Human-Computer Interaction

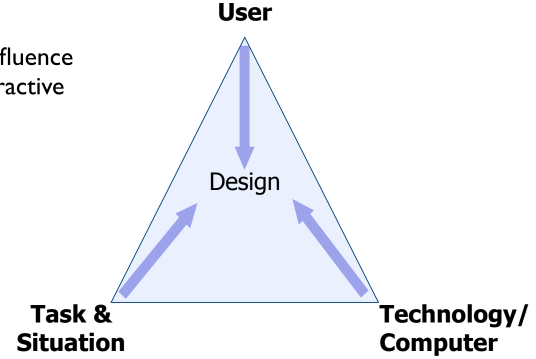
2. Session:
Psychological basis -- perception

Human-Computer Interaction

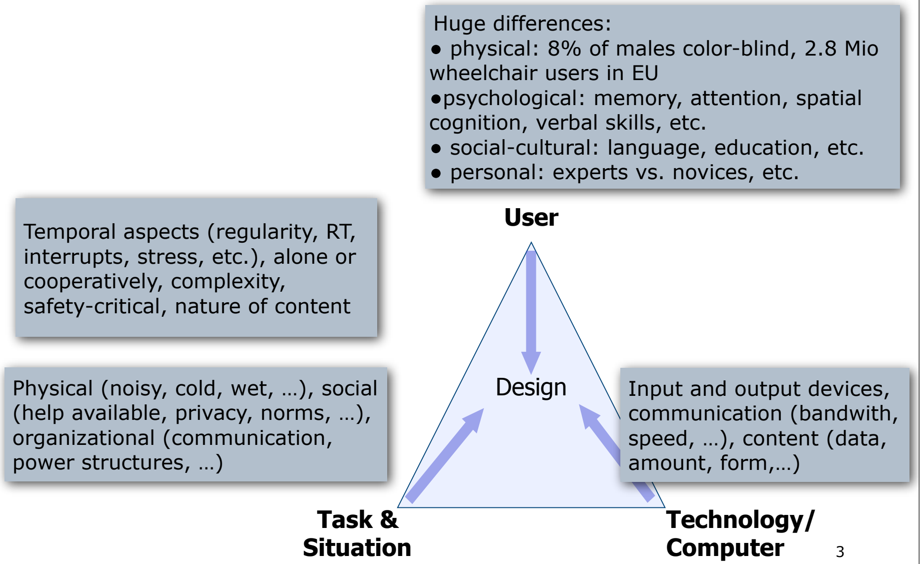
Aims at increasing the quality and efficiency of tasks that involve the human and the computer by improving the interaction between them

Concerned with the design, evaluation and implementation of interactive systems for human use.

Three factors that influence the design of an interactive system:



Human-Computer Interaction



Now...

let‘s focus on the human user!

Recommended readings:

- Dix et al.: "Human-Computer Interaction", Kap. 1, S. 12-26
- Matlin & Foley: "Sensation and Perception" (3rd ed.), Allyn & Bacon, 1992.
- Reed: „Cognition“ (5th ed.), Wadsworth, 2000, Kap. 1-5
- Benyon et al.: „Designing Interactive Systems“, 2005, Kap. 5, 15, 16

Human-centred view

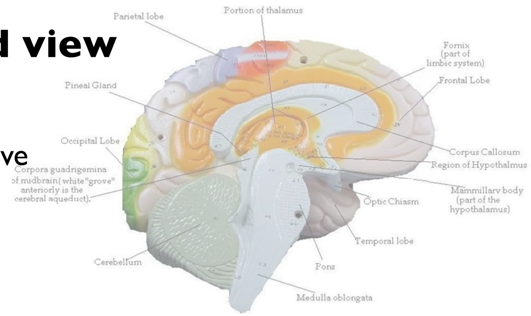
When interacting with a machine, the human processes information...

Perceptually
sees information on display, hears audio feedback, feels haptic feedback, etc.

Conceptually
tries to understand system from the information perceived, tries to remember relevant information, reasons what should be done next

Motor-physically
presses buttons, moves mouse, adjusts levers, exerts forces, etc.

