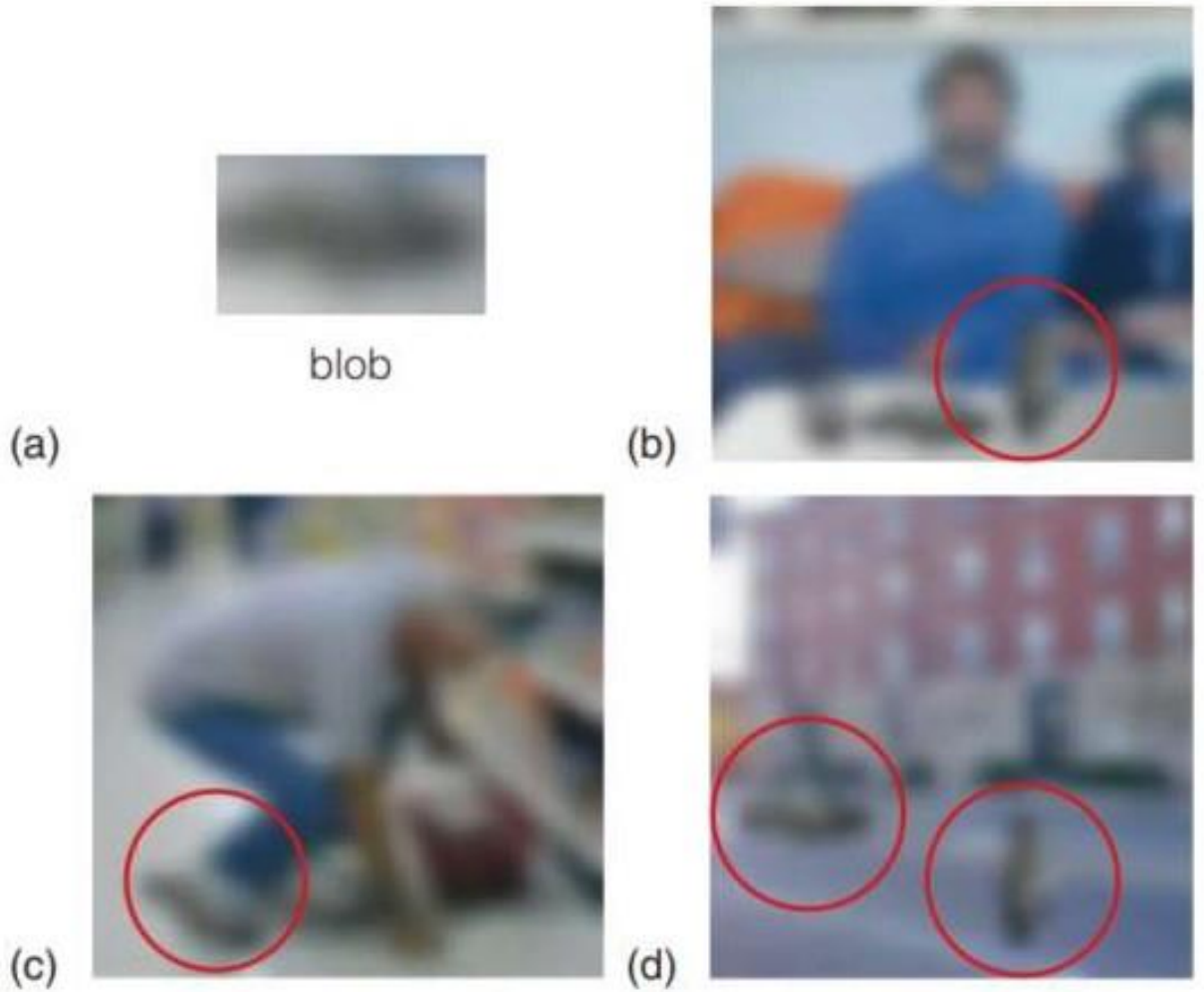
Perception & Representation

PS205 Week 3

Reading: Pages 60 - 90

Additional Material on Moodle



Perception as *Integration* of Sensory Information

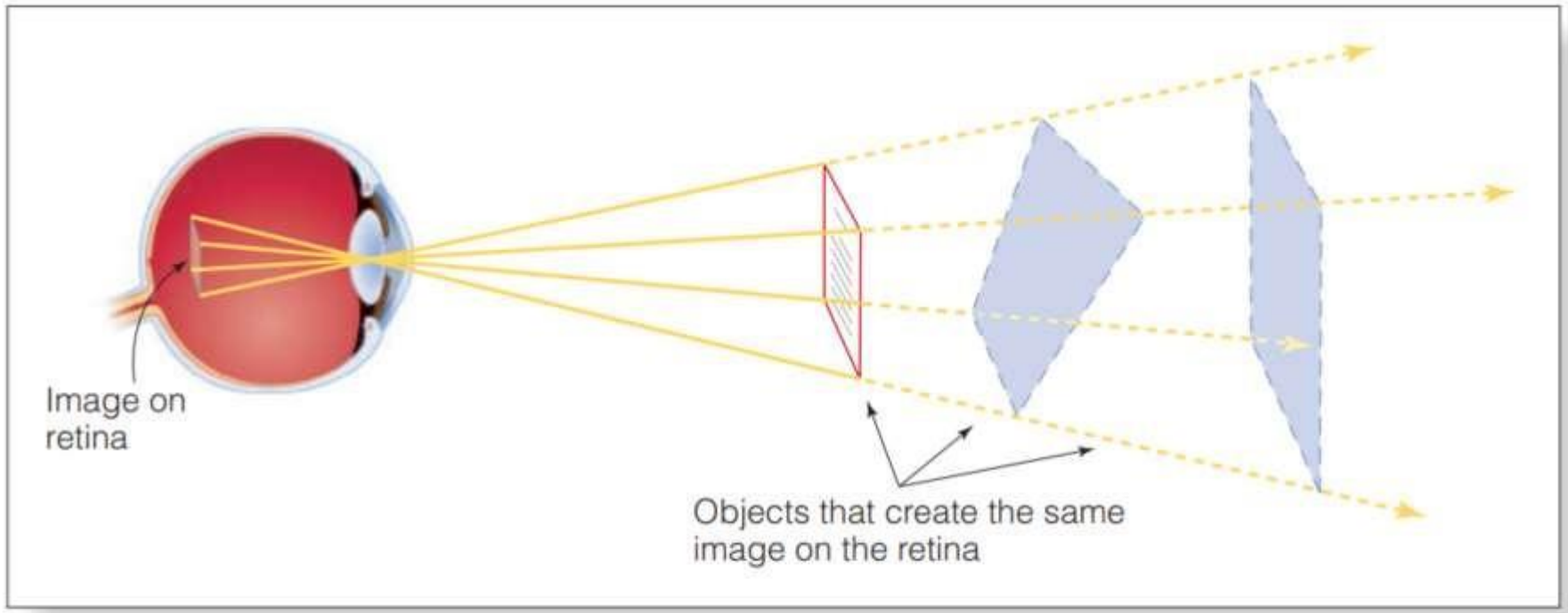
➤ **Figure 3.1** (a) Initially Crystal thinks she sees a large piece of driftwood far down the beach. (b) Eventually she realizes she is looking at an umbrella. (c) On her way down the beach, she passes some coiled rope.

Perception as *Interpretation* of Integrated Information

- Feature Extraction is necessary, but not *sufficient*
- Information acquisition ('learning') is essential for nuance
- *Inverse projection problem*: How to derive the source from the image?

➤ **Figure 3.4** Even computer-vision programs that are able to recognize objects fairly accurately make mistakes, such as confusing objects that share features. In this example, the lens cover and the top of the teapot are erroneously classified as a "tennis ball." (Source: Based on K. Simonyan et al., 2012)

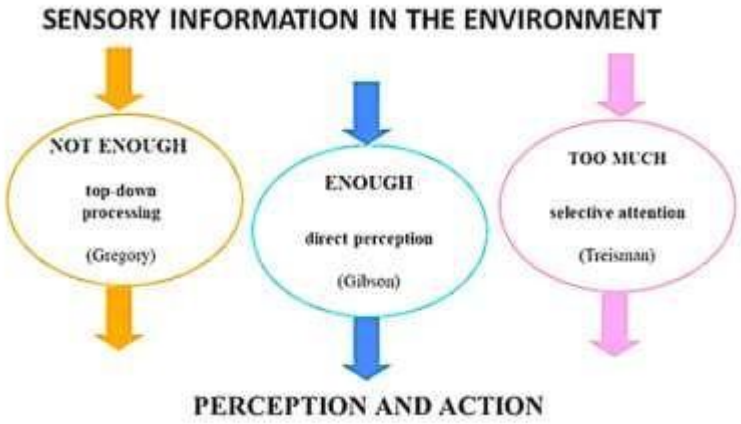
➤ **Figure 3.6** Picture similar to one that a computer vision program identified as "a young boy holding a baseball bat."



➤ **Figure 3.7** The projection of the book (red object) onto the retina can be determined by extending rays (solid lines) from the book into the eye. The principle behind the inverse projection problem is illustrated by extending rays out from the eye past the book (dashed lines). When we do this, we can see that the image created by the book can be created by an infinite number of objects, among them the tilted trapezoid and large rectangle shown here. This is why we say that the image on the retina is ambiguous.

Theories of Perception

- To interact with the world
- To acquire energy for survival
- *Movement* enhances perception
- Features constrain ('afford') the number of actions we can perform on any given feature of the environment



Where perception begins

- There cannot be a *reaction* without something being reacted *to.*
- Classic top-down theories implied constructions based on prior knowledge causally mediate perception
- Bottom-up theorists countered that perception can be directly based on complex reality
- Complex reactions can be based on 'rules' present from early on (e.g., feature detection) to those learned later (e.g., ceremonial dance) interact with bottom-up information to produce *perception.* This means what we perceive can be shaped by our experiences, similar to the brain (p. 79).
- https://www.youtube.com/watch?v=kWIagHUqD8A

