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Numeracy and Framing Bias in Epilepsy

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SUMMARY

Patients with epilepsy are frequently confronted with complex treatment decisions. Communicating treatment risks is often difficult because patients may have difficulty with basic statistical concepts (i.e., low numeracy), or might misconceive the statistical information based on the way information is presented, a phenomenon known as “framing bias.” We assessed numeracy and framing bias in 95 adults with chronic epilepsy, and explored cognitive correlates of framing bias. Compared with normal controls, epilepsy patients had significantly poorer performance on the Numeracy scale ($p=0.02$), despite a higher level of education than normal controls ($p<0.001$). Compared with patients with higher numeracy, patients with lower numeracy were significantly more likely to exhibit framing bias. Abstract problem solving performance correlated with the degree of framing bias ($r = 0.631$, $p<.0001$), suggesting a relation between aspects of executive functioning and framing bias. Poor numeracy and susceptibility framing bias place epilepsy patients at risk for uninformed decisions.

Keywords

Epilepsy; Communication; Risk assessment

INTRODUCTION

Patients with epilepsy must frequently make complex treatment decisions that can substantially affect their health status. Many of these decisions are fraught with uncertainties, as various treatment choices have both short- and long-term risks and benefit consequences. For example, deciding whether to have epilepsy surgery entails understanding and weighing the trade-off between possible treatment complications and the potential to become seizure-free.

Risk communication remains challenging. Patients’ understanding of treatment risks and benefits might be inaccurate or incomplete. Numeracy, defined as the ability to comprehend and use numbers, is essential to understanding treatment risks. To compare risks and

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benefits of treatments, patients must be able to assess risk magnitude, compare risk magnitude, and understand decimals, fractions, percentages, and probabilities (1–2).

Another factor that can influence patients' conception of treatment risks and benefits is the way in which information is presented. "Framing bias" is a well established phenomenon, in which preferences for choices change depending on whether the outcomes are described positively or negatively (3). For instance, in studies of healthy persons, people tend to prefer medical interventions with complications described in a gain format over a loss format (4–5), e.g., preferring a procedure described as having a 95% chance of survival over another presented as having a 5% chance of death, even though the risks are identical.

Numeracy and susceptibility to framing bias have not been characterized in individuals with epilepsy, even though epilepsy patients, particularly those who are refractory to pharmacological treatments, frequently encounter complex treatment decisions. Furthermore, aside from two small studies of healthy persons suggesting an association between activation of the prefrontal brain region on functional MRI with decreased susceptibility to framing bias, neuropsychological correlates of susceptibility to framing bias have not been examined to date (6–7). Understanding the neuropsychological correlates of framing bias is particularly important for the epilepsy patient population, which has a high prevalence of cognitive dysfunction (8–9). In this study, we assessed numeracy and susceptibility to framing bias in adult patients with epilepsy in order to: 1) examine their levels of numeracy and framing bias, 2) examine the relation between numeracy and framing bias, and 3) identify potential neuropsychological correlates of framing bias in epilepsy.

We hypothesized that epilepsy patients would exhibit a lower level of numeracy compared with normal controls. We further hypothesized that their degree of susceptibility to framing bias would be related to their numeracy level. Finally, we hypothesized that measures of frontal lobe functions would correlate with the degree of susceptibility to framing bias.

METHODS

Overview

To assess numeracy, we asked patients to answer a previously validated series of questions [Numeracy Scale] (10). For framing bias, we elicited patients' preferences about their current epilepsy health state using a method called the standard reference gamble (11–12), presented in a gain and a loss frame.

Study Participants—Recruitment from the Columbia Epilepsy Center outpatient clinic from August 2007 to December 2008 resulted in a sample of 95 adult patients with chronic epilepsy (Table 1). Inclusion criteria consisted of patients 18 years of age or older with at least 8 years of education and epilepsy duration >1 year, whose seizure and epilepsy types were classified by their treating epileptologist at our center. Patients who could not read English or those with hearing, visual, or cognitive impairment that would impede comprehension of study tasks were excluded. We also excluded patients with chronic medical conditions such as congestive heart failure, chronic angina, end-stage renal disease, or severe asthma requiring hospitalization, which might confound their valuation of their current health state.

All data were obtained at the in-person interview. The Columbia University Medical Center Institutional Review Board approved the study protocol, and all patients signed an informed consent.

For the comparison group, we used normative data from a study of 1,009 persons in the U.S., based on panels of households selected through probabilistic telephone (random-digit dial) survey (13).

