

Being approximately correct and being precisely wrong

1. Refer to the descriptions of the SMOG index, the Fry method, the Flesch Reading Ease, and the Flesch-Kincaid Grade Level, for measuring **readability** (under Resources for Measurement/Surveys).¹

For the article or text you have chosen (as per discussion in class), randomly select three separate 100 word passages, and use this *set of three passages* to measure the readability (F_1) using the Fry graph. Rather than do so manually, you can use the SMOG calculator to determine the average number of sentences and syllables per hundred words. Repeat the readability measurement (F_2) with a second *different* set of three passages. Repeat once more (F_3), using a *third set*.

Using these same three sets, calculate the SMOG index, the Flesch Reading Ease, and the Flesch-Kincaid Grade Level.

For each index, use the 3 estimates to calculate the standard error of measurement, and the coefficient of variation. Comment.

2. Propose a method to assess the *validity* of a readability index.
3. [m-s] Derive the link between the standard error of measurement and the (intraclass correlation) reliability coefficient [last line, column 1, p. 7 of notes on “Quantifying Reliability” in Notes on Psychometrics for students in rehabilitation sciences in Resources for Measurement/Surveys. *Hint: it’s simply a matter of using the definition of R.*
4. [m-s] Exercise in section 3: Relationship between test-retest correlation and ICC(X) [In notes on Effect of Errors in X and Y on measured correlation and slope]

¹ToneCheck (<http://tonecheck.com/>) is another interesting tool. See story at <http://www.montrealgazette.com/search/search.html?q=ToneCheck>

5. [m-s] Exercise section 4: Relationship between correlation(X, X') and ICC(X) [ibid.]
6. Francis Galton (1822-1911) found that the correlation between (*self-reported*) **parental** and (adult) **offspring heights** was strongest for the one between father and son [0.396 ± 0.024], and weakest for the one between mother and daughter [0.284 ± 0.028]. Given the way he obtained the measurements, can you imagine why this was? ²
[It was 0.302 ± 0.027 for mother & son; 0.360 ± 0.026 for father & daughter.]

	Father	Mother	Sons in order of height	Daughters in order of height.
1	18.5	7.0	13.2	9.2, 9.0, 9.0
2	15.5	6.5	13.5, 12.5	5.5, 5.5
3	15.0	about 4.0	11.0	8.0
4	15.0	4.0	10.5, 8.5	7.0, 4.5, 3.0
5	15.0	1.5	12.0, 9.0, 8.0	6.5, 2.5, 2.5
6	14.0	8.0		9.5
7	14.0	3.0	16.5, 14.0, 13.0, 13.0	10.5, 4.0
8	14.0	6.5		10.5, 8.0, 6.0
9	14.5	6.0		6.0
10	14.0	5.5		5.5
11	14.0	2.0	14.0, 10.0	8.0, 7.0, 7.0, 6.0, 3.5, 3.0
12	14.0	1.0		5.0
13	13.0	7.0	11.0	2.0
14	13.0	7.0	8.0, 7.0	
15	13.0	6.5	11.0, 10.5	6.7
16	15.0	about 5.0	12.0, 10.5, 10.2, 10.2, 9.2	8.7, 6.5, 4.5, 3.5
17	13.0	4.5	14.0, 13.0, 11.5, 2.5	6.5, 2.3
18	13.6	4.0		6.0, 4.5, 4.0
19	13.2	3.0		2.7
20	12.7	9.0	13.2, 13.0, 12.7	10.0, 9.0, 8.5, 8.0, 6.0
21	12.0	8.0	13.0	3.5, 2.0
22	12.0	abt 7.0	13.0, 11.0	7.0
23	12.0	5.0	14.2, 10.5, 9.5	6.0, 5.5, 5.0, 5.0
24	12.0	5.5		5.5

Family heights: Page 1/8 of notebook in Galton Papers : see “Galton’s family data on human stature” – the link is on the left hand side of JH’s home page.

²After you have thought about it for a while, and looked carefully at Galton’s Notebook, you might wish to compare your answer with that given by Karl Pearson: Cf. “Why Galton got different parent-offspring correlations in heights and he (KP) got a larger ones” in the ‘Measurement – Lecture Notes, etc’ section of the bios601 resources page for Measurement.

