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Utilization of Continuous "Spinners" to Communicate Risk

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Abstract

As patients become more involved in their medical care, they must consider the specific probabilities of both positive and negative outcomes associated with different treatments. Patients who are low in numeracy may be at a disadvantage when making these decisions. This study examines the use of a "spinner" to present probabilistic information compared to a numerical format and icon array. Subjects were asked to imagine they suffered from chronic back pain. Two equally effective medications, each with a different incidence of rare and common side effects were described. One hundred fifty-one subjects were randomized to one of three risk presentation formats: numeric only, numeric with icon arrays or numeric with spinners, and answered questions regarding their risk knowledge, medication preference, and how much they liked the presentation format. Compared to the numeric only format, both the spinner and icon array increased risk knowledge and were rated more likeable by subjects. Subjects viewing the spinner format were also more likely to prefer the pill with the lowest side effect burden.

Introduction

As patients take an increasingly active role in their medical care, they may be asked to weigh the risks and benefits of different options. Examples include deciding on a health plan,

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whether or not to pursue cancer screenings, or choosing between multiple possible treatment modalities.

Previous research suggests that patients who are low in numeracy are at a disadvantage when making these decisions. For example, in one survey of women aged 40–50 years, subjects overestimated the risk that they would die from breast cancer in the next 10 years, with women who were low in numeracy making the largest overestimates (1). Data also demonstrate that subjects who are low in numeracy tend to overestimate the benefits of breast cancer screening (2).

Numeracy also affects risk perceptions related to medications (3). In a study by Peters and colleagues, when risk was presented numerically, only 6% of subjects who were higher in numeracy overestimated the risk of taking a hypothetical cholesterol medication, while 18% of the less numerate subjects overestimated the risk (3). In another study in which patients with rheumatoid arthritis were interviewed regarding their treatment preferences, patients who were lower in subjective numeracy not only rated the risk of treatment more highly than those who were higher in subjective numeracy, but in the case of younger subjects, were more likely to prefer the status quo over starting a new treatment with additional benefits and potential side effects (4).

In order to assist patients who are low in numeracy in their decision-making, research has focused on finding visual aids to help clarify the magnitude of risk. Bar graphs and icon arrays, which use a matrix of discrete icons to represent an at-risk population, have been found to increase risk understanding in subjects who are low in numeracy (5–8). However, some data suggest that icon arrays may not improve understanding in subjects who are low in both numeracy and graphical literacy (9).

Research has shown that children understand probabilities better when presented in a continuous format rather than in discrete segments. Spinillo and colleagues showed that 6-year-olds were more likely to answer proportion problems correctly if the ratio in question was presented as a continuous round pie instead of a pie that was “sliced” into discrete parts (10). Jeong and colleagues presented 6–10 year old children with a “spinner,” a donut shaped figure divided into red and blue regions with an arrow attached to the center, and asked subjects to evaluate the probability that the arrow would land on red if it were spun. Subjects evaluated both “continuous” spinners, in which the red and blue regions were not divided into segments, and “discrete” spinners, in which the colored regions were divided into evenly sized segments. Children struggled with the discrete spinners, while even the youngest children had some success evaluating the continuous spinners (11). This suggests that children evaluate proportional information better when presented in a continuous format, likely because they rely less on counting the number of segments presented and more on an approximate judgement of proportion.

Given these data, we hypothesized that presenting risk in a continuous format may benefit adults who are low in numeracy, especially in those who may have difficulty evaluating the discrete icons presented in an icon array. We sought to examine the effect of adding a

continuous spinner versus an icon array to numerical information on risk understanding and medication selection.

Methods

This study was submitted to the Yale Human Subjects Committee and was determined to be exempt. Subjects were approached while in the waiting room of a primary care clinic affiliated with a large academic medical center. The two research assistants approached patients consecutively. All subjects were at least 18 years old, able to read English, and provided oral consent before participating. Subjects were asked to imagine that they had suffered from uncontrolled chronic back pain for the last 2 months. Two equally effective medications, each with a serious but rare side effect (pneumonia requiring hospitalization for a week), and a common side effect (nausea/vomiting) were described. Pill A had a slightly higher pneumonia risk (0.6% vs. 0.2%), but a lower nausea/vomiting risk (10% vs. 20%) compared to Pill B. Subjects were randomized to one of three risk presentation formats: numeric only (frequencies and percentages), numeric with icon arrays, or numeric with spinners (Figure 1). The survey was primarily self-guided, but research assistants did describe the scenario and point out how risks would be presented. For the spinner arm, research assistants administering the survey briefly held up a spinner that could actually be spun "like in a board game", but when answering the scenario questions subjects only dealt with spinner representations.

