

7

Attention and Scene Perception



- Selection in Space
- Visual Search
- Attending in Time: RSVP and the Attentional Blink
- The Physiological Basis of Attention
- Disorders of Visual Attention
- Perceiving and Understanding Scenes

Attention: Any of the very large set of selective processes in the brain.

- To deal with the impossibility of handling all inputs at once, the nervous system has evolved mechanisms that are able to restrict processing to a subset of things, places, ideas, or moments in time.

Selective attention: The form of attention involved when processing is restricted to a subset of the possible stimuli.

Varieties of Attention

- External: Attending to stimuli in the world
- Internal: Attending to one line of thought over another or selecting one response over another
- Overt: Directing a sense organ toward a stimulus, like turning your eyes or your head

Varieties of Attention (*continued*)

- Covert: Attending without giving an outward sign you are doing so
- Divided: Splitting attention between two different stimuli
- Sustained: Continuously monitoring some stimulus

Figure 7.1 We simply cannot read the left-hand and right-hand sentences at the same time

These	x	Is
letters	x	it
are	x	time
big	x	for
and	x	a
easy	x	quick
to	x	snack
read.	x	yet?

Figure 7.2 Search for the unicorn in this piece of a “Where’s Waldo?” picture



SENSATION & PERCEPTION 4e, Figure 7.2

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Selection in Space

Reaction time (RT): A measure of the time from the onset of a stimulus to a response.

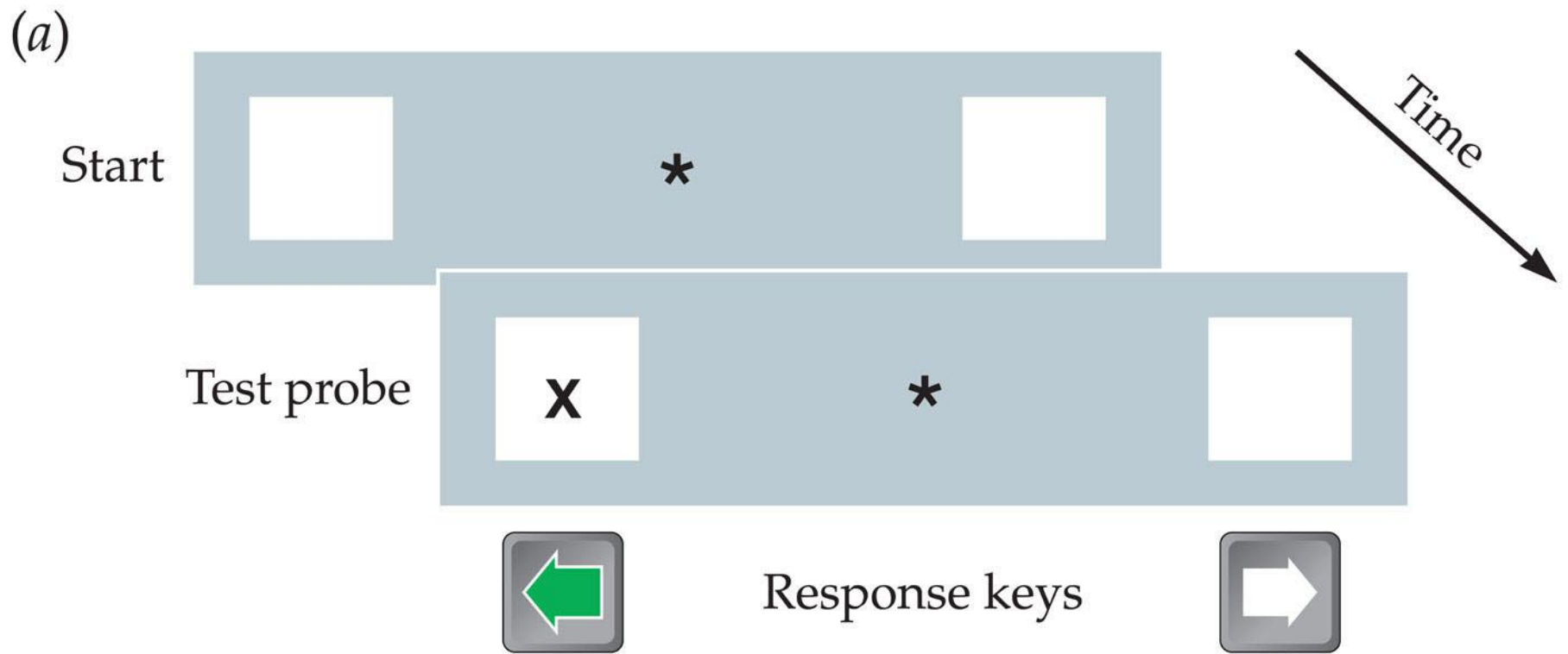
Cue: A stimulus that might indicate where (or what) a subsequent stimulus will be.

- Cues can be valid (correct information), invalid (incorrect), or neutral (uninformative).

Stimulus onset asynchrony (SOA): The time between the onset of one stimulus and the onset of another.

Cueing as a tool for examining attention

- Simple probe detection experiment
 - Posner cueing paradigm
- Cues can be valid or invalid
 - RTs are shorter on valid cue trials
 - RTs are longer on invalid cue trials



(b)

Time 1



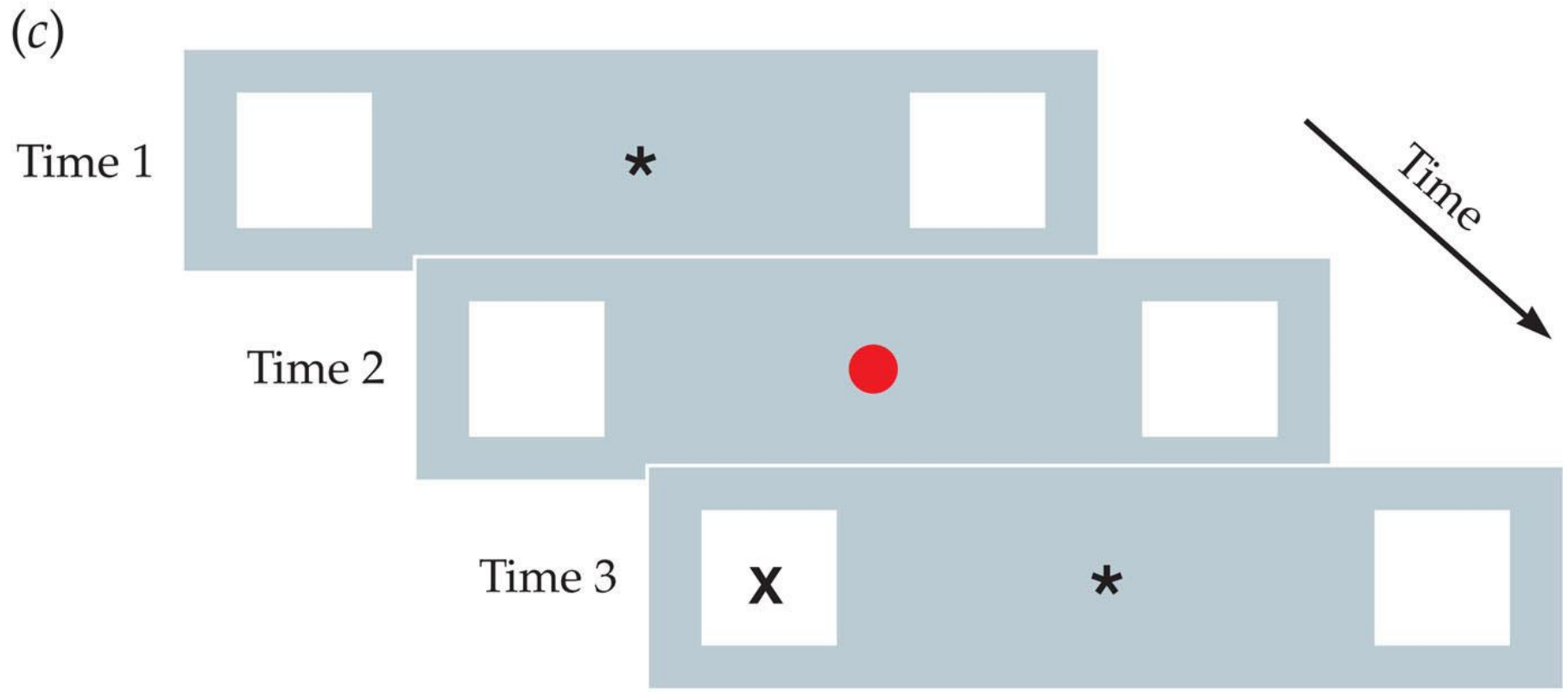
Time 2



Time 3

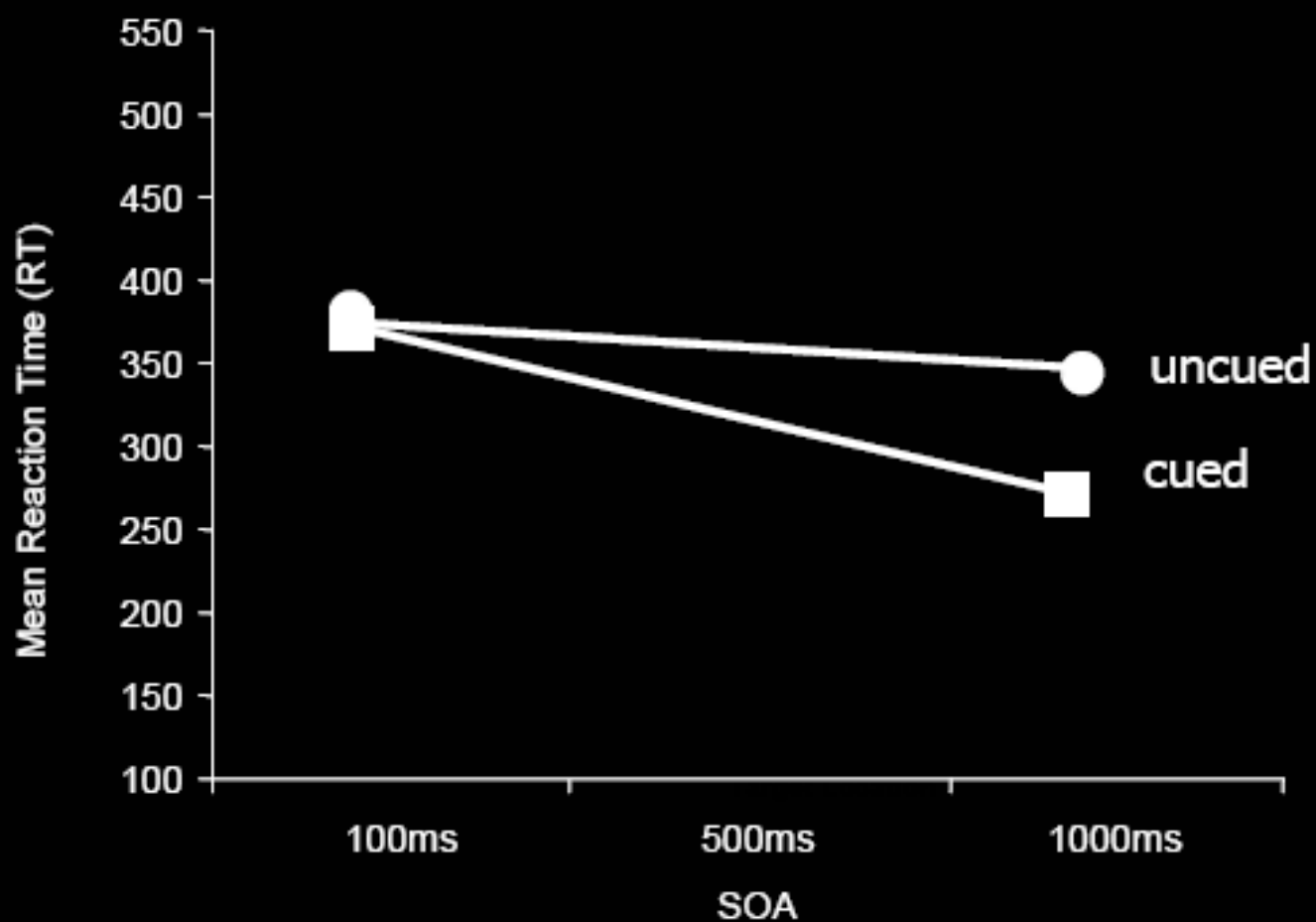


This cue is valid.



This cue is invalid.

