Accepted Manuscript

Asking for frequencies rather than percentages increases the validity of subjective probability measures: Evidence from subjective life expectancy

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PII: S0165-1765(19)30125-9
DOI: https://doi.org/10.1016/j.econlet.2019.04.001
Reference: ECOLET 8418

To appear in: *Economics Letters*

Received date : 20 February 2019
Revised date : 1 April 2019
Accepted date : 3 April 2019

Please cite this article as: Comerford DA (2019) Asking for frequencies rather than percentages increases the validity of subjective probability measures: Evidence from subjective life expectancy . *Economics Letters*, 180, pp. 33-35, https://doi.org/10.1016/j.econlet.2019.04.001

***Highlights (for review)**

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1. Tests a novel procedure to elicit subjective life expectancy.
2. The novel frequency procedure elicits a conceptually precise measure along a point estimate procedure.
3. Finds that the frequency procedure is less vulnerable to a framing effect than a percentage procedure.
4. Finds that the frequency procedure is more sensitive to age than a percentage procedure.

Asking for Frequencies rather than Percentages Increases the Validity of Subjective Probability Measures: Evidence from Subjective Life Expectancy

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Abstract: Survey measures of subjective expectations manifest anomalies in how people report percentages. The current research finds that frequency-based measures deliver more valid subjective probabilities of living to a given age than do questions that elicit a percentage chance.

JEL Codes: D15, D84, D91

Keywords: Expectations; Subjective Probabilities; Survival expectations; Numeracy

Word Count: 1,989

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1. Introduction

Behaviour is informed by subjective expectations. Despite the importance of accurately eliciting subjective expectations, there is a lack of consensus on the most suitable approach. In the domain of life expectancy elicitation, for instance, the Health and Retirement Survey (HRS) and the English Longitudinal Study of Aging (ELSA) use a percentage procedure that asks people to estimate the percentage chance that they will be alive at a given age whereas the Survey of Consumer Finances and the Health and Aging in Scotland survey (HAGIS) ask respondents for a point estimate of how long they will live. This difference in approach has consequences: studies that have compared the life expectancies implied by these two procedures find a large and systematic divergence (Wu, Stevens and Thorp, 2015; Comerford and Robinson, 2017).

Each of the point-estimate procedure and the percentage procedure has its disadvantages. The point-estimate procedure is conceptually ambiguous: it could be eliciting a mode, median, mean or something else (Douglas, Comerford and Bell, 2018). Numerical probabilities are conceptually precise but, in practice, survey questions that ask people to report percentages deliver noisy and biased responses. For instance, many respondents report 50% to indicate that they have no idea of the correct probability (Fischhoff and Bruine de Bruin, 1999). This "50% blip" in responses to life expectancy questions led the HRS survey administrators to add a follow-up question to determine what respondents actually meant by answering "50%". In 2006, 23 percent of respondents reported their probability of living to 75 as 50%. Just 37 percent of those went on to report that it was as likely as not that they would live to 75 (Hurd, 2009).

The contribution of the current research is to offer evidence on the validity of a novel approach to eliciting life expectancy. I ask people for a frequency measure of their likelihood of being alive at age 75. Experiments show that laypeople make more normative judgments when presented with statistical information as a frequency (e.g. 1 in 100) than when presented with the same information as a percentage (e.g. 1%). With the frequency format, people are less likely to neglect base rates and their judgments more closely approximate Bayesian reasoning (e.g. Gigerenzer & Hoffrage, 2005). I predict that the frequency procedure will deliver more valid measures of life expectancy than the percentage procedure, while also avoiding the conceptual ambiguity of the point-estimate procedure.

To assess the validity of the frequency format, I compare it against the percentage procedure for sensitivity to *a)* a framing effect that should not predict life expectancy and *b)* a respondent characteristic that would be expected to predict life expectancy, age.

Before introducing the study, let me clarify how the framing effect and respondents' age relate to the current research. The framing effect is that subjective life expectancy tends to be years shorter when respondents are asked about the percentage chance they will be dead by age *x* than when asked about the percentage chance of being alive at age *x* (Payne et al., 2013). Difficulties with reporting percentages appear to be a cause of this effect because the effect reduces in magnitude and reverses direction when subjective life expectancies are elicited by a point-estimate procedure i.e. *what age will you* [*live to /die at?*] (Comerford and Robinson, 2017). A valid elicitation procedure should attenuate this live-to / die-by framing effect.

