Engineering Psychology

Mgr. Ing. Jakub Jura, Ph.D.
Ing. Pavel Trnka
Ing. Matouš Cejnek
Léa Reverdy

ČVUT v Praze

Contents

Engineering Psychology

Introduction

Engineering psychology is an applied psychology discipline and is naturally interdisciplinary. Engineering psychology lies at the intersection of the humanities, science and technology. In general, it is possible to say that Engineering psychology is about the use of psychological pieces of knowledge in the field of engineering. For this purpose, Engineering psychology uses knowledge primarily from general and experimental psychology. Moreover, Engineering psychology uses psychological principles and naturally develops its own methods and adapts the old ones to the new field of use.

The general aim of Engineering psychology is to help people use, produce and design technical systems efficiently with full respect to capabilities, limits and inner lawfulness of human user (operator). Formerly, Engineering psychology was put into the context of army psychology and transportation psychology; nowadays there are more adequate connections to artificial intelligence, informatics and computer and cognitive science. The connections with work psychology, ergonomics and human factors steadily remain.

Note: Of course, there is a fundamental difference between teaching this subject in a psychology study program (where students usually know many things about psychology, but almost nothing about technology) and in a technical university (where the situation is quite the opposite). This is the reason why the first part of the laboratory exercises is devoted to experiments from general psychology (and our aim is to introduce general and experimental psychology to students). The tasks belonging to this part are experiments with afterimages or galvanic skin reaction, verification of Weber and Fechner's laws, and reaction time measurement. The second part is primarily focused on Engineering psychology tasks and contains proving of the influence of mobile phone use on a driver's capabilities, then evaluation of the influence of the type of indicator on memory functions and evaluation of different types of indicators (their legibility).

Laboratories

In this chapter is described what is common for all laboratory tasks. Laboratory task specific description will be covered in the next chapters.

Laboratory experiment report

Laboratory task report is mandatory to complete the class successfully. Reports have to contain all important information about the process of experiment. Reports could be completed during the lab, or could be finished at home. The structure of a report should be organized as follows:

1. Name of the task
2. Names of the experimentalists and experimental person
3. Tools
4. Theoretical background
5. Description of the task
6. Measured data
7. Evaluation
8. Results
9. Conclusion

As a source for the theoretical background part of the report, you could use this handbook or other literature, or internet. The sources should be referenced.

Laboratory experiment record list

The record list is a mandatory part of the laboratory report and it can be obtained only during the lab class. Record lists have to contain the following items:

- All measured and obtained values.
- Notes about used tools (and their description).
- Notes about physiological and psychological state of experimental person
- Time and date of experiment
- Important notes about used tools
- Schema of experiment

A suggested Record list (the part common for all experiments) ready to print is on the following page.

Every lab task has also a record list apendix. The apendix lists ready to print are placed in the chapters of experimental tasks.

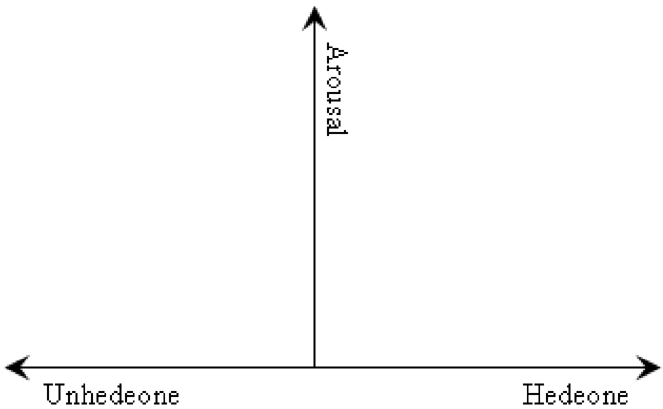
Record list

Task name: ....

Name of experimental person: ....

Description of the physiological state of the experimental person:
....
....
....

Description of the psychological state of the experimental person:
....
....
....



