2b

> Ada knowledge: Sensory organs

Only by being able to see, hear, taste, smell or feel an object do we know of its existence. Without sensory organs, we would have no concept of our environment. Ada too experiences her surroundings through her sensory organs.

This chapter contains:

- Information about the sensory organs in people and with Ada
- Illustrations
- Recommendations for instruction
- Worksheet
- Transparency

A: Factual information

Sensory organs are specialised extensions of the central nervous system

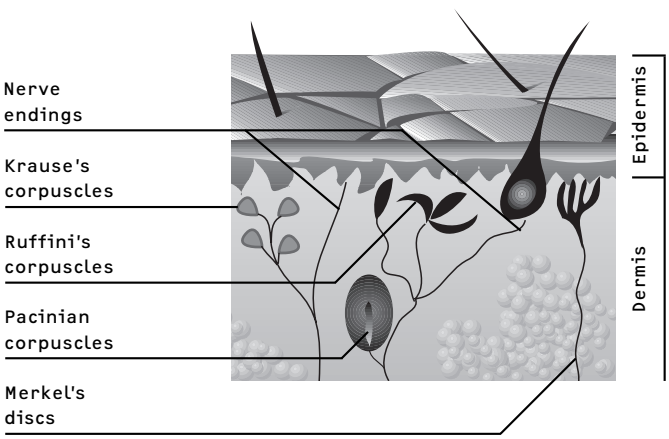
The sensory organs enable us to take in information from our surrounding environment and convert it into nerve impulses, into the "language of the brain."

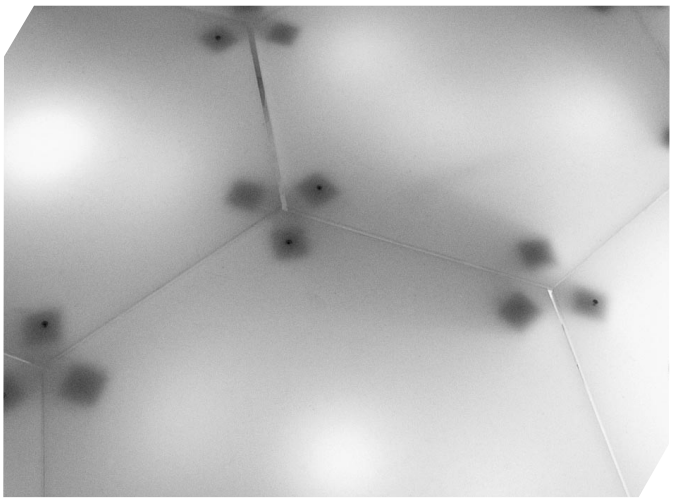
The data provided by the sensory cells is directly transmitted to the brain. Here the various data is linked together and processed, furnishing a continuously changing picture of our environment and triggering both conscious and unconscious reactions.

Sense of touch in humans

At two square metres for adults, the skin is the human body's largest organ. Through the skin, we sense pressure, temperature, vibration, physical composition and pain. This is made possible by the true skin, the dermis, with a varying number of different so-called receptors. For detecting pressure and vibration, for example, there are up to 170 tactile bodies per square centimetre. The Meissner's corpuscles are sensitive to touch. They are most frequently found on the fingertips and the tip of the tongue. Pressure is detected by means of the Pacinian corpuscles and the Merkel's discs. The Krause's corpuscles, on the other hand, react to low temperatures and the Ruffini's corpuscles to warmth.

Human skin





Ada's floor plates

Ada's sense of touch

The active sensory floor can be thought of as Ada's skin. It is composed of hexagonal floor plates equipped with weight sensors. These sensors enable Ada to determine which floor plate a visitor is standing on. With a corresponding computational procedure, Ada is able to determine where visitors are located within the space and in which direction they are moving, even if she is not able to "see" this using her cameras. She can only "feel" pressure with her sense of touch.

The floor plates function like a neural network (see **Ada knowledge: Processing data**). When a floor plate lights up, it then communicates this to the adjacent floor plates. Since the individual floor plate knows the state of the overall system as well as that of its neighbour, it is then able to react accordingly.

At the same time, Ada's skin also serves as a communications organ (see **Ada knowledge: Interaction**) whose play with light allows Ada to "communicate."

