Making Statistics Memorable: New Mnemonics and Motivations

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Abstract
This paper aims not to duplicate, but rather summarize and slightly extend the context and 31-example collection of Lesser (2011b), thus providing more on (not moron) mnemonics for teaching statistics.

Key Words: Memory, mnemonic, statistics anxiety

1. Importance

Moore (1992) calls for fewer recipes and more automation of calculation. Statistics is and should be taught as more than memorization and recipes and this does not mean that some automaticity of terms and procedures is unhelpful. What if a few well-chosen mnemonic devices can lower students' anxiety enough to concentrate more attention and time on the conceptual bigger picture or keep up with all aspects of a statistical lecture or complicated analysis in real time?

In a similar spirit, Wu (1999) calls for automaticity in algebra skills to free up mental energy for the more difficult aspects of a problem, in the same spirit that a violinist needs to move beyond having to think about fingering positions. This is perhaps in the same spirit of allowing calculators to help students "concentrate on the more central problem-solving skills" in questions that have aspects beyond computation (Bridgeman, Harvey, and Braswell, 1995, p. 323)

There are limits to our working memory and a teaching activity based on this phenomenon appears in Richardson and Reischman (2011). In times of stress, it may become even harder to access or recall information. This may explain why there are many mnemonics in safety situations in which remembering key information with accuracy and speed can be critical. Examples that can be readily found online include: what colors indicate berries in the wild that may be safe to eat, what color pattern distinguishes the poisonous coral snake from the harmless king snake, how to identify poison ivy, how to identify signs of a stroke, the order of steps to respond to someone not breathing and, if needed, the order of steps for CPR. Stengle (2010) reports that the CPR steps were recently changed by the American Heart Association from ABC to CAB (compressions, airway, breathing).

Students experience major stress or statistics anxiety (e.g., Williams, 2010) that can be a major obstacle to their achievement and positive disposition in the classroom, especially during exams. It is asserted that there is great value in being able to lower this anxiety and allow them to be confident that they will have more of the details they need so that they can be freed up to think about the conceptual bigger picture, as would be recommended by the GAISE guidelines (ASA, 2010).

Lesser (2004) found that his high school students usually remembered the two main formulas for circles (πr^2 and $2\pi r$), but were not confident about identifying which one was which. A logical explanation that *r* had to be squared in a formula to yield square units (i.e., area) did not have as much success with the students as did his writing this jingle for them:

"Take your finger 'round the jar, circumference equals $2\pi r$.
For area, we multiply *r* squared by that number π.
Twinkle, twinkle, you're a star, knowing math will take you far."

A jingle or song perhaps has the greatest number of mnemonic dimensions: rhyme, rhythm, melody, emotion, etc. Many of Lesser's later jingles address statistics content such as "What P-Value Means" (Lesser, 2007) to the tune of "Row, Row, Row Your Boat":

"It is key to know what p-value means.
It's the chance with the null you obtain data that's
at least that extreme"

This and many other statistics songs, raps, and jingles are available at http://www.causeweb.org/resources/fun/, some accompanied by soundfiles.

Lesser (2011c) listed some of the common mnemonics in mathematics (e.g., PEMDAS, FOIL, SOHCAHTOA, right-hand rule, mnemonics for the first few digits of pi, etc.) then asked attendees to raise their hands if they knew more than three mnemonics in statistics. None of the (estimated 100+) attendees did.

2. Classifications and Criteria

2.1 Definition

The word "mnemonic" is derived from the Greek word *mnemonikos* ("of memory"). A mnemonic is an artificial device or technique used to assist memory, and usage of such devices dates back to 477 BCE (Yates, 1966). We consider statistics expressions such as MSE and ANOVA, however, not to be mnemonic devices, but simply abbreviated names. As an aside, Sowey and Petocz (2010) suggest that ANOVA should actually be called ANOSS because it analyzes a sum of squares, not a variance.

2.2 Classifications

As Lesser (2011b) discusses, mnemonics can be classified by form or function. Examples of *form* include letter-based (e.g., HOMES yields the initial letters of the five Great Lakes), image (e.g., right-hand rule for finding the direction of a vector cross-product; the image at http://www.amstat.org/publications/jse/v11n2/martin_figure1.gif helps students reason that the whisker is placed at the furthest observed bone reachable from a quartile by a dog on a "1.5 IQR leash"), and a rhyme or jingle (e.g., "In 1492, Columbus sailed the ocean blue," "i before e, except after c, or when sounding like a in neighbor and weigh", and "when two vowels go walking, the first one does the talking.").