Schema of experiment:

Data evaluation

Today a big variety of data evaluation tools exists - from open-source tools like Python and Octave to commercial softwares like Matlab and Excel.

Functions needed for the labs will be described in the following subsections. Working examples of functions usage will be demonstrated on examples in Python - programming language designed by Guido by Rossum.

Mean value

For the purpose of the labs we use arithmetic mean. Its evaluation is described in the following equation

$$mean(x) = \frac{x_1 + x_2 + ... + x_n}{n}, \tag{2.1}$$

where x stands for array of measured values and n stands for length of array x.

Estimation of the arithmetic mean value of an array could be done with Python as easy as it is shown in the following snippet:

```
x = [15, 18, 2, 36, 12, 78, 5, 6, 9]
mean_value = sum(x) / float(len(x))
```

or it could be done with Numpy library even more easily:

```
import numpy
x = [15, 18, 2, 36, 12, 78, 5, 6, 9]
mean_value = numpy.mean(x)
```

In Excel you can obtain the mean value with command AVERAGE (in czech localization it is PRŮMĚR).

Standard deviation

Standard deviation describes the amount of variation of dispersion from the average. Low standard deviation means that the measured data is close to average. We can obtain standard deviation according to the following equation

$$std(x) = \sqrt{\sum_{i=1}^{n}(x_i - mean(x))^2}. \tag{2.2}$$

Estimation of standard deviation with Python is simply achievable with Numpy library. In the following snippet you can see how to do that:

```
import numpy
x = [15, 18, 2, 36, 12, 78, 5, 6, 9]
std_value = numpy.std(x)
```

In Excel you can obtain the standard deviation value with command STD (in czech localization it is SMODCH).

Polynomial regression

Evaluation of polynomial regression of $y = f(x)$ could be estimated with the following snippet:

```
import numpy
y = [0, 8, 22, 39, 80, 100,120]
x = [0, 1, 2, 3, 4, 5, 6]
n = 2
a = numpy.polyfit(x, y, n)
p = numpy.poly1d(a)
x_p = p(x)
```

where a is the array of polynomial parameters, n is the degree of the polynomial model. p is the polynomial model (in this case it is $1.643*x^2+11.64*x-3.571$). Finally x_p stands for array of values estimated by the model (in this case it is [[-3.57142857, 9.71428571, 26.28571429, 46.14285714, 69.28571429, 95.71428571, 125.42857143]).

In Excel you can get linear regression of data with command LINEST (in czech localization it is LINREGRESE), or you can do it directly in the graph.

LAB 1. Negative Afterimage *Emmert's Law Verification*

Goal

Confirm Emmert's law by a series of experiments with afterimages. Draw the dependence of the size of the afterimage seen by an observer on the distance of the observer from it.

Theory

Emil Emmert (1844 - 1911)
One of the basic functions of our perceptual system is a conservation of the constancies of perceived object . The real object has for example constant size, shape and color. But the sensory image of the given object (e.g. retinal image) can obtain a lot of forms. It depends on the distance, angle of observation or color of the lighting. The after image in itself is a byproduct of the process of the filtering of a constant lighting color. This process is realized on the retina. In general it is the process of habituation to a steady stimulus. Or it is possible to say that the afterimage is the consequence of the adaptation process of the retina to different lighting color. This adaptation takes some time (about 10 seconds) and after this time it's possible to observe an afterimage (similar image in the opposite color), as a residue of the adaptation process (It is related to the Yellow-Blue and Red-Green recording of the visual channel).