7. **Bridging the physical- and the psycho-metric:** The notes on “Increasing Reliability by averaging several measurements” on the right hand column of page 4 of JH’s notes on Quantifying Reliability give the formula for the so-called “Stepped-Up Reliability”. In psychometrics (where the number of items on a test serves as the “several measurements”) this formula serves as the basis for the “Spearman-Brown prediction formula”.³ [m-s] Invert the formula on p.4 to derive the one on the right hand column of p.1 for Spearman-Brown prediction formula relating the reliability of two versions of a test, one with N times more items than the other.
8. You are trying to estimate, from **imperfect observations** of F and C , the values of the two coefficients B_0 and B_1 in the temperature relation $F = B_0 + B_1 \times C$.

For each of the following situations, and using the true values of $B_0 = 32$ and $B_1 = 9/5 = 1.8$, simulate⁴ 1000 datasets & investigate the behaviour of the 1000 estimates, b_0 and b_1 , of B_0 and B_1 . In each simulation, use samples of size $n = 4$, with temperatures of $C = 14, 16, 18$ and 20 .

- (a) C measured perfectly, F measured with $\epsilon_F \sim \text{Gaussian}(\mu = 0, \sigma_{\epsilon_F} = 1)$ errors that are independent of F . Check – formally, using a test (or CI) based on the mean of the 1000 estimates – for evidence of bias in b_1 . Also check whether the empirical variance of b_1 agrees with that given by the theoretical formula, namely

$$\text{Var}(b_1) = \sigma_{\epsilon_F}^2 / \sum (x - \bar{x})^2.$$

- (b) F measured perfectly, C measured with $\epsilon_C \sim \text{Gaussian}(\mu = 0, \sigma_{\epsilon_C} = 1)$ errors that are independent of C [*Classical type* error: someone else chose situations when C was indeed exactly 14, 16, etc, but didn’t tell you what C was, and instead asked you to independently record C using your own imperfect instrument, and to use *your* recordings of C in your estimation of the equation]. Again, formally test for evidence of bias in b_1 .

Do your findings line up with the predictions in the Notes? If the patterns are difficult to see, you might change the number of simulations, the sizes of the errors, the range of C or the sample size.⁵

³http://en.wikipedia.org/wiki/Spearman-Brown_prediction_formula .

⁴If new to simulations, see “Computer code to simulate datasets with measurement error” at the bottom of the Resources webpage for measurement/surveys. It gives some ‘starter’ computer code, which you can modify to suit.

⁵The article by Hutcheon et al. “Random measurement error and **regression dilution bias**”, under ‘**r e p r i n t s**’ on JH’s home page, tries to explain these patterns intuitively.

9. Before we study how well we can digitize survival curves, here is an **exercise on communicating what the curves are meant to convey** and the context in which they were generated.

Refer to the article “Associations between C-reactive protein, coronary artery calcium, and cardiovascular events: implications for the JUPITER population from MESA, a population-based cohort study”, available in the Resources link opposite ‘Applications’ in bios601. We digitized the lowermost (green) curve in Figure 2A of that article.

- (a) Read the Abstract and study the Figures in the article. Then, write, *in your own words*, a short news item of 250 words or so (2-3 minutes or so on radio) for your local newspaper and radio station, where you moonlight as a health reporter. In your piece address (i) the rationale for the study (ii) the principal findings and (iii) the implications of these findings. Also suggest a headline for your story. [You might want to study some health reports to see how they are structured.. the order may not be the (i)-(iii) order listed above. An interesting but slightly more highbrow website devoted to science reporting in general is <http://www.sciencedaily.com/>. The websites
... <http://www.cnn.com/HEALTH/>,
... <http://www.nytimes.com/pages/health/index.html>,
... <http://www.bbc.co.uk/news/health/> and
... <http://www.cbc.ca/news/health/>
are also worth consulting, and indeed monitoring.]
- (b) A 65-year old relative of yours reads your story, looks on the internet and finds that a test that measures coronary artery calcium is available in a private clinic in Montreal, and phones you to ask if it would be worth being tested and getting her “score”. What would you say to this relative?