Comparative knowledge was measured by asking subjects three questions: 1) which pill had greater risk of stomach upset, 2) which pill had a greater risk of hospitalization, and 3) which pill had the greatest risk of having any side effect. A comparative knowledge score was calculated as the sum of correct answers. Subjects also indicated their preferred pill and rated how much they liked the format on a 7-point Likert scale. Subjects then completed an objective numeracy assessment (Numeracy Understanding in Medicine Instrument Short Form (12)) and demographic questionnaire. ANOVA and chi-squared analyses were used to compare groups, and multivariate linear and logistic regression were used to assess adjusted differences between groups. Multivariate models included study condition, numeracy, age, gender, education, race and ethnicity. Additional models that included interactions between format and numeracy and between format and education were also evaluated.

Results

One hundred fifty-one subjects were enrolled. Subject demographics, by risk presentation format, are presented in Table 1. Overall, just over half had a high school education or less. Minority subjects were well represented. Numeracy scores ranged from 1–8 on an 8 point scale, with the majority of patients scoring between 4 and 6. There were no statically significant differences in demographic characteristics between the three groups. The unadjusted group differences in comparative knowledge score, pill preference, and format likeability are presented in Table 2.

The results of the multivariate regressions are presented in Table 3. In the multivariate model for comparative knowledge scores, subjects in the icon array and spinner groups both

achieved significantly higher scores than the numbers only group, with subjects receiving icon arrays answering on average an additional 0.33 questions correctly and subjects receiving spinners answering an additional 0.54 questions correctly compared to the numbers only group. In an adjusted logistic regression model, subjects shown icon arrays were no more likely to prefer Pill A than were subjects that were shown numbers only, while those shown spinners were 3.96 times as likely to prefer Pill A than those who were shown numbers only. Subjects in the icon array and spinner groups rated the likability of the risk presentation significantly higher than those who received numbers only, with subjects receiving icon arrays rating the likability 0.62 points higher than the numbers only group, and subjects receiving spinners rating the likeability 0.91 points higher than the subjects receiving numbers only.

The interaction between format and numeracy was non-significant for comparative knowledge score ($p = 0.524$), preference for Pill A ($p=0.629$), and format likability ($p = 0.517$). The interaction between format and education, which was split into subjects who had a high school education or less and those with at least some college, was nonsignificant for comparative knowledge score ($p = 0.185$), preference for Pill A ($p= 0.096$) and format likability ($p = 0.972$).

Discussion

To our knowledge, this is the first study to use a “spinner” format to facilitate understanding of risk for decisions made in a health-care setting. Compared to the numeric only format, both spinners and icon arrays promoted risk knowledge. These formats were rated more likeable by subjects as well. Most interestingly, the spinner influenced preference for Pill A compared to the numeric only format. While treatment preferences depend on individual judgements of harms and benefits, Pill A, which was associated with a much lower risk of the common side effect at the price of a slightly increased risk of the rare side effect, can be considered the safer choice. These results are consistent with findings in young children (11, 13) and demonstrate that probabilistic information presented in a continuous spinner format may promote improved understanding of risk magnitude by enabling subjects to approximate overall probability without counting or other numerical skills. This finding may be consistent with the fuzzy-trace theory of dual processing, as the spinner format may encourage respondents to understand the “gist” of the communication, rather than the “verbatim” representation (13). Interestingly, contrary to our expectation, numeracy did not modify the associations between risk presentation format and knowledge, suggesting that the spinner format promoted understanding in subjects of all numeracy levels. Limitations to this study were its relatively small size, its convenience sample, and its hypothetical scenario. The spinner group was the only one to have a physical representation of probability (the example spinner), however subjects appeared to already be familiar with this type of device. Future research will need to test for interactions in larger sample sizes, replicate these results in other settings and explore the use of spinners to improve risk communication for patients facing difficult medical decisions.

Conclusion

The use of continuous spinners presents a new approach for communicating risk to patients that may increase a subject's decision-making ability.

