Vision Research 96 (2014) 96–105

Contents lists available at ScienceDirect

Vision Research

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

Efficient visual search for multiple targets among categorical distractors: Effects of distractor–distractor similarity across trials

Midori Ohkita, Yoshie Obayashi, Masako Jitsumori *

Department of Cognitive and Information Sciences, Chiba University, Japan

ARTICLE INFO

Article history:
Received 7 June 2013
Received in revised form 14 January 2014
Available online 31 January 2014

Keywords:
Visual search
Category search
Search asymmetry
Attention
Artificial category
Pigeons

ABSTRACT

We trained one group of pigeons to search for members of an artificial category among category-unspecified nonmembers. For another group of pigeons, the roles of the targets and of the distractors were reversed. Experiment 1 found that the latter group showed surprisingly efficient search for multiple nonmembers. Search times in this group were generally faster than those in the former group, regardless of the display size. In Experiment 2, search efficiency of the former group decreased with novel, poor, exemplars of the target category, whereas the latter group continued to exhibit efficient search for the nonmembers among novel members of the category. The former group eventually developed efficient search for all the targets through practice, but search time remained longer than in the latter group. These findings suggest that distractor–distractor, not target–target, similarity across trials facilitates search for multiple targets, by enhancing target salience relative to global contextual background of search scene.

1. Introduction

When we look for something special, it is easier to find it across search scenes that are the same or similar to each other than in ones that shift from time to time. This might be a factor even for animals that frequently visit certain foraging fields where they efficiently search for edible items fairly easily under similar circumstances. The present study examines the effect of similarity of background scenes on visual-search performance.

In our previous study (Ohkita & Jitsumori, 2012), we used members of an artificial category as targets and category-unspecified nonmembers as distractors for pigeons in a visual search task. An artificial category was created by morphing human faces. As shown in the upper part of Fig. 1, one face (Face P) was morphed with each of the remaining four faces (Faces A, B, C, and D, with the letters arbitrarily assigned to the four faces) to create composite faces AP, BP, CP, and DP. We also created 50% morphs of possible pairings of A, B, C, and D (AB, AC, AD, BC, BD, and CD) each of which was then morphed with P to create additional composite faces. For example, by blending AB and P, a three-component composite face ABP was created. The composite faces connected with broken lines in Fig. 1 have the same proportion (50%) of Face P which functions as a common component in this category. Faces A–D, as well as Faces AB–CD, are the item-specific components, all of which were used to create individual exemplars of this face category. Face P (P% = 100) and an item-specific component face (P% = 0) reflect, respectively, two extreme exemplars along the corresponding face-morph dimension, although the category as a whole is characterized by Face P.[1] The lower part of Fig. 1 shows the category-unspecified nonmembers.

In a series of experiments by Ohkita and Jitsumori (2012), pigeons were trained to search for the composite faces (P% = 50) among the nonmembers. Eventually, they revealed a highly efficient search (i.e., the slope of reaction time over the number of distractors was near zero) in a condition where a nonmember distractor item appeared repeatedly to form the background of given search display, with the particular nonmember item varying from trial to trial. The pigeons then transferred their efficient search to the novel members having larger proportions of the common component, including the original face used as the common component (Face P). Search efficiency dramatically decreased as

* Corresponding author. Address: Department of Cognitive and Information Sciences, Faculty of Letters, Chiba University, 1-33 Yayoi-cho, Inage-ku, Chiba 263-8522, Japan.

E-mail address: mjitsu@L.chiba-u.ac.jp (M. Jitsumori).

[1] In our categorization study (Jitsumori, Ohkita, & Ushitani, 2011), pigeons were trained in a go/no-go procedure to discriminate exemplars from two categories created similarly to the category used in the present study. The pigeons then showed a generalization gradient that increased as a function of the proportion of the common component of the positive category, with the best discrimination emerging for the untrained common component faces of the positive and negative categories. Based on this finding, we define the original face, which is the basis for morphing transformations, as the prototype of the category; this is Face P.

