

Multimodal Perception and Cognition Examination

Medialogy 7th Semester

Monday 13 January 2014, 09.00 - 12.00

Instructions and information

- You are not allowed to bring any written material or electronic devices into the examination room.
- You have 3 hours to complete the examination.
- Write your answers on the writing paper provided. Do not hand in more than one answer to any given question. Do not write your answers on the question paper. Write your answers in blue or black ink.
- There are 20 questions on this examination paper.
- The maximum number of marks for each question is 10.
- Full marks can be obtained by answering 10 questions completely correctly.
- **Do not hand in answers to more than 10 questions.** Only 10 answers will be marked by the examiners.
- You must get at least 50 marks in total to pass.
- The table below shows how the total number of marks obtained will be mapped onto grades on the 7-step scale.

<i>Mark range</i>	<i>Grade</i>
0 – 24.5	-3
25 – 49.5	00
50 – 59.5	02
60 – 69.5	4
70 – 79.5	7
80 – 89.5	10
90 – 100	12

DO NOT TURN OVER UNTIL TOLD TO DO SO!

Question 1

- a. [4 marks] Name four general approaches that scientists have adopted in order to understand human cognition.

Experimental cognitive psychology, cognitive neuroscience, cognitive neuropsychology and computational cognitive science

- b. [6 marks] What are event-related potential (ERPs)?

Repeatable patterns of electrical activity in the brain corresponding to a response to an event, measured using EEG

Briefly describe the procedure that is used to measure them.

Take an EEG (electroencephalogram) of subject responding to many repetitions of a stimulus. This involves measuring electrical potentials in the brain via electrodes placed on the scalp. EEG is sensitive and results are shown as a waveform on an oscilloscope. But results sometimes corrupted by background brain activity not related to test. Responses to many repetitions are averaged to eliminate effect of background electrical activity in the brain.

Is measuring ERPs an appropriate way to discover precisely where in the brain some activity is occurring? Explain your answer.

No. ERPs have excellent temporal resolution (down to a few ms), but limited spatial resolution. This means they cannot be used to accurately locate activity within the brain.

What advantage does using ERPs to measure brain activity have over, say, fMRI?

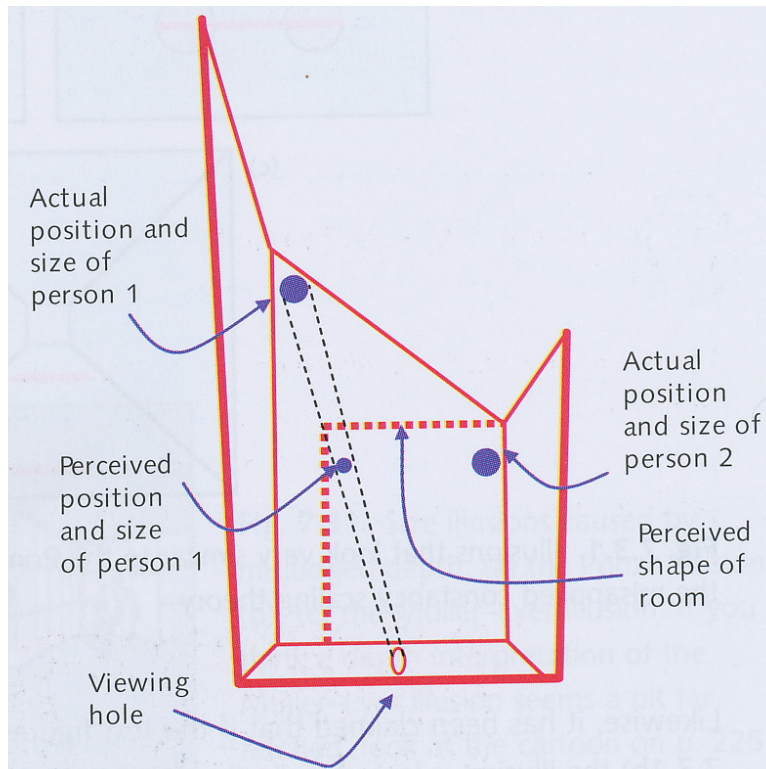
ERPs have better temporal resolution than fMRI, so they can be used to give a more detailed picture of when activity occurs in the brain in response to perceived events.