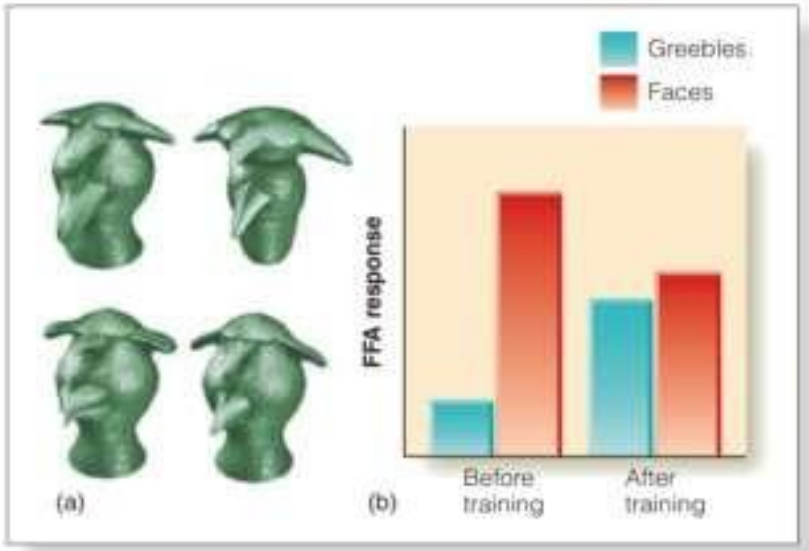
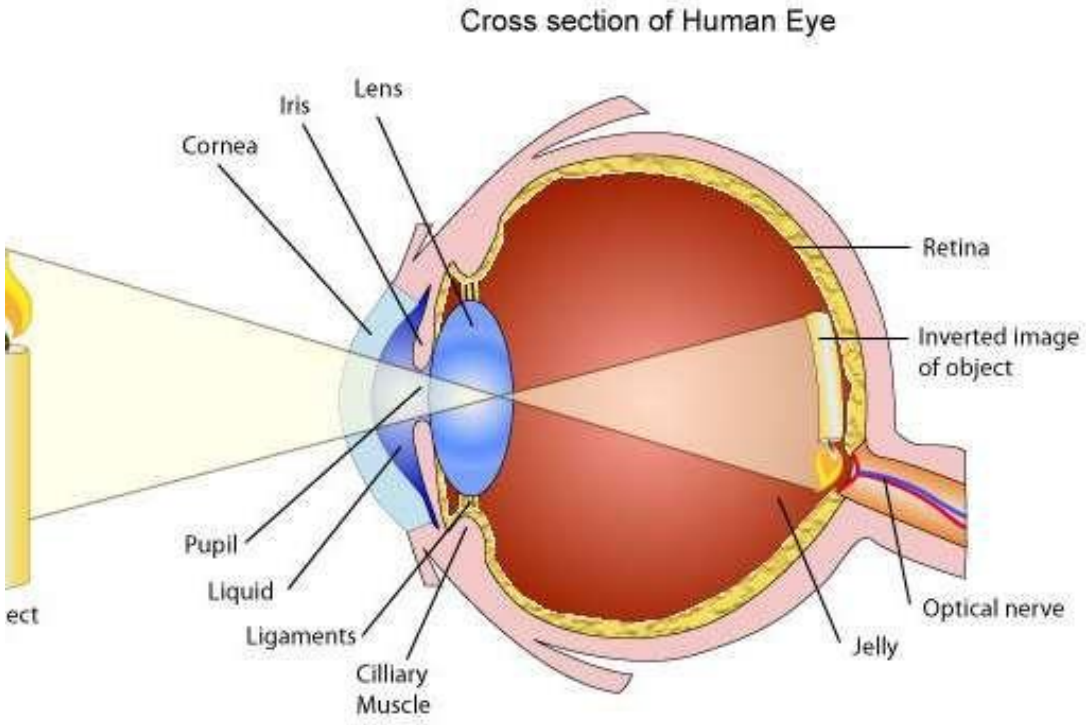


Figure 3.27 (a) Greeble stimuli used by Gauthier. Participants were trained to name each different Greeble. (b) Magnitude of FFA responses to faces and Greebles before and after Greeble training.

(Source: Based on I. Gauthier et al., 1999)

The Act of Perception

- Perception as the Interpreted Integration of Sensory, Contextual and Historical information
- Light rays from the environment project an image on the retina. *Perception* involves *interpreting* the image meaningfully.
- Inverse Projection – deriving meaningful interpretation from partial sensory information



