

INTRODUCTION

While there have been many advances over the past 40 years, barriers to effective measurement of functional communication skills in adults with aphasia remain. First, the ability range targeted by current assessments frequently falls below the ability level of many community-dwelling stroke survivors (Frattali, 1992). Second, the burden of assessment associated with most functional communication assessments is high, limiting their use in the current healthcare environment (Worrall, 2001).

These limitations may be addressed through the creation of an item bank (Thissen, Reeve, Bjorner, & Chang, 2007), a set of test items that respond to a unidimensional construct existing on an ordered continuum. The items are calibrated to a common measurement scale, typically using item response theory (IRT). The calibration process assigns a difficulty value to each item and links them to a common scale, permitting individual trait level estimates derived from different subsets of items to be directly compared. This allows adaptive testing, which can provide precise score estimates with minimal response burden.

In this paper, we report on the continuing development of a new measure of self-reported communicative functioning in aphasia: the Aphasia Communication Outcome Measure (ACOM). We address four questions:

1. How many underlying factors are necessary to adequately model responses to the ACOM item pool?
2. Can the initial ACOM item pool be productively fit to one or more unidimensional IRT measurement models?
3. Do the scales defined by the ACOM items provide reliable measurement?
4. Do the scales demonstrate concurrent validity with performance-based, surrogate-reported, and clinician-reported measures of communicative functioning?

METHOD

Participants were 305 persons with aphasia (PWA) who met the following inclusion criteria: diagnosis of aphasia ≥ 1 MPO; community dwelling; self-reported normal pre-morbid speech-language function; pre-morbid literacy with English as a first language; negative self-reported history of progressive neurological disease, psychopathology, and substance abuse; ≥ 0.6 delayed/immediate ratio on ABCD Story Retell (Bayles & Tomoeda, 1993); ≤ 5 self-reported depressive symptoms on the GDRS-15 (Sheikh & Yesavage, 1986); and BDAE severity rating ≥ 1 . Demographic and clinical characteristics of the sample are summarized in Tables 1 and 2, respectively.

The ACOM item pool is comprised of 177 items describing various communication activities. Participants were asked to rate on a 4-point scale how effectively they perform each activity. “Effectively” was defined as “accomplishing what you want to, without help, and without too much time or effort.” Responses were collected using an interviewer-assisted administration protocol in which study staff experienced in the assessment of aphasia, read each item aloud, while the item and response scale were displayed on a monitor for the participant. We also administered the PICA (Porch, 2001) to a subset of participants ($n=219$), a motor speech examination if motor speech disorder was suspected, and the ASHA FACS with each participant’s significant other or designated family member/friend as the respondent.

ANALYSIS and RESULTS

We excluded from the analysis 28 items that had substantial missing data due to item content considered “not applicable” by many study participants. The remaining 149 items were submitted to exploratory factor analysis. The initial factor extracted accounted for 44% of the variance and the first-to-second factor ratio of eigenvalues was large at 8.1, suggesting the presence of a single dominant factor. However, the one-factor solution had relatively poor fit (root mean square residual, RMSR = 0.089; < 0.08 indicates acceptable fit), and a three-factor solution, for which fit was acceptable (RMSR = 0.054), demonstrated good correspondence with item content. The three identified factors were Talking, Comprehension (both auditory and reading), and Writing and Number use. Item content and factor loadings are presented in Table 3.

Further factor analyses of each subset suggested that 66 Talking items (RMSR = 0.064), 37 Comprehension items (RMSR = 0.074), and 31 Writing and Number Use items (RMSR = 0.07) were sufficiently well described by a single underlying factor to permit application of a unidimensional IRT model. For each subset, a separate Rasch Partial Credit model (Wright & Masters, 1997) was estimated. To evaluate model fit, we examined information-weighted (infit) and outlier-sensitive (outfit) mean-square (MSQ) fit statistics based on the residuals between model expectations and the data. We began by excluding from analysis participants who grossly misfit the model (person infit or outfit MSQ >2, totaling 4-6% of cases for each scale). Next we evaluated item fit statistics, excluding items that obtained MSQ fit values >1.4. We also tested differential item functioning (DIF) along several demographic and clinical variables, including age, gender, race, education, self-reported hearing impairment, presence of motor speech disorder, and severity of communication impairment as measured by the PICA. DIF analysis tests whether persons from two groups respond differently to a given item when differences in overall score are conditioned out. Items demonstrating DIF are considered biased against the relevant subgroup and may distort measurement of the underlying variable of interest. We excluded items that obtained DIF location contrasts >0.5 logits and p-values < 0.01.

