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ASSESSMENT OF CAPACITY FOR MYOELECTRIC CONTROL – EVALUATION OF TASK DIFFICULTY, NEWLY MERGED ITEMS AND REDEFINED RATING SCALE

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INTRODUCTION

Task difficulty and validity

The *Assessment of Capacity for Myoelectric Control* (ACMC) is an observational assessment designed to assess a prosthesis user's ability to operate a myoelectric prosthetic hand in a bimanual task [1]. The prosthesis user is encouraged to select a bimanual task for the assessment. Concern has been raised over the tasks being used in the assessments [2]. Would a prosthesis user receive different ACMC scores on different tasks?

Bimanual tasks are mostly used in ACMC assessments. An ACMC rater observes the prosthesis user operates the hand during the task performance. The ACMC total score shows the user's ability to operate a prosthetic hand as defined by the ACMC items. A detailed description of the ACMC and its psychometric evaluations can be found elsewhere [1-3].

Although the reliability and validity of ACMC have been established in upper limb prosthetic users, the difficulty of tasks being used in ACMC assessments have not been examined yet. Task difficulty in ACMC is defined as the difficulty to handle different task objects and different task steps with a myoelectric prosthetic hand. Would it be more difficult to use a myoelectric hand in a task with heavier objects and hence get a lower ACMC score? Would a user receive a lower ACMC score in a task that contain more task steps? If different tasks can lead to different ACMC scores, then a change in ACMC scores can be due to task differences, not due to an improvement in prosthetic skills.

Thus, the main objective of this study was to estimate the difficulty level of several bimanual tasks that are used in ACMC assessments. The chosen tasks will have different types of objects and the steps to perform the tasks are also different. Rasch analysis [4], a mathematical technique that estimates the difficulty of tasks based on the difficulty of ACMC items in each task, will be used. Rasch fit statistics will be use to evaluate the validity of these tasks, i.e. if the tasks are appropriate to be used in ACMC. Furthermore, it is important to investigate whether all the tasks can be used for gender, all ages and both prosthetic sides. Thus, differential item functioning (DIF) will be performed to examine if any ACMC item consistently function differently in a particular task for a particular age group, gender and prosthetic side.

Merging items and re-defined rating scale

In the evaluation of the ACMC construct , merging of related ACMC items was suggested [3]. Thus, the number of ACMC items is reduced from 30 to 22 items. Reducing the length of a test can reduce administration time, which is good for a busy clinic environment. We have also changed the definition of category-2 based on the result from the previous analysis [3]. A Rasch analysis of 22-item ACMC the re-defined rating scale would thus provide us information about the functioning of merged items and the re-defined rating category.

Thus, the first aim was to examine (i) the difficulty of tasks in ACMC assessments, (ii) the validity of the tasks, (iii) if the item functioning in each task is influenced by gender, age, and prosthetic side. The second aim was to assess (iv) the functioning of the 22-item ACMC and newly merged items, (v) the use of the re-defined rating scale.

METHOD

Subjects

A sample of 58 upper limb prosthesis users was recruited from the Limb Deficiency and Arm Prosthetic Centre (LDAPC), Örebro University Hospital, Sweden. Subjects' demographics are shown in Table 1.

Development of tasks

The development of tasks was carried out in four stages. In January 2009, ACMC raters from different countries (n=52, male=5) were asked to suggest three tasks that they would normally use in their training or assessment. The task suggestions are summarized in Table 2.

