ASSESSMENT OF CAPACITY FOR MYOELECTRIC CONTROL:  
CONSTRUCT VALIDITY AND RATING SCALE STRUCTURE

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INTRODUCTION

The Assessment of Capacity for Myoelectric Control (ACMC) is a 30-item standardized clinical assessment designed for the upper limb prosthesis group [1, 2]. It measures the quality of prosthetic hand movement performed by the prosthesis user during a self-chosen two-handed functional task. ACMC is suitable for prosthesis users of all ages and of all prosthetic sides/levels [2, 3]. Previously, repeated ACMC assessments of upper limb prosthesis users were used to evaluate the validity of the construct [1]. Since the strengths and weaknesses among these users were likely to be repeated several times in the data obtained, the abilities of the prosthesis users in that sample might not give the best picture of the functioning of the items. It was hypothesised that a wider range of ability across the sample might provide a better picture of the functioning of items. Therefore, a further validation of ACMC based on single measures was considered.

The performance of the 30 ACMC items is rated on a 4-point scale, ranging from 0-not capable – to 3-spontaneously capable. One concern is if the four ACMC categories are sufficient to differentiate the prosthesis users on the basis of their abilities. Another concern is whether the raters have used the four categories in the expected manner.

The overall aim of this study was therefore (a) to evaluate the construct validity of ACMC and (b) to examine the 4-point rating scale structure and its use. With a larger sample of single measures, specific questions were asked: Does a larger number of subjects provide a wider range of prosthetic ability than was found in the first validity study? Does the hierarchical order of ACMC items match the clinical knowledge about the difficulty of the items? Do all the items work together to measure a single “prosthetic control” dimension? Do all the items function as expected? Is the 4-point rating scale appropriately constructed to differentiate between prosthesis users with different abilities? Have the four rating-scale categories been used in the expected manner?

METHODS
Subjects, instrumentation and Procedure

Ninety-six upper limb prosthesis users with different prosthetic levels/sides/experience were included (males 58, females 38, congenital deficiency 83, amputation 13, age range 02-57 years, mean age 11, median age 8, experience 0 month – 19 years). Their ACMC assessments were collected by six qualified raters. The quality of prosthetic hand movement was assessed based on the 30 functional items that are grouped into four hand use areas:
gripping, holding, releasing and co-ordinating. All items are rated on a 4-point rating scale ranging from 0 - not capable to 3 - spontaneously capable.

Data analysis
Rasch analysis was used to analyse the data since it allowed an analysis at the assessment item and rating scale category level [4]. Rasch analysis is a mathematical technique for estimating linear logit (log-odds units) measures of item difficulty and person ability from ordinal data. The range of ability existed in the sample was examined by Rasch generated measure ‘person separation index’. The construct validity was examined by the difficulty of the 30 prosthetic control items and the ACMC’s dimension (by principal components analysis -PCA). Rasch generated fit statistics for items were used to find out whether any item deviated statistically from the expectation of the Rasch model, i.e. functioned unexpectedly.

The rating scale structure was examined by different Rasch generated parameters. ‘Person ability measure’ was used to examine whether each category represents a higher level of performance than the previous category. ‘Threshold Measure’ between every two adjacent categories was used to examine the effective use of 4-rating scale categories. If the threshold distance between any two adjacent categories is too large (> 5 logits) or too small (< 1.4 logits), then this suggests a need for an extra category or a collapse of two existing categories. Thirdly, ‘outfit mean square’ (MnSq) for each category is used to examine the consistency of use of the category. A category with outfit MnSq > 2.0 indicates that highly unexpected ratings are recorded in this category.

RESULTS
Range of ability in the sample
A wider range of prosthetic ability existed in this sample (person separation index 5.21) when compared to the first ACMC validity study (person separation index 3.79).

Dimensionality of ACMC
PCA confirmed that the data collected by the ACMC items is strongly unidimensional. This implied that all the items work consistently to measure the control of a prosthetic hand.

