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General intelligence predicts reasoning ability even for evolutionarily familiar content

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ABSTRACT

The existence of general-purpose cognitive mechanisms related to intelligence, which appear to facilitate all forms of problem solving, conflicts with the strong modularity view of the mind espoused by some evolutionary psychologists. The current study assessed the contribution of general intelligence (*g*) to explaining variation in contextualized deductive reasoning. One hundred and twelve participants solved 70 contextualized reasoning problems in a computerized version of the Wason Card Selection Task that recorded both accuracy and reaction time. Consistent with prior research, in the sample as a whole, precautionary and social exchange reasoning problems were solved more frequently and more quickly than reasoning problems about arbitrary rules. At the individual-differences level of analysis, however, performance on all reasoning tests was significantly correlated and loaded on a single deductive-reasoning accuracy factor. Further, this factor was significantly correlated with *g*. There was no relation, however, between *g* and the speed of arriving at the correct answer for any form of deductive reasoning. We discuss the implications of these findings for evolutionary psychology, intelligence, and reasoning.

1. The role of general intelligence in contextualized deductive reasoning

Over 100 years ago, Spearman (1904) first discovered a consistent tendency for a diverse range of cognitive tests with differing content to be positively correlated with one another, a phenomenon he described as the "positive manifold," which suggests the existence of a general intelligence factor (*g*). The existence of the *g* factor is such a robust finding that one should expect performance on any reasonably complex explicit cognitive task (in contrast to implicit cognitive tasks such as implicit learning) to be associated with *g* (Carroll, 1993; Chabris, 2007; Gottfredson, 2002; Jensen, 1998; Johnson & Bouchard, 2005). A standard hypothesis in factor analysis is that the variables loading on a single factor co-vary due to a shared underlying cause or set of causes (Haig, 2005; although this is not a necessary condition for the existence of a factor; Bartholomew, Deary, & Lawn, 2009). The existence of *g* thus suggests the possibility of causal forces that influence performance on most complex cognitive tasks. These forces might be of at least two kinds: (1) problems such as genetic mutations or developmental abnormalities that influence many different cognitive mechanisms (Keller & Miller, 2006; Arden, Gottfredson, Miller, & Pierce, 2009; Yeo, Gangestad, Liu, Calhoun, & Hutchison, 2011); (2) cognitive mechanisms that are utilized to some extent in most or all complex

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cognitive tasks. In the present study we focus on the second of these possibilities, but note that the two are not mutually exclusive. Psychological and neural evidence suggests that *g* is not caused by a single unitary process, but is instead the result of multiple cognitive mechanisms (Jung & Haier, 2007; Kaufman, DeYoung, Gray, Brown, & Mackintosh, 2009; van der Maas et al., 2006).

Constructs, like *g*, that describe dimensions of variation in a population are neither identical to nor necessitate constructs, like cognitive mechanisms, that refer to processes in an individual. However, individual-differences research can provide relevant evidence to link the two types of construct using the principal that if process X is involved in trait Y, then individual differences in X should predict individual differences in Y (though, of course, the correlation of X and Y does not provide evidence that X causes Y). Some evidence exists to suggest that cognitive processes like working memory, explicit associative learning, and information processing speed are cognitive mechanisms involved in general intelligence (Kaufman et al., 2009). Nonetheless, the existence of cognitive mechanisms for general intelligence is controversial in evolutionary psychology. A central tenet of evolutionary psychology is that natural selection sculpted the human mind to solve specific recurring problems of survival and reproduction, and that therefore the mind consists of multiple domain-specific mental mechanisms or "modules" that are activated by specific contexts (Cosmides & Tooby, 2001). At first blush, the existence of a general factor of intelligence might appear incompatible with a strong modularity view of human cognition because *g* is domain-general rather than domain-specific: it is associated with performance on cognitive tasks in a multitude of different contexts. Although a number of evolutionary psychologists have acknowledged the existence of domain-general cognitive processes, and some have explicitly related them to *g* (e.g., Chiappe & MacDonald, 2005; Deaner, van Schaik, & Johnson, 2006; Geary, 2004, 2009; Penke, 2010; Sperber, 1994), evolutionary psychologists often downplay their importance relative to domain-specific modules (Cosmides, Barrett, & Tooby, 2010; Cosmides & Tooby, 2001).