Forty-nine (49) Talking items, 26 Comprehension items, and 20 Writing and Number Use items demonstrated adequate model fit and negligible DIF. Tables 4-6 summarize the item reduction results and Table 7 summarizes the scale properties. The Talking, Comprehension, and Writing scales obtained reliabilities of 0.97, 0.94, and 0.92, respectively, in the current sample. The Talking and Writing scales demonstrated minimal ceiling/floor effects. The three ACOM scales correlated moderately strongly with one another (Pearson r 's 0.74-0.77).

To address the final research question, we computed correlation coefficients (Table 8) between ACOM scores, overall ASHA FACS Communication Independence Score, BDAE Severity Rating, PICA overall score, and PICA modality scores derived from the relevant subtests (verbal: I, IV, IX, XII; comprehension: V-VII, X; and writing: A-D). All correlations with the ACOM scales were moderately strong. Among the ACOM-PICA modality correlations, the correlations between the corresponding modality scores were the strongest in each case.

DISCUSSION

This study indicates that self-reported communicative functioning can be productively measured along three dimensions: Talking, Comprehension, and Writing, and that items within each of

these domains demonstrate adequate fit to a unidimensional IRT measurement model. The resulting scales showed good reliability and effective targeting of the trait range of the present sample. The ACOM scale scores correlated moderately with performance-based, surrogate-reported, and clinician-reported measures of communicative functioning, and correlations between self-reported and performance-based scores were strongest for corresponding PICA modality scales. The relatively high and consistent correlations between the three ACOM scales suggests the presence of a single general underlying factor despite the relatively poor fit of the initial item pool to a unidimensional factor model. Further research with multi-dimensional IRT models may be helpful in establishing the most appropriate and efficient approaches for measuring self-reported communicative functioning in aphasia.

The large number of items in the Talking scale suggests that it will likely support computer adaptive administration. For the shorter Comprehension and Writing scales, this is less certain, though still plausible. It may be possible to lengthen the two shorter scales by re-introducing some items showing DIF by modeling them to have different scale locations for the relevant subgroups of patients. Next steps in development of the ACOM will be real-data and Monte Carlo simulations of adaptive administration of each scale, and a prospective field trial to compare adaptive and full-scale administration and to evaluate sensitivity to change.

References

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Table 1. Demographic characteristics of the study sample, n = 305 persons with aphasia.

| | |
|--------------------------------------|---------|
| Age in Years, mean (sd) | 60 (14) |
| Gender, % male | 65.2% |
| <hr/> | |
| Race | |
| Caucasian | 84.6% |
| African American | 6.9% |
| Hispanic | 6.2% |
| Mixed | 1.3% |
| Asian or Pacific Islander | 0.7% |
| Aleutian, Eskimo, or Native American | 0.3% |
| <hr/> | |
| Education | |
| Primary/Middle School | 6% |
| High School | 26% |
| Some College | 34% |
| College Graduate | 23% |
| Post-Graduate Degree | 12% |
| <hr/> | |
| Marital Status | |
| Currently Married or Cohabiting | 68% |
| Divorced or Separated | 22% |
| Never Married | 7% |
| Widowed | 4% |

Table 2. Clinical characteristics of the study sample.

| | |
|--|--------------------|
| Months Post-Onset of Aphasia, median (min-max) | 33 (1-506) |
| Etiology of Aphasia | |
| Ischemic Stroke | 71% |
| Hemorrhagic Stroke | 19% |
| Stroke, undetermined type | 9% |
| Other (TBI, tumor, radiation necrosis) | 1% |
| PICA Overall score, median (min-max) | 12.31 (7.24-14.82) |
| BDAE Severity Rating | |
| 0 | 0% |
| 1 | 23% |
| 2 | 17% |
| 3 | 23% |
| 4 | 29% |
| 5 | 7% |
| Missing | 2% |
| Motor Speech Diagnosis | |
| Aphasia Only (no motor speech disorder) | 51% |
| Apraxia of Speech | 38% |
| Dysarthria | 11% |
| Undetermined Motor Speech Disorder | 1% |

