Visual Attention

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- The observer is actively involved in creating perceptions.
  - We direct our attention toward specific objects or locations within a scene and ignore other objects or locations.
- This process of focusing on specific objects while ignoring others is the process of attention.
  - Not only brings an object into view;
  - but enhances the processing of that object and therefore our perception of the object.

Why?

- We focus on some things to the exclusion of others:
  - The perceptual system has a limited capacity for processing information. Thus, to prevent overloading the system and therefore not processing anything well.
  - The reason you are paying attention to those things is that saying hello to your friend, not crossing the street against the light, and your concern that it might rain later in the day are important to you.

1 Scanning a Scene

DEMONSTRATION

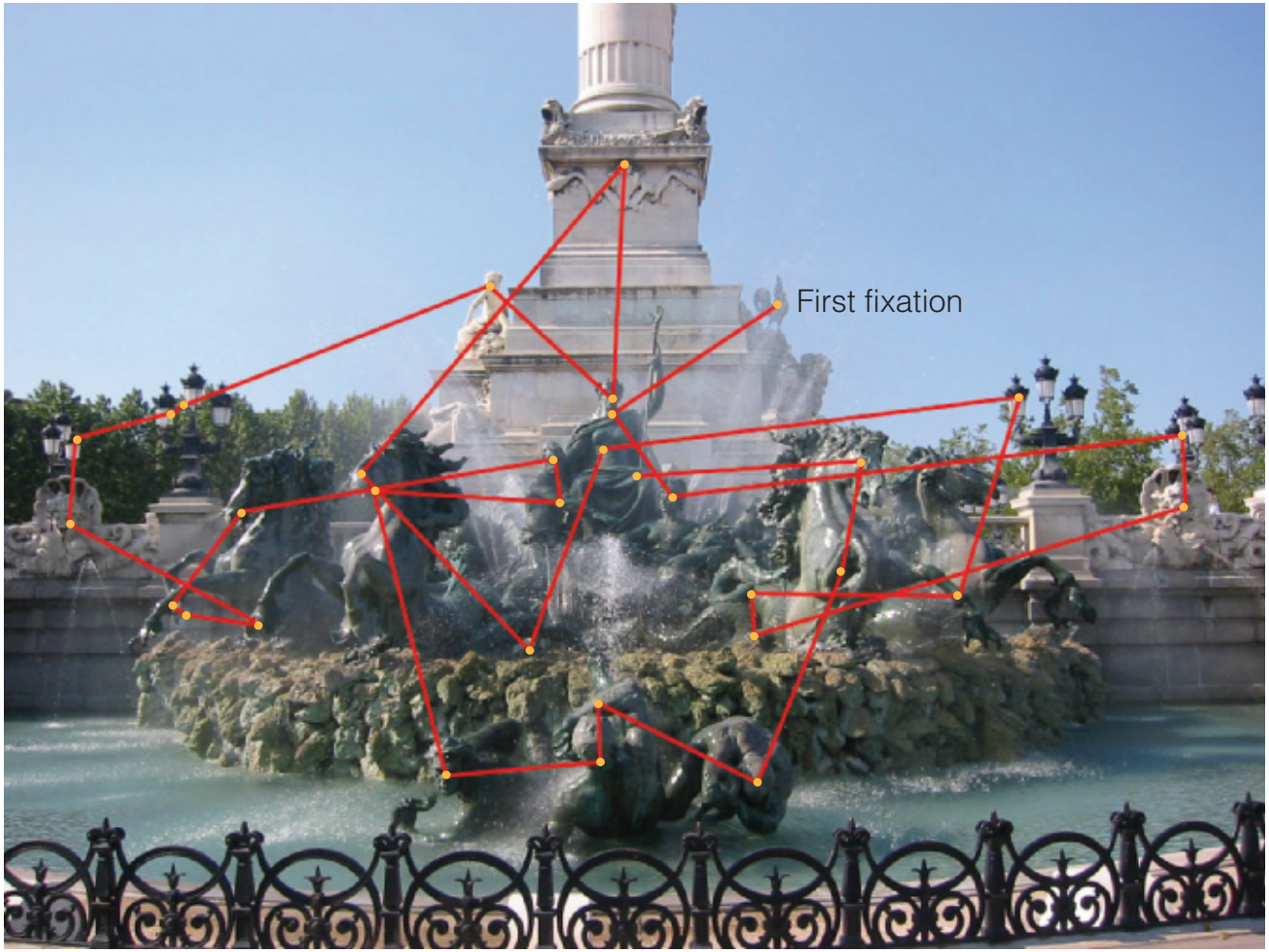
Looking for a Face in the Crowd

Your task is to find Justin Bieber's face in the group of people. Notice how long it takes to accomplish this task.

Saccadic Eye Movement:

a rapid jerky movement from one fixation to the next.

- When freely viewing an object or scene without searching for a target, you move your eyes about three times per second.



- Overt attention: Looking directly at the attended object.
- Covert attention: Objects can also be attended even when they are off fixation point to the side.

We are constantly monitoring our environment by shifting our attention both overtly, by making eye movements, and covertly, by noticing what is happening off to the side.

But what determines where we attend?

2 What Directs Our Attention?

- Where we direct attention can be caused
  - by an involuntary process, in which stimuli that stand out capture our attention
  - by voluntary processes, in which attention is guided by our goals and intentions

2.1 Stimulus Salience

- Stimulus salience: refers to physical properties such as color, contrast, movement, and orientation that make a particular object or location conspicuous.

Attentional capture: When attention due to stimulus salience causes an involuntary shift of attention.

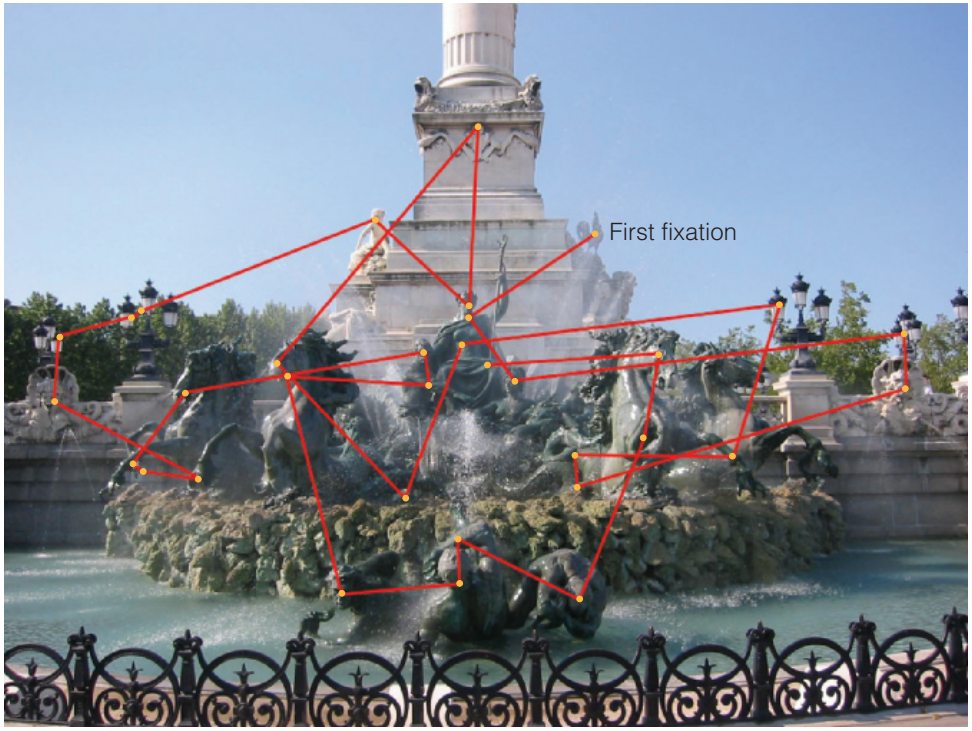
- Saliency map of the scene: determining how saliency influences how we scan a scene, typically analyze characteristics such as color, orientation, and intensity at each location in a scene.
  - The first few fixations were closely associated with the light areas on the saliency map.
  - After the first few fixations, scanning begins to be influenced by top-down, or cognitive, processes.

(a) Visual scene

(b) Saliency map

2.2 Selection Based on Cognitive Factors

- Where we look isn‘t determined only by saliency.



the fence
vs.
the fountain,
the horses

Just as there are large variations between people, such as interests and meaning, there are variations in how people scan scenes.

- Scene schemas: an observer's knowledge about what is contained in typical scenes.
  - Top-down processing is also associated with scene schemas

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People look longer at things that seem out of place in a scene means that:
Attention is being affected by their knowledge of what is usually found in the scene.