In the present study, we explored this tension between evolutionary psychology and the theory of general intelligence by examining individual differences in a cognitive paradigm that has been used extensively by evolutionary psychologists to provide evidence that cognitive abilities are domain-specific rather than domain-general: the Wason four-card selection task (Wason, 1968). In the Wason task, participants consider a rule of the generic form "If P then Q" along with four cards describing P or not-P on one side and Q or not-Q on the other (with one of each type face up). The participant is told to indicate only the cards that definitely must be turned over to determine if the rule is being broken (correct answer: P and not-Q).

The selection task is a useful tool to investigate the nature of human cognition because it is sensitive to the content and context of presentation (Evans, 2003): performance is typically poor when rules are decontextualized, abstract, or arbitrary in nature, but often quite good when problems involve potential transgressions of social norms or precautionary reasoning about physically dangerous situations (Cosmides, 1989; Fiddick, Cosmides, & Tooby, 2000; Gigerenzer & Hug, 1992).

Contextualized deductive reasoning involves if-then reasoning put into a narrative vignette context. "Social exchange" problems concern the mutual exchange of goods or services between individuals in specific situations. The rules generally involve detecting if one party might be taking a benefit without fulfilling an obligation (e.g., "If you borrow my motorcycle, then you have to wash it."). "Precautionary" problems involve rules related to avoiding potential physical danger (e.g., "If you surf in cold water, then you have to wear a wetsuit"). "Arbitrary-rule" problems (Cheng & Holyoak, 1985) have arbitrary rules (e.g., "If the soda is diet, then it has to be in a purple container") that are nonetheless contextualized in realistic scenarios. Note that by "arbitrary," we are not referring to cultural rules that are evolutionarily arbitrary but might nonetheless be influenced by evolved heuristics regarding social exchange or social norms (e.g., men must take off their hats indoors, but women may leave them on). Rather, these rules are arbitrary in that they do not correspond to established rules in the individual's experience.

The difference in performance on precautionary and social exchange vs. arbitrary-rule problems has been explained with reference to the concept of modularity (Cosmides & Tooby, 2004; Cosmides, 1989). Reasoning about social exchange and precautions is hypothesized to be supported by dedicated information processing modules that result from evolutionary selection pressure exerted by situations involving social exchange or physical danger. No such pressure has been exerted by situations involving the arbitrary rules, and thus the human mind does not have a cognitive module that allows accurate reasoning about arbitrary rules.

Note that this hypothesis describes the cognitive functions of humans as a group, and says nothing regarding individual differences. Indeed, evolutionary psychology has generally had little to say about individual differences, in part because of the assumption that, for any trait important to fitness, selection pressure would reduce variance around an optimal level of the trait, with individual differences being mere random noise. Recently, however, more attention has been paid to evolutionary processes that would maintain variation in traits that do have adaptive significance, including fluctuating selection (in which higher levels of a trait are more adaptive in some environments and lower levels are more adaptive in others) and the difficulty of maintaining certain traits in the face of factors (such as deleterious mutations) that reduce fitness (Arden et al., 2008; Buss & Hawley, 2010; Furlow, Armijo-Prewitt, Gangestad, & Thornhill, 1997; Prokosch, Yeo, & Miller, 2005; ; Keller & Miller, 2006; Miller, 2000; Nettle, 2006).

Intelligence has been proposed as an example of the latter process, which would make it a fitness indicator: higher intelligence would almost always be associated with increased fitness, but the biological difficulty of producing an individual with high intelligence would ensure that the population maintains a range of intelligence over time, despite selection pressure (Miller, 2000). These ideas open the door to reconciling the existence of general intelligence, both as a set of domain general cognitive mechanisms and as a trait with meaningful individual differences, with evolutionary psychology.

A number of researchers have attempted to unite evolutionary psychology with differential psychology (e.g., Penke, 2010; Kanazawa, 2010). Kanazawa (2004; 2010, but