Table 3. Item content and Geomin-rotated factor loadings from 149 items submitted to exploratory factor analysis. Loadings <0.4 are not shown. The item stem was “How effectively do you...”

| Item Content | Talking | Understanding | Writing and Number Use |
|--|----------------|----------------------|-------------------------------|
| have a conversation with family and friends? | 0.848 | | |
| talk about your day with family or friends? | 0.841 | | |
| find the words you want to say during conversation? | 0.836 | | |
| tell people about yourself? | 0.831 | | |
| tell a joke | 0.826 | | |
| start a new topic in conversation? | 0.788 | | |
| start a conversation with other people? | 0.782 | | |
| make small talk with neighbors? | 0.774 | | |
| talk about your past (e.g., childhood, life experiences) | 0.762 | | |
| keep a conversation going? | 0.76 | | |
| have a conversation with strangers? | 0.759 | | |
| speak to family members and friends on the phone? | 0.75 | | |
| make yourself understood when speak w/ family, friends? | 0.75 | | |
| talk to someone you don't know; a stranger | 0.75 | | |
| ask for information from store employees | 0.746 | | |
| tell a story? | 0.737 | | |
| talk about current events that you are familiar with? | 0.735 | | |
| answer questions about yourself? | 0.735 | | |
| make yourself understood when you speak w/ strangers? | 0.727 | | |
| explain how to do something | 0.727 | | |
| talk on the telephone | 0.719 | | |
| talk with a group of people? | 0.716 | | |
| talk if you are stressed or under pressure | 0.702 | | |
| correct mistakes you make when you talk | 0.693 | | |
| leave a message on an answering machine? | 0.691 | | |
| talk to your closest family member or friend | 0.687 | | |
| talk about your health concerns with family members | 0.676 | | |
| say your name | 0.665 | | |
| explain your health concerns to your doctor | 0.663 | | |
| say the names of food items | 0.655 | | |
| talk about your hobbies and interests | 0.654 | | |
| ask questions to get information? | 0.651 | | |
| say the names of body parts? | 0.647 | | |
| ask for information over the phone | 0.642 | | |
| share opinions? | 0.641 | | |
| ask for help from family or friends? | 0.637 | | |
| introduce yourself | 0.633 | | |

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| communicate at family gatherings | 0.631 | |
| introduce friends by name | 0.631 | |
| talk about your future plans with family or friends | 0.63 | |
| talk about current/previous work? | 0.625 | |
| talk about movies that you have seen | 0.619 | |
| explain how to get somewhere | 0.603 | |
| tell people how you feel | 0.6 | |
| correct yourself when people do not understand you? | 0.593 | |
| say "thank you" and "you're welcome?" | 0.584 | |
| introduce family members by name | 0.58 | |
| say the names of common objects (e.g., bed, lamp, pencil) | 0.578 | |
| spell your whole name out loud | 0.576 | |
| call friends by name | 0.559 | |
| make appointments on the phone | 0.54 | 0.44 |
| say what month it is | 0.537 | |
| tell people what you like and dislike? | 0.534 | |
| say the names of clothing items? | 0.526 | |
| say your address | 0.524 | 0.424 |
| say what day of the week it is | 0.517 | |
| make your wants and needs known? | 0.508 | |
| tell people why you can't talk very well | 0.507 | |
| read sentences aloud | 0.498 | |
| discuss family matters with your spouse and children | 0.495 | |
| say your phone number | 0.47 | 0.513 |
| greet people appropriately (e.g., Hi, how are you?)? | 0.457 | |
| say your social security number | 0.431 | 0.515 |
| read words aloud | 0.429 | |
| call family members by name | 0.428 | |
| order food in a restaurant | 0.422 | |
| follow movies | | 0.827 |
| follow TV shows? | | 0.765 |
| recognize the names of common objects when someone says them | | 0.709 |
| follow simple spoken requests (e.g., pass the salt) | | 0.686 |
| follow TV news programs | | 0.677 |
| recognize your name when called | | 0.672 |
| read signs in a store to find what you need | | 0.65 |
| understand popular sayings (e.g., It's raining cats and dogs) | | 0.623 |
| follow conversation about familiar topics? | | 0.617 |
| follow spoken instructions | | 0.615 |
| recognize the names of family members when someone says them | | 0.61 |
| follow group conversation? | | 0.61 |
| read street name signs | | 0.605 |