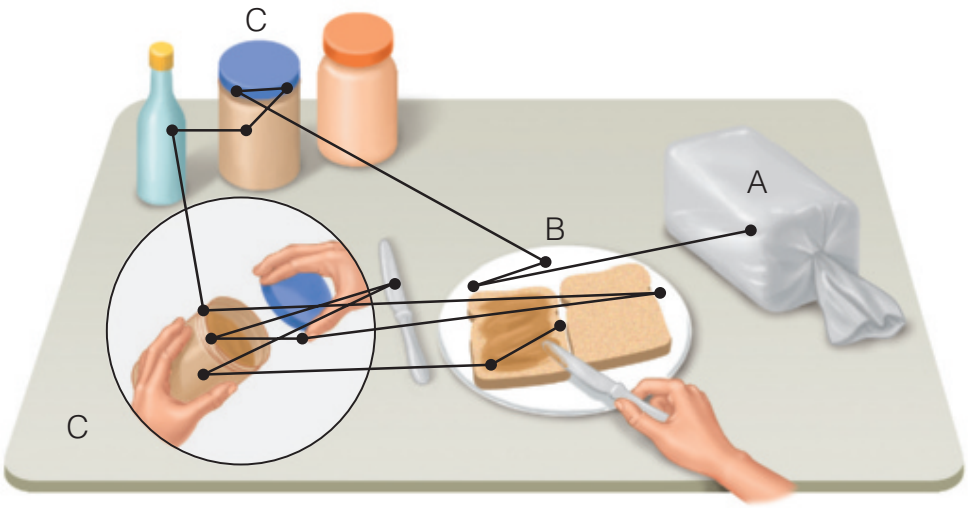
- The observers are using learning about regularities in the environment (stop signs are usually at corners) to determine when and where to look for stop signs.

More likely to detect stop signs positioned at intersections than those positioned in the middle of a block.

2.3 Task Demands

- Where people look as they are carrying out tasks？
  - Most tasks require attention to different places as the task unfolds.
  - It isn’t surprising that the timing of when people look at specific places is determined by the sequence of actions involved in the task.

Making a peanut butter sandwich.



- The process begins with an eye movement from the bag to the plate.
- Then looks at the peanut butter jar just before the jar is lifted.
- Then shifts to the knife.

- The person's eye movements were determined primarily by the task.
  - Eye movements and fixations were closely linked to the action the person was about to take.
  - The eye movement usually preceded a motor action by a fraction of a second.
- The "just in time" strategy: eye movements occur just before we need the information they will provide.

- How attention might be determined by people's sensitivity to properties of a dynamic environment.

The subject's attention depended on what they had learned about the pedestrians, named "Rogue", "Risky", "Safe".

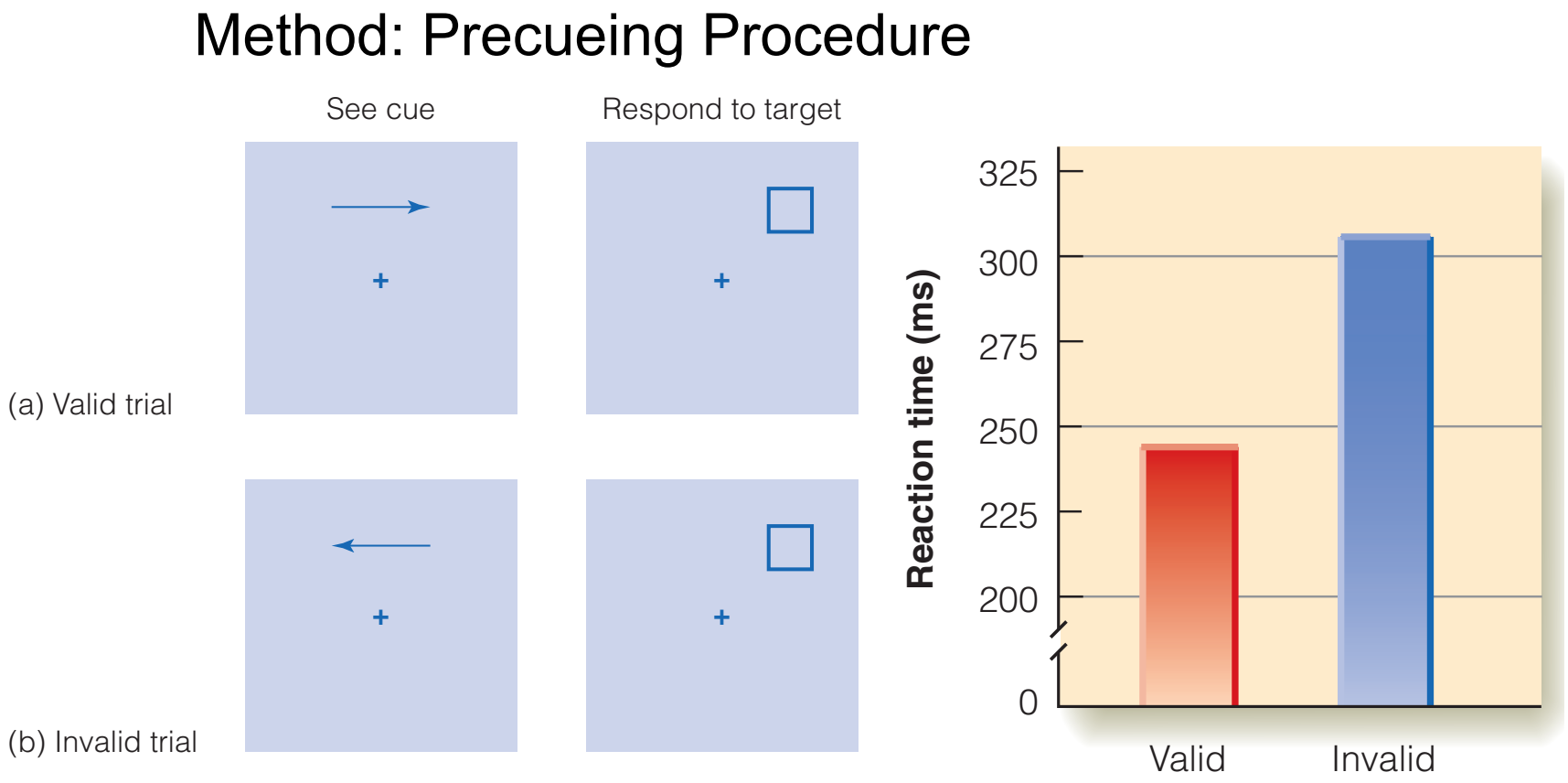
The probability of potentially colliding with risky pedestrians, the knowledge of scene statistics of dynamic events, caused a change in how the subject allocated her attention.

3 What Happens When We Attend?

- When we attend to something, we become aware of it. But the effects of attention extend beyond creating awareness.
- Attention enhances
  - our response to objects: faster to things that are located where we are attending.
  - perception of objects: make it easier to see an object.
  - physiological responding: enhance neural firing to objects.

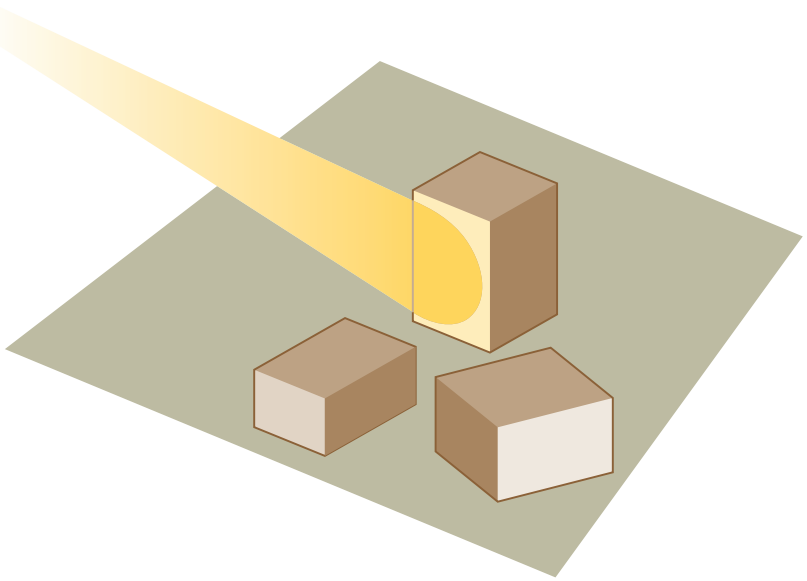
3.1 Attention Speeds Responding

Speeding Responding to Locations: Attention to a specific location is called spatial attention.

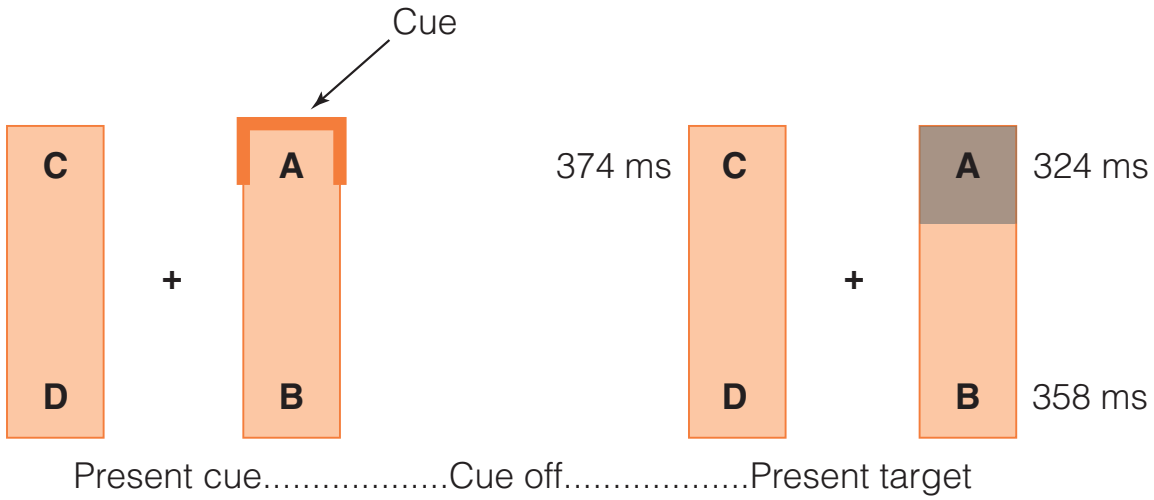


- The results of this experiment indicate that subjects reacted more rapidly on valid trials than on invalid trials.
- Showing that information processing is more effective *at the place where attention is directed*.

