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The Assessment of Rational Thinking: IQ ≠ RQ

Keith E. Stanovich[1] and Richard F. West[2]

Variation in intelligence has been one of the most studied topics in psychology for many decades (Geary, 2005; Hunt, 2011; Lubinski, 2004). Because people frequently assume that assessments of intelligence (and similar tests of cognitive ability) are the quintessence of good thinking, one might assume that such measures would serve as proxies for judgment and decision-making skills. It is important to understand why such an assumption would be misplaced.

Judgment and decision making are more properly regarded as components of rational thinking, and people often fail to recognize that rationality and intelligence (as traditionally defined) are two different things. In scientific psychology, intelligence definitions derive from performance on established tests and cognitive ability indicators. Statistical study of this performance yields a scientific concept of general intelligence, usually symbolized by g; a concept of fluid intelligence (Gf); and a concept of crystallized intelligence (Gc). The latter two concepts refer to the Cattell/Horn/Carroll (CHC) theory of intelligence—as close as there is to a consensus view in the field of intelligence research (Carroll, 1993; Horn & Cattell, 1967). Sometimes called the theory of fluid and crystallized intelligence (symbolized Gf/Gc theory), this theory posits that tests of mental ability tap a small number of broad factors, of which two are dominant. Gf reflects reasoning abilities operating across of variety of domains—in particular, novel ones. Gf is measured by tasks of abstract reasoning such as figural analogies, Raven Matrices, and series completion (e.g., What is the next number in the series 1, 4, 5, 8, 9, 12, __?). Gc reflects declarative knowledge acquired from acculturated learning experiences and is measured by vocabulary tasks, verbal comprehension, and general knowledge measures. The two dominant factors in the CHC theory reflect a long history of considering two aspects of intelligence: intelligence as process (Gf) and intelligence as knowledge (Gc). The IQ-test components that measure Gf do not assess judgment and decision making and neither do the IQ-test components that measure Gc. In short, no components of currently popular IQ tests measure aspects of rationality.

Distinguishing between rationality and intelligence thus helps explain how people can be, at the same time, intelligent *and* irrational (Stanovich, 2009). As such, researchers need to study separately the individual differences in cognitive skills that underlie intelligence and the individual differences in cognitive skills that underlie rational thinking because they are conceptually and empirically different.

What IQ Tests Miss: Rational Thinking

Cognitive scientist Daniel Kahneman of Princeton University won the 2002 Nobel Prize in Economics for research he conducted 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 their award-winning work in "the analysis of human judgment and decision-making by cognitive psychologists" (The Royal Swedish Academy of Sciences, 2002a, 2002b). 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. (The Royal Swedish Academy of Sciences, 2002a, 2002b)

One reason Kahneman and Tversky's (1973, 1979, 2000) work was so influential was because 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 Royal Swedish Academy of Sciences, 2002a, 2002b). The thinking errors uncovered by Kahneman and Tversky are thus not trivial errors in a parlor game. Rather, because being rational means acting to achieve one's own life goals using the best means possible, making thinking errors has the practical consequence that

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people may be less satisfied with their lives than they might otherwise be.

The work of Kahneman and Tversky, along with that of many other investigators, has shown how the basic architecture of human cognition makes everyone prone to these errors of judgment and decision making. But being prone to these errors does not mean that people always make them. Every person, at least on some occasions, overrides the tendency to make these reasoning errors and instead makes a rational response. 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, 2009, 2011; Stanovich & West, 2000; West, Toplak, & Stanovich, 2008).

The fact that there are systematic individual differences in the judgment and decision-making situations studied by Kahneman and Tversky means that there are variations in important attributes of human cognition related to rationality (Manktelow, 2004; Stanovich, 2009, 2011). It is a curious fact that none of these critical attributes of human thinking are assessed on IQ tests (or in proxies such as academic ability tests). This fact is curious because most laypeople think that IQ tests measure "good" thinking (to put it colloquially). Moreover, scientists and laypeople alike tend to agree that good thinking encompasses good judgment and decision making—the type of thinking that helps people achieve their goals. As such, one might assume that IQ tests would include assessements of good thinking. Yet they do not.