Human-centred view

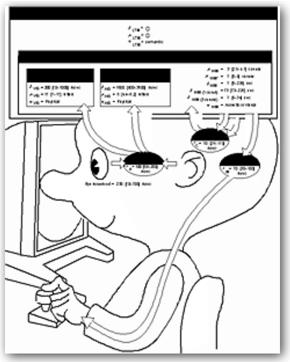


Cognitve Science/Cognitive Psychology approach

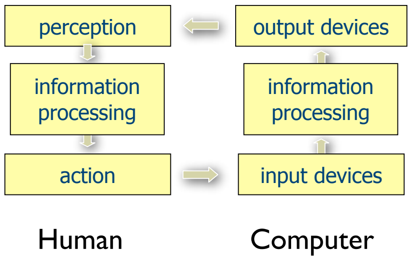
Human brain as information processor

- *modules*: specialized areas with distinctive functions
- *input/output*: visual, auditory, haptic, movement, force
- *memories*: sensory, short-term, long-term, working
- *processes*: reasoning, problem-solving, skills and routines, experiences, errors
- *regulators*: influenced by emotions and motivations

Psychology of HCI (Card, Moran & Newell; 1983)

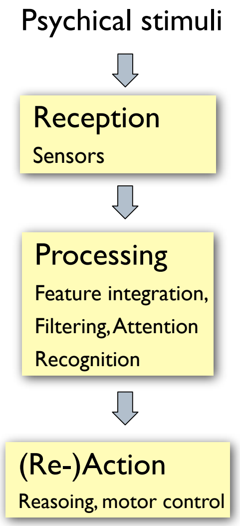


HCI = two information processors coupled in goal-directed action

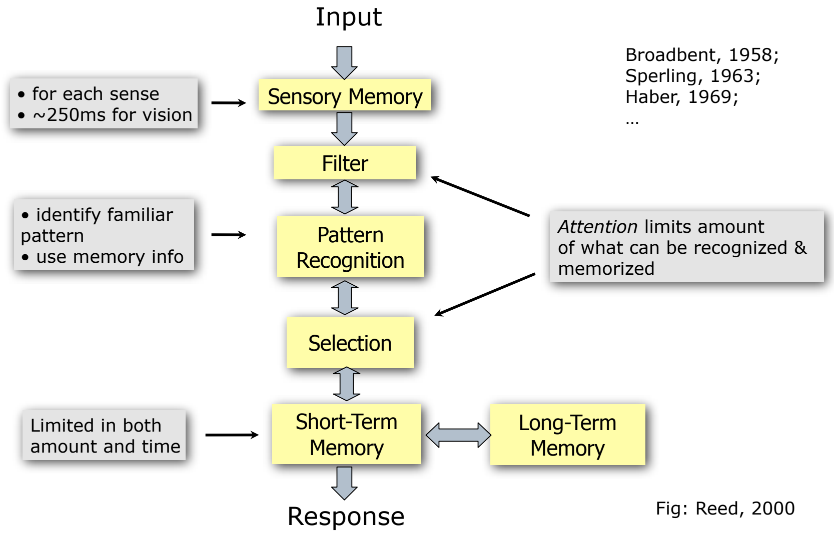


Psychological basis: Perception

Perception process



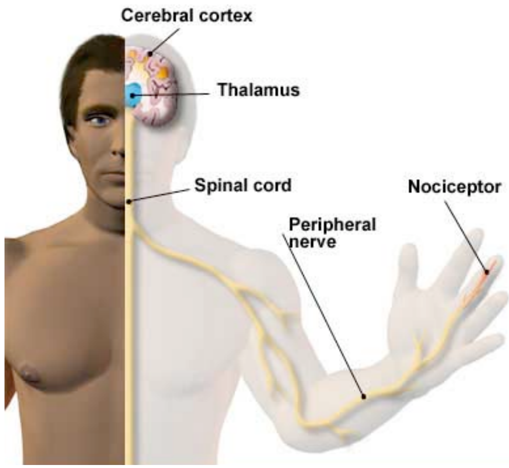
Perception process



Broadbent, 1958;
Sperling, 1963;
Haber, 1969;
...