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References

1. Black WC, Nease RF, Tosteson AN. Perceptions of breast cancer risk and screening effectiveness in women younger than 50 years of age. Journal of the National Cancer Institute. 1995; 87:720–31. [PubMed: 7563149]
2. Schwartz LM, Woloshin S, Black WC, Welch HG. The role of numeracy in understanding the benefit of screening mammography. Annals of internal medicine. 1997; 127:966–72. [PubMed: 9412301]
3. Peters E, Hart PS, Tusler M, Fraenkel L. Numbers matter to informed patient choices a randomized design across age and numeracy levels. Medical Decision Making. 2014; 34:430–42. DOI: 10.1177/0272989X13511705 [PubMed: 24246563]
4. Fraenkel L, Cunningham M, Peters E. Subjective numeracy and preference to stay with the status quo. Medical Decision Making. 2014 0272989X14532531.
5. Galesic M, Garcia-Retamero R, Gigerenzer G. Using icon arrays to communicate medical risks: overcoming low numeracy. Health Psychology. 2009; 28:210–6. DOI: 10.1037/a0014474 [PubMed: 19290713]
6. Fagerlin A, Ubel PA, Smith DM, Zikmund-Fisher BJ. Making numbers matter: present and future research in risk communication. American Journal of Health Behavior. 2007; 31:S47–S56. DOI: 10.5555/ajhb.2007.31.supp.S47 [PubMed: 17931136]
7. Lipkus IM, Hollands J. The visual communication of risk. Journal of the National Cancer Institute Monographs. 1998:149–63.
8. Peters E, Hibbard J, Slovic P, Dieckmann N. Numeracy skill and the communication, comprehension, and use of risk-benefit information. Health Affairs. 2007; 26:741–8. DOI: 10.1377/hlthaff.26.3.741 [PubMed: 17485752]
9. Garcia-Retamero R, Galesic M. Who proficts from visual aids: Overcoming challenges in people's understanding of risks. Social science & medicine. 2010; 70:1019–25. DOI: 10.1016/j.socscimed.2009.11.031 [PubMed: 20116159]
10. Spinillo AG, Bryant PE. Proportional reasoning in young children: Part-part comparisons about continuous and discontinuous quantity. Mathematical Cognition. 1999; 5:181–97.
11. Jeong Y, Levine SC, Huttenlocher J. The development of proportional reasoning: Effect of continuous versus discrete quantities. Journal of Cognition and Development. 2007; 8:237–56.
12. Schapira MM, Walker CM, Miller T, Fletcher KE, Ganschow PS, Jacobs EA, et al. Development and validation of the numeracy understanding in medicine instrument short form. Journal of health communication. 2014; 19:240–53. [PubMed: 25315596]
13. Reyna VF. A theory of medical decision making and health: fuzzy trace theory. Medical Decision Making. 2008

A.

B.

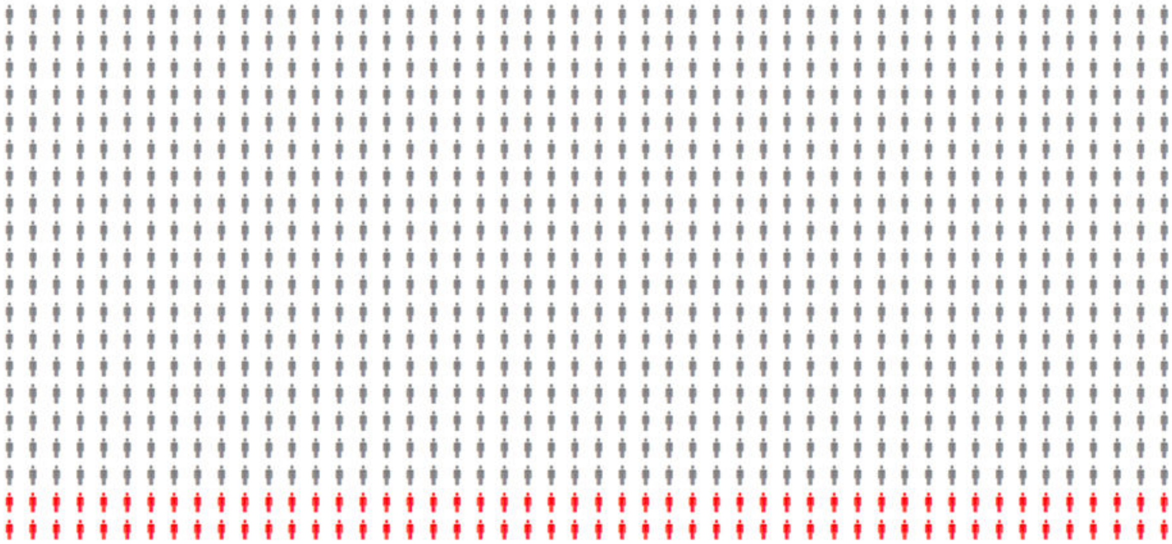

Figure 1.

