

Music 175: Cognitive Psychology and Music

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April 30, 2019

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Information to Representation

- **Information:** what is happening on the surface of the retina or the basilar membrane provides *information* of the external world.
- **Representation:** In the final processing, the brain uses information to construct a *representation* of what is going on.
- Cognitive psychologists are principally interested in the final representation.

Information, Perception, and Cognition

- There is a chain of processes between **physical events** and **their perception** by humans:
 1. generation of energy
 2. transmission of energy from event to observer
 3. reception and processing by ear/eye
 4. transmission of signals to the brain
 5. more processing: interpretation, formation of a representation
- **Cognition:** set of *mental abilities and processes* related to knowledge: attention, memory, judgment, evaluation, learning, understanding, remembering;

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Two Tables

- Consider two tables as if in different orientations in space.

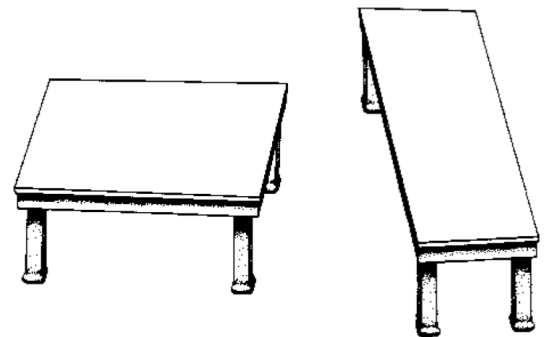
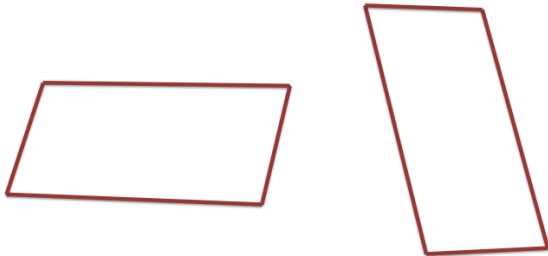


Figure 1: Two tables vs. two parallelograms that are the same size (Cook, Chapt. 3).

- Stating they are tables is a *cognitive interpretation*.
- Patterns of lines are being interpreted as 3-D objects.

Removing Cognitive Interpretation

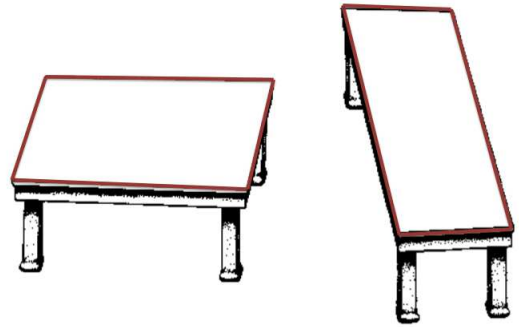
- Turning off the interpretation of “tables in space”, we see two parallelograms of identical size and shape.



- See also Muller-Lyer illusion

Information vs. Representation

- The difficulty in seeing the two tabletops as simple parallelograms having the same size and shape, shows that the internal representation in the brain is quite different from the pattern present on the retina.



- The interpretation process in the brain is quick and automatic, and very difficult to suppress.

Unconscious Inference

- *Unconscious inference* is a cognitive principle formulated by Hermann von Helmholtz:
 - an automatic (involuntary or reflex-like) mechanism contributing to visual impressions
 - 3-D objects are automatically inferred from cues present in a 2-D pattern on the retina.

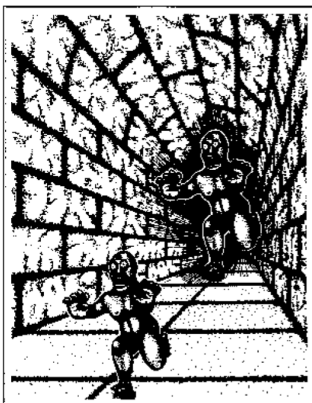


Figure 2: Monsters of same size illustrate unconscious inference.

Cues Supporting 3-D Inference

- 2-D cues supporting 3-D representation:
 - *Linear perspective*: converging lines in 2-D convey parallel lines and depth in 3-D
 - *Gradient of size*: elements of uniform texture decrease in size as they approach the horizon
 - *Aerial perspective*: objects in the far distance appear lighter and blue
 - *Binocular parallax*: each eye receives a slightly different image allowing the brain to make inferences about distance;
 - *Motion parallax*: movement on the part of the observer changes images on each retina;
- Cues support inference to 3-D interpretation but inference is *unconscious*.
 - experiments suggest we have no notion of the cues our brains are using;
 - cues can be removed without sacrificing judgment about relative distances and placements of objects.