- This result gave rise to the idea that attention is like a *spotlight* that improves processing when directed toward a particular location.

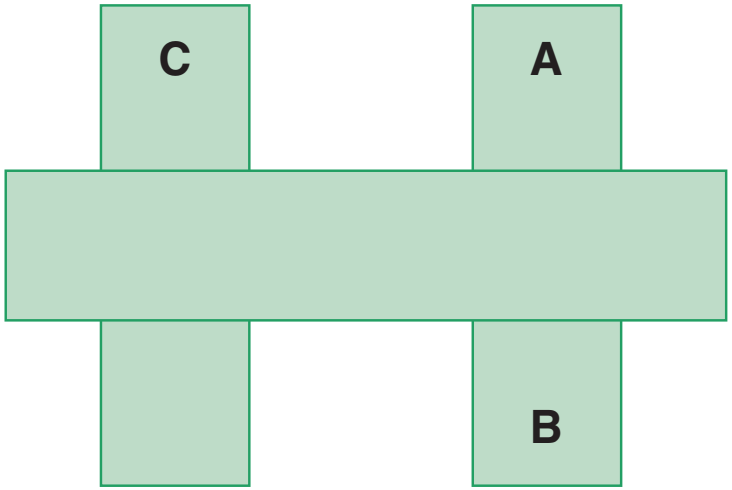


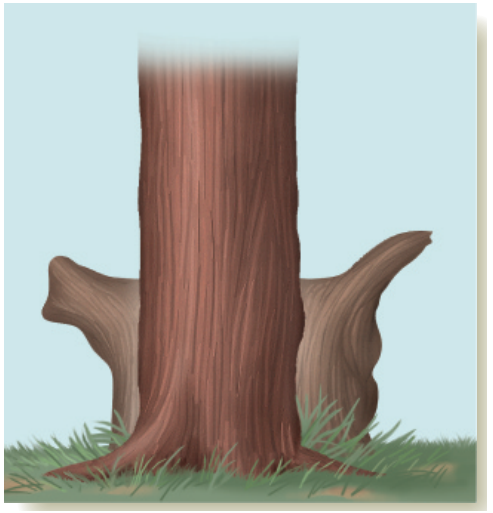
- **Speeding Responding to Objects** We also attend to specific objects in the environment, such as focusing a person you know in a crowd.



  - Attention can enhance our response to objects
  - when attention is directed to one place on an object, the enhancing effect of that attention spreads to other places on the object.

- The most interesting result is that subjects responded more rapidly when the target was presented at B (358 ms) than at C (374 ms).
- Why does this occur?
  - It can't be because B is closer to A than C, because B and C are exactly the same distance from A.
  - B's advantage occurs because it is located *within the object* that was receiving the subject's attention.
- The faster responding that occurs when enhancement spreads within an object is called the same-object advantage.

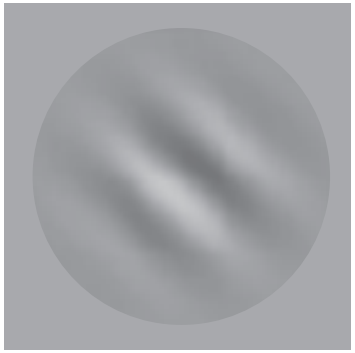


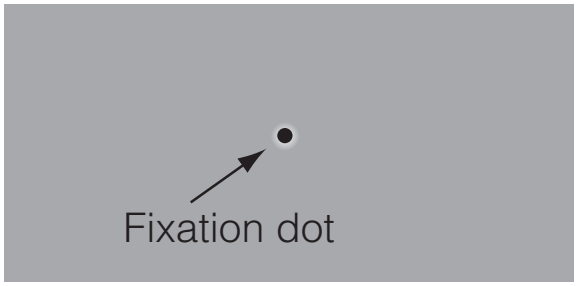


- Even though the bar is covering the vertical rectangles, presenting the cue at A still results in enhancement at B.
- “spreading enhancement”
  - The effects of attention spread behind the tree
  - our awareness spreads throughout the object
  - thereby enhancing the chances we will interpret the interrupted shape as being a single object.

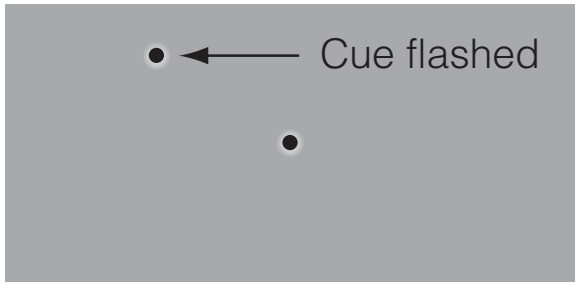
3.2 Attention Can Influence Appearance

- Whether attention affects an object's appearance?
  - To measure the *perceptual response* to a stimulus rather than the *speed of responding* to the stimulus.
- Determining whether attention affected the *perceived contrast* between the bars.
  - The contrast between the bars of the gratings was randomly varied.
  - The subject decided which grating had a higher contrast.

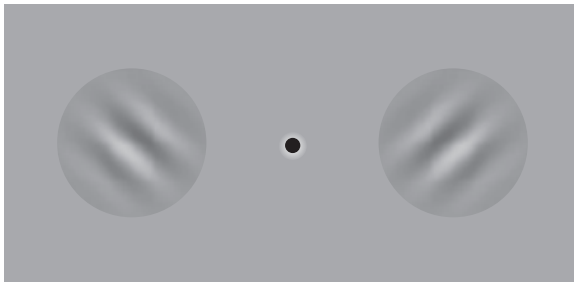




(a) Fixate



(b) Cue flashed



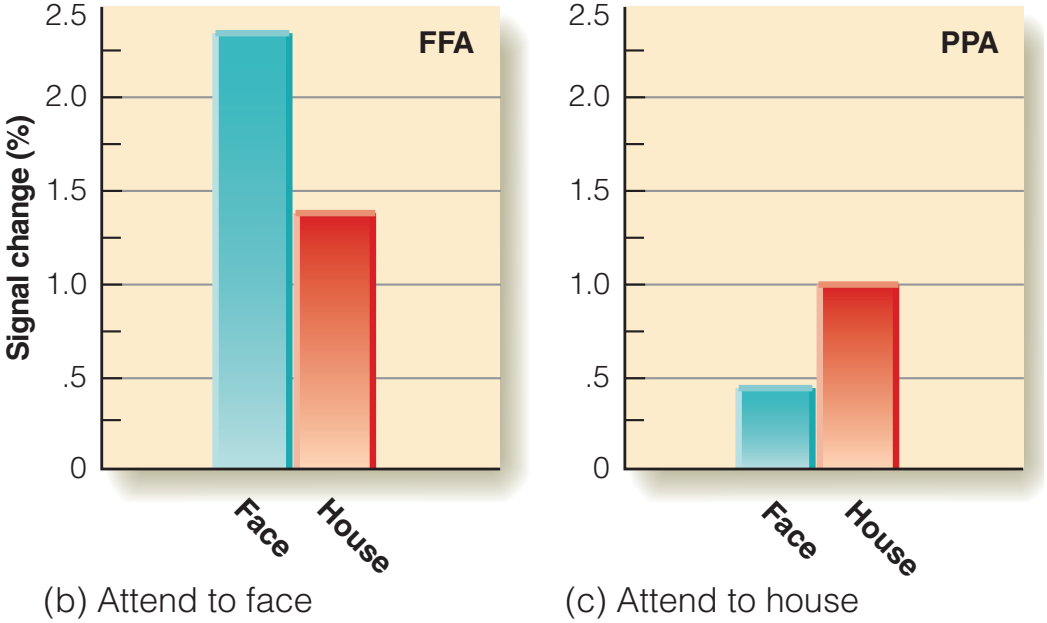
(c) Stimuli presented

- When two gratings were different, the attention-capturing dot had no effect.
- When the two gratings were the same, the one that received attention appeared to have more contrast.

3.3 Attention Can Influence Physiological Responding

- **Attention to Objects Increases the Response of Specific Areas in the Brain**

  - Binocular rivalry, so perception alternated between the two images.
    - face—>FFA, house—>PPA
  - Direct their attention to one stimulus or the other.
    - One of the stimuli was stationary and the other was moving slightly back and forth.