Fig: Reed, 2000

Touch perception



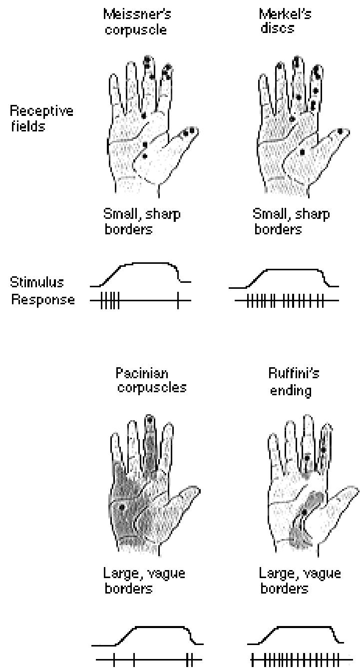
Touch reception

Receptors underneath the skin, in muscles, and in joints

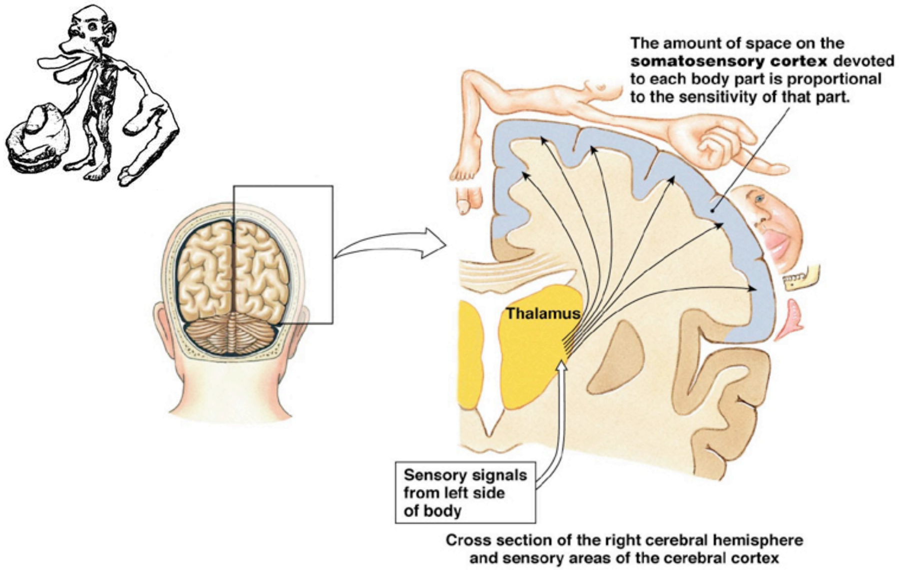
- ~2qm receptive skin surface, but not equally distributed!

Three types of skin receptors

- thermoreceptors: heat and cold
- nocireceptors: pressure, heat, pain
- mechanoreceptors: respond differently to pressure, for different skin areas, in females vs. males



Touch processing

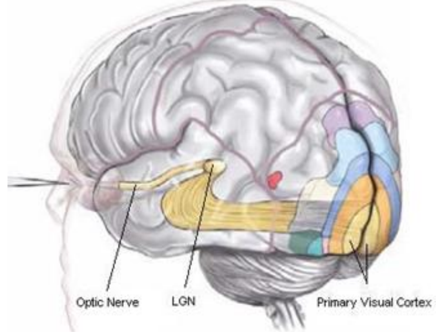


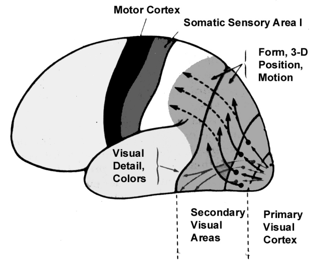
Cross section of the right cerebral hemisphere and sensory areas of the cerebral cortex

Fig. 10-10

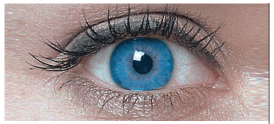
Visual perception

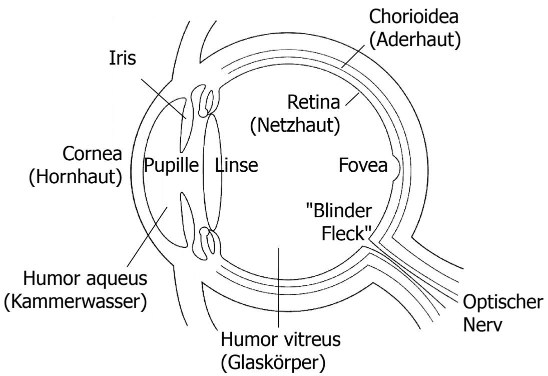
1. Physical reception of stimuli
   - Light sensation by optical appartus of the eye
   - Transformation into neural impulses in photo receptors of the retina
2. Processing & interpretation
   - starts right in the retina
   - Further processing and interpretation in brain structures (hierarchical visual cortex)