Voluntary attention



Reflexive Attention

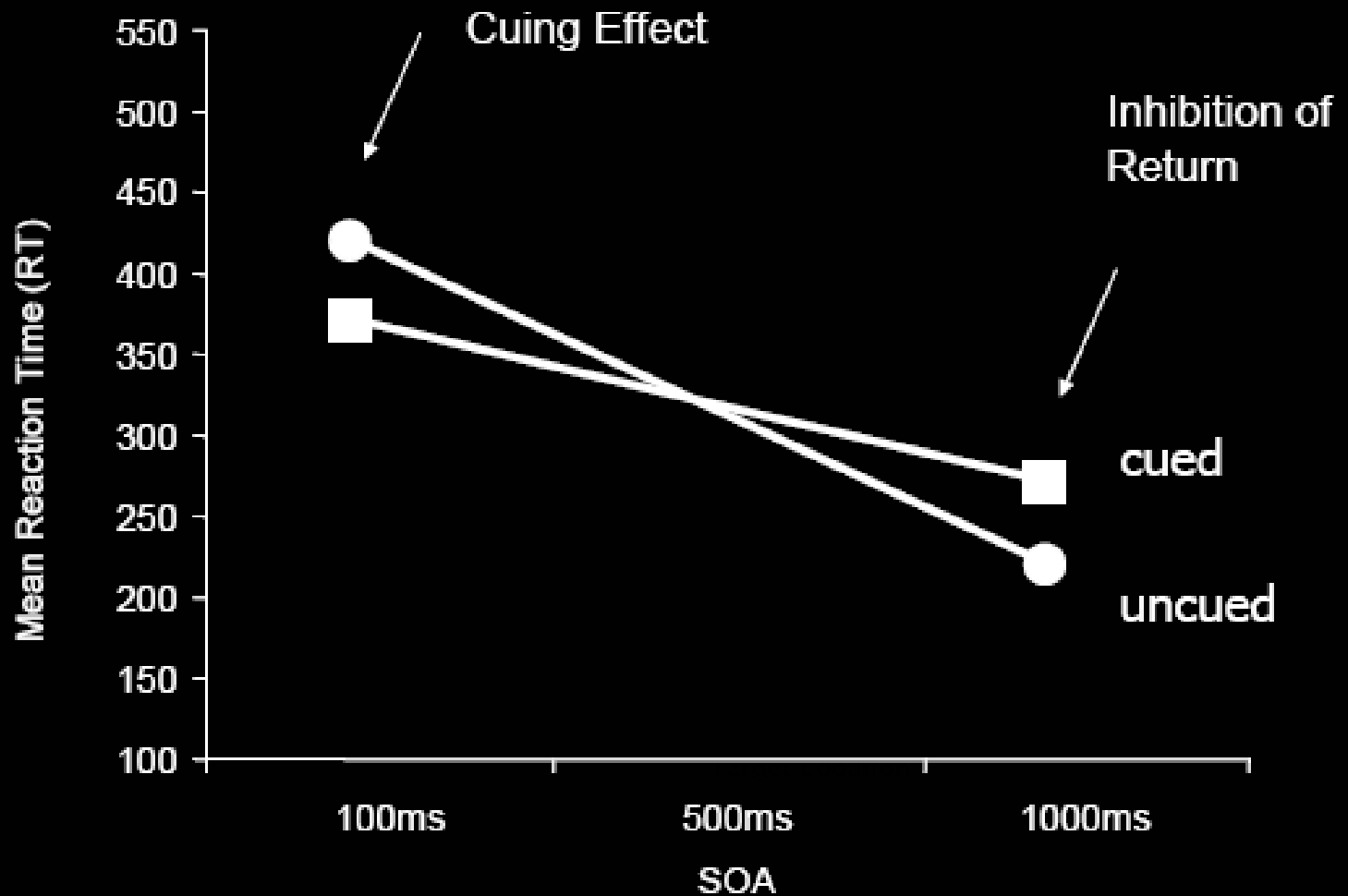
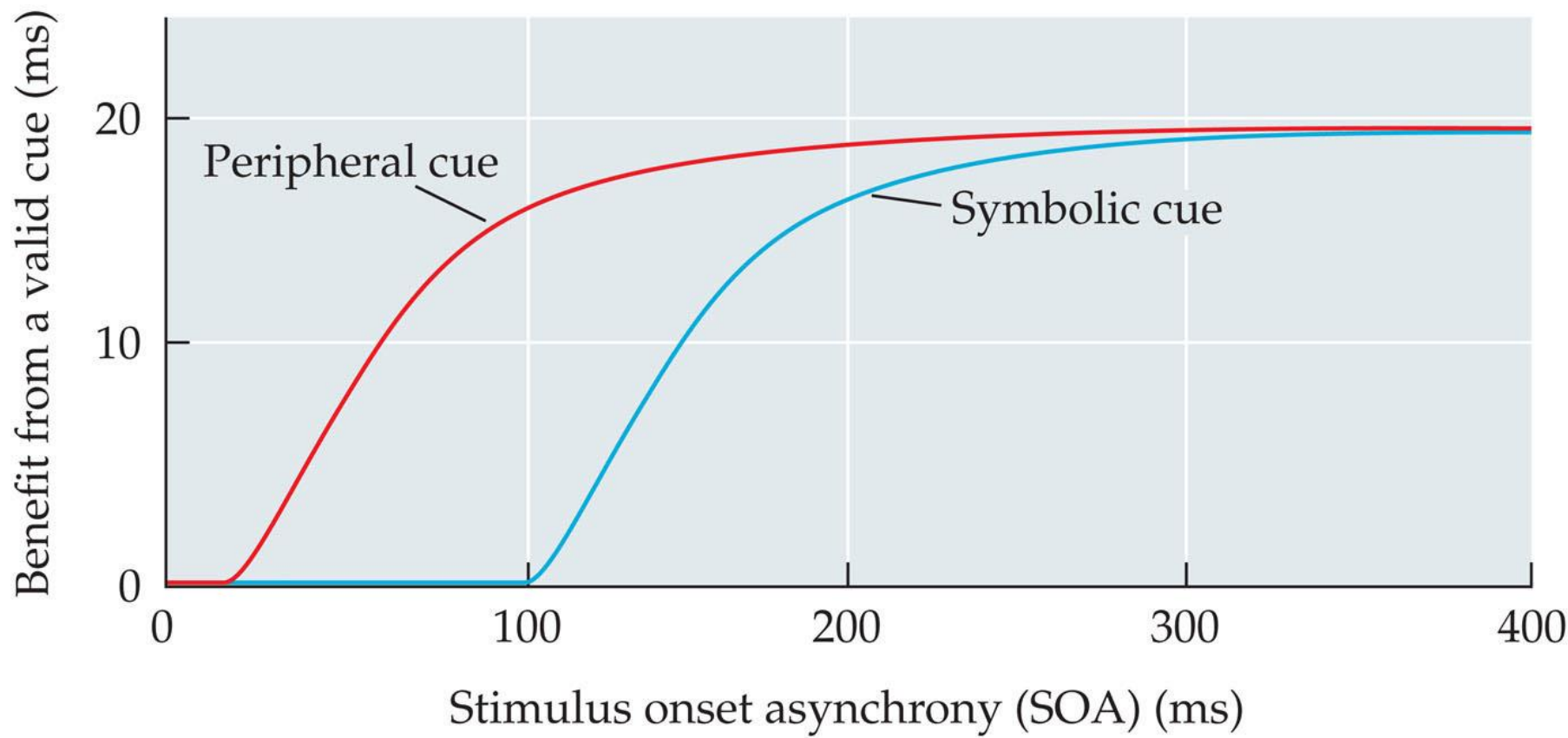


Figure 7.4 The effect of a cue develops over time



Inhibition of return (IOR): The relative difficulty in getting attention (or the eyes) to move back to a recently attended (or fixated) location.

- During search, IOR stops you from getting stuck continually revisiting one spot.

Theories of Attention

- “Spotlight” model: Attention is restricted in space and moves from one point to the next. Areas within the spotlight receive extra processing.
- “Zoom lens” model: The attended region can grow or shrink depending on the size of the area to be processed.

Visual search: Looking for a target in a display containing distracting elements.

- Examples: Finding weeds in your lawn or the remote control on the coffee table

Target: The goal of a visual search.

Distractor: In visual search, any stimulus other than the target.

Set size: The number of items in a visual search display.

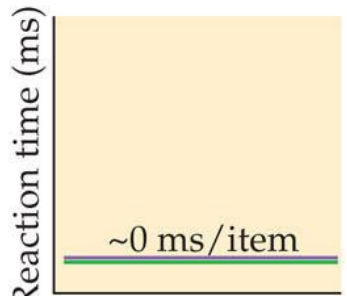
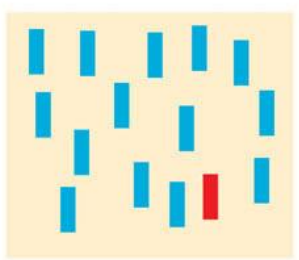
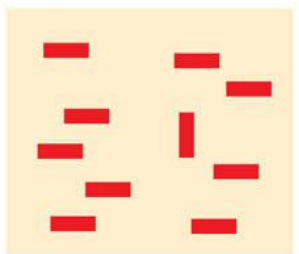
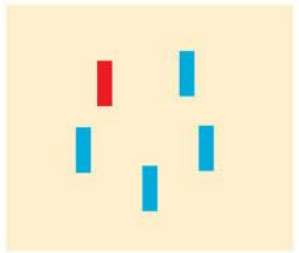
The efficiency of visual search is the average increase in RT for each item added to the display.

- Measured in terms of search slope, or ms/item
- The larger the search slope (more ms/item), the less efficient the search
- Some searches are efficient and have small slopes
- Some searches are inefficient and have large slopes


Figure 7.6 Laboratory visual search tasks

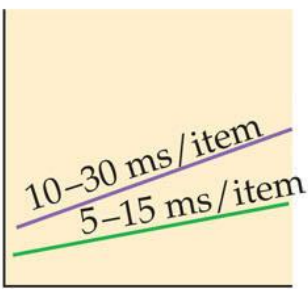
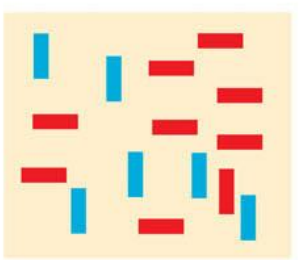
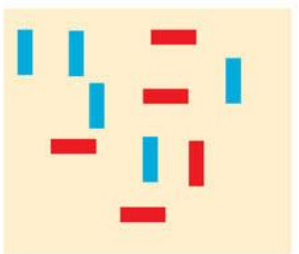
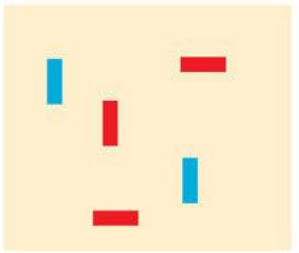
(a) Feature search

Find 



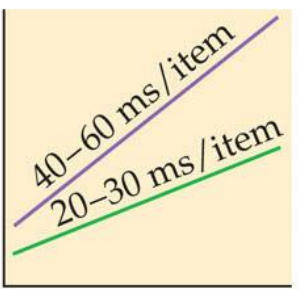
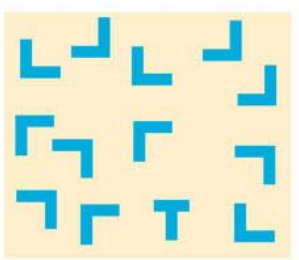
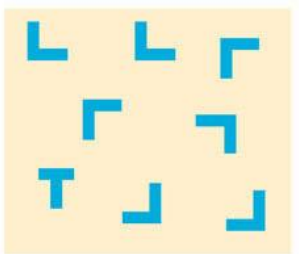
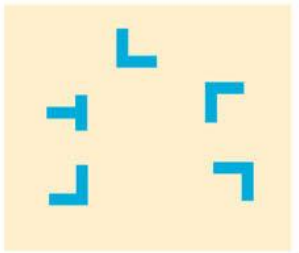
(b) Conjunction search

Find 



(c) Spatial configuration search

Find    or 



— Correct target present
— Correct target absent

Feature searches are efficient.

- Feature search: Search for a target defined by a single attribute, such as a salient color or orientation.
- Saliency: The vividness of a stimulus relative to its neighbors.
- Parallel: In visual attention, referring to the processing of multiple stimuli at the same time.

Many searches are inefficient.