The size of a primary afterimage is the same as the one of the stimulus. But if we change the distance between the observer and place for afterimage projection, then the size of the afterimage changes. Emil Emmert discovered that *"The size of an afterimage changes proportionally to its distance from the observer"* (Figure 3.1 and formula 3.1) [8].

$$\frac{l'}{a'} = \frac{l}{a} \tag{3.1}$$

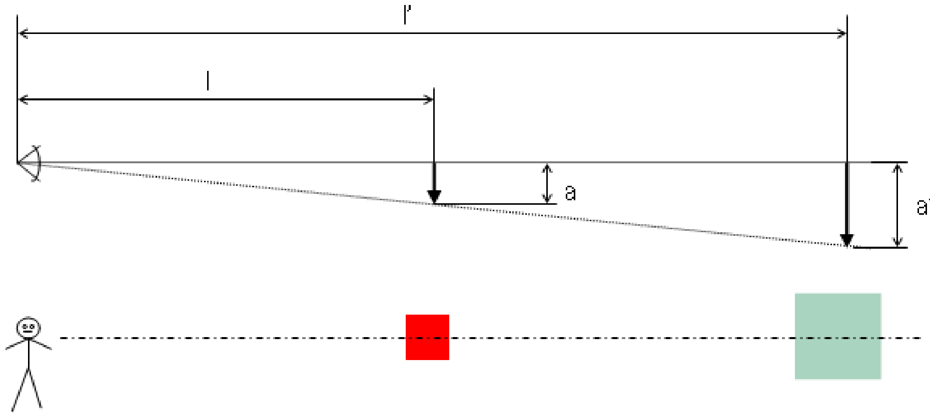


Figure 3.1: Emmert's law principle

Practical application

There is a problem when we talk about the practical use of this principle – whether the emergence of afterimages or their size changes. We can see this phenomenon for example in the situation of a longtime intensive observation of one given point (e.g. pointer of indicator). And we usually have intent to eliminate this disturbing phenomenon. Positive use of the afterimage effect is possible to see in the field of visual art or hypnosis induction.

Tools

Meter
Color template
Comparison raster

The procedure of the experiment

1. Experimental person (EP) stands on the line which is marked on the floor in a fixed distance from the color template. Experimentalist (E) measures real distance between EP's eye and the template and records it into table.

2. EP observes the color template for 15-20 seconds (fixing its sight to the small point in the middle of the template). Experimentalist watches the time.

3. After the 20 seconds EP looks from the template to the white comparison raster immediately.

4. Once EP begins to perceive the afterimage, he takes a step forward or backward in order to fit the afterimage in one of the squares on the raster.

5. Experimentalist measures distance between EP's eye and the raster.

6. The afterimage size and the eye-to-afterimage distance have to be recorded. (Add 7 mm to the distance – the correction on the eye center.)

7. Experimentalists record values into table. Repeat experiment for all sizes on the comparison raster.

8. Experiment should be repeated for every person in a group.

Evaluation

One of the way how to evaluate this task and verify Emmert's law (formula 3.1)is to make a trend curve from the measured points [l(i),a(i)], where i is the index of the measurement. If the trend curve is close to the line then we can declare that Emmert's law (formula 3.1)is verified.

Example of experiment evaluation is shown on Figure 3.2.

