CPSC 532E — Week 7: Lecture

Attention II

- The Role of Visual Attention
- The Limits of Visual Attention

What is the role of visual attention?

Old view: Attention "welds" preattentive features into more complex structures.
The accumulation of these structures is then the basis for visual perception

But: 1) A lot of the "welding" is already done at the preattentive (rapid) level

2) If structures accumulate, why can we fail to see large changes (change blindness)?

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Intuition: *Accumulation of information*

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So why should change blindness exist?

Proposal: Attention is needed to perceive change in an object.

Under normal circumstances, a change creates a motion transient, which draws attention.

When change is made same time as another event, transients interfere with drawing of attention, causing change to become “invisible”.

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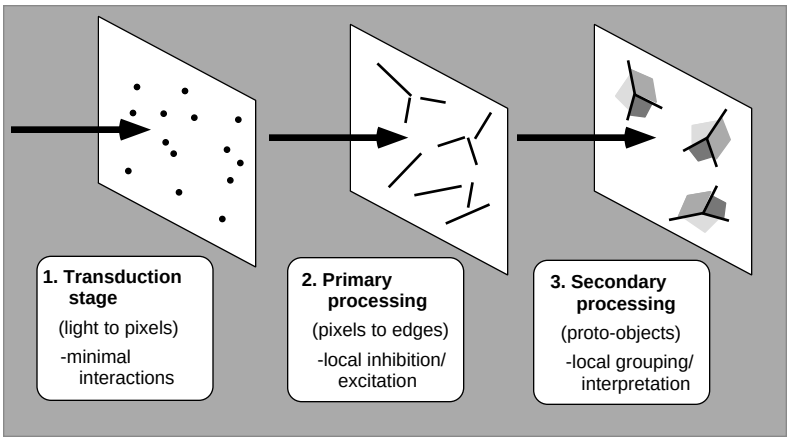
How does attention enable change perception?

Recap: Initial stages of visual processing



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Coherence theory

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Without attention, proto-objects are volatile, i.e., have limited coherence in space and time. Thus, they are **replaced** by any new stimuli.

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Coherence theory— (cont'd):

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Focused attention acts as a metaphorical hand that "grabs" selected proto-objects and makes them **coherent** across time as well as space

As such, they maintain an **identity**, and thus can be perceived to change

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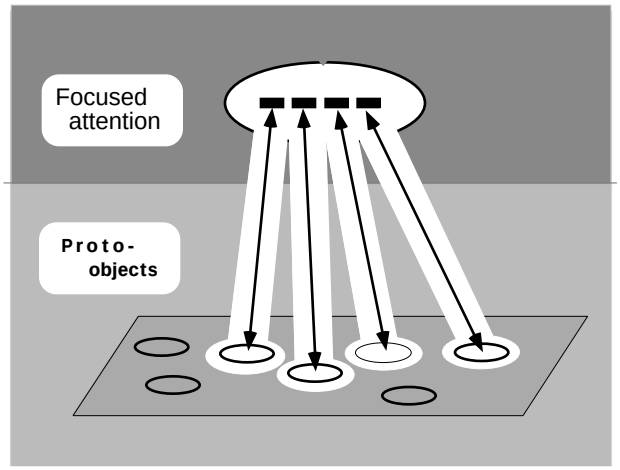

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Coherence theory— (cont'd):

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Once attention is released, objects "dissolve" back into proto-objects

- There is no buildup of information after attention is withdrawn from items (see also Wolfe, 1999)

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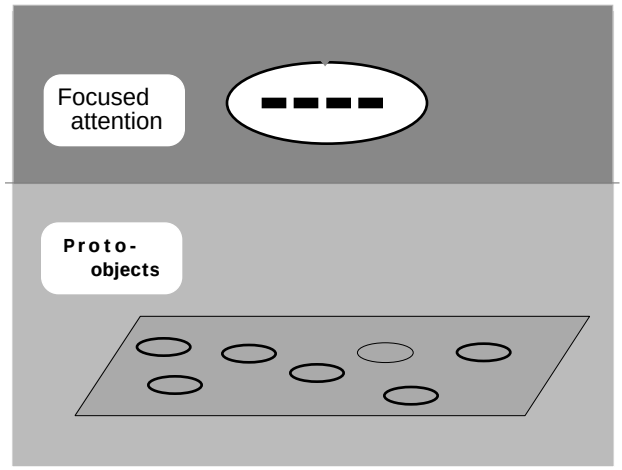

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Exploring Attentional Mechanisms

Can use experimental techniques and theories to explore the nature of visual attention

Example: Use them to explore aspects like:

- **capacity** — how many items are “held” at a time?
- **speed** — how fast are attended objects formed?
- **coding** — what are the “primitives” of attention?
- **guidance** — what attracts visual attention?

