Available online at www.sciencedirect.com
SCIENCE DIRECT®
Brain and Cognition 55 (2004) 415–426
Brain and Cognition
www.elsevier.com/locate/b&c

Imposing structure on a Corsi-type task: Evidence for hierarchical organisation based on spatial proximity in serial-spatial memory

Carlo De Lillo*

School of Psychology, University of Leicester, Leicester LE1 7RH, UK

Accepted 11 February 2004
Available online 15 April 2004

Abstract

Structure was imposed on a tapping task by requiring participants to reproduce sequences of responses to icons organised in spatial clusters. A first experiment featured sequences either segregated or not segregated by clusters. Accuracy was higher for sequences segregated by clusters. Moreover, inter-response times were longer at cluster boundaries than within cluster boundaries. To rule out possible confounding effects of movement length, this temporal pattern was replicated in a second experiment requiring a single response indicating the next sequential step, following the presentation of a portion of a previously practised sequence. These results suggest that sequence reproduction can be sustained by a hierarchical representation based on spatial proximity and provide a first indication of the role of spatial structure in serial-spatial memory.

Keywords: Corsi task; Serial pointing; Spatial memory; Working memory; Hierarchical organisation; Chunking

1. Introduction

We are constantly faced with the problem of having to temporarily retain serial-spatial information in order to keep track of sequences of displacements of objects and to plan and execute sequences of movements in space.

The Corsi Tapping Test (CTT), or basic variations of it, is one of the most popular experimental tools for the assessment of serial-spatial temporary memory and the factors that influence it. Initially developed by Corsi (1972) for his unpublished dissertation, and presented to a wider scientific readership by Milner (1971), the CTT, as originally devised, required the participants to reproduce a sequence of tapping responses previously performed by the tester on an array of wooden blocks.

In recent years, the Corsi test has been used in a growing body of research on serial-spatial memory that has been accumulated following the development of the working memory model (Baddeley & Hitch, 1974). Within this framework, independent sub-systems have been identified that are specifically dedicated to the processing of either verbal (the phonological loop) or spatial information: (the visuo-spatial scratch-pad). In a recent review, Baddeley (2001) indicates the CTT as the test that is most closely associated with spatial short-term memory on the basis of both behavioural and neuropsychological evidence.

Although research on working memory has initially focused mainly on the verbal processing sub-system (as pointed out, for example, by Jones, Farrand, Stuart, & Morris, 1995; Logie, 1995), more recently, research on the visuo-spatial component of the model has enjoyed a renewed interest and major advancements have been made in our understanding of its characteristics and functions. For example, on the basis of careful experimental investigations, a sub-system of the visuo-spatial scratch-pad has been suggested, the "inner scribe," that would be specifically responsible for the retention and processing of spatial information and would play an essential role in processing and planning movement sequences (Logie, 1995; Logie & Marchetti, 1991). The

* Fax: +44-116-252-2067.
E-mail address: cdl2@le.ac.uk.

0278-2626/$ - see front matter © 2004 Elsevier Inc. All rights reserved.
doi:10.1016/j.bandc.2004.02.071

CTT seems to capture accurately the working of the inner scribe, as performance on this test seems to rely on a purely serial spatial component of working memory that is selectively affected by the concurrent presentation of spatial but not visual tasks (Logie, 1995; Reisberg & Logie, 1993; Salway & Logie, 1995) and tasks that make demand on spatial attention (Smyth & Scholey, 1994b). Performance on CTT shows, moreover, a double dissociation with visual tasks in neuropsychological patients (Della Sala, Gray, Baddeley, Allamano, & Wilson, 1999), and presents developmental fractionation with visual tasks (Logie & Pearson, 1997).

Movement per se has recently received further emphasis through a proposed distinction, within the visuo-spatial scratch-pad, of sub-systems specialised for processing static and dynamic information (Pickering, Gathercole, Hall, & Lloyd, 2001), the latter being conveyed by tasks with a strong serial component. CTT performance seem to rely on resources that are specifically allocated to the processing of movements to spatial targets and independent from the resources used for the processing of configurations of movements, such as hand configurations or body postures (Smyth, Pearson, & Pendleton, 1988; Smyth & Pendleton, 1989, 1990).