10. Errors in digitization

Refer to the duplicate readings you made of the Kaplan-Meier survival curve in the study entitled “Associations between C-reactive protein, coronary artery calcium, and cardiovascular events: implications for the JUPITER population from MESA, a population-based cohort study” available in the Resources link opposite ‘Applications’ in bios601

For now, ignore the point-wise measures of precision, i.e., the standard errors and confidence intervals, that often accompany such curves. These are (decreasing) functions of the numbers of subjects and the numbers of ‘events’; we will cover their calculation later in the term. For now, focus only on the loss of precision as a result of your digitization.

Focus on your two measurements of each of the reported y -year risks, where $y = 1, 2, 3, 4, 5, 6, 7$:

$$y\text{-year CHD risk} = 100 \times (1 - \text{proportion free of CHD at year } y)\%$$

- (a) From your two measurements at each of the 7 timepoints, obtain a 7d.f. estimate of the ‘standard error of measurement’. Do so using a ‘canned’ statistical routine and also ‘from scratch’ in R

Write out the statistical model that you used to obtain this, and list any assumptions it makes.

- (b) The estimate in (a) is an estimate of the ‘within’ observer variation. In order to estimate the ‘*between*’-observer variation, what is the *minimal* information you would need from each of you co-observers? (since JH has access to all of them, he will supply each of them once you email him with your specific request: he can supply the full raw data that could be then put into a canned statistical routine, but he would prefer that you do the calculations ‘from scratch’ in R).

Again, write out the statistical model that you used to obtain this, and list any assumptions it makes.

- (c) Here the ‘objects’ to be measured were 7 very specific (fixed) timepoints. Assume for the sake of this exercise that the 7 objects were 7 randomly selected human subjects and that we were interested in calculating an intra-class correlation coefficient to serve as a reliability measure. Carry out the ICC calculation. Restrict your attention to years 1-5 and recalculate the new ICC. Comment on why the ICC becomes smaller.

11. **Bernoulli Error?** A not-discovered-for-almost-300-years error in Bernoulli’s book? Or a not-discovered-for-almost-7-years error by A.W.F. Edwards. *Which is it?*

In his ‘Ars conjectandi three hundred years on’ article this summer in Significance Magazine, Cambridge University Professor Edwards tells us that, a few years ago, he was reviewing Sylla’s English translation of (Jacob) Bernoulli’s book. He worked through one of the expectation problems, and came up with a different answer than Bernoulli. In early June of 2013, a week before the Edwards item was published in Significance, Julian Champkin, the magazine Editor, and a journalist by profession, used this ‘300-year-old error’ in the ‘trailer/teaser’ for the upcoming piece, and his question ‘Can you correct it?’ generated a number of responses on the Significance website.

In the bios601 resources for surveys and measurement, at the bottom of the Webpage, JH has collected together in one .pdf file the item by Champkin, some of the original Bernoulli text in Latin, the full article by Edwards, the Edwards review of the Sylla translation into English, and Sylla’s translation of Bernoulli’s treatment of the problem.

The question arises as to whether it is the probabilities that are incorrect, or the expectation based on them, or whether it is Edwards who is incorrect.

What is your answer? [Remember that Edwards had studied Bernoulli earlier, when writing his book on Pascal’s triangle, and had found an error, that had been reproduced over the centuries in different books, in a table of Bernoulli numbers. So might Bernoulli (or the printers) had been a little bit careless?]

12. Imprecision in recording event times

The Introduction to a recent (2013) journal article “Driving under the (Cellular) Influence” by Saurabh Bhargava and Vikram S. Pathania of Carnegie Mellon University begins:

Does talking on a cell phone while driving increase your risk of a crash? The popular belief is that it does – a recent New York Times/CBS News survey found that 80 percent of Americans believe that cell phone use should be banned. This belief is echoed by recent research. Over the last few years, more than 125 published studies have examined the impact of driver cell phone use on vehicular crashes. In an influential paper published in the New England Journal of Medicine, Redelmeier and Tibshirani (1997) – henceforth, RT – concluded that cell phones increase the relative likelihood of a crash by a factor of 4.3. Laboratory and epidemiological studies have further compared the relative crash risk of phone use while driving to that produced by illicit levels of alcohol.

