difficulty of All Items for Three Scales

| CVA scale | | RCVA scale | | LCVA scale | |
|---|---|---|---|---|---|
| Item | Item Difficulty | Item | Item Difficulty | Item | Item Difficulty |
| Apathy | 3.12 | D-Ideational apraxia | 4.61 | G-Unilateral spatial neglect | 4.21 |
| F-Perseveration | 2.70 | T-Ideational apraxia | 4.61 | F-Unilateral body neglect | 4.21 |
| F-Unilateral body neglect | 2.40 | F-Ideational apraxia | 4.61 | Apathy | 4.21 |
| Confusion | 2.42 | C-Paraphasia | 4.61 | D-Unilateral spatial neglect | 2.96 |
| F-Ideational apraxia | 1.97 | C-Perseveration | 4.61 | F-Unilateral spatial neglect | 2.96 |
| Lability | 1.82 | Apathy | 4.61 | Confusion | 2.96 |
| Frustration | 1.80 | T-Motor apraxia | 3.38 | G-Unilateral body neglect | 2.20 |
| Restlessness | 1.80 | F-Perseveration | 3.38 | T-Spatial relations | 2.20 |
| Motivation | 1.80 | C-Broca aphasia | 2.65 | T-Unilateral spatial neglect | 2.20 |
| T-Ideational apraxia | 1.65 | Restlessness | 2.65 | T-Perseveration | 2.20 |
| T-Perseveration | 1.65 | G-Ideational apraxia | 2.21 | F-Spatial relations | 2.20 |
| C-Perseveration | 1.65 | Frustration | 2.21 | F-Perseveration | 2.20 |
| Confabulation | 1.65 | Confusion | 2.21 | Lability | 2.20 |
| Depression | 1.52 | Confabulation | 2.21 | Frustration | 2.20 |
| Irritability | 1.40 | F-Unilateral body neglect | 1.88 | Motivation | 2.20 |
| D-Ideational apraxia | 1.01 | Lability | 1.88 | G-Spatial relations | 1.74 |
| Initiative | 1.01 | Irritability | 1.88 | Confabulation | 1.74 |
| T-Motor apraxia | 0.93 | T-Perseveration | 1.62 | Depression | 1.40 |
| F-Spatial relations | 0.85 | C-Anomia | 1.62 | Irritability | 1.40 |
| Performance latency | 0.85 | Depression | 1.62 | Restlessness | 1.40 |
| F-Unilateral spatial neglect | 0.77 | Motivation | 1.62 | Initiative | 1.40 |
| C-Paraphasia | 0.77 | G-Perseveration | 1.41 | D-Unilateral body neglect | 1.13 |
| D-Unilateral spatial neglect | 0.70 | G-Motor apraxia | 1.22 | D-Spatial relations | 1.13 |
| G-Perseveration | 0.57 | F-Motor apraxia | 1.22 | T-Unilateral body neglect | 1.13 |
| D-Perseveration | 0.51 | C-Sensory aphasia | 1.05 | F-Ideational apraxia | 1.13 |
| G-Unilateral spatial neglect | 0.51 | Initiative | 1.05 | Performance latency | 1.13 |
| G-Ideational apraxia | 0.39 | Performance latency | 0.90 | T-Ideational apraxia | 0.70 |
| G-Unilateral body neglect | 0.39 | D-Motor apraxia | 0.76 | C-Perseveration | 0.52 |
| G-Spatial relations | 0.18 | D-Perseveration | 0.76 | D-Perseveration | 0.36 |
| C-Broca aphasia | 0.18 | T-Topographical disorientation | 0.76 | D-Ideational apraxia | 0.07 |
| D-Unilateral body neglect | 0.08 | F-Spatial relations | 0.39 | G-Perseveration | 0.07 |
| C-Anomia | 0.08 | F-Unilateral spatial neglect | 0.08 | T-Motor apraxia | −0.06 |
| T-Spatial relations | 0.03 | D-Unilateral spatial neglect | −0.01 | G-Ideational apraxia | −0.50 |
| D-Motor apraxia | −0.15 | F-Organization and sequencing | −0.01 | F-Organization and sequencing | −0.50 |
| T-Unilateral spatial neglect | −0.15 | Distraction | −0.11 | C-Anomia | −0.79 |
| G-Motor apraxia | −0.32 | G-Unilateral body neglect | −0.28 | D-Motor apraxia | −0.97 |
| T-Unilateral body neglect | −0.32 | G-Spatial relations | −0.36 | T-Topographical disorientation | −1.05 |
| F-Motor apraxia | −0.32 | G-Unilateral spatial neglect | −0.36 | C-Broca aphasia | −1.05 |
| T-Topographical disorientation | −0.36 | D-Unilateral body neglect | −0.53 | Distraction | −1.05 |
| F-Organization and sequencing | −0.40 | T-Spatial relations | 0.60 | F-Motor apraxia | −1.14 |
| C-Sensory aphasia | −0.47 | Insight | −0.90 | G-Motor apraxia | −1.30 |
| Distraction | −0.62 | Working memory | −1.12 | C-Sensory aphasia | −1.46 |
| D-Spatial relations | −0.99 | T-Unilateral body neglect | −1.19 | Insight | −1.46 |
| Insight | −1.18 | T-Unilateral spatial neglect | −1.19 | Attention | −1.46 |
| C-Dysarthria | −1.33 | C-Dysarthria | −1.19 | Working memory | −2.12 |
| Attention | −1.60 | T-Organization and sequencing | −1.73 | T-Organization and sequencing | −2.42 |
| Working memory | −1.66 | Attention | −1.73 | Judgment | −2.72 |
| T-Organization and sequencing | −2.10 | Judgment | −2.20 | G-Organization and sequencing | −2.95 |
| Judgment | −2.45 | D-Spatial relations | −2.33 | D-Organization and sequencing | −3.28 |
| G-Organization and sequencing | −2.83 | G-Organization and sequencing | −2.68 | F-Motoric | −3.93 |
| D-Organization and sequencing | −3.06 | D-Organization and sequencing | −2.98 | G-Motoric | −4.52 |
| F-Motoric | −4.00 | F-Motoric | −4.73 | D-Motoric | −4.82 |
| G-Motoric | −4.67 | D-Motoric | −5.23 | T-Motoric | −5.61 |
| D-Motoric | −4.81 | G-Motoric | −5.45 | | |
| T-Motoric | −5.33 | T-Motoric | −5.71 | | |

