The longer one views, the worse one performs

When top down factors impair visual search

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Abstract
In each search display A-D below (schematics of the actual stimuli), a target has a uniquely oriented bar. Each distractor is identical to, or a rotated version of all other distractors. A and B have identical distractors; the target is a rotated version of the distractors in stimulus A but not in B. Subjects take longer reaction time (RT) of button responses to localize targets in A than in B and other stimulus conditions, even though A and B have comparable reaction time (RTe) of eye position’s first arrival at the target (during search). Much more frequently in A, eyes first arrive at the target, dawdle around, leave the target before returning later. This is as if the uniquely oriented bar in the target load the eyes to it, while higher level object recognition processes, presumably rotationally invariant, identify the target as identical to distractors and thus veto the target candidate. If a mask replaces the search display at a variable time (0-2000 milliseconds) after the eyes locate the target at RTe, later mask onset leads to more errors in A to locate the target (by forced choice responses of left or right). This is as if longer viewings allow more top-down vetoing to impair performance.

Visual Search
for a target which has a uniquely oriented bar

A & B have the same distractors, each distractor is a rotated version of another. In A, but not in B, the target is a rotated version of the distractors. In stimulus A, C, D, the target is identical to all distractors after a rotation.

In A-D, each target has an uniquely oriented bar (in the whole display), which should pop out when background orientation is sufficiently uniform.

Note: red circle marks the target, not part of the stimulus. The directions of orientation in target and distractors are not fixed, they can be to right or left randomly from trial to trial. There are 30x22 elements in actual stimulus, extending about 46x54 visual angle. All targets are at 16 deg eccentricity, at least 12 deg eccentricity laterally.

In stimulus conditions A, C, D, the target is identical to all distractors after a rotation.

Discussion after Experiment 1:
Object rotational invariance may be a top-down knowledge causing the confusion in stimulus A: The bottom-up feature of an object orientation in the target attracts the attention to the target. Then the subject expects the target candidate in detail, preparatory, using top-down attention, to notice that it is the same as the distractors other than a rotation. Since object identity in relation invariant, the subject may identify the unique target candidate and the distractors as the same object, thus vet it, and continue to search for the target candidates.

In stimulus B, the target is not a rotated version of the distractors, hence is an uniquely different object with or without rotation invariance. Hence the subject is not confused.

To understand the time course of the top down influence of “object rotational invariance”, we carry out experiment 2:

Experiment 1: visual search with eye tracking

Task: Subjects were instructed to take their time to respond for the location of the target, before or after the mask appearance as they like. They were instructed to guess the target location if necessary. The mask onset time seemed random to subjects.

Stimulus A - - - subjects expected it interleaved A & B. Different subjects participated in different combinations of stim and t design. Other details as in Experiment 1.

Within a range of time intervals --- the longer time one looks, the worse one sees --- for stimulus A

In comparison, stimulus condition B does not lead to time delayed confusion

Can an increased expectation for an unique target increase the top down interference?

When the subjects increase their expectation that targets are unique in shape from distractors even after rotations, they may be more ready to immediately veto a target candidate if it is identical to the distractors after a rotation.

Stimulus A: When blocked sessions --- subjects expect all targets are rotated versions of distractors. Data from average of 6 subjects.

When randomly interleaved with stimulus B --- subjects expect 50% chance that the target is uniquely shaped. Data from average of 5 different subjects.

On average, expectation plays an insignificant role, perhaps because too many (and all) distractors are also rotated versions of each other. Not paying too much attention to anything that is identical to distractors after rotation would mean paying too much attention to all items (in a blocked session), and is perhaps too consuming.

Conclusion:
- We have discovered a visual search condition in which longer viewing makes the performance worse, likely due to top-down feedback factors.
- Based on the observation that this happens when the search target is a rotated version of the distractors, we suggest that the knowledge of object invariance under rotations is a likely cause of the top-down impairment. Additional requirement for such impairment maybe the orientation variability of the distractors, as implied by stimuli C & D and our other data not shown.