Difficulty and functioning of ACMC items
All 30-item difficulty measures and all 96 person ability measures are displayed graphically in the person-item map in Figure 1. On this map, the measurement scale is drawn vertically. The persons are plotted on the left side and the items are plotted on the right. The difficulty of ACMC items targeted well at the subjects’ abilities. The mean item difficulty is set at zero logit (by convention). The mean person ability was +0.48 logit with SD of 2.81 logits. As seen in Figure 1, the two means are close together, indicating that the difficulty of items targeted well at the subjects’ abilities.

The hierarchy of items shows that the items cover a substantial distance on the construct of prosthetic ability. Items relating to prosthetic hand movements performed without visual feedback are the most difficult items. Items that need good timing in catching or receiving objects are also relatively difficult. Prosthetic movements that are performed with the arm/hand supported are the easiest items. This hierarchy of item difficulty matches the clinical knowledge about the difficulty of different prosthetic hand movements.
According to the fit statistics, two items functioned unexpectedly (gripping-without visual feedback and item releasing—same time, arms in motion). Three persons, who were rated higher than Rasch model’s expectation, contributed to the ‘poor functioning’ of these two items. Both items functioned well after the removal these unexpected assessments. This suggested that the ‘poor functioning’ of items was idiosyncratic to this sample, not systematic to the items. It was therefore decided to retain the items in this analysis. The fit statistics of another item ‘gripping - tripod pinch, with support’ showed that there was too little variation in the response pattern, perhaps suggesting that the item was redundant. Since a redundant item is no threat to the construct validity, this item will not be investigated further.

Rating scale structure and its use

Summary statistics for the four rating-scale categories are shown in Table I. The ‘frequency of use’ of categories 0, 1 and 2 were fairly even. Category 3 - spontaneously capable was used roughly three times more often than any of the other three categories (count = 949). This implied that many subjects were spontaneously capable in many items.
The distance between the 1st and the 3rd thresholds was 3.13 logits (from -1.72 to 1.41), indicating that the functional range of the rating for any particular item is about 4 logits. This was wider than the standard deviation of the person ability measures (2.81 logits), indicating that the 4-point rating scale usefully differentiates the persons on the basis of their abilities.

The person ability measure and threshold measure increases with the category value. The distance between two thresholds on each side of category 2 was 1.1 logits (1.41 to 0.31), slightly less than the 1.4 logits indicative of optimal rating-scale functioning, but large enough to be clinically unambiguous. The finding that the distance between thresholds on each side of category 1 was 2.03 logits (-1.72 to 0.31) suggests that an adjustment of the clinical criteria for category 2, “capable on request”, to include a slightly lower level of performance, would improve the functioning of the rating scale.

<table>
<thead>
<tr>
<th>Category</th>
<th>Frequency of Use</th>
<th>Threshold Measure</th>
<th>Observed Person Measure</th>
<th>Outfit MnSq</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - not capable</td>
<td>388</td>
<td>NONE</td>
<td>-3.07</td>
<td>1.14</td>
</tr>
<tr>
<td>1 - sometimes capable</td>
<td>380</td>
<td>-1.72</td>
<td>-0.69</td>
<td>1.00</td>
</tr>
<tr>
<td>2 - capable on request</td>
<td>366</td>
<td>0.31</td>
<td>1.10</td>
<td>0.50</td>
</tr>
<tr>
<td>3 - spontaneously capable</td>
<td>949</td>
<td>1.41</td>
<td>3.90</td>
<td>1.09</td>
</tr>
</tbody>
</table>

Table I. Summary statistics for the four ACMC rating scale categories

- **Frequency of use:** the number of persons rated in that category
- **Threshold measure:** The difficulty measure between every two adjacent categories
- **Observed person measure:** average person ability measure
- **Outfit MnSq:** This is used to examine the consistency of use of the category

DISCUSSION

The consistency of item hierarchy with clinical expectation and the unidimensionality of ACMC confirmed the construct validity. The item misfit could be due to the difficulty of the tasks. The originators of another Rasch derived test found that persons’ measures were dependent on the task performed during the assessments [5]. Thus, it is reasonable to assume that the control of prosthetic grip is easier in some tasks than in others. Therefore, further research is needed to test if the ACMC items are functioning in a similar way independent of the choice of tasks. Revision of category 2’s definition – capable on request would improve the functioning of the rating scale.

REFERENCES