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Probability Numeracy: Measurement and Applications

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Very brief summary

Aim

A battery of probabilistic questions are used to provide insights into people's probability numeracy.

The paper

- presents a model to compute a probability numeracy index
- identifies groups of people who have low probability numeracy
- relates probability numeracy to anomalies in answers to subjective probability questions (such as relative high frequency of 50% answers).
- provides suggestions how to improve questionnaires.
- analyses the role of probability numeracy in the predictive power of subjective expectations for actual outcomes.

Overall: a well-crafted paper. It delivers a lot of useful insights.

Probability numeracy score

A battery of probabilistic questions are used to construct a probability numeracy score using a sophisticated statistical model.

- A very nice contribution from an academic viewpoint.
- For practitioners:
  - it makes it possible to identify that four basic probability numeracy questions might suffice (as interview time is costly).
  - As it is one variable: easier to analyze PN determinants.
- Correlations between a naïve score (average number of correct answers) & sophisticated scores/indices (complicated model) are very high: >0.9.
  - What about the correlation with a PCA based index? (based on the 4 basic or all 13 PN questions)
  - For practitioners: is it worthwhile to calculate the sophisticated numeracy score?

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Why do people incorrectly answer probability questions?

The answer to this question is important since,

- if they truly don't understand, they make suboptimal life deicions
- if it is for other reasons (survey fatigue, e.g.), they may do well in real life.

Suggestions (if one really likes to know):

- An intensive laboratory experiment. Provide people with the time to read and think, monitor the way they look at a question (do they look at the relevant information) and how much time they need, ask what is difficult and why. In Humanities this is done for financial literacy and pension knowledge (in NL). Compensate people for their time.
- Internet survey: tailor it to respondents' needs. Perhaps some prefer more frequent but shorter questionnaires, and/or interview time tailored on probability numeracy (in a previous wave), hence give low-numeracy or lower educated people more time to complete "hard" survey questions (or step-wise). With compensation for their time.

Two findings/implications (there are more)

1. It is suggested that people understand conditional probabilities better than joint probabilities. If this is true, it has important implications for survey questions; e.g. the question about the probability to retire before the age of 65, could be made conditional on being in good health.

2. Research that uses subjective probabilistic expectations to predict actual outcomes, should interact this expectation with a probability numeracy score. It has been shown this interaction is significant.

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1. Joint versus conditional probabilities

Q11 (conditional/autocorrelation question)

Suppose that the chance of a sunny day is 80%. Also suppose that a sunny day is more likely to be followed by another sunny day. If it is a sunny day, what **is** the percent chance that tomorrow will also be sunny? **(later on “can be”; p.24 vs p.39)**

Is this an open-answer question? Or categories including <80%, 80%, >80%?

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1. Joint vs. conditional probabilities

Conclusion/Suggestion: It is easier for people to work with conditional probabilities than with joint probabilities. (P.10 & conclusions)

This suggestion is based on Q9 & Q12 (rain in Paris and town of residence), which is the special case of independent events.Cond.Prob Q12 was also considered a “medium” & joint-prob Q9 a “hard” question (needed to multiply probabilities; 0.5x0.5=0.25). An increase in correct answering 0.136->0.644.

For dependent events: Q8 vs Q11, the increase is from 0.151 -> 0.377. But Q11 is arguably also not a very hard question (compared to Q8), as it does not require a computation (Q8 does, see note below).

Note: for Q8 one as to figure out a lower bound of 0.5x0.5=0.25 when independent, and an upper bound of 0.5x1 when totally dependent.

(Q8: if rain today, more likely it rains tomorrow, chance rainy day is 50%; what is the chance of two rainy days in a row?). Table 3: answers are “random”.

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1. Joint vs. conditional probabilities

The difference in improvements is important, as it is about dependent versus independent events: 0.151 -> 0.377 versus 0.136 -> 0.644.

Hence, conditional probabilities are easier (an empirical fact), and as concluded in the paper, but, not mentioned, in particular if it relates to independent events. And this is worrisome.

One may as well conclude that dependent events are difficult to deal with, also when asked in a conditional probability format.

It would be interesting to experiment with conditional probability questions in the ALS, e.g. with the retirement/work & health questions, and see if they yield reasonable joint probabilities and if the implied marginal probability is equal to the elicited marginal probability.

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2. Interaction expectation with probability numeracy (PN) score.

Conclusion: expectations are stronger related to actual behaviour for people with high than for for people with low probabiity numeracy. (because high PN people provide more accurate answers). Table 10: expectation/realisation – job loss within a year

- What has been done with response anomalies (rounding; focal point 50%)? (I understand it is just one probability)
- More descriptive statistics would be appreciated on, e.g,
    - raw distribution of the probabilities/expectations,
    - distribution by level of probability numeracy (quintiles),
    - a comparison with job-loss distribution (0-1).

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2. Interaction expectation with probability numeracy score.

More or less: it is the 5th quintile PN versus the lower quintiles. It is argued that this latter group has less accurate expectations.

Why are some expectations less accurate?

a) Table 7, response anomalies (rounding; focal point 50%, etc.). In real life they may have realistic expectations but they just do not know how to report on these (low PN). If so, are there models that may use PN to correct expectations for response anomalies?
b) They are, e.g., overly optimistic (perhaps correlated with PN). They know how to answer probabilistic questions. Then an interaction with PN is perhaps not they way forward as it gives less weight to low PN expectations and somehow forces a certain explanation/justification.