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| understand humor in pictures (e.g., comics, photographs) | 0.605 | |
| understand warning signs (e.g., slippery floor, "do not enter") | 0.6 | |
| understand what the doctor tells you | 0.6 | |
| follow a story someone tells? | 0.599 | |
| recognize your name in print | 0.583 | |
| read product labels | 0.578 | 0.438 |
| understand price tags | 0.565 | |
| express agreement or disagreement | 0.565 | |
| read traffic signs | 0.555 | 0.437 |
| tell time | 0.551 | |
| understand restroom signs | 0.545 | |
| understand jokes and funny stories | 0.539 | |
| follow therapy instructions | 0.534 | |
| follow spoken directions? | 0.525 | |
| understand your closest family member/friend when talk? | 0.522 | |
| read food labels | 0.507 | |
| understand a single written word? | 0.506 | |
| let people know if you understand them | 0.493 | |
| follow conversation about unfamiliar topics | 0.484 | |
| follow simple written instructions? | 0.481 | 0.44 |
| answer yes/no questions | 0.477 | |
| understand newspaper headlines | 0.474 | |
| understand legal documents, such as a will or advanced directive | 0.465 | |
| understand medical insurance information | 0.457 | 0.432 |
| understand magazine/newspaper articles | 0.444 | |
| understand medicine labels | 0.437 | 0.476 |
| understand someone you don't know; a stranger? | 0.425 | |
| recognize your address when someone says it | 0.423 | |
| communicate your basic needs (hunger, restroom, pain, discomfort, etc.) | 0.413 | |
| understand a fast-paced conversation | 0.41 | |
| write checks | | 0.8 |
| write a shopping list | | 0.77 |
| use the internet to get information | | 0.77 |
| write a simple "to do" list | | 0.757 |
| write your social security number | | 0.74 |
| write a personal letter | | 0.734 |
| pay bills | | 0.733 |
| write a business letter | | 0.725 |
| use a computer at home | | 0.716 |
| write your phone number | | 0.696 |
| manage your personal finances | | 0.695 |
| fill out simple forms | | 0.689 |

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| communicate by e-mail | | 0.687 |
| write your address | | 0.676 |
| write simple messages | | 0.665 |
| make transactions with a bank teller | | 0.664 |
| use a credit/debit card to buy things | | 0.656 |
| write sentences | | 0.628 |
| write down a phone message | | 0.602 |
| follow driving directions | | 0.59 |
| write messages in greeting cards | | 0.586 |
| dial a telephone number | | 0.578 |
| fill out complex forms | | 0.577 |
| count change at the store | | 0.549 |
| write words | | 0.517 |
| use cash to buy things | | 0.511 |
| write your name | | 0.508 |
| use a calendar to plan and keep track of events | | 0.501 |
| buy things at a store | | 0.485 |
| add and subtract | | 0.475 |
| understand computer icons | 0.418 | 0.599 |
| understand your bank/credit card statements | 0.403 | 0.539 |
| read a book for pleasure | | |
| get help in an emergency | | |
| ask for clarification when you do not understand something | | |
| recognize when people do not understand you | | |
| respond to greetings | | |
| get your point across when you are upset or angry | | |
| understand conversation in a noisy place (party, crowd)? | | |
| understand people when you are stressed or under pressure | | |

Table 4. Summary of item reduction results for the ACOM Talking scale. Item locations represent the average category location for each item.

