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Journal Title: Patient Education and Counseling
Volume: Volume 95, Number 2
Publisher: Elsevier: 12 months | 2014-05-01, Pages 211-217
Type of Work: Article | Post-print: After Peer Review
Publisher DOI: 10.1016/j.pec.2014.02.002
Permanent URL: https://pid.emory.edu/ark:/25593/tw0tx

Final published version: http://dx.doi.org/10.1016/j.pec.2014.02.002

Copyright information:

Published in final edited form as:
Patient Educ Couns. 2014 May ; 95(2): 211–217. doi:10.1016/j.pec.2014.02.002.

Abilities, skills and knowledge in measures of health literacy

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Abstract

Objective—Health literacy has been recognized as an important factor in patients' health status and outcomes, but the relative contribution of demographic variables, cognitive abilities, academic skills, and health knowledge to performance on tests of health literacy has not been as extensively explored. The purpose of this paper is to propose a model of health literacy as a composite of cognitive abilities, academic skills, and health knowledge (ASK model) and test its relation to measures of health literacy in a model that first takes demographic variables into account.

Methods—A battery of cognitive, academic achievement, health knowledge and health literacy measures was administered to 359 Spanish- and English-speaking community-dwelling volunteers. The relations of health literacy tests to the model were evaluated using regression models.

Results—Each health literacy test was related to elements of the model but variability existed across measures.

Conclusion—Analyses partially support the ASK model defining health literacy as a composite of abilities, skills, and knowledge, although the relations of commonly used health literacy measures to each element of the model varied widely.

Practice implications—Results suggest that clinicians and researchers should be aware of the abilities and skills assessed by health literacy measures when choosing a measure.

Keywords

Health literacy; Cognition; Crystallized abilities; Fluid abilities

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Conflict of interest: The authors state that they have no conflict of interest in the study.

1. Introduction

Health literacy, defined as an individual's ability to obtain and use health information to make choices about health care, is related to patients' health [1,2], health status, service utilization, self-care behaviors, and even risk for death [2,3] and has been tied to race- and ethnicity-related disparities [4–6]. In spite of the large amount of research on it, important questions about health literacy remain, such as how it can most effectively be defined to facilitate measurement and develop effective interventions. In most studies, health literacy has been assessed as patient performance on a test of health literacy, but each of the commonly used measures evaluates health literacy in a different way. In some instances, health literacy is defined as reading comprehension (the Reading subtest of Test of Functional Health Literacy in Adults, or TOFHLA [7]), sight-word reading (the Rapid Estimate of Adult Literacy in Medicine, or REALM [8]), calculation (the Numeracy subtest of the TOFHLA), or identifying synonyms (the Short Assessment of Health Literacy for Spanish Adults, or SAHLSA [9]). Each of these strategies assesses something related to health literacy, but their diversity leaves open the question of what each has in common with the “social construct of health literacy”. [10]

Each measure samples different content, uses different response formats, and has been developed on different populations [11]. The TOFHLA, for example, evaluates reading comprehension by asking a person to supply words eliminated from the text (the cloze procedure), while its numeracy scale asks that he or she explain how to take medications. The REALM requires the person to correctly read aloud words related to healthcare. The need for a similar measure for Spanish speakers led to the development of the SAHLSA, but the low frequency of orthographically irregular words in Spanish meant that it was necessary to develop a different response format. The SAHLSA asks the person tested to view a stimulus word on a card and choose which of two other words is most similar in meaning.

Performance on these measures requires reading and health knowledge, and several, especially the TOFHLA subtests, also require reasoning, problem solving and numeracy [12]. The variety of contents and formats, however, suggests that the abilities, skills, and knowledge required for successful performance on each are different [13,14]. Griffin et al., for example, showed substantial differences in which patients were identified as having limited health literacy by different measures [15], and similar findings have been reported in other studies [13,16]. Because of this, it was hypothesized that more clearly establishing the relations of widely used tests of health literacy to other variables might provide a better understand what each measures. It was also hypothesized that a better understanding would also provide a clearer picture of what health literacy is by more clearly delineating its component skills. In this paper, it is hypothesized that the variables most relevant to health literacy are individuals' general cognitive abilities and academic skills, and their health-related knowledge, after their demographic characteristics (race, ethnicity, age, and SES) are taken into account.

