ELSEVIER

Acta Psychologica 117 (2004) 65–77

acta psychologica

www.elsevier.com/locate/actpsy

Mental rotation depends on the number of objects rather than on the number of image fragments

Arno Koning *, Rob van Lier

NICI—University of Nijmegen, Room B.01.25, P.O. Box 9104, 6500 HE Nijmegen, The Netherlands

Received 12 December 2003; received in revised form 5 May 2004; accepted 12 May 2004
Available online 25 June 2004

Abstract

It is often intuitively assumed that disconnected image fragments result in a representation of separate objects. When objects are partly occluded, disconnected image fragments can still result in a representation of a single object, based on visual completion. In a simultaneous matching task, displays showing one object, partly occluded objects, or two objects were compared with each other. When only a translation was required to match pairs of displays, one-object displays were matched faster than both occluded-object and two-object displays, which did not differ significantly from each other. When mental rotation and translation were required, the one-object displays were again matched the fastest. In addition, an advantage for occluded-object displays compared with two-object displays was found. We conclude that when the generation of a mental representation is likely, object-based connectedness determines object matching. Mental rotation then seems to depend on the number of objects rather than on the number of image fragments.

PsycINFO classification: 2323
Keywords: Form and shape perception; Spatial organization; Mental rotation

* Corresponding author. Tel.: +31-24-361-5590.
E-mail address: a.koning@nici.kun.nl (A. Koning).
URL: http://www.nici.kun.nl/~arnok.

0001-6918/$ - see front matter © 2004 Elsevier B.V. All rights reserved.
doi:10.1016/j.actpsy.2004.05.002

1. Introduction

Image fragments are usually grouped into objects by means of various grouping factors. Here we will focus on connectedness between image fragments, where connections between image fragments enhances grouping. Palmer and Rock (1994) emphasized the importance of connectedness in the grouping process, with a special role for so-called uniform connectedness that deals with connections between image fragments that show uniform visual properties. In general, connectedness between image fragments appears to be a crucial factor in specific tasks (Saiki & Hummel, 1998; Van Lier & Wagemans, 1998). Saiki and Hummel looked at various types of connectedness and part-relation integrations, using a rapid serial visual presentation paradigm. They found that connected target shapes were easier to distinguish among a set of distractors, compared to disconnected target shapes. Similarly Van Lier and Wagemans (1998) found that it is easier to mentally rotate a configuration of connected image fragments than it is to rotate a configuration of disconnected fragments, indicating a higher representational unity of the first configuration.

Connectedness refers not only to connections between image fragments, but connectedness can also be described at a more representational level. For example, two three-dimensional (3-D) objects can be connected to each other or disconnected from each other in 3-D space. A distinction can then be made between image-based (IB) and object-based (OB) connectedness, where IB connectedness refers to connections between objects in the 2-D image, and OB connectedness refers to connections between objects in 3-D space. Recent research has shown that IB connections between objects are less important than OB connections between objects (Koning & Van Lier, 2003; Saiki & Hummel, 1998). Koning and Van Lier examined three different types of displays in one of their experiments, in which IB and OB connectedness between pairs of 3-D objects (a small and a large object) were varied. OB (dis)connectedness was realized by adding a shadow of the small object onto the larger object (see e.g. Kersten, Mamassian, & Knill, 1997; Madison, Thompson, Kersten, Shirley, & Smits, 2001; Meng & Sedgwick, 2001). The first type of display showed the small object resting on the large object (i.e., IB/OB connected objects). The second type of display showed the small object positioned above the large object (i.e., IB/OB disconnected objects). The third type of display showed the small object seemingly floating above the large object as suggested by appropriate shadowing (i.e., IB connected/OB disconnected objects). Koning and Van Lier found that when objects were OB connected, matching was faster as compared with objects that were OB disconnected, regardless of the IB connections between the objects. In a second experiment, this result was also found, but now binocular depth cues were used to differentiate OB connectedness from OB disconnectedness, as well as different objects. Note that, in addition to the conditions tested by Koning and Van Lier, a fourth combination is possible as well. Such an image would show an OB connected object, but with IB disconnectedness between the image fragments. In the present study, we examine such a combination.

It is often intuitively assumed that disconnected image fragments lead to a representation of two separate (OB disconnected) objects. However, it is not uncommon