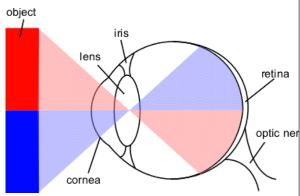




Human eye

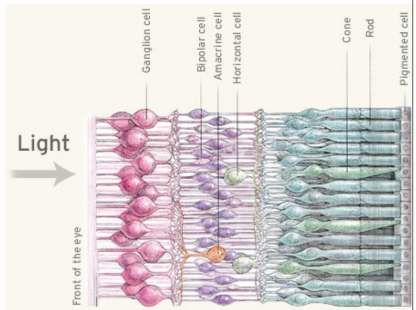


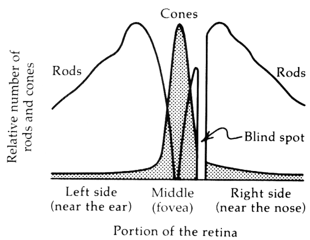




Human eye

	Cones (Zäpfchen)	Rods (Stäbchen)
Function	Color sight	Black-white sight
Number	7 Millions	125 Millions
Distribution	everywhere, conentrated at Fovea	not at Fovea
Lighting conds.	well illuminated	dark
Resolution	very good	weak
Sensitivity	weak	very good



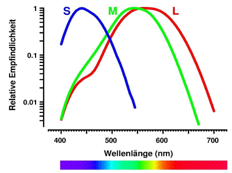


- Rods dominate peripheral vision
- details better seen in foveal region
- more sensitive with peripheral vision
- visual system compensates blind spot

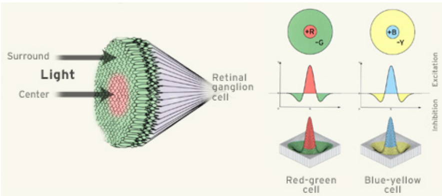
Color vision

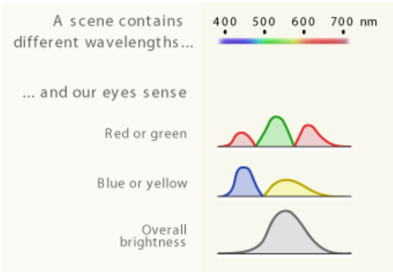
Receptors

- Three cone types with preferred wave lengths
  - S: blue, M: green-yellow, L: yellow-red
- Humans can distinguish 150 colors, with varying saturation and brightness ca. 7 Mio colors
- More M and L receptors in fovea than S type

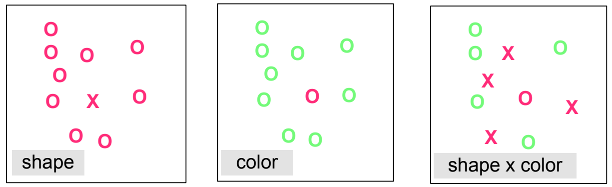


Ganglion cells





Attentive vs. Preattentive Vision

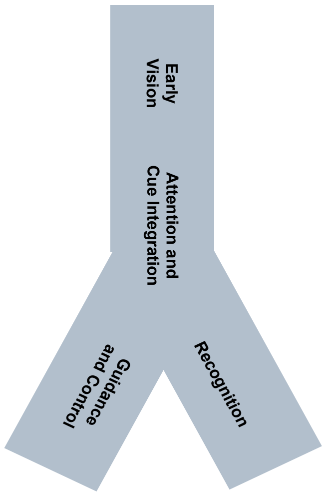


Find deviating element ("odd man out")!

- One feature dimension: Parallel search, time is independent of number of distractors
- Conjunctions of feature dimensions: Serial search, time covaries with number of distractors

Feature integration theory (Treisman & Gelade, Cogn. Psychol 1980): Binding of feature maps by focus of attention (saliency)

Visual perception



Preattentive vision
- image-like “maps” for depth, color, texture, contrast, and motion
- Parallel processing
- Perceptual learning

“Middle Vision”
- Serial processing within a focus of attention
- Cue integration
- Figure and ground segmentation

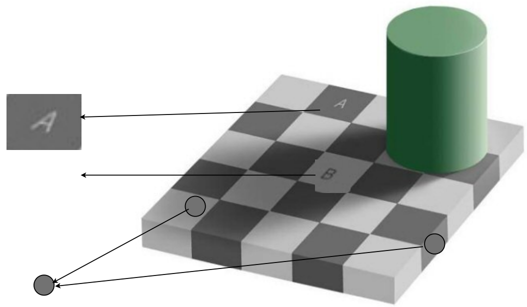
Recognition
- Generates judgements (“names”)
- Invariances with respect to position, pose, illumination, etc
- Learning of categories

Guidance and Control
- Eye-hand coordination
- Body posture
- Movement control and stabilization