Question 2

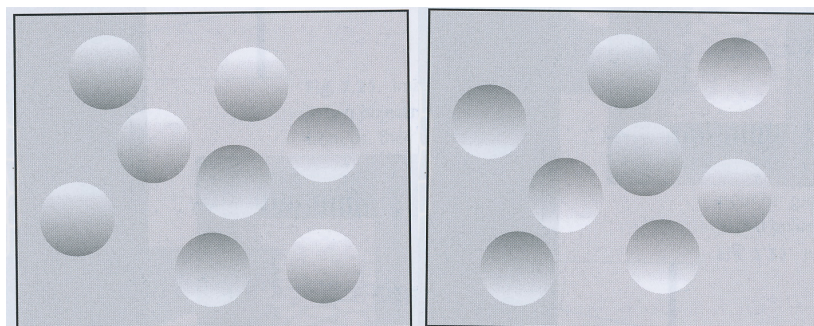


- a. [5 marks] In the photograph above, the girl and the boy are physically approximately the same height. Explain why the boy on the right looks so much bigger than the girl on the left. You may find it helpful to draw a diagram.

This is the Ames room. The room has a special shape, as shown in the diagram below. The shape makes us see the two children as being at the same distance from us, and therefore different in size. Whereas they are actually the same size but at different distances. The illusion is based on Emmert's law, which states that for a given retinal image size, the perceived size is proportional to the perceived distance.



- b. [5 marks] Describe and explain the illusion shown below. How can this illusion be understood to provide evidence in favour of the likelihood principle of perceptual organisation (as opposed to the simplicity principle)?



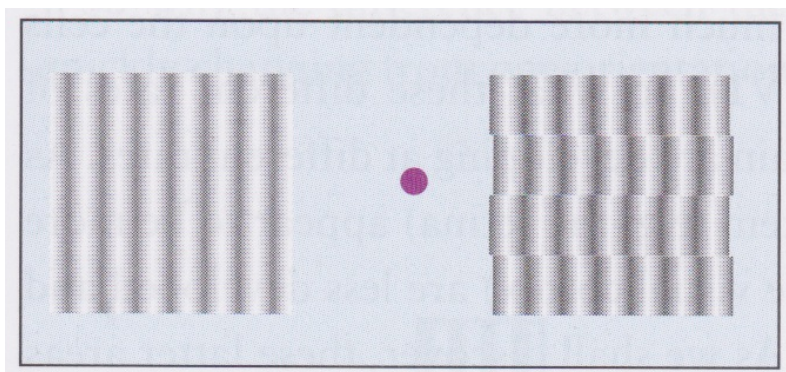
The right-hand image is the same as the left-hand image but rotated through 180 degrees. Each circular figure can be interpreted as either a dimple (i.e., concave) or a bump (i.e., convex). Figures interpreted as bumps in the left-hand figure are typically seen as dimples in the right-hand figure and vice versa. The illusion relies on the visual system typically

assuming that light comes from above. This determines how the shading is perceived as shadows in the figure. If the figures are both rotated through 90 degrees, the percept becomes ambiguous, because there is no strong preference in the visual system for the source of light being on the left or the right of a scene.

The illusion weakly supports the likelihood principle of perceptual organization over the simplicity principle since, in the real world, light is more likely to come from above than below, whereas assuming light comes from any particular direction does not provide a simpler explanation for the data.

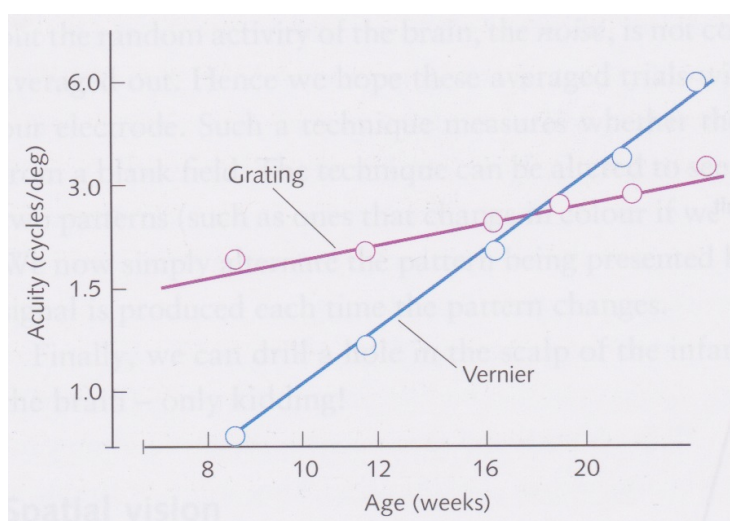
Question 3

Explain the difference between Vernier acuity and grating acuity. [2 marks]