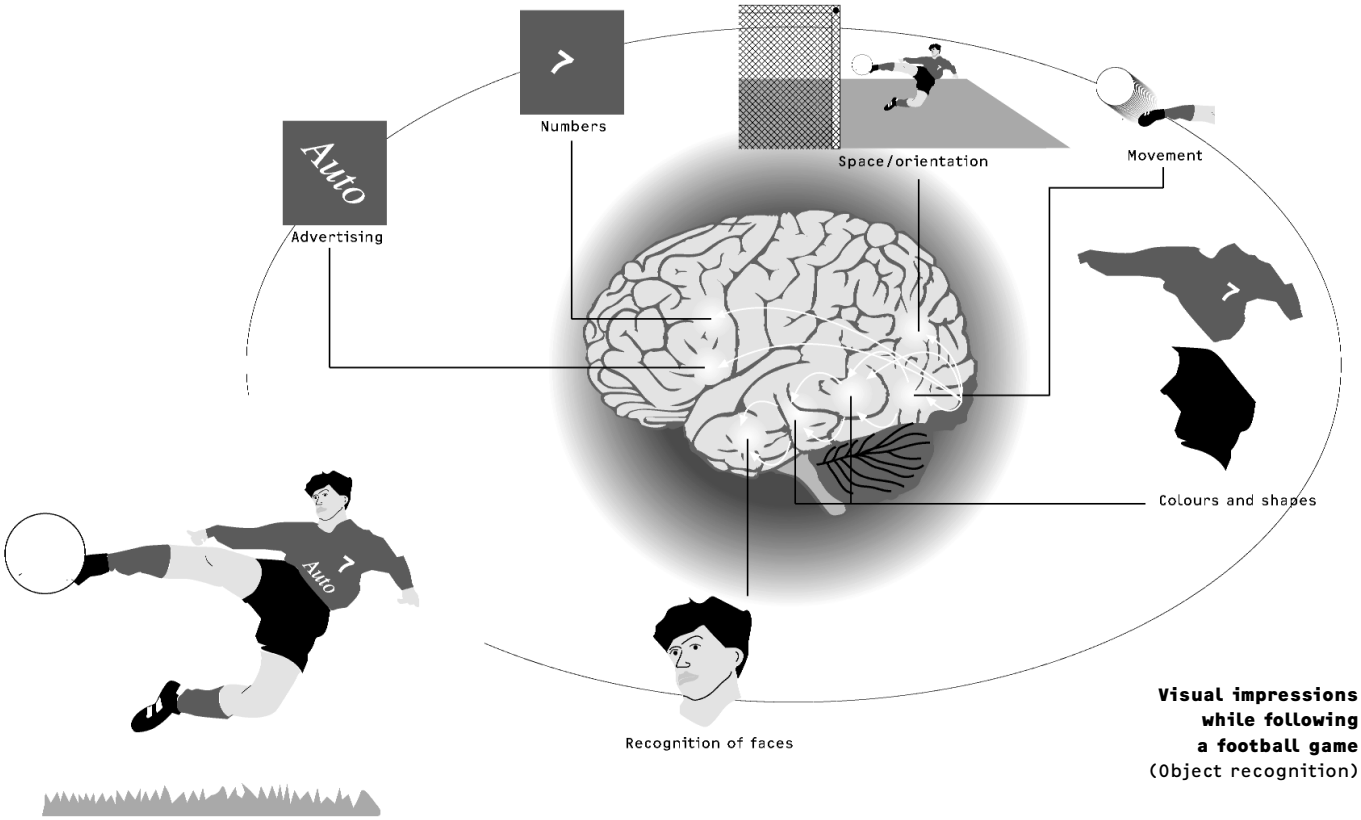
Seeing in humans

Using our eyes, we are able to perceive our environment in the form of images. This is facilitated by cells located on the retina of the eyes that react sensitively to light. The cones of the retina are specialised cells that react to light intensity and colours, while the so-called rods react to white and black and the various gradations of grey tones. The sensory cells transmit the data to the brain which, based on this information, deduces an object's form, colour, light intensity and speed of movement.

To ensure a sharp image of the viewed object, the muscles in the iris narrow or widen the pupil to regulate the amount of light entering the eye; and the lens alters its curvature according to the distance to the object being viewed. As a rule, this occurs automatically and unconsciously. The rays of light that come through the lens produce an image on the retina that is dispersed into many individual dots. Each dot corresponds to a cone or a rod. The impulses generated in these cells are transmitted via the optic nerve to the visual centre of the two halves of the brain, which then supplies the overall image of the object being viewed. And since we have two eyes, we are capable of seeing in three dimensions and judging an object's distance.

Object recognition

The ability to recognise objects seems so trivial to us that we are hardly even aware of it. We recognise friends even with new glasses, make out individual persons within a group and estimate the relative distances between them. From afar, we recognise a tree and, upon closer inspection, we are able to classify it as an apple tree. We are also able to recognise patterns, even when the concrete expressions of the pattern strongly vary.