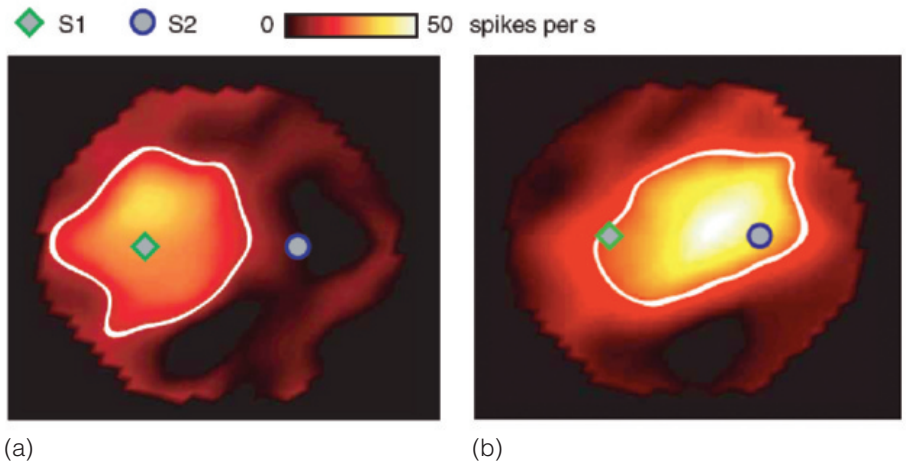


Attending to the moving or stationary *face* caused enhanced activity in the FFA and attending to the moving or stationary *house* caused enhanced activity in the PPA.

- Thus, attention to different types of objects influences the activity in areas of the brain that process information about that type of object.

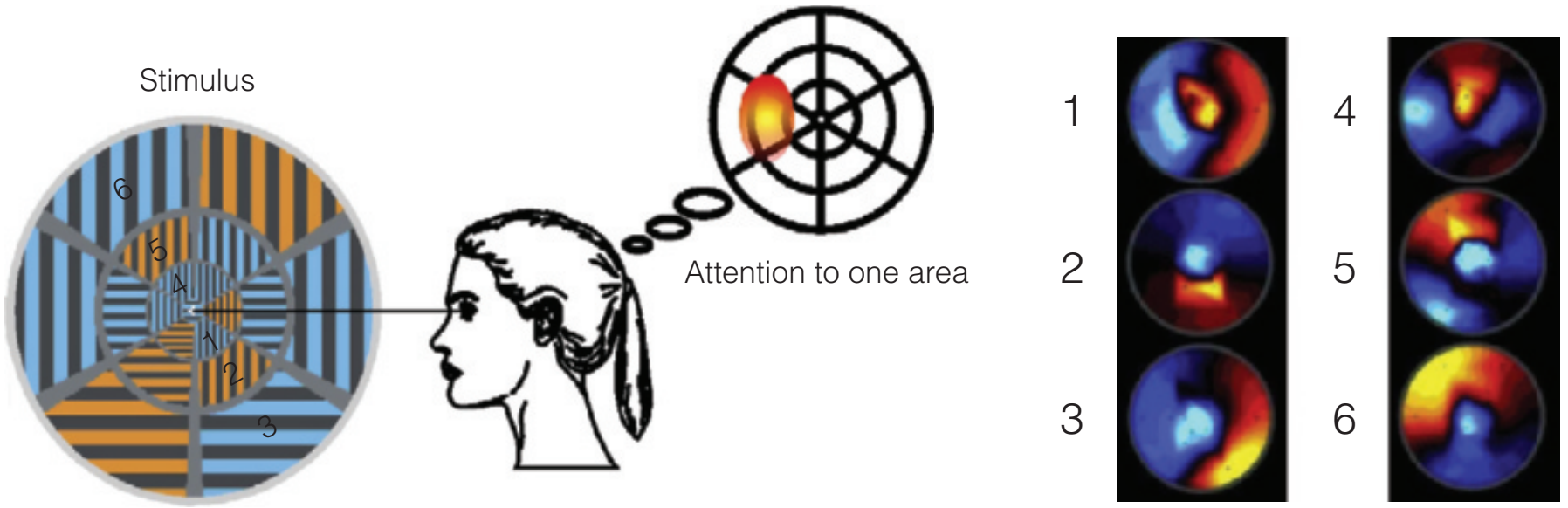
- **Attention to Locations Increases the Response at Specific Locations in the Brain**
  - What happens in the brain when people shift their attention to different locations while keeping their eyes stationary?
  - Found that the area of the brain that was activated depended on where the subject was directing his or her attention.

- **Attention Can Shift the Location of a Neuron's Receptive Field**
  - Neuron's receptive field: A particular neuron receives signals from a specific area on the retina, so when that area is stimulated, the neuron responds.



An amazing result: Attention is changing the organization of part of the visual system.

Receptive fields, it turns out, aren't fixed in place but can move in response to where the monkey is attending.



- Attention maps: show how directing attention to a specific area of space activates a specific area of the brain.
  - The retinotopic map, in which presenting objects at different locations on the retina activates different locations on the brain.
  - Brain activation is changing because the subject is directing his or her mind to different places in the visual field.

4 What Happens When We Don‘t Attend?

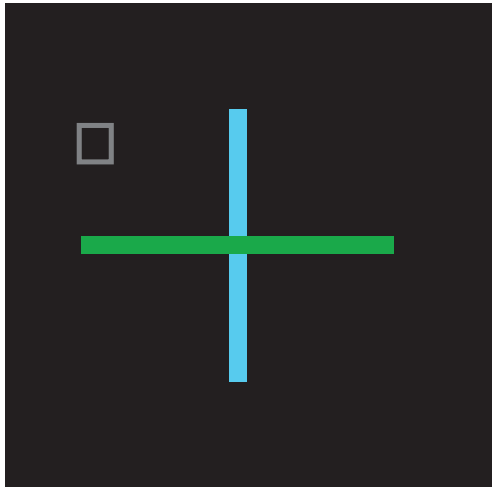
- What happens when we don’t pay attention?
  - One idea is that you don’t perceive things your aren’t attending to.
  - But research has shown not only that we miss things that are out of our field of view, but that not attending can cause us to miss things even if we are looking directly at them.

a phenomenon called “inattentional blindness”

4.1 Inattentional Blindness

- Experiment:
  - The cross was presented for five trials, and the observer's task was to indicate which arm of the briefly flashed cross was longer, the horizontal or the vertical.
  - On the sixth trial, a small outline of a square was added to the display.

Trials 1 – 5



Trial (6)

Subjects can be unaware of clearly visible stimuli if they aren't directing their attention to them.

- Similar effects occur for more naturalistic stimuli that are visible for longer periods of time.
- For example, imagine looking at a display in a department store window.

  - When pay your attention on the display, you probably fail to notice the reflections on the surface of the window.
  - Shift your attention to the reflections, and you become less aware of the display inside the window.

- Basketball Game:
  - Observers were told to count the number of passes, a task that focused their attention on the team wearing white.
  - After 45 seconds, either a woman carrying an umbrella or a person in a gorilla suit walked through the game, an event that took 5 seconds.

When observers are attending to one sequence of events, they can fail to notice another event, even when it is right in front of them.

4.2 Change Detection

DEMONSTRATION

Change Detection

Look at the first picture for just a moment, and then turn to next, see whether you can determine what is different.

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Look at the first picture for just a moment, and then turn to next, see whether you can determine what is different.

- This difficulty in detecting changes in scenes is called change blindness.
- The importance of attention in determining change blindness is demonstrated by the fact that when added a cue indicating which part of a scene had been changed, participants detected the changes much more quickly.

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Change Detection

Look at the first picture for just a moment, and then turn to next, see whether you can determine what is different.

- The change blindness effect also occurs when the scene changes in different shots of a film.

(a)

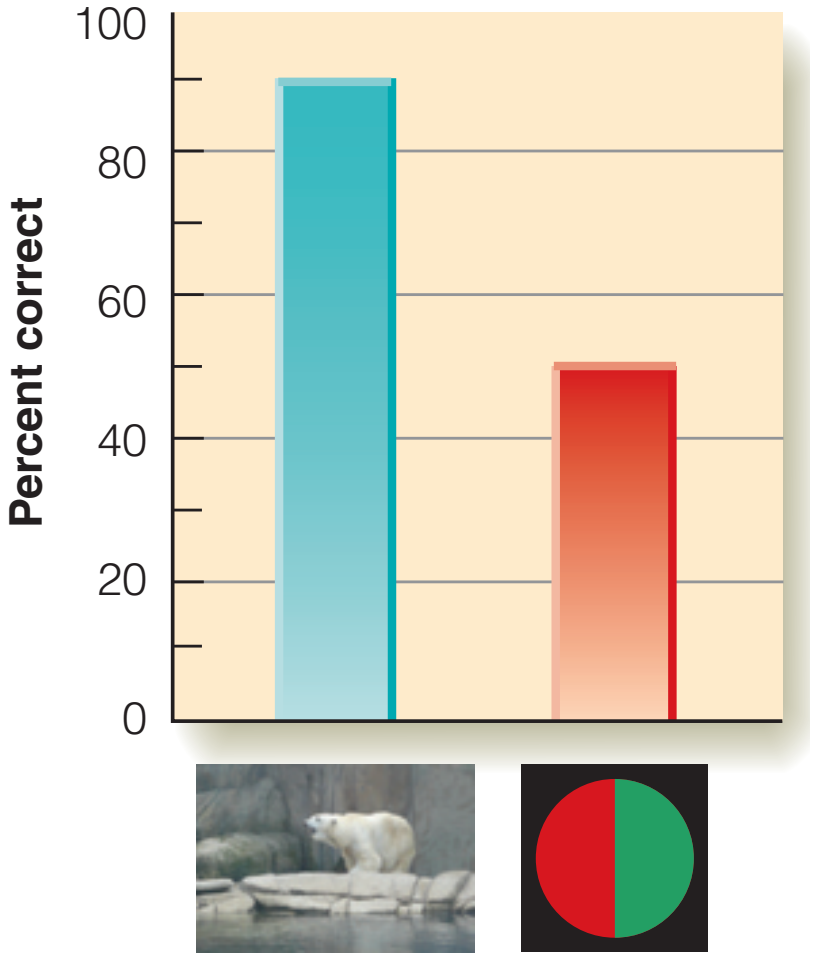
(b)

4.3 Is Attention Necessary for Perceiving Scenes?

- Attention may not be necessary for perceiving scenes!?
  - People can identify the gist of a scene after seeing a picture for less than a quarter of a second.
- The dual-task procedure experiment(Fei Fei Li , 2002), in which subjects are required to carry out simultaneously a *central task* that demands attention and a *peripheral task* that involves making a decision about the contents of a scene.