- Serial self-terminating search: A search from item to item, ending when a target is found.

Figure 7.8 Search can be much more laborious if you're not familiar with what you're searching for

Find: 优 "Grace"

Among: 福 "Happiness" 恕 "Forgiveness" 花 "Flower"

恕 福 恕
花 恕 花
福 优 花

In real-world searches, basic features guide visual search.

- Guided search: Attention is restricted to a subset of possible items based on information about the item's basic features (e.g., color or shape).
- Conjunction search: Search for a target defined by the presence of two or more attributes.
 - No single feature defines the target
 - Defined by the co-occurrence of two or more features

Figure 7.9 A real-world conjunction search



SENSATION & PERCEPTION 4e, Figure 7.9

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In real-world searches, the real world guides visual search.

- Scene-based guidance: Information in our understanding of scenes that helps us find specific objects in scenes.
 - For instance, a mug will typically be found on a horizontal surface and a picture will typically be found on a vertical surface.

Figure 7.10 Search for arbitrary objects is not very efficient



SENSATION & PERCEPTION 4e, Figure 7.10
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Figure 7.11 Scene-based guidance would help you find the faucet in this scene

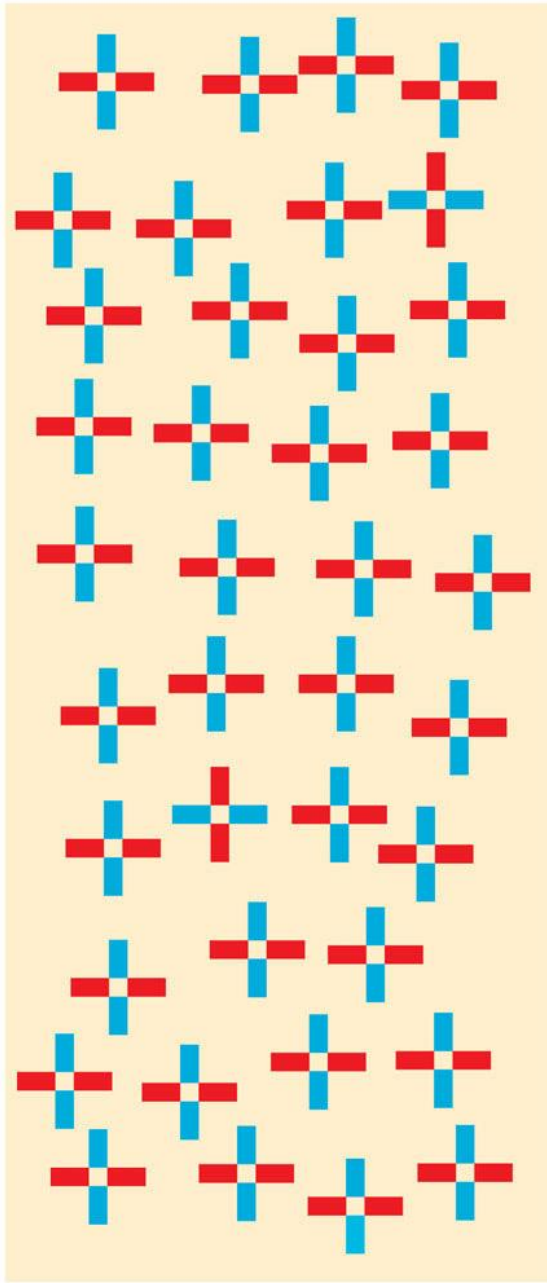


SENSATION & PERCEPTION 4e, Figure 7.11

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The binding problem: The challenge of tying different attributes of visual stimuli, which are handled by different brain circuits, to the appropriate object so we perceive a unified object.

- Example: A vertical red bar moving to the right
 - Color, motion, and orientation are represented by separate neurons.
 - How do we combine these features when perceiving the bar?



SENSATION & PERCEPTION 4e, Figure 7.12

Feature integration theory: Treisman's theory of visual attention, which holds that a limited set of basic features can be processed in parallel preattentively, but that other properties, including the correct binding of features to objects, require attention.

- Preattentive stage: The processing of a stimulus that occurs before selective attention is deployed to that stimulus.

Is there any evidence that features are represented independently of each other and need to be bound together? Yes.

Illusory conjunction: An erroneous combination of two features in a visual scene.

- Example: Seeing a red X when the display contains red letters and Xs but no red Xs
- Illusory conjunctions provide evidence that some features are represented independently and must be correctly bound together with attention.

Figure 7.13 Illusory conjunctions



SENSATION & PERCEPTION 4e, Figure 7.13

Rapid serial visual presentation (RSVP):

An experimental procedure in which stimuli appear in a stream at one location (typically the point of fixation) at a rapid rate (typically about eight per second).

- RSVP is used to study the temporal dynamics of visual attention.

Attentional blink: The difficulty in perceiving and responding to the second of two target stimuli amid a RSVP stream of distracting stimuli.

- The second target is often missed if it appears within 200 to 500 ms of the first target.

Green and Bavelier (2003) reported that people who play first-person shooter video games have a reduced attentional blink.

- This suggests that visual attention performance can be improved with practice.

Figure 7.14 The attentional blink (AB) in video game and non-video game players (Part 1)

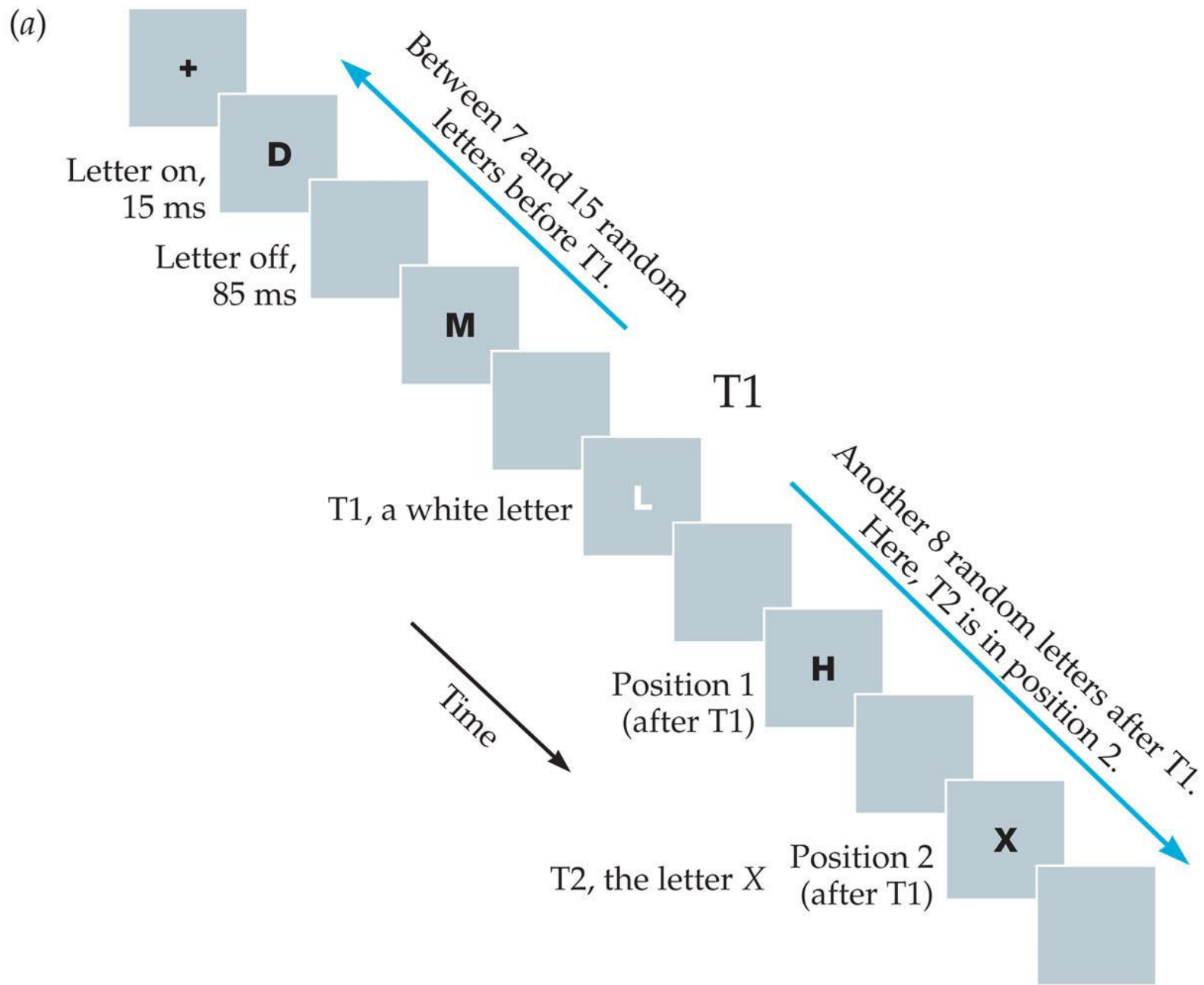


Figure 7.14 The attentional blink (AB) in video game and non-video game players (Part 2)

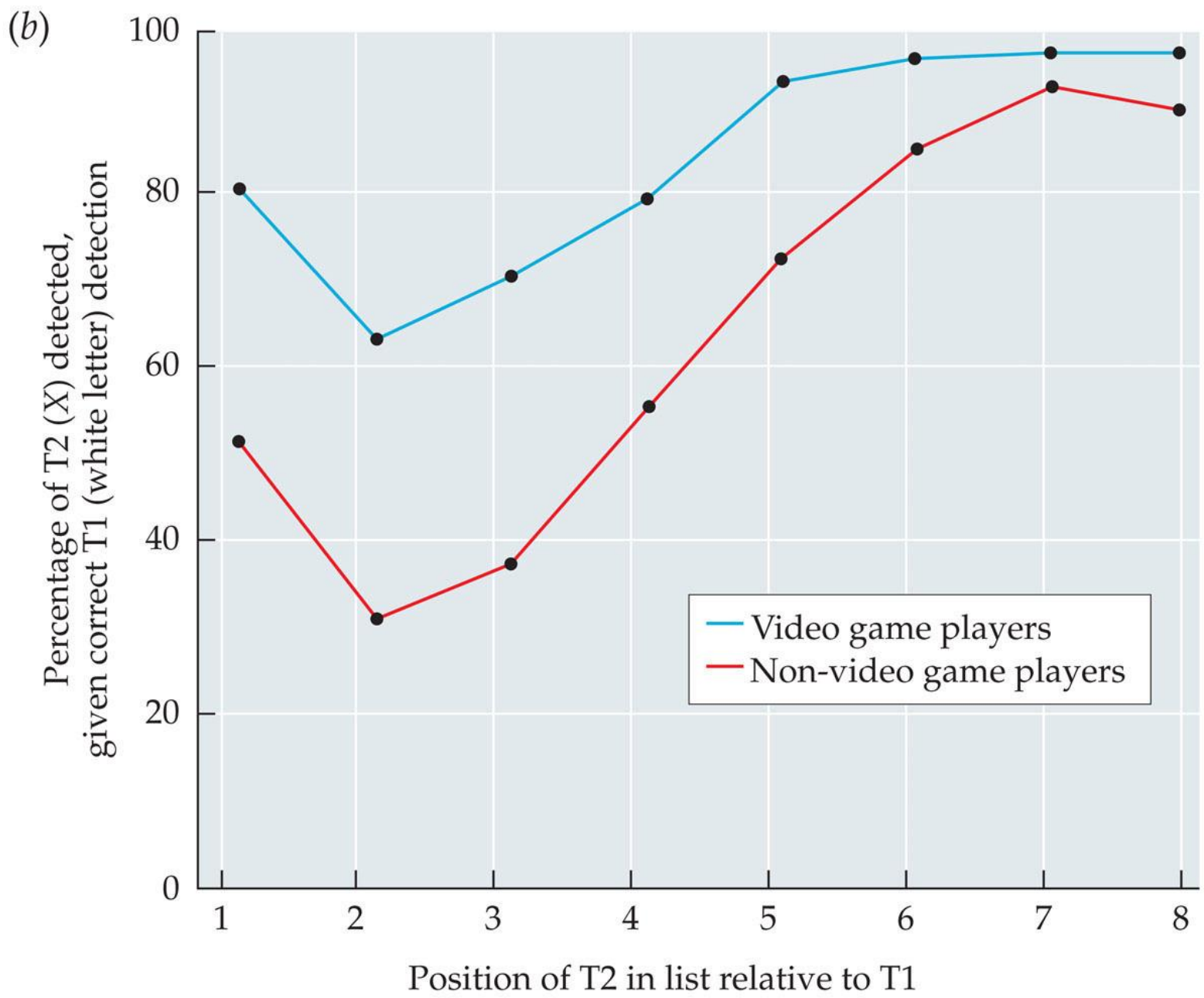
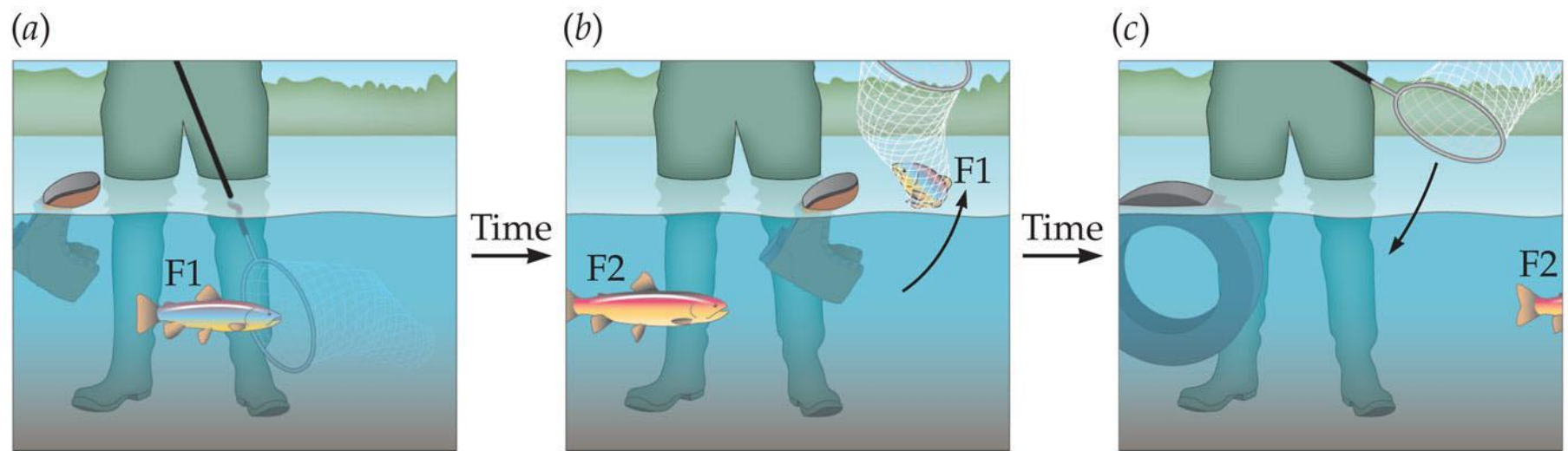


