Conceptual grouping effects in visual search: categories matter (and named categories matter more)

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Introduction

Familiar stimuli are not simply perceived, but are quickly categorized as members of meaningful categories (e.g., Grill-Spector & Kanwisher, 2005). Yet, theories of visual perception have often ignored the possible contributions of conceptual categories to visual perception (Wolfe & Horowitz, 2004 for discussion). In particular, the effects of conceptual categories in visual search have fallen into disfavor following failures to replicate Jonides and Gletiman's (1972) oh-zero effect (e.g., Duncan, 1983) and findings that have offered convincing accounts that category effects hinge on perceptual rather than conceptual factors (Krueger, 1984; Levin et al., 2001).

The first aim of the present work was to test for the presence of category effects in visual search while controlling for all physical factors. This was accomplished by varying the conceptual heterogeneity of the distractors. It is known that physical distractor heterogeneity correlates positively with search times (Duncan & Humphreys, 1989). Experiment 1 tests whether *conceptual* distractor heterogeneity similarly slows search. Experiment 2 tests an explanation of the discovered conceptual-grouping effect based on perceptual warping–the hypothesis that prior experience categorizing together members of the same conceptual category resulted in a collapsing of perceptual differences, making the stimuli look more similar (e.g., Goldstone, 1994). Alternatively, conceptual grouping may arise dynamically, through top-down modulation of attention by category-level representations.

Effects of Verbal Labels

A "B" is not just a member of a familiar category; it is a member of a named category. Over time, category labels (e.g., "bee") become strongly associated with features that are most diagnostic (or typical) of the named category (Lupyan, under review). Naming a stimulus might therefore produce a perceptual representation that is more influenced by top-down conceptual information compared to a stimulus that is not named. Experiment 3 compares search times for verbally labeled and unlabeled targets within the same block (in which the target is always known). A prediction is tested that labeling a target exaggerates differences between items that span a category boundary, while collapsing differences between items from the same category.

The Questions

What is the effect of conceptual categories in visual search, controlling for all perceptual differences?

Are conceptual grouping effects caused by long-term representational change (perceptual learning), or emerge on-line (perhaps through top-down feedback)?

Does verbally labeling the target exaggerate effects of conceptual categories?

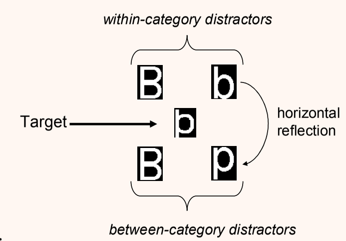
Experiment 1

Purpose: **To test for the existence of *conceptual grouping* effects by varying conceptual distractor heterogeneity (between-category vs. within-category) among perceptually equidistant distractors.**

Methods

Participants: 18 Carnegie Mellon undergraduates were run in a standard visual search task.

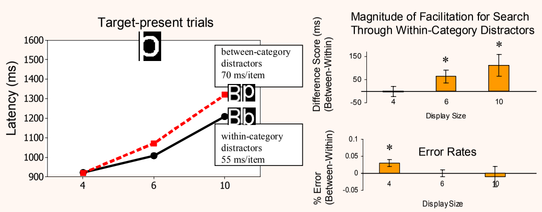
Materials:



Procedure:
The white characters each subtended .7º × .8º. of visual angle. The characters were displayed on a black background and arranged along the circumference of an imaginary circle having a diameter of 7º around a fixation cross (.5º diameter). The placement of the target and distractors was random with the stipulation that the same number of items were present on the left and right sides of the display. All conditions were within-subject.

Results

Search through within-category distractors was faster, $F(1,17) = 4.74$, $p < .05$, and more efficient, $F(2,34) = 4.74$, $p < .05$ than search through between-category distractors. There were no overall differences in error rates, though, accuracy was significantly higher in the within-category distractor condition for display size = 4, $t(17) = 2.15$, $p < .05$.



* = significantly better performance during search through within-category distractors

Experiment 2

Purpose: **To ensure there were no perceptual confounds in Experiment 1 and to discriminate between alternatives 1 and 2.**
Alternative 1: The conceptual grouping effect observed in Experiment 1 is due to long-term representational change that has resulted in B's looking more like b's than p's (a perceptual warping effect).
Alternative 2: The conceptual grouping effect emerges on-line during the search task, e.g., due to top-down attentional guidance by category-level information.