Later, in bios602, you will be introduced to the very clever study design that RT used to arrive at the 4.3.

The 2013 authors then go on to study the topic using a very different but also clever design.

We investigate the causal link between driver cell phone use and crash rates by exploiting a natural experiment induced by the 9pm price discontinuity that characterizes a majority of recent cellular plans. We first document a 7.2 percent jump in driver call likelihood at the 9 pm threshold. Using a prior period as a comparison, we next document no corresponding change in the relative crash rate. Our estimates imply an upper bound in the crash risk odds ratio of 3.0, which rejects the 4.3 asserted by Redelmeier and Tibshirani (1997). Additional panel analyses of cell phone ownership and cellular bans confirm our result.

But while they had very precise data on when cell phones were being used, (see Fig2) the data on crashes were quite messy. To quote the authors:

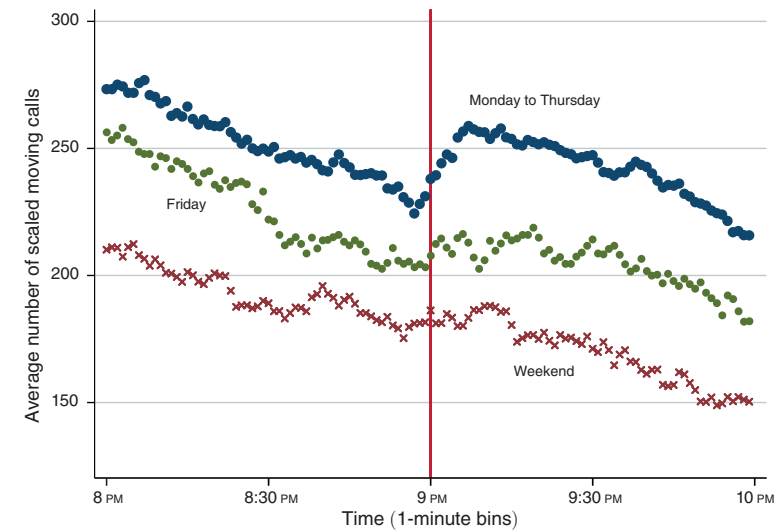


FIGURE 2. CELL PHONE CALL VOLUME FROM MOVING VEHICLES FOR CALIFORNIA FROM 8PM TO 10PM IN 2005

Our analysis principally relies on two sources of crash data. First, the State Data System (SDS) provides data for the universe of reported crashes from 1990 to 2005 for California, Florida, Illinois, Kansas, Maryland, Mississippi, Missouri, Ohio, and Pennsylvania. A well recognized drawback of using a crash database based on self-reports is the presence of substantive periodic *heaping*.

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The trajectory of a crash record helps to illuminate the origins of this bias. Once a vehicular crash is reported, police at the scene document various details of the incident, including the minute of the crash occurrence, and submits the paperwork to one of several possible state agencies. While states vary in the specifics that govern data collection and crash qualification criteria, crash records are ultimately centralized and sent once a year to the NHTSA where they are standardized and maintained.

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Figure 4 illustrates the nature of the heaping in reports that characterizes a representative hour in 2005 across the states in our sample. A close examination indicates that nearly 11 percent of crash reports fall exactly on the hour, 31 percent are on the hour, half hour, or quarter hour, and 61 percent reside in a minute ending in either zero or five.