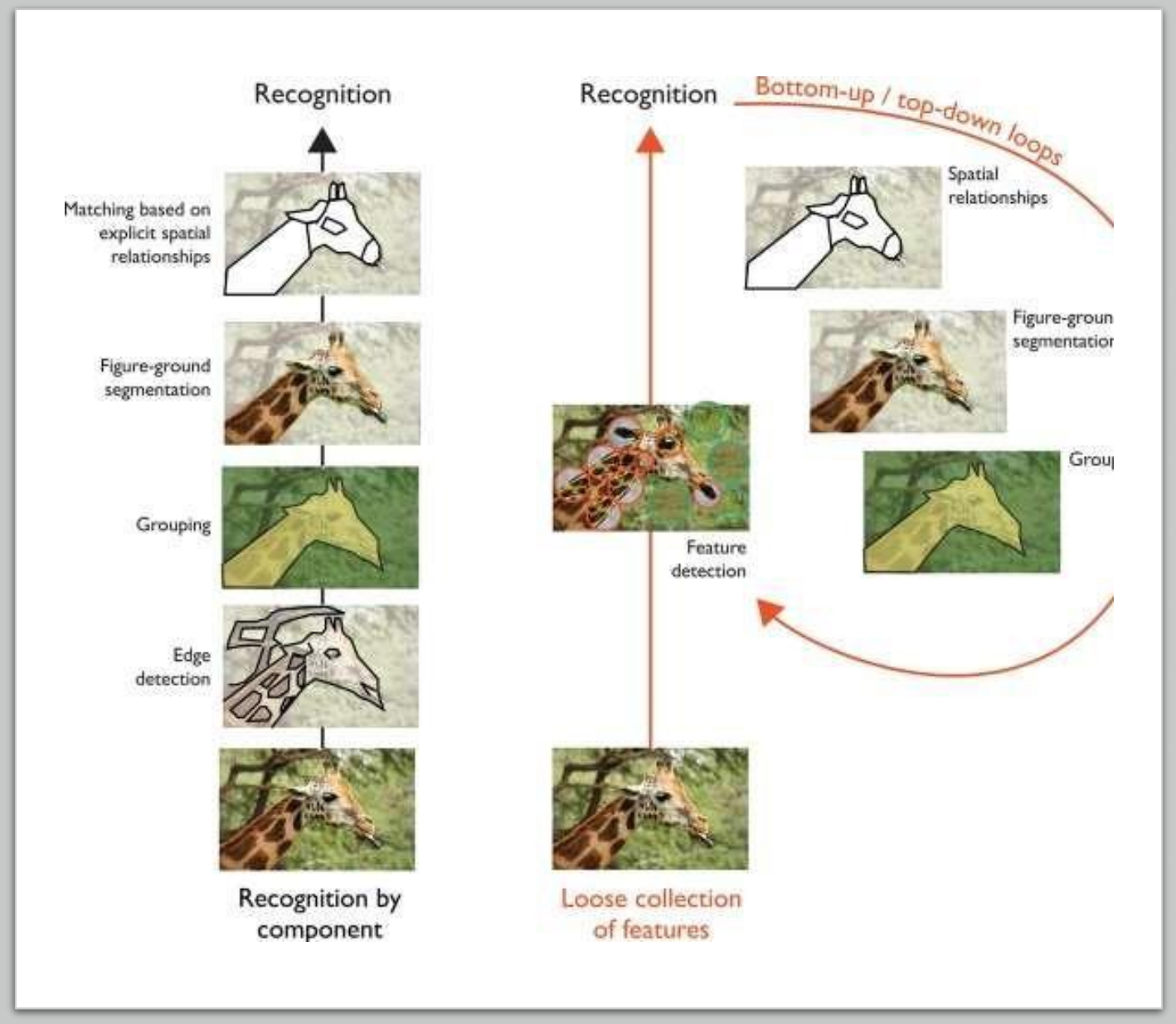
Interpretation of Stimulus Information

- Do you know who these individuals are?

- Are these images of the *same* object or of different objects?
  - The capacity to recognize it is the same chair is an example of *viewpoint invariance*