Instruments and Outcome Measures

Numeracy Assessment: Numeracy, defined as the ability to comprehend, use, and attach meaning to numbers, was assessed with a previously validated 11-question scale, covering orders of magnitude, probability, converting metrics, and arithmetical computation (10). Questions include open responses and multiple choice questions (see Table 3). This instrument's reliability has been found to range from 0.7 to 0.75 (10). It's validity has been supported by correlations between this scale and health-relevant judgments such as risk perceptions (14). The scale was scored as percent correct.

Assessment of susceptibility to framing bias: To assess susceptibility to framing bias, we asked patients to express, quantitatively, their quality of life given their current epilepsy health state using the standard reference gamble (11–12). The gamble assesses the amount of hypothetical treatment risk they would be willing to accept to be cured of their epilepsy. Susceptibility to framing bias was measured by: 1) framing health outcomes in a negative (mortality) format, and subsequently in a positive (survival) format, and then 2) calculating the risk difference between the two formats. Individuals who are immune to framing bias should provide identical amounts of risk in response to both formats, yielding a risk difference of zero.

To assess susceptibility to framing bias, patients were presented with mortality format first. Patients were asked in an iterative fashion whether they would be willing to undergo a hypothetical procedure to be cured of their epilepsy starting the following day, if 1 out 100 persons died from the procedure, followed by if 99 out 100 persons died from the procedure, and so on, until patients reached a threshold of acceptable risk.

After a respite, during which patients completed a study demographic questionnaire, patients were then presented with survival format. Patients were asked whether they would be willing to undergo a hypothetical procedure to be cured of their epilepsy, for example, if 99 out of 100 persons survived the procedure, followed by if 1 out of 100 persons survived the procedure, and so on, until patients expressed their acceptable threshold risk.

Neuropsychological Assessment: As part of their clinical care, neuropsychological assessment was available for 33 patients. Measures of interest included Full Scale IQ (15), Wisconsin Card Sorting Test (WCST) (16), Stroop interference (17), Trails B (18), Boston Naming Test (19), WAIS III subtests including Vocabulary, Digit Span, Matrix Reasoning, and Block Design (15), California Verbal Learning Test I or II (short and long delayed free recall) (20), WMS-III Visual Reproduction and Face Memory (21), Brief Visual Memory Test (22), and SCL-90-R depression and anxiety subscales (23).

Statistical Analysis—Numeracy scores, expressed as percent correct, were compared with those of normal controls (13). We compared the numeracy performance between epilepsy patients and published normal controls using independent t-test and compared the education level between the two groups using the chi-square test.

Among epilepsy patients, we examined the effect of IQ, educational level, gender, and age using the multivariate ANOVA. We used the Fisher's exact test to compare the degree of susceptibility to framing bias as a function of numeracy level. We tested for relationships between continuous variables with Pearson's correlation and for relationships between continuous and categorical variables with Spearman's correlation. All analyses were conducted with SPSS statistical software, version 18 (Chicago, Il, U.S.A).

RESULTS

Numeracy performance

The 95 epilepsy patients (Table 1) answered 57% (SD, 31%) of the 11 numeracy scale items correctly. This overall performance among epilepsy patients was significantly lower than that of a representative national sample of 1,009 persons surveyed in the U.S. (13), who answered 65% (SD, 32%) of items correctly (p=0.02). To examine whether this was due to differences in self-reported attained education levels achieved between the two groups, we compared their education levels. Epilepsy patients' education level for this sample was significantly higher than that of the national normative sample (68% of epilepsy patients had some college education or higher versus 29% of national normative sample who had some college education or higher, p<.001), suggesting epilepsy patients' performance on numeracy could not be compensated by their high level of education.

Patient characteristics and numeracy performance: Education and IQ

As shown in Table 2, we found a significant effect of education on numeracy performance, but found no effect of gender or age on numeracy performance. Among epilepsy patients, the correlation between numeracy performance and education was significant (Pearson correlation=0.40, p=.002) and between numeracy scale and Full Scale IQ was even stronger (r = 0.75, p<.0001).

Numeracy and Framing bias

After categorizing patients into low or high numerate group based on a median split (median = 7; those with 0–6 items correct versus those with 7–11 items correct), susceptibility to framing bias occurred in 17 of 22 (77%) patients with lower numeracy and in 14 of 33 (42%) patients with higher numeracy (Fisher's exact test p=.014), indicating that epilepsy patients with lower numeracy were significantly more likely to be susceptible to framing bias.