Optical Illusions and Unconscious Inference

- Certain optical illusions are instances of unconscious inference:
 - Example by Helmholtz: sun going down behind a stationary horizon (sun is fixed; horizon moves)

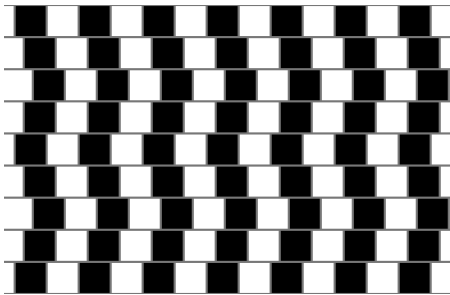


Figure 3: Cafe wall: a *distorting* illusion with parallel horizontal lines

- **interactivie cafe wall** (change black to white)
- **interactivie cafe wall** (more change of geometry)

- E.g.: a person standing in a library would see books, shelves, and other furniture:
 - superpositioning of shelves and their decreasing size provides direct information about depth and size of library;

Direct Perception

- James Gibson (20th century psychologist in *visual perception*) rejected *information processing* view of cognition:
 - “Information is sufficient to construct an accurate representation of disposition of objects in space.”
- **Ecological psychology**: mind directly perceives environmental stimuli without additional cognitive construction or processing.
- **Direct perception (or realism)**: sensory perception is the *direct* result of information from the surrounding environment.
 - sensory information is all that is necessary (inferences are not);
 - a “bottom-up” approach:
 - * knowledge about an environment is “pieced together” from what is *directly* perceived;
 - * larger subsystems are gradually created until a complete top-level system is formed;

Direct Perception vs. Unconscious Inference

- Direct perception conflicts with theories involving need of “inferences” or “beliefs” to make sense of their sensory experience.
- What about cognitive tricks (seeing something that is not really there)?
- It is suggested that *direct perception* can be reconciled with *unconscious inference* in that
 - complex computation is required to process the information coming into the sensory systems
 - most of that computation is unconscious

Size and Loudness Constancy

- The image on the retina of objects of constant size will expand and contract as the object moves closer and farther away.
- *Size constancy* allows us to perceive objects as they are, independent of their distance from us.

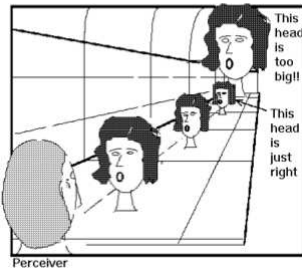


Figure 4: The head closest to the perceiver is the same size as the farthest head.

- A direct analog in the auditory domain is that sound intensity decreases with distance (inverse square law).
- *Loudness constancy* allows us to perceive an increase in distance from a source if there is a decrease in amplitude.

Intensity vs. Distance Cues

- A balloon deflating isn't necessarily perceived as moving farther away.
- Likewise, it's possible to change sound intensity without changing the source's distance.
- Cues determining whether change is in the intensity of the source or its distance from the observer:
 - **spectral balance**: increased intensity is usually accompanied by increased higher frequency components for closer sounds;
 - **reverberation**:
 1. intensity ratio of direct to reflected sound
 2. time delay between direct and reflected sound decreases with distance from source.

Spatial Inversion

- A human observer is “wired” to interpret information in its usually encountered form:
 - if a familiar pattern is transformed, even though all the information is retained, that pattern may be interpreted differently.
- Consider Rotation:

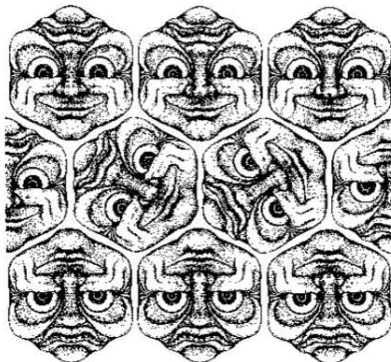


Figure 5: We are more accustomed to seeing faces right-side up, thus the upper and lower rows are perceived as being of two different faces rather than one face in two orientations.