1.1. Health literacy and demographic variables

Studies have shown that health literacy is related to age, race, ethnicity, and socioeconomic status. For example, persons older than 65 years of age performed at lower levels on the

Health Literacy scale of the National Assessment of Adult Literacy [17]. Blacks and Hispanics have also been shown to perform at lower levels on measures of health literacy. Closely intertwined with other demographic characteristics is socioeconomic status, itself related to health literacy [18]. The finding that English-speaking Hispanics may be at a disadvantage to non-Hispanics when their health literacy is assessed in English [19] suggests that preferred language may also be a key characteristic. Gender may also be related to performance on tests of health literacy [19].

1.2. Health literacy and cognition

Understanding the relation of tests of health literacy to basic cognitive abilities (or intelligence, often assessed by IQ tests) may be especially important since research has shown that both general intellectual abilities and health literacy are related to health [20–23]. General intellectual ability can be defined as reflecting a person's acquired knowledge and communication ability (crystallized ability) and capacity to reason and solve novel problems (fluid ability) [24–26]. Baker et al. [23] showed that overall performance on the Mini-mental State Exam (MMSE; [27]) was related to S-TOFHLA scores. Levinthal et al. [28] evaluated the relation of demographic and cognitive variables to performance on the S-TOFHLA and found that both were related. Chin et al. [21] found that age, education, basic cognitive abilities, and disease-related knowledge were related to performance on the S-TOHLA and REALM. Others have shown that performance on tests of health literacy is related to various abilities including memory, verbal fluency, reasoning, and general intellectual functioning [22,29,30].

1.3. Health literacy and academic skills

By its very nature, health literacy appears related to academic skills such as reading and mathematics [31–33]. Academic skills can be distinguished from basic cognitive abilities by their acquisition via formal instruction during schooling. While basic cognitive abilities are thought to be stable over time [34], academic skills such as reading, writing, and arithmetic are amenable to change through formal interventions well into adult life [35]. While it is important to distinguish between general reading skills and health literacy [36,37], the correlation between patients' performance on measures of academic skills and health literacy has been presented as evidence of the measures' validity [7,38].

1.4. Health literacy and health knowledge

In addition to demographics, cognitive abilities and academic skills, health knowledge is related both to performance on tests of health literacy and health. Disease-specific knowledge, for example, has been linked to health literacy in diabetes [39], hypertension [21,40], HIV infection [41], asthma, and congestive heart failure [40].

1.5. Synthesis: the ASK model

These studies illustrate the diverse influences affecting performance on tests of health literacy. Demographics, cognitive abilities, academic skills, and health knowledge are each related to scores on measures of health literacy. Few studies have included variables from all of these domains, however, and studies that have used variables from multiple domains have

shown that variables from one domain may reduce the importance of others. In this paper, it is hypothesized that after taking demographic characteristics into account, each group of variables will define health literacy as a unique entity depending on a person's general intellectual abilities, academic skills and health-related knowledge (ASK).

2. Method

As part of a larger study whose purpose has been to develop a new computer-administered measure of health literacy [42], participants completed a battery of general intellectual, academic skills, and health literacy measures. They were recruited from the community through publicity at various local organizations, distribution of flyers, and referral by persons who had already completed the study.

2.1. Measures

2.1.1. Demographics—Participant age, education, occupation, income, gender, and race were recorded. Principal factor analysis was used to construct a composite index of socioeconomic status based on education, income, and occupational prestige index [43]. The index was constructed to address the limitations of single-indicator measures [44], as single indicators such as education, income, and occupational status are only moderately correlated and only partially represent an individual's status [45]. The index was calculated by including education, occupational prestige, and income in a principal factor analysis [46]. Each indicator's loading on a single factor (0.27, 0.27, and 0.16 for education, occupational status, and income, respectively) provided weights for calculation of factor scores for each participant.

