Available online at www.sciencedirect.com

SCIENCE DIRECT®

Intelligence 33 (2005) 5–26

INTELLIGENCE

# Individual differences in time estimation related to cognitive ability, speed of information processing and working memory

A. Fink*, A. C. Neubauer

*Institute of Psychology, University of Graz, Universitaetsplatz 2/III, A-8010 Graz, Austria*

Received 16 February 2004; received in revised form 14 September 2004; accepted 17 September 2004
Available online 6 November 2004

**Abstract**

In experimental time estimation research, it has consistently been found that the more a person is engaged in some kind of demanding cognitive activity within a given period of time, the more experienced duration of this time interval decreases. However, the role of individual differences has been largely ignored in this field of research. In a previous study, we tested the hypothesis that different ability groups, who are differentially demanded during cognitive task performance, differ with respect to the extent to which cognitive resources can be allocated to concurrent experience of time (Fink, A., & Neubauer, A. C. (2001). Speed of information processing, psychometric intelligence and time estimation as an index of cognitive load. *Personality and Individual Differences*, 30, 1009–1021.). Actually, we found brighter individuals displaying larger and more realistic subjective time estimations (STEs) than less intelligent individuals, even if both ability groups tend to underestimate actual duration length. In relating experience of time to specific mental ability constructs that are known as important sources in individual differences in psychometric intelligence, we intend to describe the STE–intelligence relationship more deeply here. In study I ($n$=49), we found that the STE–intelligence relationship is not exclusively restricted to speed of information processing tasks (as used in our previous study); we observed intelligence effects in timing during working memory (WM) performance as well. In study II ($n$=96), we assessed the relative importance of mental speed and working memory capacity in explaining the STE–intelligence relationship within one and the same experimental design. The data suggest that both mental ability constructs might be considered in explaining intelligence effects in the experience of time.


*Keywords:* Intelligence; Time estimation; Time experience; Mental speed; Working memory; Central executive; APM

* Corresponding author. Tel.: +43 316 380 8505; fax: +43 316 380 9811.
*E-mail address:* andreas.fink@uni-graz.at (A. Fink).

0160-2896/$ - see front matter © 2004 Elsevier Inc. All rights reserved.
doi:10.1016/j.intell.2004.09.001

## 1. Introduction

The study of individual differences in human cognitive abilities is among the most traditional as well as prominent research fields in scientific psychology. Starting from Galton's (1883) mental aptitude testing and Spearman's (1927) report of a general factor (i.e., general mental ability or *g*) in intellectual abilities, extensive research efforts have been undertaken to explore the structure of human cognitive abilities or intelligence. Recently (i.e., in the last 3 decades), research on human intelligence might also be characterized by attempts to identify and analyze cognitive components or correlates of psychometrically determined intelligence. In this context, two important cognitive components have been identified in research literature: mental speed and working memory (WM) capacity (see for example, Kyllonen, 1993; Neubauer, 1997).

### *1.1. Mental speed approach to human intelligence*

The mental speed approach to human intelligence suggests that the speed of information processing is a basic constituent of individual differences in human intelligence. This assumption is based on a large body of empirical evidence indicating a robust negative relationship between psychometrically determined intelligence and reaction time measures (RTs) in so-called elementary cognitive tasks (ECTs; for reviews see Deary, 2000; Jensen, 1987; Neubauer, 1997). The rather low (although consistent) negative correlations in the majority of studies (up to −0.30, or at best −0.40) gave several authors reason to conclude that the speed of information processing in single ECTs cannot explain more than 10% of variance in intelligence tests (see for example, Hunt, 1980; Stankov & Roberts, 1997). However, most of the critics ignore the fact that the relatively low RT–intelligence correlations are partially due to the homogeneity of the samples tested. As shown in some recent studies conducted in our own laboratory (Neubauer & Bucik, 1996; Neubauer & Knorr, 1998), much higher correlations—even between single ECT parameters and psychometrically determined intelligence—can be observed (of about −0.50) when using more representative or heterogeneous samples with respect to the distribution of intellectual ability (cf. also Deary, Der & Ford, 2001; Vernon, 1990).

### *1.2. Working memory*

Another source of individual differences in intelligence might be assumed in the capacity of working memory (WM). Working memory, which refers to a limited capacity system, is often defined as a mechanism responsible for temporary storaging or maintaining information in memory for use in ongoing mental operations. There is relatively strong empirical evidence that WM capacity is related to a wide variety of higher-order cognitive functions, e.g., reading comprehension (Daneman & Carpenter, 1980), language comprehension (Daneman & Merikle, 1996), vocabulary learning (Daneman & Green, 1986) or numeracy (De Rammelaere, Stuyven & Vandierendonck, 1999). Individual differences in WM capacity are not only related to these rather domain-specific skills but also to individual differences in general mental ability as well. In a very influential study, Kyllonen and Christal (1990) related various measures of reasoning ability to measures of WM capacity. They reported high correlations between these two measures—an impressive finding that has been replicated in several other studies in this field of research (e.g., Conway, Cowen, Bunting,