| Item Content | |
|---|--|
| Excluded Items | Reason for Exclusion |
| make small talk with neighbors | DIF, biased against participants with mild aphasia |
| explain how to get somewhere | DIF, biased against women |
| communicate at family gatherings | DIF, biased against participants with mild aphasia |
| discuss family matters with your spouse and children | DIF, biased in favor of participants with motor speech disorder |
| tell people how you feel | DIF, biased in favor of participants with motor speech disorder |
| tell people what you like and dislike | Model misfit, outfit MSQ ≥ 1.4 |
| say your address | DIF, biased against participants with motor speech disorder and mod-severe aphasia |
| ask for information over the phone | DIF, biased against participants with mod-severe aphasia |
| greet people appropriately (e.g., Hi, how are you?) | DIF, biased against mild aphasics |
| make appointments on the phone | DIF, biased against participants with mod-severe aphasia |
| ask for help from family or friends | DIF, biased against participants with mild aphasia |
| say your name | DIF, biased against participants with motor speech disorder |
| say the names of common objects (e.g., bed, lamp, pencil) | DIF, biased against young participants (< 62 years old) |
| spell your whole name out loud | DIF, biased against participants with motor speech disorder and mod-severe aphasia |
| say your social security number | DIF, biased against women and participants with mod-severe aphasia |
| make your wants and needs known | DIF, biased in favor of participants with motor speech disorder |
| talk if you are stressed or under pressure | DIF, biased against participants with mild aphasia |
| Retained Items | Item location |
| correct yourself when people do not understand you | -1.93 |
| talk to your closest family member or friend | -1.36 |
| say "thank you" and "you're welcome"? | -1.16 |
| say the names of clothing items | -0.99 |
| explain how to do something | -0.87 |
| tell a joke | -0.79 |
| have a conversation with strangers | -0.76 |
| start a new topic in conversation | -0.74 |
| have a conversation with family and friends | -0.68 |
| find the words you want to say during conversation | -0.58 |
| talk about your future plans with family or friends | -0.57 |
| say the names of food items | -0.54 |

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| order food in a restaurant | -0.52 |
| tell people why you can't talk very well | -0.48 |
| make yourself understood when you | |
| speak with family or friends | -0.42 |
| answer questions about yourself | -0.33 |
| call family members by name | -0.31 |
| tell a story | -0.3 |
| say what day of the week it is | -0.18 |
| talk about your past (e.g., childhood, life | |
| experiences) | -0.13 |
| say what month it is | -0.11 |
| speak to family members and friends on | |
| the phone | 0.0 |
| share opinions | 0.03 |
| introduce yourself | 0.09 |
| say your phone number | 0.09 |
| talk about your hobbies and interests | 0.10 |
| correct mistakes you make when you | |
| talk | 0.12 |
| introduce friends by name | 0.13 |
| introduce family members by name | 0.24 |
| say the names of body parts | 0.29 |
| talk about current events that you are | |
| familiar with | 0.33 |
| read words aloud | 0.35 |
| talk about movies that you have seen | 0.37 |
| ask questions to get information | 0.38 |
| call friends by name | 0.4 |
| tell people about yourself | 0.4 |
| start a conversation with other people | 0.44 |
| keep a conversation going | 0.49 |
| talk on the telephone | 0.52 |
| make yourself understood when you | |
| speak with strangers | 0.62 |
| talk about your health concerns with | |
| family members | 0.70 |
| talk to someone you don't know | 0.71 |
| talk about your day with family or | |
| friends | 0.73 |
| talk with a group of people | 0.75 |
| explain your health concerns to your | |
| doctor | 0.78 |
| read sentences aloud | 0.88 |
| talk about current/previous work | 1.14 |
| ask for information from store | |
| employees | 1.18 |
| leave a message on an answering | |
| machine | 1.49 |

Table 5. Summary of item reduction results for the ACOM Comprehension scale.

| Item Content | |
|---|--|
| Excluded Items | Reason for Exclusion |
| understand computer icons | DIF, biased against older participants (>62) |
| understand jokes and funny stories | DIF, biased against Caucasians |
| follow movies | DIF, biased against participants with mild aphasia |
| follow TV news programs | DIF, biased against women |
| follow TV shows | DIF, biased against participants with mild aphasia |
| follow conversation about unfamiliar topics | DIF, biased against women |
| follow group conversation | DIF, biased against participants with hearing impairment and motor speech disorder |
| follow simple written instructions | DIF, biased against men |
| understand a fast-paced conversation | DIF, biased against participants with hearing impairment and motor speech disorder |
| understand popular sayings (e.g., It's raining cats and dogs) | DIF, biased against younger participants (<62) |
| Retained Items | Item location |
| understand what the doctor tells you | -2.83 |
| understand warning signs (e.g., “slippery floor”, “do not enter”) | -1.29 |
| recognize the names of family members when someone says them | -1.19 |
| recognize the names of common objects when someone says them | -0.59 |
| read traffic signs | -0.55 |
| understand price tags | -0.51 |
| express agreement or disagreement | -0.51 |
| follow spoken instructions | -0.44 |
| answer yes/no questions | -0.42 |
| understand your closest family member or friend when they talk to you | -0.23 |
| follow spoken directions | -0.15 |
| read signs in a store to find what you need | 0.15 |
| read street name signs | 0.21 |
| understand newspaper headlines | 0.21 |
| follow a story someone tells | 0.25 |
| understand someone you don't know | 0.27 |
| understand magazine/newspaper articles | 0.33 |
| follow therapy instructions | 0.46 |
| read food labels | 0.56 |
| understand medicine labels | 0.6 |
| follow conversation about familiar topics | 0.64 |
| understand your bank/credit card statements | 0.67 |