To think rationally means taking appropriate action, given one's goals and beliefs (instrumental rationality); it also entails holding beliefs that are commensurate with available evidence (epistemic rationality). Collectively, the many tasks that measure heuristics (a mental shortcut) and biases (a tendency to think a certain way) comprise the operational definition of rationality found in much of modern cognitive science (Stanovich, 2011). Psychologists have extensively studied (see Baron, 2008) many aspects of instrumental rationality and irrationality, including:

- 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 overweight short-term rewards at the expense of long-term well-being;
- the tendency to have choices affected by vivid stimuli;
- the tendency for decisions to be affected by irrelevant context.

Likewise, psychologists have studied (see Baron, 2008) 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;
- the tendency to ignore the alternative hypothesis.

In short, there is an extensive and rich set of operationalizations for the concept of rationality in modern cognitive science. But, as noted previously, IQ tests do not include these measures, even though many people (including scientists) often talk as if they do.

There is an important caveat, however (discussed extensively in Stanovich, 2011). Although IQ tests fail to assess rational thinking directly, one could argue that the processes that these tests measure largely overlap with variation in rational thinking ability. Perhaps intelligence is highly associated with rationality, although tasks measuring the latter are not assessed directly on the tests. Here is where empirical research comes in, some of which our research group has generated. We have found that many rational thinking tasks show surprising degrees of dissociation from intelligence in samples of college students. Myside bias (processing information from an overly egocentric perspective), for example, is virtually independent of intelligence (Stanovich, West, & Toplak, 2013). Individuals with higher IQs are no less likely to process information from an egocentric perspective than 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 analyzed using between-subject designs (Stanovich & West, 2008). Researchers have also found correlations with intelligence 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; see Bruine de Bruin, Parker, & Fischhoff, 2007; Stanovich, 2009, 2011; Stanovich & West, 1998, 2000, 2008). In fact, even after corrections for reliability and range restriction, this magnitude of correlation allows for substantial discrepancies between intelligence and rationality. In short, high intelligence is no inoculation against many of the sources of irrational thought.

Steps Toward an RQ Test: An Assessment Framework

To summarize, rationality is a mental quality that is theoretically and empirically separable from intelligence, and individual differences on IQ tests are not proxies for individual differences in rational thinking. Thus, if one wants to assess differences in rational thinking, one needs specifically to assess the components of rational thought directly because an intelligence quotient does not provide a RQ. At present, of course, there is no IQ-type test for rationality—that is, there is not a test

Table 1. Rational Thinking Skills in the Stanovich and West Framework.

Components of Rationality		
	Crystallized Rationality	
Fluid Rationality	Crystallized Facilitators	Crystallized Inhibitors
Resistance to miserly information processing	Probabilistic and statistical reasoning	Belief in the paranormal and in intuition
Absence of irrelevant context effects in decision making	Practical numeracy	
Sensitivity to expected value	Risk knowledge	Value placed on ungrounded knowledge sources
Proper knowledge calibration: avoiding overconfidence	Knowledge of scientific reasoning	Overreliance on introspection
Avoidance of myside bias	Financial literacy and economic thinking	Dysfunctional personal beliefs
Openminded/objective reasoning styles		
Prudent attitude toward the future		
Sensitivity to emotions		

of one's RQ. But researchers know the types of thinking processes that such an instrument would assess, and they 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 3-year grant from the John Templeton Foundation. Specifically, we are attempting to construct the first assessment instrument that will comprehensively measure individual differences in rational thought.

Table 1 shows a conceptual structure for rational thought that serves as our assessment framework. Specifically, rational thought can be partitioned into fluid and crystallized components by analogy to the fluid-crystallized theory of intelligence discussed earlier (see Carroll, 1993). Fluid rationality encompasses the process part of rational thought—the thinking dispositions of the reflective mind that lead to rational thought and action. Crystallized rationality encompasses the knowledge structures that relate to rational thought.

Unlike fluid intelligence, though, fluid rationality is likely multifarious—it is 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, for example, in the same way that a more homogeneous test such as the Raven Progressive Matrices can assess fluid intelligence.

Table 1 illustrates that the concept of crystallized rationality has two subdivisions: crystallized facilitators, which are knowledge structures that promote rational thought (e.g., knowledge of probability), and crystallized inhibitors, which are knowledge structures that impede rational thought (e.g., belief in astrology). Each of these subcategories of crystallized rationality is, like fluid rationality, multifarious. Without learning crystallized faciltators, 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.