Visual impressions while following a football game
(Object recognition)

How Ada sees

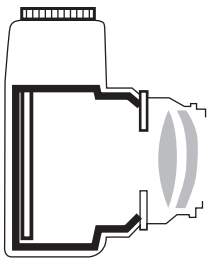
Ada's eyes are fixed ceiling cameras and movable directional cameras. Using ceiling cameras, Ada can "survey" the entire space. She compiles the images from the individual cameras to form an overall picture and is thus able to determine where people are located within the space, how many there are and in which direction they are moving.

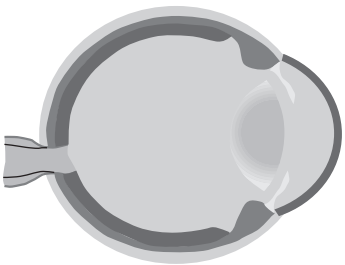
Ada's "eye"

"Gazers" serve as Ada's eyes

The movable directional cameras (gazers) enable Ada to classify motion signals and colour histograms of hands and faces. What Ada finds interesting, for instance, are persons exhibiting a high light value (such as light-coloured clothing), fast-moving individuals and those who are in motion relative to other visitors. Ada is also able to resolve a group of persons into individual persons. If Ada finds a person interesting, then she can follow the individual with her movable directional cameras and take close-ups. While Ada does not recognise faces, she is able to differentiate among individuals, such as by the colour of their clothing. Ada will also be able to recognise and accordingly interpret simple gestures like waving one's hand.

Comparison of camera and eye





	Camera	**Eye**
Similarities in structure	• Casing • Dark interior lining • Aperture • Objective with multiple lenses • Film • Silver bromide crystals	• Sclera • Pigment layer • Iris • Lenses • Cornea/retina • Optic cells
Differences in performance	• Fixed lenses • Film only able to be exposed once • Photos are laterally inverted and upside down • Objective images	• Elastic lenses • The retina can be exposed again and again • The brain rotates the images 180 degrees • Subjective images; formed in the brain and linked with experiences • High resolution (compared to film)

•Foster, Jakob: **Menschenkunde.** Langnau am Albis 1996, p. 517.

>Ada knowledge: Sensory organs

Ada's "ear"

Human sense of hearing

Using our ears, we are able to detect sounds from our environment within a certain frequency range. In addition, the inner ear also contains our organ of equilibrium. For human beings, the sense of hearing is quite essential since oral communication would not be possible without it: The articulation of sounds would be of no use, as they could not be picked up by a sensory organ.

All noises generate sound waves (oscillations of the air), which are picked up by the ear. The sound waves strike the tympanic membrane, or eardrum, which starts oscillating in the corresponding frequency and intensity. The auditory ossicles of the middle ear amplify these oscillating motions and transmit them to the oval window. From the oval window, the oscillations are transmitted to the liquid that fills the inner ear. The oscillations are detected by so-called hair cells and translated into electrical impulses. These are then conveyed to the brain, where they get processed.

Stereophonic hearing

The auditory threshold for a sound increases considerably when other sounds are heard at the same time. Humans and animals hence have the ability to detect unexpectedly rapid changes in volume. Having two ears, we are able to make use of the stereo principle to localise the source of noises.

Ada's auditory system

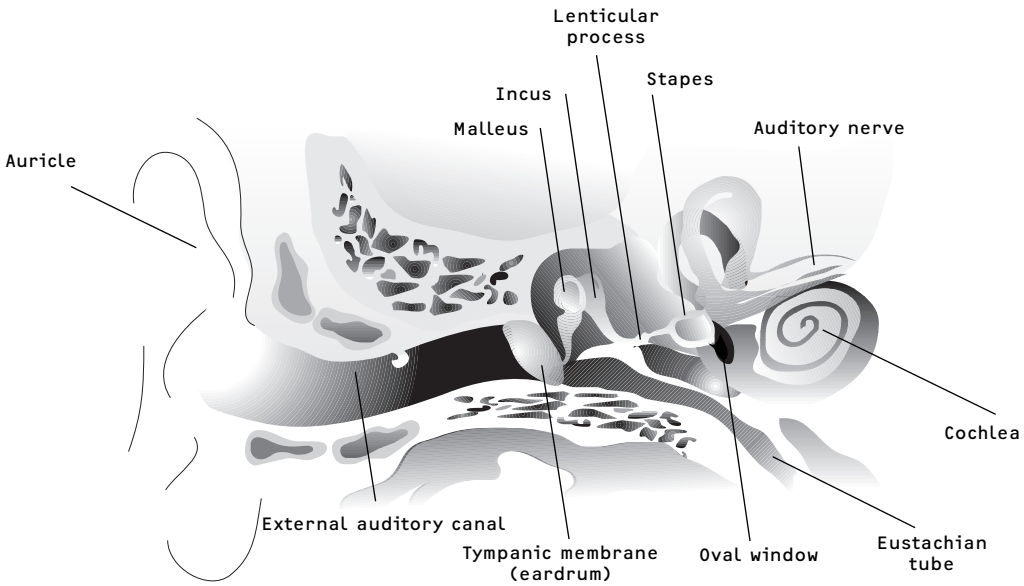
By means of ceiling and directional microphones, Ada is able to localise, identify and analyse sounds. She can filter out interesting individual noises from a noisy environment through her ability to detect rapid changes in volume. If a special noise is discovered, Ada has to determine where it is coming from. To do so, she makes use of ceiling microphones, which are continually listening for interesting sounds in the surrounding environment. Once such a sound is registered, the signals picked up by the different microphones are compared to then compute the most likely source of the sound.