The function of a mnemonic can be classified as *fact* (usually a single fact or definition) or process. Examples of process mnemonics include multiplying binomials (FOIL), opening jars ("rightsy tighty, lefty loosey"), and the steps of CPR. Many process mnemonics in Lesser (2011b) are referred to in Section 3.4 of this paper. Among the fact mnemonics in Lesser (2011b), we note that some recall an individual definition, while others are used to distinguish between two concepts (e.g., population versus sample, permutation versus combination, left-skewed versus right-skewed, null hypothesis versus alternative hypothesis, and Type I versus Type II error).

2.3 Criteria

Lesser (2011b) discussed criteria for effective mnemonics, asserting that they should: (1) not be more complex than the target information, (2) not depend unduly on a particular culture (if not language), and (3) use as many senses, independent dimensions, and interconnected elements as possible.

3. Examples

The 31 examples of Lesser (2011b) are listed roughly in order of when they might be encountered by statistics students. Lesser (2011c) and this proceedings paper do not simply repeat the entire collection in Lesser (2011b), but instead offer a few representative clusters of examples with a few additions for illustrative purposes.

3.1 Mean, Median, and Mode

The strongest examples in Lesser (2011b) included mnemonics to help remember and distinguish mean, median, and mode. This is quite important because these measures are encountered by students in virtually every statistics course (and even in middle school and high school), usually introduced in the same day's lesson. Because the words are so similar to each other and to other everyday words (e.g., see Table 1 in Lesser and Winsor, 2009), it is especially critical to give students tools to keep them straight.

Lesser (2011b) defines the words mode, median, and mean with phrases that form acronyms for those very words: "Most Often-occurring Data Element", "Middle Element Denoted In Ascending Numbers", and "Massed Elements Averaged Numerically".

Lesser (2011b) also provides or describes visual images to help remember mode (ice cream on top of pie), median (middle of a road), and mean (a wordplay image for the balance-point interpretation as well as an image for the leveling value interpretation – both images use a "large N" and a small "ME", reflecting how statisticians value data over personal anecdote! These wordplay images for mean (see Figures 1 and 2 below) are particularly striking and original and are more fully described in Lesser (2011b).

Figure 1: Mnemonic for the 'leveling value' interpretation of the mean (Lesser 2011b); the height of the A's crossbar is the mean of the heights of the four letters: $(.5x + .5x + 2x + x)/4 = x$

Figure 2: Mnemonic for the 'balance point' interpretation of the mean (Lesser 2011b); the position of the fulcrum is roughly the mean of the positions of the M, E, and doubled N: $[(x-2) + (x-1) + 2(x+1)]/4 \approx x$

An attendee at Lesser (2011c) noted that for typical continuous unimodal skewed distributions, the relative positions of mean, median, mode are in an order that is either alphabetical (for left-skewed) or reverse-alphabetical (for right-skewed). Exceptions to this order, however, can occur (e.g., von Hippel, 2005).

3.2 Mnemonics for Formulas and Laws

Mnemonics can even help students recall formulas. Gill (2004) presents Bayes' Law in a stripped-down verbal form that makes its components conceptually explicit:

$$\text{posterior probability} \propto \text{prior probability} \times \text{likelihood function}$$

As Gill explains (p. 56),

> "Renormalizing to a proper form can always be done later, plus, using proportionality is more intuitive and usually reduces the calculation burden. [The formula shows] that the posterior distribution is a compromise between the prior distribution, reflecting research beliefs, and the likelihood function, which is the contribution of the data at hand."

Near the end of Lesser (2011c), Soma Roy of Cal Poly shared this chi-square formula mnemonic that she learned from her University of Delhi teacher Renu Kaul: "Old MacDonald used chi-square: E, I, E, I, O". The chi-square test statistic formula $\sum \frac{(E-O)^2}{E}$ contains two E's (for expected counts), two I's (appearing horizontally as the subtraction sign and vinculum), and an O (for observed count). The exponent is already recalled because it's in the name chi-*squared* and it would be obvious not to swap the O with the E in the denominator.

Another example is using the very word "mnemonic" to recall the pdf formula for the Poisson distribution, $m^n e^{-m}/n!$, as **m**, **n**, **e**, **-m**, **o**ver, **n** with **i c**apsized. Lesser (2011b) cited a 1977 source for this (inadvertently reproducing its typo in the exponent of *e*), but it now appears that there is an earlier published reference to this mnemonic in Greenblatt (1965, p. 123).