- Subjects looked at the + on a fixation screen and then saw the central stimulus, an array of five letters.
  - On some trials, all of the letters were the same; on other trials, one of the letters was different from the other four.
  - The letters were followed immediately by the peripheral stimulus, flashed for 27 ms at a random position on the edge of the screen

- The central task: indicate if all of the letters in the central stimulus were the same.
- The peripheral task: indicate whether the scene contained an animal or whether the colored discs were red–green or green–red.



The performance was 90% on the peripheral picture task, but only 50% on the peripheral colored-disc task.

- Concluded that: properties of scenes can be perceived with little or no attention.

- If central task did not distract attention enough?
  - a letter–number task: (G, N, W, 4, A, Y, 5, T), indicated how many numbers they saw.
  - indicat if a rapidly flashed picture contained an animal or a vehicle.
- Results:
  - When the peripheral animal–vehicle task was presented alone, subjects were correct 89%.
  - The performance dropped to 63% when their attention was distracted by the central task.
- Concluded that “the perception of natural scenes does require attention, but some aspects of scene perception may not require attention ” .

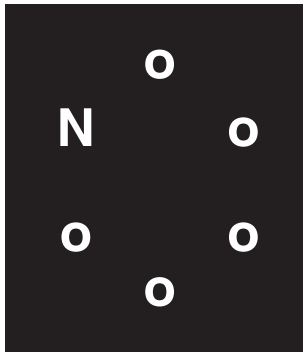
5 The Distracting Effect of Task-Irrelevant Stimuli

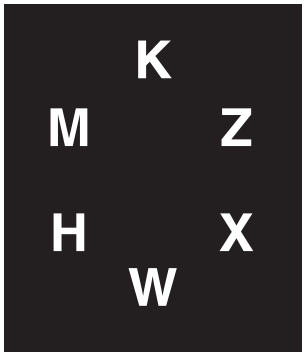
- Task-irrelevant stimuli: Stimuli that don't provide information relevant to the task.
  - Which can potentially decrease our performance of a task.
  - The amount of distraction depends on properties of the distracting stimulus, with highly salient stimuli being more likely to cause distraction.
  - The effect of a potentially distracting stimulus also depends on the characteristics of the task.

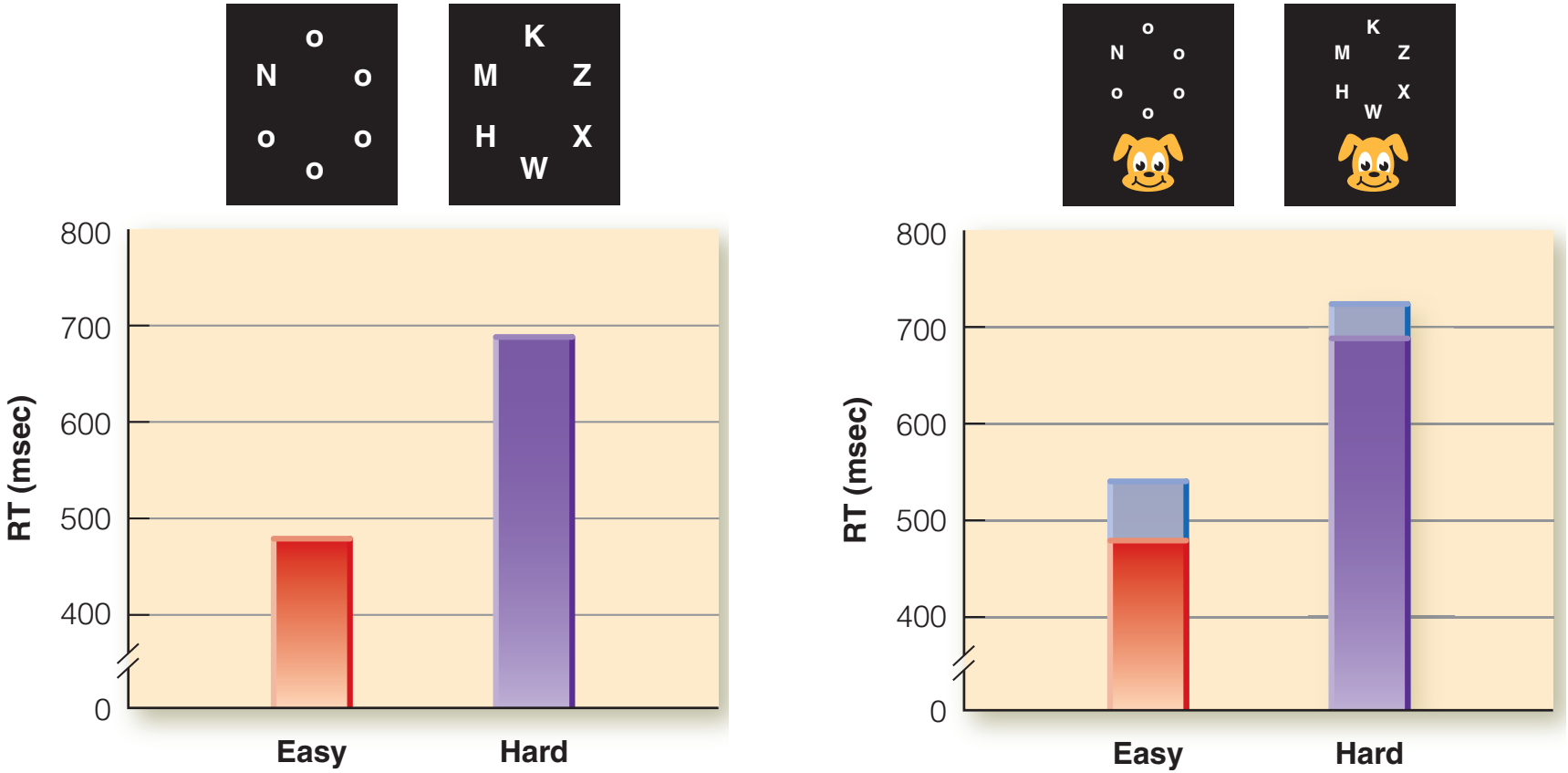
5.1 Distraction and Task Characteristics

- The effect of an unattended stimulus depends on the nature of the task.
  - if the task is easy, then task-irrelevant stimuli have an effect on performance.
  - if the task is hard, task-irrelevant stimuli have little or no effect on performance.

- The subjects' task was to respond as quickly as possible when they identified a target, either X or N.



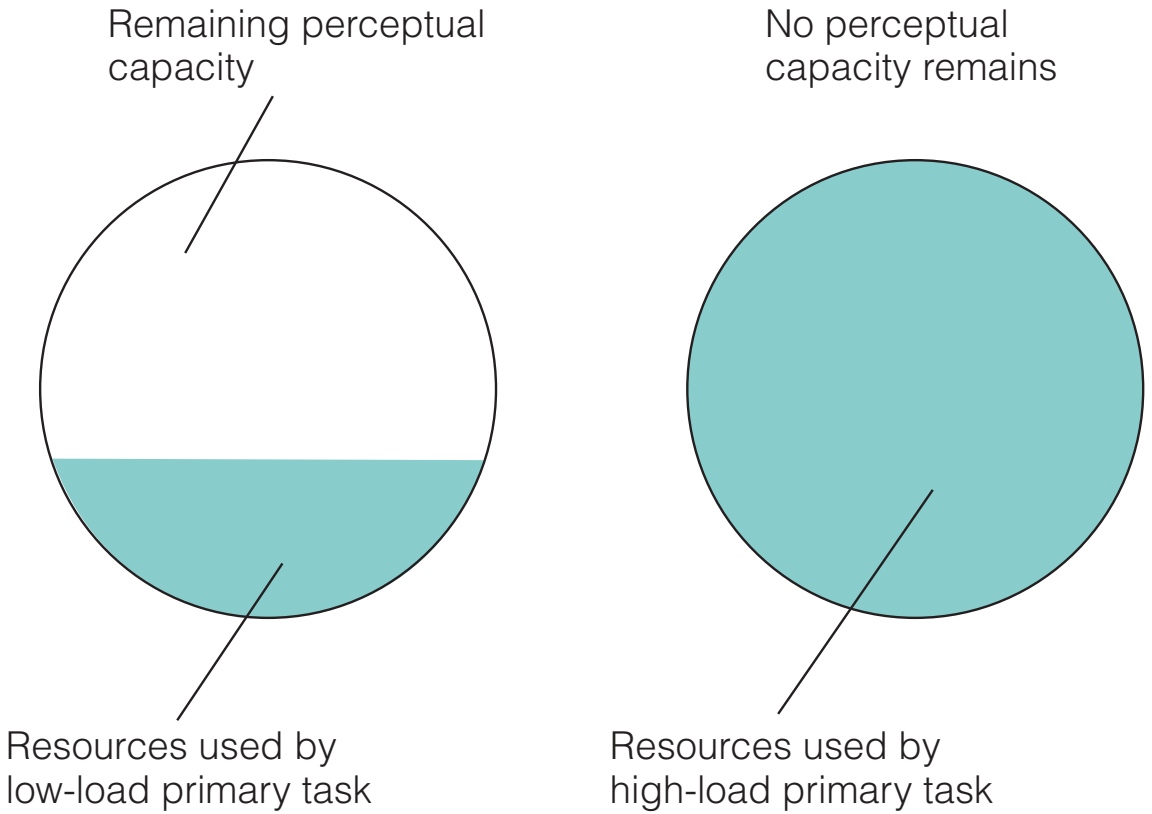




- When a task-irrelevant stimulus is flashed off to the side, like the cartoon character, responding slows for the easy task and is affected only slightly for the hard task.