Temporal Reversal

- An auditory analog to spatial inversion is **temporal reversal**:
 - in normal surroundings we receive direct and reflected sound;
 - echos/reverb/decay allow inference of the character of the space/source;
 - reflected sounds reach a listener *later* than direct sounds;
- It is more difficult to deal with echos/decay preceding a signal:
 1. a resonant object produces a sound that decays exponentially over time—when played in reverse, the sound is quite different.
 - what is this instrument in this sample (played in reverse)? [Click to listen](#)
 - the original sound: [Click to listen](#)
 2. example in which reverberation precedes speech: [Click to listen](#)

Perceptual Completion

- Our perception may compensate for incomplete information coming into our sensory systems.
- Consider the disk atop a bar:

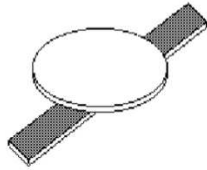


Figure 6: We would normally assume one bar instead of two beneath the disk.

Broken Bar Unexpected

- We normally assume one bar, rather than two, beneath the disk.

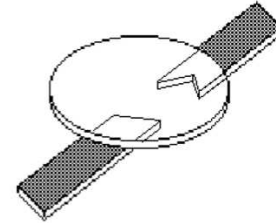


Figure 7: This result would likely surprise the observer.

Implied Triangle

- In an example by psychologist Gaetano Kanizsa, a white triangle appears located at the center of the figure (illusory contours).

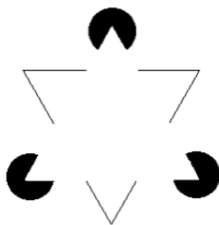


Figure 8: The suggestion is a triangle lying on objects.

- Though no such triangle actually exists, the presence of the triangle is the most likely explanation in the external world.

Auditory Perception Completion I

- The auditory analog is demonstrated by Al Bregman with sinusoids and noise.
- Part of signal A is replaced with silence then with signal B.

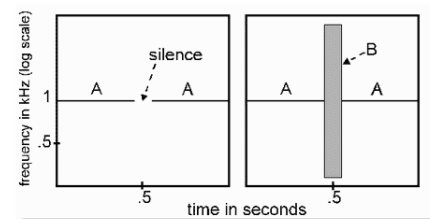


Figure 9: Replacing a gap with signal B can create perception of completion (continuity).

- If signal B is loud enough, signal A appears to continue behind it.
- [Click to listen](#)
- This effect occurs when neural activity during B includes activity very similar to what would normally occur during A.

Auditory Completion II

- In another experiment by Al Bregmen, the signals are swept up and down in frequency.

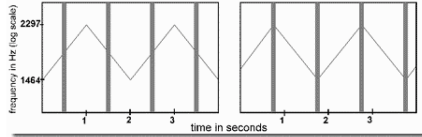


Figure 10: Discontinuity in the middle of ascending and descending legs or at peaks and valleys.

- Continuity is not dependent on the signal being in a steady state.
- [Click to listen](#)

Summary

- Fundamental Principles of Perception:
 - Unconscious Inference vs. Direct Perception



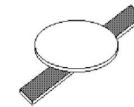
- Size and Loudness Constancy



- Spatial and Temporal Inversion



- Perceptual Completion



Gestalt Psychology

- *Gestalt* “shape, form”
- Gestalt psychology: the mind considers objects in their entirety before, or in parallel with, perception of their individual parts.

“The whole is other than the sum of its parts”.

- Gestalt psychologists sought to understand the perception of whole forms rather than just a collection of simpler elements (points, lines, curves, etc.)
- Max Wertheimer, principal founder of Gestalt psychology, formulated **Gestalt principles of grouping** which are used by the brain when parsing sensory input into objects in the world.

The Gestalt Grouping Principles

- Gestalt principles are based on Helmholtz’s concept of unconscious inference:

- Proximity



- Similarity



- Symmetry



- Continuity



- Common fate



- The first 4 are *weaker* than the much stronger “common fate”.

Common Fate

- In the world, it is extremely improbable that two things move in a perfectly correlated way unless they are in some way connected.
- When visual elements are moving together, they are perceived as a single Gestalt.



- Animation: [Click to watch](#)



Audio Common Fate

- Isolating a sound source involves grouping harmonics or partials making up the sound.
- Since harmonics/partials tend to move together, in both frequency and amplitude, grouping, and isolation, is done by the principle of common fate.
- Examples of auditory common fate include:
 - common onset time;
 - common amplitude and frequency modulation: partials tend to move in ensemble, in both amplitude and frequency;
- Examples:
 - isolating the voice of a speaker;
 - isolating a solo instrument in an ensemble.