

## 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  $\geq 1$  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;  $\geq 0.6$  delayed/immediate ratio on ABCD Story Retell (Bayles & Tomoeda, 1993);  $\leq 5$  self-reported depressive symptoms on the GDRS-15 (Sheikh & Yesavage, 1986); and BDAE severity rating  $\geq 1$ . 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%
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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%
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Education	
Primary/Middle School	6%
High School	26%
Some College	34%
College Graduate	23%
Post-Graduate Degree	12%
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Marital Status	
Currently Married or Cohabiting	68%
Divorced or Separated	22%
Never Married	7%
Widowed	4%
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**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...”

<b>Item Content</b>	<b>Talking</b>	<b>Understanding</b>	<b>Writing and Number Use</b>
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		

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

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

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	Reason for Exclusion	Item location
<b>Excluded Items</b>		
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 $\geq 1.4$	
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	
<b>Retained Items</b>		
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

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

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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

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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

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

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Item Content	
<b>Excluded Items</b>	<b>Reason for Exclusion</b>
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
<b>Retained Items</b>	<b>Item location</b>
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

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**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