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naturally find their dual process theory very congenial to our own (Evans & Over 1996) and note that their Systems 1 and 2 develop the rudimentary notions of type 1 and type 2 processes first discussed by Wason and Evans (1975). We limit our comments on their paper, however, largely to their distinction between what they call evolutionary rationality and normative rationality. It is better, we think, to describe normative rationality as individual rationality. Both types of rationality are broadly instrumental, as S&W realize. Evolutionary rationality can be thought of as serving the metaphorical goal of the genes, that is, reproductive success. Individual rationality serves the goals of the whole individual, which can be many and varied in different individuals and have to do with avoiding reproduction altogether.

In our own theory, we distinguish rationality 1 from rationality 2. The former results from implicit type 1 or System 1 processes, and the latter from explicit rule following in type 2 or System 2 processes. As S&W point out, our distinction is between different mechanisms – tacit heuristics versus reason-based rule following – for achieving individual goals and so individual rationality. We had already identified the need for an explicit System 2 of hypothetical thinking to account for rationality 2, but we now know from S&W's work that the facility for this rationality is related to measures of general intelligence. The question is how to apply these distinctions usefully to the notion of evolutionary rationality.

S&W are certainly right to emphasize the distinction between evolutionary and individual rationality, as serious confusion may result from the failure of psychologists to pay attention to it. For example, the group they call the cognitive ecologists as well as many evolutionary psychologists presuppose that what has evolutionary or ecological rationality (Todd & Gigerenzer, this issue) also has individual rationality. This group does sometimes argue that the heuristics they try to discover were adaptive under primitive conditions, but still tends to presuppose that these heuristics always have individual rationality in the contemporary world. It would be more plausible to argue, on the contrary, that these heuristics can be the source of biases in advanced technological societies. And however rare the bias, demonstrating its presence is good evidence for the existence of the heuristic. The Panglossian perspective of this group may have prevented them from getting better experimental evidence for their heuristics and making a positive contribution to the heuristics and biases literature.

System 1 heuristics can produce damaging biases for individuals, but we agree with S&W that System 1 not only contributed to evolutionary rationality, but still on the whole facilitates individual rationality. The more interesting question concerns System 2 and the rationality 2 which comes with it. S&W say that System 2 acts more to serve individual rationality than evolutionary rationality, but in some tension with this, they add that System 2 evolved by natural selection. However, consider the technical concept of heritability and its relation to adaptation. Heritability is the proportion of phenotypic variance which is due to the genes. It is arguable that an adaptation should generally have low heritability. For example, take the ability to speak a natural language as an adaptation. It has low heritability, for if a human being fails to have a high level of this ability, that is probably the result of nongenetic influence, like being severely neglected as a child. But the vast literature on intelligence implies that having a high IQ is not like that – much more of the variance in IQ is down to the genes. Thus, it could be suggested that System 2, which S&W link to high IQ, is not an adaptation. Indeed there are evolutionary psychologists who deny the existence of System 2 as an adaptation and reject any dual process theory as an account of the natural human mind (Tooby & Cosmides 1992).

We ourselves hold that a basic level of System 2 ability and rationality 2 contributed to reproductive success under primitive conditions, at least by helping with novel problems (Evans & Over 1997; Over & Evans 1997). But it may be that the development of large brains with the capacity for language and explicit rule following coincided with and contributed to the curtailing of the influence of natural selection on our gene pool. That is, once humans became social and communicating animals with organized social structure, the presence of highly intelligent people, with high System 2 ability, boosted the development of culture and technology, without contributing differentially to their own reproductive success, but benefiting everyone more equally in this respect. In other words, highly intelligent people may have themselves, in effect, prevented their level of System 2 ability from becoming more widespread.

Data, development, and dual processes in rationality

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Abstract: Although Stanovich & West (S&W) are likely to be criticized for not proposing a process model, results of such a model (fuzzy-trace theory) support many of their conclusions. However, arguments concerning evolution and Gricean intelligence are weak. Finally, developmental data are relevant to rationality, but contradictory results suggest a dual-processes approach that differs from S&W's based on fuzzy-trace theory.