Neuropsychological correlates of framing bias

IQ correlated negatively with the degree of framing bias, with higher IQ being associated with smaller risk difference and hence "protective" (Pearson correlation, −.43, p=.03). Among the neuropsychological performance measures examined, WCST perseverative errors (higher score reflects poorer performance) correlated with the degree of framing bias (r = 0.631, p<.0001) and WCST categories (higher score reflects better performance) correlated negatively with the degree of framing bias (r = −.3999, p=.029), possibly reflecting a relation between certain aspects of executive functioning and framing bias. On the other hand, other neuropsychological measures (such as Trails B, Stroop, and California Verbal Learning Task) did not correlate with framing bias, suggesting that framing bias is not merely a function of general ability level across cognitive domains. No significant correlation was found between measures of mood and the degree of framing bias.

DISCUSSION

Low numeracy was common among this epilepsy patient population, with epilepsy patients obtaining a mean of 57% correct on numeracy testing compared with 65% in a representative national sample of over a thousand people in the U.S (p=0.02) (13) and was not due to lower education level among epilepsy patients. In fact, epilepsy patients in this study were significantly more likely to have college or higher education compared with a

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representative national sample, suggesting that epilepsy patients' relative difficulty with numeracy was not compensated by their self-reported attained education level.

Low numeracy in patients has important implications. Sir William Osler once said "Medicine is a science of uncertainty and an art of probability." For epilepsy patients to make an informed choice, they should have knowledge about the options, the outcomes, and their likelihood, and then integrate their preferences or values for those outcomes. Often medical choices require weighing trade-offs between desirable and adverse outcomes, thus, comprehension of quantitative numerical or at least qualitative estimates becomes essential for optimal patient-centered care. For example, epilepsy patients often make complex decisions such as whether to undergo resective brain surgery, to have an implantable device, or to enroll in an experimental protocol of a new treatment with unknown benefits or risks. Our findings suggest that many epilepsy patients may not understand risk information as typically presented by physicians. For example, 23% of patients in this study did not know which of the following fractions represents the greatest risk (1 in 100, 1 in 1000, and 1 in 10), and 33% could not convert a 10% risk of disease to the number of people that would be affected out of 100 (Table 3).

Our findings confirm that education level correlates with numeracy skill but also suggest that a high education level is not sufficient to obtain a high level of numeracy. Studies have shown that even highly educated individuals such as physicians and medical students sometimes have difficulty understanding numerical risk estimates and are susceptible to misinterpreting numerical risk estimates (24–25).

In addition to numeracy, we also examined the relation between patients' level of numeracy and their susceptibility to framing bias. It is well documented that different presentations of identical risk information can affect patient risk perception and decisions (5,14,26–30). However, a limited number of studies have examined the role of numeracy in framing bias and only among healthy controls. In one such study, primarily college students were presented with exam scores as either the percent correct or incorrect and then asked to rate the quality of hypothetical students. The study found that although both low- and high-numerate college students were susceptible to framing bias, the less numerate students were more susceptible to framing bias (31). Our results confirmed this same directionality among our epilepsy patient group and highlight the importance of presenting numerical information to patients in ways that should minimize framing bias.

Physicians should also be cognizant of other factors that can influence patient decisions. For example, describing anecdotal information about treatments as resulting in clearly positive or negative outcomes (as opposed to ambiguous outcomes), was weighted more heavily than statistical information by normal controls (32).

Little is known about the neuropsychological basis of framing bias. Two recent studies have reported that prefrontal cortex activity as assessed on functional MRI predicted a reduced susceptibility to the framing bias (6–7). We therefore explored whether performance on measures known to assess frontal lobe functioning would correlate with susceptibility to framing bias. We indeed found significant correlations between the degree of framing bias and WCST performance measures, but not with other measures of frontal lobe functioning such as Trails B or Stroop. These findings support divergent validity. WCST assesses problem solving and abstract thinking ability, similar to the task involved in determining whether two numbers framed differently are indeed equal. On the other hand, Trails B measures rapid set switching and Stroop measures response inhibition. Similarly, we found no significant relation between the degree of framing bias and measure of memory performance (i.e., CVLT), which, taken together, suggests that susceptibility to framing bias does not simply reflect general ability level across cognitive domains.

With respect to limitations, our clinical sample included only patients with epilepsy referred to a tertiary care subspecialty practice, limiting the generalizability of our data to other patient populations. Second, only a subgroup of our patient population had a clinical neuropsychological testing, which in turn, might have limited the power to detect small to moderate associations between framing bias and other cognitive variables. Third, although the level of education was higher in our epilepsy population than that of normal controls, the academic quality of education attained in either group is unknown. It is possible that academic quality in the epilepsy patients in this study was poorer than that of the controls, which might have contributed to lower numeracy in epilepsy patients. Lastly, we did not examine other cognitive biases that might impact decisions. Biases such as anchoring bias (tendency to rely too heavily on one piece of information) (33) and familiarity bias (judging events as more important because they are more familiar in memory) (34) can be explored in future studies.