Note: High positive scores refer to that the item is rarely seen impacting performance, and low negative scores refer to that performance errors/items are observed impacting performance more frequently.

**Table 5** Comparison of the psychometric properties of the A-ONE J NB scales and the original A-ONE NB scales

| | CVA Scale | | RCVA Scale | | LCVA Scale | | Criteria | Comparison of results A-ONE J/A-ONE |
|---|---|---|---|---|---|---|---|---|
| | A-ONE J | A-ONE | A-ONE J | A-ONE | A-ONE J | A-ONE | | |
| Persons (n) | 185 | 215 | 87 | 108 | 76 | 114 | 30 | Less than A-ONE |
| Items (i) | 55 | 53 | 55 | 51 | 53 | 42 | – | almost same |
| Number of categories | 2 | 2 | 2 | 2 | 2 | 2 | – | same |
| Item model fit MnSq | ≤ 1.4 | ≤ 1.4 | ≤ 1.4 | ≤ 1.4 | ≤ 1.4 | ≤ 1.4 | – | very good/very good* |
| PCA: Rasch factor | 45.9% | 79.2% | 52.7% | 89.7% | 50.9% | 91.1% | – | Less than A-ONE |
| PCA: First contrast | 5.9% | 1.7% | 7.1% | 1.6% | 5.3% | 1.3% | < 15% | Good/Excellent* |
| Person separation index | 2.31 | 2.20 | 2.52 | 2.57 | 2.38 | 1.94 | > 2 | Fair/Fair · Poor* |
| R (persons) | 0.84 | 0.83 | 0.91 | 0.87 | 0.91 | 0.79 | > 0.8 | Good/Good · Fair* |
| Item separation index | 6.03 | 6.93 | 3.21 | 4.98 | 3.19 | 4.43 | > 2 | Very Good/Very Good* |
| R (items) | 0.97 | 0.98 | 0.91 | 0.96 | 0.91 | 0.95 | > 0.8 | Excellent/Excellent* |

*Interpretation based on Fisher's quality criteria.
Note: Comparison of psychometric qualities of Rasch analyzed versions of the Neurobehavioral Scale on the A-ONE J and the original A-ONE.

