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Position *and color* priming in briefly presented search arrays

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Introduction

In efficient visual search, ***priming of pop-out*** (PoP; Maljkovic & Nakayama, 1994, 1996) is usually reported as a speeded response when a target feature is repeated on consecutive trials.

Feature facilitation accounts: Sensitization to features via short-term memory. Priming at perceptual level.

Post-perceptual accounts:
PoP affects response times, not accuracy, via response repetition benefits, decision bias or other "late" effects.

Questions:

1. *Do color and/or position repetitions increase accuracy at brief exposure durations?*

2. If so, *is a category weighting account a viable explanation of the PoP when applied within a TVA-framework* (Bundesen, 1990)?

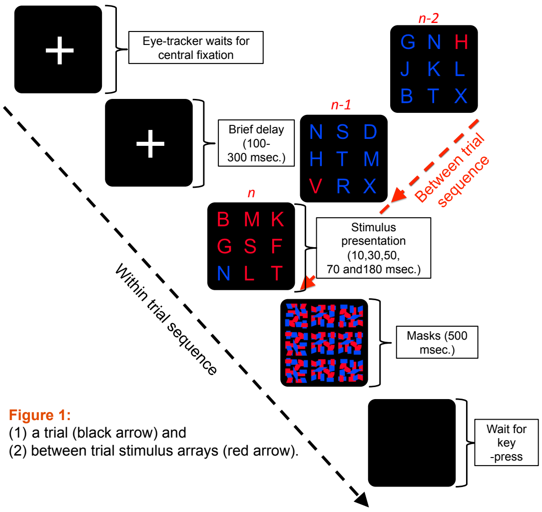


Figure 1:
(1) a trial (black arrow) and
(2) between trial stimulus arrays (red arrow).

The experiment

We tried to replicate perceptual priming effects in an accuracy based design (Yashar & Lamy, 2010) while generalizing to alphanumeric stimuli. Our design also has the advantage of multiple responses (15 consonants), which minimizes any effects of response repetition and visuomotor effects, leaving the results more readily interpreted as *perceptual effects.*

We presented subjects with a 3x3 consonant matrix where a target would always occupy one of the four corner positions. The displays where present for from 10-180 msec.
The subjects' task was to report the odd-one-out letter by pressing the appropriate key on a keyboard. The target identity was determined by color and varied randomly (Figure 1).

Methods

Participants were 8 students at the University of Iceland (3 male), ages 22-28. Each subject participated in, at least, 10 blocks of 100 trials. Trials following incorrect trials are discarded, since it may be meaningless to speak of repetitions/alternations from an "unseen" trial.
Stimuli were 15 consonants common to the Icelandic and English alphabets. These were presented as **ARIAL BOLD** capitals. All letters were equally likely to appear at any time, but only one sample of each letter could appear on a single trial. Targets and distractors were either red or blue. This was determined randomly for each trial (P(red)=P(blue)=0.5). Positions were also equilikely, i.e. probability of target being in position X would always be ¼. All stimulus positions were masked by pattern masks, made from bits of Arial Bold capital letters.
Eye-movements were controlled for by making the start of each trial dependent on a successful fixation to a central fixation cross. Eye-movement data was recorded by a Cambridge Research Systems Video Eyetracker.
Stimulus presentation and eye-tracker control was exerted by MATLAB, using the VET and the Psychophysics toolboxes.

Accounting for repetition priming within TVA (Bundesen, 1990)

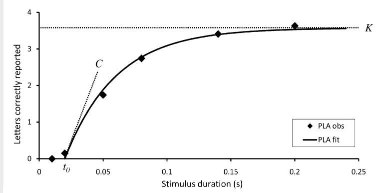
A Theory of Visual Attention (TVA) is a combined theory of selection and recognition. It has been mathematically formalized in a fixed capacity independent race model (FIRM). The central assumptions of the theory are described by the *rate* and *weight* equations (figure 2). *

In TVA selectivity is obtained by adjusting *attentional weights* for perceptual categories by differentiating their *pertinence* values (π). Pertinence can be adjusted voluntarily by current goals or instructions, but involuntary factors can also affect π.

Here we treat π as a parameter that can be involuntarily affected from trial to trial by varying target identity during a task. The assumption is that π-calculations are ongoing and the current importance of a target category is affected by its importance on the previous trial.

Param.	
C (fixed)	50
t0 (msec.)	6.6
alpha	0.19
CR weight	0.8
PR weight	0.98
Least Sq.	0.0327

We present least squares fits by a simple additive TVA based model of PoP. The model is only instructional, since it is limited to short-term-memory, which will not suffice to describe PoP in detail. PoP has shown to be a cumulative effect, building up over several trials and decaying relatively slowly (Maljkovic & Nakayama, 1994). The model also applies to pooled, rather than individual data. However, the goodness of fit is quite promising.
The model has 4 free parameters (t0, alpha, col.rep. and pos.rep. weights) and a fixed *C* (processing speed). The *C* parameter is fixed at 50 items/s (table 1).
The fits in figure 3. show the curves predicted by the model.



Weight equation

$$w_x = \sum_{j \in R} \eta(x,j)\pi_j$$

Rate equation

$$v(x,i) = \eta(x,i)\beta_i \frac{w_x}{\sum_{z \in S} w_z}$$

Figure 2

Results

- A 2x2 within subjects analysis revealed significant main effects of position and color repetition (*ps* <0.001 and 0.003, respectively). No interaction was found between the two (*p*=0.619).
- Position priming effects ranged from 2.5-11.4 pp, between subjects.
- Color priming effects ranged from 1.7-11.8 pp, between subjects.
- All subjects showed the same pattern of lowest accuracy under the 'no-repetition' condition and highest accuracy under the 'both repeated' condition. These within-subject differences ranged from 10-23 pp.

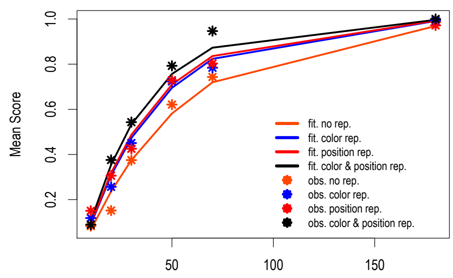


Figure 3

Conclusions

- **PoP affects accuracy at very brief exposures.**
- The effects cannot be explained by reference to response related mechanisms.
- **The results suggest a perceptual component in PoP.** This does in not exclude response related PoP.
- A simple additive TVA model can be fitted quite well to experimental data.
- Recent literature suggests that repetition are the result of **two or multiple mechanisms** (see Lamy & Yashar, in press; Kristjánsson & Campana, 2010).

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* For a concise introduction to TVA, please consult the CVC website (left) where you'll find *Introduction to a Theory of Visual Attention* by Kyllingsbæk & Habekost