

Cognitive Systems

Foundations of Information Processing
in Natural and Artificial Systems

Lecture 6

Color Perception
Auditory, Tactile, Olfactory, and Taste Perception



Perception of Various Modalities

- (1) Vision: Color Perception
- (2) Audition
- (3) Haptic / Tactile Perception
- (4) Olfactory Perception
- (5) Gustation / Taste Perception
- (6) Multisensory Integration

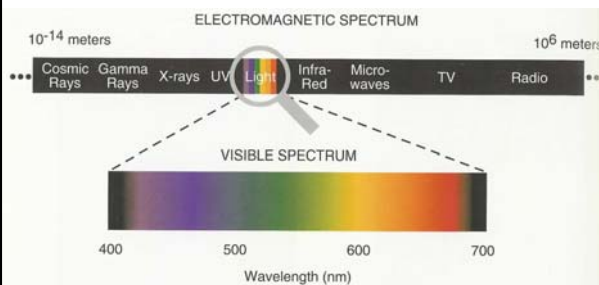
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Color Perception

6.1

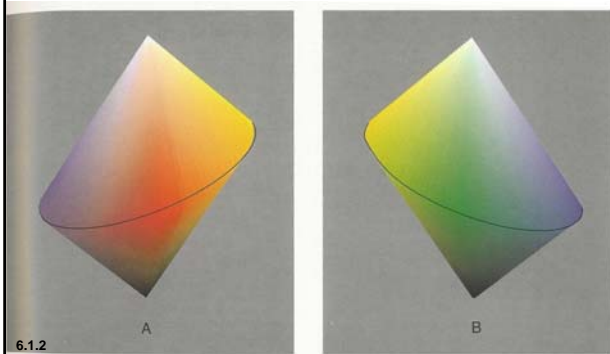
Visible Electromagnetic Waves



6.1.1

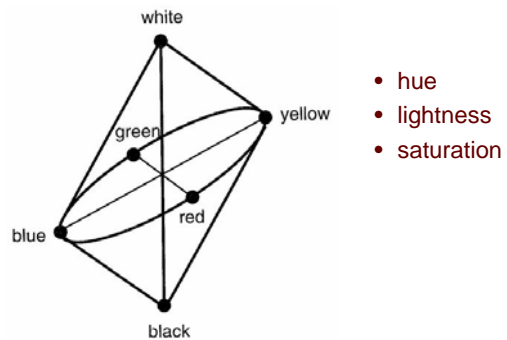
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The 3-D Color Space



6.1.2

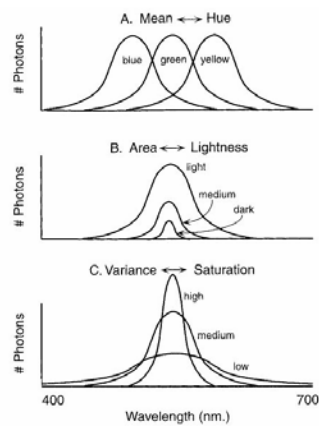
The 3-D Color Space Schematically



6.1.3

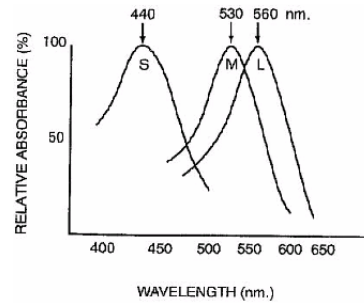
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Color Spectra