Respondents' age should predict their subjective life expectancy because objective life expectancy at birth increased in the US by 0.19 years each year between 1950 (current age: 68) and 2000 (current age: 18) (National Vital Statistics Report, 2002). If the respondents in my study, 98 percent of whom are aged between 18 and 68, are sensitive to this increase in life expectancy then we would expect to see a negative coefficient on respondents' current age in our subjective life expectancy measure.

In summary, if the frequency procedure is less sensitive to the framing effect and more sensitive to age than the percentage procedure, then the frequency procedure looks to be eliciting more meaningful measures of life expectancy than the percentage procedure.

2. Study

I manipulate whether respondents are asked the chance that they will live to age 75 or die by age 75. In an orthogonal manipulation, I vary whether respondents are asked to report a percentage chance or a frequency.

2.1. Methods

I recruited 566 US-based respondents on Amazon Mechanical Turk on February 18th 2019. To insure that my respondents were attentive, I included an instructional manipulation check at the beginning of the survey (Oppenheimer, Meyvis and Davidenko, 2009) and 104 respondents who failed this attention check were routed out of the survey, leaving 462 respondents (67 percent female, mean age = 39, age range: 18 - 87).

The survey opened with the following text:

This is a question to elicit your estimate of how likely it is that you will still be alive by a given age.

This sort of question is asked in certain surveys to estimate people's decisions and behaviors around health, retirement etc.

Immediately beneath this text respondents saw one of the questions presented in Table 1. There then followed some questions on macroeconomic trends for a separate study. The survey closed by eliciting age, gender and five numeracy questions related to percentages (Weller et al., 2013).

Table 1: Question wordings by condition

Condition	Question wording
Percentage cond. live-to	Taking into account genes, habits, preferences, health history etc., the percentage chance that I will live to be 75 years old or older is ...
Percentage cond. die-by	Taking into account genes, habits, preferences, health history etc., the percentage chance that I will die at 75 years old or younger is ...
Frequency cond. live-to	Imagine 100 people who are absolutely identical to you right now – they have the same genes, habits, preferences, health history etc. Of those 100, how many will live to be 75 years old or older?
Frequency cond. die-by	Imagine 100 people who are absolutely identical to you right now – they have the same genes, habits, preferences, health history etc. Of those 100, how many will die at 75 years old or younger?

2.2. Results

I subtracted the raw responses made in the die-by conditions from 100 to deliver subjective probabilities of being alive at age 75. Subjective probability of being alive at age 75 is the dependent measure in all analyses reported below.

Figure 1 graphs this dependent variable by condition. Each condition should show an equal likelihood of being alive at age 75 because the randomization process did not result in any observable differences across the live-to/ die-by conditions in terms of age, gender or numeracy (all ps > 0.30).