Figure 7.15 Marvin Chun's fishing metaphor for attentional blink



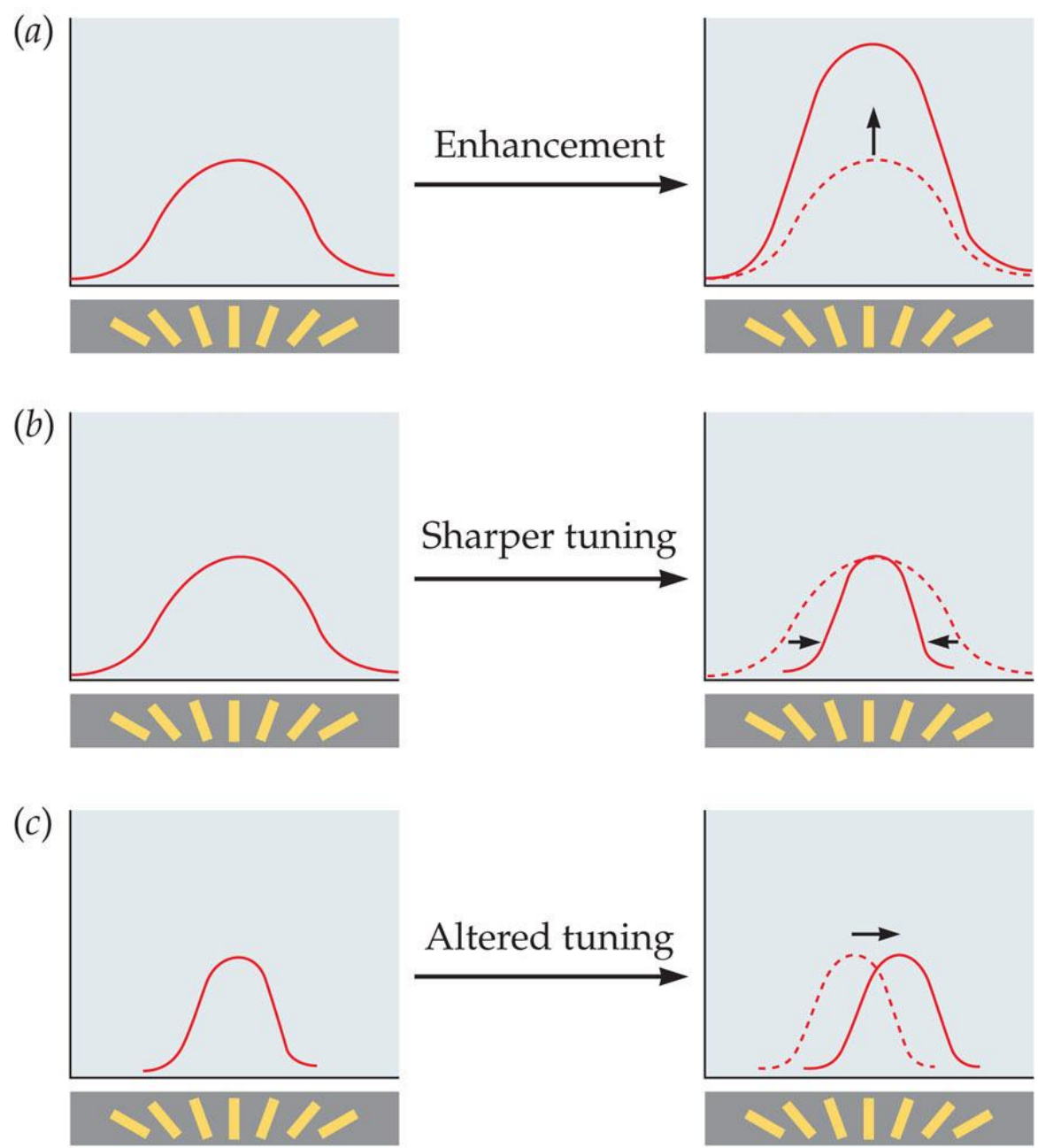
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How might attention work, in terms of neural activity?

Three ways responses of a cell could be changed by attention:

1. Response enhancement
2. Sharper tuning
3. Altered tuning

Figure 7.21 Three ways that the response of a cell could be changed as a result of attention

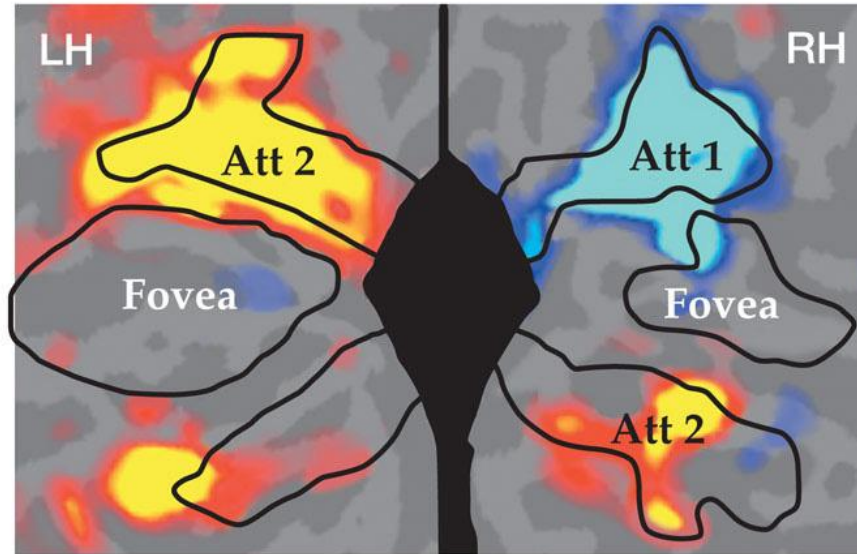


Attention could enhance neural activity.

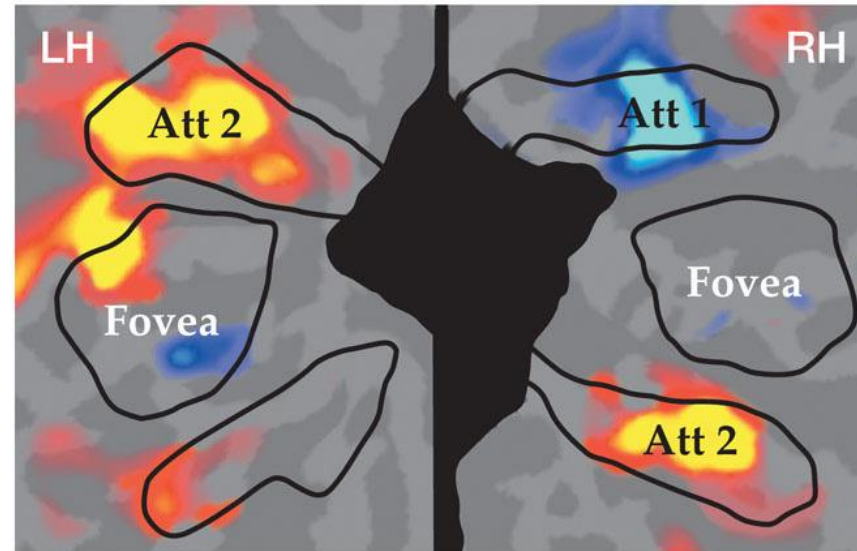
- Attention to a specific part of the visual field causes neurons coding those locations to have increased activity.
- This increased activation has been detected using fMRI technology.

Figure 7.16 Spotlights of attention in the human brain

Subject A

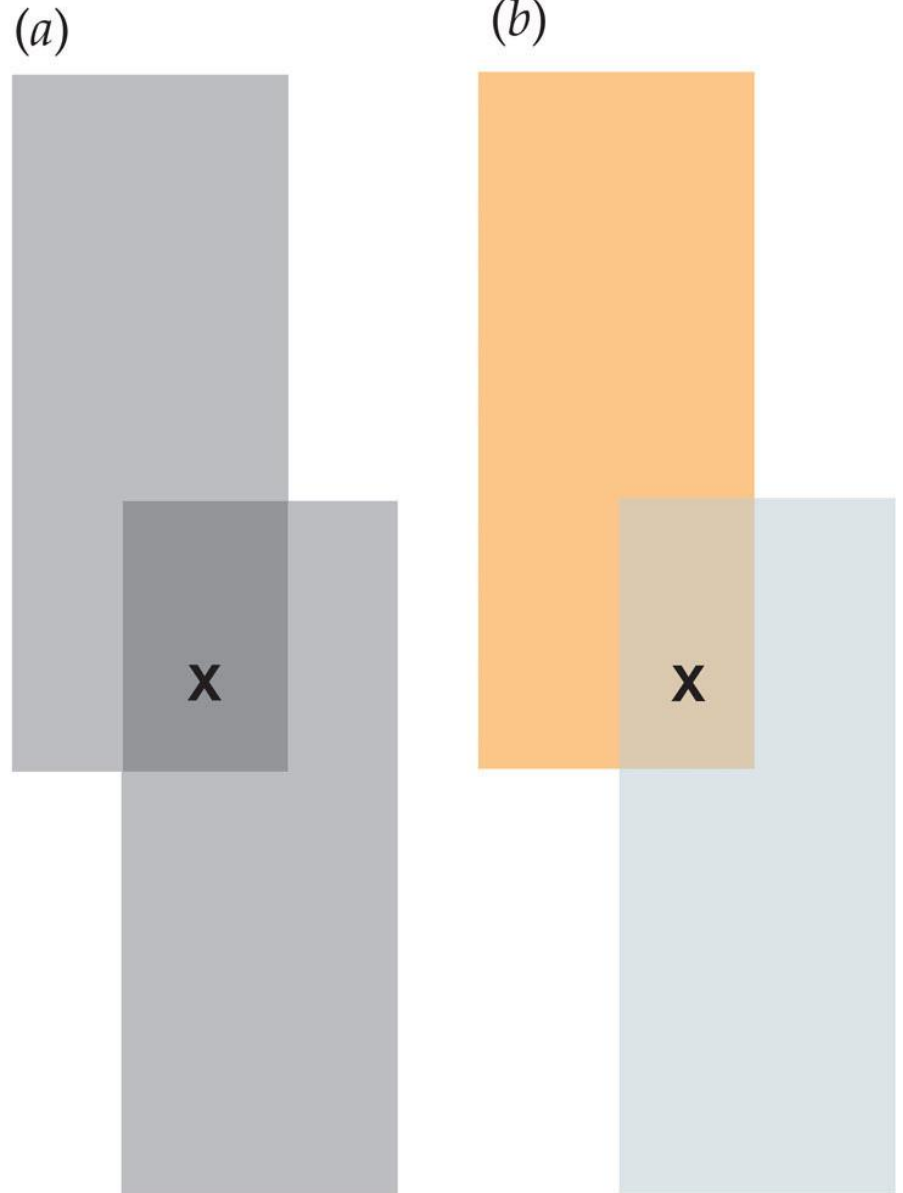


Subject B



The Physiological Basis of Attention

Attention could enhance the processing of a specific type of stimulus



Attention could enhance the processing of a specific type of stimulus (*continued*)

- Fusiform face area (FFA): An area in the fusiform gyrus of human extrastriate cortex that responds preferentially to faces according to fMRI studies.
- Parahippocampal place area (PPA): A region of cortex in the temporal lobe of humans that appears to respond strongly to images of places (as opposed to isolated objects).