2.1.2. Cognitive abilities—Crystallized general cognitive abilities [24,25] were assessed using the Verbal Composite score of the Woodcock-Johnson Psycho-Educational Battery for English speakers and the Wood-cock-Muñoz Psycho-Educational Battery for Spanish speakers (WJPEB/WMPEB; [47,48]). These measures tap word knowledge, general information, and verbal reasoning in a series of tasks that yields a single score. Fluid general cognitive abilities were assessed with the Block Design and Matrix Reasoning subtests of the Wechsler Adult Intelligence Scale, Third Edition [49]; the average of these subtests' age-corrected scores yielded an index [24,25].

2.1.3. Academic skills—Reading and mathematics skills were assessed with the Passage Comprehension and Applied Problems subtests of the WJPEB/ WMPEB [47,48]. The Passage Comprehension subtests use items based on one or two sentences to evaluate reading comprehension. The Applied Problems subtests assess mathematics skill through items requiring problem solving as well as calculation.

2.1.4. Health knowledge—Health knowledge was assessed with a subscale of the new measure developed during the study [42]. Baker commented on the potential usefulness of a brief measure of general health knowledge [33] and as part of our project [42], we developed such a measure. It comprises 15 questions, all of which assess knowledge of a specific fact, such as a disease risk factor or a specific drug treatment for a disease, and do not require substantial reading or numeracy skills, as for example, “Cholesterol is measured

with a…". Other items assessed a broad range of health-related facts, include the part of the body most commonly treated by a specific medical profession (nephrology), what common over-the-counter medications are used for (aspirin for heart attack), and the meaning of blood lipid indices (e.g., HDL).

The health knowledge scale was developed in two stages. A group of candidate items was first administered to older and younger Spanish or English speaking individuals. Preliminary analyses of item performance in both languages and of item discrimination and difficulty allowed us to choose items for the second phase of the study. In this phase, scale items were administered along with the additional measures as described here. The dimensional structure of the new knowledge scale as well as item difficulties were supported through psychometric analyses [42], although its marginally acceptable internal reliability (Cronbach's alpha = 0.67) limits its use to research.

2.1.5. Health literacy—All participants completed either the Spanish or English versions of the Test of Functional Health Literacy in Adults (TOFHLA; [7]). English-speakers completed the Rapid Estimate of Adult Literacy in Medicine (REALM [8]), while Spanish speakers completed the Short Assessment of Health Literacy for Spanish-speaking Adults (SAHLSA [9]).

2.2. Analyses

Linear regression models using progressively more complex blocks of variables representing, first, demographics and then the elements of the ASK model were created to assess study hypotheses. Variable blocks after correcting for demographics were evaluated in a logical order from the most general and basic (core intellectual abilities) through the more specific skills acquired early in life (reading or mathematics) to the most specific (health-related knowledge). Models assessed the relative contribution of each element to prediction of each measure. Analyses were completed using SPSS version 21 (Montauk, NY: IBM).

All study procedures were completed under a protocol approved by the Nova Southeastern University Institutional Review Board. Verbal consent was obtained from participants for screening procedures and written informed consent was obtained from all subjects prior to their participation.

3. Results

Descriptive statistics for the sample are presented in Table 1. Our sample intentionally included participants from a wide range of ages (18–85) and the mean age for the combined sample was 51.0 years (standard deviation = 16.5). The sample included individuals with a wide range of education (3–20 years) with a combined sample mean of 12.9 years (standard deviation = 2.6).

Regression models are presented in Tables 2–5. Results for the TOFHLA Reading subtest (Table 2) show that in the model only including demographic variables (Model 1), SES was related to higher scores on the TOFHLA Reading while age, being black, and speaking

Spanish were related to lower scores (Model 1 $R^2 = 0.19$, $F = [df = 5, 278] = 13.32$, $p < 0.001$). Both crystallized and fluid abilities added to the model's prediction of TOFHLA scores (Model 2 $R^2 = 0.41$, F for change = $[df = 2, 276] = 49.11$, $p < 0.001$), while reading added still further to the model ($R^2 = 0.43$, F for change = $[df = 1, 275] = 9.86$, $p = 0.002$), as did health knowledge ($R^2 = 0.44$, F for change = $[df = 1, 274] = 8.20$, $p = 0.005$).