Importantly, one should not mistake the information in Table 1 for the lists of "good thinking styles" that often appear 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 tasks that have been extensively researched (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 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 1 are each grounded in established paradigms 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, they have generated enormous empirical literatures. For example, there are many paradigms that researchers have used to measure resistance to miserly information processing, the first major dimension of fluid rationality in Table 1. 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). Another is Frederick's (2005) Cognitive Reflection Test, which measures miserly processing and has been studied extensively (Toplak, West, & Stanovich, 2011, 2014). The most famous item on this test reads: A bat and a ball cost $1.10 in total. The bat costs $1 more than the ball. How much does the ball cost? When they answer this problem, many people give the first response that comes to mind—10 cents—without thinking further and realizing that this cannot be correct. The bat would then have to cost $1.10, and the total cost would be US$1.20 rather than the required $1.10. People often do not think deeply enough to realize their error, and cognitive ability is no guarantee against making the error. Frederick (2005) found that large numbers of highly select university students at Massachusetts Institute of Technology, Princeton, and Harvard were cognitive misers—they responded that the cost was 10 cents, rather than the correct answer: 5 cents.

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 this 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).

Many crystallized facilitators have been extensively studied as well. For example, assigning the right probability values to events is a critical aspect of rational thought. It is involved, for example, in medical diagnosis. Consider the following problem on which both medical personnel and laypersons frequently make a critical thinking error:

Imagine that the XYZ virus causes a serious disease that occurs in 1 of every 1,000 people. Imagine also that there is a test to diagnose the disease that always indicates correctly that a person who has the XYZ virus actually has it. Finally, imagine that the test has a false-positive rate of 5%—the test wrongly indicates that the XYZ virus is present in 5% of the cases where it is not. Imagine that we choose a person randomly and administer the test and that it yields a positive result (i.e., it indicates that the person is XYZ positive). What is the probability that the individual actually has the XYZ virus?

The point is not to get the precise answer; rather, the point is to see whether a guess is in the right ballpark. The answers of many people are not. The most common answer given is 95%. Actually, the correct answer is approximately 2%! Why? Of 1,000 people, just one will actually be XYZ positive. If the other 999 are tested, the test will indicate incorrectly that approximately 50 of them have the virus (.05 multiplied by 999) because of the 5% false-positive rate. Thus, of the 51 patients testing positive, only 1 (approximately 2%) will actually be XYZ positive. In short, the base rate is such that the vast majority of people do not have the virus. This fact, combined with a substantial false-positive rate, ensures that, in absolute numbers, the majority of positive tests will be of people who do not have the virus. Rational thinking errors due to such knowledge gaps can occur in a potentially large set of coherent knowledge bases in the domains of probabilistic reasoning, causal reasoning, practical numeracy, financial literacy, and scientific thinking (e.g., the importance of alternative hypotheses). In other publications (e.g., Stanovich, 2011), we have provided numerous examples of tasks like this that measure each of the rational thinking concepts in Table 1.

Future Directions

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 laboratory demonstrations in the literature will be a main task of our future research. 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 discussed how each of the subcomponents of rational thought has been linked to real-life outcomes of practical importance. In the absence of space to explicate all of the linkages, let us just give a few examples: 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; Hilton, 2003; Stanovich, 2004, 2009). Moreover, suboptimal investment decisions have been linked to overconfidence in knowledge judgments, the tendency to overexplain chance events, and the tendency to substitute affective valence for thought—all of which are components of our rational thinking test. Errors in medical decision making and legal decision making have also been linked to specific irrational thinking tendencies that we will assess in our instrument. And it is critically important to state, once again, that intelligence provides insufficient inoculation against these thinking errors and their negative consequences.

Enhancement of Rational Thinking

Although the basic architecture of human cognition makes us all prone to judgment and decision-making errors, knowledge about the processes that underlie these errors and the situations that make them likely can serve as a pedagogical guide. There

Table 2. A Graphical Depiction of the XYZ Problem Demonstrating How the Elements in Diagnostic Problem Can Be Made Relatively Transparent for Bayesian Reasoning.

