Mathematical modeling is more than fitting equations

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The article by Brown, Sokal, and Friedman (December 2013) regarding the Fredrickson and Losada (2005) article discussed the use of differential equations in science and repeated our earlier observation (Luoma, Hämäläinen, & Saarinen, 2008) that there is lack of justification for the use of the Lorenz equations in the latter article. In this comment we want to point out that Brown et al. presented a very narrow view on mathematical modeling in behavioral research. We describe how the conceptual use of mathematical models is essential in many fields.

Fredrickson and Losada (2005) used mathematical modeling to suggest a hypothesis that at least three positive emotional experiences to every negative emotional experience is a bifurcation point separating people who flourish from those who languish. The hypothesis was based on an analysis of Losada’s (1999) model of team interaction, which in turn was based on the famous Lorenz (1963) equations. We (Luoma et al., 2008) had previously pointed out that the “reasoning behind the model equations” (p. 760) and “the predictive validity of the model” (p. 757) is questionable. Brown et al. (2013) addressed these problems again and claimed that the “contains numerous fundamental conceptual and mathematical errors” (p. 801). This is an overstatement, as there are no clear mathematical errors, but the problems lie in the justification of the use of the model in this context, as we had already shown before. Brown et al. based their article on general skepticism toward mathematical modeling in the behavioral sciences. Their set
of requirements for using mathematical modeling, in general, and differential equations, in particular, is too restrictive. The view that models should be used as in physics by fitting equations to empirical data is too narrow. In the behavioral sciences, phenomena are enormously complex. In this context, very few problems can be described by differential equations so that these could be fitted to empirical data successfully. However, we believe that these challenges are a rationale to embrace mathematical modeling, not to discard it.

We argue that mathematical modeling constitutes a useful tool for the behavioral sciences in a more general way. Mathematical modeling constitutes a tool and a language to help in the process of scientific reasoning. Modeling should be considered not only as finding equations to describe the reality but as a process of giving structure to theoretical knowledge and empirical observations. For example, Losada (1999) had strong empirical data about the ratio of positivity and negativity in teams, and thus it was quite natural to try to find a simple mathematical model which could give insight into the possible dynamics of the phenomenon.

There are many examples where mathematical models have helped generate useful insight and even create entirely new fields of research despite the fact that these models have not been fitted to empirical observations. For example, models may be used in a metaphorical way, to ease understanding of a complex phenomenon. Smith and Thelen (2003) used the mathematical theory of nonlinear dynamic systems to understand questions concerning how the human mind emerges during the early years of a child’s life. Very simple mathematical models have been used effectively to aid reasoning about the complex system of evolution. Hamilton (1964) introduced an equation to help understand when genes that promote altruistic behaviors are likely to spread in a population. This “Hamilton’s rule” has been very influential in evolutionary theory. Game-theoretical models have been used extensively to explain individual and group behavior in competitive and cooperative settings. These models have been influential
even though they have not been fitted to empirical observations. Modern economic theory is based on mathematical models with very strong assumptions about human rationality. These assumptions have been the basis of economics despite the known fact that the assumptions are not in agreement with the actual behavior of people.

We argue that researchers should increase, not decrease, the use of models but be sensitive to the way in which they are used. When models are used to facilitate scientific reasoning, the most important issue is not the adequacy of fit with empirical data, but whether the model fits the purpose of the model at hand (see Sterman 2002). Models of psychological phenomena can be contributive even if they contain problematic assumptions. Likewise, we can use mathematical models of social phenomena even if their psychological assumptions are controversial. In a recent article we have shown how psychological phenomena related to communicating about models can lead to unjustified conclusions (Hämäläinen, Luoma & Saarinen 2013). The history of science has shown that even geniuses like Einstein have published results with mistakes (Ohanian, 2008). These are typically fixed later by the authors themselves or the scientific community, usually by presenting new constructive ideas without playing down the professional competence of the original authors.

References


