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What does that Picture Sound Like to You? Oculomotor Evidence for Phonological Competition in Visual Search

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Consider an experiment wherein, on each trial, you are shown a picture of some object (e.g., a hammer) as a visual search target, and then must find an image of a hammer against a background of other depicted objects. For obvious reasons, such studies of attentional guidance in visual search have primarily focused on the visual features of objects (e.g., Wolfe, 2007; Wolfe, Cave & Franzel, 1989). However, several studies have shown that other, non-visual object features can influence attentional guidance and interference from distractors. These include conceptual and semantic factors (Dahan & Tanenhaus, 2005; Huettig & Altmann, 2005), specificity of target descriptions in categorical search (Schmidt & Zelinsky, 2009), and phonological similarity (Gorges, Oppermann, Jescheniak & Schriefers, 2013; Meyer, Belke, Telling & Humphreys, 2007). In the present study, we further examined the phonological dimension, testing whether distractor object names may be implicitly activated during visual search, as indicated by potential interference from distractors whose names partially overlapped with targets. In an experiment similar to the foregoing description, we investigated two key questions, embodied in two key manipulations: The first was whether phonological interference (if present) would be greater when targets were specified using verbal labels, rather than visual icons. The second was whether cognitive load, operationalized by having participants search for either one or three potential targets per trial, would modulate interference from distractors.

Given these manipulations, we had two main predictions. First, we expected the greater memory demands of multiple-target search to encourage participants to encode targets using less memory-taxing verbal representations, rather than holding images in memory. We predicted that these verbal representations would result in phonological interference when targets and distractors shared phonological onsets. Second, we predicted that verbal target cues would result in greater interference than visual target cues, due to a lack of guidance from internal visual templates. Previous findings have supported our predictions when participants were only given verbal target cues (Walenchok, Hout & Goldinger, 2013). Here, we conducted two new eye-tracking experiments to determine the nature of this interference.

In both experiments, participants were initially familiarized with the names of all stimuli. For the main search task, participants were given either visual (Experiment 1) or verbal (Experiment 2) target cues. Within each experiment, participants quickly determined target presence or absence for either one or three targets (low and high Target Load, respectively), with search sets of 12, 16 or 20 items. Only one target could be present in multiple-target search (Figure 1a). Our main variable of interest was Competition: Target(s) and distractors could either share /bi/ phonological onsets in the experimental condition (e. g., “beaker”, “beast” and “beanie”) or were grouped into three control conditions: (1) /bi/ target onset(s)

with distractors coming from a heterogeneous pool, each having different onsets, (2) target(s) coming from the heterogeneous pool, with all distractors having /bi/ onsets and (3) both target(s) and distractors coming from the heterogeneous pool. Both RTs and eye movements were recorded.

The following analyses report the effects of Target Load and Competition, our primary variables of interest. In the RTs, we observed a main effect of Competition with verbal target cues, $F(3, 11) = 9.76$, $p = .002$, $\eta_p^2 = .73$, as participants were slower to find targets that shared phonological onsets with the distractors. We also observed a Target Load $\times$ Competition interaction with image target cues, $F(3, 12) = 4.30$, $p = .028$, $\eta_p^2 = .52$. As Figure 1b indicates, this effect emerged when people searched for multiple, but not single, targets. In the eye movements, three variables were analyzed: (1) mean distractor fixations, (2) mean distractor fixation durations, and (3) the proportion of total items fixated (per trial). In the analysis of distractor fixations, we again observed a main effect of Competition with verbal target cues, $F(3, 11) = 5.43$, $p = .015$, $\eta_p^2 = .60$. We also observed a Target Load $\times$ Competition interaction with verbal cues, $F(3, 11) = 5.06$, $p = .019$, $\eta_p^2 = .58$, indicating greater tendency to fixate distractors that are phonologically similar to the targets in multiple-target search (Figure 1c). The analysis of distractor fixation durations revealed a main effect of Competition with verbal target cues, $F(3, 11) = 10.46$, $p = .001$, $\eta_p^2 = .74$; participants fixated distractors for a longer duration in the presence of phonological competitors (Figure 1d). The analysis of proportional fixations revealed a Target Load $\times$ Competition interaction with verbal target cues, $F(3, 11) = 4.05$, $p = .036$, $\eta_p^2 = .53$. However, as Figure 1e indicates, the means were in the opposite direction than predicted: Participants fixated fewer distractors in the phonological competition condition than in the control conditions in multiple-target search.

The latter analysis, together with the other eye movement results, indicate that, although fewer items were fixated overall under phonological competition in multiple-target search, participants tended to return to those distractor items a greater number of times and remain fixated for a longer average duration. These effects emerged primarily when subjects searched for multiple, but not single, targets, and when these targets were specified with labels, but not when they were specified with images. This pattern conforms to our previous experiments (Walenchok, et al., 2013) and suggests that – when people search for several targets that are specified with images – they are able to guide attention with great efficiency, and are relatively immune to distractor names. However, when targets are specified verbally, participants must consider the distractor items more carefully. In such conditions, search is affected by overlapping object names, despite the ostensibly visual nature of the task.

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Figure 1.

(A) Sequence of events in a multiple-target search trial, (B) Search time (RT), (C) Mean distractor fixations, given that these distractors had previously been fixated, (D) Mean distractor fixation durations for fixated distractors and (E) Proportion of total items fixated, as a function of Competition and Target Load.