Grating acuity is the ability to distinguish fine lines in a grating (e.g., in figure at left above). Vernier acuity is the ability to see small shifts or misalignments in lines in a grating stimulus (e.g., in figure at right above).

Describe with a graph how each type of acuity develops over the first 6 months or so of life. [3 marks]



In adults, which of the two types of acuity is generally better? [1 marks]

Vernier acuity

How can the relative development of Vernier and grating acuity be explained in terms of the parts of the visual system that each type of acuity depends on? [4 marks]

Grating acuity depends on the eye and the retina. Vernier acuity depends on the cells in V1. The eye and the early parts of the visual system are more developed at birth than the more central parts (e.g., V1). V1 develops more than the eye over the early years of life, so vernier acuity increases faster than grating acuity.

Question 4

In an experiment to test the perception of mismatches between a graphics overlay and an underlying camera feed (augmented reality) due to tracking errors, each test subject is asked to go through a series of 90 trials. The factors involved are the visual scenario used (2 types), and the type of mismatch (3 types). Furthermore, each combination of visual scenario and mismatch type is tested at 15 different levels of severity. The severity of a mismatch is given as an angular displacement measured in degrees. In each trial, the participant is asked to tell if there is a mismatch or not. The time taken to arrive at this decision is logged.

- a. [1 mark] What experimental variables are involved in this setup?

Visual scenario, mismatch type, severity, mismatch response, response time.

- b. [2 marks] What levels of measurement are involved? Specify the level for each variable given above.

Nominal/categorical: Visual scenario, mismatch type, mismatch response (mismatch response is also a binomial variable)

Ratio: Angular displacement, completion time.

- c. [4 marks] In what way does/can this experimental design incorporate the principles of blocking and replication?

The experiment has $2 \times 3 \times 15 = 90$ possible combinations that are tested. Since it is specified that each participant goes through 90 trials, the experiment uses blocking on each participant (a within subjects design).

Replication is only ensured if several people participate in the test.

- d. [3 marks] Give at least one way of randomizing the experiment.

The most immediate and important way of randomizing the experiment would be to let the participants test the 2×3 different scenarios in random order. Furthermore, the 15 different displacements tested inside each scenario can be a new random set for every participant, or a pre-chosen set of random displacements that are identical for everybody. It is also possible to randomize the order of all $2 \times 3 \times 15$ unique experimental conditions instead.

Question 5

The data gathered in an experiment comes from a questionnaire only consisting of 7-step Likert scales. One set of questionnaires was filled out by 10 people who tested version A of a product, and another set was filled out by another group of 9 people who tested version B of the same product. Our goal is to find out if there is any difference between the two products.

- a. [1 mark] Does this data come from a balanced or unbalanced, complete or incomplete, experiment?

The experiment was unbalanced (10 vs. 9 participants in the two cases) and complete (all conditions, versions A and B, were tested.)

- b. [1 mark] What is the level of measurement for the explanatory and response variables?

The explanatory variable is the product version (A or B) - hence it is of nominal/categorical level. The response variable(s) are Likert scale measurements - hence the level is ordinal.

- c. [2 marks] What general family of experiment does this belong to (and why)?

It is an unpaired two-sample experiment, because two samples of data have been gathered from two independent (unrelated) groups of people. I.e. there is nothing to justify associating each observation in sample A with another observation in sample B.

- d. [4 marks] What specific type of statistical test would you employ in the analysis (and why)?

There are two possible answers: (i) Since the responses are ordinal, the only theoretically correct way of testing this is through a non-parametric method. The appropriate test would be a Mann-Whitney-Wilcoxon test, because the experiment is unpaired with two samples. (ii) The pragmatic response would be to employ an unpaired t-test, even though the responses are ordinal. This choice can be justified by the fact that very often the conclusion of both tests will be the same (and many people don't care, anyway), even if the t-test is theoretically inappropriate for the data.