Color perception

Color cues are interpreted and integrated with other information in the brain to yield an „impression“ of color

Categorical perception (see below)



Use of color in HCI

Color-coding: use of colour improves effectiveness of

- recognition process
- detection of patterns
- search (scanning)

Use color carefully:

- segmentation: powerful way of dividing a display into separate regions, items belonging to each other should have the same color
- amount of color: too many will increase search time
- task demands: most powerful in search tasks, less powerful in categorization/memorization
- users: more valuable to novice than to experts, limited value for the color-blind

Depth perception

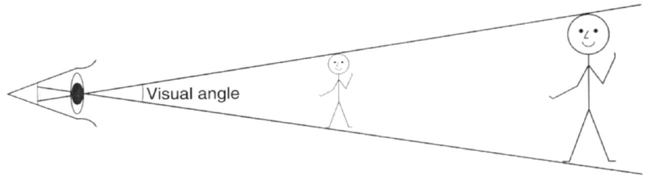


Fig.: Dix et al., 1998

Visual angle depends on size + distance of stimulus

But (same) objects with different visual angles are perceived as being of same physical size

→ How? Brain needs to take depth information into account

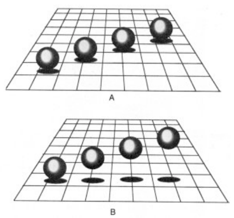
Depth perception

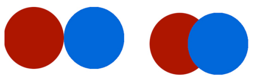
Primary depth cues

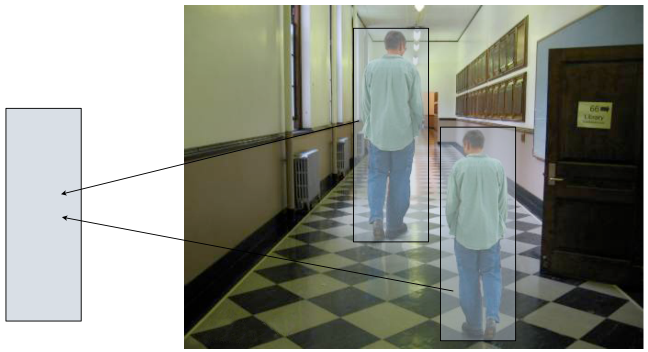
- difference of left-/right-eye images
- process of matching these images
- process of shaping the lens
- inward movement of eyes to focus (2-7m)

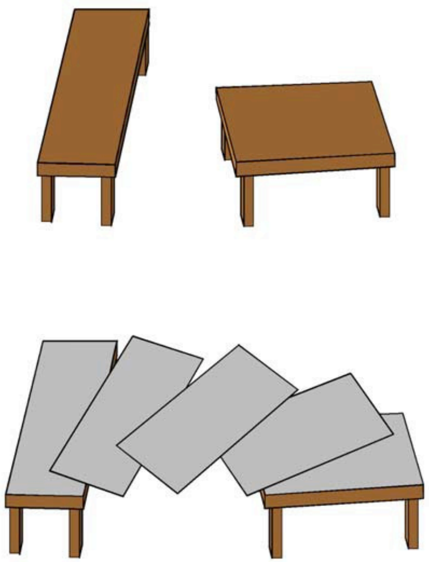
Secondary depth cues

- Light & shade
- Linear perspective
- Height over horizontal plane
- Motion parallax
- Overlap & occlusion
- Relative size
- Texture gradient

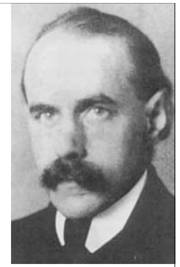








Recognizing structure



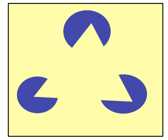
(Max Wertheimer)

The brain looks for structure to make visual impressions clearer, simpler, better understandable

Gestalt psychology assumes „Prägnanz“ to be a basic principle of perception: more concise forms provide better conditions for perception and memory

„Gestalt qualities“ are given, if some structure is recognizable that eases perception

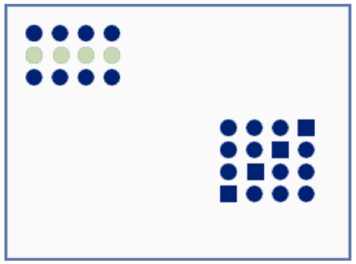
- the more difficult the order, i.e. the harder to group elemens together, the more reduced the Gestalt and perceptive qualities



Gestalt principles (examples)

proximity - how elements tend to be grouped together depending on their closeness.