The model for the TOFHLA Numeracy subtest (Table 3) also showed that SES was positively and Spanish language was inversely related to scores ($R^2 = 0.18$, $F = [df = 5, 279] = 12.53$, $p < 0.001$). The addition of general cognitive abilities increased prediction ($R^2 = 0.21$, F for change = $[df = 2, 277] = 8.36$, $p < 0.001$). The addition of math skills did not improve prediction ($R^2 = 0.21$, F for change = $[df = 1, 276] = 1.60$, $p = 0.21$) even though it was related to the Numeracy subscale (Table 3). Addition of health knowledge to the model did not improve prediction ($R^2 = 0.22$, F for change = $[df = 1, 275] = 3.17$, $p = 0.08$).

The model for English speakers on the REALM is presented in Table 4. In Model 1, female gender was positively and black race was inversely related to scores. ($R^2 = 0.17$, $F = [df = 4, 134] = 6.62$, $p < 0.001$). The addition of general cognitive abilities improved prediction ($R^2 = 0.25$, F for change = $[df = 2, 132] = 7.88$, $p = 0.001$), as did the addition of reading ($R^2 = 0.28$, F for change = $[df = 1, 131] = 5.03$, $p = 0.02$), and knowledge ($R^2 = 0.34$, F for change = $[df = 1, 130] = 19.77$, $p < 0.0001$).

The model for the SAHLSA is presented in Table 5. In Model 1, only SES was associated with better scores although the value for female gender approached statistical significance ($R^2 = 0.07$, F model = $[df = 3, 142] = 3.42$, $p = 0.02$). The addition of crystallized and fluid abilities did not improve prediction ($R^2 = 0.10$, F for change = $[df = 2, 140] = 2.81$, $p = 0.06$) although crystallized abilities were a significant predictor. Neither the addition of academic reading ($R^2 = 0.12$ F for change = $[df = 1, 139] = 2.51$, $p = 0.12$) nor knowledge ($R^2 = 0.14$, F for change = $[df = 1, 139] = 2.69$, $p = 0.10$) increased prediction.

Table 6 presents a summary of the variability (R^2) accounted for by each block and the significance of change associated with each. The percentage of variability related to demographic variables was similar for the TOFHLA subtests and the REALM while the SAHLSA was less strongly related to demographic variables. TOFHLA Reading scores were significantly related to cognitive abilities, while scores on the other measures were much less clearly related to cognition. Academic skills provided similar contributions in each model, except for the TOFHLA Numeracy subtest which, while a significant predictor, did not improve overall model prediction. In most models, health knowledge provided a small but significant contribution.

4. Discussion and conclusion

4.1. Discussion

The purpose of these analyses was to assess how performance on health literacy measures was related to abilities, skills, and knowledge as specified by the ASK model. Results for several measures support the model, especially those for the TOFHLA Reading subscale. Support was less substantial for other measures, but all included at least one model element.

Analyses for each measure do not uniformly include model elements, suggesting that important aspects of health literacy as measured by some tests are not captured by the model. The elements of the model are most clearly related to the TOFHLA Reading subtest; to the extent that it can be considered a gold standard for health literacy measurement, the ASK model is supported, but further research is needed. These findings provide insight into diverse factors related to performance on health literacy measures and are consistent with the view of health literacy as a unique combination of abilities, skills and knowledge.

Results of these analyses raise an important issue about the use of these measures in research, since most studies have implicitly operationalized “health literacy” as participants' performance one of them. Although researchers in the field of health literacy have acknowledged that it is a complex concept [10,31], and have argued for the evolution of its definition [32], substantial work remains in order to better define what health literacy is and how it can be distinguished from closely related concepts such as general literacy, education, and mathematics skills. Clear differences exist in these measures, and it may be difficult to generalize about the concept of health literacy from studies that use different measures. Results thus confirm and extend others' observations of the diverse relations of health literacy measures to other abilities and skills [13,14,16] and support the recommendation of Haun et al. [13] that researchers and clinicians be alert to differences among measures.