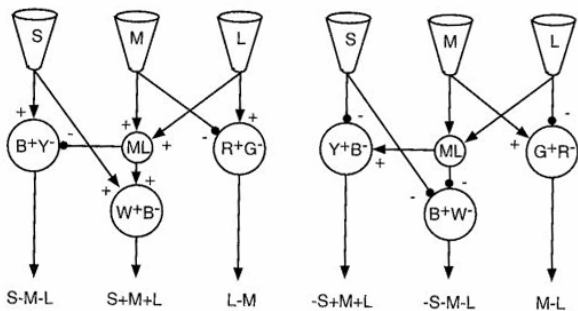
6.1.4

Neural Response Curve Three Types of Cones: S, M, L



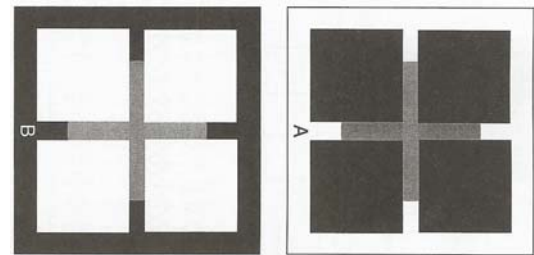
6.1.5

Neural Circuits for Color Perception



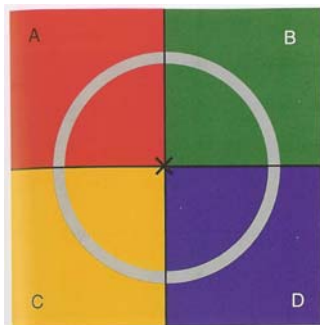
6.1.6

Context Sensitivity of Brightness Perception



6.1.7

Context Sensitivity of Color Perception



6.1.8

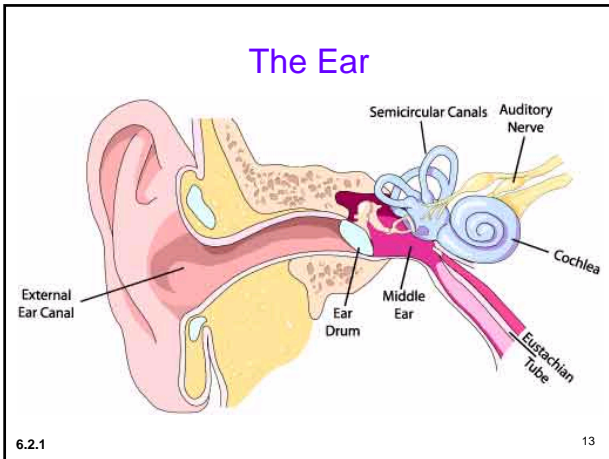
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Audition

- Perceptual experience associated with stimulation of the sense of hearing
- Acoustic energy: Sound waves (rather than electromagnetic waves)
 - Info coded in time (rather than space)
- Receptors convert mechanical energy into neural impulses
 - stimulation of sensory hair cells
- Separation of simultaneous signals necessary (e.g. party talks)

6.2

12



Tonotopical Maps

- Frequency of stimulating sound is mapped onto a location along basilar membrane in cochlea providing a *place code*
- Frequency selectivity throughout auditory pathway
- Basis for spectral analysis of sounds

6.2.2 14

Aspects of Sound

- pitch
 - ~ fundamental sound frequency
- loudness
 - ~ sound intensity
- timbre (“Klangfarbe”)
 - ~ distribution of acoustic energy across frequency (shape of power spectrum)
- perceived spatial location
 - direction and distance

6.2.3 15

Cocktail Party Effect

- Person can selectively listen to one particular speaker while tuning out several other simultaneous conversations
- Selective attention: process by which perception of certain stimuli is enhanced relative to concurrent stimuli of lesser immediate priority

6.2.4 16

Theories of Selective Auditory Attention

- Early stimulus selection?
 - early filtering mechanism to attenuate irrelevant input
 - attenuation by means of descending modulatory pathways?
 - strong suggestive evidence for top-down biasing of stimulus input channels
- Late selection?
 - all stimuli are processed to considerable detail before selection due to attention takes place
 - perceptual analysis as a basis for selection due to attention

6.2.5 17

Haptic / Tactile Perception

- Subcutaneous receptors (beneath skin surface) and kinesthetic receptors (in muscles, tendons, and joints)
- info about objects and surfaces in contact with perceiver and heat/vibration from remote sources
- mechanoreceptors: transduce force applied to skin into neural signals
- thermal receptors

6.3 18

Classification of Tactile Receptors

- Size of receptive field
 - large or small
- Temporal properties
 - fast adapting, slowly adapting

6.3.1

19

Active and Purposive Haptic Perception

- By virtue of differences in their temporal and spatial responses, the various mechanoreceptors mediate different types of sensations
- Determining roughness of an object surface:
 - exploratory procedure: stroking or rubbing a surface laterally with skin
 - produces characteristic response patterns
 - different activation procedures exhibit different properties

