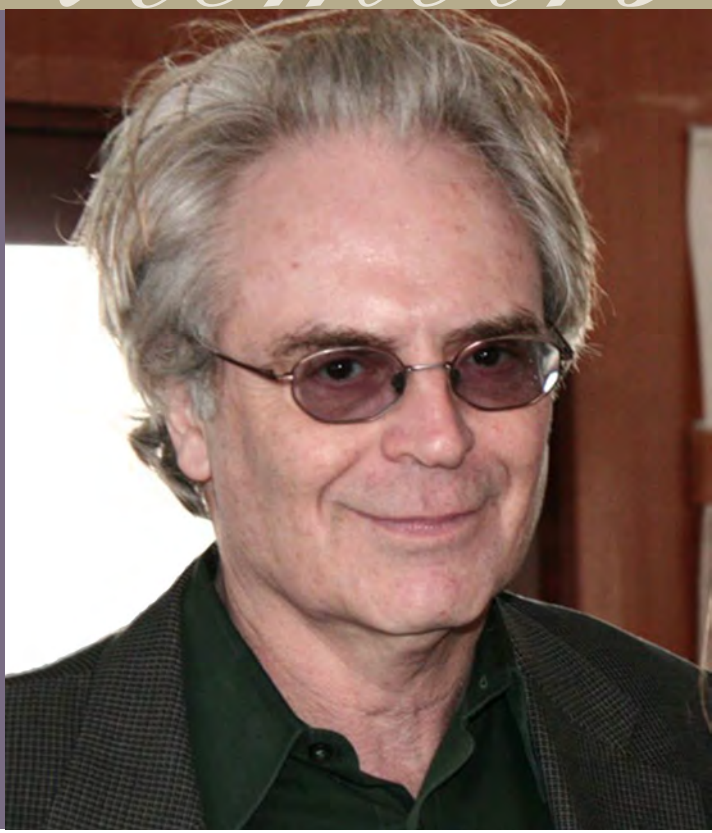
Edward E. Smith

1940–2012

BIOGRAPHICAL *Memoirs*



A Biographical Memoir by
Douglas L. Medin

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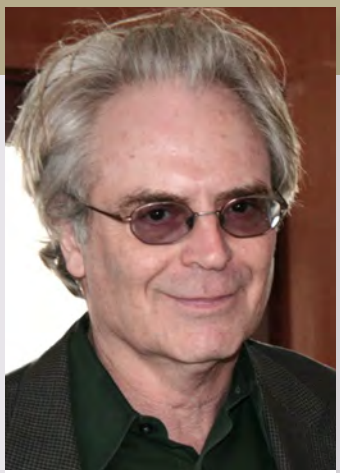
NATIONAL ACADEMY OF SCIENCES

EDWARD E. **SMITH**

April 23, 1940—August 17, 2012

Elected to the NAS, 1996



By Douglas L Medin

Our friend and colleague Edward E. Smith—an extraordinary scholar—passed away on August 17, 2012, at the age of 72. Most recently, he was the William B. Ransford Professor of Psychology at Columbia University as well as the director of the Division of Cognitive Neuroscience at the New York State Psychiatric Institute.

Although Ed's career sadly was cut short, it was nonetheless long and illustrious. He was elected to the American Academy of Arts and Sciences in 1994 and to the National Academy of Sciences in 1996. Moreover, in recognition of his work, Ed was the recipient of the 1999 William James Fellow Award (bestowed by the Association for Psychological Science) and of the 1997 Award for Distinguished Scientific Contributions (given by the American Psychological Association).

Personal and professional history

Ed was born on April 23, 1940, in Brooklyn, New York, of parents who were Jewish immigrants. His father was a tailor and his mother a homemaker. Ed went to Brooklyn College and was initially an English major until his friend Irving Biederman (now a renowned vision scientist) suggested he try psychology. It was a good match. Ed took experimental psychology with Elizabeth Ferher and was impressed by the elegance of the field's approach to the mind.