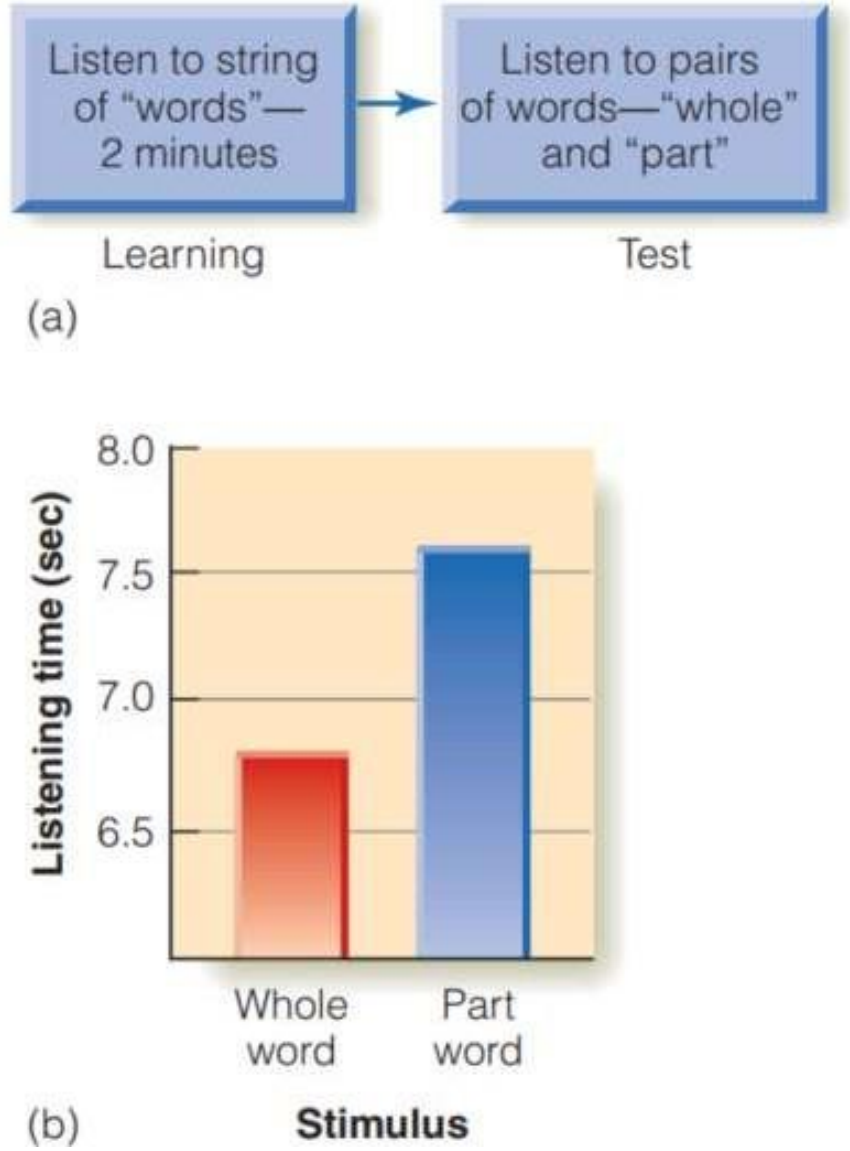
Perceiving Complex Objects

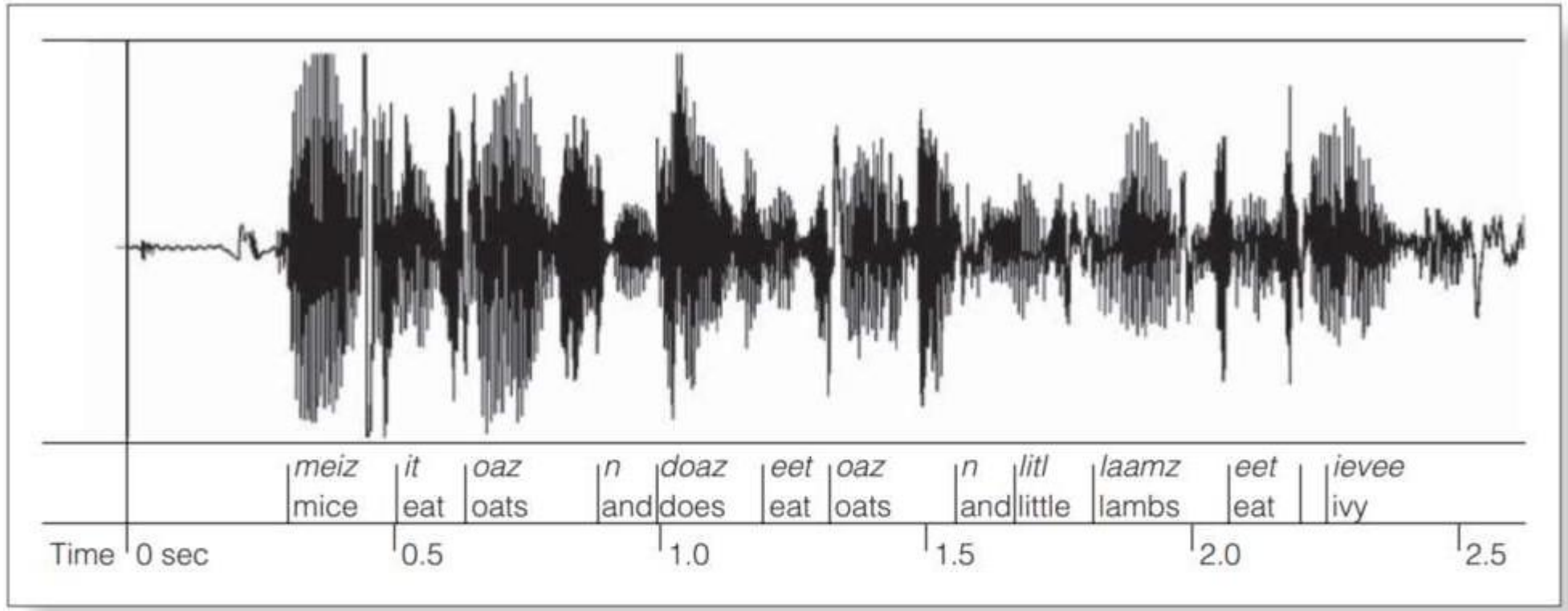
- Information is acquired from the environment and interpreted based on context and history
- **Bottom-up processing** (environment, context)
  - Stimulus → Retinal Image → Visual System
- **Top-down processing** (brain, mind)
  - Awareness → Memory → Action/Behavior



Perceiving Language

- Segmenting speech requires *knowing* what distinguishes the sounds of individual words
  - *Listening segment* (try to find where each word begins and ends)
- A side effect of learning a new language is knowing when sounds meaningfully transition into separate words/phrases
- How likely is the sequence *ty-la* relative to *et-ty* across English speakers? Think of the phrase *pr**etty la**dy*.
- Learning of *transition probabilities* (and other patterns) within a language is part of *statistical learning*
- Saffran et al 1996 - https://www.youtube.com/watch?v=CSMjKDZvNWA



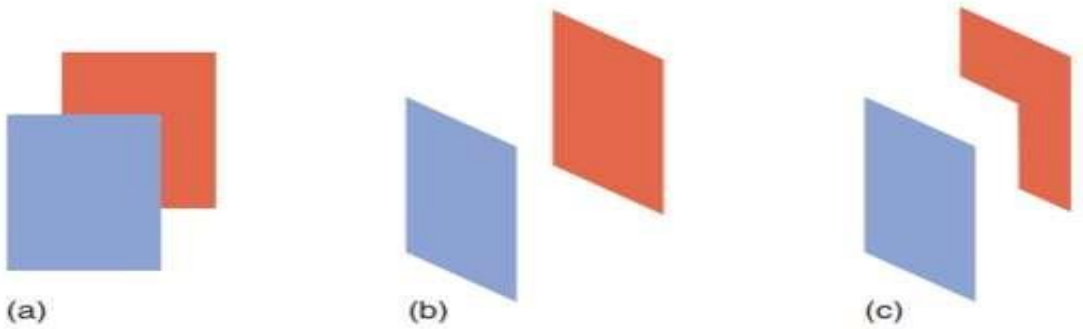


➤ **Figure 3.12** Sound energy for the sentence "Mice eat oats and does eat oats and little lambs eat ivy." The italicized words just below the sound record indicate how this sentence was pronounced by the speaker. The vertical lines next to the words indicate where each word begins. Note that it is difficult or impossible to tell from the sound record where one word ends and the next one begins.