Examination of groups of predictors in sequential blocks also assists in interpretation of findings from other studies of race- and language-related differences in health literacy. Results for Model 1 (demographic variables only) across measures revealed differences in performance on health literacy measures related to age, SES, race, and language; the impact of these factors was reduced or eliminated when cognitive abilities, academic skills, and health knowledge were included in models. For example, while in Model 1 for the TOFHLA Reading subscale blacks performed at lower levels compared to whites, race was no longer a significant predictor when abilities, skills and health knowledge were taken into account (Model 4 in Table 2). This might imply that a portion of the often-observed relation of demographic variables to health literacy may reflect individuals' history of educational opportunities [50] and that race- or ethnicity-related differences in health literacy could be addressed through educational interventions [6,51–55].

An important aspect of the TOFHLA analyses presented here is the use of a combined sample that had been evaluated in either Spanish or English. We chose this combined sample strategy as it provided the opportunity to understand the impact of ASK model variables while taking language into account. The combined sample also conferred the benefit of increased statistical power to detect relationships while evaluating the relation of SES, age, cognitive abilities, academic skills, and health knowledge on ethnicity-related differences in performance on health literacy measures. Similar to our findings on the reduced relation of race to health literacy when other variables are controlled, these analyses show that the relation of language was reduced when ability, skills, and knowledge were included in regression models. It should be noted, however, that language-related differences in performance on the TOFHLA subtests may reflect differences in the measures as well as difference in the persons assessed, since to the best of our knowledge no study has

demonstrated that the Spanish and English versions of the TOFHLA, while similar in content, are psychometrically equivalent.

Another noteworthy result related to the TOFHLA was our failure to find a relation of its Numeracy scale to general intellectual abilities or knowledge (although fluid abilities and knowledge approached significance as predictors). Examination of the content of the TOFHLA Numeracy scale shows that it includes a number of task demands beyond numeracy, including auditory attention and listening skills (most questions are presented orally even if supported by props such as pill bottles and information cards), visual attention (detecting specific information on pill bottle labels), and reasoning (deciding who should be included in determining the number of members in a household). It may be that this scale assesses a construct that is not included in the ASK model, or conversely, that its independent relation to other measures is weak due to its diverse content and brevity. Few studies have investigated its psychometric properties independent of the full TOHFLA, and we note that many investigators have chosen to use the S-TOHFLA [56], which reduces the number of numeracy items to four. A clearer explanation of this finding must await additional study.

Other studies have reported regression models and the variability accounted for by similar groups of variables, though none has included all of the domains reported on here. Levinthal et al. [28] included demographics and cognitive variables in predicting the S-TOFHLA; their model accounted for 49% of the variability scores. Chin et al. also included demographic and cognitive variables in predicting the S-TOFHLA and the REALM. Their models accounted for 32% of the variability in REALM scores and 42% of S-TOFHLA scores. Yost et al. report a model included demographic and several brief cognitive measures predicting scores on the computer-administered Health LiTT [30]; it accounted for 27% of its variability. The values we report for the TOFHLA Reading and the REALM are thus similar to those found by other investigators, but also demonstrate the importance of reading skills and health knowledge.

Limitations of our study should be acknowledged and include the nature of our sample. Our participants were drawn from the community rather than from groups of patients in health care organizations as has been true of many other studies [11]. Although in some ways a strength, our sample, as is common in volunteer research, has higher levels of education than the general population. Because of our strategy of sampling across age groups, it included a wider age range than in most other studies. It is possible that our findings might not be the same in groups with a lower education levels, older persons, or in persons seeking medical care. It should be noted that education is included in the SES index used so that differences related to education are accounted for in regression models. It may also be noted that although the mean level of education of our participants is high, the sample included a wide range of educational attainment (as low as three years to doctoral-level), potentially reducing this issue's impact. Conversely, as the sample includes a wide range of age and educational levels and was recruited from the community, these results may be more broadly generalizable to the general population.

