Vision Research 77 (2013) 51–58

Contents lists available at SciVerse ScienceDirect

Vision Research

journal homepage: www.elsevier.com/locate/visres

Multiple cues add up in defining a figure on a ground

Frédéric Devinck [a,*], Lothar Spillmann [b]

[a] University Rennes 2, CRPCC, EA 1285, F-35000 Rennes, France
[b] Neurozentrum, Neurological Clinic, University Hospital, Breisacher Strasse 64, D-79106 Freiburg, Germany

ARTICLE INFO

Article history:
Received 1 March 2012
Received in revised form 3 October 2012
Available online 29 November 2012

Keywords:
Figure–ground segregation
Convexity
Symmetry
Wide base
Perceptual organization

ABSTRACT

We studied the contribution of multiple cues to figure–ground segregation. Convexity, symmetry, and top-down polarity (henceforth called wide base) were used as cues. Single-cue displays as well as ambiguous stimulus patterns containing two or three cues were presented. Error rate (defined by responses to uncued stimuli) and reaction time were used to quantify the figural strength of a given cue. In the first experiment, observers were asked to report which of two regions, left or right, appeared as foreground figure. Error rate did not benefit from adding additional cues if convexity was present, suggesting that responses were based on convexity as the predominant figural determinant. However, reaction time became shorter with additional cues even if convexity was present. For example, when symmetry and wide base were added, figure–ground segregation was facilitated. In a second experiment, stimulus patterns were exposed for 150 ms to rule out eye movements. Results were similar to those found in the first experiment. Both experiments suggest that under the conditions of our experiment figure–ground segregation is perceived more readily, when several cues cooperate in defining the figure.

1. Introduction

In everyday scenes, multiple objects are viewed by observers and relevant information might be thought to be hard to extract because of object overlap and occlusion. Here, figure–ground segregation comes to help as an important mechanism by which the visual system organizes a visual scene through labeling some regions as foreground figures (e.g., salient shapes) and others as background. Gestalt psychologists were the first to recognize the importance of figure–ground assignment. Rubin (1915, 1921, reprinted in 2001) stated that figures have object character, possess a shape (often symmetrical), are surrounded by a boundary (usually unilateral) and are more salient than the ground (which they occlude). They are also perceived as being closer to the viewer. The ground is characterized by the opposite features. The figure–ground process plays a central role in visual perception by reducing visual scene complexity and enhancing crucial information, so that observers recognize and act upon figures and not backgrounds.

Several cues have been proposed to affect figure–ground assignment. These cues enable us to predict which region is likely to attain the status of figure. They include convexity, symmetry, small area, and closure. For example, a small region possessing one of these cues will likely be perceived as figure rather than ground, the latter being reserved for the region that seemingly passes behind the figure. Recent research has added a number of cues to this list that are characterized by the following features: high vs. low spatial frequency (Klymenko & Weisstein, 1986), flicker vs. non-flicker (Wong & Weisstein, 1984), wide base vs. narrow top as compared to its converse (Hulleman & Humphreys, 2004a, 2004b), lower vs. upper region (Vecera, 2004; Vecera, Vogel, & Woodman, 2002), shading or texture gradient vs. uniform surface (Palmer & Ghose, 2008). Moreover, observers are more likely to perceive a familiar figure than an unfamiliar one (Peterson, 1994; Peterson & Gibson, 1994). In addition, context has been shown to influence figure–ground assignment. For example, Peterson and Salvagio (2008) presented displays with concave and convex regions side-by-side that contained two, four, six or eight regions. In such stimulus patterns convex regions were preferably seen as figures when the number of regions increased.

In a natural scene, different cues occurring together typically bias figure–ground segregation. Kaniza (1979) and Kanisza and Gerbino (1976) studied various figure–ground cues by pitting them against one another. In this study we asked how adding one or more cues to a pattern containing a given figure–ground cue might influence observer responses. We hypothesized that the reaction time to figures would be shorter when several cues cooperate in defining the figure. Moreover, subjects would be expected to more reliably perceive the figure (i.e., fewer errors) when the number of cues defining a given region increases. To this extent, we performed two experiments designed to investigate the consequences of adding cues to figure–ground assignment. Convexity, symmetry, and wide base were used as cues. Single-cue displays as well as

* Corresponding author. Fax: +33 2 99 14 19 54.
E-mail address: frederic.devinck@uhb.fr (F. Devinck).

0042-6989/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.visres.2012.10.021

stimulus patterns containing two or three cues were presented. Examples are shown in Fig. 1.

The task in the first experiment was to report, which regions were perceived as foreground figure. In a second experiment the same stimulus patterns were presented for only 150 ms. This short exposure time was chosen to minimize the effect of eye movements. Results were expected to provide a quantitative measure of the relative strength of one as compared to several cues in figure–ground segregation.

2. Experiment 1

2.1. Observers

Thirty-two observers were recruited (psychology students from the University of Rennes) receiving course credit for their time. Observers ranged in age between 19 and 25 years. All had normal or corrected-to-normal vision, and they were naïve to the purpose of the experiment. Experiments were performed in accordance with the principles of the Declaration of Helsinki for the protection of human subjects.