Ed received his bachelor's degree from Brooklyn College in 1961 and attended graduate school at the University of Michigan, where his fellow graduate students included future leaders in the field such as Irving Biederman, Allan Collins, Bob Crowder, Howard Egeth, and Amos Tversky. Ed's Ph.D. advisors were Paul Fitts and Arthur Melton, the latter stepping in after the former's premature death. At this time cognitive psychology did not exist as an official field, but information processing was in the air and the use of

reaction times to draw inferences about mental processes was undergoing a renaissance. Fitts and Melton created the Human Performance Center with memory and information-processing as its focus.

Just two years after receiving his Ph.D., Ed wrote a major review and analysis of choice reaction time (Smith 1968). He must have been working on this paper when he was a (draft-board inspired) NIMH [National Institute of Mental Health] Research Associate at St. Elizabeth's Hospital, a huge governmental psychiatric hospital in Washington, D.C. But neither did Ed neglect his NIMH job, as he published articles on schizophrenia in the same decade (and returned to the study of schizophrenia almost 40 years later).

The remainder of this biographical memoir will intermingle professional history with professional accomplishments, tracing Ed's career from the University of Wisconsin, to Stanford University, to the company Bolt, Beranek, and Newman (now BBN Technologies), back to the University of Michigan, and then finally to Columbia University.

Professional history and scientific contributions

Ed took his first academic job in 1968 as an assistant professor at the University of Wisconsin. His interest in reaction times almost immediately found a focus when he read Collins and Quillian's 1969 paper on the organization of semantic memory, or knowledge.[1] (This was the same Collins who had been a fellow graduate student at Michigan.) At about the same time, Stanford University offered Ed an assistant professorship, and he moved west in 1970. There he rejoined Amos Tversky and another colleague and friend from graduate school, (now) Barbara Tversky. The Tverskys were visitors at the time but later they both became psychology faculty members at Stanford. Ed had other notable cognitive-area colleagues, Dick Atkinson, Gordon Bower, Herb Clark, Ewart Thomas, and Roger Shepard, as well as developmental colleagues Ellen Markman and Dan Osherson. According to Ed, all of them influenced his thinking and research. According to them, Ed was a mentor as much as a mentee. During his tenure at Stanford, Ed began his studies of semantic memory and conceptual behavior. Ed's work there was notable on two counts and each represented something of a breakthrough.

1 Collins, A. M., and M. R. Quillian. 1969. Retrieval time from semantic memory. *Journal of Verbal Learning and Verbal Behavior* 8:240–247.

In tasks where participants are asked to verify the category membership of different examples, they are much faster to say that a robin is a bird than they are to say that a chicken is a bird. One interpretation of this effect is that robins have many features typical of birds, such as singing, flying, and building nests in trees—properties that chickens lack.

First, Ed began to apply his familiarity with methods and theories of choice reaction time to the emerging field of psycholinguistics and to studies of semantic memory. Psycholinguistics involves the cognitive processes that make it possible to use language—to generate grammatical and meaningful sentences as well as to understand utterances, words, and text. Semantic memory is the part of long-term memory concerned with ideas, concepts, conceptual knowledge, and meanings. What was common to both of these areas was the possibility of using reaction-time measures to obtain insights into the details of language processing and the organization of semantic memory, respectively.

Second, around this time almost all work on concepts was based on laboratory studies of what was then called "concept identification." In these studies researchers created categories according to various rules, and the participant's task was to learn the correct rule or categorization scheme. The primary focus was on the relative difficulty of learning different types of rules (e.g., conjunctive, as in "red and triangular," versus disjunctive, as in "red or triangular" rules); and most theories were based on the idea that participants were testing hypotheses about the rule and that learning occurred when they hit on the correct hypothesis or rule. All examples of a category were equal in the sense that they met the definition of the rule.