4.2. Conclusion

These analyses suggest that the ASK model may be useful in understanding individuals' performance on measures of health literacy. They highlight the impact of demographic characteristics and general cognitive abilities as determinants of performance on measures of health literacy and extend our understanding of the role of academic skills and health knowledge in health literacy. To the extent that health literacy measures are used to operationally define it, then results can be interpreted as support for the definition of health literacy as a unique combination of abilities, skills, and knowledge. Results thus provide support for the ASK model and suggest it might be a helpful framework within which to understand health literacy and to distinguish it from general cognitive ability or literacy alone.

4.3. Practice implications

Differences in predictors among the measures highlight the heterogeneity of what they measure. While the TOFHLA Reading Comprehension scale was clearly associated with both crystallized and fluid abilities as well as academic reading skills and conceptual knowledge, in the model including all predictors the SAHLSA was not clearly associated with any. Our findings thus confirm and extend those of others who have noted the diverse number of abilities and skills assessed by measures of health literacy and the various ways in which they are related [13,14,16]. It is suggested that practitioners be aware of this variability in choosing a health literacy test since it is clear that different tests of health literacy measure different things. The relations of the TOFHLA Numeracy subtest and the SAHLSA to other relevant variables is small. Since few studies have confirmed either measure's independent validity, these measures should be used with caution until it becomes clearer what constructs they measure.

A key practice implication depends on the extent to which abilities, skills, and knowledge can be considered as elements of health literacy. While general intellectual abilities may not be readily changed, core academic skills and health-related knowledge can clearly be improved through targeted interventions. We thus suggest the use of the ASK model as an organizing framework for interventions to promote health literacy. The model not only provides for organization but also provides guidance for the assessment of intervention effects through assessment of changes in patient skills and knowledge.

Acknowledgments

This study was supported by a grant to Dr. Ownby from the US National Heart, Lung, and Blood Institute (R01HL096578). The authors also acknowledge other members of the team of investigators: Drs. Sara J. Czaja and David Loewenstein (Center on Aging at the University of Miami Miller School of Medicine), Rosemary Davenport, RN, MSN, ARNP, Study Coordinator, Dr. Ana-Maria Homs, Assessor, and Ms. Lilly Valiente who provided data management assistance.

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Table 1

Sample description.

	English mean (SD)	Spanish mean (SD)
N	161	198
Age	52.5 (17.5)	49.8 (15.6)
Years of education	13.6 (2.3)	12.4 (2.8)
Income	$31,188	$27,889
SEI[a]	44.6 (22.4)	39.2 (20.1)
SES factor score[b]	0.19 (0.80)	−0.14 (0.82)
Crystallized[c]	95.9 (10.6)	89.6 (9.0)
Fluid[d,e]	10.6 (2.3)	10.6 (2.7)
WJ passage comprehension[c]	97.4 (11.0)	94.8 (11.2)
WJ applied problems[c]	97.1 (11.30)	87.1 (10.4)
Health knowledge[d,e]	8.8 (3.1)	7.5 (2.6)
TOFHLA Reading[f]	46.4 (4.4)	43.3 (7.6)
TOFHLA Numeracy[f]	47.8 (2.8)	43.5 (6.1)
	English *N*	Spanish *N*
Gender: Men/Women	70/91	81/118
Race: White/Black	91/70	198/0

[a] The occupation socioeconomic index ranges from 0 to 100.

[b] Factor score index combining education, income and socioeconomic index with mean of 0 and standard deviation of 1.

[c] This score has a mean of 100 and standard deviation of 15.

[d] Average of scaled scores that each have a mean of 10 and standard deviation of 3.

[e] Raw score on scale with maximum of 15.

[f] Maximum total score for each is 50.

Table 2

ASK predictors of TOFHLA Reading scores (combined sample).

