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Effective decision making in complex situations: A matter of intelligence or cognitive style?

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ABSTRACT
We report an experiment assessing individual naturalistic decision making effectiveness in a complex simulated situation management task. The individual factors associated with success were mainly related to the cognitive style of participants rather than to the participant's fluid intelligence as measured by the Raven's advanced progressive matrices.

Keywords
Sensemaking, macrocognition, complexity, individual factors

1. INTRODUCTION
Naturalistic decision making (NDM) performance in complex simulated tasks (i.e., microworlds) is known to vary considerably across individuals. Several studies have found a relationship between scores on intelligence tests (particularly the Raven's advanced progressive matrices) and performance in microworlds (Elg, 2005; Gonzalez, Thomas & Vanyukov, 2005; Goode & Beckmann, 2010). However, these results are not consistent across studies (Kluwe, Shilde, Fisher, & Oellerer, 1991; Rigas & Brehmer, 1999). Previous microworld studies also found no significant relationship between personality type (e.g., Myers–Briggs test) and performance (Rouwette, Größler, & Vennix, 2004, Scott-Trees, Doyle, & Radzicki, 1996). Arguably, the main determinants of success may be the specific sensemaking behaviors (e.g., information acquisition, hypothesis formation, outcome assessment) of participants and the specific traits (e.g., cognitive style) that relate to them (see Dörner, 1996). Here we report an experiment that further investigates the relative contribution of intelligence and cognitive style on success of individuals in a complex NDM situation.

2. METHOD
Forty participants recruited at Université Laval took part in a 45-min practice session followed by a 90-min test session. The microworld, called Ecopolicy (MCB-Verlag, Munich) is a computer simulation that aims to educate people about the importance of "networked thinking", i.e., striving to understand how variables interrelate, when dealing with complex systems (Vester, 2007). Participants are in charge of managing a country for 12 simulated years (or turns), by allocating "action points" in one of four areas that can be influenced directly: sanitation, production, education, or quality of life. The state of the situation in a given year is described through eight variables that range from 0 to 30 (Politics, sanitation, production, environmental stress, education, quality of life, growth rate, and population). These eight dimensions mutually influence each other so that each decision results in a chain of effects within the system. Depending on its current value, each variable can be in a desirable or undesirable state as described by a five-color scale that goes from green to red. The goal of the participant is to bring all eight dimensions within the green zone by Year 12. Information about the underlying interrelationships and variables pertaining to this complex system was accessible to the participants. A striking aspect of this game is that even though causes and effects within the system are clearly shown, participants have a great difficulty bringing the system to the targeted state. This game highlights the pitfalls of focusing on isolated problems without carefully considering the whole set of interactions within the system.

The experiment involved two sub-groups of 20 participants each. One group benefited from the support of a decision aid while the other did not. The analyses evaluating the impact of the decision aid are reported elsewhere (see Lafond, DuCharme, St-Louis, & Tremblay, 2011). Below, we report correlational analyses for the whole 40-participant sample while controlling for the group effect using the partial correlations method (Prokhorov, 2001).

3. MEASURES
Performance (represented on a scale from 0 to 100) is measured by the combined relative distance of the eight variables of the society to the green value-range (i.e., this is a multicriteria optimization problem). A comprehension measure was also administered via computer at the end of each turn, testing the ability of the participants to anticipate proximal outcomes of the current situation. This measure requires mentally integrating all the interactions within the system in order to correctly extrapolate the value of each of the eight variables for the next turn. The comprehension score corresponds to the goodness-of-fit (R^2) of the participant's predictions.

The short version of Raven's advanced progressive matrices (APM) developed by Bors and Stokes (1998) is used as a non-verbal reasoning test, which measures the ability to recognize and combine complex visual patterns. The general decision making style (GDMS) inventory developed by Thunlholm (2009) is a 25-item questionnaire used to measure one's decision making approach along five dimensions: rational, intuitive, dependent, avoidant, and spontaneous. Finally, a post-experimental questionnaire asked participants to rate (on a 5-point likert scale) their overall decision making behavior during the task along five dimensions: focalized vs. integrative, short vs. long term, reactive vs. proactive, intuitive vs. analytic, and simple vs. elaborate.

4. RESULTS
For each statistical test, an alpha level of .05 was selected as the criterion for rejecting the null hypothesis. The Raven's APM was found to be significantly correlated to the comprehension measure, $r(36) = .404$, $p = .012$, but not to performance $r(36) = .030$, $p = .086$. None of the five dimensions of the GDMS were correlated to performance, yet the intuitive decision style was significantly (negatively) correlated to the comprehension measure, $r(36) = -.403$, $p = .012$. Among the five dimensions in the post-experimental questionnaire, individual performance was significantly correlated to three: focalized/integrative, $r(36) = .337$,

p = .038, reactive/proactive, r(36) =.426, p = .008, and intuitive/analytic, r(36) =.325, p = .047. All the significant correlations reported above are of moderate size (i.e., ranging between .3 and .5).

5. DISCUSSION

The present findings show mixed results concerning the relationship between intelligence and NDM effectiveness. While intelligence is not a reliable predictor of performance in the present task, it is related to how well participants understand the interrelationships within that system, which arguably is of key importance. The comprehension measure may be more reliable than the measure of performance since the former was measured multiple times (each turn) whereas the latter involved a single measurement. The lack of a relationship with performance may therefore be due to a lack of reliability of this measure (see also Rigas, Carling, & Brehmer, 2002). Results show that taking an intuitive approach may not be favorable when dealing with complex systems. A more analytic, integrative and proactive approach seems to be important to improve the likelihood of success. Further research will test other individual factors such as general risk aversion (Mandrik & Bao, 2005) and ambiguity tolerance (Norton, 1975). We conclude that cognitive style may play a prominent role in determining success in complex NDM situations, and that it may take precedence over the fluid intelligence of individuals.

The recognition-primed decision making (RPD) model (Klein, 1993) can help understand the present findings – even though decision makers were not domain experts in this fictitious task. The RPD model includes three variants that refer to situations with varying degrees of uncertainty and complexity. Variant 1 is the quickest decision process and involves situation recognition and recall of an effective response. Variant 2 takes more time and requires a diagnosis of the situation first (i.e., feature matching or story building). Variant 3 also takes more time and requires an evaluation of possible courses of action. The complex society management task presented herein involved high novelty (little or no past experience or repetition of events) and did not involve time pressure. This highly complex task thus required a combination of the processes described in variant 2 and variant 3. Thus, in such a situation, the RPD model suggests that effective decision makers need to both diagnose the situation and evaluate courses of action. The RPD model may therefore explain why – in the present context – the decision makers' complex pattern recognition ability (as measured by Raven's APM) is not as important as taking a more analytic (yet informal and far from exhaustive), integrative and proactive approach to problem solving (i.e., sensemaking). One particular form of sensemaking – anticipatory thinking – may play a critical role in such NDM situations. Anticipatory thinking is fundamental to the generation of expectancies, attention management, problem detection, and planning (Klein, Snowden, & Chew, 2007). Indeed, we found that a decision aid designed to support anticipatory thinking improved performance in this task (Lafond et al., 2011).

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