- e. [2 marks] Suppose that the chosen test gives you a p-value of 0.023. How would you use this number to reach a conclusion about the test?

You would first need to know the significance level. If the p-value is less than the significance level, then the null hypothesis can be rejected, otherwise not. If we use a standard significance level of 5% in this test, then the null hypothesis is rejected, i.e. the products are different.

Question 6

- a. [4 marks] Explain what is meant by *categorical perception*.

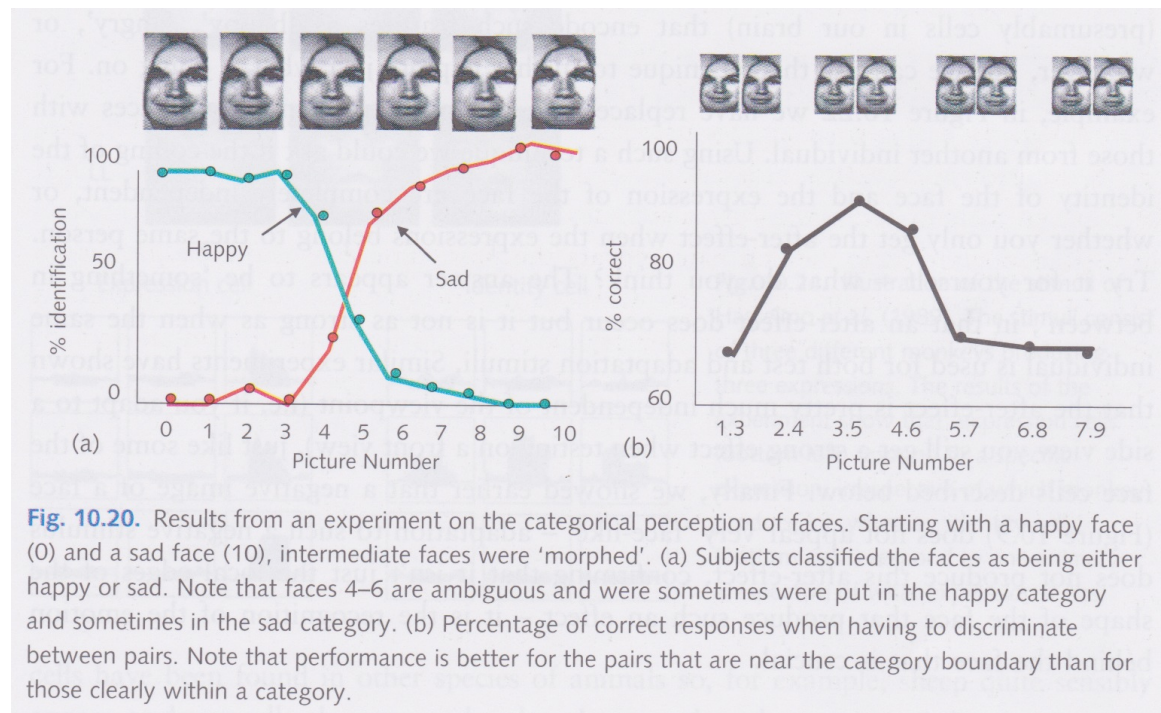
Categorical perception is said to occur when we perceive a continuously varying stimulus to be divided up into categories. Many different types of stimulus are perceived categorically such as musical pitch (C, D, E,...), colour (“blue”, “green”, “red”, “yellow” are categories), facial expression (“happy”, “sad”)

Are we better or worse at distinguishing between stimuli that fall into the same category?

Worse

- b. [6 marks] Calder and his colleagues used morphed images of faces with different expressions in an experiment that provided evidence that facial expressions are perceived categorically. Briefly describe the methodology used and the results obtained in this experiment.

Calder et al (1996) took a happy face and a sad face of the same person, then produced “morphed” mixtures of the two images. Gave images that were, e.g., 80% happy, 20% sad; 70% happy + 30% sad; and so on. The three pairs at left differ by the same amount, but most people find B look the most different. Pictures in B are both close to 50% happy, so commonly fall in different categories. Other pictures usually fall in the same category and so are not seen as being so different. Note that people’s judgement of whether a face was happy or sad in isolation corresponded to the relative amounts of the happy and sad faces used to construct the picture.