Hearing with high sound intensity

As the sound intensity within the space is continually changing, Ada's ability to discover sounds and react to them changes as well. In the case of high sound intensity, visitors might have to clap their hands to get Ada's attention while speaking at a normal volume will suffice in the case of low sound intensity. In registering sounds, Ada measures the frequency, the pitch and the duration of the signal.

The directional microphones are only active when Ada directs her attention at a visitor. These microphones then try to collect acoustic data about this person. Ada is able to learn certain sound patterns (such as hand clapping or the name "Ada") and associate them with certain behavioural patterns.

The human ear



When Ada detects a salient sound, she localises this person and turns her attention to the individual. She indicates this, for instance, by directing a spotlight at the person (see **>Ada knowledge: Interaction**).

Ada is not able to understand the gist of words or whole sentences.

Sense of smell and tastein humans and with Ada

The human olfactory mucous membrane contains ca. 30 million olfactory cells that allow us to differentiate among ca. 1,000 different groups of odiferous molecules. The gaseous molecules latch onto the sensory hairs of the olfactory cells, which serves to trigger a nerve impulse. Compared to certain types of animals, the human sense of smell is relatively undeveloped.

In humans, the taste function is handled by the tongue. The mucous membrane of its upper surface contains four different types of papillae, which function as the chemical receptors for the gustatory stimuli. Humans can distinguish among at least five basic tastes: sweet, salty, bitter, sour and umami.

Sense of smell and taste have not been realised with Ada.

Definition of terms

•Histogramm

Graphic representation of a frequency distribution using bars. The height of the columns corresponds to the frequency of the measured value.

•umami

Umami means "savoury" in Japanese. The corresponding sensory cells react to the amino acid glutamate, found in protein-rich natural foods such as meat, seafood and cheese, but also in flavouring preparations like Aromat and soy sauce.

B: Recommendations for instruction

Sheets with border can be copied and distributed to students.

Explanations of **Worksheet 2b.8**

The goal of the worksheet is for students to become aware of the significance of their senses and reinforce their knowledge of Ada's sensory capabilities. An assortment of additional worksheets and suggestions is provided by Foster 1996 (see Bibliographic information*).*

For exercises on the sense of touch and seeing, a Braille alphabet and additional teaching material can be ordered free of charge from the addresses listed below.

Answers

1. *This first exercise yields individual answers. The sense of sight is so critical for handling everyday tasks that we have difficulties orienting ourselves when suddenly not able to see.*

2. *This exercise can be worked on with the illustration* **"Comparison of camera and eye" (Sheet 2b.4)**.

3. *The human sense of touch is more differentiated than Ada's. Ada can "only" react to pressure or weight, while human skin can detect warmth, cold, touch, pressure and vibration. Yet Ada is also capable of communication via her "skin," which is only possible to a limited extent with humans (blushing, blanching).*

Links and addresses

Informational website of the prevention campaign "GanzOhr" promoted by the Swiss Federal Office for Public Health (SFOPH):
www.ganzohr.ch

Swiss National Association for the Blind SNAB
Schützengasse 4
9000 St.Gallen
Tel. 071 223 36 36
www.szb.ch

Swiss Federation of the Blind and Visually Impaired SBV
Laupenstrasse 4
3008 Berne
Tel. 031 390 88 00
www.blindenverband.ch

Bibliographic information

•Foster, Jakob: **Menschenkunde.** Langnau am Albis 1996.
(can be ordered from www.sekzh.ch*)*

>**Ada knowledge: Sensory organs** (Worksheet)

1. This exercise is solved in groups of two:
One person puts on a blindfold and leads the other through the school building. As an extra challenge, try doing so for a short distance without making contact. Upon reaching the destination, the "blind" person is given several objects to make out by feel. Then the roles are exchanged.

Think about what you felt, sensed and heard while blindfolded, and record your experiences following the experiment. Which conclusions can be drawn from what you experienced in regard to the senses of seeing, hearing and touching?

2. Compare and contrast the human eye and a photo or film camera.

3. Compare and contrast human skin and Ada's floor.