2.2. Apparatus

A PC was used for the presentation of the stimuli on a 17 in. CRT monitor, in 800 × 600 graphics mode. The experimental software was written with E-Prime 2. Observers viewed the screen binocularly from a distance of 180 cm with the head stabilized by a chin-rest.

2.3. Stimuli

Observers viewed figure–ground displays that contained two abutting regions similar to those shown in Fig. 1. Figures characterized by convexity, symmetry, and wide base were presented as individual cue displays. These cues were also combined to create stimulus patterns containing more than one cue. There were three combinations consisting of two cues: convexity and symmetry, convexity and wide base, symmetry and wide base; additionally, there was one condition using three cues, convexity, symmetry, and wide base. Therefore, there was a total of seven cue conditions. For each condition, there were five different stimulus patterns. Each of these patterns was presented in four different versions, thus for each one of the seven experimental conditions, 20 different stimuli were used. In each stimulus pattern the regions on the right and left side were exchanged. Thereby, the same region appeared equally often on either side of the display. In addition, the contrast polarity of each of these flipped versions was randomly varied, resulting in 10 black/white and 10 white/black pairings. Altogether, observers viewed a total of 140 patterns on a medium gray background. The displays were created such that the two stimulus areas on either side of the central contour were approximately equal. The order of the displays was chosen randomly. The displays measured 5.44° on the horizontal axis and 6.02° on the vertical axis and were centered relative to the screen.

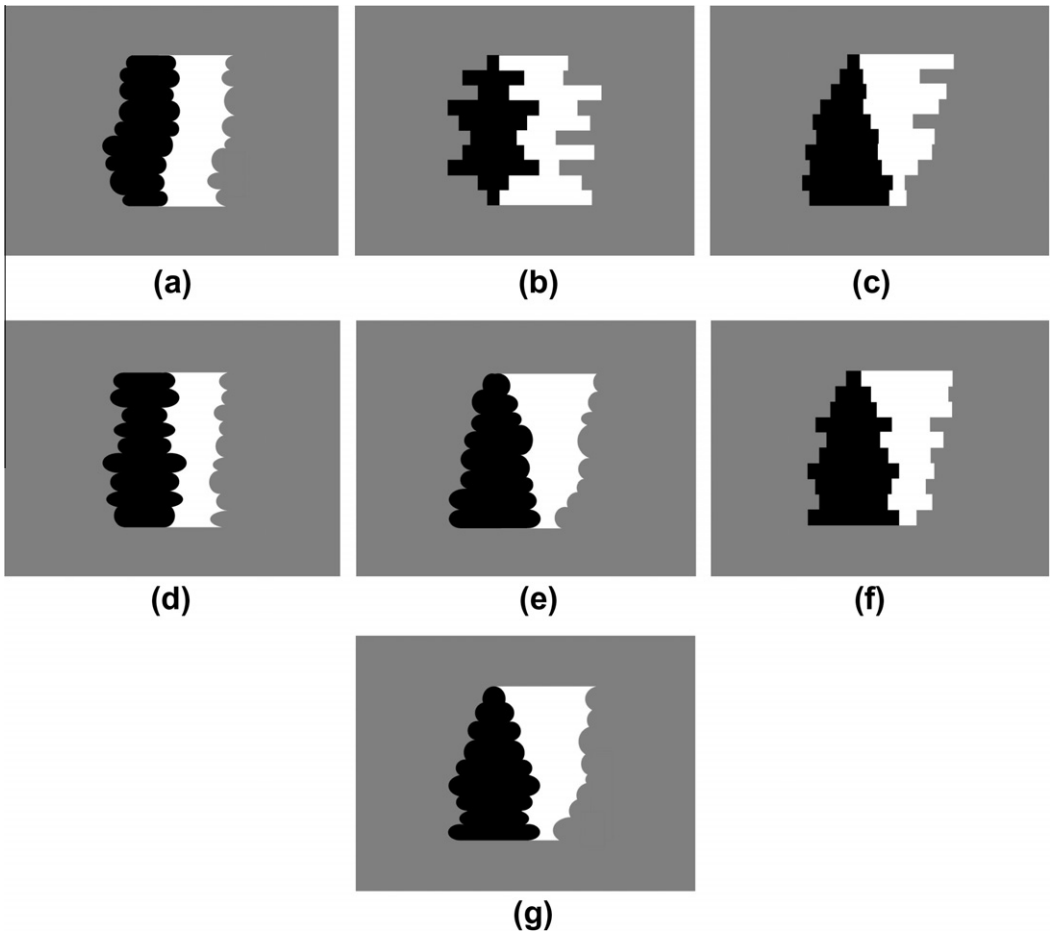

Fig. 1. Examples of stimuli used for figure–ground assignment. Here, the black regions are usually seen as foreground figures. Pattern displays containing a single cue are presented on the top: (a) convexity (b) symmetry, and (c) wide base. Stimuli combining two cues are shown in the middle: (d) convexity and symmetry (e) convexity and wide base, and (f) symmetry and wide base. A pattern representing three cues is presented on the bottom: (g) convexity, symmetry and wide base.