3.3 Mnemonics Using Images or Wordplay

In addition to the two image mnemonics for the mean in Lesser (2011b), the image of Figure 1 in Martin (2003) helps students making a box-and-whisker plot reason that the whisker is placed at the most distant bone (i.e., observed data value) reachable from a quartile by a dog on a "1.5 IQR leash."

The company Creative Instruction publishes "Math Graffiti" cards and posters with visual representations or wordplay for various mathematical concepts for display in precollege classrooms. One of their few statistics-related examples is "Negative Correlation" from their "High School Exit Exam" set. The image consists of a scatterplot clustered around the downward-sloping segment of the N in the word Negative.

In Lesser (2011b), there is a mnemonic for the F ratio in an ANOVA test consisting of visual wordplay to reinforce that the numerator is variance *between* samples and the denominator is *within*-sample variance. Here is a slight refinement of that mnemonic, by left-justifying the denominator of the fraction so that the lengths of the numerator and denominator mirror the lengths of the horizontal bars in a capital F:

SAMPLE VARIANCE SAMPLE
SVARIMAPNLCE

3.4 Mnemonics to Trigger a Process

Mnemonics reviewed by Lesser (2011b) in this category include a mnemonic for the steps of hypothesis testing (lest students forget to, for example, check the assumptions of the test), mnemonics to remember to check *all* assumptions of a particular model (binomial, linear regression, etc.), a mnemonic to remember to consider many interpretations (besides causation) of correlation, a mnemonic to help students not stop with just one or two things when summarizing a dataset, a mnemonic to help students think more critically about statistics in the media, and trigger phrases for statistical thinking. The latter comes from the article by Pfannkuch et al. (2010) that was awarded the 2010 *Journal of Statistics Education* Best Paper Award at the 2011 Joint Statistical Meetings. As an aside, it could be interesting to create a mnemonic that suggests a flow chart for choosing among the most common hypothesis tests.

4. Discussion and Future Directions

Lesser and Pearl (2008) discuss emerging experimental evidence (e.g., Garner, 2006) of the ability of pedagogical modalities such as humor to aid recall and retention of statistics content, but there seems to be a dearth of research on the effectiveness of specific mnemonics. Now that collections (e.g., Hunt, 2010, Lesser 2011b) have been catalogued, perhaps such research can now be readily done. One possible sign of the worthiness of such research is that near the end of Lesser (2011c), the 100+ attendees were asked to raise their hands if they saw at least one useful new mnemonic during the 15-minute presentation and the vast majority did.

There have been studies on individual mnemonics, but these have generally had limitations. For example, Lakin et al. (2007) found that students were better at remembering and elaborating on the steps of the scientific method if their instructor discussed the mnemonic acronym (HOMER) more frequently – i.e., as a structure for the entire course rather than just when transitioning from one step of the scientific method to the next. Those authors, however, acknowledge the limitations that students were not randomly assigned to sections of the course and there were two different instructors as well. VanVoorhis (2002) sang mnemonic statistics jingles in one section and read definitions of the same terms in another section she taught. The section that was sung to performed better on test items (related to the content of the definitions/jingles) and had a significant correlation between performance and self-rated familiarity with the jingle. While randomization was not used to assign students to the sections, the sections had statistically equivalent GPAs.

It is important to view mnemonics as dynamic and give students the opportunity to request or suggest refinements to increase effectiveness. For example, Schield (2011) discussed how some students more readily embraced his “Take CARE” mnemonic (e.g., in Schield, 2010) when they changed the “A” from “Assembly” to “Assumptions,” for example.

Lesser (2011b) calls for research to gather data on which mnemonics are most effective and what traits of mnemonics are most important to that effectiveness. This may be of even greater interest in particular populations such as students with learning disorders, (e.g., the experiments of Manalo, Bunnell, & Stillman, 2000) or students who are English language learners. After the 31 regular examples, Lesser (2011b) also offers some numerical “landmarks” that are not mnemonics per se, but may similarly serve to help readily navigate the domain, in the sense of the environment metaphor (Greeno, 1991). Finally, we note that there may be some value in constructing memorable datasets with desired properties (e.g., {1, 2, 3, 4, 4, 16} in Lesser, 2011a)

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