The Measurement of Task Complexity and Cognitive Ability: Relational Complexity in Adult Reasoning

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STATEMENT OF ORIGINALITY

The work contained in this thesis has not been previously submitted for a degree at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

Damian Patrick Birney

Signed: _______________________________ Date: ________________________

7 March, 2002
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ABSTRACT

The theory of relational complexity (RC) developed by Halford and his associates (Halford et al., 1998a) proposes that, in addition to the number of unique entities that can be processed in parallel, it is the structure (complexity) of the relations between these entities that most appropriately captures the essence of processing capacity limitations. Halford et al. propose that the relational complexity metric forms an ordinal scale along which both task complexity and an individual’s processing capacity can be ranked. However, the underlying quantitative structure of the RC metric is largely unknown. It is argued that an assessment of the measurement properties of the RC metric is necessary to first demonstrate that the scale is able to rank order task complexity and cognitive capacity in adults. If in addition to ordinal ranking, it can be demonstrated that a continuous monotonic scale underlies the ranking of capacity (the natural extension of the complexity classification), then the potential to improve our understanding of adult cognition is further realised. Using a combination of cognitive psychology and individual differences methodologies, this thesis explores the psychometric properties of RC in three high level reasoning tasks. The Knight-Knave Task and the Sentence Comprehension Task come from the psychological literature. The third task, the Latin Square Task, was developed especially for this project to test the RC theory.

An extensive RC analysis of the Knight-Knave Task is conducted using the Method for Analysis of Relational Complexity (MARC). Processing in the Knight-Knave Task has been previously explored using deduction-rules and mental models. We have taken this work as the basis for applying MARC and attempted to model the substantial demands these problems make on limited working memory resources in terms of their relational structure. The RC of the Sentence Comprehension Task has been reported in the literature and we further review and extend the empirically evidence for this task. The primary criterion imposed for developing the Latin Square Task was to minimize confounds that might weaken the identification and interpretation of a RC effect. Factors such as storage load and prior experience were minimized by specifying that the task should be novel, have a small number of general rules that could be mastered quickly by people of differing ages and abilities, and have no rules that are complexity level specific.
The strength of MARC lies in using RC to explicitly link the cognitive demand of a task with the capacity of the individual. The cognitive psychology approach predicts performance decrements with increased task complexity and primarily deals with aggregated data across task condition (comparison of means). It is argued however that to minimise the subtle circularity created by validating a task’s complexity using the same information that is used to validate the individual’s processing capacity, an integration of the individual differences approach is necessary. The first major empirical study of the project evaluates the utility of the traditional dual-task approach to analyse the influence of the RC manipulation on the dual-task deficit. The Easy-to-Hard paradigm, a modification of the dual-task methodology, is used to explore the influence of individual differences in processing capacity as a function of RC. The second major empirical study explores the psychometric approach to cognitive complexity. The basic premise is that if RC is a manipulation of cognitive complexity in the traditional psychometric sense, then it should display similar psychometric properties. That is, increasing RC should result in an increasing monotonic relationship between task performance and Fluid Intelligence (Gf) – the complexity-Gf effect. Results from the comparison of means approach indicates that as expected, mean accuracy and response times differed reliably as a function of RC. An interaction between RC and Gf on task performance was also observed. The pattern of correlations was generally not consistent across RC tasks and is qualitatively different in important ways to the complexity-Gf effect. It is concluded that the Latin Square Task has sufficient measurement properties to allows us to discuss (i) how RC differs from complexity in tasks in which expected patterns of correlations are observed, (ii) what additional information needs to be considered to assist with the a priori identification of task characteristics that impose high cognitive demand, and (iii) the implications for understanding reasoning in dynamic and unconstrained environments outside the laboratory. We conclude that relational complexity theory provides a strong foundation from which to explore the influence of individual differences in performance further.