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Attentional Capacity

Approach: Visual Search for Change

- use images that change back and forth in time, like the scene examples

- **but** images that are **much simpler** in content
  - can control the number of items, the type of change, etc.

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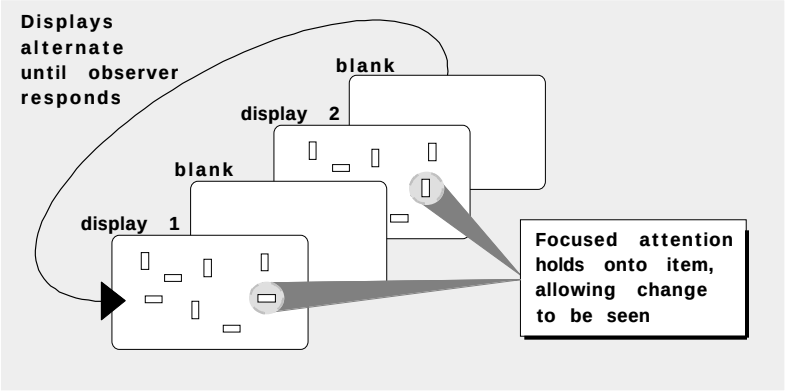
Visual Search for <u>Change</u> (Rensink, 2000c)

- on half the trials, one of the items changes (target)
- observer must report if change present or absent



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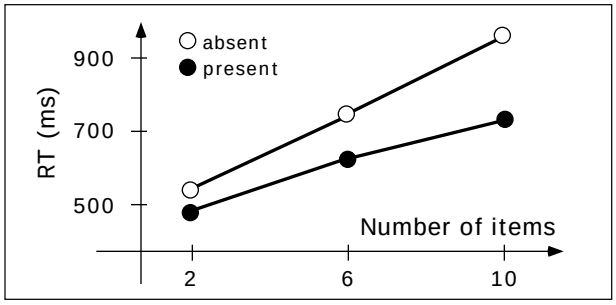
Measure: Reaction time (RT) vs. set size

RT is a linear function of number of items



search slope = Δ (reaction time) / Δ (# of items)

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Determination of attentional capacity:

The number of items held by attention across a gap

hold = (alternation rate) / (search rate)

To determine capacity (maximum hold):

1. Find search speeds for **various display times**
   - the longer the display, the more items held
   - loading will eventually **saturate**
2. **Asymptotic value of hold = attentional capacity**

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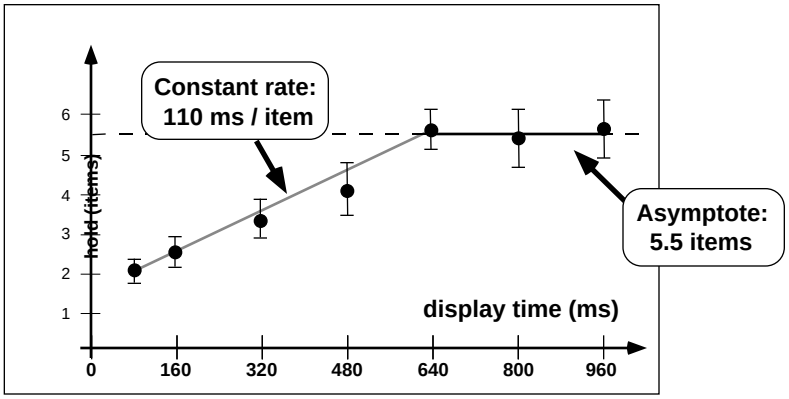
Results: Search for **presence of change (orientation)**
(task: look for horizontal items changing to vertical)