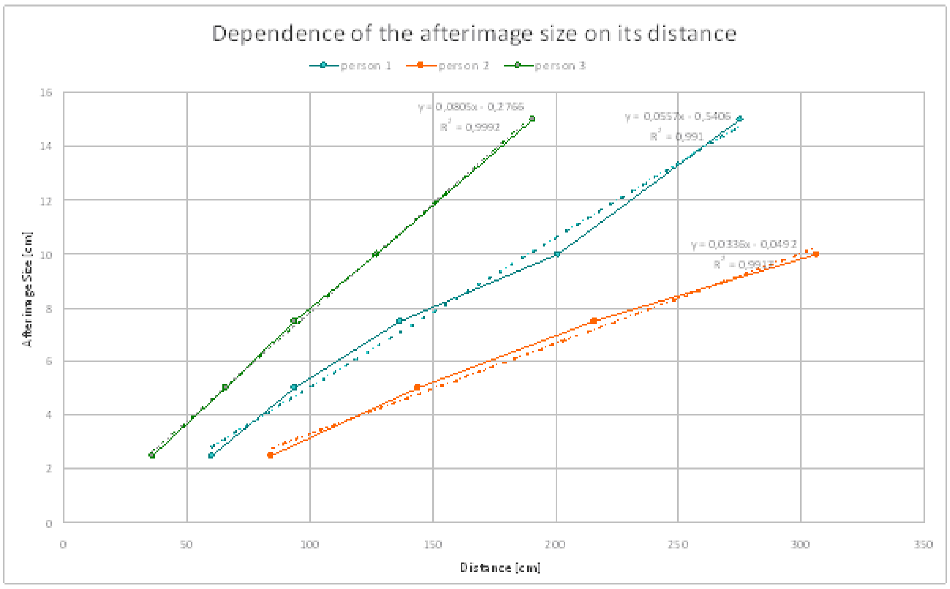


Figure 3.2: Example of the evaluation of an experiment

Record list appendix

Task: Negative Afterimage

Table for person 1:

Experiment number	Original image		Negative afterimage	
[1]	Size [cm]	Distance [cm]	Size [cm]	Distance [cm]
1	5		2.5	
2	5		5	
3	5		7.5	
4	5		10	
5	5		15	

Table for person 2:

Experiment number	Original image		Negative afterimage	
[1]	Size [cm]	Distance [cm]	Size [cm]	Distance [cm]
1	5		2.5	
2	5		5	
3	5		7.5	
4	5		10	
5	5		15	

Table for person 3:

Experiment number	Original image		Negative afterimage	
[1]	Size [cm]	Distance [cm]	Size [cm]	Distance [cm]
1	5		2.5	
2	5		5	
3	5		7.5	
4	5		10	
5	5		15	

LAB 2. Evaluation of the influence of the Type of Indicator on Memory

Goal

Discover which type of indicator (analog or digital) is easier to memorize.

Theory

Indicators are usually evaluated from the legibility point of view (e.g. LAB 9.). However, by reading the indicator, the cognitive processing doesn't terminate – conversely, it starts. The operator (person) usually needs to retain the content he has read for further use. And his memory is used for this task. The basic memory processes are imprint, retain, remember and recognition. Imprint and retain are tested in this experiment. The imprint is tested by the prompt read of viewed values. And the retain is tested by the hold of the red data in the memory. The retain of data in short-term memory is disturbed by the next reading and the control of the apparatus (especially camera shutter).

Practical application

When designing a human machine interface, it is important to know which kind of indicator is better for a given task at given conditions. Very often we need to work with the value we have to read – and this is the reason why we need to hold this value in our memory. Repeated reading from an indicator causes the time of our intervention to be longer and in a situation where we have only a very short time to act it can have fatal consequences.

An appropriate indicator is important, for example for machine operators like airplane pilots, car and train drivers etc. A lot of studies on readability of indicator features exist (readability of small displays [9], in-vehicle displays features comparison [7, 13]).

Tools

Tachistoscop (electronically controlled exposition time by the camera shutter) with range 1/1000–1 second.
Display, clock and the bar indicator realized by computer interface and SCADA HMI Reliance.
(Power pack and potentiometer.)