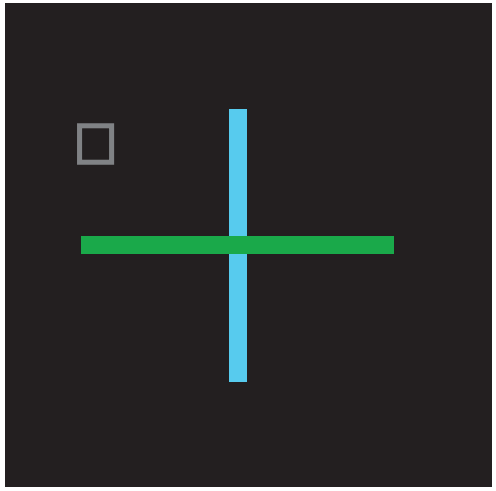
5.2 Attention and Perceptual Load

- Load theory of attention
  - *Perceptual capacity*: a person has a certain capacity that can be used for carrying out perceptual tasks.
  - *Perceptual load*: the amount of a person‘s perceptual capacity needed to carry out a particular task.
    - low-load tasks: especially easy, well-practiced tasks.
    - high-load tasks: difficult and perhaps not as well practiced.
  - The amount of perceptual capacity that *remains* as a person is carrying out a task determines how well the person can avoid being distracted by task-irrelevant stimuli.



- Left: The circle represents a person's total perceptual capacity, and the shading represents the portion that is used up by a task.
- Right: all or most of a person's perceptual capacity is being used by a high-load task.

Trials 1 – 5



Trial (6)

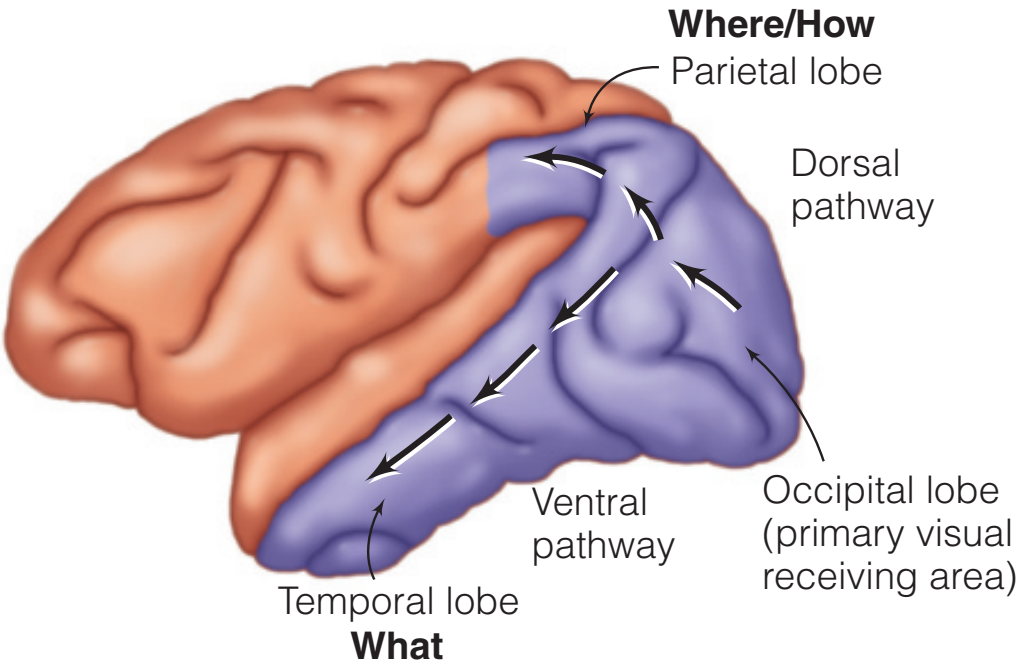
- inattentional blindness (to decide which line in a display longer)
- In terms of load theory, the difficult length estimation task is a high-load task that uses up most of a person's perceptual capacity.
- when the task was turned into a low-load task
  - asking subjects to indicate which of the cross-hairs was green (horizontal or vertical)

6 Attention and Experiencing a Coherent World

- We have seen that attention is an important determinant of what we perceive.
- Attention brings things to our awareness and can enhance our ability to perceive and to respond.
- Another function of attention is to help create binding, which is the process by which features (such as color, form, motion, and location) are combined to create our perception of a coherent object.

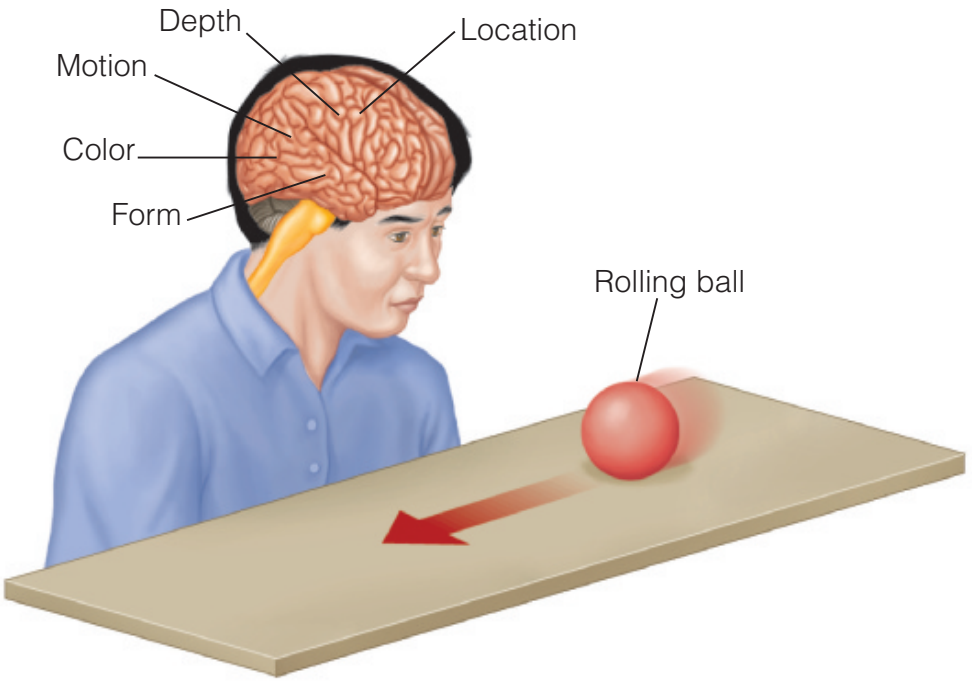
6.1 Why Is Binding Necessary?

- Separated areas of the brain are specialized for the perception of different qualities.



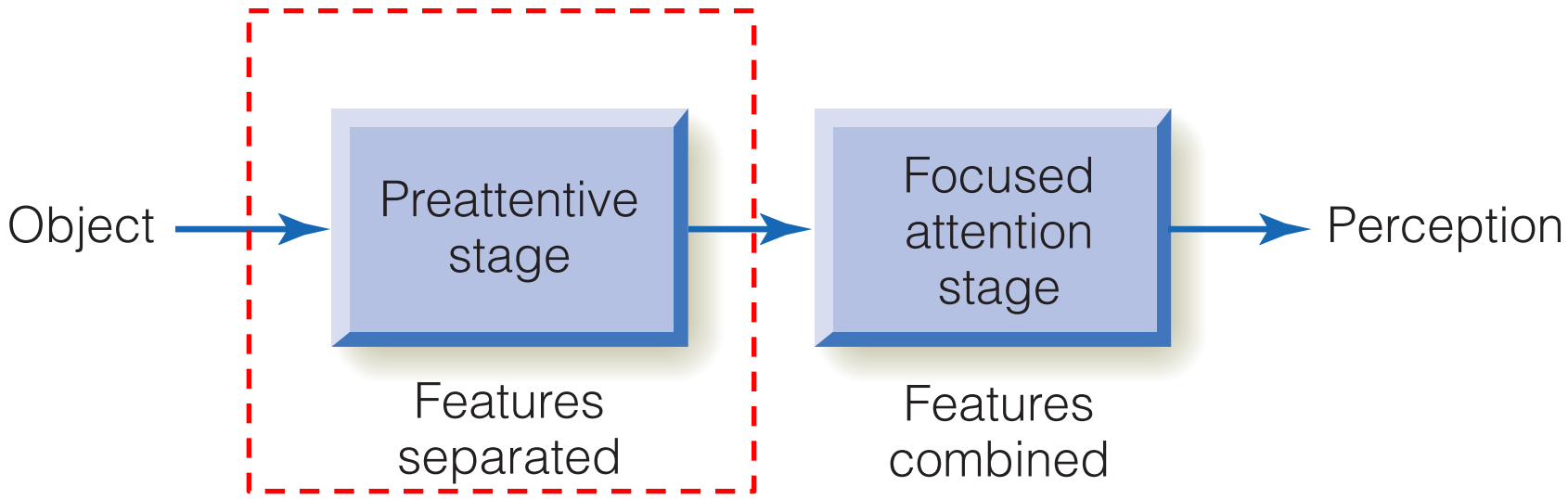
- The observer doesn‘t perceive the ball as separated shape, movement, and color perceptions.
- He experiences an integrated perception of a ball, with all of the ball’s features being bound together to create a coherent perception of a “rolling red ball.”