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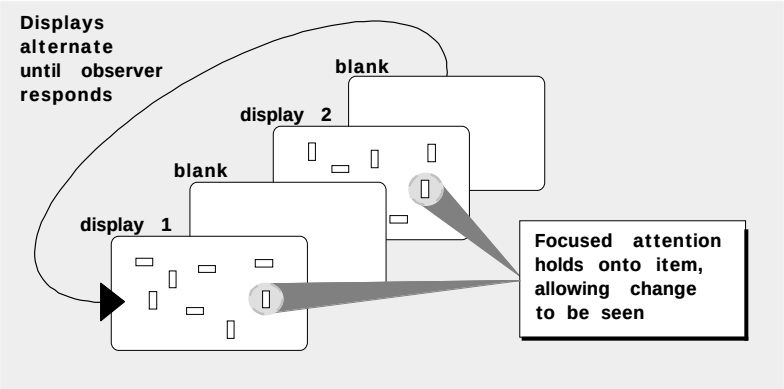
Visual Search for Absence of Change

-on half the trials, one of the items doesn't change (target)
-observer reports if a nonchange is present or absent



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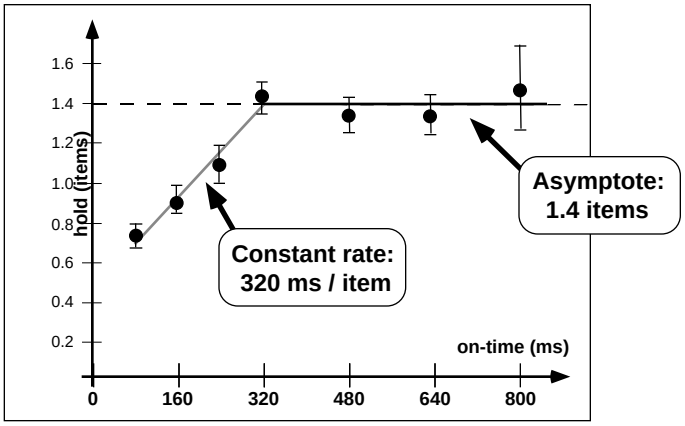
Results: Search for **absence of change (orientation)**
(task: look for items that remain horizontal or vertical)



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Search for **presence of change (orientation)**
- capacity is ~ 5 items
- similar to limits found via other techniques
(e.g. item tracking)

Search for **absence of change (orientation)**
- capacity is ~ 1 item

Why?

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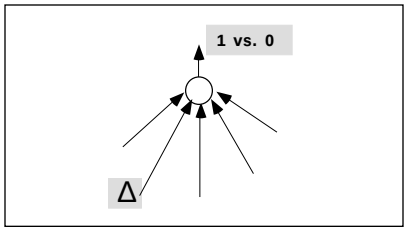
Hypothesis: Attention pools information from 4-5 links into a single **nexus**

(a) Searching for presence of change

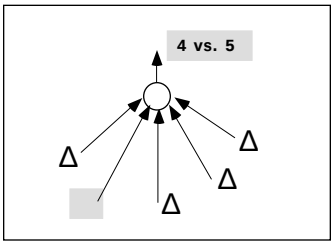


If change present, nexus value = 1

If change absent, nexus value = 0

Thus, present vs absent is 1 vs 0 — strong signal

(b) Searching for absence of change



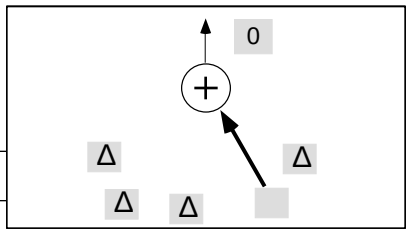
If nonchange present, nexus value = 4

If nonchange absent, nexus value = 5

Thus, present vs absent is 4 vs 5 — weak signal

(b) Searching for absence of change

one item at a time



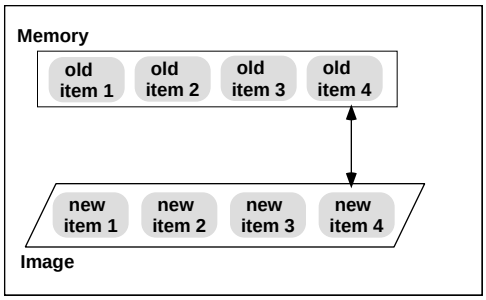
If nonchange present, nexus value = 1

If nonchange absent, nexus value = 0

Present vs absent is 1 vs 0 — **strong signal**

Note: Limitation is not just in comparison operation

If several items in memory, could check them all:



But for absence of change, capacity is only 1…

Thus, attended items (items in memory) are **not independent — linked via nexus**

