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Validation of a Short, 3-Item Version of the Subjective Numeracy Scale

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Abstract

Background and Objective—Efficiency in scale design reduces respondent burden. A brief but reliable measure of numeracy may provide a useful research tool eligible for integration into large epidemiological studies or clinical trials. Our goal was to validate a 3-item version of the Subjective Numeracy Scale (SNS-3).

Design and Setting—We examined seven separate cross-sectional datasets (patients in the emergency department (n=208), clinic (n=205), and hospital (n=460; n=2,053); patients with chronic kidney disease (n=147), diabetes (n=318), and on hemodialysis (n=143)).

Measurements—Internal reliability of the SNS-3 was assessed with Cronbach's alpha. Criterion validity was determined by nonparametric correlations of the SNS-3 with SNS-8 and other measures of numeracy; construct validity was determined by correlations with measures of health literacy and education.

Results—The SNS-3 had good internal reliability (median Cronbach's alpha = 0.78) and correlated highly with the full SNS (median rho = 0.91). The SNS-3 was significantly correlated with other measures of numeracy (e.g., median rho = 0.57 with the WRAT), health literacy (e.g., median rho = 0.35 with the S-TOFHLA), and education (median rho = 0.41), providing good evidence of criterion and construct validity.

Conclusion—The SNS-3 is sufficiently reliable and valid to be used as a measure of subjective numeracy.

Introduction

Although important research questions still remain, numeracy plays an fundamental role in decision making, including cognitive reasoning, understanding treatment options and risks, and the ability to convey preferences about health communication to healthcare providers.

(1–6) Fagerlin et al. (7, 8) developed and validated the 8-item Subjective Numeracy Scale (SNS-8), composed of self-reported numeracy abilities and preferences, as an alternative to objective measures of numeracy. Efficiency in scale design is important to limit potential burden on respondents while achieving the overall research objective and to provide a useful research tool eligible for integration into large epidemiological studies or clinical trials. The initial report of the acceptability and validity of the SNS-8 suggested that it could be shortened to 5 items (items 1, “fractions”; 2, “percentages;” 3, “15% tip;” 5, “newspaper;” and 6, “chance of something happening”), although to our knowledge implementation and use of the 5-item version is not widespread.

Our research team aimed to identify and use the fewest SNS items that contributed to valid differentiation of subjective numeracy skills among respondents while maintaining a balance between items that assess abilities versus those that measure preferences. In 2011, we reported in a post-hoc data analysis of 208 adult emergency department (ED) patients that a 3-item version of the SNS (SNS-3) appeared to perform as well as the full SNS-8 (9), although we did not report the correlations between the SNS-3 and SNS-8 or other measures of numeracy or health literacy. The shortened SNS-3 consisted of the following items each on a 6-point Likerttype scale, with interior responses labeled by numbers 2 through 5: (1) How good are you at working with fractions? (“Not good at all, 1” to “Extremely Good, 6”); (2) How good are you at figuring out how much a shirt will cost if it is 25% off? (“Not good at all, 1” to “Extremely Good, 6”); and (3) How often do you find numerical information to be useful? (“Never, 1” to “Very Often, 6”). The first two questions focus on self-reported numeracy skills (“fractions” and “shirt”), while the third focuses on subject preference (“useful”).

The purpose of this report is to describe the criterion and construct validity of the SNS-3 in seven different study samples of patients, including the sample of ED patients, between 2010 and 2014. The full SNS-8 was administered in six studies among more than 1,400 subjects, while in the seventh study (n=2,053) the SNS-3 was the sole measure of numeracy. In each study, other more expansive measures of numeracy or health literacy were also administered. We also report associations with education, which has consistently been shown to correlate with measures of numeracy and health literacy.

Methods

The SNS-3 items were selected to maximize correlation coefficients with the SNS-8 and objective measures of numeracy while preserving content validity of the SNS-8 and demonstrating comparability of the SNS-3’s and SNS-8’s correlation with measures of health literacy. Six independent adult patient samples from a single academic medical center where the SNS-8 was administered were examined:

1. ED patients (n=208) completed the Wide Range Achievement Test-4 (WRAT-4 (10)), Rapid Estimate of Adult Literacy in Medicine (REALM (11)), the reading portion of the Shortened Test of Functional Health Literacy in Adults (S-TOFHLA (12)), and the Brief Health Literacy Screen (BHLS (13, 14)), a subjective measure of health literacy. The SNS-3 items were identified using this study sample (15).