Base Rate of XYZ Virus 1 in 1,000 People			
1 Has Virus		999 Do Not Have Virus	
Correct Positives	False Negative	False Positives	Correct Negatives
100% of 1 1 Correct positives	0% of 1 (0 False negatives)	5% of 999 ∼ 50 False positives	95% of 999 (∼ 950 Correct negatives)

You know that the test result is positive.
Is this positive a correct positive or a false positive?
How many correct positives and false positives you would expect if 1,000 people were tested?
1 Correct positive (has virus)
+ **50** False positives (not have virus)
51 Total positives
1 Correct positive/**51** total positives = **.02 or 2%** chance a correct positive (has XYZ virus)

is no reason why we must live with this status quo. We can do better. We can acquire strategies and habits that make our judgments and decisions less error prone. By so doing, we can increase the likelihood of achieving our goals and improving the veracity of our beliefs. Insight about the types of errors that we are likely to make can reduce our natural tendency to be unduly overconfident about the quality of our judgments. It can motivate us to cultivate effective habits like that of approaching problems, particularly problems that are important to us, in a flexible and reflective fashion.

Our thinking is vulnerable to a variety of irrational framing effects. For example, many people are willing to pay more for hamburger meat labeled 94% fat free than for the same meat when labeled 6% fat. Many physicians are more likely to recommend a life-extending surgical procedure for cancer patients who are described as having a 1-month survival rate of 90% than the same procedure when it is described as having a 1-month mortality rate of 10%. Knowledge of the extent to which we are susceptible to being unduly affected by irrelevant framing and context can motivate the development of the productive habit of routinely examining options from multiple frames or perspectives. Decision making can improve by employing the simple strategy of reminding yourself to "think/consider the opposite."

A lack of knowledge of scientific and probabilistic thinking accounts for much potentially avoidable irrational thinking. Educational experiences that emphasize the importance of using control groups, exploring and testing alternative hypotheses, and looking for falsifying information are important. Without knowledge of basic probability theory, people routinely make strikingly poor decisions about probabilistic situations. Even individuals with substantial sophistication about probability can slip into a cognitive miserly style of thinking that results in their being remarkably insensitive to important factors such as sample size and regression to the mean. Educational experiences that cultivate a practical understanding of basic probabilistic thinking can be invaluable. It is also important to cultivate an awareness of the need to avoid miserly thinking about probability and randomness so that acquired probabilistic knowledge will actually be used effectively.

Both medical personnel and laypeople often make dramatically inaccurate estimations of the likelihood that an individual has a disease, when given information about a diagnostic test's correct positive rate, its false-positive rate, and the disease's incidence (i.e., its base rate). Learning about the importance of overcoming the tendency to ignore base-rate information and how to reason in a Bayesian fashion has the potential to dramatically improve the accuracy of these types of decisions. Augmentation of classroom discussions with graphical depictions of problems can be very helpful. Table 2 shows a graphical depiction of the XYZ problem discussed earlier to demonstrate how the elements in a diagnostic problem can be made relatively transparent for Bayesian reasoning.

Teachers can also find a more detailed discussion of ways to enhance rational thinking in Chapter 10 of Stanovich (2011). In addition, a chapter by Toplak, West, and Stanovich (2012) describes a wide variety of efforts to train and improve various different components of rational thinking. Table 4.1 in Toplak et al.'s (2012) chapter also includes a list of several relevant empirical studies.

Conclusions

When a layperson thinks of individual differences in reasoning, he or she often thinks of IQ tests. This thinking is quite natural 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; Hunt, 2011). Nonetheless, certain 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" (e.g., adaptation to the environment, showing wisdom, creativity, and so on), despite the fact that existing tests of intelligence do not measure these aspects. 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. The grounded view of intelligence then takes the operationally defined construct and validates it in studies of brain injury, educational attainment, cognitive neuroscience, developmental trends, and information processing.

The operationalization of rationality is different from that of intelligence and thus, as every introductory psychology student is taught, the concepts must be treated differently. Our comprehensive test of rational thinking will go a long way toward grounding the rationality concept—a concept that captures aspects of thought that have heretofore gone unmeasured.

In summary, we have coherent and well-operationalized concepts of rational action and belief formation. We also 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, differentiating the concepts will result in scientific progress. We have a decade-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.

Authors' Note

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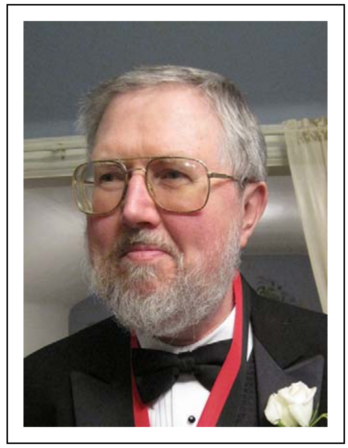
Author Biographies



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