A-ONE J CVA scale meeting the previously set criteria. From a research perspective, the CVA scale could be useful for making comparisons between subgroups of CVA clients [5, 12]. However, the PCA (Rasch factor) for the A-ONE J CVA scale was less than for either the RCVA or LCVA scales. The wider the spread of the persons and items, the higher the Rasch factor becomes [19]. Thus, as the CVA scale has the narrowest spread of the three A-ONE J NB scales, it can be expected to be less precise than both the RCVA and LCVA scales. Therefore, depending on the purpose of measuring, when measuring change in impact of NBIs on ADL task performance over time, using either the RCVA or the LCVA subscales may turn out to be a more precise alternative than the CVA scale. The CVA scale on the other hand is useful when comparing performance of RCVA and LCVA persons.

Regarding the hierarchy, for all three A-ONE J NB scales, the logit value of the item labeled "Motoric" referring to impaired motor function was the lowest value on the hierarchy; thus, performance errors related to diminished motor function were the most likely errors to be detected during the ADL task performance. The participants in this study were diagnosed with CVA and hospitalized in acute and rehabilitation hospitals. This finding of impaired motor function such as paralyses is thus not surprising and consistent with the literature where impaired motor function has been identified as one of the most frequently detected impairment limiting ADL performance [20]. This finding is also consistent with results from previous studies of the NB scale of the A-ONE for the stroke population [1]. Subsequently, the right hemisphere functions such as unilateral spatial neglect and spatial relations were frequently apparent on the RCVA scale, and the frequency of items related to left hemisphere function such as ideational apraxia and aphasia was low. For the LCVA scale, motor and ideational apraxia as well as language impairments were commonly detected as opposed to neglect items that were very unlikely to be detected. These results were reasonable considering the characteristics of right and left hemisphere function [12].

For an overall analysis of the participants, we analyzed the data of 185 individuals; however, when we analyzed the RCVA and LCVA separately, the data was divided into 87 RCVA and 76 LCVA cases. Although the minimum sample size criterion was satisfactory, more stable results would be obtained by analyzing 150 participants for each of the RCVA and LCVA scales to obtain 99% confidence interval for estimated item difficulty calibrations remaining within the absolute value of 0.5 logit [15, 16]. Thus, it would be desirable to raise the number of participants in future studies.

***Limitations and future considerations***

Our right and left CVA samples were < 100 persons in each group. To obtain more stable results 150 participants are required [16, 17]. We therefore plan to enlarge the sample size to 150 participants and reanalyze the data including analyses of differential item functioning between RCVA and LCVA in future studies.

As pointed out in the previous study [5], the A-ONE and A-ONE J include only ADL tasks. Thus, the findings of this study cannot be generalized to the performance of other tasks, such as IADL, without further investigations. The original A-ONE was intended to be used for clients with different types of neurological diagnoses including, for example, dementia and head trauma in addition to CVA. In this study of the A-ONE J, the sample only included people with CVA as opposed to studies of the original A-ONE that also include analysis of performance of people with dementia. Therefore, our recommendation for future studies is to include more diverse diagnostic categories in the analyses of the A-ONE J.

Finally, in this study, we chose to dichotomize all items in accord with the previous study [5]. However, the original NBSIS scale is a five-category rating scale, and this procedure may have reduced the separation of the participants. We further plan to explore the use the partial credit Rasch model with the five-category rating scale in future studies and compare the results with results from the dichotomous analysis.

## Conclusion

In this study, we demonstrated that the NB scale of the translated A-ONE J can be used as an outcome measure. We converted the NB rating scale into a dichotomous scale and subsequently developed three separate scales, a 55 item RCVA scale and 53 item LCVA scale as well as a 55 item CVA scale. By using these Rasch analyzed NB scales of the A-ONE J, we confirmed the findings of earlier A-ONE studies regarding the possibility of quantitatively measuring the changes in a wide range of NBIs that interfere with ADL task performance.

