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A model for the assessment of rational thought and its potential operationalization

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Introduction

When a layperson thinks of individual differences in reasoning they think of IQ tests. It is quite natural that this is their primary association, because IQ tests are among the most publicized products of psychological research. This association is not entirely inaccurate either, because intelligence is correlated with performance on a host of reasoning tasks (Carroll, 1993; Deary, 2000, 2001; Flynn, 2007; Hunt, 2011; Lubinski, 2004). Nonetheless, a major theme of this chapter will be that certain very important classes of individual differences in thinking are ignored if only intelligence-related variance is the primary focus. A number of these ignored classes of individual differences are those relating to rational thought.

We tend not to notice the mental processes that are missing from IQ tests because many theorists have adopted a permissive conceptualization of what intelligence is rather than a grounded conceptualization. Permissive theories include aspects of functioning that are captured by the vernacular term intelligence (adaptation to the environment, showing wisdom, creativity, etc.), whether or not these aspects are actually measured by existing tests of intelligence. Grounded theories, in contrast, confine the concept of intelligence to the set of mental abilities actually tested on extant IQ tests. Adopting permissive definitions of the concept of intelligence serves to obscure what is missing from extant IQ tests. Instead, in order to highlight the missing elements in IQ tests, we adopt a thoroughly grounded notion of the intelligence concept.

Grounded theories adopt the operationalization of the term that is used in psychometric studies of intelligence, neurophysiological studies using brain imaging, and studies of brain disorder. This definition involves a statistical abstraction from performance on established tests and cognitive ability indicators. It yields a scientific concept of general intelligence usually symbolized by g or, in cases where the fluid/crystallized theory is adopted, Gf and Gc. The latter
theory is sometimes termed the Cattell/Horn/Carroll (CHC) theory of intelligence (Carroll, 1993; Cattell, 1963, 1998; Horn & Cattell, 1967). The theory posits that tests of mental ability tap a small number of broad factors, of which two are dominant. Fluid intelligence (Gf) reflects reasoning abilities operating across a variety of domains—including novel ones. It is measured by tests of abstract thinking such as figural analogies, Raven Matrices, and series completion. Crystallized intelligence (Gc) reflects declarative knowledge acquired from acculturated learning experiences. It is measured by vocabulary tasks, verbal comprehension, and general knowledge measures. The CHC theory reflects a long history of considering two aspects of intelligence: intelligence-as-process (Gf) and intelligence-as-knowledge (Gc).

The grounded view of intelligence then takes these operationally defined constructs—g, Gf, Gc—and validates them in studies of brain injury, educational attainment, cognitive neuroscience, developmental trends, and information processing. These constructs are grounded in the types of mental abilities measured on traditional tests of intelligence. Critics of intelligence tests are eager to point out that the tests ignore important parts of mental life—many largely noncognitive domains such as socioemotional abilities, empathy, and interpersonal skills, for example. However, a tacit assumption in such critiques is that although intelligence tests miss certain key noncognitive areas, they do encompass most of what is important in the cognitive domain. It is just this unstated assumption that we wish to challenge. Instead, we wish to argue that intelligence tests are radically incomplete as measures of cognitive functioning—in addition to whatever they fail to assess in noncognitive domains.

Revealing what IQ tests miss: rational thinking

Cognitive scientist Daniel Kahneman of Princeton University won the Nobel Prize in Economics in 2002 for work done with his longtime collaborator Amos Tversky (who died in 1996). The press release for the award from the Royal Swedish Academy of Sciences drew attention to the roots of the award-winning work in “the analysis of human judgment and decision-making by cognitive psychologists.” Kahneman was cited for discovering “how human judgment may take heuristic shortcuts that systematically depart from basic principles of probability. His work has inspired a new generation of researchers in economics and finance to enrich economic theory using insights from cognitive psychology into intrinsic human motivation.”

One reason that the Kahneman and Tversky work was so influential was that it addressed deep issues concerning human rationality. As the Nobel announcement noted, “Kahneman and Tversky discovered how judgment under uncertainty systematically departs from the kind of rationality postulated in traditional economic theory.” The thinking errors uncovered by Kahneman and Tversky are thus not trivial errors in a parlour game. Being rational means acting to achieve one’s own life goals using the best means possible. To violate the thinking rules examined by Kahneman and Tversky thus has the practical consequence that we are less satisfied with our lives than we might be.