	Model 1: demographics				Model 2: abilities				Model 3: skills				Model 4: knowledge			
	B	**SE**	***t***	***p***	***B***	**SE**	***t***	***p***	***B***	**SE**	***t***	***p***	***B***	**SE**	***t***	***p***
Intercept	57.80	2.69	21.51	**<0.001**	28.86	4.02	7.18	**<0.001**	26.79	4.01	6.68	**<0.001**	27.83	3.98	7.00	**<0.001**
Age	−0.09	0.02	−4.59	**<0.001**	−0.07	0.02	−4.13	**<0.001**	−0.08	0.02	−4.57	**<0.001**	−0.09	0.02	−4.93	**<0.001**
SES	1.93	0.33	5.85	**<0.001**	0.97	0.30	3.23	**0.001**	0.79	0.30	2.62	**0.009**	0.55	0.31	1.76	0.08
Female gender	0.51	0.54	0.94	0.35	1.56	0.48	3.26	**0.001**	1.50	0.47	3.17	**0.002**	1.23	0.48	2.59	**0.01**
Black race	−3.10	0.86	−3.62	**<0.001**	−0.93	0.77	−1.21	0.23	−0.96	0.76	−1.27	0.21	−0.72	0.75	−0.96	0.34
Spanish language	−3.22	0.72	−4.46	**<0.001**	−1.17	0.67	−1.74	0.08	−1.40	0.67	−2.10	**0.04**	−1.23	0.66	−1.86	0.06
Crystallized					0.16	0.03	5.30	**<0.001**	0.10	0.03	3.02	**0.003**	0.08	0.04	2.18	**0.03**
Fluid					0.56	0.11	5.06	**<0.001**	0.47	0.11	4.13	**<0.001**	0.46	0.11	4.15	**<0.001**
Reading									0.09	0.03	3.14	**0.002**	0.09	0.03	2.95	**0.003**
Knowledge													0.28	0.10	2.86	**0.01**

All values less than 0.05 are bolded.

Table 3

ASK Predictors of TOFHLA Numeracy scores (combined sample).

	Model 1: demographics				Model 2: abilities				Model 3: skills				Model 4: knowledge			
	B	**SE**	***t***	***p***	***B***	**SE**	***t***	***p***	***B***	**SE**	***t***	***p***	***B***	**SE**	***t***	***p***
Intercept	56.31	2.89	19.48	**<0.001**	43.12	4.86	8.87	**<0.001**	38.64	5.34	7.24	**<0.001**	39.40	5.33	7.40	**<0.001**
Age	−0.04	0.02	−1.72	0.09	−0.03	0.02	−1.28	0.20	−0.03	0.02	−1.29	0.20	−0.03	0.02	−1.52	0.13
SES	0.85	0.36	2.39	**0.02**	0.38	0.37	1.03	0.30	0.26	0.37	0.70	0.49	0.05	0.38	0.12	0.90
Female gender	0.39	0.58	0.68	0.50	0.92	0.58	1.58	0.12	1.14	0.59	1.93	*0.054*	0.92	0.60	1.53	0.13
Black race	−1.67	0.92	−1.81	0.07	−0.61	0.94	−0.65	0.51	−0.43	0.93	−0.46	0.65	−0.24	0.94	−0.26	0.80
Spanish language	−4.94	0.78	−6.35	**<0.001**	−4.06	0.82	−4.97	**<0.001**	−3.49	0.86	−4.05	**<0.001**	−3.37	0.86	−3.92	**<0.001**
Crystallized					0.06	0.04	1.68	0.10	0.03	0.04	0.91	0.37	0.01	0.04	0.23	0.82
Fluid					0.34	0.14	2.54	**0.01**	0.24	0.14	1.70	*0.10*	0.23	0.14	1.64	*0.10*
Math									0.07	0.04	1.98	**0.049**	0.07	0.04	2.00	**0.047**
Knowledge													0.23	0.12	1.89	*0.06*

All values less than 0.05 are bolded and those that are between 0.05 and 0.10 are in italics.

Table 4

ASK Predictors of REALM scores (English speakers only).

