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In memoriam

In memoriam Patrick Colonel Suppes (1922–2014)

Genius strikes in the strangest places. In the case of Patrick Colonel Suppes (pronounced soup ees) the strike occurred in the oil fields of Oklahoma. Suppes' grandfather and father were oilmen devoted to extracting that valuable commodity from a rough land. Pat was to follow suit. But then genius interfered with the plan. Although his mother passed away when he was only four, his stepmother fostered in him an attitude of self-improvement and the pursuit of intellectual interests. By grade six Pat was identified as an outstanding intellect and entered into a six year experiment of accelerated education. He comments: "In many respects the most competitive and ablest classes I ever attended were those in high school".

His university education began in 1939 at University of Oklahoma, continuing at the University of Chicago where he received a BS degree in Meteorology in 1943. World War II sent him to the South Pacific until 1946. He returned to enter Columbia University as a graduate student in philosophy in 1947. Ernest Nagel's skeptical, patient, and detailed analysis of F.H. Bradley and John Dewey won his attention and respect. Nagel especially guided Pat toward an informal approach to the foundations of physics as a PhD thesis. This "informal" approach developed into an analytical study of the concept of action at a distance in the works of Descartes, Newton, Boscovich, and Kant.

Graduating in 1950 Pat immediately began teaching Philosophy at Stanford University. He comments that his education was hardly over. J.C.C. McKinsey, a logician at Stanford, served as his post-doctoral tutor. McKinsey introduced Suppes to Alfred Tarski's graduate seminar at UC Berkeley. Suppes comments "It was from McKinsey and Tarski that I learned about the axiomatic method and what it means to give a set-theoretical analysis of a subject". McKinsey died in 1953 bringing to an end the collaboration on axiomatic foundations of empirical sciences. About the same time Suppes began work with David Blackwell and Meyer Girshick while they wrote their influential book *Theory of Games and Statistical Decisions* (1954).

By 1954 Suppes was primed to begin the amazing career that followed. His creativity revealed itself in a variety of interests, applications and important theoretical contributions to the foundations of physics, decision theory, foundations of probability and causality, foundations of psychology, and Philosophy and science. These topics are treated by Suppes in exquisite detail with profound ramifications for the empirical studies that characterize these fields. Many developments are revealed in the 32 books and hundreds of articles devoted to creating foundations to support empirical investigations into these intellectual areas. Here I will examine some of the more important papers that illustrate Suppes' capabilities.

The potential for a future of important theoretical contributions suggested by a PhD thesis on the concept of action at a distance was fulfilled in Suppes' papers on foundations of physics, special relativity, entangled particles, quantum mechanics, and measurement. Four early papers on foundations of physics with McKinsey pushed forward the idea of creating axiomatic foundations for classical mechanics in the spirit of modern mathematics rather than the "physical" axiomatics common in physics. The path was not easy. "Axiomatic foundations of classical particle mechanics" authored by McKinsey, Sugar and Suppes in the *Journal of Rational Mechanics and Analysis* (1953) was introduced by this comment from the communicator of the article: "The communicator is in complete disagreement with the view of classical mechanics expressed in this article. ... he hopes that publication of this paper may arouse the interest of students of mechanics and logic alike, thus perhaps leading eventually to a proper solution of this outstanding but neglected problem". A lesser mind might be discouraged but Suppes gained unusual strength in debating these issues. His later papers "Axioms for relativistic kinematics with or without parity" (1959), "Probability concepts in quantum mechanics" (1961), "Existence of hidden variables having only upper probabilities" (1991), and with de Barros, "Diffraction with well-defined photon trajectories: A foundational analysis" (1994), prove the strength and intensity of his continued interest.

During the mid-50's the Center for Advanced Study in the Social Sciences on the Stanford Campus brought distinguished scholars to Stanford to interact with each other and the Stanford faculty. Duncan Luce and Richard Christie visited in 1954–55, and in 1955–56 James Coleman, William Estes, Leon Festinger, Louis Guttman, Gardner Lindzey, Howard Raiffa, Frank Restle, and Patrick Suppes were part of the class of scholars. These interactions stimulated the development of the Institute for Mathematical Studies in the Social Sciences (IMSSS) on the Stanford Campus. Suppes and Kenneth Arrow founded IMSSS which Suppes directed from 1959 to 1992.

IMSSS brought together major talents to pursue formal bases for the Social Sciences. During the academic year IMSSS invited visiting professors, provided support for graduate students and post-doctoral fellows, while continuing to create technical reports, journal articles and books. Suppes' book *An introduction to logic* (dedicated to J.C.C. McKinsey) and Davidson, Suppes and Siegel's book *Decision Making: An Experimental Approach* appeared in 1957. *The Axiomatic Method with Special Reference to Geometry and Physics* by Henkin, Suppes and Tarski and *Mathematical methods in the social sciences* with Arrow and Karlin, containing Suppes' generalization of learning theory to a continuum of responses, appeared in 1959. At the end of this decade's growing development of the application of formal methods to the social sciences Suppes and Richard Atkinson, a new Professor in IMSSS, published *Markov Learning Models for Multiperson Interactions* (1960) and Suppes completed his famous text, *Axiomatic Set Theory* (1960).

