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Individual differences in cognitive biases: Evidence against one-factor theory of rationality☆

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ABSTRACT

In this paper we seek to gain an improved understanding of the structure of cognitive biases and their relationship with measures of intelligence and relevant non-cognitive constructs. We report on the outcomes of a study based on a heterogeneous set of seven cognitive biases — anchoring effect, belief bias, overconfidence bias, hindsight bias, base rate neglect, outcome bias and sunk cost effect. New scales for the assessment of these biases were administered to 243 undergraduate students along with measures of fluid (Gf) and crystallized (Gc) intelligence, a Cognitive Reflection Test (CRT), Openness/Intellect (O/I) scale and Need for Cognition (NFC) scale. The expected experimental results were confirmed — i.e., each normatively irrelevant variable significantly influenced participants' responses. Also, with the exception of hindsight bias, all cognitive biases showed satisfactory reliability estimates ($\alpha s > .70$). However, correlations among the cognitive bias measures were low ($rs < .20$). Although exploratory factor analysis produced two factors, their robustness was doubtful. Cognitive bias measures were also relatively independent ($rs < .25$) from the Gf, Gc, CRT, O/I and NFC and they define separate latent factors. This pattern of results suggests that a major part of the reliable variance of cognitive bias tasks is unique, and implies that a one-factor model of rational behavior is not plausible.

1. Introduction

Intelligence encompasses a very broad range of cognitive processes and empirical evidence for its generality is derived from the presence of positive manifold and the finding of about .30 average correlation between a large collection of cognitive tests (see Carroll, 1993). Developments from the outside of individual difference tradition may lead to creation of new types of cognitive tasks that can enrich our understanding of intelligence. A good example has been the study of working memory (Baddeley & Hitch, 1974). Recently, Stankov (2013) has pointed out that some measures of rationality – e.g., measures of scientific and probabilistic reasoning (Stanovich, 2012) – may reach .25 to .35 correlation with tests of intelligence. Although there is paucity of information about psychometric properties of measures of rationality, Stankov (2013) stated that "… cognitive measures based on studies of decision making and principles of scientific and probabilistic reasoning are perhaps the most interesting recent addition to the study of intelligence …" (p. 728). He also pointed out that since probabilistic reasoning and scientific reasoning are known to be open to cognitive biases which, as we shall see shortly, do not always show correlations with intelligence, it is important to study cognitive as well as non-cognitive aspects of the latter.

In this paper we examine factorial structure of rational reasoning tasks used to assess seven cognitive biases and relate these to the well-known psychometric measures of intelligence and aspects of personality and thinking dispositions. Two plausible outcomes can be anticipated. First, there may be

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sufficient evidence for communality among the bias measure and one or more well-defined bias factors, correlated with tests of intelligence, may arise. This would place cognitive bias measures well within the traditional understanding of intelligence. Second, there may be poor support for the presence of either common factors or for the correlation of bias measures with tests of intelligence. While this outcome would not necessarily place cognitive biases outside cognitive domain, their standing would become restricted to a relatively narrow domain of decision making. Under this latter scenario, cognitive biases will have a status similar to some of the measures from neuropsychology; they are employed to detect cognitive deficits but are infrequently used in mainstream intelligence assessment.

1.1. Cognitive biases as departures from normative models of rationality

Empirical research in the areas of judgment and decision making, as well as memory and reasoning, has produced reliable evidences that the outcomes of cognitive processes often systematically depart from what is normatively predicted to be rational behavior. With the arrival of the heuristics and biases research program in the early 1970s, these findings have been referred to as cognitive biases[1] (see Method section for example tasks) that arise as a consequence of heuristics, that is, experience-based strategies that reduce complex cognitive tasks to simpler mental operations (Gilovich, Griffin, & Kahneman, 2002; Kahneman, Slovic, & Tversky, 1982; Tversky & Kahneman, 1974). By producing many cognitive bias tasks that depict circumstances under which relying on heuristics leads to systematic violations of normative models, this program emphasized the conditions of *predictable irrationality* (Ariely, 2009).