6.3.3

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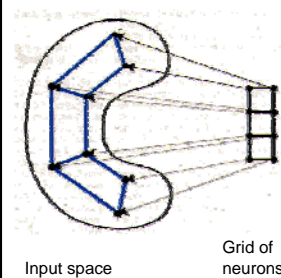
Somatotopic Maps

- Haptic information is represented in neighborhood-preserving somatotopic structures
- The surface of the skin is mapped to the surface of the cortex
- Important regions receive more cortex area than less important regions
- Different regions are important for sensory and for motor representations

6.3.4

21

Neighborhood-Preserving Maps

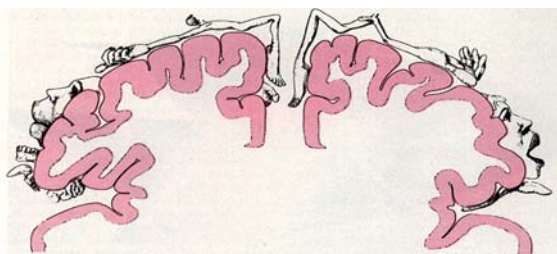


- Input space is mapped to a grid of 'neurons'
- Similarity is represented in the relative position of the neuron
- Neurons point to a location in sensory space (*center of their receptive field*)

6.3.5

22

Schematic Map of Sensory/Motor Cortex



Somatosensory cortex

Motor cortex

6.3.6

23

Interaction between haptic input and motor control

- A critical role for haptic perception is to support manipulatory actions on objects
- During lifting, incipient slip is sensed, leading to corrective adjustments in grip force
- Adjustments also occur during initial contact in response to perceived object properties such as coefficient of friction

6.3.7

24

Olfactory System / Smell Perception

- Phylogenetically ancient sensory system capable of detecting and discriminating among a vast number of different odorants
- Odorant molecules are collected and directed to sensory neurons
- Critical to survival of a variety of lower animals
- In humans olfaction appears less important than other senses

6.4

25

Gustation / Taste Perception

- Oral chemoreceptive and also mechanoreceptive and thermoreceptive sensory system
- Responds during drinking, biting, licking, chewing, and swallowing
- From hydrogen ions to large and complex protein molecules
- Number of gustatory response types ≥ 4

6.5

26

Multisensory Perception

- Any sensory modality provides a restricted set of cues about the environment
- Each sensory channel reflects a different feature of a stimulus and increases likelihood of accurate identification
- Multiple modalities provide enhanced information about environment and/or can substitute for missing information from some modalities
- Additional modalities provide reassurance of information from other modalities

6.6

27

Multimodal Integration

- To construct a coherent representation of the external world the information from the various sensory channels must be integrated into a common representation
- One way to do this is to feed the information from the different channels to a common group of neurons

6.6

28

McGurk Effect

- A speaker lip-synchronizes the syllable “ga” in time with the sound “ba”.
- The perception is neither “ga” nor “ba” but a synthesis of the two “da”.

6.6.1

29

Ventriloquism Effect

- The sight of movement of a head and lips compels one to believe it is the source of the sound.

6.6.2

30

Stroop Effect

Plate 11.1 A demonstration of the Stroop effect. Name the color of the ink as quickly as possible for each letter string in a given column. This should be hardest and slowest in the conflicting conditions, intermediate in the control condition, and easiest and fastest in the consistent condition.

6.6.3

31

| Control | Conflicting | Compatible |
|---------|-------------|------------|
| XXXXX | BLUE | YELLOW |
| XXXXX | GREEN | BLUE |
| XXXXX | RED | GREEN |
| XXXXX | YELLOW | RED |
| XXXXX | BLUE | YELLOW |
| XXXXX | RED | GREEN |
| XXXXX | GREEN | BLUE |
| XXXXX | BLUE | YELLOW |
| XXXXX | YELLOW | RED |
| XXXXX | RED | GREEN |

6.6.4

Next week

• Memory and Reasoning

- perceptual memory
- short-term memory
- working memory
- long-term memory

6.7

33