Question 7

Explain the difference between an *endogenous cue* and an *exogenous cue* [4 marks].

Endogenous cue is when subject consciously and deliberately averts his/her attention towards the cue (e.g., sees an arrow pointing in a particular direction and chooses to look in that direction). **Exogenous cue** is when subject's attention is involuntarily drawn towards an unexpected cue (e.g., flash of light, sudden loud noise).

Which of these two types of cue is associated with top-down processing? [1 mark]

Endogenous cues

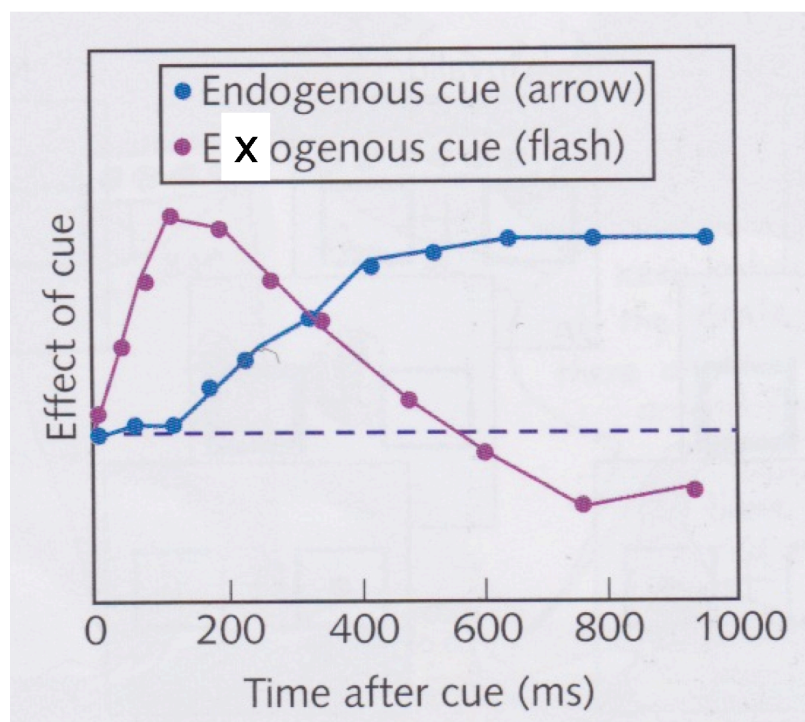
Which of these two types of cue has the longer-lasting effect? [1 mark]

Endogenous cues

If the effect of a cue lasts 200-500 ms, is the cue likely to be endogenous or exogenous? [1 mark]

Exogenous

How can the principle of *inhibition of return* be used to explain the longer-term effect of an exogenous cue? [3 marks]



Immediately after the cue and up to about 500ms, an exogenous cue stimulates attention in the direction of the cue. However, after about 600 ms, an exogenous cue tends to inhibit attention in the direction of the cue. This could be due to an “inhibition of return” effect that starts having an effect after about 500ms.

Question 8

- a. [2 marks] According to David Chalmers, what is the “hard problem” of consciousness?

According to Chalmers, the “hard problem” of consciousness is experience: what it is like to be an organism. How can physical processes in the brain give rise to subjective experience? How can an organism have a “point of view”?

- b. [1 mark] Give an example of what Chalmers considers to be an “easy problem”.

Discrimination of stimuli, attention, accessing and reporting mental states, deliberate control of behaviour, differences between waking and sleep. These can all be studied using the standard methods of cognitive science.

- c. [3 marks] Dualism, epiphenomenalism and idealism are three different perspectives that have been adopted on consciousness. Briefly explain what characterises these three perspectives.

Dualism proposes that the “mind” is made of unextended, thinking stuff that is different in kind from the extended stuff from which physical objects are made. Epiphenomenalism proposes that mental states are created by physical processes but cannot have any causal effect on physical events. Idealism is a form of monism that proposes that only ideas or perceptions exist.

- d. [4] Explain, with examples, what is meant by the term *qualia*. Briefly describe how a dualist, an epiphenomenalist and an idealist would differ in their perspective on qualia.