| | |
|--|------|
| read product labels | 0.91 |
| understand legal documents, such as a will or advanced directive | 1.06 |
| let people know if you understand them | 1.15 |
| understand medical insurance information | 1.22 |

Table 6. Summary of item reduction results for the ACOM Writing and Number Use scale.

| Item Content | |
|---|---|
| Excluded Items | Reason for Exclusion |
| use a computer at home | DIF, biased against older participants (>62) |
| communicate by e-mail | DIF, biased against participants with < bachelor's |
| follow driving directions | DIF, biased against women; Model misfit, outfit MSQ > 1.4 |
| use the internet to get information | DIF, biased against older participants (>62) |
| manage your personal finances | DIF, biased against women |
| count change at the store | DIF, biased against women |
| understand computer icons | DIF, biased against older participants (>62) |
| add and subtract | DIF, biased against women |
| write words | DIF, biased against men |
| use cash to buy things | Model misfit, outfit MSQ > 1.4 |
| write your name | Model misfit, outfit MSQ > 1.4 |
| Retained Items | Item location |
| write your name | -2.96 |
| write your social security number | -1.08 |
| use a credit/debit card to buy things | -0.96 |
| write your address | -0.85 |
| dial a telephone number | -0.70 |
| use cash to buy things | -0.69 |
| write your phone number | -0.63 |
| buy things at a store | -0.33 |
| write a personal letter | -0.20 |
| use a calendar to plan and keep track of events | -0.01 |
| write a shopping list | 0.12 |
| write a simple to-do list | 0.23 |
| make transactions with a bank teller | 0.27 |
| pay bills | 0.43 |
| fill out complex forms | 0.98 |
| write down a phone message | 1.12 |
| write a business letter | 1.22 |
| write sentences | 1.26 |
| write simple messages | 1.38 |
| write messages in greeting cards | 1.40 |

Table 7. Summary of ACOM scale properties

| | Talking | Comprehension | Writing |
|---------------------------------|--------------|---------------|--------------|
| Item location reliability | 0.97 | 0.98 | 0.98 |
| Mean item category location | 0.02 | 0.03 | 0.01 |
| Sd item category locations | 2.18 | 2.38 | 2.28 |
| Min-max item category locations | -3.88 - 4.03 | -3.76 - 4.58 | -5.91 - 4.07 |
| Person (scale) reliability | 0.97 | 0.94 | 0.92 |
| Mean person location | -0.32 | 0.02 | -0.86 |
| Sd person locations | 1.63 | 1.83 | 2.4 |
| Min-max person locations | -7.35-4.57 | -4.94 - 6.12 | -7.28 - 6.50 |
| Participants at ceiling | 0 | 0 | 1 |
| Participants at floor | 1 | 0 | 2 |

Table 8. Spearman rank correlations between ACOM scale scores and PICA modality scores, PICA Overall score, ASHA FACS mean Communication Independence score, and BDAE Severity Rating.

| ACOM Scale | PICA Verbal | PICA Comprehension | PICA Writing | PICA Overall | ASHA FACS | BDAE Severity Rating |
|------------------------|-------------|--------------------|--------------|--------------|-----------|----------------------|
| Talking | 0.67 | 0.54 | 0.52 | 0.61 | 0.57 | 0.73 |
| Comprehension | 0.59 | 0.61 | 0.48 | 0.56 | 0.63 | 0.63 |
| Writing and Number Use | 0.61 | 0.60 | 0.66 | 0.68 | 0.62 | 0.65 |