Incidental learning speeds visual search by lowering response thresholds, not by improving efficiency

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Attention & memory in visual search

**Attention:**

- Novel displays; essential for studying guidance. ¹
- How do bottom-up and top-down influences steer our eyes? ²
- What aspects of a scene capture our attention? ³

**Memory:**

- Fixed scenes; the ubiquitous nature of repeated search.
- How much information is acquired while viewing? ⁴
- How does that information influence subsequent searches? ⁵

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The current investigation

- Repeated visual search is speeded by:
  - implicit learning of predictive spatial configurations (i.e., *contextual cuing*), ¹
  - knowledge of search item identities, ²
  - and the conjunction of spatial and object memory. ³

- Are people more adept or efficient searchers when viewing a repeated scene?

- What’s happening to viewing behavior?
  - Do we become better locators, view items less frequently?
  - Can learning speed item identification?

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Please remember these targets...
Ps searched for a new target(s), among repeated distractors. †
- Target present vs. absent?
- Instructions emphasized accuracy (but not speed!).

1-3 potential targets for low, medium, and high WM Load conditions, respectively. ¹
- Identify a single target or search exhaustively.

3 blocks (96 total trials):
- Three set sizes (12, 16, 20 items). ‡
- DVs examined as a function of Epoch (1-4); each comprised of 25% of the trials per block.

† - Spatial organization was randomized individually for each subject and block.
‡ - Permuations (i.e., order of presentation of Set Size) counterbalanced across participants.
Method, cont'd

• Stimuli:
  • Gray-scaled photographs (2 - 2.5° visual angle).

• Apparatus:
  • E-Prime v1.2 & Eyelink 1000 (monocular sampling, 1000HZ)

• Surprise recognition memory test:
  • Tested all distractors and subset of targets. †
  • Two-alternative forced-choice with semantically matched foils.

2 - SR Systems Research Ltd., Mississauga, Ontario, Canada.
† - Pooled-random presentation
<table>
<thead>
<tr>
<th>Objects</th>
<th>Space</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exp 1a:</td>
<td>Fixed</td>
</tr>
<tr>
<td>Exp 1b:</td>
<td>Random</td>
</tr>
<tr>
<td>Exp 2a:</td>
<td>Fixed</td>
</tr>
<tr>
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</tr>
</tbody>
</table>

**Trial 1**

**Trial 2**

**Trial k**
Differentiating questions:

1) When are RTs speeded?
2) What are the changes in viewing behavior?

1) **Rapid identification and dismissal (RID):**
   - Increased fluency in identification and dismissal of distractors.

2) **Spatial mapping:**
   - Spatial consistency enhances memory for item locations.

3) **Search confidence:**
   - Learning may lower response thresholds.

<table>
<thead>
<tr>
<th>Speeded RTs</th>
<th>Eye movements</th>
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</thead>
<tbody>
<tr>
<td>When items are learned.</td>
<td>Shorter fixation durations.</td>
</tr>
<tr>
<td>When space is fixed.</td>
<td>Fewer fixations.</td>
</tr>
<tr>
<td>When objects are fixed.</td>
<td>Fewer fixations.</td>
</tr>
</tbody>
</table>
Results – Exp 1

Exp 1a: Fixed objects, fixed space
Exp 1b: Random objects, fixed space

**Facilitation**: Interactions between Experiment (1a, 1b) and Epoch (1-4). ¹

**Efficiency**: Changes in the slope relating DVs to Set Size. ²

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### Visual Search RTs

- **Facilitation:**
  - Exp 1a: faster
  - Exp 1b: constant

- **Search efficiency:**
  - No change

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Number of Fixations

- Facilitation:
  - Exp 1a: fewer
  - Exp 1b: constant

Fixation Durations

- Facilitation:
  - Exp 1a: slower!
  - Exp 1b: constant

- Search efficiency:
  - No change
Fixations decrease over epochs.
- Fixation durations do not shorten, efficiency does not increase.

RID hypothesis ruled out:
- Objects learned in Exp 1b, but no facilitation.
- Fixation durations did not shorten.

Exp 2 designed to differentiate Spatial Mapping and Search Confidence hypotheses.
- What happens when spatial memory is disrupted?

Ps in both conditions remembered items above chance (50%).

Exp 1 summary
- Only when objects are coherent, is search faster.
Results – Exp 2

Visual Search RTs

- Facilitation:
  - Exp 2a: faster
  - Exp 2b: constant
- Search efficiency:
  - No change

Number of Fixations

- Facilitation:
  - Exp 2a: fewer
  - Exp 2b: constant
- Search efficiency:
  - No change
Facilitation:
- Exp 2a: slower!
- Exp 2b: constant

Search efficiency:
- No change

Exp 2 summary & evaluation
- Despite randomized space, coherent objects speeded RTs.
  - Fixations decrease, but durations and efficiency are not enhanced.

Rapid Identification and Dismissal:
- Object learning may speed item processing, akin to frequency effects in reading. ¹
- But, fixation durations did not shorten.

Evaluation, cont'd

- **Spatial Mapping:**
  - Attention is biased away from visited locations \(^1\); thus, spatial learning may discourage refixations.
  - But, spatial consistency is neither necessary (Exp 2a) nor sufficient (Exp 1b) to speed RTs.

- **Search confidence:**
  - Scene learning increases familiarity, thereby lowering response thresholds.

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**Search confidence, cont’d:**

- Search efficiency does not change, suggesting no benefit to attentional guidance. \(^2\)–\(^3\)
- Response selection mechanisms interfere with contextual cuing. \(^4\)

**Current findings:**

- During search, objects are incidentally learned, increasing familiarity.

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• Evaluation, current findings:

• Facilitation dampened by disruption of space, but eliminated by disruption of object coherence.

• Facilitation incurs faster termination of the search process (i.e., fewer fixations); no change in item processing.

• Performance does not become more “efficient”, suggesting a stable level of attentional guidance.

Significantly greater facilitation in Exp 1a, relative to Exp 2a.

Conclusion: we seem to search faster because incidental learning (of objects and space) increases familiarity with the scene.

In short, we become confident of our search decision more quickly, without becoming “better” searchers.
Thank you for your attention...

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