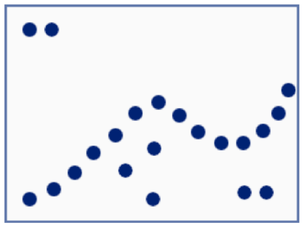
similarity - how items that are similar in some way tend to be grouped together. Similarity can be shape, colour, etc.



Gestalt principles (examples)

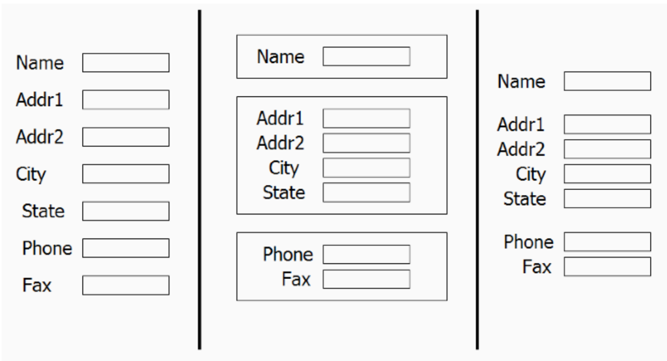
closure - how items are grouped together if they tend to complete a pattern.

good continuation - we tend to assign objects to an entity that is defined by smooth lines or curves.



Gestalt principles in HCI

Example in user interface design – proximity used to give structure in a form:



Recognizing form

Comparison with patterns stored in LTM, but processed & stored in terms of ....?

- Templates (Philipps, 1974)
- Features (Gibson, 1969; Egeland, 1975; …)
- Features + structure (Marr, 1978; Biederman, 1987)

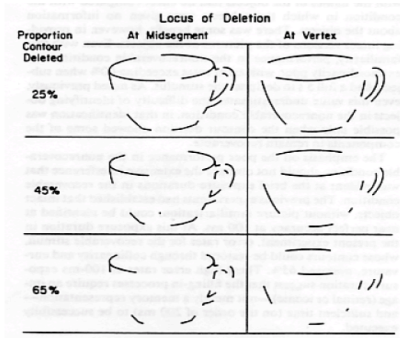


Figure 18. Illustration for a single object of 25, 45, and 65% contour removal centered at either midsegment or vertex. (Unlike the nonrecoverable objects illustrated in Figure 16, vertex deletion does not prevent identification of the object.)

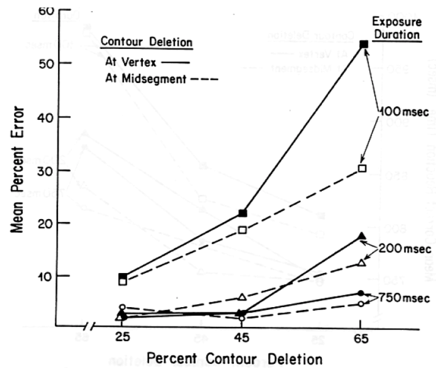
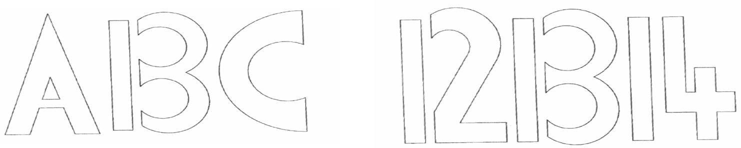


Figure 19. Mean percent object naming errors as a function of locus of contour removal (midsegment or vertex), percent removal, and exposure duration.

Integration with visual context



Reading - applied pattern recognition

Not a sequential process

- Saccades & fixations, perception occurs during fixations
- Words are patterns too, can be recognized as quickly as letters
- Recognition on three interacting levels in parallel: features, letters, words (McClelland & Rumelhardt, 1981; Massaro & Cohen, 1991)

Word superiority effect (Reicher, 1969):

- Stimulus: 1 letter, 4-letter word, 4-letter non-word
- Question: which of 2 alternative characters was at a certain position? Most accuracte in word condition!

Speed ~ 250 words per minute

- Dark characters on light backround easier to read
- Negative contrast improves reading in display with low freq.

Reading

Both bottom-up and top-down process, guided by context and expectations

"Luat enier sidtue an eienr elgnhcsien uvrsnäiett, ist es eagl in wcheler rhnfgeeloie die bstuchbaen in eniem wrot snid. das eniizg whictgie ist, dsas der etrse und der lztete bstuchbae am rtigeichn paltz snid. der rset knan tatol deiuranchnedr sien und man knan es ienrmomch onhe porbelm lseen. das legit daarn, dsas wir nhcit jeedn bstuchbaen aeilln lseen, srednon das wrot als gzanes."

