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Introduction to the 2006 Rumelhart Prize Special Issue Honoring Roger Shepard

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I am extremely humbled by the honor of introducing Roger Shepard, recipient of the 2006 David E. Rumelhart Prize for Contributions to the Theoretical Foundations of Human Cognition. Like so many of my generation of cognitive scientists, along with those of the generations that preceded and followed, I have been greatly inspired and profoundly moved by the power, depth, and sheer beauty of Professor Shepard's work. Throughout his career, Roger Shepard has repeatedly demonstrated that it is possible to conduct research at the highest levels of scientific rigor on the innermost secrets of the human mind and, more remarkable still, that the hidden structure of the mind thereby revealed exhibits a degree of formal elegance and simplicity normally thought to be found only in the fundamental physical sciences.

Cognitive science has emerged as the study of mental representations and mental processes. How can such invisible, abstract representations possibly be characterized with formal precision? Roger Shepard's research on multidimensional scaling provided cognitive science with a mathematical method for exposing the metrical or distance structure of the space of mental representations in a particular cognitive domain, extracting this structure from relative judgments of similarities among elements of that domain. Multidimensional scaling methods have brought to light highly revealing structures in a great many cognitive domains, including such breathtakingly elegant structure as the double helix formed by the mental representation of musical pitch. These methods also led to a stunning discovery concerning the elusive notion of "generalization" among abstract mental representations: Roger Shepard's Universal Law of Generalization, according to which generalization probability falls as an exponential function of mental representational distance. When I recall reading that *Science* article nearly 20 years ago, I still get goosebumps of excitement from the model it provided of a formally exact science of the mind.

Roger Shepard's seminal work has exposed the hidden structure not only of mental representations, but also of mental operations. How can inaccessible, abstract operations on such ephemeral mental objects as mental images possibly be characterized with tight, formal precision? The landmark research of Roger Shepard and his students on the chronometric properties of mental rotations revealed strikingly simple mathematical properties of

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these operations. Subsequent work on such mental operations as computing apparent motion furnished additional compelling evidence of the centrality of mental simulation of relationships in the world—Roger Shepard's "second-order isomorphism," which formally captures how internal relations among mental representations mirror external relations among the entities represented.

Roger Shepard has developed revolutionary, highly influential techniques for formally identifying the hidden structure of mental representations and operations; he has used these techniques to expose the particular mental structures subserving multiple cognitive domains, and he has provided extensive experimental validation of these findings. Even more remarkably, he has repeatedly shown that principles of mental organization can be explained—derived mathematically—from still more fundamental and general principles. In recent years, he has shown how highly general symmetry principles governing the external world, together with general evolutionary principles governing the evolution of cognition, can explain deep facets of cognition ranging from the ubiquity of mental simulation to the crucial role of thought experiments in the most revolutionary discoveries of science.

The singular depth and breadth of Roger Shepard's scientific contributions have long been recognized at the highest levels. He has received many extremely distinguished awards, including election to the American National Academy of Sciences in 1977; he received the National Medal of Science from President Clinton in 1995.

Normally, in a situation like this, the recipient is honored by the prize. But on this occasion, the prize is honored by the recipient.