

About Seth Roberts

Seth and I became interested in each other's research about thirty-five years ago, when he was a graduate student at Brown. In the years since then we were collaborators and friends. (Each of us has attested to how much we learned from the other.) I followed his work in detail, and as you'll see from my comments below about his scientific accomplishments (from a letter that I wrote in 2004) I admire them greatly. Except for occasional visits, our interchanges were long-distance ones, phone or email. We discussed many topics — from how to make thicker yogurt to the fairest procedure in considering a tenured professor for dismissal. And of course, various aspects of science.

Starting around 1990 we collaborated in some research concerned with inferences from distributions of reaction times to the structure of mental processes, of which I'm proud. The resulting paper appeared in 1993. (Roberts & Sternberg, "The meaning of additive reaction-time effects: Tests of three alternatives".)

Around 2001 we became interested in some remarkable claims made by a celebrated Canadian medical researcher about the effects of a multivitamin and mineral supplement that he had designed and that was marketed by a company led by his daughter. We read and discussed his papers, and became suspicious of his claims. Among our conclusions was that in the case of one paper, not only were the data (published in a journal that he had been editing for about 20 years) fabricated, but so was the author. (Our suspicions were partly based on calculations that persuaded us that the agreement between original and replication was too good to be true.) Some of our concerns were published as letters to the editor of *Nutrition*, and *The Lancet*. Others were described in a 2006 article: Sternberg & Roberts, "Nutritional supplements and infection in the elderly: Why do the findings conflict?" Results included retraction of one of his papers by its editor, discovery of other evidence of his data fabrication and fraud, his departure from his professorship and from Canada, and a three-part TV series about the case by the Canadian Broadcasting Corp.

What follows is extracted from a letter that I wrote in 2004 concerning Seth Roberts and his scientific accomplishments.

#####

I have known Seth Roberts since he was a graduate student in the 1970s, when I became sufficiently intrigued by his multiplicative-factors method to arrange for him to visit the department I headed at Bell Laboratories, Murray Hill [on January 18, 1978]. I and my colleagues were much impressed.

I had many chances to interact with Seth and to hear him interact with others during the Spring quarter of 1979, at Berkeley. I found my exchanges with him to be the most interesting and stimulating I had during that wonderful visit.

Later I asked Seth for comments on a manuscript describing a complicated series of psychophysical studies of timing and time perception by musicians (now published as "Timing by Skilled Musicians" in Diana Deutsch's 1984 *The*

Psychology of Music). Seth pointed out a weakness in a critical argument from observation to inferred process; it indicated a more penetrating understanding of that argument than was shown by any other of a set of sophisticated and far more experienced readers.

In the spring of 1983, when he came east for the N.Y. Academy of Sciences Conference on Timing and Time Perception, I again arranged for him to spend a day at Bell Laboratories, this time to discuss animal timing. Again my colleagues and I were much impressed.

MULTIPLICATIVE FACTORS, I was one of the reviewers of Seth's 1987 paper on "Evidence for distinct serial processes in animals: The multiplicative-factors method." I still believe what I then said: "I consider this to be potentially the most significant paper I have ever reviewed." The article describes and interprets 17 examples of multiplicative effects of experimental factors on response rate in experiments with rats, pigeons, and goldfish, which provide evidence for distinct serial processes (sets of processes such that each can be changed by an experimental factor without changing the other, and such that generating a response requires that a signal be transmitted from each of these processes to the next). The examples suggest and/or support new and old ideas about generalization, attention, timing, learning, motivation, and response production. Most important, Seth shows that the assumption of distinct serial processes that has been used to explain the additive effects of factors on mean reaction time in humans also explains another kind of data — multiplicative effects of factors on response rate in animals — collected under very different conditions. I have been astonished at how little influence this paper has had, and believe that this reflects a deficiency in the field of animal learning and animal behavior.

ANIMAL TIMING. By posing novel questions, conducting simple but ingenious experiments, and using penetrating arguments, Seth has produced a deep, elegant, and persuasive analysis of animal timing, much of which described in his papers of the early 1980s. During that phase of his work on timing, Seth succeeded in demonstrating separate processes that converge in the control of a single behavioral output. His "peak procedure" provides four independent measures of that output, in the sense that each measure can be changed without changing the others. Such data, together with data from his method of multiplicative factors, indicate four distinct processes. This work on temporal information processing in animals substantially leads corresponding work on humans: in terms of the identification of interesting questions and alternative possibilities it is far advanced relative to any work I know of on human timing.

Because we regarded this research program as a model for cognitive science, Don Scarborough and I invited Seth to contribute a chapter to *An Invitation to Cognitive Science, Volume 4* (1998). This is an excerpt from our introduction to his chapter ("The mental representation of time: Uncovering a biological clock"):

"In this chapter, Seth Roberts describes research on the sense of time in an animal, the rat, asking whether a rat might have a sort of clock that it uses in

controlling its behavior. Exploring the rat's abilities in a series of ingenious experiments, Roberts concludes that, indeed, even a rat has a refined sense of time and is able to measure intervals of time as if it had some sort of internal stopwatch. Moreover, Roberts shows that the rat's mental clock shares nine distinct properties with an ordinary stopwatch. Along the way, he discusses what a clock is, and provides us with an analysis of the varieties of nonbiological clocks that we encounter every day. Because of Roberts' research and related investigations we now know more about some aspects of time-keeping in animals than in people, and research of this sort in animals has recently inspired analogous human experiments. Roberts also discusses the general pros and cons of using animals to study cognition, considerations that also apply to the study of insect navigation as discussed by Gallistel in chapter 1."