The quick brown

fox jumps over the

the lazy dog.

Auditory perception

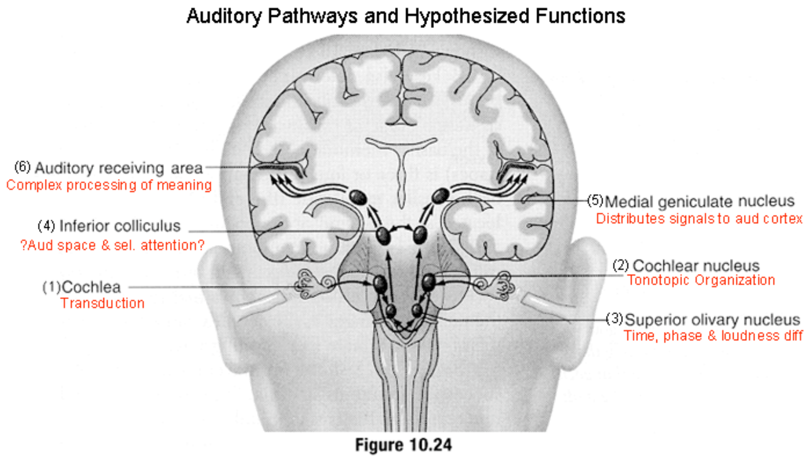
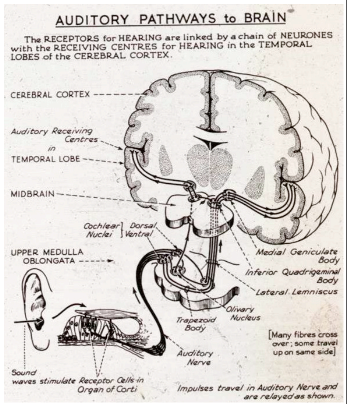


Figure 10.24

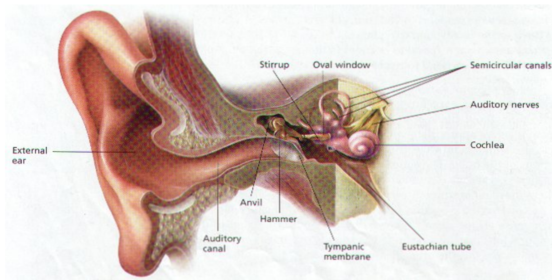
Auditory perception

1. **Transduction**
   - translates sound waves into neural impulses
2. **Auditory grouping**
   - segregation & integration of sound streams
3. **Scene analysis & organisation**
   - extraction of perceptual properties
4. **Interpretation**
   - experience of the auditory environment



(McAdams & Bigand, 1993)

Transduction



- Sound wave travels through ear canal
- Transformation of ear drum vibrations into bone movements (ossicls) and amplification
- Transmission into cochlea (inner ear), filled with liquid
- Delicate hair cells bend and cause neural impulses

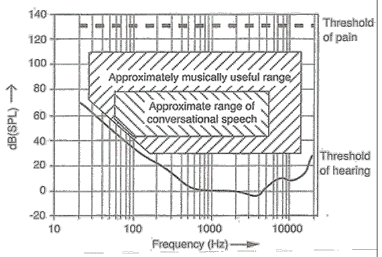
Auditory processing

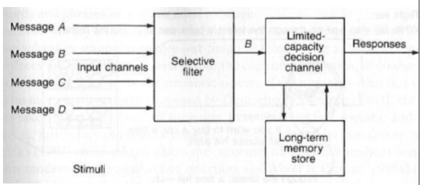
Features processed:

- Loudness (= amplitude)
  - Whisper (15 dB), conversation (60), car horn (110), rock concert (120+)
- Frequency (= pitch)
  - Human hearing range: 20 Hz - 15.000 Hz
- Timbre (type or quality of sound)

Final perception in auditory cortex

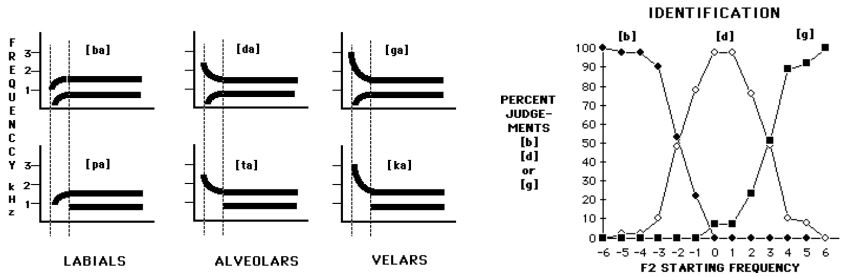
- Directed hearing from temporal and intensity differences at the ears, helps to separate sound sources
- Filtering („cocktail party effect“)
- Impression of non-existent sounds (tinitus)





