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# Beyond IQ: A latent state-trait analysis of general intelligence, dynamic decision making, and implicit learning☆

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ABSTRACT

The present study investigated cognitive performance measures beyond IQ. In particular, we investigated the psychometric properties of dynamic decision making variables and implicit learning variables and their relation with general intelligence and professional success. $N = 173$ employees from different companies and occupational groups completed two standard intelligence tests, two dynamic decision making tasks, and two implicit learning tasks at two measurement occasions each. We used structural equation models to test latent state-trait measurement models and the relation between constructs. The results suggest that dynamic decision making and implicit learning are substantially related with general intelligence. Furthermore, general intelligence is the best predictor for income, social status, and educational attainment. Dynamic decision making can predict supervisor ratings even beyond general intelligence.



## 1. Introduction

General intelligence is one of the most successful psychological constructs. Since Spearman's (1904) early investigations, there is a wealth of evidence for the reliability, stability, and validity of intelligence measures (Carroll, 1993). Furthermore, general intelligence is a powerful predictor of success in many domains of real life (Ng, Eby, Sorensen, & Feldman, 2005; Salgado et al., 2003; Schmidt & Hunter, 2004). Beside its undisputed usefulness, some researchers have suggested to use additional constructs for characterizing individuals' cognitive ability such as dynamic decision making and implicit learning (Dörner, 1980; Mackintosh, 1998).

The concept of dynamic decision making was developed by Dörner (1980, 1986) who proposed that situations in real life are complex and solving problems in real life requires managing complex information. He criticized that standard measures of general intelligence only assess whether individuals perform accurately and quickly in rather simple tasks but not whether they show intelligent behavior in complex tasks. Therefore, he suggested to measure performance in computer based scenarios that simulate complex, connected, dynamic, and non-transparent environments. Further on, he hypothesized that individual differences in dynamic decision making are unrelated to general intelligence but are substantially related to professional success.

Mackintosh (1998) suggested to consider another construct. He proposed that there are two independent mental systems: an explicit, hypothesis generating and testing system and an implicit, associative learning system. In particular, the explicit learning system is necessary for discovering regularities with intention and awareness (like in a numerical series task). The implicit learning system, on the other hand, detects contingencies without awareness or intention (like judging whether a sentence is grammatically

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right or wrong without being able to report the respective grammatical rule). Mackintosh suggested that standard intelligence tests capture individual differences in the explicit system but not individual differences in the implicit learning system. Therefore, he suggested to take individual differences in implicit learning into account. He hypothesized that these differences are independent from general intelligence measures but are nevertheless important predictors of educational and professional success.

Dörner and Mackintosh's proposals raise two interesting questions. Are there reliable individual differences in dynamic decision making and implicit learning which are independent from general intelligence? Can these differences predict real life performance beyond IQ? Investigating these issues will be the aim of the present study.

### 1.1. Previous findings

#### 1.1.1. Dynamic decision making

Dörner's (1980, 1986) critique of standard intelligence tests laid the foundation for a field of research, which has been called *dynamic decision making* (Gonzalez, Vanyukov, & Martin, 2005) or *complex problem solving* (Funke, 2010). Over the years, several dynamic decision making tasks have been developed. For example, the Tailorshop scenario (Funke, 1983) simulates a fictional company where the participants have to control many variables like the number of workers or the costs for advertising to maximize their company value. Other tasks simulate a forestry (Wagener, 2001), a power plant (Wallach, 1998), or a space flight (Wirth & Funke, 2005) where the participants have to control several variables to reach a given goal state. Recently, dynamic decision making tasks have also been included in the Programme for International Student Assessment (PISA; Wirth & Klieme, 2003).

Over the years, there have been many studies investigating the relation between dynamic decision making and general intelligence. Whereas several studies found non-significant or only small correlations (for an overview see Kluwe, Misiak, & Haider, 1991), other studies reported significant standardized path coefficients between $\beta = 0.38$ and $\beta = 0.54$ from latent intelligence to latent dynamic decision making variables (Kröner, Plass, & Leutner, 2005; Rigas, Carling, & Brehmer, 2002; Wittmann & Hattrup, 2004). One study even found a correlation between a latent intelligence and a latent dynamic decision making variable of $r = 0.84$ (Wirth & Klieme, 2003).

There are only two studies that investigated the predictive validity of dynamic decision making measures. Wagener and Wittmann (2002) assessed a sample of $N = 35$ trainees and reported correlations between $r = 0.16$ and $r = 0.40$ between the performance in a dynamic decision making task and the performance in different assessment center tasks. However, the study did not report whether these relationships were incremental or due to an overlap between dynamic decision making and general intelligence. Kersting (2001) reported a correlation of $r = 0.37$ between the performance in a dynamic decision making task and supervisor ratings in a sample of $N = 73$ policemen. He further reported that this correlation remained significant after controlling for individual differences in general intelligence, $r = 0.29$, which points towards the incremental predictive validity of this dynamic decision making measure.

Taken together, these findings draw a rather heterogeneous picture of the relation between dynamic decision making and general intelligence and there is only preliminary evidence for the predictive validity of dynamic decision making variables.

#### 1.1.2. Implicit learning

Mackintosh (1998) suggested to use artificial grammar learning tasks (Reber, 1967) to measure performance differences in implicit learning. In such a task, the participants are asked to learn a list of apparently arbitrary letter strings (like WNSNXS). Afterwards, they are told that these strings were constructed according to a complex rule system (a grammar) and they are asked to judge newly presented strings as grammatical or non-grammatical. Typically, the participants show above chance performance but are not able to report the grammar rules. Therefore, Reber (1967) suggested that the participants learned the grammar implicitly. Although Reber's interpretation released a long and fertile discussion about implicit learning processes, there have been only a few studies investigating the relation between performance in artificial grammar learning tasks and general intelligence.

Reber, Walkenfeld, and Hernstadt (1991) reported a correlation of $r = 0.25$ between the performance in an artificial grammar learning task and IQ, and Gebauer and Mackintosh (2007) reported respective correlations between $r = -0.03$ and $r = 0.17$ depending on the task and the instruction. To our knowledge, there is no published study investigating the relation between educational or professional success and the performance in an artificial grammar learning task. Thus, there is a paucity of evidence on the relation between implicit learning and general intelligence as well as on the relation between implicit learning and success in real life.

### 1.2. Some psychometric considerations

Previous studies that investigated the relation between general intelligence, dynamic decision making, and implicit learning treated the performance measures as trait-like variables. A trait may be defined as a variable that is stable over several measurement occasions, consistent across different situations, and consistent across different methods. However, the variance of a performance measure may capture additional factors beyond individual differences in a trait.

First, a performance measure may also be influenced by the specific measurement situation even in standardized experiments. For example, one person may be well rested whereas another person may already have worked several hours before testing. One person may be motivated to show maximum performance whereas another person may have gotten a stinging rebuke by his or her supervisor that day and may not be motivated to show performance at all. Because these effects may contribute unwanted variance, it may be beneficial to take this *occasion specificity* of performance variables into account.