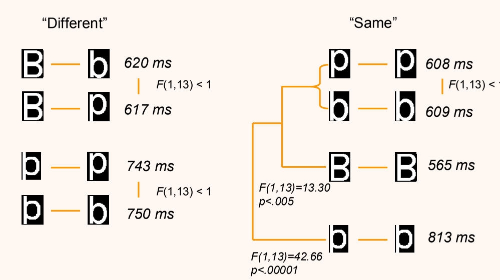
Methods

Participants: 14 Carnegie Mellon undergraduates participated for course credit.

Materials & Procedure: The stimuli were identical to Experiment 1. A speeded same/different judgment task was used. Participants were presented with with all possible combinations of the target and distractors used in Experiment 1. The pairs were randomly placed to the left or right of fixation and participants were instructed to respond "same" only if the stimuli were physically identical.

Results

(1) Same/different latencies confirmed that the target used in Experiment 1 was perceptually equidistant from both "b" and "p" distractors, ruling out any spurious perceptual confounds.
(2) The failure to find significant differences between B/p and B/b judgments supports Alternative 2 over Alternative 1, suggesting that the conceptual grouping effect observed in Exp. 1 emerges on-line during the search task (i.e., is a true grouping effect) rather than a function of pre-existing perceptual similarity.



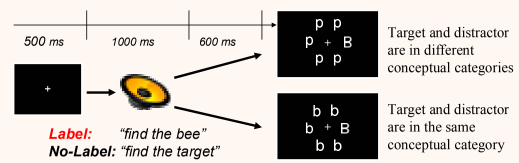
Experiment 3

Purpose: **To determine whether cuing a target (B) with a verbal label ("bee") facilitates search over and above knowing what the target is. A facilitation effect would support the hypothesis that conceptual category effects results from on-line top-down modulation. Insofar as verbal labels are associated with category exemplars, hearing a label may allow conceptual categories to further penetrate visual processing.**

Methods

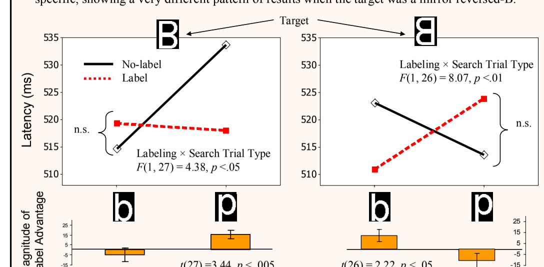
Participants: 28 Carnegie Mellon undergraduates participated for course credit.

Materials & Procedure: Participants searched for a "B" among "b" distractors (within category trials) or "p" distractors (between-category trials). Prior to each search trial, the target letter ("B") was either verbally cued (label condition) or not. Target identity was always known, so the label did not add any additional information. To assess the specificity of label-effects, an additional block of trials maintained all the low-level properties of the original "B" target, but mirror-reversed it, thus arguably disrupting the association with the label. Target-identity was blocked and the order was counterbalanced.



Results

Search was highly efficient (<5 ms/item) so the analyses collapse across display size. Hearing "find the bee" prior to to the appearance of the search display facilitated performance, but only on between-category trials (searching for a B among p's). The label-facilitation effect was highly specific, showing a very different pattern of results when the target was a mirror reversed-B.



Conclusions

Controlling for novelty and perceptual similarity, conceptual categories affected visual search performance as revealed by faster search times through within-category distractors (low conceptual heterogeneity) compared to between-category distractors (higher conceptual heterogeneity) (Exp. 1). This *conceptual grouping effect* seems to arise on-line, perhaps through top-down feedback of category-level representations onto lower-level visual representations (Lupyan, under review), rather than through pre-existing differences in within- vs. between-category perceptual similarities (Exp. 2). Verbal labels further enhanced the degree to which conceptual categories penetrated perceptual processing. Search times were reduced when a target was labeled compared to trials on which the same participants do not hear the verbal label (yet still know the identity of the target) (Exp. 3). The facilitation due to labels was highly specific to targets (or distractors, see Lupyan, 2007) that have pre-existing associations with the label—"**B**", but not ꓭ

Through their associations with visual features typical of the named category, verbal labels may facilitate the response of object-selective regions of cortex which in turn can guide attention to the members of the named category, possibly in parallel and throughout the visual scene (Lupyan, 2007).

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