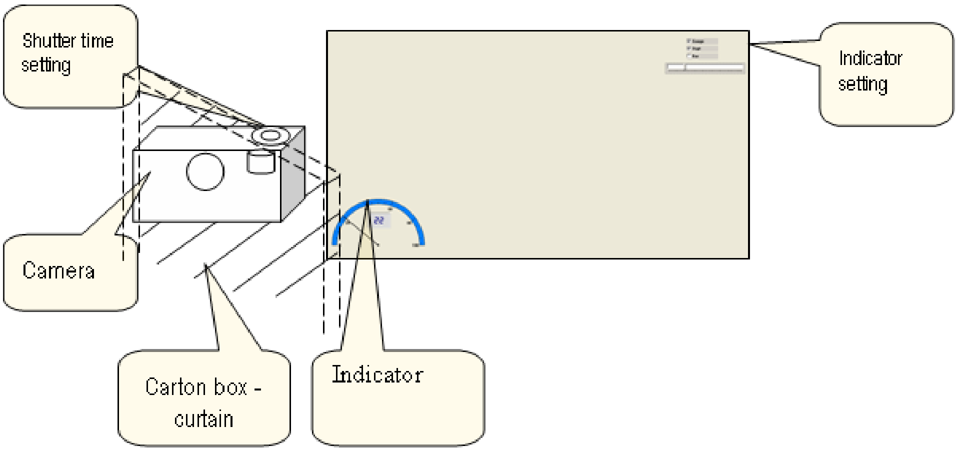


Figure 4.1: Schema of the task

The procedure of the experiment

Preparation

Start the SCADA HMI Reliance Design. Open project named Project1. Run project – F9.

The value displayed on the given instrument/indicator (clock etc.) is shown by the experimentalist to the experimental person (EP) for a short time. Arrange the observed instrument in front of the curtain (cardboard box with camera) in order to see it relatively comfortably. Use the "B" shutter setting (permanently open) for this purpose on the ring control of the camera.

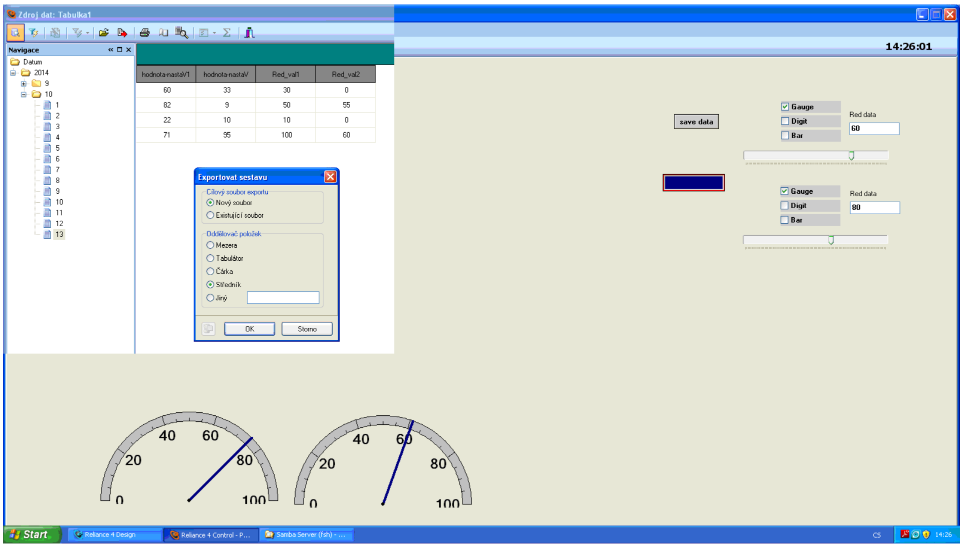


Figure 4.2: The experimental screen

Experiment

1. Set the shutter time to 1 s or 1/2 s (2 on the ring).
2. Experimentalist sets the values on both observed instruments. He changes the values whenever the experimental person tries to read the values (also when the experimental person doesn't recognize the values).
3. Experimental person pushes the shutter button and watches both indicators through the camera window. And he reads the values on the indicator consecutively.
4. Experimentalist writes the read values into SCADA HMI at the field "red data" and presses the button save (the set, red and remembered data are saved into the working database - you just have to click anywhere OUT of any input field).
5. Repeat fifteen times.

Note

- If there is a serious problem when trying to read both indicators (the standard deviation of the measurement is to high), then you can simplify this task and use only one of the indicators in all the measurement.
- Measure for all members of your group!