The work of Kahneman and Tversky, along with that of many other investigators, has shown how the basic architecture of human cognition makes all of us prone to these errors of judgment and decision making. But being prone to these errors does not mean that we always make them. Every person, on some occasions, overrides the tendency to make these reasoning errors and instead makes the rational response. It is not that we make errors all the time. Even more importantly, our research group has shown that there are systematic differences among individuals in the tendency to make errors of judgment and decision making (Stanovich & West, 1998, 1999, 2000, 2008; West, Toplak, & Stanovich, 2008).
Misunderstandings about rationality

Dictionary definitions of rationality tend to be of the weak sort—often seeming quite lame and unspecific (“the state or quality of being in accord with reason”). The meaning of rationality in modern cognitive science (the strong sense) is, in contrast, much more specific and prescriptive than this. The weak definitions of rationality derive from a categorical notion of rationality tracing to Aristotle (humans as the only animals who base actions on reason). As de Sousa (2007) has pointed out, such a notion of rationality as “based on reason” has as its opposite not irrationality but arationality (outside the domain of reason). Aristotle’s characterization is categorical—the behavior of entities is either based on thought or it is not. Animals are either rational or arational. In this conception, humans are rational, other animals are not. There is no room for individual differences in rational thinking among humans in this view.

In its stronger sense (the sense employed in most of cognitive science and in this chapter) rational thought is a normative notion. Its opposite is irrationality, not arationality. Normative models of optimal judgment and decision making define perfect rationality in the noncategorical view employed in cognitive science. Rationality (and irrationality) come in degrees defined by the distance of the thought or behavior from the optimum defined by a normative model. De Sousa (2007) points out that the notion of rationality in Aristotle’s sense cannot be normative, but in the strong sense of cognitive science, it is. Other animals may be arational but only humans can be irrational. As de Sousa (2007) puts it, “if human beings can indeed be described as rational animals, it is precisely in virtue of the fact that humans, of all the animals, are the only ones capable of irrational thoughts and actions” (p. 7).

When a cognitive scientist terms a behavior irrational he/she means that the behavior departs from the optimum prescribed by a particular normative model. The scientist is not implying that there was no thought or reason behind the behavior. Some of the hostility that has been engendered by experimental claims of human irrationality (for discussions, see Stanovich, 2004; Stanovich & West, 2000; Stein, 1996) no doubt derive from a (perhaps tacit) influence of the Aristotelian view—the thought that cognitive psychologists are saying that certain people are somehow less than human when they are said to behave irrationally. But in using the strong sense of the term rationality, most cognitive scientists are saying no such thing. When we find a behavioral pattern that is less than optimally rational, we could easily say that it is “less than perfectly rational” rather than that it is irrational—with no loss of meaning.

Cognitive scientists recognize two types of rationality: instrumental and epistemic. The simplest definition of instrumental rationality is: Behaving in the world so that you get exactly what you most want, given the resources (physical and mental) available to you. Somewhat more technically, we could characterize instrumental rationality as the optimization of the individual’s goal fulfillment. Economists and cognitive scientists have refined the notion of optimization of goal fulfillment into the technical notion of expected utility. The model of rational judgment used by decision scientists is one in which a person chooses options based on which option has the largest expected utility (see Baron, 2008; Dawes, 1998; Hastie & Dawes, 2001; Wu, Zhang, & Gonzalez, 2004).

The other aspect of rationality studied by cognitive scientists is termed epistemic rationality. This aspect of rationality concerns how well beliefs map onto the actual structure of the world. Epistemic rationality is sometimes called theoretical rationality or evidential rationality (see Audi, 1993, 2001; Foley, 1987; Harman, 1995; Manktelow, 2004; Over, 2004). Instrumental and epistemic rationality are related. In order to take actions that fulfill our goals, we need to base those actions on beliefs that are properly calibrated to the world.

Although many people feel (mistakenly or not) that they could do without the ability to solve textbook logic problems (which is why such a caricatured view of rationality works to
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undercut its status), virtually no person wishes to eschew epistemic rationality and instrumental rationality, properly defined. Virtually all people want their beliefs to be in some correspondence with reality, and they also want to act to maximize the achievement of their goals. Manktelow (2004) has emphasized the practicality of both types of rationality by noting that they concern two critical things: What is true and what to do. Epistemic rationality is about what is true and instrumental rationality is about what to do. For our beliefs to be rational they must correspond to the way the world is—they must be true. For our actions to be rational, they must be the best means toward our goals—they must be the best things to do.