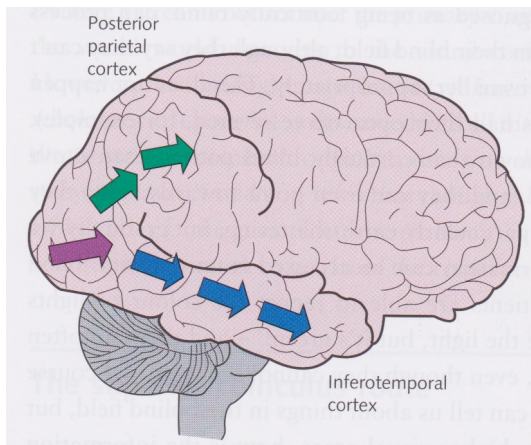
A quale is the direct experience of something. For example, what the colour red looks like, what coffee smells like or what love feels like are all qualia. A dualist says that qualia are made of different stuff from the physical world. An epiphenomenalist says that qualia exist but have no effect on the world. An idealist says that qualia are the only things that exist.

Question 9

- a. [4 marks] Briefly explain what is meant by the “what” and the “where” pathways in the visual system. Describe approximately where these pathways occur in the brain (you may use a labelled sketch).

The extra-striate centres through which visual information passes after passing through V1 can be understood to be organised into two “pathways”: the “what” and the “where” pathway. The “what” pathway (blue in the diagram below) travels ventrally from V1 to the inferotemporal cortex and is involved in object recognition and discrimination. The “where” pathway (green in the figure) travels dorsally from V1 to the posterior parietal

cortex and is involved in locating objects in the world and allowing us to interact with them.



- b. [4 marks] Briefly describe the phenomenon of *blindsight*. How is the superior colliculus thought to be involved in blindsight?

Some patients who are blind in at least parts of their visual field because of damage to the visual cortex, show evidence of being able to see certain features in these “blind” areas (or scotomas). They are in fact able to see certain things without being aware of being able to see them. This condition is called “blindsight”. In such subjects, pupils constrict when light is shone in the scotoma and they sometimes move their direction of gaze towards lights they are not aware of being able to see. Some patients can correctly identify the colour and aspects of shape of objects in their scotomas.

An explanation for blindsight is that, although information about a scotoma is no longer getting through to certain areas in the cortex because of damage, some information continues to reach the superior colliculus, which is part of the “reptilian”, non-cortical brain and processes some visual information (particularly to do with movement and coarse-grained features).

- c. [2 marks] If you are in a dark room and you have a light flashed in one eye, you are unable to tell which eye the light was flashed in. What does this tell us about the relationship between consciousness, monocular cells and binocular cells?

It suggests that we are only conscious of activity in binocular cells. All cells in the visual pathway are monocular until the information reaches the primary visual cortex. So we are presumably only conscious of visual information after it reaches the cortex. Also, many cells in V1 are monocular – we apparently do not have conscious access to the information coded in these cells either.

Question 10

- a. [4 marks] Briefly describe the experimental procedure and the typically observed results used to invoke the *rubber-hand illusion*.

Participant sat at a table and asked to lay one hand on the table (see figure below). This hand is concealed from view by the experimenter and a rubber hand is placed next to the

participant's own hand. The experimenter uses a paintbrush to simultaneously stroke the middle finger of both the rubber hand and the participant's hand. After a few minutes, the participant typically begins to feel that they are feeling the touch of the paintbrush at the location of the rubber hand rather than their own hand. It seems to the participant that the touch felt is caused by the paintbrush touching the rubber hand and that the rubber hand is his/her own hand.



- b. [6 marks] Briefly describe the experimental procedure used by Lenggenhager et al. to explore bodily self-consciousness.