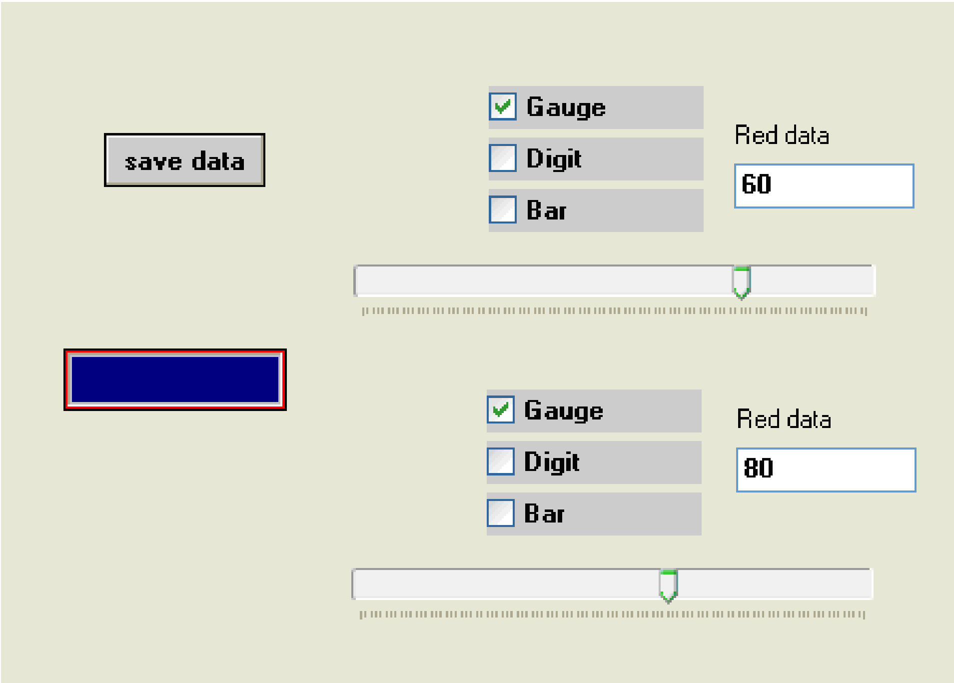


Figure 4.3: Interface for experimentalist

- It is possible to extract the data from the Reliance into the CSV (comma separated values) format and open it in Excel, Python or Matlab (see Figure 4.4).

Evaluation

Calculate mean values and standard deviations for both individual results and summary results. Compare statistical parameters for analog and digital indicator and make a verbal interpretation of the these results. Results presentation for one person could look like the following table and figure 4.5

Table 4.1: Table of example results

	Analog	Digital
Mean reading error	19.89	19.86
Mean remembering error	22.43	3.86
Reading error standard deviation	13.93	22.27
Remembering error standard deviation	24.44	5.24