The literature of cognitive science contains many examples of advantages of epistemic rationality and the disadvantages of epistemic irrationality. People who lack epistemic rationality tend to get many surprises in life—they think they know things that they do not. They have poor knowledge calibration, to use the technical term. In a knowledge calibration paradigm, for example, they tend to say that they are 99% certain of things that they actually know with only 70% accuracy (Fischhoff, Slovic, & Lichtenstein, 1977). Likewise, research has demonstrated the many practical consequences of failing to follow the strictures of instrumental rationality. For example, in the domains of personal finance and investing it has been found that people who violate the principles of instrumentally rational thought suffer more financial misfortune and make less money from investments (Camerer, 2000; Fenton-O’Creevy, Nicholson, Soane, & Willman, 2003; Hilton, 2003).

Operationalizing rationality in cognitive science

One of the fundamental advances in the history of modern decision science was the demonstration that if people’s preferences follow certain patterns (the so-called axioms of choice—things like transitivity and freedom from certain kinds of context effects) then they are behaving as if they are maximizing utility—they are acting to get what they most want (Edwards, 1954; Jeffreys, 1983; Luce & Raiffa, 1957; Savage, 1954; von Neumann & Morgenstern, 1944). This is what makes people’s degrees of rationality measurable by the experimental methods of cognitive science. Although it is difficult to assess utility directly, it is much easier to assess whether one of the axioms of rational choice is being violated. This has been the logic of the seminal heuristics and biases research program inaugurated in the much-cited studies of Kahneman and Tversky (1973, 1979; Tversky & Kahneman, 1974, 1983).

Collectively, the many tasks of the heuristics and biases program—and the even wider literature in decision science—comprise the operational definition of rationality in modern cognitive science (Stanovich, 2011). Psychologists have extensively studied aspects of instrumental rationality and irrationality, such as: the ability to display disjunctive reasoning in decision making; the tendency to show inconsistent preferences because of framing effects; the tendency to show a default bias; the tendency to substitute affect for difficult evaluations; the tendency to over-weight short-term rewards at the expense of long-term well-being; the tendency to have choices affected by vivid stimuli; and the tendency for decisions to be affected by irrelevant context. Likewise, they have studied aspects of epistemic rationality and irrationality, such as: the tendency to show incoherent probability assessments; the tendency toward overconfidence in knowledge judgments; the tendency to ignore base-rates; the tendency not to seek to falsify hypotheses; the tendency to try to explain chance events; the tendency toward self-serving personal judgments; the tendency to evaluate evidence with a myside bias; and the tendency to ignore the alternative hypothesis.

In short, we have an extensive and rich set of operationalizations for the concept of rationality in modern cognitive science. None of these operational measures are assessed on common IQ
tests. Yet people (including scientists) often talk as if they were. For example, many conceptions of intelligence define it as involving adaptive decision making. Adaptive decision making is the quintessence of rationality, but the items used to assess intelligence on widely accepted tests bear no resemblance to measures of decision making.

However, there is an important caveat here. Although the tests fail to assess rational thinking directly, it could be argued that the processes that are tapped by IQ tests largely overlap with variation in rational thinking ability. Perhaps intelligence is highly associated with rationality even though tasks tapping the latter are not assessed directly on the tests. Here is where empirical research comes in, some of which has been generated by our own research group. We have found that many rational thinking tasks show surprising degrees of dissociation from cognitive ability in university samples. Myside bias, for example, is virtually independent of intelligence in university samples (Stanovich, West, & Toplak, 2013). Individuals with higher IQs in a university sample are no less likely to process information from an egocentric perspective than are individuals with relatively lower IQs. Many classic effects from the heuristics and biases literature—base-rate neglect, framing effects, conjunction effects, anchoring biases, and outcome bias—are also quite independent of intelligence if run in between-subjects designs (Stanovich & West, 2008). Correlations with intelligence have been found (Bruine de Bruin, Parker, & Fischhoff, 2007; Stanovich, 2009, 2011; Stanovich & West, 1998, 2000, 2008; West et al., 2008) to be roughly (in absolute magnitude) in the range of .20—.35 for probabilistic reasoning tasks and scientific reasoning tasks measuring a variety of rational principles (covariation detection, hypothesis testing, four-card selection task, disjunctive reasoning tasks, denominator neglect, and various indices of Bayesian reasoning). In fact, even after corrections for reliability and range restriction, this is a magnitude of correlation that allows for substantial discrepancies between intelligence and rationality. Intelligence is thus no inoculation against many of the sources of irrational thought. None of these sources are directly assessed on intelligence tests, and the processes that are tapped by IQ tests are not highly overlapping with the processes and knowledge that explain variation in rational thinking ability.

