Integrating Trends in Decision-Making Research

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Decision-making research is a central component of current cognitive engineering and decision making (CEDM) work. CEDM is characterized by the application of principles and theories from cognitive science and psychology to the design of effective technology (Endsley, Hoffman, Kaber, & Roth, 2007). The growth of CEDM research parallels rapid development of decision-making research in various domains. However, decision-making research has developed in different, contrasting and occasionally extreme directions. CEDM is in a unique position to support the integration of different perspectives given recent developments in decision-making research.

Decision-making research can be viewed in at least three different but related traditions. First, in economics, initial theoretical developments were "held responsible" for the belief that people make decisions by maximizing a utility function in which all of the relevant constraints and preferences are accounted for accurately. Experimental economics changed the direction of this view with studies of human behavior in situations in which the assumption of perfect information and utility maximization do not necessarily apply. Experimental research is intended to elucidate how people make decisions in the face of incomplete information and limited cognitive resources, complementing the quantitative work of theoretical

economics (Bereby-Meyer & Roth, 2006; Erev & Roth, 1998). In more recent developments, the field of economic engineering is emerging (Bolton & Ockenfels, 2012). This area is based on the notion that it is possible to engineer social systems and mechanisms, so that when the preferences of individuals are known, one can generate efficient and stable outcomes, using algorithms that are based on mathematical theorems of game theory. Some of this work focused on the study of matching markets, in which people cannot just choose what they want, but they also have to be chosen. Examples are matching interns and hospitals in labor markets with beginning physicians (Roth & Peranson, 1999) and matching kidney donors with recipients (Roth, Sönmez, & Ünver, 2004). Economic engineering is based on the theoretical foundation of game theory and empirical data from laboratory experiments, and it is also prominently applied to various settings, connecting it closely to the interests of the CEDM community.

Second, in psychology, behavioral decision-making research, referred to as judgment and decision making (JDM), has shown that humans often rely on simple heuristics to solve complex problems (e.g., Gigerenzer & Todd, 1999; Tversky & Kahneman, 1974). JDM has shown that cognitive, emotional, social, and other human limitations result in behaviors that differ from the predictions of traditional economic models (cause biases) (Gilovich, Griffin, & Kahneman, 2002). Several popular books presented ideas from JDM to wide audiences, such as *Predictably Irrational* (Ariely, 2008), *The Honest Truth About Dishonesty* (Ariely, 2012), *Misbehaving* (Thaler, 2015), and *Thinking Fast and Slow* (Kahneman, 2011). The insights gained from JDM have been applied to create "nudges" or "choice architectures" in which information or situations are designed to induce people to make specific choices (as described in *The Nudge*, by Thaler & Sunstein,

2009). Governments, including those of the United Kingdom (with the "Behavioral Insights Team"), the United States, and New South Wales in Australia, established units applying these methods to issues of societal interest. Furthermore, in the past decade, JDM started a relevant shift of attention from the study of one-shot choice problems to the study of repeated decisions that rely on experience (see Gonzalez, 2013, for a historical summary). This breakthrough is relevant because it connects expertise and dynamic decision making studies in CEDM to traditional JDM research. The study of experience-based decisions advances theories of decision making towards providing explanations of the process by which people make decisions.

Third, in human factors, a successful and relevant area of research is naturalistic decision making (NDM). It focuses on the attempt to describe and understand how people make decisions in context, within the constraints of the real world (Klein, 1986). The NDM perspective is often viewed as a contrast to other perspectives on decision making, including JDM and traditional economics (Lipshitz, Klein, Orasanu, & Salas, 2001), because it emerged from the need to address features of naturalistic contexts such as ill-defined goals, time pressure, high cognitive workload, and many other issues of experts' decision making. NDM tends to reject strong assumptions from other perspectives of decision making, arguing that such approaches often fail to capture critical aspects of how people actually make decisions in real-world contexts (Endsley et al., 2007; Lipshitz et al., 2001). These disagreements were discussed in a paper coauthored by Kahneman and Klein (2009). They agree on two major problems in decision-making research, the question of expert intuition—when can one trust an experienced professional and when not to—and the limitations of the approaches and perspectives adopted by each of the two communities. They conclude that "although we agree with both of these conclusions, we have yet to move much beyond recognition of the problem" (p. 525).

ACTIONABLE ITEMS: MOVING CEDM FORWARD

So far the many important developments in decision-making research had relatively little impact on research in human factors. We suggest that a better understanding of these different approaches and their integration can have great value for CEDM. Some concrete directions for such developments have emerged from recent discussions (Gonzalez, Meyer, Klein, Yates, & Roth, 2013). The theoretical discussions made us aware of questions and opportunities that are highly relevant for CEDM but also for any other application of decision research:

1. What is the effect of knowledge, experience, and intuition on decision making? How are decisions different when they follow explicit deliberation, rather than when they are adaptive responses to a situation? Recognition-based decision making in NDM and the use of heuristics in behavioral decision making describe such immediate responses, whereas economic theory deals with the explicit analysis of the alternatives, the outcomes, and the available information. Research on experience-based decisions and models of dynamic decisions from experience provide a way to reconcile and bring together these divergent perspectives (Gonzalez, 2013).

2. How do properties of the situation affect decisions, and how should a situation be structured, so that decisions are in line with some predetermined goals? In game theory, mechanism design involves the design of incentive systems, decision mechanisms, and information displays, so that decisions will be in line with some goals. In human factors, the focus is on the interface used to accomplish a task, which is likely to affect the decisions involved in the task. In behavioral decision making, the presentation of the outcomes (their "framing") will affect the choices made. System design will involve all three aspects—the definition of incentives and costs, the interface design, and the presentation of the setting to the user.

3. How do we scale up our models and knowledge of an individual decision maker to collective decision processes that are becoming widespread in our society? Economic engineering, network science, and many other areas of research present new opportunities for systems design that facilitate participatory decision processes. Prediction and matching markets are a prominent perspective for the study of social and collective decision processes that emerge from the individual.

The overarching questions need to be addressed in all applications of decision research. However, they are particularly relevant for CEDM because the field not only studies decision making and decision makers, but it also designs the parts of systems that provide the information for decisions or in which decisions are implemented. This is usually done within organizational, legal, and social frameworks that affect various parts of the decision process. As such, CEDM has the potential not only to adopt the integrated view of decision making, proposed here, but it may also spearhead it and help to introduce it into other domains.

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