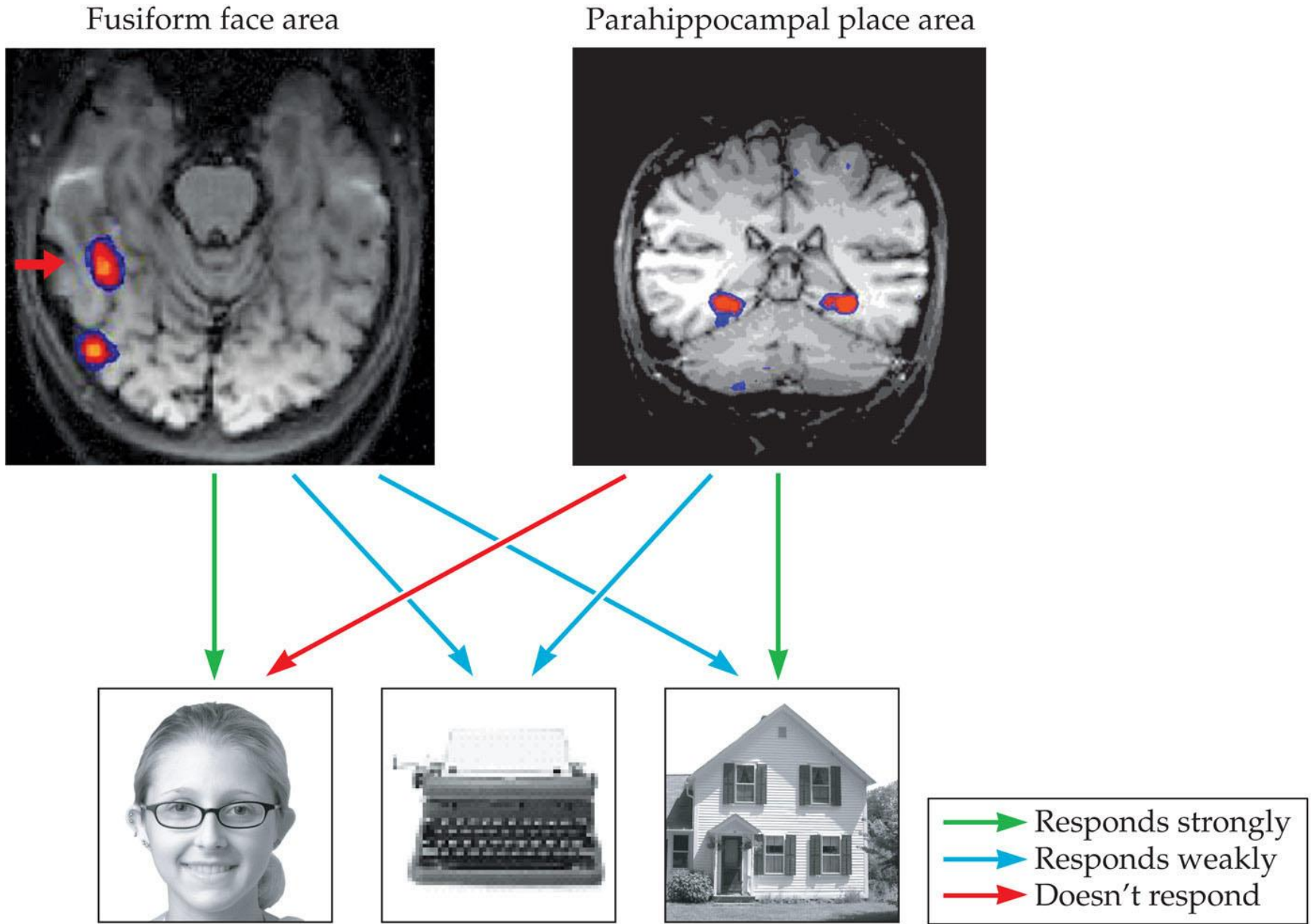
Figure 7.20 These images combine faces and houses



***SENSATION & PERCEPTION 4e*, Figure 7.20**

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Figure 7.19 Functional MRI reveals that different pieces of the cortex are activated by faces and by places

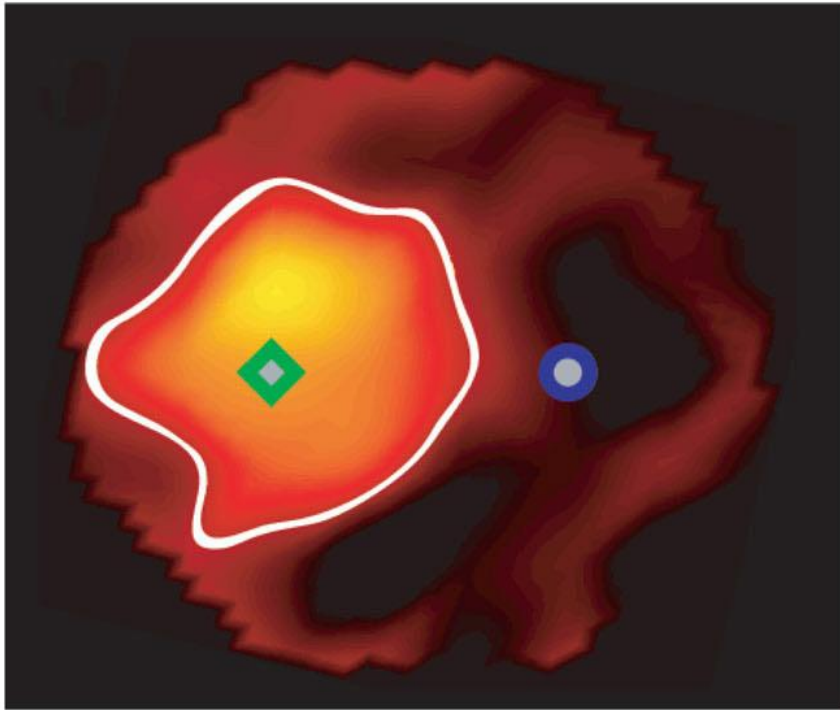


Attention could alter the tuning of a neural receptive field.

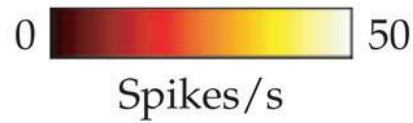
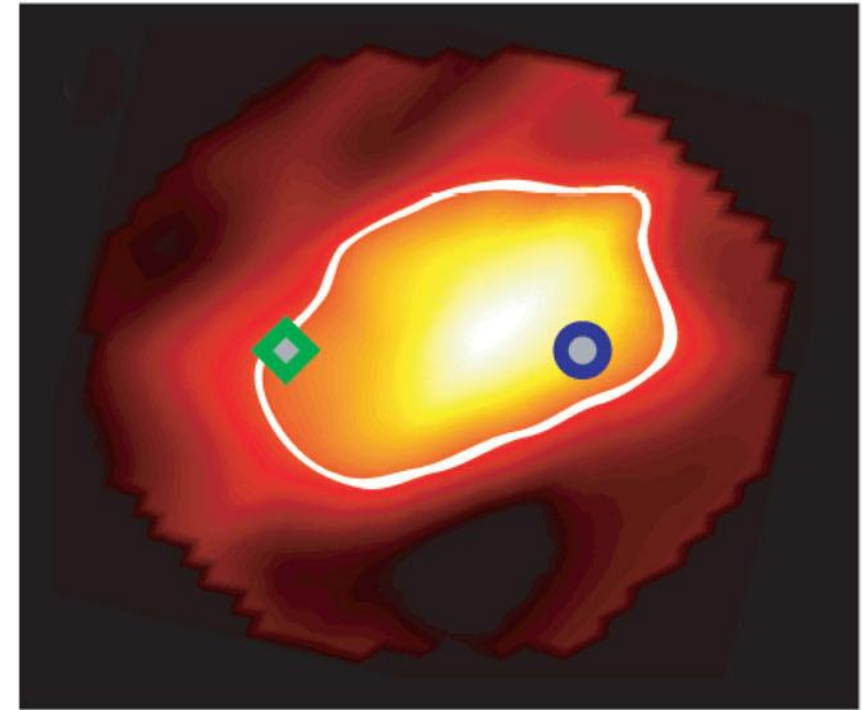
- Receptive fields of neurons are not completely fixed and can change in response to attentional demands.

Figure 7.22 Each of these images is a receptive-field map of the responses of one cell

(a)



(b)



Visual-field defect: A portion of the visual field with no vision or with abnormal vision, typically resulting from damage to the visual nervous system.

Parietal lobe: In each cerebral hemisphere, a lobe that lies toward the top of the brain between the frontal and occipital lobes.

- Damage to the parietal lobe can cause a visual field defect such that one side of the world is not attended to.

Neglect: In visual attention, the inability to attend to or respond to stimuli in the contralesional visual field.

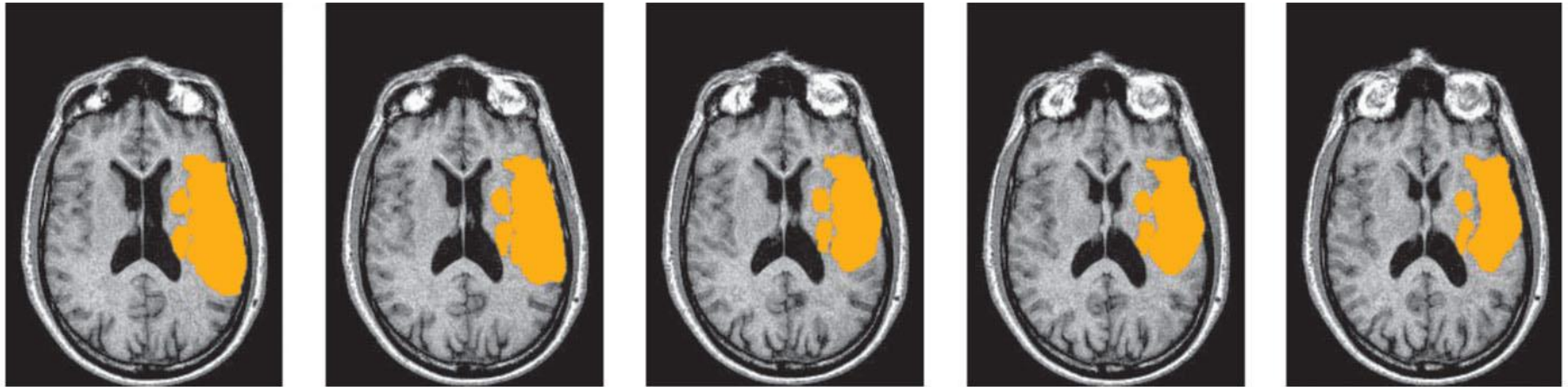
- Typically, neglect of the left visual field after damage to the right parietal lobe

Contralesional field: The visual field on the side opposite a brain lesion.

- For example, points to the left of fixation are contralesional to damage to the right hemisphere of the brain.

Ipsilesional field: The visual field on the same side as a brain lesion.