Toward an RQ test: a framework for assessing rational thinking

Thus, rationality is a mental quality that is theoretically and empirically separable from intelligence. Individual differences on IQ tests are not proxies for individual differences in rational thinking. If we want to assess differences in rational thinking, we will need to specifically assess the components of rational thought directly. An IQ score does not give us an RQ (rationality quotient). At present, of course, there is no IQ-type test for rationality—that is, a test of one’s RQ. But the point is that, practically, in terms of the cognitive technology now in place, it is doable. There is nothing conceptually or theoretically preventing us from developing such a test. We know the types of thinking processes that would be assessed by such an instrument, and we have in hand prototypes of the kinds of tasks that would be used in the domains of both instrumental rationality and epistemic rationality. Thus, there are no major roadblocks preventing the development of an RQ test. Indeed, this is what our research lab is doing with the help of a three-year grant from the John Templeton Foundation. Specifically, we are attempting to construct the first prototype of an assessment instrument that will comprehensively measure individual differences in rational thought.

Table 28.1 shows a conceptual structure for rational thought that serves as our assessment framework. The table shows that rational thought can be partitioned into fluid and crystallized components by analogy to the Gf and Gc of the Cattell/Horn/Carroll fluid-crystallized theory of intelligence (Carroll, 1993). Fluid rationality encompasses the process part of rational
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— the thinking dispositions of the reflective mind that lead to rational thought and action. Crystallized rationality encompasses all of the knowledge structures that relate to rational thought.

Unlike the case of fluid intelligence, fluid rationality is likely to be multifarious—composed of a variety of different cognitive styles and dispositions. As a multifarious concept, fluid rationality cannot be assessed with a single type of item in the manner that the homogeneous Raven Progressive Matrices, for example, provide a good measure of Gf.

Table 28.1 illustrates that the concept of crystallized rationality has two subdivisions. Knowledge structures that promote rational thought are termed crystallized facilitators. Knowledge structures that impede rational thought are termed crystallized inhibitors. Each of these subcategories of crystallized rationality is, like fluid rationality, multifarious. Without learning crystallized facilitators, people will lack declarative knowledge that is necessary in order to act rationally. However, not all crystallized knowledge is helpful—either to attaining our goals (instrumental rationality) or to having accurate beliefs (epistemic rationality). Hence the category of crystallized inhibitors (e.g., astrology) in the table.

Table 28.1 should not be mistaken for the kind of list of “good thinking styles” that appears in textbooks on critical thinking. In terms of providing a basis for a system of rational thinking assessment, it goes considerably beyond such lists in a number of ways. First, unlike the many committee-like attempts to develop feature-lists of critical thinking skills, our conceptual components are grounded in paradigms that have been extensively researched within the literature of cognitive science (see Stanovich, 2011; Stanovich, West, & Toplak, 2011). Second, many textbook attempts at lists of “good thinking styles” deal only with aspects of fluid rationality and give short shrift to the crystallized knowledge bases that are necessary supports for rational thought and action. In contrast, our framework for rationality assessment emphasizes that crystallized knowledge underlies much rational responding (crystallized

<table>
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<tr>
<th>Components of rationality</th>
<th>Crystallized facilitators</th>
<th>Crystallized inhibitors</th>
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<tbody>
<tr>
<td>Resistance to miserly information processing</td>
<td>Probabilistic and statistical reasoning</td>
<td>Belief in the paranormal and in intuition</td>
</tr>
<tr>
<td>Absence of irrelevant context effects in decision making</td>
<td>Practical numeracy</td>
<td></td>
</tr>
<tr>
<td>Sensitivity to expected value</td>
<td>Risk knowledge</td>
<td>Value placed on ungrounded knowledge sources</td>
</tr>
<tr>
<td>Proper knowledge calibration: avoiding overconfidence</td>
<td>Knowledge of scientific reasoning</td>
<td>Overreliance on introspection</td>
</tr>
<tr>
<td>avoidance of myside bias</td>
<td>Financial literacy and economic thinking</td>
<td>Dysfunctional personal beliefs</td>
</tr>
<tr>
<td>Openminded/objective reasoning styles</td>
<td></td>
<td></td>
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<tr>
<td>Prudent attitude toward the future</td>
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<td></td>
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<tr>
<td>Sensitivity to emotions</td>
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facilitators) and that crystallized knowledge can also be the direct cause of irrational behavior (crystallized inhibitors).