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Table 1: Demographic characteristics of subjects

Subject Characteristics	*N=58*
Mean Age (range)	20 (2-72)
Median	13
Gender	
Male	31
Female	27
Age group	
≥ 6 years old	10
7 to 15 years old	24
≥16 years old	24
Cause of absence	
Congenital	48
Trauma	9
Illness	1
Prosthetic side	
Right (unilateral)	20
Left (unilateral)	36
Both (bilateral)	2
Prosthetic level	
Unilateral	
Shoulder disarticulation or above elbow	3
Below elbow	49
Wrist disarticulation	4
Bilateral	
Below elbow on both sides	1
Above elbow (left) & below elbow (right)	1
Prosthetic experience	
Unilateral	
< 1 year	7
1 to 4 years	14
≥ 5 years	35
Bilateral	
< 1 year on both sides	1
< 1 year (left) & >5 years (right)	1

The second stage was to select tasks for this study. The selection was based on six criteria: i) tasks can be performed with a prosthetic hand, ii) tasks of functional relevance that challenge the use of a prosthetic hand, iii) tasks that can be adapted to different ages; (iv) tasks can be performed at a clinic, v) tasks can be accomplished within 10 minutes, (vi) all ACMC items can be observed in the performance of the tasks. Six tasks were selected: *packing suitcase, mixing a ready-mix food product, sorting mail, repotting plant, setting table* and *assemble a ready-made product.*

The third stage was to write the detailed task steps and find materials for each task. Task versions for different age groups were created. The fourth stage was to pilot-test the tasks. This was to see the time needed to perform the tasks and, if all the ACMC items can be observed.

Table 2: Task suggestions

Self-caring	Household/Transportation	Construction/hobby
• Dressing • Brushing teeth • Eating and drinking	• Changing car tires/car oil • Installing smoke alarm • Grocery shopping/using wallet • Stocking groceries in shelves • Making simple food or drinks • Changing bed • Dishwashing • Sorting mail • Ironing • Setting table • Hanging laundry • Washing small laundry items • Packing suitcase • Setting up curtains • Driving	• Making clipboard, birdhouse, coat rack, or putting together a small furniture • Painting • Hanging up pictures • Sewing • Fishing • Repotting plants • Pitching a tent • Wrapping gift • Making handcraft • Playing doll dress-up • Knitting

Instrumentation

The ACMC consists of 22 items assessing six quality aspects in prosthetic control: *the need for arm support, choose the right grip strength, show good timing, use in different positions, repetitive grasp and release of objects, the need for visual support and coordination between the hands*. During an ACMC assessment, an ACMC rater takes notes of all the observable prosthetic actions performed by the prosthesis user during the task performance. The ACMC rater then scores the 22 items, using a 4-point rating scale.

Procedure

Each subject was asked to perform three tasks during one visit. An allocation technique 'Minimization' was used to assign three tasks to each subject [5]. This was to minimize the differences between the subjects' characteristics in each task. The characteristics we would want to be similar in each task were: gender, prosthetic side, prosthetic level, prosthetic experience and age.

All subjects performed the tasks in the kitchen or in the training room at the centre. Each subject had around 10 minutes break between each task. The subject or the occupational therapist decided randomly which task to perform first. The task performances were videotaped.

Since an ACMC assessment focuses on one prosthetic hand at a time, 56 unilateral users gave 168 assessments and 2 bilateral users gave 12 ACMC assessments. The 1st author watched and scored all the task videos with the ACMC. The scoring started with one task from one subject at a time. Then the 1st author selected another video from another subject, usually the same task. This was to avoid scoring the same subject in three tasks and hence gave similar scores to the three tasks. All the scores were written down on the

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ACMC scoring sheets. The 1st author consulted the 3rd author for advice if there was any doubt about the scoring.

Data analysis

Rasch analysis was carried out using WINSTEPS 3.72. Item difficulty measures and person ability measures were constructed using the ACMC raw scores. Task difficulty measure is the average difficulty of the task-items for the task.

Task validity was examined by the mean-square (MnSq) statistics. Infit and outfit MnSq and were used to examine any measurement disturbance occurred in each task. The range for an acceptable goodness-of-fit is between 0.6 to 1.3 MnSq was selected. A task that shows an acceptable goodness-of-fit is considered as an appropriate task for an ACMC assessment. Differential item functioning (DIF) was performed to examine any item consistently function differently in a particular task for a particular age group, gender and prosthetic side.