http://dx.doi.org/10.1016/j.visres.2014.01.009
0042-6989/

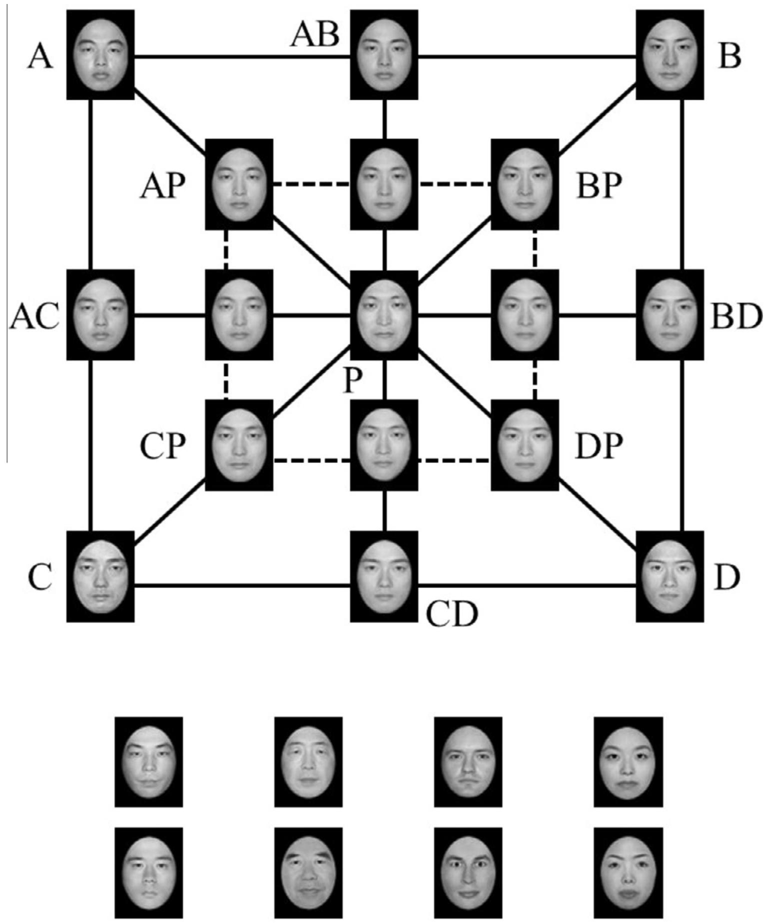

Fig. 1. Upper part: Grayscale reproduction of an artificial category. One face (Face P) arbitrarily selected from the five original faces was used as the common component of the category. The common component was morphed with each of the remaining four original faces (A, B, C, or D) and the 50% morphs of the possible pairs of these faces. Faces AD, BC, and those created by blending each of these faces with P are not shown. Lower part: Category-unspecified nonmembers.

the common component decreased to 25% and to 0% (the original faces used as the item-specific components A, B, C, and D), indicating that the pigeons searched for the targets primarily on the basis of common component features. The face used as the common component for one pigeon was used as an item-specific component for another pigeon and vice versa; therefore the effect was related to the structure of the category and not to specific properties of the face used as the common component. Moreover, because the face used as Face P for each pigeon was selected arbitrarily from a set of five original faces, the novel displays containing Face P and Faces A–D as targets could not be differentiated without a pigeon having acquired knowledge of the target category. Therefore, we concluded that an efficient search for Face P was accomplished by top-down control due to learning category information and not by bottom-up similarity relationships between targets and distractors within search displays.

In the present study, one group of experimentally naïve pigeons, the C-N (Category Targets among Non-category Distractors) group, were trained to search for the good members (P% = 50) of the category among the nonmembers, as in Ohkita and Jitsumori (2012). For another group of pigeons, the N-C (Non-category Targets among Category Distractors) group, the target–distractor roles were reversed. Fig. 2 illustrates examples of the search stimuli used in the C-N (left panels) and N-C (right panels) tasks. The target and distractor sets were thus not interchanged for the same pigeon, thereby preserving a constant mapping of stimuli to response. The present study examined the search strategy adopted by each of these groups and compared its impact on search performance. The training and testing procedure was the same for the two groups, thereby equating learning history, except that the roles of the targets and of the distractors were reversed between the groups.

In a categorization study with humans, Corneille et al. (2006) used category exemplars that comprised a series of faces that were located along the left end or the right end of a continuum of morphed faces. Participants learned to classify exemplars into a reference category (i.e., a category labeled “club members” consisted of exemplars lying either at one end or the other of a continuum) and a non-reference category (i.e., a category labeled “not club members”). After learning these categories, participants were tested in a visual search task. They showed better detection of the reference category items than of the non-reference category items among novel, category-unspecified, original faces. Corneille et al. argued that membership in the reference category acts as a salient feature that increases detection of the faces in this category, compared with the non-reference category faces that are defined merely as lacking this feature.

Search asymmetry studies, where the roles of targets and of distractors are reversed, often find that the presence of a feature is more salient than its absence (e.g., Treisman & Gormican, 1988; Treisman & Souther, 1985). For example, the search for an intact circle among circles with an intersecting line is more difficult and less efficient than the other way around. That is to say, looking for the presence of a feature (a line in this case) is easier than looking for its absence, as far as the targets and distractors are clearly differentiated by the presence vs. absence of a feature. Treisman