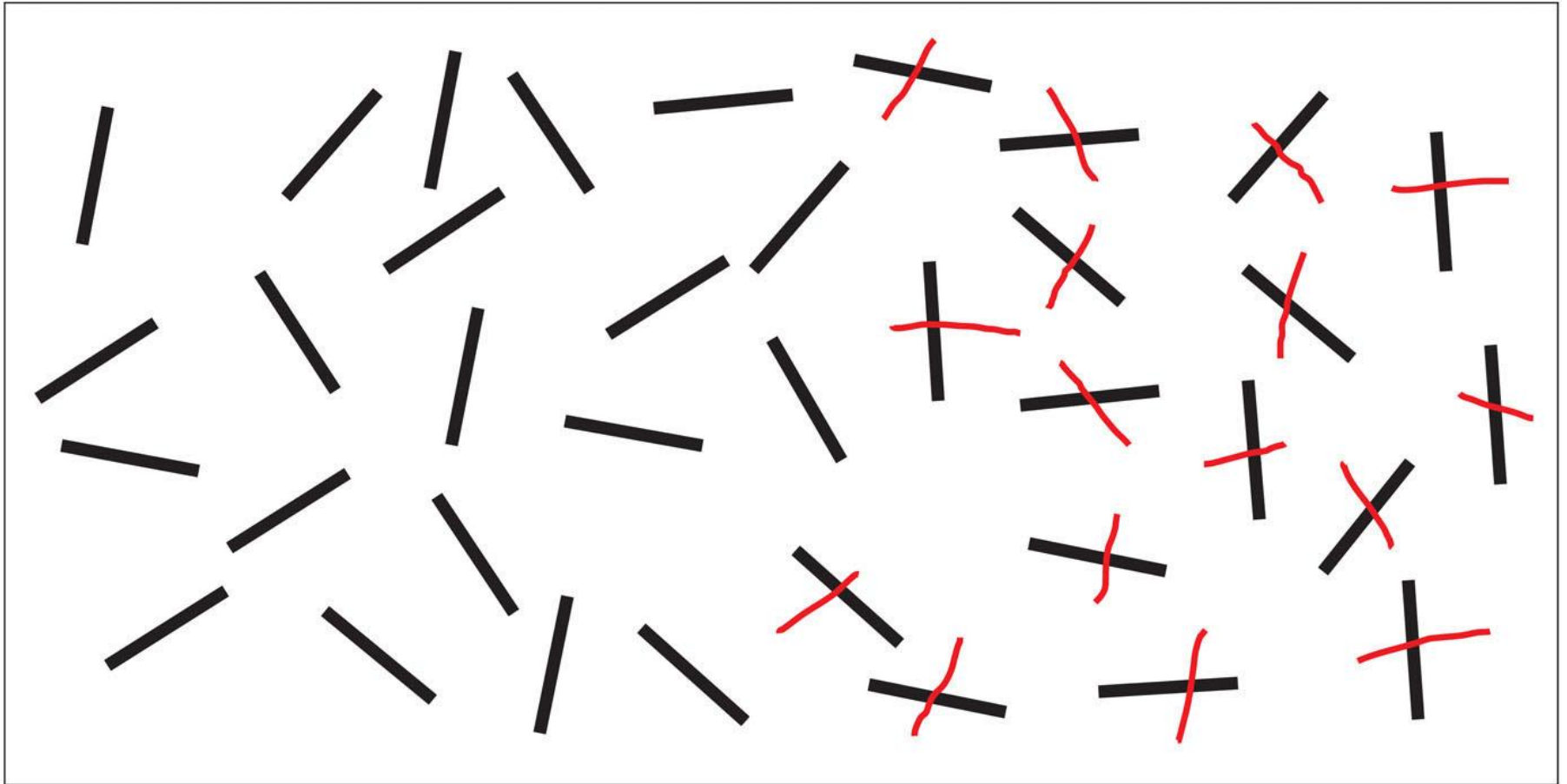
Figure 7.23 Five “slices” through the brain of a neglect patient



SENSATION & PERCEPTION 4e, Figure 7.23

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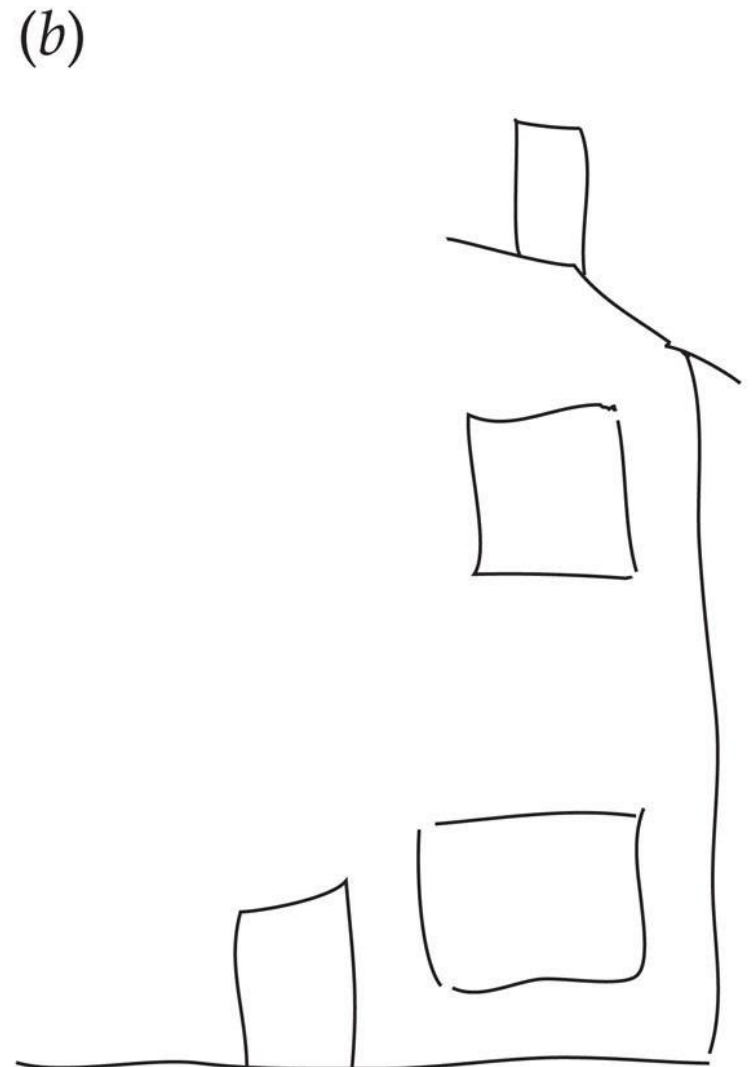
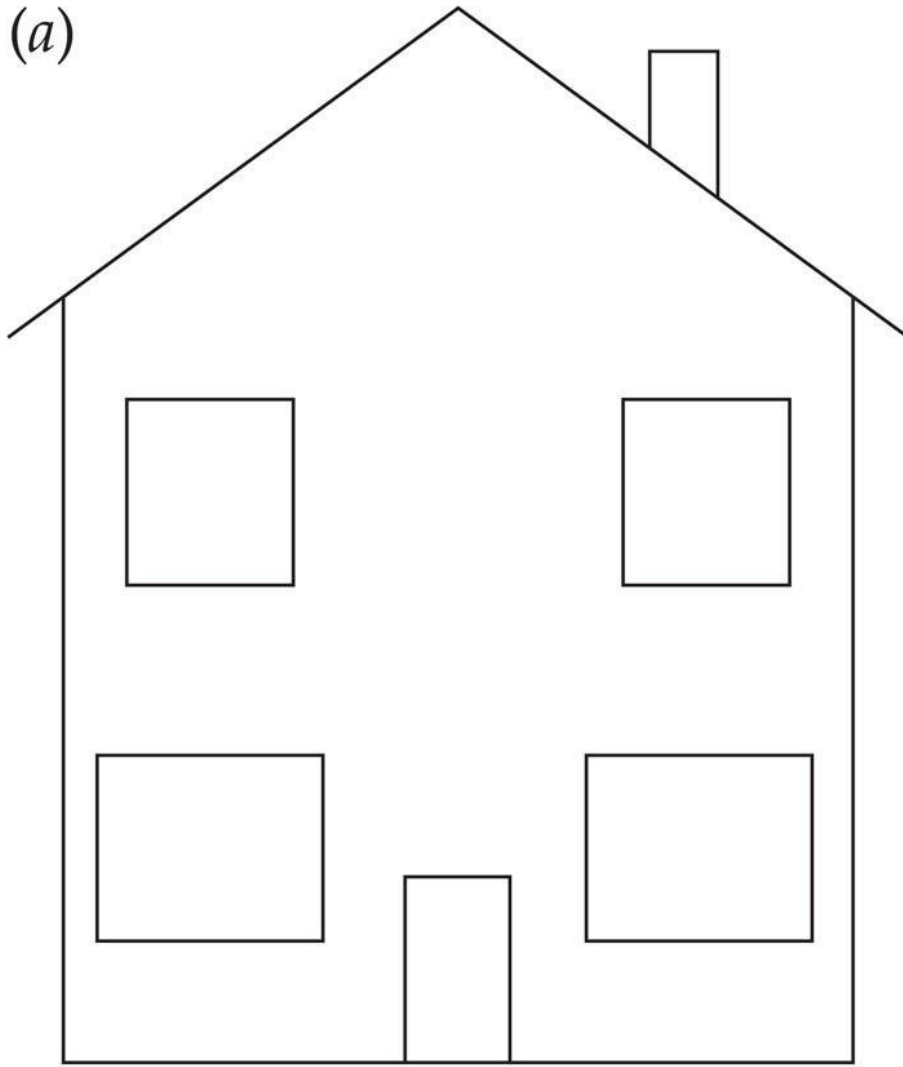
Figure 7.24 A neglect patient might produce this sort of result if asked to cross out all the lines



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Figure 7.25 In copying a drawing like the one in (a), a neglect patient often omits one side of the object, as in (b)

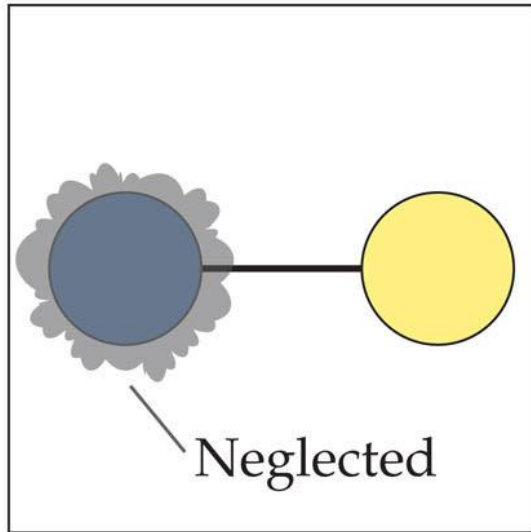


Attention can be object-based.

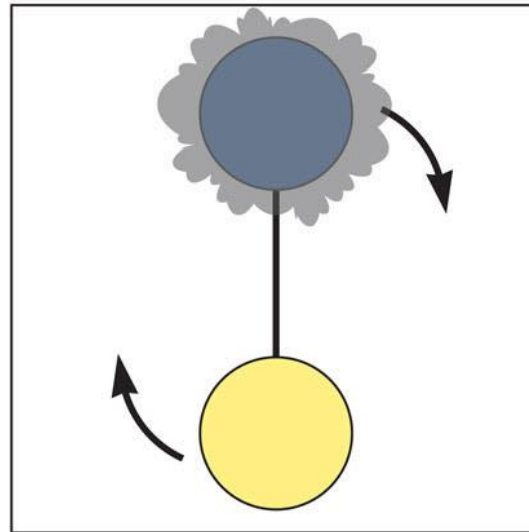
- Evidence from neglect patients indicates that they sometimes neglect one side of an object rather than one side of the visual field.

Figure 7.26 Tipper and Behrmann's experiment

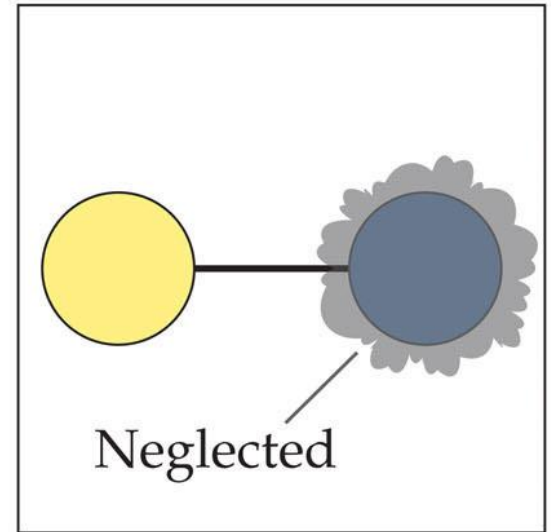
Step 1



Step 2



Step 3



SENSATION & PERCEPTION 4e, Figure 7.26
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Extinction: In visual attention, the inability to perceive a stimulus to one side of the point of fixation (e.g., to the right) in the presence of another stimulus, typically in a comparable position in the other visual field (e.g., on the left side).

