The effect of training on search for complex stimuli.
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Introduction

Practice can improve visual search with simple stimuli (e.g. Schneider and Shiffrin, 1977; Shiffrin & Schneider, 1977; Triesman and Gelade, 1980). Practice also alters neuronal responses to stimuli in the anterior inferior temporal cortex suggesting increased stimuli salience (Jagadeesh et al., 2001).

Generalisation after practice:
Visual search involves a number of different skills including
– those specific to properties of stimuli and targets;
– general skills for improved deployment of attention and search strategy.
In general, improved performance resulting from acquiring stimuli-specific skills does not transfer to novel tasks, whilst more general skills do transfer (e.g. Sireteanu and Rettenbach, 2000; Sowden et al., 2000; Hillstrom and Logan, 1998).

Orientation and viewpoints:
Training on a single viewpoint (Logothetis et al., 1994):
– results in a viewer-centred representation of the object, based on the retinal projection alone.
– does not give rise to effective generalisation to the same object at other orientations.

Training on multiple viewpoints:
– as few as three different views increases generalisation to other views of the object (Logothetis et al., 1994).

Aims

Investigate changes in search efficiency over time for complex visual objects:
1) Compare search learning for a single object against search learning for an entire class of objects.
2) Compare search learning for a single viewpoint against search learning for multiple viewpoints.
3) How does practice at searching for one object transfer to other objects of the same category?
4) How does practice at searching for one viewpoint of an object transfer to other viewpoints?
Method

- N = 24
- Stimuli: 287 X-ray images of baggage items
- Display size = 8 items
- Task: respond “present” if there is a gun image in the display, “absent” if not.

Figure 1: Example display: Is there a gun present?

- Initial exposure to the display at start of training was 2000ms.
- Three-up-one-down staircase procedure used to calculate minimum exposure time for target detection at 79% accuracy.
- Participants were university students and not trained security scanners.

Training

- 500 trials per block
- 12 participants did 15 training blocks
- there was no evidence of learning in the last five blocks (no effect of block)
- therefore the remaining 12 participants did 10 training blocks
- Four training conditions:

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<tr>
<th>Exemplar</th>
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<tr>
<td>Single</td>
<td>SESO</td>
<td>Meso</td>
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<td>Multiple</td>
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SESO: search for an image of a specific gun at a fixed orientation.
SEMO: search for an image of a specific gun at any of 20 possible orientations (five different images in three dimensions each of which has four possible rotations).
MESO: search for any instance of a gun, of the 19 different guns available. Each displayed at the same orientation.
MEMO: search for any instance of a gun at any orientation.
In all conditions, distractors were randomly selected non-threat items displayed at any orientation.

Testing

- All participants completed 5 blocks of 500 trials with multiple exemplar, multiple orientation (MEMO) displays.
- Initial exposure time and the staircase were reset at start of testing.
Results

Training: blocks 1-10 (figure 2):
- Performance improves with practice (main effect of block).
- Search learning occurs more quickly with training on a fixed orientation: SESO and MESO (main effect of orientation).
- Overall, there was no difference between training with multiple and single exemplars.
- Significant interaction between orientation and exemplar in blocks 1 and 2:
  - training with multiple orientations - no difference between multiple and single exemplars
  - training with a single orientation - single exemplar required less exposure time than multiple exemplars (approaching significance in both blocks)

Extended training: blocks 11-15:
- No effect of block in the last five blocks of training suggesting no learning took place over the additional training period.

Testing: (figure 3):
- Initially performance in most conditions drops with the switch to MEMO displays.
- Performance improves with practice (main effect of block).
- No significant interactions.
- Training at a single orientation leads to poor generalisation to multiple orientations (main effect of orientation in blocks 1 and 2).

Figure 2: Training phase. Harmonic mean of the median exposure times by condition and block.

Figure 3: Testing Phase. Harmonic mean of the median exposure times by condition and block.
Conclusions

Training can improve search efficiency with complex stimuli.

Training with single-orientation targets:
1) produced faster searches with less practice than in multiple-orientation conditions, particularly with a single exemplar (SESO);
2) resulted in poorer generalisation;
3) shallow slopes indicate the task is easy and requires little learning.

Training in the multiple-orientation conditions:
1) results in slower learning than single-orientation conditions;
2) is effective in improving efficiency for an initially difficult search task;
3) gives rise to better generalisation.

Variability in exemplars:
1) has no effect on generalisation;
2) only affects learning when orientation is constant.
3) This may be because multiple exemplars has less overall effect on target appearance than variability in orientation.

Implications

Learning is more effective when a template of a target is based upon multiple viewpoints.

Training in visual search tasks involving 3-D objects can only be expected to improve generalisation if targets appear at varying orientations. This fact has important implications for tasks such as security screening that requires visual search of X-ray images.

Further Work

• To investigate the generality of search learning for 3-D rotated objects by measuring the degree to which search for one category of objects (guns) improves search for another class of objects (knives).
• To determine the effect of practice on search for multiple targets.

References


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