Although one can point to concepts that do have definitions and sharp boundaries (e.g., a triangle is a three-sided closed geometric figure for which the sum of interior angles equals 180 degrees), these laboratory studies of concept identification failed to address much of the richness of everyday concepts. Ed, working with then graduate students Ed Shoben and Lance Rips, and along with independent work by Eleanor Rosch and Carolyn Mervis, established the principle that some examples of a category are "better" than others. (Rosch and her then graduate student Mervis were at the University of California, Berkeley, at this time; the cognitive-area scholars of the Berkeley and Stanford departments got together every spring for lively interchanges.)

For example, in tasks where participants are asked to verify the category membership of different examples, they are much faster to say that a robin is a bird than they are to say that a chicken is a bird. One interpretation of this effect is that robins have many features typical of birds, such as singing, flying, and building nests in trees—properties that chickens lack. Even lab studies with artificially created categories demonstrated typicality effects when they employed properties that were not necessary or sufficient for the category but only were "characteristic" of category members.

In 1974, Ed Smith and his students Lance Rips and Ed Shoben (Smith, Shoben, and Rips 1974) published a very influential two-stage model for categorization. According to this model, categorization decisions may be based either on a rapid overall assessmentof how well an example fits into the category (e.g., how similar it is to other category members) or on a slower process using more diagnostic information. For instance, robins could be readily classified as birds based on the initial assessment stage, but examples such as chickens, which are not especially similar to other birds, would require slower, second processing to verify that chickens are birds. This feature-comparison model nicely accounted for goodness-of-example effects and was an instant classic.

This research also raised the possibility that concepts may be represented not in terms of rules or definitions but rather according to characteristic properties. In this view, concepts are organized around "prototypes"—summary representations of what is often true for category members. Classification of examples would be based on similarity to prototypes —roughly speaking, if an example has enough of the usual features of a category then it is assigned to that category. The notion of goodness-of-example or typicality effects has both theoretical and practical implications. With respect to the latter, Cantor, Smith, French, and Messich (1980) applied the notion of prototype categorization to psychiatric diagnosis, suggesting that a quest for sharp category boundaries is futile.

Ed returned to New York City for a sabbatical at Rockefeller University for the 1976–1977 academic year, but his mentoring was not interrupted during this period. He hit it off with Doug Medin, a University of South Dakota Ph.D. working in Rockefeller's William K. Estes lab, and a few years later Ed and Medin published an influential book on models of knowledge representation under the title *Categories and Concepts* (1981). This book reviewed not only prototype models of classification but also so-called exemplar models, which assume that categories are simply represented by examples and that classification decisions are based on similarity to examples rather than similarity to a prototype. One way of distinguishing these two types of models is that a prototype

summary does not preserve information about within-category feature correlations (e.g., large birds are less likely to sing than small birds).

Indeed, Malt and Smith (1984) showed that people are sensitive to correlated properties in natural-object categories. This result suggested that people's decisions are based not on a summary prototype but either on retrieved examples or on multiple prototypes (e.g., one for small birds and one for large birds). Throughout his career Ed Smith continued to explore and assess the properties of alternative categorization theories, collaborating with a range of graduate students and colleagues—perhaps most notably, Daniel Osherson.

The sabbatical year had two clear residual effects. One was that Bill Estes, one of the founders of mathematical psychology, continued to provide Ed with advice and guidance on models of categorization. The other effect was to give Ed the desire to return east. That opportunity came soon: in 1979 he moved to Cambridge, Massachusetts, to join Bolt, Beranek, and Newman (BBN), Inc. as a senior scientist. Together with colleagues there such as Dedre Gentner and Allan Collins, Ed worked on a range of projects that included efforts to train people in thinking skills (see the book *Teaching Thinking* [Nickerson, Perkins, and Smith 1985]). Being on the East Coast also facilitated Ed's collaboration with Dan Osherson.