## Acknowledgements

We would like to thank the clients who participated as research participants for their valuable contribution to this study. We would also like to acknowledge the occupational therapists that used the A-ONE J to evaluate their clients. The study was supported by grants from the Japanese Association of Occupational Therapists in 2016.

## References

[1] Árnadóttir G. Measuring the impact of body functions on occupational performance: Validation of the ADL-focused Occupation-based Neurobehavioral Evaluation (A-ONE). Doctoral dissertation, Umeå University, Sweden. Medical Dissertations, New Series No. 1322; 2010.

[2] Gillen G. Cerebrovascular accident/stroke. In: Pendleton HM, Schultz-Krohn W, editors. Pedretti's Occupational Therapy: Practice Skills for Physical Dysfunction. 7th ed. St. Louis, MO: Mosby Elsevier; 2013. p. 844–80.

[3] Steultjens EM, Dekker J, Bouter LM, van de Nes JCM, Cup EHC, van den Ende CH. Occupational therapy for stroke patients: a systematic review. Stroke. 2003; 34: 676–87.

[4] Chaytor N, Schmitter-Edgecombe M. The ecological validity of neuropsychological tests: a review of the literature on everyday cognitive skills. Neuropscyhol Rev. 2003; 13: 181–97.

[5] Árnadóttir G, Löfgren B, Fisher AG. Neurobehavioral functions evaluated in naturalistic contexts: Rasch analysis of the A-ONE Neurobehavioral Impact Scale. Scand J Occup Ther. 2012; 19: 439–49.

[6] Gillen G. A fork in the road: an occupational hazard? Am J Occup Ther. 2013; 67: 641–52.

[7] Árnadóttir G. Impact of neurobehavioral deficits on activities of daily living. In: Gillen G & Nilsen DM, editors. Stroke Rehabilitation: A Function-Based Approach, 5th ed. St Louis, MO: Elsevier; 2021. p.556–92.

[8] Árnadóttir G, Fisher AG. Rasch analysis of the ADL scale of the A-ONE. Am J Occup Ther. 2008; 62: 51–60.

[9] Merbitz C, Morris J, Grip JC. Ordinal scales and foundations of misinference. Arch Phys Med Rehabil. 1989; 70: 308–12.

[10] Bond TG, Yan Z, Heene M. Applying the Rasch model: Fundamental measurement in the human sciences. 4th ed. New York; Routledge; 2021.

[11] Árnadóttir G, Fisher AG, Löfgren B. Dimensionality of nonmotor neurobehavioral impairments when observed in the natural contexts of ADL task performance. Neurorehabil Neural Repair. 2009; 23: 579–86.

[12] Árnadóttir G, Löfgren B, Fisher A. Difference in impact of neurobehavioral dysfunction on activities of daily living performance between right and left hemisphere stroke. J Rehabil Med. 2010; 42: 903–7.

[13] Linacre JM. Detecting Multidimensionality: Which residual data-type works best? J Outcome Meas. 1998; 2: 266–83.

[14] Higashi Y, Takabatake S, Matsubara A, Nishikawa J, Shigeta H, Árnadóttir G. Reliability and Validity of the Japanese version of the ADL-focused Occupation-based Neurobehavioral Evaluation (A-ONE J): Applying Rasch Analysis Methods. Hong Kong J Occup Ther. 2019; 32: 32–40.

[15] Linacre JM. A User's Guide to WINSTEPS MINISTEP Rasch model computer programs: Program manual 4.5.3. 2020.

[16] Linacre JM. Sample size and item calibration stability. Rasch Measurement Transactions. 1994; 7: 328.

[17] Linacre JM. Winsteps (Version 4.5.0) [Computer software]. Chicago, IL: Winsteps.com.; 2020.

[18] Fisher WPJ. Rating scale instrument quality criteria. Rasch Measurement Transactions. 2007; 21: 1095 (Revised February 1, 2018, p.1095).

[19] Linacre JM. Variance in Data Explained by Rasch Measures. Rasch Measurement Transactions. 2008; 22(1): 1164.

[20] Nilsen DM, Gillen G, Geller D, Hreha K, Osei E, Saleem GT. Effectiveness of interventions to improve occupational performance of people with motor impairments after stroke: an evidence-based review. Am J Occup Ther. 2015; 69(1): 1–9.