In conclusion, our findings suggest that poor numeracy and framing bias are common among epilepsy patients. Facilitating epilepsy patients' understanding of medical information should be individualized to the numeracy level of the patient. In general, using visual displays during verbal explanation of treatment risks and benefits has been shown to augment patient understanding (35). To minimize framing bias, presentation of risk information should include both positive (gain) and negative (loss) frames, with clear examples that demonstrate equivalence between identical risks presented in both gain and loss frames. Nonetheless, although these methods have been found to be helpful in other populations (36), they remain untested in epilepsy patients. Systems-minded, evidence-based, patient-centered care [as recommended by the Institute of Medicine's Crossing the Quality Chasm (37)] remains a goal for epilepsy patients.

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Table 1

Demographic Data of Epilepsy Patients and Normal Controls

	Epilepsy patients (N=95)	Normal Controls (N=1,009)(13)
Sex		
■ Male	40%	48%
■ Female	60%	52%
Age, y	39.1 (SD 13.6)	¶
Educational Level		
■ Less than high school	4.6%	12.2%
■ High school	27.7%	31.8%
■ Some college	9.2%	26.1%
■ College or higher	58.5%	29.9%
Epilepsy severity in past year*		
■ Very mild	26.1%	-
■ Mild	31.5%	-
■ Moderate	21.7%	-
■ Severe	15.2%	-
■ Very severe	5.4%	-
Seizure Frequency		
■ Seizure free to a seizure every year	29.3%	-
■ A seizure every few month to one seizure every 6 month	19.6%	-
■ Seizure monthly	26.1%	-
■ Seizure daily to weekly	25%	-

*Patients’ subjective severity rating

¶Not available

Table 2

Average Percentage of Correctly Answered Items by Demographic Groups in Epilepsy Patients (N=95)

Demographic characteristics	**% (SD)**
Overall	
Sex (p=.34 by ANOVA)	
▪ Male	62.2 (25.8)
▪ Female	55.8 (34.3)
Categories of education (p=.014)	
▪ Less than high school	39.4 (10.5)
▪ High school	47.5 (36.6)
▪ Some college	54.6 (19.9)
▪ College or higher	72.3 (26.6)
Ages, y (p=.278)	
▪ 17–39	62.6 (31.9)
▪ 40–59	54.6 (30.1)
▪ 60–89	46.6 (30.1)

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Table 3

Performance on Individual Questions on Numeracy Scale among Epilepsy Patients and Normal Controls

	% participants answering correctly among epilepsy patients (N=95)	% participants answering correctly among normal controls (N=1,009)
1) Imagine that we roll a fair, six-sided die 1,000 times. Out of 1,000 rolls, how many times do you think the die would come up even (2, 4, or 6)? ________times	37%	57%
2) In the BIG BUCKS LOTTERY, the chances of winning a $10.00 prize are 1%. What is your best guess about how many people would win a $10.00 prize if 1000 people each buy a single ticket from BIG BUCKS? ________people	59%	58%
3) In the ACME PUBLISHING SWEEPSTAKES, the chance of winning a car is 1 in 1,000. What percent of tickets of ACME PUBLISHING SWEEPSTAKES win a car? ________%	23%	24%
4) Which of the following numbers represents the biggest risk of getting a disease? Choose only one of the following: __ 1 in 100, __ 1 in 1000, __ 1 in 10	77%	75%
5) Which of the following represents the biggest risk of getting a disease? Choose only one of the following __ 1%, __ 10%, __ 5%	87%	83%
6) If Person A's risk of getting a disease is 1% in ten years, and Person B's risk is double that of A's, what is B's risk? ________	75%	---*
7) If the chance of getting a disease is 10%, how many people would be expected to get the disease out of 100? ________people	67%	---*
8) If Person A's chance of getting a disease is 1 in 100 in ten years, and Person B's risk is double that of A, what is B's risk? ________	58%	57%
9) If the chance of getting a disease is 10%, how many people would be expected to get the disease out of 1000? ________people	55%	83%
10) If the chance of getting a disease is 20 out of 100, this would be the same as having a _____% chance of getting the disease.	66%	70%
11) The chance of getting a viral infection is .0005. Out of 10,000 people, about how many of them are expected to get infected? ________people	37%	---*

*Numeracy Scale items used in the study of normal controls (13) was adapted from the original scale by Lipkus et al., 2001, and did not include these questions.