2. Patients with kidney disease, half of whom were on dialysis (n=75) and the other half with chronic kidney disease not yet requiring dialysis (n=75) completed the Lipkus numeracy assessment (16), REALM, and BHLS.
3. Primary care (PC) outpatients (n=205) completed the WRAT-3 and REALM(17).
4. Patients at four outpatient hemodialysis units (n=146) completed the WRAT-3, the math and reading portions of the TOFHLA (12, 18), the REALM, and the BHLS.
5. Patients with Type 2 diabetes enrolled from 10 State Health Department clinics (n=318) completed the reading portion of the S-TOFHLA and the 5-item version of the Diabetes Numeracy Test (DNT-5 (19)) as part of a baseline battery for the Partnering to Improve Diabetes Education (PRIDE) study(20).
6. Patients with hypertension admitted to a university hospital in the Health Literacy Screening (HEALS) study (21) (n=460) completed the BHLS and the reading portion of the S-TOFHLA at enrollment.

In a seventh study (Vanderbilt Inpatient Cohort Study, VICS (22)), 2,053 subjects hospitalized for acute coronary syndrome and/or heart failure completed the SNS-3, the BHLS, and STOFHLA.

Surveys were administered by research assistants and completed using pencil/pen and paper in the two kidney disease study cohorts and in the PRIDE study; PRIDE subjects with low health literacy were administered surveys orally by research assistants. In the ED, primary care, HEALS, VICS study cohorts research assistants read the surveys to subjects. Convenience sampling was used for all studies. The SNS-8 (range: 8 – 48) was scored by summing the responses to the eight SNS items after reverse-coding item 7 (“weather”). The SNS-3 (range: 3 – 18) was scored by summing items 1, 4, and 8 from the SNS-8. Internal consistency reliability for the SNS-3 and SNS-8 was computed using Cronbach’s alpha. Spearman’s correlation coefficients were used to calculate all associations between the SNS measures and the other variables. In these secondary analyses, only complete surveys were used. All seven studies received institutional review board approvals, and all subjects gave their informed consent to participate.

Results

Table 1 presents the means, standard deviations and Cronbach’s alphas for the two versions of the SNS among the six study samples. Table 2 presents Spearman’s rank order correlations between the SNS-3 and SNS-8 with other measures of numeracy, measures of health literacy, and education.

Internal Reliability

Cronbach’s alphas for the SNS-3 ranged from 0.67 to 0.86 (median alpha = 0.78) for the seven study samples, including the VICS subjects who completed the SNS-3 as a standalone measure of numeracy, compared to a range of 0.80 to 0.87 (median alpha = 0.83) for the full SNS-8.

Criterion Validity: Correlations with other Measures of Numeracy

The SNS-3 correlated very highly (range: 0.89 to 0.95; median $\rho = 0.91$) with the SNS-8 (Table 2). The SNS-3 also demonstrated statistically significant correlations with the other measures of numeracy, as did the SNS-8, thus providing evidence of criterion-related validity for both versions of the SNS. In the hemodialysis sample, the correlations of the SNS-3 with the WRAT-3 and numeracy portion of the TOFHLA were comparable to correlations for the SNS-8. The same was true for the PRIDE study where the correlations of the SNS-8 and SNS-3 with the DNT were comparable with one another.

Additional Construct Validity: Correlations with Measures of Health Literacy and Education

The SNS-3 demonstrated significant correlations with measures of health literacy and education, with correlations between 0.21 and 0.51, varying by measure of health literacy and study sample (Table 2).

Discussion

Among more than 3,500 patients in seven studies across a variety of healthcare settings, we found the SNS-3 to be an internally reliable and valid measure of subjective numeracy compared to reference measures of numeracy or health literacy. The SNS-3 demonstrated adequate criterion validity, as evidenced by its correlations with four objective measures of numeracy, and construct validity as shown by its consistent pattern of correlations with measures of health literacy and years of education.

Our findings are important because they describe SNS-3 function among a broad range of subjects and settings and include a large study in which the SNS-3 items were administered as a stand alone measure of numeracy, not embedded within the full 8-item version. The SNS-3 may serve a role in large cohorts, advancing our general understanding of self-reported numeracy skills and preference as mediators or moderators in decision making. Future use of the SNS-3 may enable a more comprehensive characterization of the relationships between numeracy and patient, healthcare provider, and clinical practice variables. The SNS-3 could also be integrated into trials examining the efficacy of interventions or decision aids, or it could be used to better characterize patient numeracy preferences and self-reported skills, in large healthcare populations in order to identify and meet the numeracy-related needs of patients.

Given the high internal consistency of the SNS-8, it could be argued that there might be other combinations of three SNS items that would serve as well as those we selected for the SNS-3. In fact, in our initial item analyses among ED patients we saw that two of the items, “shirt” and “tip,” both focused on numeracy skills, behaved equivalently and we could have chosen either one. The SNS-3 includes assessment of self-reported numeracy skills, which may be more closely related to objective measures of numeracy or measures of self-efficacy, as well as numeracy preferences, which may be more closely related to health literacy or communication preferences. Within the wide range of alternative measures of both numeracy and health literacy across the seven included studies, distinguishing whether the

SNS-3 may function better as a measure of numeracy skills versus preference is outside the scope of our analysis.