	Model 1: demographics				Model 2: abilities				Model 3: skills				Model 4: knowledge			
	B	**SE**	***t***	***p***	***B***	**SE**	***t***	***p***	***B***	**SE**	***t***	***p***	***B***	**SE**	***t***	***p***
Intercept	64.32	3.37	19.11	**<0.001**	43.62	6.17	7.06	**<0.001**	39.68	6.33	6.27	**<0.001**	41.84	5.94	7.04	**<0.001**
Age	−0.01	0.03	−0.19	0.85	−0.01	0.03	−0.34	0.74	−0.02	0.03	−0.70	0.49	−0.03	0.03	−1.17	0.25
SES	1.00	0.60	1.68	*0.10*	0.09	0.61	0.15	0.88	−0.26	0.62	−0.42	0.67	−0.91	0.60	−1.52	0.13
Female gender	2.38	0.96	2.46	**0.02**	2.86	0.93	3.09	**0.002**	2.91	0.91	3.19	**0.002**	2.09	0.87	2.39	**0.02**
Black race	−3.42	1.16	−2.96	**<0.001**	−2.61	1.17	−2.23	**0.03**	−2.65	1.15	−2.30	**0.02**	−1.88	1.09	−1.72	*0.09*
Crystallized					0.21	0.06	3.51	**0.001**	0.12	0.07	1.79	*0.08*	0.05	0.07	0.78	0.44
Fluid					−0.07	0.25	−0.26	0.80	−0.20	0.26	−0.80	0.42	−0.21	0.24	−0.88	0.38
Reading									0.14	0.06	2.24	**0.03**	0.13	0.06	2.20	**0.03**
Knowledge													0.79	0.18	4.45	**<0.001**

All values less than 0.05 are bolded and those that are between 0.05 and 0.10 are in italics.

Table 5

ASK predictors of SAHLSA scores (Spanish speakers only).

	Model 1: demographics[a]				Model 2: abilities				Model 3: skills				Model 4: knowledge			
	B	**SE**	***t***	***p***	***B***	**SE**	***t***	***p***	***B***	**SE**	***t***	***p***	***B***	**SE**	***t***	***p***
Intercept	42.40	2.10	20.20	**<0.001**	29.38	6.12	4.80	**<0.001**	27.17	6.25	4.35	**<0.001**	29.98	6.44	4.65	**<0.001**
Age	0.01	0.04	0.19	0.85	0.04	0.04	0.91	0.36	0.03	0.04	0.77	0.44	0.02	0.04	0.50	0.26
SES	1.42	0.55	2.58	**0.01**	1.19	0.57	2.09	**0.04**	1.06	0.57	1.86	*0.07*	0.76	0.60	1.27	0.21
Female gender	1.71	0.92	1.87	*0.06*	1.83	0.97	1.89	*0.06*	1.67	0.97	1.73	*0.09*	1.38	0.98	1.41	0.16
Crystallized					0.15	0.06	2.34	**0.02**	0.10	0.07	1.40	0.16	0.06	0.07	0.80	0.43
Fluid					−0.15	0.20	−0.73	0.47	−0.24	0.21	−1.16	0.25	−0.24	0.21	−1.16	0.25
Reading									0.09	0.05	1.58	0.12	0.08	0.05	1.39	0.17
Knowledge													0.34	0.21	1.64	*0.10*

All values less than 0.05 are bolded and those that are between 0.05 and 0.10 are in italics.

[a]Models do not include race as all Spanish-speaking participants identified themselves as white.

Table 6

Percent of variability (R^2) attributed to each block and significance for regression models.

	TOFHLA Reading	*p*	TOFHLA Numeracy	*p*	REALM	*p*	SAHLSA	*p*
Demographics	19	**<0.001**[a]	18	**<0.001**[a]	17	**<0.001**[a]	7	**0.02**[a]
Abilities	22	**<0.001**[b]	3	**<0.001**[b]	5	**0.001**[b]	3	**0.10**[b]
Skills	2	**0.002**[b]	0	**0.21**[b]	3	**0.02**[b]	2	**0.12**[b]
Knowledge	1	**0.005**[b]	1	**0.08**[b]	5	**<0.001**[b]	2	**0.10**[b]
Total	44		22		34		14	

All values less than 0.05 are bolded.

[a] Significance associated with model predictors for this block of variables; complete statistics included in text.

[b] Significance associated in change in model prediction for this block of variables; complete statistics included in text.