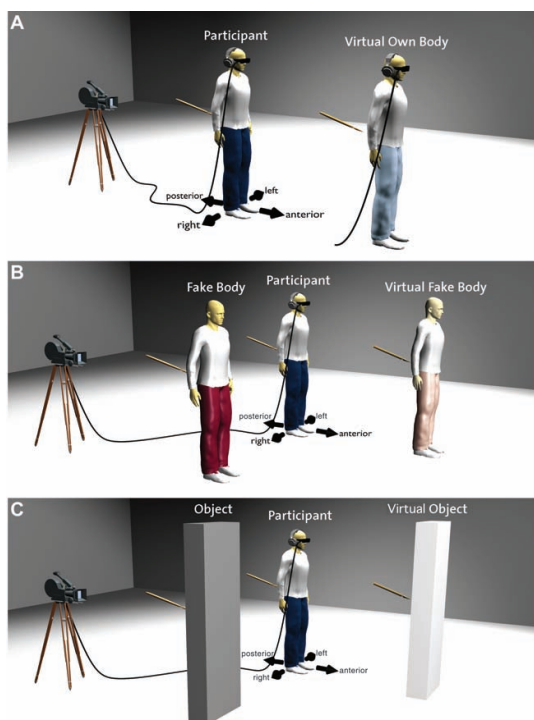


Fig. 1. (A) Participant (dark blue trousers) sees through a HMD his own virtual body (light blue trousers) in 3D, standing 2 m in front of him and being stroked synchronously or asynchronously at the participant's back. In other conditions (study II), the participant sees either (B) a virtual fake body (light red trousers) or (C) a virtual noncorporeal object (light gray) being stroked synchronously or asynchronously at the back. Dark colors indicate the actual location of the physical body or object, whereas light colors represent the virtual body or object seen on the HMD. [Illustration by M. Boyer]

What did participants typically experience in this procedure?

They experience a virtual body as if it is their own and localize themselves outside of their bodily borders. Participants claim that they feel the touch of the highlighter in the location where they see the virtual body/mannequin and that the virtual body was their own body.

Why does this experience come about?

The experience arises from multisensory conflict: vision dominates over proprioception and touch. So if the visual and tactile stimuli are synchronized but in conflict, the participant reinterprets the tactile and proprioceptive stimuli so that it is consistent with the visual stimuli.

Question 11

- a. [3 marks] Provide a definition of *semantic congruency*.
- b. [3 marks] Exemplify a hypothetical experiment on semantic congruency.
- c. [4 marks] Explain how and what kind of behavioral and psychophysiological data you could gather for such an experiment.

Question 12

- a. [4 marks] Explain the phenomenon of categorical perception.
- b. [3 marks] Explain what the opposite of categorical perception is. Give an example.
- c. [3 marks] Elaborate on the examples of categorical perception of faces and emotions.

Question 13

- a. [4 marks] Explain three examples of psychophysiological measurements used to monitor affective states or cognitive functions in digital immersive-interactive applications.
- b. [3 marks] Indicate whether each of these signals originate in the central, the autonomic or the somatic nervous system.
- c. [3 marks] Explain what these measurements are being correlated to.

Question 14

- a. [3 marks] Explain what is the research field encompassed by “affective computing”, what are its goals and what kind of technologies it intends to integrate.
- b. [4 marks] List and define at least three different affective states and how they relate to each other.
- c. [3 marks] Explain how you see the relation between emotions and cognitive processes.

Question 15

- a. [5 marks] Describe the three main empirical strategies available for the assessment of cognitive processes and affective states when interacting with immersive media.
- b. [5 marks] Give examples for each strategy.

Question 16

- a. [5 marks] Provide an example from the literature representing a situation of conflict between vision and audition, where audition dominates vision.
- b. [5 marks] Provide an example from the literature representing a situation of conflict between audition and touch, where audition dominates touch.

Question 17

- a. [5 marks] What is the spatial and temporal resolution of touch?
- b. [2 marks] Is it equally distributed across the human body?
- c. [3 marks] How does it compare to vision?

Question 18

Choose one paper from the literature investigated in class where a quantitative experiment related to multimodal perception is performed.

- a. [3 marks] Describe the hypothesis of the experiment.
- b. [3 marks] Describe the experimental procedure.
- c. [4 marks] What are the results?

Question 19

- a. [5 marks] Provide a definition of pseudo-haptic feedback.
- b. [3 marks] Describe how it was first implemented.
- c. [2 marks] how can it be used?

Question 20

- a. [4 marks] Provide a definition of crossmodal enhancement
- b. [2 marks] Provide an example of audition enhancing touch
- c. [2 marks] Provide an example of vision enhancing touch
- d. [2 marks] Provide an example of touch enhancing vision

END OF EXAMINATION