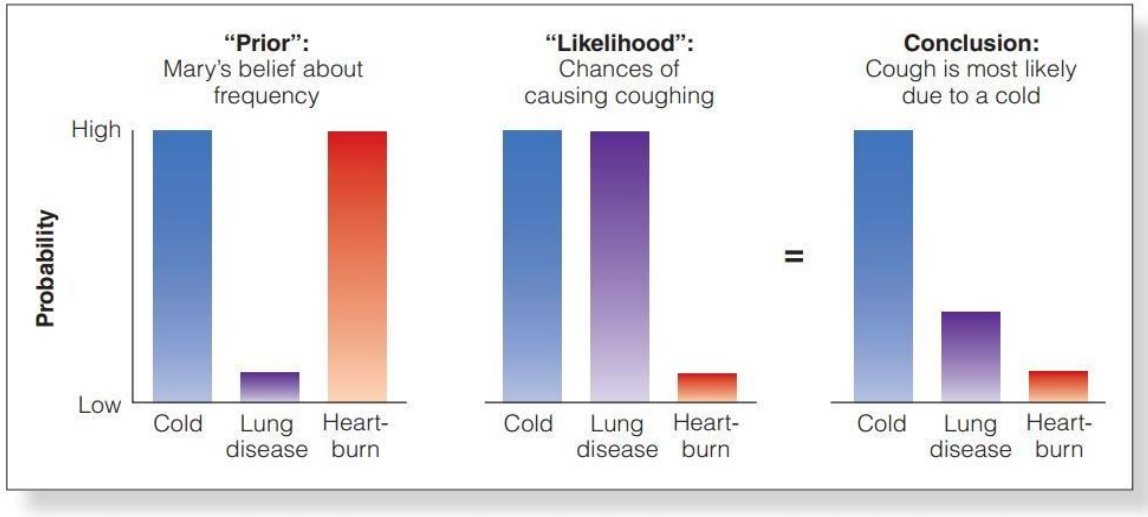
(Source: Speech signal courtesy of Peter Howell)

Speech segmentation requires sufficient familiarity with the transitional probabilities inherent to a specific language and sensitivity to context to determine 'meaning'

Is Perception Constructed?



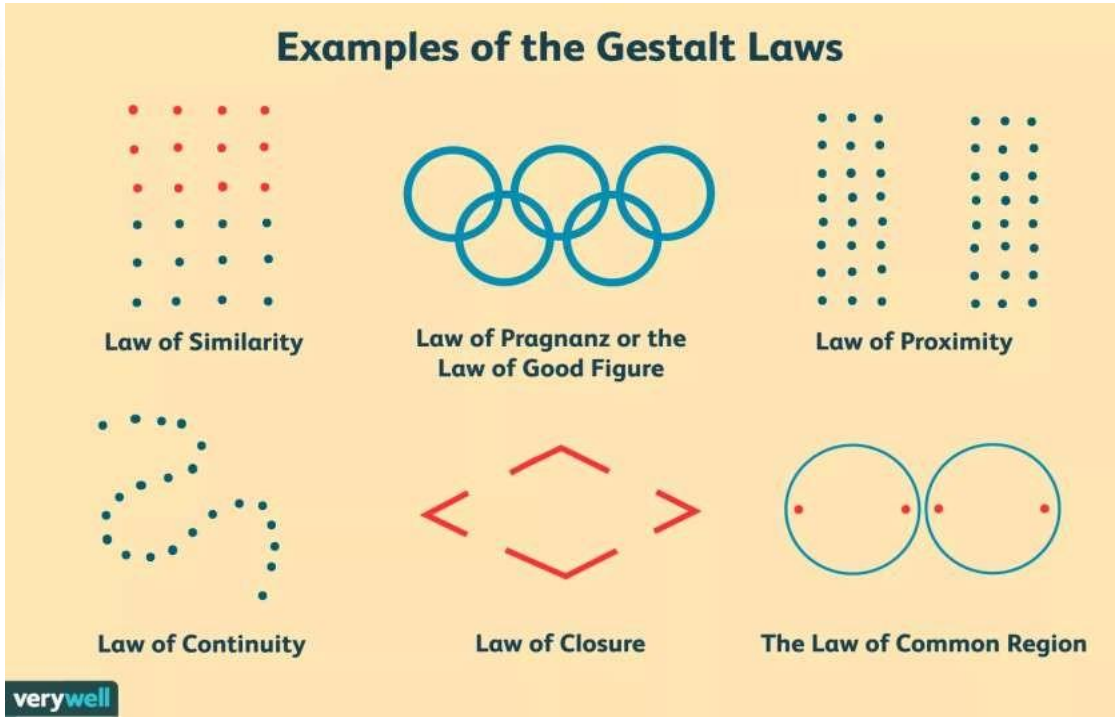
- The likelihood principle suggests *p*erceptual organization can be described following *Bayesian* principles
  - (top image) Why do we think (b) is more representative of (a) relative to (c)? Because (b) is more likely than (c).
  - (bottom image) Why does Mary believe in the likelihood of a cold more than heartburn? Because of prior probabilities
- Perceptions are *constructed* as top-down Hypotheses about reality https://www.youtube.com/watch?v=QbKw0_v2clo
- Limited sensory information requires access to stored information



Principles of perceptual organization

The whole is different than the sum of it's parts? (Yes, but…)

- *How are elements 'integrated' into a whole?*
  - *Good continuation*: When sequences of dots appear close together in the form of a line/curve, they are perceived as part of the same structure (Easy to follow the rope)
  - *Similarity*: Similar things become perceptually grouped together
  - *Closure*: Disconnected features are combined to imply a whole object
  - *Praganaz*: (Principle of simplicity) What is the simplest interpretation possible of the observed structure? (Overlapping circles as opposed to 9 distinct shapes)



https://www.verywellmind.com/gestalt-laws-of-perceptual-organization-2795835

Regularities and Contingencies

- Gestalt principles are important, but they may themselves have been learned early in our history
- **Physical Regularities**: *Blue – Sky*; *Green – Grass*; features of the physical environment which regularly occur together
  - Humans perceive horizontal/vertical lines more readily than angled lines (oblique effect)
  - Humans perceive light sources for observed images to be originating from above (light-from-above assumption)
  - Both symbols and objects that regularly appear with meaningful events are more likely to be perceptually identified (remember conditioning?)
- **Semantic Regularities**: The characteristics and/or functions of perceived scenes or objects based on prior knowledge