Another distinctive characteristic of Ed's research is that he did not shy away from challenges. In the case of categories and concepts, he repeatedly emphasized that concepts serve multiple functions. Concepts are used both in deductive and inductive reasoning. They are also used in conceptual combinations—as in adjective-noun conjunctions (e.g., merging the concept of "red" with the concept of "apple" to derive an understanding of "red apple" as an apple with red skin); and in noun-noun combinations (e.g., joining the concept of "conversation" with the concept of "telephone" to understand "telephone conversation" as a discussion by means of a telephone rather than a discussion about telephones). Smith and Osherson (1982; 1984) and Smith et al. (1988) reported some success in using prototype models to predict the typicality of combined adjective-noun concepts, but they also were keenly aware of the model's limitations (e.g., Smith et al, 1988.) Nonetheless, their model did capture an important facet of conceptual combination, one that is rapidly accessible but may be modified by other, more slowly retrieved, information as it becomes accessible.

Similarly, Ed's work on the use of categories in inductive reasoning relied on multiple processes. In these sorts of studies participants might be told that robins and eagles produce some enzyme x and then be asked how likely it is that vultures produce enzyme x or how likely it is that all birds produce this enzyme. The Osherson, Smith, et al. (1990) studies yielded a number of distinct and counterintuitive phenomena that were nicely explained by a two-process model that Smith and Osherson formalized. Around this time, Eldar Shafir became an important addition to this research duo. The empirical and theoretical work associated with the model opened up an important area of research (much of scientific reasoning is inductive reasoning). Not content with this success using abstract and relatively noninformative properties such as "has enzyme x," Smith et al. (1993) extended the work on inductive reasoning to more concrete properties that allowed both reasoning about the categories and the properties. For example, for a statement such as "a poodle can bite through wire" one might wonder about what other kinds of dogs could bite through wire, the wonderer relying not only on the similarity of other dogs to poodles but also on how powerful their jaws might be.

Ed's interest in semantic memory and in concepts and categorization continued throughout his career. Although he made major contributions to our understanding of the role of similarity in categorization and reasoning, he also provided strong evidence for the role of rules (e.g., Smith, Langston, and Nisbett [1992]) and multiple mechanisms of categorization (e.g., Smith, Patalano, and Jonides [1998]).

The University of Michigan still had its pull on Ed, and he left BBN to return there in 1986. Dick Nisbett became an important collaborator and Douglas Medin joined the faculty at Michigan a few years later. Smith and Medin held joint lab meetings together, affectionately called "the Ed and Doug show." But Ed's return to Michigan also marked something of a career shift for him. Ed always liked the challenge of learning new things and in the late 1980s and early 1990s the emerging field of cognitive neuroscience attracted his attention. He not only mastered the new imaging technologies, such as PET and fMRI, remarkably quickly but also, almost as quickly, became a leader in this field. His work included imaging evidence for multiple strategies and mechanisms of categorization (e.g., Smith and Jonides [1999]; Patalano, Smith, Jonides, and Koeppe [2001]; Koenig, Smith, et al. [2004]; and Smith and Grossman [2008]) as well as studies with patient populations bearing on these issues (e.g., Bozoki, Grossman, and Smith [2006]; Koenig, Smith, and Grossman [2006; 2010]; Koenig, Smith et al. [2007]; and Koenig, Smith, et al. [2008].)

Ed's colleague John Jonides became a close collaborator, and their studies of working memory using cognitive-neuroscience tools represent key contributions to our bfield. Working memory—a system used for temporary storage and manipulation of information—is a necessary component of higher cognitive processes. Generally, working memory is divided into two primary functions: the brief storage of information (for a matter of seconds); and "executive processes" that operate on representations, control attention, and coordinate processes in complex tasks that may require inhibition and task switching. Short-term storage and executive processes are mediated in part by the prefrontal cortex, but they are dissociable (Smith and Jonides 1999).