Although the CTT has enjoyed an enormous popularity in both experimental research and clinical practice, it is unfortunate, as pointed out by Berch, Krikorian, and Huha (1998) in a recent review, that in different studies featuring the CTT almost every task parameter (ranging from the block arrangement to the scoring method) has been varied, often without providing an adequate description of important procedural details (Berch et al., 1998).

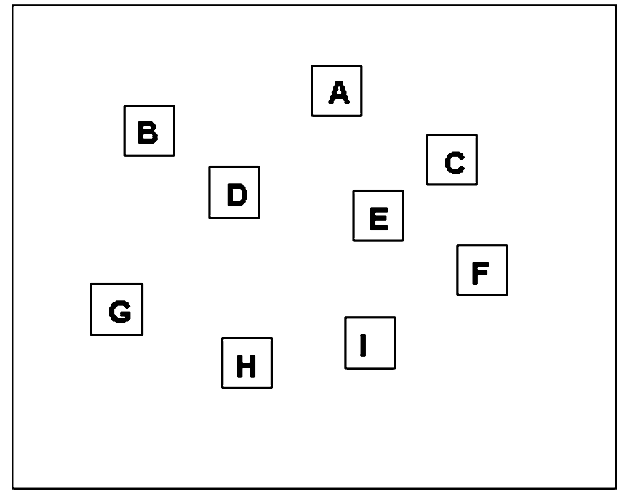
It seems particularly surprising that very little, if any, consideration has been given to the potential importance of the relative spatial position of the blocks and how spatial constraints might interact with the particular sequence to be reproduced. Berch et al. (1998) note that none of the 38 studies included in their review, including the original work by Corsi (1972), had reported the relative distance between the blocks.

When studying serial memory in non-spatial domains it is possible to devise relatively unstructured material, such as lists of non-sense words. By contrast, in the spatial domain structural constraints are always present and might play a role in how the information to be retained is organised in a serial representation. An observer can always detect structure in the spatial layout of the environment, provided, for example, by the relative spatial proximity of different objects or their location along spatial vectors.

An example of constraints that can be used in a spatial display is provided in Fig. 1A, which depicts a typical arrangement of blocks featured in a Corsi-type task.

Even in this relatively unstructured configuration, it is possible to see how some blocks (e.g., blocks B and D and blocks C and E) can be perceptually grouped on the basis of their spatial proximity and that the array can be segmented in three diagonal lines (i.e., blocks A–C; B–D–E–F; and G–H–I).

A



B

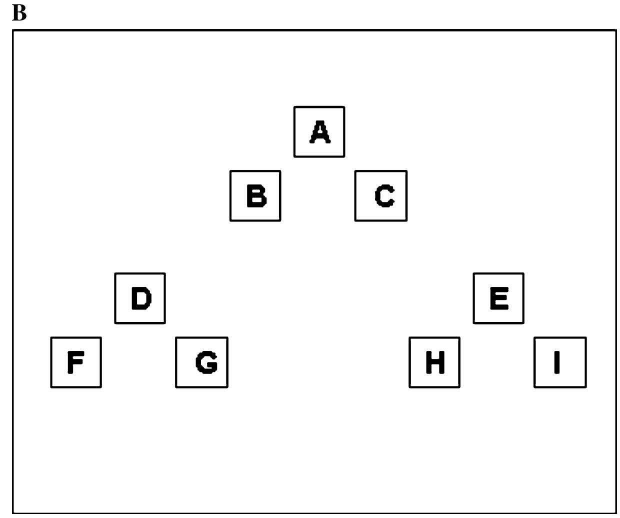


Fig. 1. An example of a conventional configuration of items used in Corsi-type tasks (A) and of a clustered configuration as featured in the present study (B).

In those studies which have reported a graphical depiction of the block arrangement, it is possible to detect variations in the way in which the blocks form subgroupings and clusters based on spatial proximity (see Berch et al., 1998, Fig. 2). Even when the spatial configuration was kept constant, it has been shown that the use of different tapping paths through the block-array selectively affects the ability of the participants to reproduce sequences of the same number of ordinal steps (Smirni, Villardita, & Zappala', 1983).

However, the question of why some sequences should be easier to reproduce than others has not been specifically addressed. The fact that participants might find some sequences easier to remember has been mostly