Internal reliability and validity coefficients for the SNS-3 when administered as a standalone assessment were comparable to that when derived from administration of the SNS-8 in the other six studies, demonstrating that the psychometric characteristics of the shortened scale are not dependent on the other five SNS items. We did, however, note an overall trend to lower internal reliability and slightly lower correlations for the SNS-3 and reference measures of literacy and numeracy, compared to the SNS-8. Researchers should bear these potential tradeoffs in mind when deciding how to best measure numeracy. In addition, future research is needed in order to examine the ability of the SNS-3 to predict health behaviors or outcomes.

Conclusions

The 3-item Subjective Numeracy Scale (SNS-3) correlates very highly with and is nearly as internally consistent as the original 8-item version (SNS-8). In seven distinct patient samples, validity coefficients for the shortened version of the SNS are comparable to those of the longer version.

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Table 1

Means, Standard Deviations, and Cronbach's Alphas for the SNS-8 and SNS-3 Among Seven Study Samples

	SNS-8 Mean (SD) [Alpha]	SNS-3 Mean (SD) [Alpha]
Emergency Department Patients (n=208)	34.58 (8.83) [0.83]	13.50 (3.87) [0.78]
Kidney Disease Patients (n=150)	27.55 (9.19) [0.83]	10.79 (4.04) [0.78]
Primary Care Clinic Patients (n=204)	29.74 (9.37) [0.87]	11.81 (4.20) [0.86]
Hemodialysis Patients (n=143)	27.77 (9.14) [0.84]	10.99 (3.85) [0.78]
Diabetes Clinic Patients (n=318)	25.51 (9.76) [0.83]	9.83 (4.21) [0.76]
Hospitalized Hypertension Patients (n=460)	33.33 (9.23) [0.80]	13.52 (3.76) [0.67]
Hospitalized Cardiovascular Patients (n=2,053)	--	13.21 (4.00) [0.80]

Abbreviation: SNS-8, 8-item Subjective Numeracy Scale; SNS-3, 3-item version of the Subjective Numeracy Scale; SD, standard deviation

Table 2

SNS-3 Cross Validation: Spearman's correlations of the SNS-3 and SNS-8 other measures of numeracy, health literacy, and education

	Emergency Department Patients (n=208)		Kidney Disease Patients (n=150)		Primary Care Clinic Patients (n=205)		Hemodialysis Patients (n=143)		Diabetes Clinic Patients (n=318)		Hospitalized Hypertension Patients (n=460)		Hospitalized Cardiovascular Patients (n=2,053)	
	SNS-8	SNS-3	SNS-8	SNS-3	SNS-8	SNS-3	SNS-8	SNS-3	SNS-8	SNS-3	SNS-8	SNS-3	SNS-8	SNS-3
Reference Standard Numeracy Measures														
WRAT	0.59***	0.59***	--	--	0.59***	0.57***	0.41***	0.39***	--	--	--	--	--	--
TOFHLA math portion	--	--	--	--	--	--	0.30**	0.25**	--	--	--	--	--	--
Diabetes Numeracy Test	--	--	--	--	--	--	--	--	0.44***	0.41***	--	--	--	--
Lipkus	--	--	0.54***	0.56***	--	--	--	--	--	--	--	--	--	--
SNS-8	1	0.89***	1	0.94***	1	0.95***	1	0.89***	1	0.92***	1	0.89***	--	--
Health Literacy Measures														
REALM	0.37***	0.38***	0.42***	0.46***	0.36**	0.33**	0.33***	0.26**	--	--	--	--	--	--
S-TOFHLA	0.40***	0.38***	--	--	--	--	--	--	0.26***	0.24***	0.41***	0.35***	0.27***	0.27***
TOFHLA reading portion	--	--	--	--	--	--	0.27**	0.21**	--	--	--	--	--	--
BHLS	0.40***	0.41***	0.44***	0.48***	--	--	0.49***	0.40***	0.34***	0.30***	0.45***	0.43***	0.35***	0.35***
Education ⁺	0.49***	0.50***	0.40***	0.40***	0.51***	0.48***	0.41***	0.35***	0.45***	0.40***	0.34***	0.31***	0.45***	0.45***

Abbreviations: SNS-3, 3-item version of the Subjective Numeracy Scale; SNS-8, full Subjective Numeracy Scale; PRIDE, Partnering to Improve Diabetes Education study; HEALS, Health Literacy Screening Study; WRAT, Math portion of the Wide Range Achievement Test; REALM, Rapid Estimate of Adult Literacy Measure; TOFHLA, Test of Functional Health Literacy in Adults; S-TOFHLA, short form of the TOFHLA; BHLS, Brief Health Literacy Screen

p < 0.001;

**
p < 0.01;

*
p < 0.05

⁺ Education: Categorized as elementary, middle, high school, college, graduate school in the ED study; otherwise, years of education