Selective Attention and Attention Deficit Hyperactivity Disorder (ADHD)

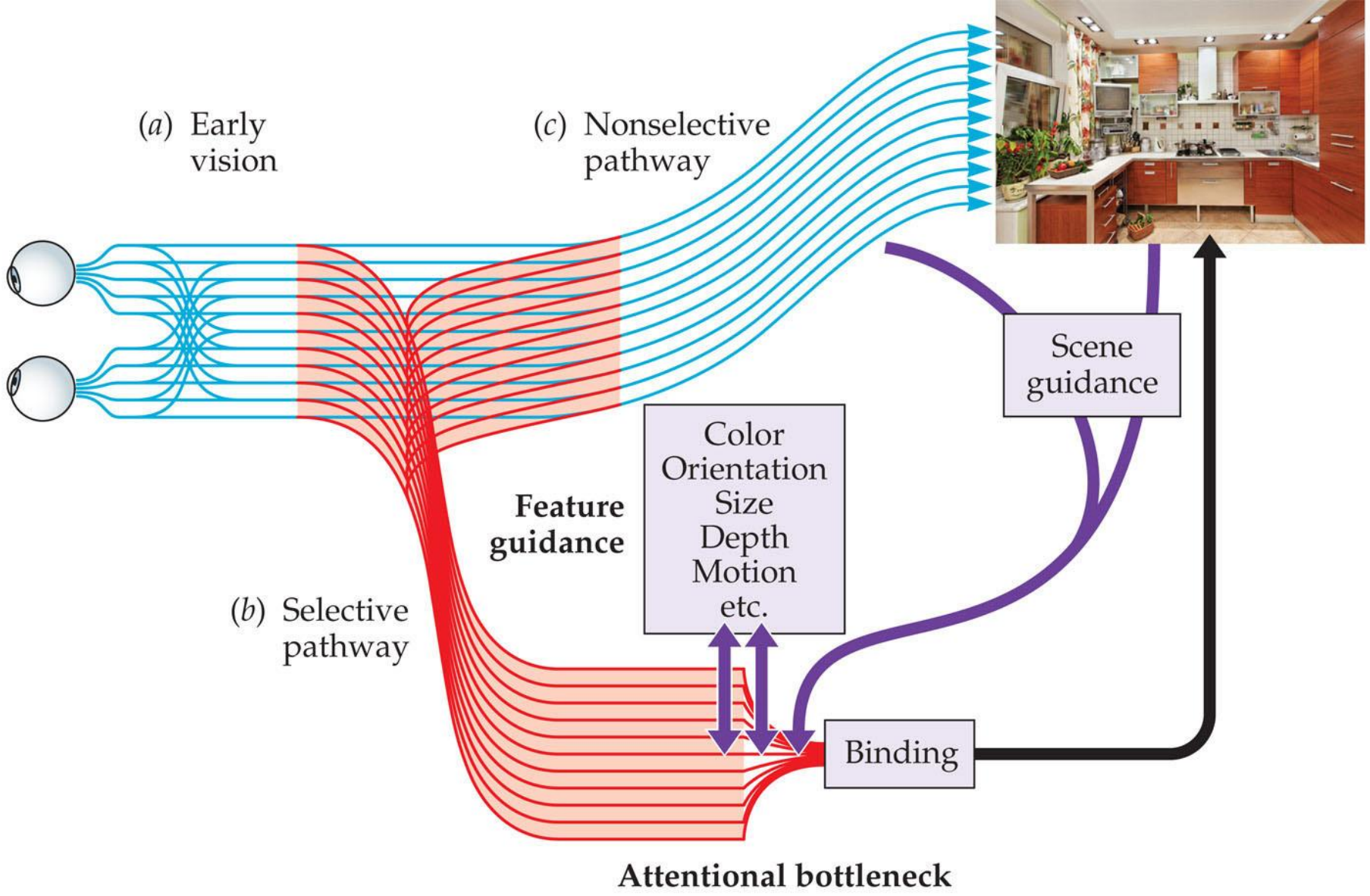
- One of the most common disorders of attention
 - Impulsivity
 - Hyperactivity
 - Inattentiveness

Despite the deficits in attention listed above, visual attention of those with ADHD seems to be fairly normal.

Two pathways to scene perception

- **Selective pathway:** Permits the recognition of one or a very few objects at a time. This pathway passes through the bottleneck of selective attention.
- **Nonselective pathway:** Contributes information about the distribution of features across a scene as well as information about the “gist” of the scene. This pathway does not pass through the bottleneck of attention.

Figure 7.27 Two pathways from the world to our perception of the world



The nonselective pathway computes ensemble statistics.

- Ensemble statistics: The average and distribution of properties, such as orientation or color, over a set of objects or a region in a scene.

Figure 7.28 Some “fishy” ensemble statistics

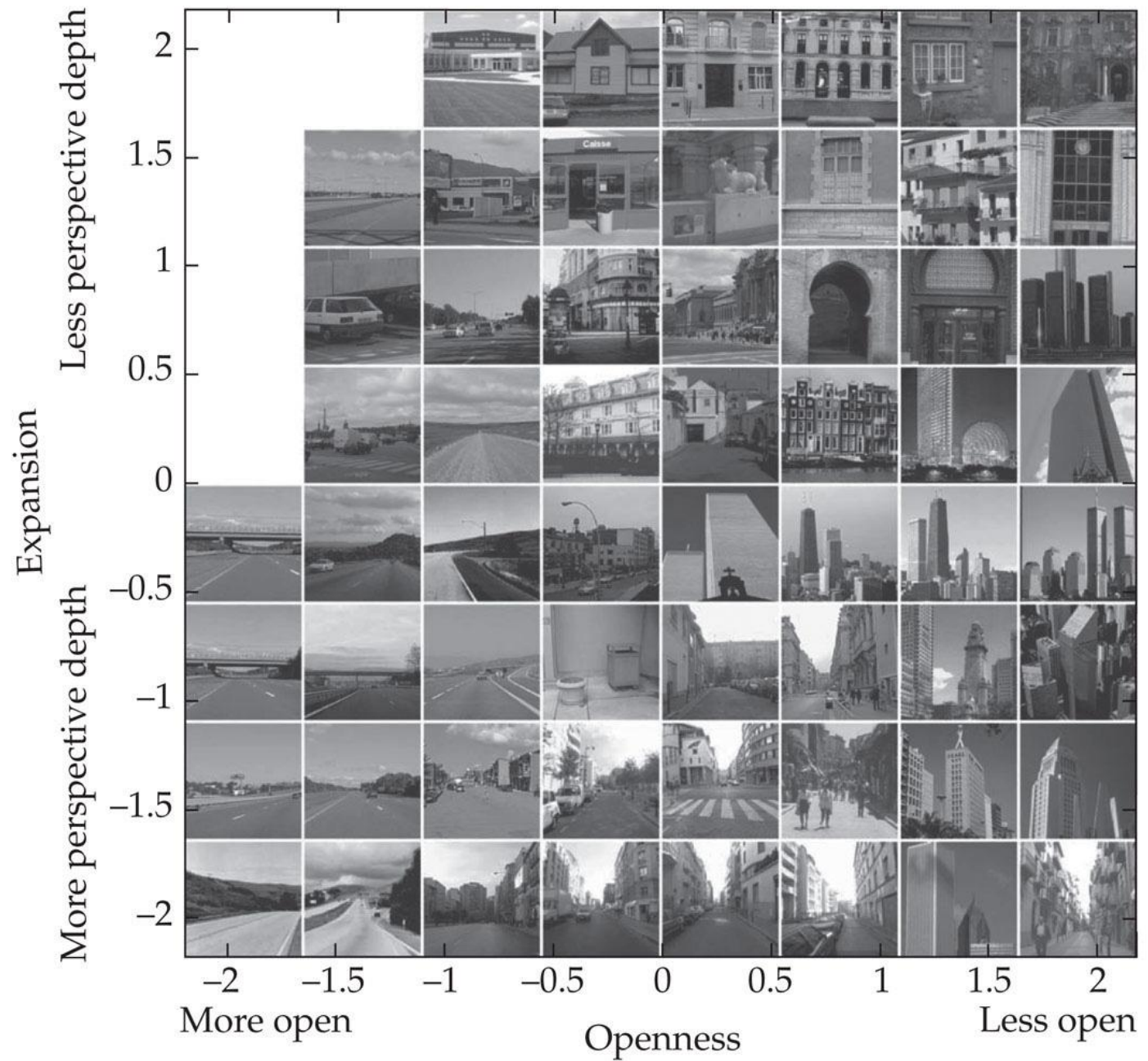


SENSATION & PERCEPTION 4e, Figure 7.28

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The nonselective pathway computes scene gist and layout very quickly.

- Spatial layout: The description of the structure of a scene (e.g., enclosed, open, rough, smooth) without reference to the identity of specific objects in the scene.



SENSATION & PERCEPTION 4e, Figure 7.30

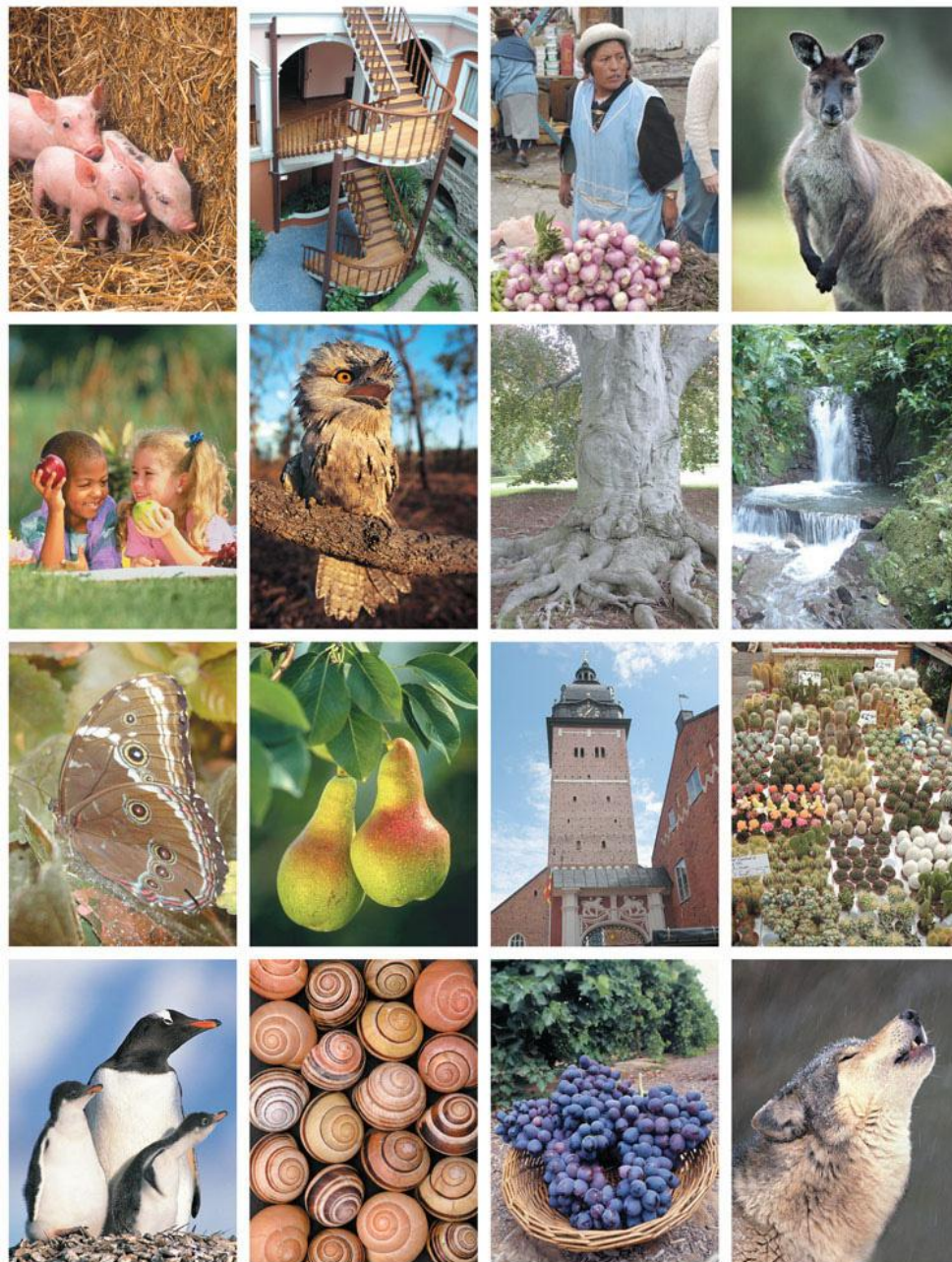
Memory for objects and scenes is amazingly good.