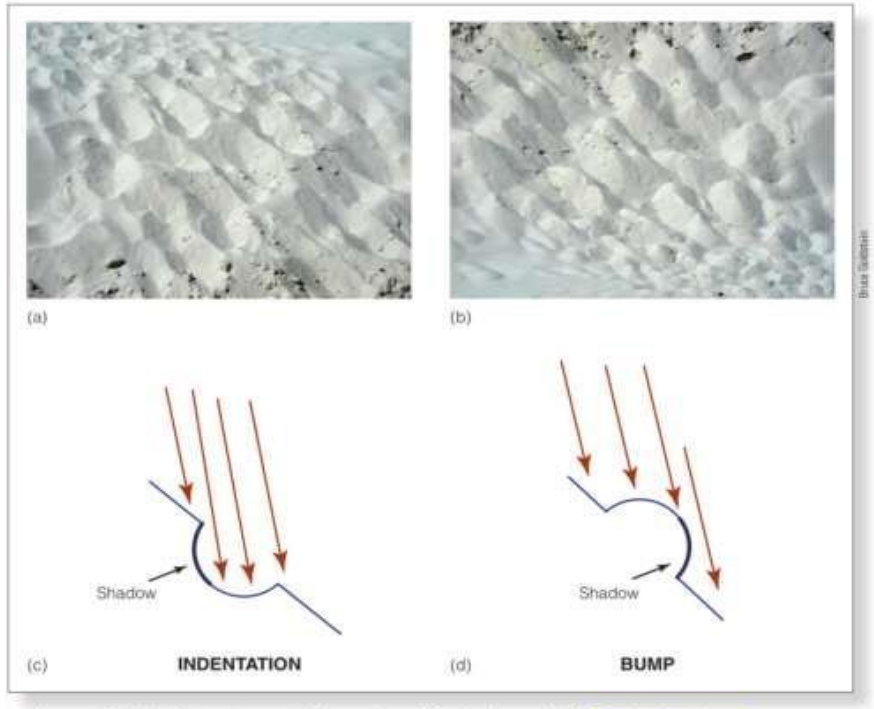
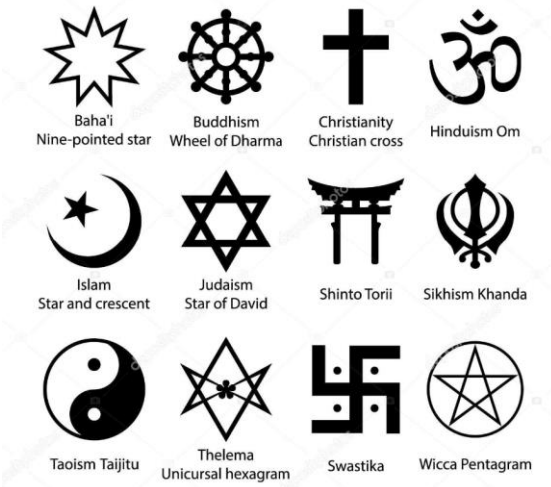


Figure 3.23 (a) Indentations made by people walking in the sand. (b) Turning the picture upside down turns indentations into rounded mounds. (c) How light from above and to the left illuminates an indentation, causing a shadow on the left. (d) The same light illuminating a bump causes a shadow on the right.



Perceiving Objects vs Places

- *What* (object) is perceived and/or *where* is it located in the environment (landmark)?
- Object (e.g., between rectangular and triangular solids) and Landmark (e.g., Near Cue and Far Cue) discrimination tasks
  - Increased difficulty with discrimination following brain ablations/lesions suggest a critical role of the lesioned region

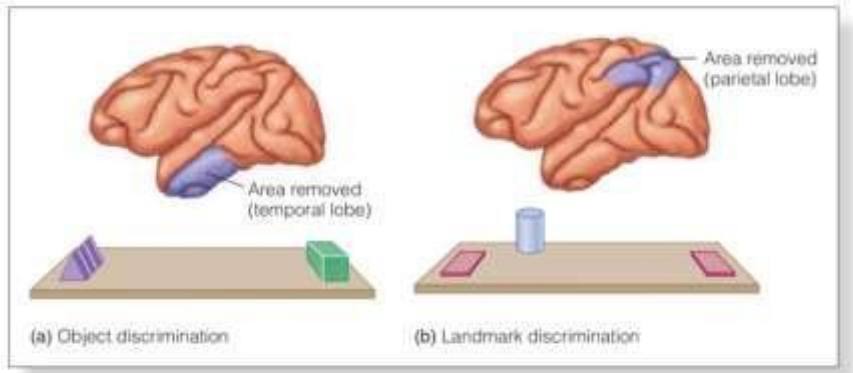
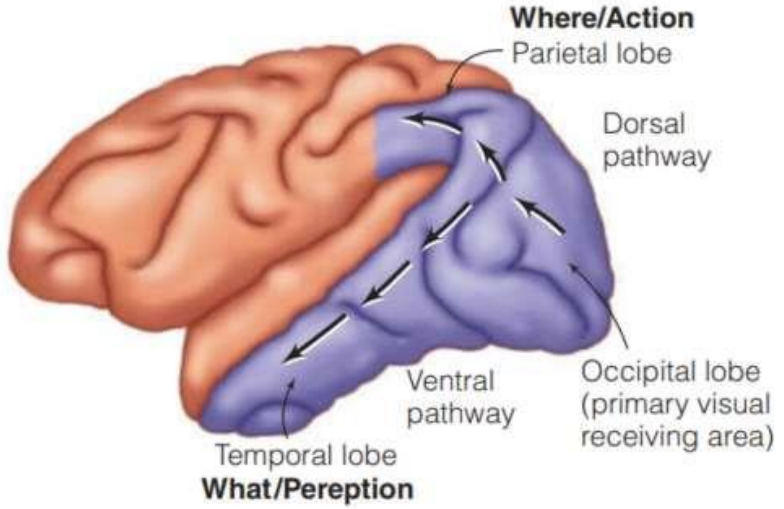