A. Example of Spinner Format

Pill A can cause stomach upset and nausea in 10% of people (100 per 1000).

This is a spinner like you might see in a board game or casino. People who get stomach upset and nausea are in red. People who do not get stomach upset are in white.

B. Example of Icon Array

Pill A can cause stomach upset and nausea in 10% of people (100 per 1000).

This is a picture of 1000 people. People who get stomach upset and nausea are in red. People who do not get stomach upset are in gray.

Table 1

Subject Demographics

	Total (N=151)	Numbers Only (n=51)	Icon Arrays (n=51)	Spinners (n=49)	Chi-square or F	*P* value
Female, No.(%)	83 (56.4)	27 (54.0)	30 (60.0)	26 (55.3)	0.40	0.818
Race, No.(%)					2.98	0.562
White	46 (32.2)	13 (26.5)	15 (31.3)	18 (39.1)		
Black	50 (35.0)	16 (32.7)	18 (37.5)	16 (34.8)		
Other	47 (32.9)	20 (40.8)	15 (31.3)	12 (26.1)		
Hispanic, No.(%)	42 (28.8)	17 (34.0)	8 (16.3)	17 (36.2)	5.63	0.060
Age, y, mean (SD)	41.7 (15.3)	40.1 (13.9)	43.8 (15.6)	41.2 (16.6)	0.76	0.472
Education, No.(%)					6.98	0.137
High school or less	74 (51.0)	30 (58.8)	20 (40.8)	24 (53.3)		
Some college	50 (34.5)	17 (33.3)	17 (34.7)	16 (35.6)		
College degree	21 (14.5)	4 (7.8)	12 (24.5)	5 (11.1)		
Numeracy, mean (SD)	4.8 (1.53)	4.9 (1.61)	4.9 (1.36)	4.8 (1.62)	0.15	0.865

Table 2

Unadjusted Group Differences in Comparative Knowledge Score, Pill Preference, and Format Likeability

	Numeric (n=51)	Icon Arrays (n=51)	Spinners (n=49)
Comparative knowledge score, mean (SD)	1.96 (0.87)[a]	2.49 (0.83)[a]	2.24 (0.90)
Subjects preferring Pill A, No. (%)	23 (46.0)	27 (52.9)	31 (66.0)
Format likeability, mean (SD)	5.41 (1.44)[b]	5.86 (1.54)	6.13 (1.21)[b]

[a]Statistically significant difference ($p < 0.05$) between numeric group and icon arrays.

[b]Statistically significant difference ($p < 0.05$)between numeric group and spinners.

Table 3

Results from Multivariate Regressions

	Comparative Knowledge Score		Preference for Pill A		Format Likability	
	b	**95% CI**	**OR**	**95%CI**	**b**	**95% CI**
Intercept	1.47	(0.74 – 2.19)	0.76*	(0.09 – 6.35)	4.79	(3.51 – 6.07)
Format						
Numbers	REF		REF		REF	
Spinner	0.54	(0.21 – 0.87)	3.96	(1.48 – 10.60)	0.91	(0.34 – 1.48)
Icon array	0.33	(0.01 – 0.66)	1.56	(0.64 – 3.83)	0.62	(0.05 – 1.19)
Numeracy score	0.14	(0.05 – 0.23)	0.94	(0.73 – 1.23)	0.09	(−0.07 – 0.24)
Age	−0.004	(−0.013 – 0.005)	1.02	(0.99 – 1.04)	0.004	(−0.01 – 0.02)
Male	−0.23	(−0.50 – 0.04)	1.74	(0.79 – 3.80)	0.16	(−0.32 – 0.63)
Education						
High school or less	REF		REF		REF	
Some college	0.21	(−0.09 – 0.50)	1.01	(0.43 – 2.36)	−0.06	(−0.57 – 0.46)
College graduate	−0.23	(−0.63 – 0.17)	0.34	(0.11 – 1.08)	−0.62	(−1.32 – 0.08)
Race						
White	REF		REF		REF	
Black	−0.08	(−0.41 – 0.26)	0.61	(0.24 – 1.61)	−0.42	(−1.00 – 0.16)
Other	0.11	(−0.27 – 0.49)	0.42	(0.14 – 1.23)	0.54	(−0.12 – 1.19)
Hispanic	0.15	(−0.21 – 0.52)	0.90	(0.32 – 2.33)	−0.43	(−1.07 – 0.20)

* OR represents the baseline odds of preferring Pill A.