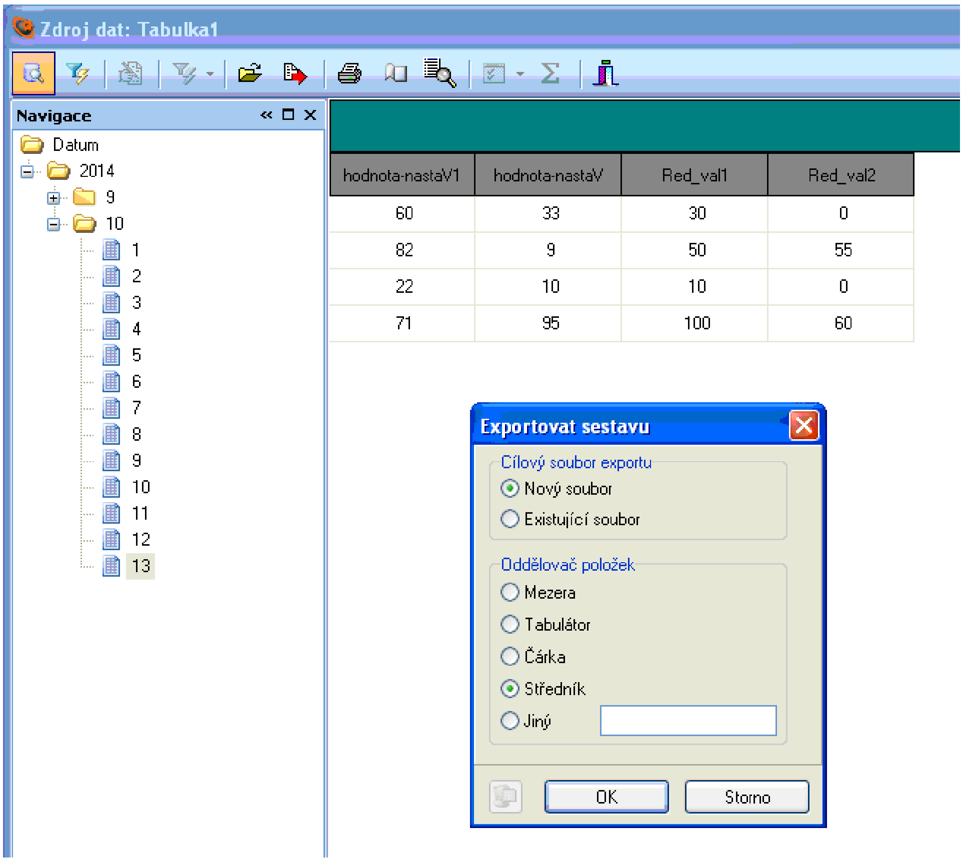


Figure 4.4: Database of measured values

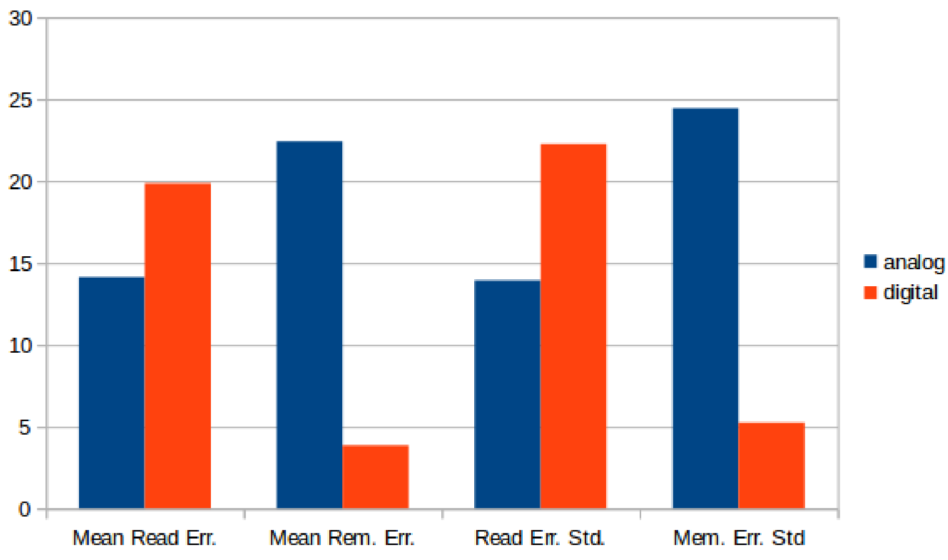


Figure 4.5: Bar chart of example results

Record list appendix

Task: Evaluation of the influence of the Type of Indicator on Memory
Person:

Read error = abs(Set - Read)
Remember error = abs(Set - Remembered)

Analog

no.	Set	Red	Remembered	Read error	Remember error
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					

Digital

no.	Set	Red	Remembered	Read error	Remember error
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					

LAB 3. Measurement of Reaction Time (RT)

Goal

Measure personal value of four types of reaction time (RT).

1. Basic reaction time
2. Reaction time for simple clear two choice decisions.
3. Reaction time for confused two-choice decisions.
4. Basic reaction time with attention divided into two tasks.

Theory

Reaction time RT is the amount of time it takes to prepare the movement. Reaction time is primarily a physiological variable that is determined by the speed of the neural signal on the way from a sensor (e.g. retina) to an actuator (usually muscle). It depends on the quality of the neural system of the experimental person and also her/his psycho-physiological state. This simple reaction time is usually about 200 ms and increases a little bit with the education level. On the other side – the reaction time with choice is a little bit more psychological and one decision (which is needed to do) usually takes about 50 ms extra time. The first rigorous measurement of reaction time was made by Sir Francis Galton [1] . From the psychological point of view, the attention process has three sub-processes - scanning, filtering and watching. The last one is as essential for the task as reaction time measurement is.