Stanovich & West (S&W) have brought the discussion of rationality back to data, after a period of mostly post hoc speculation. With due reverence for philosophy, they rightly argue that an entire dimension of data has been ignored, namely, individual differences. A likely criticism of this approach is that it is not process oriented. I accordingly begin by noting results predicted by a process-oriented theory (Fuzzy-trace theory) that support many of S&W's conclusions. Next, I discuss weaknesses of arguments concerning evolution and Gricean maxims that are used to characterize intuitive processes.

Last, I discuss an additional stream of research that S&W claim, on analogy with individual differences, is relevant to rationality: developmental data. Contrary to their claim, however, a major theme of such research is that heuristics and biases increase with age, despite parallel improvements in computational competence. This paradox, along with task analyses in adult reasoning, have been pivotal in formulating an alternative to both the heuristics/biases (irrationality) and the adaptive/ecological (rationality) frameworks, fuzzy-trace theory. Fuzzy-trace theory offers a dual-process account of rationality grounded in memory research that differs in important respects from other dual-process approaches, including S&W's.

S&W provide evidence that diverse reasoning tasks are related to one another and to SAT scores. Computational capacity has been investigated in these tasks, but has been ruled out (for literature reviews, see Reyna 1992; 1995). Limitations of correlational analyses, as used by S&W, have also been discussed (Brainerd & Reyna 1992a; 1992b; Brainerd et al. 1999; Reyna & Brainerd 1990). However, cognitive mechanisms have been found that are operative across tasks. In 1991, Reyna extended fuzzy-trace theory's process model of inclusion illusions to syllogistic reasoning, conditional probability judgment, base-rate neglect, class-inclusion errors, and the conjunction fallacy. Reasoning errors were explained by interference from inappropriate gist representations, from irrelevant reasoning principles, and, most important, processing interference from nested classes (Brainerd & Reyna 1990; 1993; Reyna 1995; 1996; Reyna & Brainerd 1993; 1994; 1995; Reyna et al., in press; Wolfe 1995). Dempster (1992) and others have argued that individual differences in susceptibility to interference account for relations across tasks, consistent with S&W's data.

Consistent with S&W's attribution of framing effects to intuitive processing, research has shown that analytical, quantitative processing reduces such effects and categorical, qualitative processing increases them (Reyna & Brainerd 1991; 1995). S&W ascribe intuitive processing to evolutionary adaptation and interactional intelligence that "support[s] a Gricean theory of communication." The main "evidence" for the evolutionary argument is that subjects give intuitive responses. However, the mere existence of a bias or behavior is not evidence that it is adaptive.

As for Gricean intelligence, similar arguments were made in the developmental literature when children failed Piagetian tasks. The denouement in that literature, as in this one, is that effects remained when ambiguities and supposed Gricean implicatures were controlled for (Reyna 1991; Reyna & Brainerd 1991; Tversky & Kahneman 1983). Unfortunately, post hoc speculations about Gricean maxims are accepted at face value. For example, it is claimed that Gricean maxims encourage the inference that 200 "or more" people are saved in the framing disease problem. However, these speculations actually violate Grice's maxim of quantity (Clark & Clark 1979; Grice 1978). Speakers are not supposed to omit crucial information. For example, failing to mention that the "woman" a man is meeting tonight is his wife violates the maxim of quantity (if you knew she was his wife, you should have said so). Thus, the Gricean prediction is that if more than 200 people might be saved, a cooperative speaker would have said so.

Without the justification of evolutionary adaptation or Gricean implicatures, what evidence remains for dual-process approaches? I have argued that developmental data are a crucial source of evidence implicating dual processes (Reyna & Brainerd 1994, 1995; 1998). Developmental theorists have assumed that development unfolds in the direction of increasing rationality, as knowledge and experience increase (Piaget 1953; Werner 1948). However, framing biases increase with age, and processing becomes more intuitive (Reyna 1996; Reyna & Ellis 1994). Other biases also increase with development, such as availability, representativeness, and noncompensatory decision-making (Byrnes 1998; Davidson 1995; Jacobs & Potenza 1991). Finally, college students fail Piagetian concrete operational tasks such as conservation of mass (Winer et al. 1992). For example, they think that they weigh more sitting down than standing up.