- Brady, et al. (2008) performed a task where subjects looked at 2500 objects in the training phase and then chose which of two objects they had seen in a test phase.
 - When the objects were of different types (e.g., a sailboat and a telephone), the subjects got 92% correct.

Perceiving and Understanding Scenes

- When the objects were the same category (e.g., an office chair and a dining room chair), the subjects got 88% correct.
- When the same objects were in different states (e.g., a breadbox with the bread inside or outside the box), the subjects got 87% correct.

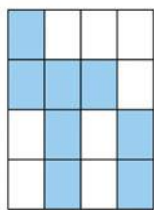
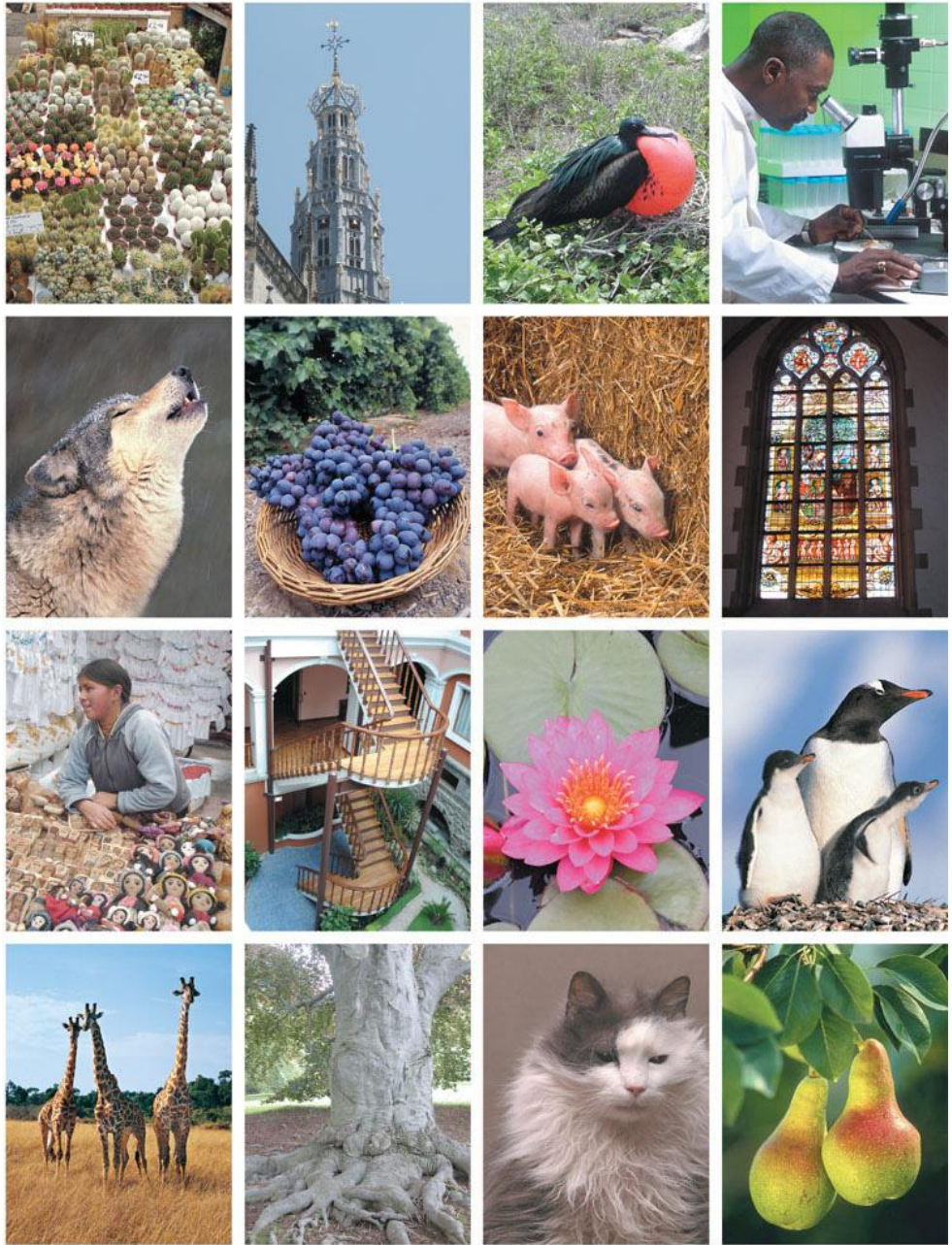
Figure 7.31 Spend a second or two looking at each of these pictures. Then move on to Figure 7.32



SENSATION & PERCEPTION 4e, Figure 7.31

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Figure 7.32 Without referring back to Figure 7.31, identify which of these pictures you already saw



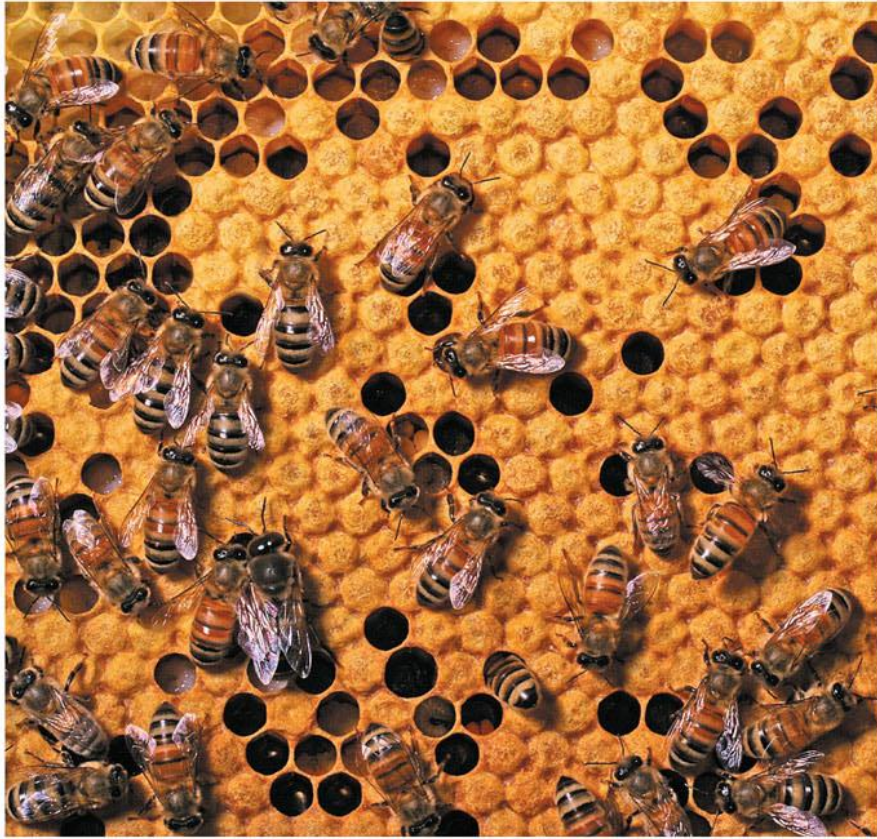
SENSATION & PERCEPTION 4e, Figure 7.32
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Memory for objects and scenes is amazingly bad.

Change blindness: The failure to notice a change between two scenes.

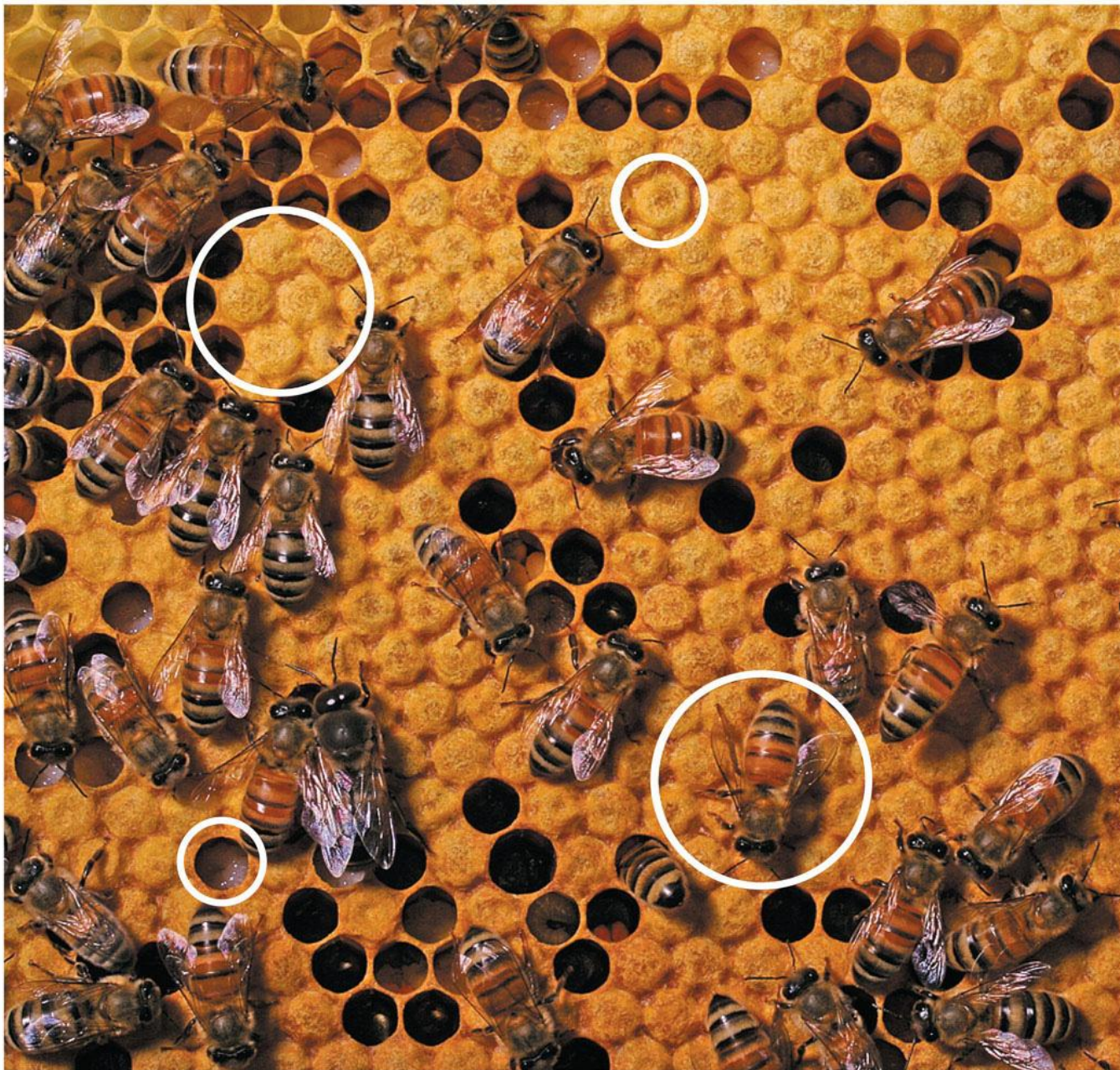
- If the change does not alter the gist, or meaning, of the scene, quite large changes can pass unnoticed
- Demonstrates that we don't encode and remember as much of the world as we might think we do

Figure 7.33 There are four differences between these two images. Can you find them?



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Figure 7.34 Here are the locations of the differences between the two images in Figure 7.33



SENSATION & PERCEPTION 4e, Figure 7.34

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Perceiving and Understanding Scenes

What do we actually see?

- We *feel* like we see a lot of details in a scene.
- Change blindness shows us that we are not encoding as many details as we might think.
- What we see is often driven by our expectations of what we “should” be seeing.

Inattentional blindness: A failure to notice—or at least to report—a stimulus that would be easily reportable if it were attended.