METONYMY AS A LENS INTO STUDENT UNDERSTANDING OF SAMPLING DISTRIBUTIONS

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We use metaphor and metonymy on a regular basis in everyday language, but what sorts of metaphors and metonymies materialize as part of students' conceptions of sampling distribution and informal inference in an introductory statistics course? This research aims to answer this question. Student difficulties in understanding ideas of sampling distributions and informal inference are well documented in the literature. Although we know that these ideas are complex and difficult for students, little is known about the ways in which students' language mediates their statistical problem solving activities. Based on semi-structured interviews with undergraduate students in an introductory statistics course, this research explores students' use of metonymy when speaking about distributions, sampling ideas, and statistical inference, allowing us to gain deeper insight into these students' statistical thinking.

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Metaphor and metonymy are both figures of speech which relate two entities, A and B. In a metaphor, B represents A, where A and B live in two different conceptual domains. On the other hand, a metonymy occurs when B represents A and both A and B live in the same conceptual domain. Zandieh and Knapp (2006) give the metonymy example "the suits on Wall Street," where "suits" stand in for the people who work on Wall Street, or more generally, financial corporations. A phrase such as "life is a journey" is a metaphor, where all the entailments of a journey are mapped to the life of a person, but the concept of the life of a person is in a different domain than the concept of journey. Other examples of metonymies are "I just bought a new set of wheels," where "wheels" stands in for the entire car, or "Washington's approval rating is low" where "Washington" stands in for the U.S. government.

Cognitive scientists argue that metonymy and metaphor are more than just figures of speech; they frame the way we make sense of the world. For example, Lakoff and Johnson (1980) argue that the way in which people think and act is fundamentally metonymic and metaphoric in nature. Lakoff and Núñez (2000) reason that metonymy is a "cognitive mechanism that permits general proofs in mathematics" (p. 75). Presmeg (1992; 1998) provides compelling evidence that students use mathematical images in metonymic and metaphoric ways, which are key components in their mathematical development. Metonymies and metaphors have received some attention in mathematics education research, but have not been studied in statistics education. If metonymies and metaphors support structuring human cognition, then they may provide powerful tools for better understanding students' statistical development.

In this study, semi-structured interviews with eleven undergraduate students in introductory statistics courses from two universities were conducted; each interview was comprised of several tasks. Students were first asked to define, compare, and give examples of a population distribution, a sample distribution, and a sampling distribution. Then students were led through several problems that explored ideas of distribution and informal inference. Analysis of the

interviews focused on student use of metonymy when describing statistical concepts or working through problems. The analysis focused on two research questions: (1) What examples of metonymies arise in statistics within the context of distribution, sampling, and informal inference? (2) What insights into students' developing conceptions of distribution can we gain by using metonymy as a lens? Written pre- and post-assessments were also given to students, which will be analyzed in future work.

Two primary metonymies arose from the analysis of student interviews. First, we observed a paradigmatic metonymy in which students use a normal distribution as a prototype for all distributions. For example, seven of the eleven students applied the empirical rule, a property of normal distributions, to a population for which the histogram in front of them displayed a right skewed distribution. Some of these students later added that they would need a normal distribution to apply the empirical rule, but were unable to continue if asked what they would do if the distribution were not normal.

Second, we observed a proper metonymy where students referred to a sampling distribution as a distribution of *samples* (rather than a distribution of *sample statistics*). We found that this "metonymic shortening" was not necessarily a hindrance to students, but if students sincerely believed that a sampling distribution was a compilation of many samples, they had difficulty using sampling distributions for informal statistical inference.

We note that some of the "problematic" uses of metonymy seen in student interviews are similar to the kinds of misunderstandings that could take place in conversational English when metonymies are used and one of the participants in the conversation is not a native English speaker. Statistics is a new language to these students, and instructors fluent in this language should be aware of the types of metonymic devices that may arise in instruction. Future research is required to investigate further metonymies and metaphors that arise in statistics, how these constructs may help or hinder students' statistical development, and ways in which teachers may leverage these ideas in instruction.

References:

Chance, B., DelMas, R., & Garfield, J. (2004). Reasoning about sampling distributions. In D. Ben-Zvi & J. Garfield (Eds.), *The challenge of developing statistical literacy, reasoning, and thinking* (pp. 295–323). Dordrecht, the Netherlands: Kluwer.

Lakoff, G., & Johnson, M. (1980). *Metaphors we live by*. Chicago: The University of Chicago Press.

Lakoff, G., & Núñez, R. (2000). *Where mathematics comes from: How the embodied mind brings mathematics into being*. New York: Basic Books.

Pfannkuch, M. (2005). Probability and statistical inference: How can teachers enable learners to make the connection? In G. A. Jones (Ed.), *Exploring probability in school: Challenges for teaching and learning* (pp. 267–294). New York: Springer.

Presmeg, N. C. (1992). Prototypes, metaphors, metonymies and imaginative rationality in high school mathematics. *Educational Studies in Mathematics*, *23*(6), 595–610.

Presmeg, N. C. (1998). Metaphoric and metonymic signification in mathematics. *Journal of Mathematical Behavior*, *17*(1), 25–32.

Zandieh, M. J., & Knapp, J. (2006). Exploring the role of metonymy in mathematical understanding and reasoning: The concept of derivative as an example. *Journal of Mathematical Behavior*, *25*(1), 1–17.

Zieffler, A., Garfield, J., Alt, S., Dupuis, D., Holleque, K., & Chang, B. (2008).What does research suggest about the teaching and learning of introductory statistics at the college level? A review of the literature. *Journal of Statistics Education*, *16*(2).