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Patrick Suppes (right) and Bill Estes enjoying a humorous comment by Bob Bjork at the 1992 IMSSS reunion at Stanford University's Ventura Hall.
Source: Photo courtesy of Dr. Donald Horst.

This rather amazing production of books was paralleled by an equally impressive number of technical reports and journal articles, certainly enough to occupy an academic's life. However, there were five more decades to go. During the next decades Suppes and Atkinson developed computer assisted instruction, foundations of measurement flourished with the three volume series authored by David Krantz, Duncan Luce, Patrick Suppes, and Amos Tversky; *Foundations of Measurement, Vol. I: Additive and Polynomial Representations* (1971) followed by *Foundations of Measurement, Vol. II: Geometrical, Threshold, and Probabilistic Representations* (1989) and *Foundations of Measurement, Vol. III: Representation, Axiomatization, and Invariance* (1990). Continued development of the application and teaching of Suppes' ideas appeared in Hawley and Suppes' *Geometry for Primary Grades* (1960), Suppes and Hill's *First Course in Mathematical Logic* (1964), and Suppes' *Sets and Numbers* (1966, 1968, 1969).

The 1960's mark the maturation of Suppes' devotion to the development of formal models of psychological processes. Beginning in 1956 at the Center, Suppes collaborated with William Estes on the foundations of Stimulus Sampling Theory, Estes' famous 1950 theory of learning. Estes, who joined the IMSSS faculty, Suppes, and Richard Atkinson began a series of important advances in the application of Markov models to psychological processes. Suppes and Lamperti (1959) wrote on "Chains of infinite order and their application to learning theory". Applications of theoretical ideas appeared in "Modern learning theory and the elementary-school curriculum" (1964), "Stimulus response theory of finite automata" (1969), and "Theory of automata and its application to psychology" (1973). Later in 2012, Suppes, with co-authors de Barros and Oas published "Phase-oscillator computations as neural models of stimulus-response conditioning and response selection". His interest in psychological processes never left him.

Computer assisted instruction (CAI), created with Richard Atkinson, began at IMSSS using a Digital Equipment PDP-1 computer having a memory of 8KB and a word size of 12 bits in 1963. Later, in 1967, Suppes in collaboration with Richard Atkinson created the Computer Curriculum Corporation. In 1967 the International Business Machines Corporation established a partnership with IMSSS, to develop the first comprehensive CAI elementary school curriculum to be implemented on a large scale in schools in both California and Mississippi. New ideas and applications Suppes described in articles such as the 1964 "Modern learning theory and the elementary school curriculum" and in 1966 "The use of computers in education" and later in 1992 "Instructional computers: Past, present and future".

The Suppes' approach to graduate education was revealed by his lectures. A typical 50 minute lecture might occur after landing in San Francisco from New York, helicoptering to Stanford to deliver his lecture and picking up another suitcase of clean clothes before continuing on to Tokyo. His lectures were dramatic. First the topic. Then war raged between Suppes, his weapon of chalk, and the blackboard — a furious attack, chalk splintering, pieces flying here, chalk dust there, his voice asserting the axioms that began to whiten the blackboard. At the end of 50 minutes there remained an elegant display of axioms and theorems written across the entire front of the lecture hall from the several blackboards' upper left hand corners to the lower right hand corners.

This, of course, was a summary because during the lecture proofs were given, and then quickly erased to provide room for new theorems. Fast, deeply structured, but occasionally interrupted when he might suddenly, unexpectedly, swirl toward the class, point to a student and say, "Mr. Link, what is the answer to that question?" Those not so fast paced in their note taking might stumble in their reply. But stumbling was not allowed. These graceful, beautiful, inspiring lectures not only taught graduate students a style, and how to think fast, but remain a most vivid and pleasant memory. Many students, post-doctoral fellows, and faculty appear in a 1967 photo published by the Association for Psychological Science's *Observer* in July 2005.

Suppes received the American Psychological Association's Distinguished Scientific Contribution Award, Columbia University Teachers College Medal for Distinguished Service (1978). He was a President of the Pacific Division, American Philosophical Association (1972–73), the American Educational Research Association

(1973–74), National Academy of Education (1973–77), and International Union of History and Philosophy of Science (1976, 1978). Suppes was elected to the National Academy of Sciences (1978), and the American Philosophical Society (1991). His deep and extensive creation of foundations for so many areas of knowledge and the applications of these ideas earned him the National Medal of Science awarded by President George H.W. Bush in 1990. The award reads:

> For his broad efforts to deepen the theoretical and empirical understanding of four major areas: the measurement of subjective probability and utility in uncertain situations; the development and testing of general learning theory; the semantics and syntax of natural language; and the use of interactive computer programs for instruction.

Patrick Suppes was a gentleman, a vigorous supporter of intellect, and a generous contributor to Stanford University. We can remember him as an excellent teacher, an enthusiastic professor, and a man of genius who inspired the people surrounding him, as well as the lives of many who will follow.

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Note: Suppes' quotes are drawn from published and unpublished versions of his "Intellectual Autobiography".