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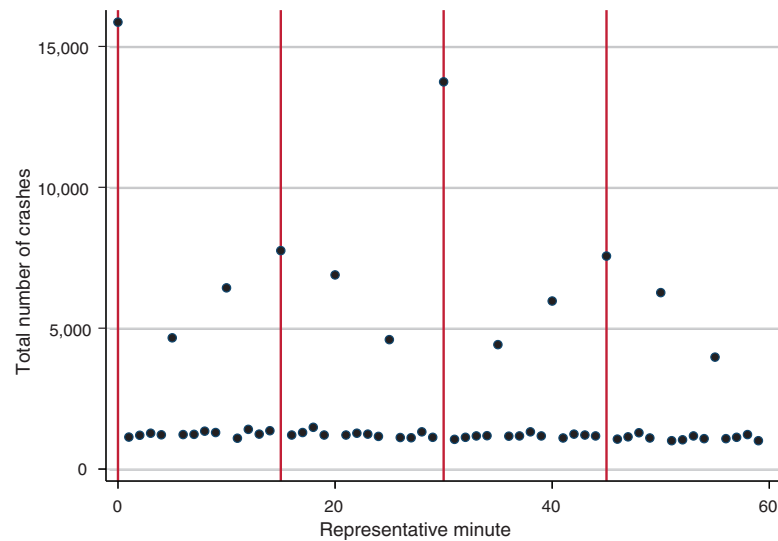


FIGURE 4. PERIODICITY IN SIDS CRASHES ACROSS REPRESENTATIVE HOUR IN 2005 FOR ALL STATES IN SAMPLE

Exercise: In this study, the primary contrast involves crash rates in the 1 hour after and the 1 hour before cellphone calls became “free” at 9 pm. Do you think the heaping errors are an insurmountable problem? If you do, why? If not, suggest ways to deal with them.

XXI. Experiments to determine the Density of the Earth. By Henry Cavendish, Esq. F.R.S. and A.S.

Read June 21, 1798.

MANY years ago, the late Rev. JOHN MICHELL, of this Society, contrived a method of determining the density of the earth, by rendering sensible the attraction of small quantities of matter; but, as he was engaged in other pursuits, he did not complete the apparatus till a short time before his death, and did not live to make any experiments with it. After his death, the apparatus came to the Rev. FRANCIS JOHN HYDE WOLLASTON, Jacksonian Professor at Cambridge, who, not having conveniences for making experiments with it, in the manner he could wish, was so good as to give it to me.

The following Table contains the Result of the Experiments.

Exper.	Mot. weight	Mot. arm	Do. corr.	Time vib.	Do. corr.	Density.
1	m. to +	14,32	13,42	"	-	5,5
	+ to m.	14,1	13,17	14,55	-	5,61
2	m. to +	15,87	14,69	-	-	4,88
	+ to m.	15,45	14,14	14,42	-	5,07
3	+ to m.	15,22	13,56	14,39	-	5,26
	m. to +	14,5	13,28	14,54	-	5,55
4	m. to +	3,1	2,95	-	6,54	5,36
	+ to -	6,18	-	7,1	-	5,29
5	- to +	5,92	-	7,3	-	5,58
	+ to -	5,9	-	7,5	-	5,65
6	- to +	5,98	-	7,5	-	5,57
	m. to -	3,03	2,9	-	-	5,53
7	- to +	5,9	5,71	-	-	5,62
	m. to -	3,15	3,03	7,4	6,57	5,29
8	- to +	6,1	5,9	by mean.	-	5,44
	m. to -	3,13	3,00	-	-	5,34
9	- to +	5,72	5,54	-	-	5,79
	+ to -	6,32	-	6,58	-	5,1
10	+ to -	6,15	-	6,59	-	5,27
11	+ to -	6,07	-	7,1	-	5,39
12	- to +	6,09	-	7,3	-	5,42
	- to +	6,12	-	7,6	-	5,47
13	+ to -	5,97	-	7,7	-	5,63
	- to +	6,27	-	7,6	-	5,34
14	+ to -	6,13	-	7,6	-	5,46
	- to +	6,34	-	7,7	-	5,3
15	- to +	6,1	-	7,16	-	5,75
	- to +	5,78	-	7,2	-	5,68
17	+ to -	5,64	-	7,3	-	5,85

http://en.wikipedia.org/wiki/Cavendish_experiment: in 1798 Cavendish found that the Earth’s density was 5.448 ± 0.033 times that of water (due to a simple arithmetic error, found in 1821, the erroneous value 5.48 ± 0.038 appears in his paper).