Figure 3.30 The two types of discrimination tasks used by Ungerleider and Mishkin. (a) Object discrimination: Pick the correct shape. Lesioning the temporal lobe (purple-shaded area) makes this task difficult. (b) Landmark discrimination: Pick the food well closer to the cylinder. Lesioning the parietal lobe makes this task difficult.
(Source: Adapted from M. Mishkin et al., 1983)



When Actions and Perceptions collide: The case of D.F.

- Following brain damage to the temporal (object) and parietal (landmark) regions, D.F. would have difficulty trying to match card orientations (orienting towards the *object*)
- Yet if the task was re-framed as purposive, viz. *goal-oriented*, the task could be completed
- Evidence of perception-action couplings that involve *independent* processes

➤ Figure 3.33 (a) D.F.'s orientation task. A number of different orientations were presented. D.F.'s task was to rotate the card to match each orientation. (b) Results for the orientation task. Correct matches are indicated by vertical lines.

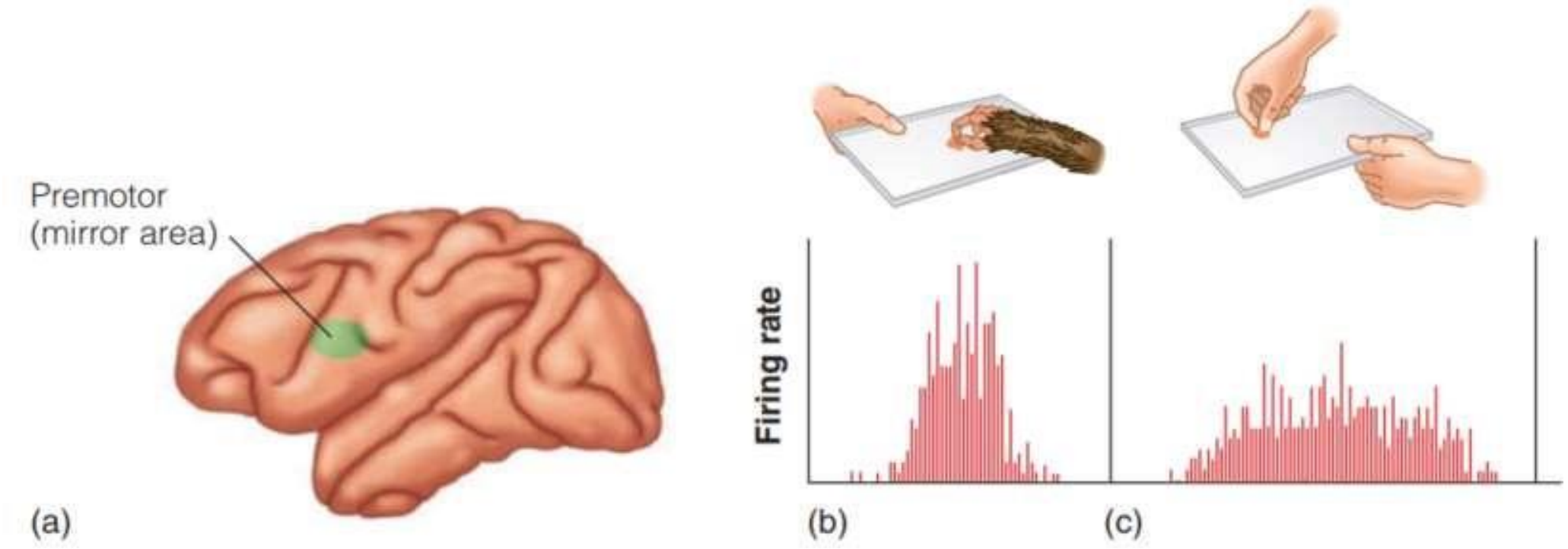
(Source: Based on A. D. Milner & M. A. Goodale, 1995)

➤ Figure 3.34 (a) D.F.'s "mailing" task. A number of different orientations were presented. D.F.'s task was to "mail" the card through the slot. (b) Results for the mailing task. Correct orientations are indicated by vertical lines.

(Based on A. D. Milner & M. A. Goodale, 1995)

Mirror neurons

- Certain neurons that fire when the agent is performing an action (e.g., picking up food) can *also* be observed to fire when *another* agent is committing the same action
- Biological foundations of 'empathy'? Or 'likelihood detectors'?
- Allows identifying the 'goals' of others, and re-orients the agent accordingly



Conclusion

- Perception involves the integration of partial sensory inputs
- Sensory information integrates with prior history to identify meaningful patterns (‘percepts’) from our surrounding
- The inverse projection problem summarizes the difficulty of re-creating meaningful representations based on partial information
- Contemporary theories of perception maintain that percepts are organized along perceptual rules (Gestalt) which may likely have been acquired early in our learning histories (physical and semantic regularities)
- Independent cortical systems have been correlated with targets of perception (objects vs landmarks vs faces) and the actions coupled with those objects (speaking vs holding).