Complexity, Metacognition, and Fluid Intelligence

Lazar Stankov
The University of Sydney, Sydney, Australia

From among five tests of fluid intelligence employed in this study, two (Swaps and Triplet Numbers) were designed to investigate increases in complexity and difficulty. This was accomplished by manipulating the number of steps needed to reach a solution. The increase in task difficulty is related to changes in the overall performance levels that are reflected in arithmetic means. The complexity of a task is related to the increase in correlation with measures of fluid intelligence or in the increase in factor loadings on a fluid intelligence factor. Both these tendencies are present in the results of this study.

A metacognitive process of self-confidence was assessed by asking participants to indicate how confident they were that the item they have just answered was correctly solved. A metacognitive process of self-evaluation was assessed by estimating the number of correctly solved items at the end of each test. The analyses of the overall performance also indicate that an "easy/difficult" distinction provides a reasonable account of the calibration data that show over- and underconfidence. Exploratory and confirmatory analyses indicate the presence of a relatively strong self-confidence factor. Confirmatory analysis also indicates the presence of a self-evaluation factor.

The aims of this study are twofold: the examination of the role of cognitive complexity in fluid intelligence and the identification of metacognitive factors in test performance. Cognitive complexity refers to the amount of common variance that a given test shares with a broadly defined cognitive ability (i.e., fluid intelligence). The expectation is that more complex tasks will have higher loadings on a broad factor.

Two types of metacognitive processes are of interest: self-confidence judgments (captured by measures of subjective probability that the answer that is provided to a test item is correct) and self-evaluation judgments (measured by the post-test estimate of the number of correctly solved items). Both self-confidence and self-evaluation can be compared to the actual performance measures (i.e., percentage correct scores) and an assessment of the accuracy of these two types of judgment can be obtained. Three outcomes are possible with respect to self-confidence: good calibration (i.e., close correspondence between judgment and performance) or two sub-divisions of poor

Direct all correspondence to: Dr. Lazar Stankov, Department of Psychology, The University of Sydney, Sydney, NSW 2006, Australia. E-mail: lazar@psych.usyd.edu.au

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calibration that can be conveniently classified as over- or underconfidence. Self-evaluation can also provide three outcomes: good self-evaluation and over- and under-evaluation. An issue of theoretical importance is whether self-confidence and self-evaluation are different at an empirical level. This can be resolved using two kinds of evidence. First, if at the overall level of analysis different degrees of realism are obtained from the measures of evaluation and confidence. Second, if factor analysis can identify two separate factors corresponding to self-confidence and self-evaluation.

Another issue of theoretical importance suggests a link between the notion of complexity and a metacognitive process tapped by self-confidence judgments. In particular, an important current debate in studies of probabilistic decision making is about the presumed causes of miscalibration of confidence judgments. One view holds that difficult tasks tend to show overconfidence and easy tasks tend to show good calibration or even underconfidence. This is the "easy/difficult" position. The other view holds that the main distinction is not in terms of task difficulty but rather with respect to the nature of the task. The claim is that perceptual tasks tend to show underconfidence and general knowledge tasks tend to show overconfidence. This is the "different processes" position. The present study is not designed to compare these two positions directly since it employs only fluid intelligence tests rather than perceptual or general knowledge tasks. It will, however, provide a check of the related assumption that there is no change in the nature (i.e., factorial structure) of the task as one moves from easy to difficult versions of the same test. This is relevant to both positions. If easy versions of the tasks turn out not to measure the same process as the difficult versions, the "different processes" position will be strengthened. If they all measure the same process, and there is a systematic reduction in overconfidence, as the tasks become easy, the "easy/difficult" position will gain support.

The Roots

The present approach derives from the psychometric tradition in psychology. Contemporary representatives of this tradition such as Carroll (1993), Cattell (1971), Horn (1997), Jensen (1998), Roberts and Goff (1997) continue the work of many predecessors with Spearman (1927) and Thurstone (1938) having the greatest influence. Our own work over the past decade deals with both methodological and substantive issues in the study of complexity (see Fogarty & Stankov, 1988; Myors, Stankov, & Oliphant, 1989; Raykov & Stankov, 1993; Roberts, Beh, & Stankov, 1988; Spilsbury, Stankov, & Roberts, 1990; Stankov, 1988a,b, 1989, 1994; Stankov & Crawford, 1993; Stankov & Cregan, 1993; Stankov & Myors, 1990; Stankov & Raykov, 1995; Stankov, Fogarty, & Watt, 1989; Stankov, Boyle, & Cattell, 1995) and metacognition (Crawford & Stankov, 1996, 1997; Kleitman & Stankov, in press; Stankov, 1998a,b; Stankov & Crawford, 1996a,b, 1997). Each term in the title of this manuscript has a rich background that needs to be spelled out in more detail.

Intelligence

Intelligence refers to fluid intelligence (Gf) or fluid reasoning ability. "This ability is measured in tasks requiring inductive, deductive, conjunctive, and disjunctive reasoning to arrive at understanding relations among stimuli, comprehend implications, and draw