On the other hand, proponents of ecological rationality have argued that rational behavior should not be defined with respect to abstract normative standards, or – as Gigerenzer (2004) puts it – "rationality is not logical, but ecological" (p. 64). Within this paradigm, cognitive biases are not considered as errors of cognitive processing, but rather a result of highly constrained and artificial experimental conditions since cognitive bias tasks diverge considerably from those in the natural environment (Gigerenzer, 1996, 2004; Gigerenzer, Hoffrage, & Kleinbölting, 1991; Hertwig, Fanselow, & Hoffrage, 2003; Hoffrage, Hertwig, & Gigerenzer, 2000).

It was only in the late 1990s that researchers became cognizant of the considerable variability across participants on each of the cognitive bias tasks. After Stanovich and West's (1998, 2000) call for a debate about the role individual differences play in the deviation between the outcomes of cognitive process and those of normative models, a growing body of correlational studies of cognitive biases emerged. Two separate topics, which can be distinguished from the perspective of differential psychology, are briefly summarized in the following sections.

1.2. Correlates of cognitive biases

Intelligence was undoubtedly the prime candidate for predicting individual differences in cognitive biases. The initial findings of negative modest correlations of intelligence tests with belief bias, confirmation bias, base rate neglect, outcome bias, overconfidence bias and hindsight bias were interpreted as clues about the importance of algorithmic limitations in the emergence of predictable fallacies (Stanovich & West, 1998, 2000). However, some studies suggest that at least two cognitive biases included in the present study – anchoring effect (Furnham, Boo, & McClelland, 2012; Stanovich & West, 2008) and sunk cost effect (Parker & Fischhoff, 2005; Stanovich & West, 2008) – may not be related to cognitive ability measures. As a result of the most comprehensive study on this subject, Stanovich and West (2008) have provided lists of cognitive biases that do and do not show association with intelligence and have argued that the correlation should be expected only when considerable cognitive capacity is required in order to carry out the computation of a normatively correct response to a bias task.

Some other aspects of cognitive functioning are also related to cognitive biases. Previous research has shown that low scores on the Cognitive Reflection Test (CRT), which was devised as a measure of "the ability or disposition to resist reporting the response that first comes to mind" (Frederick, 2005, p. 36), are related to probability overestimation (Albaity, Rahman, & Shahidul, 2014), conjunction fallacy (Hoppe & Kusterer, 2011; Oechssler, Roider, & Schmitz, 2009) and impatience in time-preference judgment (Albaity et al., 2014; Frederick, 2005). CRT is also related to performance on a broad range of cognitive bias tasks and it has predictive validity over and above intelligence (Toplak, West, & Stanovich, 2011, 2014). This is reminiscent of Stanovich's assertion that individual differences in the detection of the need to override heuristic responses, that are assessed by the scales of Actively Open-Minded Thinking and Need for Cognition (Stanovich, 2009, 2012; Stanovich & West, 2000, 2008), may be related to cognitive biases. Similarly, it is plausible to assume that the personality trait of Openness/Intellect, which is associated with cognitive performance, may also account for variance in performance on cognitive bias tasks.

1.3. Relationships among cognitive biases

The other topic deals with the generality of individual differences in cognitive biases, and questions how these biases are related to each other. De Bruin, Parker, and Fischhoff (2007) have stated that positive manifold among cognitive bias tasks might indicate an underlying ability construct which they have termed the decision-making competence. Stanovich and West (1998) were the first to report significant positive correlations among belief bias, base rate neglect and outcome bias (Experiment 1), as well as between overconfidence and hindsight bias (Experiment 4).

Subsequent studies have shown that reliability of composite scores derived from a relatively large set of bias tasks is poor (Toplak et al., 2011, 2014; West, Toplak, & Stanovich, 2008) and that correlations among cognitive biases are only of modest strength (Klaczynski, 2001; Stanovich & West, 1998, 2000). Eventually, it became clear that it is possible to extract at least

[1] Systematic departures from normative models are sometimes referred to as *cognitive illusions* (Pohl, 2004), *thinking errors* (Stanovich, 2009) and *thinking biases* (Stanovich & West, 2008).