Across the same age range in which the use of heuristics and biases is increasing, computational competence as tapped by traditional cognitive developmental tasks (class inclusion, conservation, probability judgment) is also increasing. These contradictions across ages and across tasks (within individuals of the same age) provide a major motivation for fuzzy-trace theory's approach to rationality (Klaczynski & Fauth 1997; Reyna & Brainerd 1995). Such task variability cannot be reduced to either Type I or II measurement error, arguing against both the Meliorists (competence is overestimated) and the Panglossians (competence is underestimated).

In sum, a decade of adult and developmental data leads to a conception of rationality that differs from those discussed by Stanovich & West, but which reconciles seemingly contradictory results. Key points of departure include the following: (1) Reasoners encode multiple gist and verbatim representations, which confers cognitive flexibility. (2) However, reasoning operates at the least precise level of gist that the task allows, increasingly so with development. (3) This fuzzy processing preference explains why reasoning has been found to be independent of computational capacity. (4) Thus, rationality is identified with gist-based reasoning rather than with precision as in computational or logicist theories. Despite predictable pitfalls, reliance on gist across superficially different problems is essential for achieving descriptive invariance – the fundamental criterion of rationality. (5) Finally, a given response can reflect more or less rationality depending on the processing used to generate it. Levels of rationality are predicted based on task features and the developmental status of the reasoner. Therefore, rationality is not an immutable aptitude of individuals, but changes from task to task and from one stage of life to another.

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An elitist naturalistic fallacy and the automatic-controlled continuum

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Abstract: Although a focus on individual differences can help resolve issues concerning performance errors and computational complexity, the understanding/acceptance axiom is inadequate for establishing which decision norms are most appropriate. The contribution of experience to automatic and controlled processes suggests difficulties in attributing interactional intelligence to goals of evolutionary rationality and analytic intelligence to goals of instrumental rationality.

Stanovich & West (S&W) have made an important contribution to the rationality debate by focusing on the value of the individual differences approach in identifying markers of performance errors and computational limitations. Nevertheless, there is a danger of overstating how much the individual differences approach can buy. S&W's operationalization of Slovic and Tversky's (1974) understanding/acceptance assumption equates normative behavior with the response of individuals who are of high intelligence (as measured by SAT scores). Their position is hence an elitist version of the naturalistic fallacy wherein normative status is ascribed to what more intelligent people do. Although we might expect that those with superior intellectual skills will often adopt better decisions strategies, this seems an inadequate criterion for rationality. Where is the reference to actual success in the environment? S&W seem to suggest that rationality should be defined by what intelligent people do without checking to see in each instance whether the intelligent people end up any better off.

At best, the understanding/acceptance assumption can be viewed as a necessary but not a sufficient criterion for rational behavior. Approaches that are regularly eschewed by intelligent people are not likely to be adopted as normative. S&W (sect. 4.2) argue the converse, borrowing from Larrick et al. (1993): "Because intelligence is generally regarded as being the set of psychological properties that makes for effectiveness across environments . . . intelligent people should be more likely to use the most effective reasoning strategies than should less intelligent people." This view is oversimplified because it suggests (a) that intelligent people will be in agreement on the best course of action in a given situation and (b) that "general regard" for what contributes to effectiveness across environments can stand in for empirical evidence of decision quality across innumerable specific situations.

Rationality requires objective criteria so that it can be distinguished from mere opinions about what is best. If no such criteria are available, the rationality argument is likely to remain hopelessly moot. In cases such as formal logic, for which proofs are available to establish the validity of reasoning, rationality may be easier to define than in cases such as risky choice, for which acceptability of axioms is hotly debated. There are intelligent people on both sides of the fence. Moreover, locally non-normative strategies may be globally functional (e.g., optical illusions can result from responding to the same cues that enable depth perception), adding to the complexity of identifying reasonable criteria.

S&W's argument regarding the limitations of using central ten-