Seth's approach to animal timing is heavily driven theoretically, with the goal of discovering a set of underlying mechanisms and establishing their properties. I like the fact that he attempts to do this in the context of the weakest (least constraining) auxiliary assumptions; that he tries to make models explicit, thereby bringing out alternative explanations, that he devises new experimental procedures ("peak", "bias") in light of theoretical goals, and that he provides penetrating analyses of the rules of inference that he and others use. The payoff is a brilliant success, in my view. By posing novel questions, conducting simple but ingenious experiments, and using penetrating arguments, Seth has produced a deep, elegant, and, persuasive analysis of animal timing.

Later, Seth used this well-analyzed time discrimination procedure in conjunction with brain lesions to apply a new method of functionally mapping the brain in rats: his goal was to identify the parts of the brain that control each of the behavioral measures, and hence implement the corresponding distinct processes, by observing the effects of lesions on the four independent measures.

For my 2001 paper on "Separate modifiability, mental modules, and the use of pure and composite measures to reveal them" I included ten diverse examples involving behavioral and brain measures from several species. Two of the persuasive examples of dividing a mental mechanism into parts were from Seth's work. And I acknowledged the important influence he had on the ideas in that paper.

Seth's 1998 chapter included discussion of features of the response durations from the peak procedure that he had not reported earlier, when response latencies were the focus of interest. In the 2001 paper with Gharib and Derby ("Timing and the control of variation"), he reported the discovery that these two behavioral measures are independent. The ingenious analysis of response duration in this paper not only provides new information about animal timing (showing that the precision of the rat's clock is much better than had been previously thought) but, probably more important, yields new insights into the control of behavioral variability, fundamental in the understanding of instrumental

learning. The important question of the control of variation is followed up in the forthcoming paper ("Control of variation by reward probability") by Gharib, Gade, and Roberts.

SELF-EXPERIMENTATION. Seth's forthcoming *Behavioral and Brain Sciences* paper ("Self-experimentation as a source of new ideas: Ten examples about sleep, mood, health, and weight") on several projects involving self-experimentation is also extremely impressive. I quote from my review of the manuscript:

"This paper describes a body of ingenious, systematic, and risky research conducted over more than a decade. It is focused on the use of self-experimentation (SE) as a source of new ideas. However, it also demonstrates the use of SE as a means of testing ideas that would be difficult and expensive to test using conventional methods, because the testing involves treatments that radically affect life-style, that must be applied for long periods, and that involve measurements that in some cases would be difficult without a live-in sleep-in laboratory and/or major modifications of a home and/or work environment.

"The domains of research are interesting and important: as the title says, they include sleep quality, mood, level of health, and control of weight. It is true that the research involves just one subject, experimenting on himself, raising issues of generality and bias, and no doubt raising alarms in some readers because of their belief that SE is taboo as a research method. But if further work, suggested by these findings, showed that they were valid and that they applied to even a small fraction of the general population, the payoff in human health and happiness would be very great. And it is not at all clear that such systematic work on these questions would have been attempted, using conventional methods. Indeed, the fact that so many new, interesting, surprising, and potentially important and useful findings could have emerged from this work shows that SE may promote research that is otherwise not done, even though in principal it could be. And one major new finding with these features -- and one that was surprising to the investigator, is the remarkable productivity of SE in answering questions in these domains....

"Overall, I find this paper fascinating, provocative, profoundly original, imaginative, highly controversial, and likely to change some readers' beliefs about how to make progress in behavioral and biological science. It reflects the many years of research and thinking that led up to it, in its refinement of ideas and consideration of their implications...."

HIS BREADTH AND SCIENTIFIC STYLE. Seth's interests in areas of experimental psychology outside his own specialty are broad and deep; His unusual willingness to question the conventional wisdom (to the annoyance of some) and his ability to relate issues, approaches, and methods from different areas appeal enormously to me. Indeed, I would judge him to be the most interesting and original thinker I know.

There are numerous aspects of Seth's scientific style that appeal to me greatly. His self-consciousness about the process of investigation and inference is highly productive: among other benefits it leads to his making arguments explicit and hence available for scrutiny. He succeeds in bringing out assumptions and beliefs that are important, but elsewhere only implicit. (Indeed, in the past, Seth has given me explicit reasons for scientific choices that I made only "intuitively.")

Seth has a knowledge and understanding of some parts of human experimental psychology ("information processing") that is deeper and more penetrating than that of most specialists. He adapts ideas from that area to his, sharpening, elaborating, and explicating them in the process. Thus, his discussions of the additive-factor method of reaction-time analysis are as helpful as any I have seen. Seth is so creative in his adaptations that it would be inappropriate to describe even these as derivative. Indeed, his multiplicative factors method is the most interesting and promising development that I have seen related to the additive-factor method since I described the latter in 1969.

I can make brief comments on other aspects of Seth's work. First, he is unusually sensitive to issues of data analysis, and better informed about modern statistical methods than most experimental psychologists. (See, for example, his 1993 book review "Beneath the sums of squares", the methods used in the two papers on behavioral variation with Gharib, and his 1987 paper on "less-than-expected variability ..".) Second, he thinks deeply about what it means when a model is successfully fitted to data, or when it fails to fit. (See his 2000 paper with Pashler, "How persuasive is a good fit? A comment on theory testing", which has attracted considerable attention.). Third, I like the fact that Seth thinks about the broad implications of his work and that of others.

In short, I regard Seth as brilliant, scholarly, acute, deep, creative, and productive.

#####

My interactions with Seth contributed greatly to the enjoyment of my scientific life. I am deeply grateful for all that he gave me. Hearing about his untimely death (on April 26, 2014), another friend said: "What a tragedy. I am so sorry to hear that. I know he was a dear friend of yours and a kind of intellectual child. And such a brilliant and brave intellect. This must leave a hole in your world." Indeed, it does.

Saul Sternberg
May 2, 2014