The person-item map was used to assess the alignment between the subjects and the 22 items. The distribution of the items shows the difficulty of the newly merged items relative to the existing items.

The rating scale was examined by (i) the "Frequency of Use" of each category, (ii) "Person Measures" for each category, which should increase from a category representing low ability to one representing high ability, (iii) "Threshold Measure" between any two ratings. This should also increase with increasing category number.

RESULT

Task difficulty and validity

Based on this sample, *packing suitcase* (-0.26 logits) is the easiest task (Table 3). *Assemble a ready-made product* and *setting table* are equally difficult (0.13 logits). The difficulty range is -0.26 to 0.13 logits, i.e. 0.39 logits difference. From the ACMC raw score to logits conversion table in Winsteps, a change in 0.5 logits is equivalent to 2 ACMC raw scores. Hence, a change in 0.39 logits is less than 2 ACMC raw scores, suggesting that the impact of the task difficulty difference on the ACMC score is minimal.

The Infit and Outfit MnSqs are all within the acceptable range (Table 3), implying that these tasks are appropriate to be used in ACMC assessments.

No item exhibit DIF in gender and prosthetic side, implying that the tasks are appropriate for both genders and both prosthetic sides. Two items '*holding without visual feedback*' and '*holding in motion without visual feedback*' exhibit age DIF. These two items are relatively easier for those who are age 6 or younger.

Table 3: Task difficulty measures and task fit statistics

Task	Mean age (yr)	Difficulty (in logits)	Infit MnSq	Outfit MnSq
Packing a suitcase	18.1	-0.26	1.15	0.88
Sorting mail	20.0	-0.13	0.81	0.63
Mixing a ready-to-eat product	18.5	0.05	0.94	0.73
Repotting plant	19.7	0.09	1.15	0.88
Assemble a ready-made project	19.7	0.13	0.77	0.66
Setting table	22.1	0.13	0.92	0.70

The 22item ACMC with newly merged items

The person-item map in Fig.1 clearly shows the distribution of subjects in relation to the ACMC items. The mean person ability is 2.34 logits (mean item difficulty is set at 0 by default), indicating that this sample has a high ability in operating a myoelectric prosthetic hand. Since 35 out of 58 subjects have more than 5 years of prosthetic experience, a high mean ability is expected.

The newly-merged items are circled (Fig.1). Their positions along the vertical scale are similar to their positions in the 30 item ACMC [2], indicating they are functioning as expected.

The redefined rating scale

The use of 4 rating categories is shown in table 4. The observed person measures increase as the category increases. The use of category-2 is slightly lower than we expected (22%). In Fig.2, however, it shows that the probability of selecting category-2 is the same as selecting category 1, indicating that the new category-2 definition has improved the functioning of the rating scale.

DISCUSSION

Using the ACMC items, which measure how a prosthesis user grasps, hold and release different objects, the six tasks have similar difficulties. This may be surprising for the readers since; in general, as in our knowledge, some tasks are more difficult than other tasks. However, the ACMC is not designed to measure how well a prosthesis user performs a task. The ACMC items do not measure, for example, if the plant is not straight after repotting, or if the milk is spilt on the table during mixing the food product.

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The ACMC items measure, for example, if the user is able to grasp the plant with the prosthetic hand using the right grip force, or, if the user is able to maintain holding a shoe bag when putting shoes inside. In the task 'packing a suitcase', a few prosthesis users dropped the shoe bag when putting shoes inside. This was because the users did not increase the grip force when the shoe bag got heavier after putting the shoes in it.

It is interesting to find that children got higher scores in the two items that measure holding without looking at the hand. When children are engaged in these tasks, they only focused on mixing the dough or putting soil into the pot, not on their hands. Adults, who were fully aware of the video cameras, looked at their prosthetic hands more often than children and hence received lower scores on these two holding items.