The Binding Problem: the question of how an object’s individual features become bound together.



6.2 Feature Integration Theory

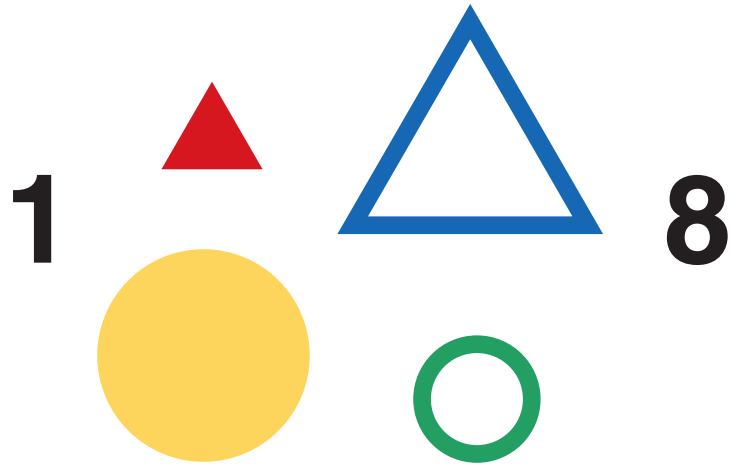
- Feature integration theory tackles the question of how we perceive individual features as part of the same object.
- The first step in processing an image of an object is the preattentive stage.
  - Objects are analyzed into separate features.
  - Each of these features is processed in a separate area of the brain independently.



Flow diagram of feature integration theory

- The reason we aren't aware of this process of feature analysis is that it occurs early in the perceptual process, before we have become conscious of the object.

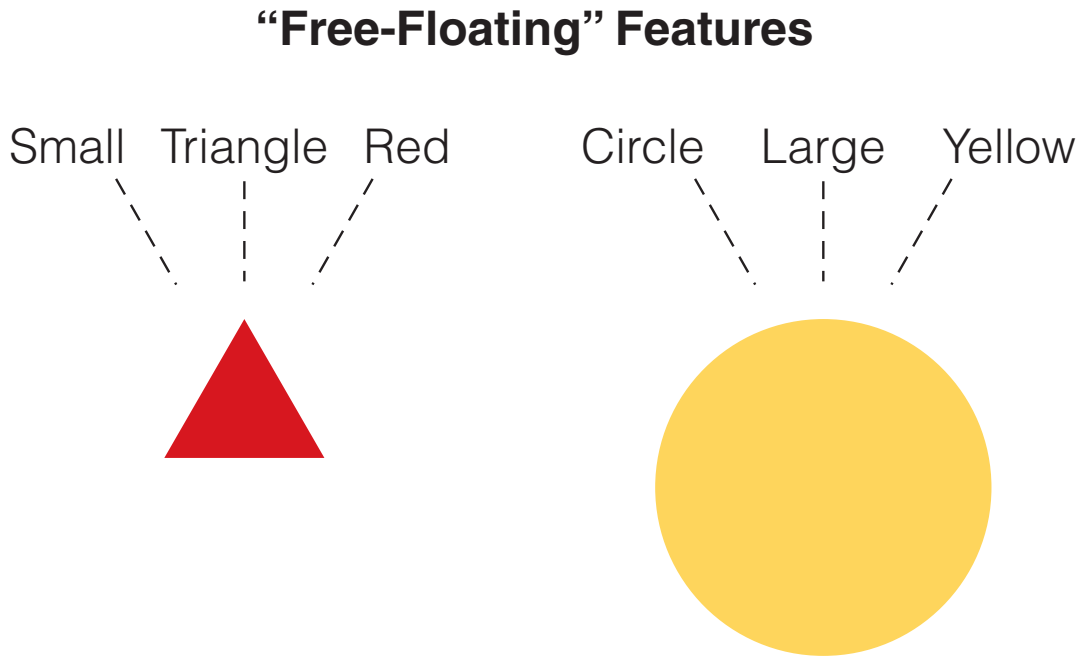
- **Evidence That Objects Are Analyzed Into Features**



- Subjects first attended to the black numbers.
  - to report the black numbers first and then to report what they saw at each of the four locations.
- Illusory conjunction: Seeing objects that were made up of a combination of features from two different stimuli.

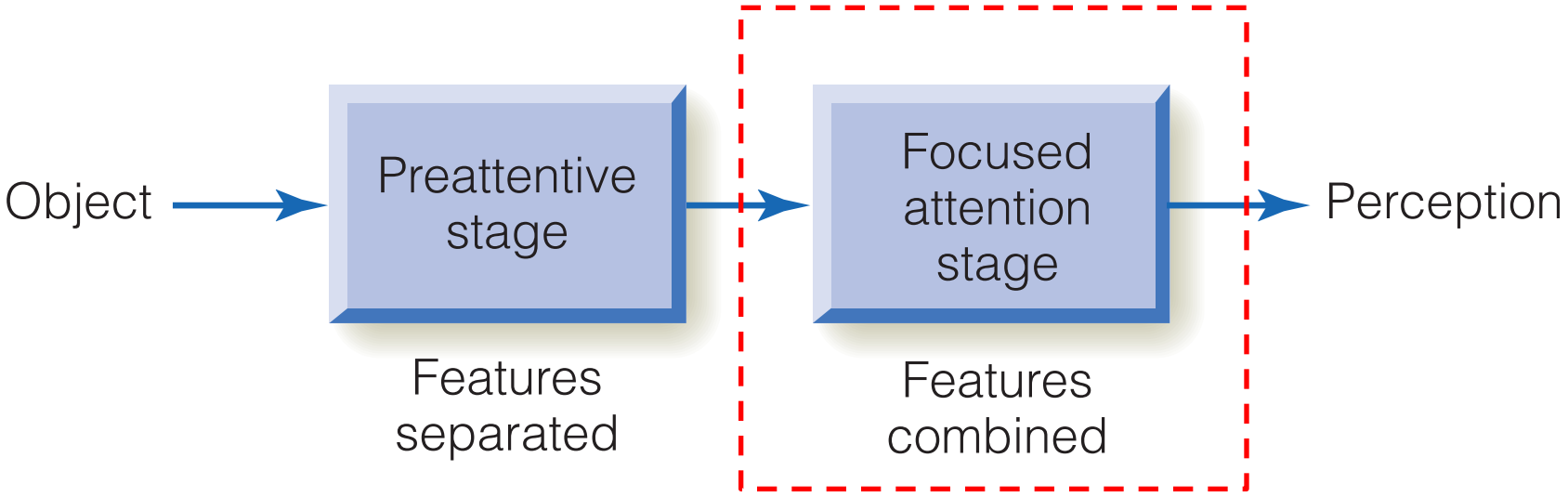
- Although illusory conjunctions are usually demonstrated in laboratory experiments, they can occur in other situations as well.
  - A demonstration to illustrate that observers sometimes make errors in eyewitness testimony.

- Illusory conjunctions occur because at the beginning of the perceptual process, each feature exists independently of the others.
  - Features such as “redness”, “curvature”, or “tilted line” are not associated with a specific object.

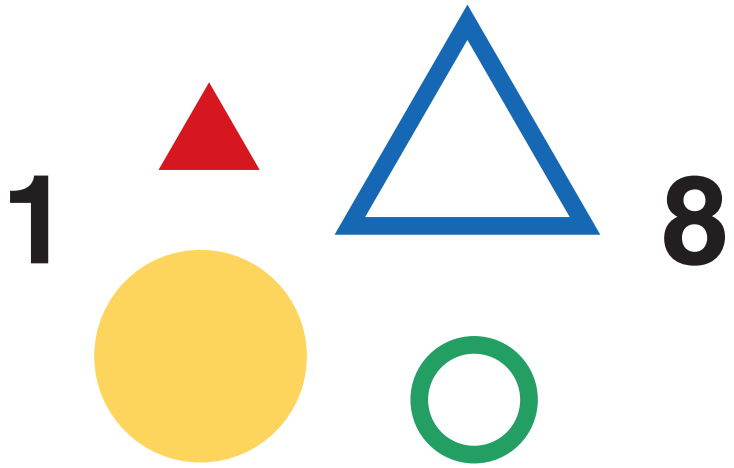


  - You can think of these features as components of a visual “alphabet.”

- **Focused Attention Stage** These features are combined in the second stage. Once the features have been combined in this stage, we perceive the object.