Even more important than these points, and unlike many such lists of thinking skills in textbooks, the conceptual components of the fluid characteristics and crystallized knowledge bases listed in Table 28.1 are each grounded in established paradigms in the literature of cognitive science. That is, they are not just potentially measurable, but in fact have been operationalized and measured at least once in the scientific literature—and in many cases (e.g., context effects in decision making; probabilistic reasoning) they have generated enormous empirical literatures.

Most of the actual paradigms that will be used in our assessment device are well known to most cognitive psychologists. For example, there are many paradigms that have been used to measure the resistance to miserly information processing, the first major dimension of fluid rationality in Table 28.1. Many of these paradigms have been extensively investigated and have yielded tasks that could be used to devise assessment items. The study of belief bias—that people have difficulty processing data pointing toward conclusions that conflict with what they think they know about the world—has yielded many such items (e.g., Evans & Curtis-Holmes, 2005). Frederick’s (2005) Cognitive Reflection Test measures miserly processing and it has been much investigated (Toplak, West, & Stanovich, 2011, 2014).

Good decision making is in part defined by decisions that are not unduly affected by irrelevant context (the second major dimension of fluid rationality). Two paradigms that assess the latter tendency have each generated enormous literatures. Resistance to framing has been measured with countless tasks (Maule & Villejoubert, 2007), as has the resistance to irrelevant anchoring in decisions (e.g., Epley & Gilovich, 2004, 2006).

As a final example of an area of rational thinking with a dense history of empirical research and with paradigms that could serve as assessment devices, consider the tendency to conform, qualitatively, to the insights of normative decision theory—the third major dimension of fluid rationality (sensitivity to expected value). Since the early 1950s (see Edwards, 1954), psychologists have studied the tendency to adhere to the axioms of expected utility theory with a variety of tasks and paradigms (e.g., Baron, 2008; Kahneman & Tversky, 2000). Not all of the concepts of rational thought listed in Table 28.1 have potential measurement paradigms with as much background research on them as those we have just singled out, but in fact most of them do. For the reader not as conversant with the literature of cognitive psychology as the last several paragraphs have presumed, in other publications (see Stanovich, 2011) we have provided numerous citations to the relevant paradigms.

Conclusions

Our framework illustrates the basis for our position that there is no conceptual barrier to creating a test of rational thinking. However, this does not mean that it would be logistically easy. Quite the contrary, we have stressed that both fluid and crystallized rationality are likely to be more multifarious than their analogous intelligence constructs. Likewise, we are not claiming that there presently exist comprehensive assessment devices for each of these components. Indeed, refining and scaling up many of the small-scale demonstrations in the literature will be a main task of our three-year grant from the John Templeton Foundation. Our present claim is only that, in virtually every case laboratory tasks that have appeared in the published literature give us, at a minimum, a hint at what comprehensive assessment of the particular component would look like.

The ability to measure individual differences in rational thinking could have profound social consequences. For example, in a recently published book (Stanovich, 2011), we have shown that each of the subcomponents of rational thought has been linked to a real-life outcome of practical importance. In the absence of space to explicate all of the linkages, let us just say that although
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some of the subcomponents are inadequately developed it has been shown that: physicians choose less effective medical treatments; people fail to accurately assess risks in their environment; information is misused in legal proceedings; millions of dollars are spent on unneeded projects by government and private industry; parents fail to vaccinate their children; unnecessary surgery is performed; billions of dollars are wasted on quack medical remedies; and costly financial misjudgments are made (Baron, 2008; Stanovich, 2004, 2009). For example, suboptimal investment decisions have been linked to overconfidence in knowledge judgments, the tendency to over-explain chance events, and the tendency to substitute affective valence for thought—all components of our rational thinking test. Errors in medical decision making and legal decision making have also been linked to specific irrational thinking tendencies to be assessed in our instrument. And it is critically important to realize that intelligence has been shown to be an insufficient inoculation against these thinking errors and their negative consequences.

In summary, we have coherent and well operationalized concepts of rational action and belief formation. We have a coherent and well operationalized concept of intelligence. No scientific purpose is served by fusing these concepts, because they are very different. To the contrary, scientific progress is made by differentiating concepts. We have a decades long history of measuring the intelligence concept. It is high time we put equal energy, as a discipline, into the measurement of a mental quality that is just as important—rationality.

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