Categorical perception

When hearing similar sounds (ba, da, ga), that differ slightly in the starting frequency of an harmonic (2nd formant, F2), humans seem to perceive and discriminate between clear categories



Categorical perception

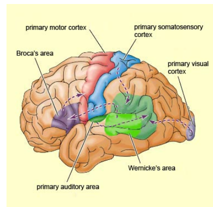
Experience of percept *invariances* in sensory phenomena

- within-category differences perceived smaller than the between-category differences, even when the physical differences are actually the same
- First noted in speech perception (A. Lieberman): when people listen to sounds that vary along voicing continuum, they hear only /ba/s and /pa/s, nothing in between

Not peculiar to speech, occurs whenever perceived within-category differences are compressed and/or between-category differences are separated

- innate (speech, colors) and learned
- special case of the effect that stimuli to which you learn to make a different response become more distinctive, and stimuli to which you learn to make the same response become more similar

Multisensory perception

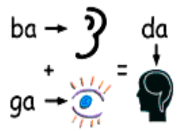


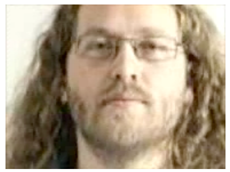
Binding problem

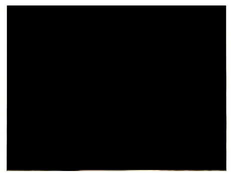
- how to bind different perceptual features together?
- possibly based on location, synchronization, labels, etc.
- combination of modality-specific brain areas and fusion areas

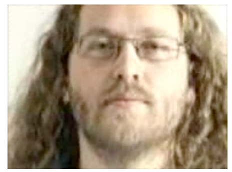
Example: „McGurk effect“

- stimuli that can be visually or audibly confused
- brain computes the „most reasonable“ integration

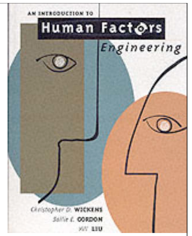








Consequences for HCI?



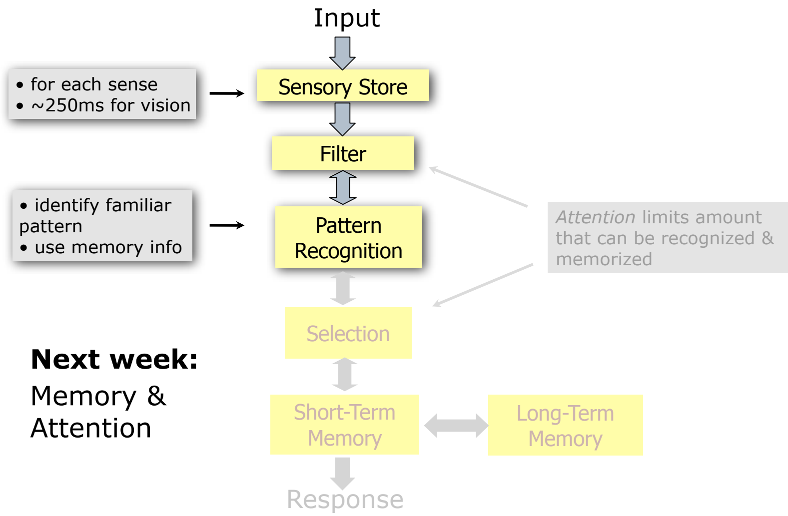
(Wickens et al.)

<u>Human Factors Engineering</u>

Perceptual principles of display design

1. **Make displays legible** (or audible), the characters or objects being displayed must be discernible
2. **Avoid absolute judgment limits**. Do not ask the user to determine the level of a variable based on a single sensory variable
3. **Top-down processing**. Signals are perceived in accordance with what is expected based on past experience. Signals contrary to expectation need more physical evidence to be understood
4. **Redundancy gain**. Present a signal more than once, possibly in alternative physical forms (as redundancy does not imply repetition)
5. **Similarity causes confusion**. Use discriminable elements, remove unnecessary similar features and highlight dissimilar features

Human Information Processing



Next week:
Memory & Attention