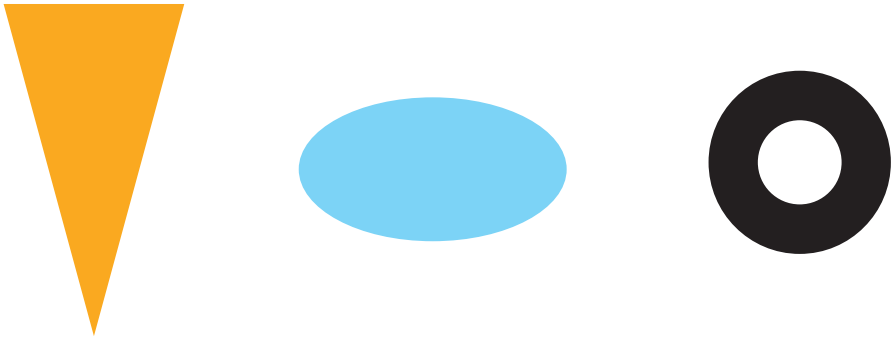


- The observer's attention plays an important role in combining the features to create the perception of whole objects.
- Repeated the illusory conjunction experiment
  - To ignore the black numbers and to focus all of their attention on the four target items.
  - This focusing of attention eliminated illusory conjunctions so that all of the shapes were paired with their correct colors.



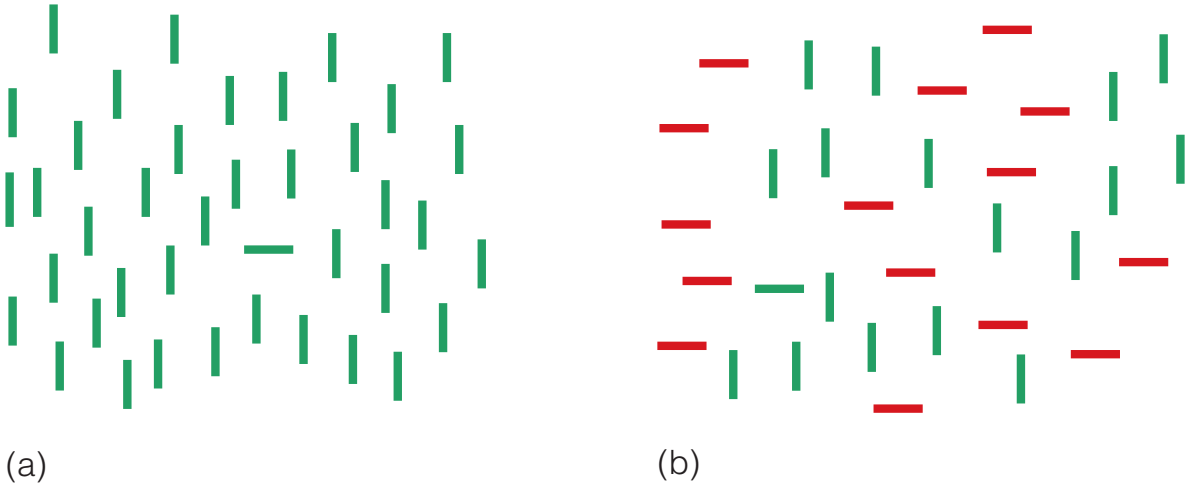
- Balint's syndrome: a patient who had parietal lobe damage that resulted in a condition.
  - A crucial characteristic is an inability to focus attention on individual objects.
- Reported illusory conjunctions

T O



- When subjects were told that they were being shown a carrot, a lake, and a tire, illusory conjunctions were less likely to occur.
  - The knowledge of the usual colors of objects influenced their ability to combine the features of each object.
- In our everyday experience, in which we often perceive familiar objects, top-down processing combines with feature analysis to help us perceive things accurately.

- **Visual Search**: Another approach to studying the role of attention in binding.
  - Feature search: to find the target by looking for a single feature.
  - Conjunction search: to search for a combination (or conjunction) of two or more features in the same stimulus.



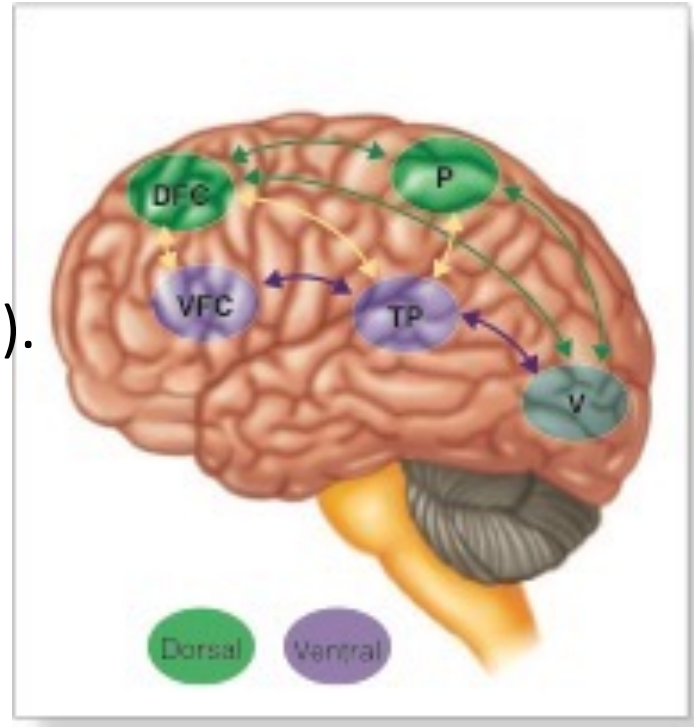
- Conjunction searches are useful for studying binding:
  - because finding the target in a conjunction search involves scanning a display in order to focus attention at a specific location.
  - attention-at-a-location is not required for the feature search. The Balint's patient can finish the task.
- Feature integration theory therefore considers *attention* to be an essential component of the mechanism that creates our perception of objects from a number of different features.

6.3 Attention Network

- Ventral attention network: which controls attention based on salience.
- Dorsal attention network: which controls attention based on top-down processes.
- Executive attention network: inhibitory control dealing with conflicting responses.

Dynamics and Control of Attention:

- changes depending on changing conditions (stimulus, top-down factors).
- *Effective connectivity*: how easily activity can travel along a particular pathway among different areas in a network.



7 Attention in Autism

- Not only is attention important for detecting objects in the environment, it is also a crucial component of social situations.
  - People pay attention not only to what others are saying, but also to their faces and to where they are looking
  - These provide information about the other person's thoughts, emotions, and feelings.

7.1 Autism

- The link between attention and perceptions of social interactions becomes especially evident when we consider a situation in which that link is disturbed.
- Autism is a serious developmental disorder in which the major symptoms are:
  - typically do not make eye contact with others
  - have difficulty telling what emotions others are experiencing in social situations.

7.2 Differences between autistic and nonautistic observers

- One difference is the way autistic people observe what is happening.
  - Comparing eye fixations of autistic and nonautistic people as they watched the film.

- Another difference is related to the tendency of nonautistic people to direct their eyes to the place where a person is pointing.

  - The nonautistic person follows the pointing movement from the finger to the painting and then looks at the actor's face to await a reply.
  - In contrast, the autistic observer looks elsewhere first, then back and forth between the pictures.

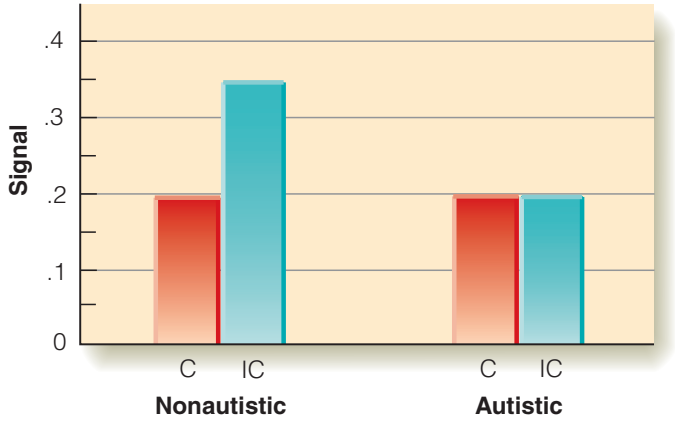
- These results indicate that they may perceive the environment differently than normal observers.
  - Autistic people look more at things.
  - Nonautistic observers look at other people's actions and especially at their faces and eyes.
- It is likely that autistic observers create a mental representation that does not include much of the information that nonautistic observers usually use in interacting with others.

7.3 The exact causes of the differences in eye movement

- Autistic observers experience negative emotional reactions when interacting with other people.
  - These negative emotions influence where they look, which influences how well they can understand what is happening.
- Autistic observers process face stimuli differently
  - when look at faces they focus on individual features or details within the face and don't see faces as whole.
- Attentional differences are caused by a combination of social and perceptual factors.

- The superior temporal sulcus (STS) shown to be sensitive to how other people <u>direct their gaze in social situations</u>.
- Both groups of observers saw the character's eyes move, but there was a large difference in the STS responses.
  - The STS of the nonautistic observers was activated more for the *incongruent situation*
  - The STS of the autistic observers was activated equally in the *congruent* and *incongruent situations*.

(a)



- What does this result mean?
  - The difference may have to do with how observers *interpreted* what the eye movements meant, which is ability to read other people‘s *intentions*.
    - The nonautistic observers vs. Autistic observers
- What people *expect* will happen is something we will encounter again in the next chapter when we consider the connection between perception and how people interact with the environment.

Conclusions

- Scanning a Scene
- What Directs Our Attention?
- What Happens When We Attend?
- What Happens When We Don‘t Attend?
- The Distracting Effect of Task-Irrelevant Stimuli
- Attention and Experiencing a Coherent World
- Attention in Autism: intention and expectation in social interaction

Question?