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Working memory capacity — facets of a cognitive ability construct

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Abstract

Working memory capacity is differentiated theoretically along two dimensions: contents and functions. The resulting 3×3 matrix was operationalized by 23 tasks sampled from the literature. Data for these tasks from 128 participants were analyzed by exploratory and confirmatory factor analysis. Regarding the content facet, spatial working memory was clearly distinct from the other two content categories. A distinction between verbal and numerical working memory was not warranted. On the functional dimension the postulated categories of simultaneous storage and transformation and of coordination could not be separated. The third category was clearly separate from the first two functions. This factor could be interpreted to reflect a mixture of variance due to mental speed and to supervisory functions of the central executive.

Keywords: Working memory; Coordination; Supervision; Speed; Factor analysis; Structural equation models; Facet theory

1. Introduction

Working memory has become one of the central constructs in theories of cognition both from the perspective of individual differences research (Daneman & Carpenter, 1980; Engle, Kane & Tuholski, 1999; Kyllonen & Christal, 1990) and of experimental psychology and cognitive modelling (Anderson, 1983; Baddeley, 1986; Miyake & Shah, 1999). It is generally

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assumed that working memory has a constrained capacity which acts as a limiting factor of performance in cognitive tasks, especially complex reasoning tasks.

Through its extensive use the concept of working memory has become a construct with increasingly broad scope of application, including different functions in different content domains. This breadth of theoretical use stands in contrast to the usually quite narrow and unsystematic operationalization of the construct, often through a single task. The purpose of the present work is to operationalize working memory capacity in a more systematic way that does justice to both the generality of the construct and its internal differentiation. With this goal in mind, we draw on the rationale and methodology of intelligence structure research, with its relatively broad and coarse view on cognitive abilities. On the other hand, we use tasks from the experimental literature which were designed to operationalize specific theoretically relevant aspects of working memory. To integrate the perspectives of experimental and differential psychology, we use facet theory (Canter, 1985; Guttman, 1954) as a framework.

2. Facets of working memory

Different theories emphasize different aspects of the working memory construct. Facet theory serves as a tool for the systematization of these aspects. The resulting facet schema forms a hypothetical structure for working memory capacity which can be tested against the data by structural analysis techniques.

We propose to differentiate working memory along two facets, one representing the function of working memory resources, the other the content domain of the task material. Each facet has three categories. On the content facet, we distinguish verbal, numerical, and spatial working memory. The categories on the functional facet reflect the three main functions which are attributed to working memory in the literature: Simultaneous storage and manipulation, supervision (or executive control), and coordination.

2.1. Functional categories

2.1.1. Storage and transformation

Most researchers define working memory as a system for the 'simultaneous processing and storage of information' (Salthouse, 1990). By this definition, working memory has the dual function of holding certain mental contents in an active accessible state, and performing cognitive operations on the same or different contents.

The characterization of working memory as 'simultaneous processing and storage' is frequently used to distinguish the more active working memory from the concept of a passive short term memory store in order to explain why the former, but not the latter, is a good predictor for reading performance and other higher order cognitive skills (Daneman & Carpenter, 1980). This implies that the term 'processing' is used in a narrow sense, excluding, for example, rote rehearsal which is also involved in digit span or word span. We categorize a task as involving 'processing' in the narrow sense when it requires the transformation of information, as opposed to merely conserving the information given.