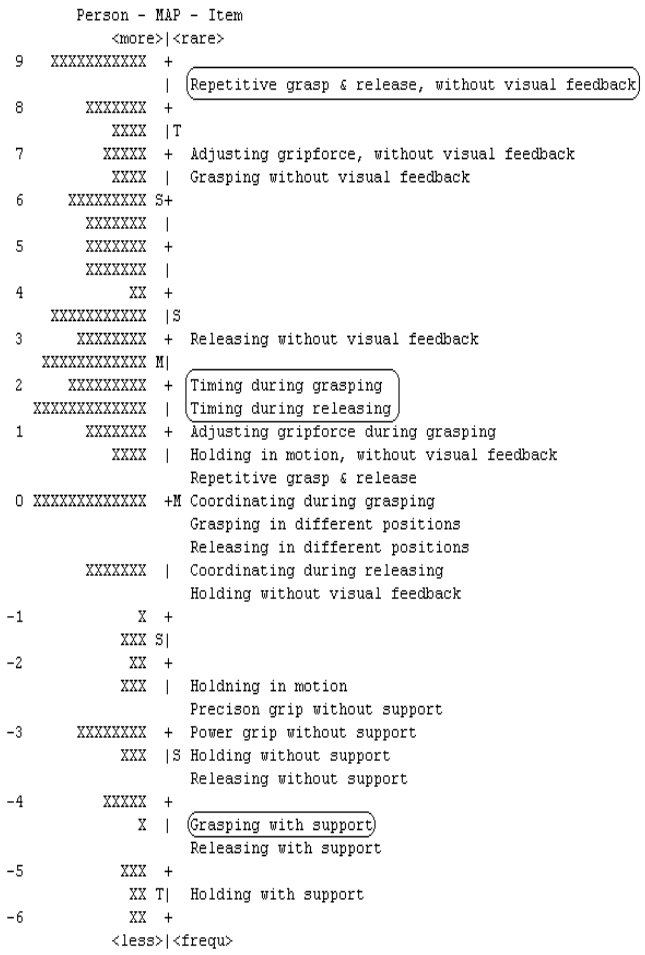

Figure 1: Relationship between ACMC items and the subjects

X= subjects, M=mean, S=1 standard deviation (SD) from the mean, T=2 SD from the mean

Table 4: Summary statistics for the 4 rating categories

Category	Frequency of use (%)	Person measure	Threshold measure
0- not capable	616 (16)	-5.38	None
1-somewhat capable	642 (16)	-1.20	-3.02
2-generally capable	882 (22)	1.69	-0.01
3-extremely capable	1776 (45)	6.39	3.03

Frequency of use: the no. of persons being scored
Person measure: mean person ability measure in the category
Threshold measure: the difficulty measure between 2 adjacent categories

The six tasks were selected from ACMC raters' suggestions. Many suggestions are suitable for ACMC assessments. However, because of the selection criteria, for example, can perform at a clinic, suitable for all ages and takes only 10 minutes, limited the task choice for this study. These six tasks are now standardized and are suitable for retest purpose. A change in ACMC scores between different test occasions from these tasks may indicate an improvement in prosthetic skills or even a change of device.

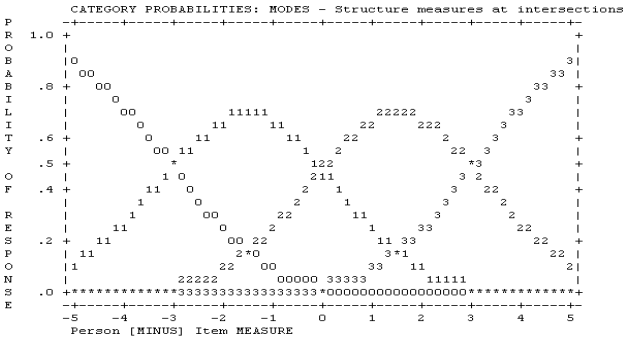

Figure 2: The probability curves of the 4 rating categories. The 0, 1, 2 and 3 curves represent the 4 categories

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