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-> All attended items form a single integrated structure
- coherence field (Rensink, 2002)

Places severe limits on what can be seen in a dynamic display

-> If attended items are part of a single field, may not be possible to keep changing items separate.
May only be able to see one change at a time

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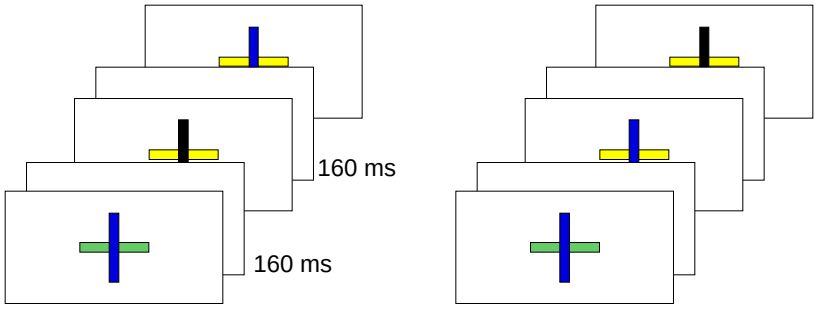
Rensink (2002c)



(a) Sequence contains **a** simultaneous change

(b) Sequence contains **no** simultaneous changes

Observer asked to report if sequence contains a simultaneous change

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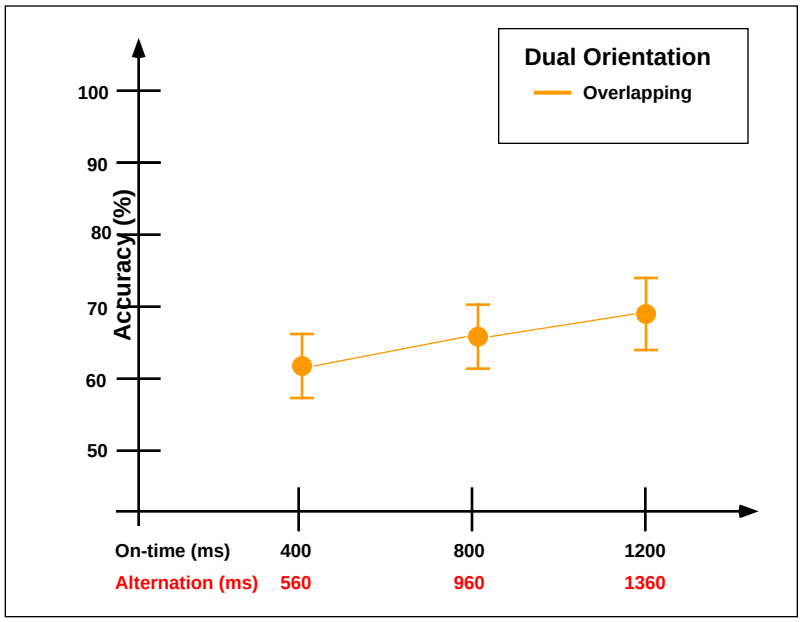

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Thus,observers have difficulty distinguishing one change from two changes

→ **Observers cannot see more than one change at a time**

→**All attended items are linked together in some way**

- pooled into a single **nexus**
- form a single **coherence field**

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Summary

Attention loads up over time
loading rate = 8 items/sec

Attention has a capacity of 5 items
- similar to other estimates of attentional capacity
- demonstrates that visual detail is not built up
  - otherwise, capacity estimate would be unlimited

Only one object can be attended at a time
- info can be collected from up to 5 items
- pooled into a single attentional nexus
- these then form parts of a single coherence field

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Implications for Display Design

1. Rapid Pickup of Information

→ maximum amount of information that can be picked up at any instant is from 4-5 items
- only a small amount from each item

→ can use flicker paradigm to find the basic units of visual attention.
- units = properties which have capacity of 4-5
- items that are compounds will take longer to see

→ switches to new (coherent) objects should be minimized
- each switch can take c. 300 ms

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2. Conveying Information via Dynamic Means

→ No attentional distraction from other parts of display
- would create change blindnes)

→ Keep important sources of information together
- minimize eye movements -> less change blindness

→ Only one dynamic information source at a time
- can't separate two simultaneous changes

→ Only a limited amount of information can be conveyed
- perception of dynamic patterns requires attention, and attention is severely limited in capacity.

(e.g. blindness to more than one movement parameter)

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