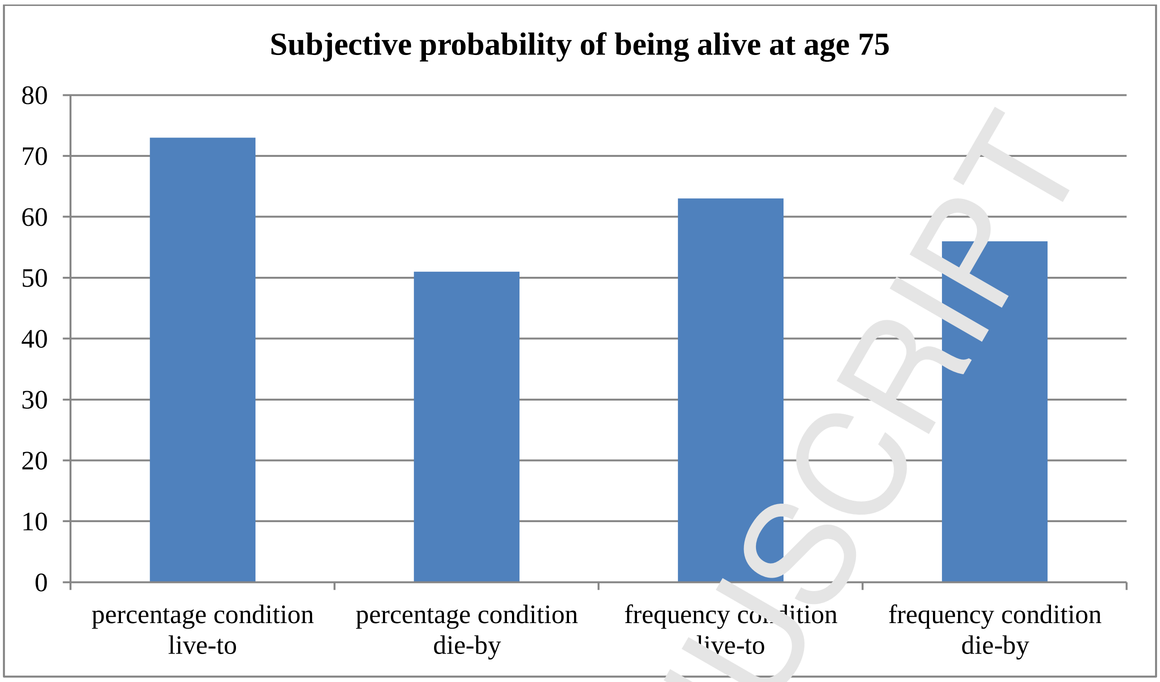

Figure 1: Subjective Probability of Being Alive at Age 75

Figure 1 shows a live-to / die-by framing effect consistent with that reported in Payne et al. (2013): the live-to frame had a significant positive effect in the percentage condition (*b* = 22, *t* = 6.85, $p < .001$) and also had a significant, though smaller, effect in the frequency condition (*b* = 7, *t* = 2.18, *p* = .031). This live-to/ die-by framing effect was attenuated by the frequency condition. An OLS regression shows that, after controlling for age, gender, numeracy and main effects of the live-to frame and the percentage change procedure, the interaction of the live-to condition and the percentage condition is positive and statistically significant (*t* = 3.34, *p* = .001, see Table 2, Model 1).

This result is not explained by a difference across procedures in the likelihood of responding "50"; the two procedures performed similarly in this respect (frequency procedure: 16%; percentage procedure: 15%; *z* = .45, *p* = .651).

In the percentage condition, a regression that controls for the live-to frame and gender finds that the coefficient on age is of the wrong sign; those born earlier, who mortality tables predict will die younger, estimated a higher probability of living to 75 than those born later (model 2: $b = 0.172$, $t = 1.52$, $p = .129$). In the frequency condition, an analogous regression finds the expected sign (model 3: $b = -.110$, $t = .92$, $p = .359$). Model 4 of Table 2 assesses whether respondents' age is a stronger negative predictor of probability of living to 75 in the frequency condition than in the percentage condition. The independent variable of interest is the *Age*percentage condition* interaction, which shows that age is significantly less negative a predictor in the percentage condition than in the frequency condition (model 4: $b = .287$, $t = 1.73$, one-sided $p = .042$).

Table 2: OLS regressions of Self-reported Probability of Living to 75

	Model 1	Model 2	Model 3	Model 4
Percentage condition	-5.383			-9.233
	(3.159)			(6.862)
Live-to condition	7.245*	22.411	7.323	14.884**
	(3.180)	(3.181)**	(3.184)*	(2.273)
Percentage cond*live-to cond	**15.006****			
	(4.498)			
Age	0.040	**0.172**	**-0.110**	-0.123
	(0.082)	**(0.113)**	**(0.120)**	(0.121)
Gender	1.927	-0.782	4.425	1.888
	(2.308)	(3.447)	(3.256)	(2.390)
Numeracy	1.664*	1.384	1.817	1.649*
	(0.694)	(0.990)	(0.973)	(0.701)
Age*Percentage condition				**0.287**[a]
				(0.166)
Constant	46.514**	47.570**	41.094**	48.973**
	(5.755)	(7.717)	(8.246)	(6.591)
R^2	0.12	0.05	0.19	0.10
N	459	230	229	459

Notes: coefficients highlighted in bold are those referred to in the text.
* $p < .05$, ** $p < .01$, [a] $p < .05$ in one-sided test

Discussion

Previous research suggests that researchers face a trade-off when choosing how to elicit subjective expectations: they can either use a percentage chance procedure that respondents struggle to answer but that asks about a conceptually precise measure; or else they can use a point-estimate procedure that is easier for the respondent to answer but is less conceptually meaningful (Douglas, Comerford and Bell, 2018). The current research suggested that eliciting a frequency might offer the best of both options – a question that respondents can meaningfully answer and that delivers an unambiguous numerical estimate for construction of a full probability distribution. In support of this suggestion, I found that the frequency elicitation procedure yielded estimates of life expectancy that were less sensitive to a framing effect and were more sensitive to an objective predictor of life expectancy than did the widely-used percentage chance procedure. These results are consistent with evidence that laypeople better approximate Bayesian reasoning when working with frequencies than when working with percentages (Gigerenzer & Hoffrage, 2005).

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