Ed and Jonides used neuroimaging to further establish the brain mechanisms associated with working memory. For example, Smith and Jonides (1998; 1999) reported that verbal working memory is implemented by areas in the left-hemisphere posterior parietal cortex and a subvocal component in left-hemisphere speech areas. This contrasts with spatial working memory, mediated mainly by right-hemisphere regions, including posterior parietal, occipital, and frontal cortex. Importantly, they also demonstrated that the executive function of inhibition is implemented in the left-prefrontal area and that it can be dissociated from verbal storage and rehearsal areas.

These neuroimaging studies also opened up new avenues for research that Smith, Jonides, and their colleagues pursued—e.g., Sylvester et al. (2003); Postle et al. (2004); Marshuetz et al. (2006). This research has also provided insights into our understanding of aging (Smith et al. [2001]; Reuter-Lorenz et al. [2001]), frontal lobe damage (Thompson-Schill et al. 2002), schizophrenia (Barch and Smith 2008), and individual differences in attention (Wager, Jonides, and Smith 2006).

Ed was also involved in work using fMRI to understand placebo effects associated with pain perception (Wager et al. 2004). Because pain perception involves both physiological and psychological components, an enduring question is whether placebos affect a response bias in reported pain versus the experience of pain itself. Previously it had been shown that naloxone, an opiate antagonist, blocks placebo effects, suggesting that pain experience is altered by placebos. However, an alternative interpretation of this finding is that naloxone may offset rather than block placebo analgesia. Here fMRI data proved to be very illuminating. Wager et al. (2004) found that placebo effects were correlated with decreased activity in pain-sensitive brain regions (e.g thalamus, insula, and anterior cingulated cortex). They also observed that anticipation of pain was correlated with activity in the prefrontal cortex (consistent with the idea that anticipation may be related

to opiate system activation). Overall, these studies provide strong support for the idea that placebos affect the experience of pain.

A cognitive-neuroscience bonus for Ed was frequent opportunities to consult with colleagues at New York University and Columbia University. This also laid the groundwork for Ed's third return to the East Coast, when he joined the faculty at Columbia University in 2004. Ed was now home. Walter Mischel, who had been a social-area faculty member at Stanford, became a close friend and colleague; Ed and Jonides continued to work together; and Tor Wager also became a frequent collaborator. And Ed never slowed down.

Broader service and impact

Ed's impact extends far beyond cognitive psychology and cognitive neuroscience. He was a bridge to almost all the other subdisciplines of psychology— social, clinical, personality, developmental, and education— and he collaborated with colleagues in each of these fields. Moreover, his conversance with psycholinguistics, artificial intelligence, and epistemology allowed him to have an impact far beyond psychology. It is no accident that Ed served on the editorial boards of the Harvard University Cognitive Science Series and of the MIT Cognition and Cognition Series, just when the field of cognitive science was developed. He was an editor of the journal *Cognitive Science* almost from the time of its inception, and he later was elected as a fellow of the Cognitive Science Society. He served on the boards of many professional organizations, including the Association for Psychological Science, and overall his service record was outstanding. He served as chair of the governing boards of both the Psychonomic Society and the Cognitive Science Society. As a National Academy of Sciences member he served on several study committees.

This biography can only begin to hint at Ed Smith the person and scholar. Ed was extraordinarily helpful to everyone he interacted with. He could get to the heart of an issue virtually instantly, and where many of us saw only limitations in a body of work Ed saw its strengths, notwithstanding its problems. Ed's incisive analysis was the key to research progress time after time. He also had a quick wit that could have been deployed in sharp critiques, but Ed used it solely for teaching and entertainment, often quoting his favorite philosopher, Woody Allen.

Ed was a dedicated and hugely successful teacher both of undergraduate and graduate students, and he mentored some of the finest cognitive psychologists we have. He was a coauthor of one of the most successful Introduction to Psychology textbooks in the field (Atkinson et al. 2000) and he edited a number of textbooks intended for graduate students.

Ed's research impact was broad and deep, but he always had time for his colleagues. Our field has lost a true star.

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