Practical application

The amount of choices and their complexity can hugely influence the reaction time of an operator. Everytime a fast reaction time is needed in industry, it is necessary to simplify the human machine interface to a maximal possible level. You can also see the effect of the confused information on the reaction time of the operator. And you can imagine the effect of this in the field of transportational psychology (e.g. in aviation).

Tools

HW system for measurement of RT

- PLC (programmable logic controller) TC 500 from TECO Kolin Company with uploaded code for measurement of time.
- two switches (red and green)
- two pilot lamps (red and green)

Procedure of experiment

Measure personal value of the defined types of RT to a visual stimulus. Measure it for all persons in your group.

- Experimentalist can use the HW system (its control is on Figure 5.2) to measure the time of reaction.
- Experimentalist prepares his/her finger on button F1 (or F2) which he/she will use to switch on the lamp.
- Experimental person cannot see F1 and F2 buttons.
- Experimental person prepares (places) his/her fingers on the button. If he/she needs to use two buttons, then she should use the same finger on both hands.
- Experimental person reacts as quickly as possible to the given signal and the given way (describe below).
- Experiments (for each group member) have four experimental settings (shown in Figure 5.1)
    1. Basic reaction time measurement (B). It is the basic measurement design with one simple signal and one kind of reaction (without

choice). The experimental person has to react as quick as possible. The output is the basic reaction time and it is just a physiological value (depending on the speed of nervous signal and the length of the nervous path from sensor to actuator).

2. Measuring the Reaction time for simple clear two choice decisions (D). The experimentalist accidentally switches on red and/or green pilot lamp. The experimental person pushes the suitable button as quickly as possible.
3. Measuring the Reaction time for confuse two choice decisions (C). The experimentalist again accidentally switches on red and/or green pilot lamp. But the experimental person has to push the opposite button (cross the signals and reactions - side, or colors).
4. Measuring the Basic Reaction time on attention divided into two tasks (DA).Repeat the experimental settings B, but simultaneously play the game on the cell phone. The first choice is Tetris, but other games are also acceptable.

Op. Measure RT with special conditions (tiredness, exhaustion, sleepiness etc.).

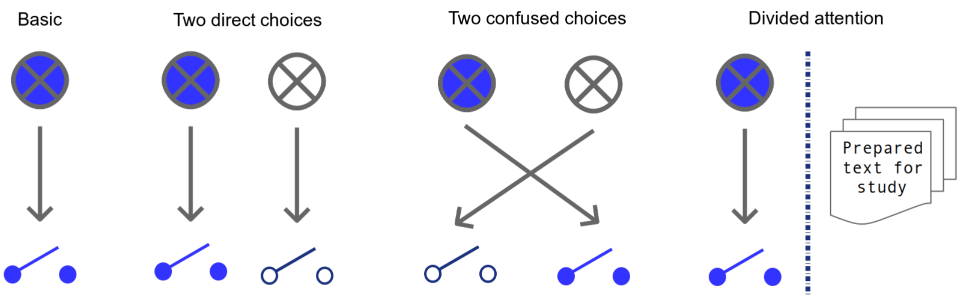


Figure 5.1: Settings of the experiment

Evaluation

1. Calculate the mean value for all experimental persons and experimental settings (according to the table in the Record list).
2. Calculate the overall average time for all experimental persons and experimental settings, according to the following table.
3. Calculate and compare the difference between the mean value of non-choice RT (B - basic) and all other experimental settings (C - confused choices, D - direct choices, DA - divided attention). Also estimate B - D, B - C and B - DA.

	B	D	C	DA	B - D	B - C	B - DA
	[ms]	[ms]	[ms]	[ms]	[ms]	[ms]	[ms]
Person A							
Person B							
Person C							
mean							

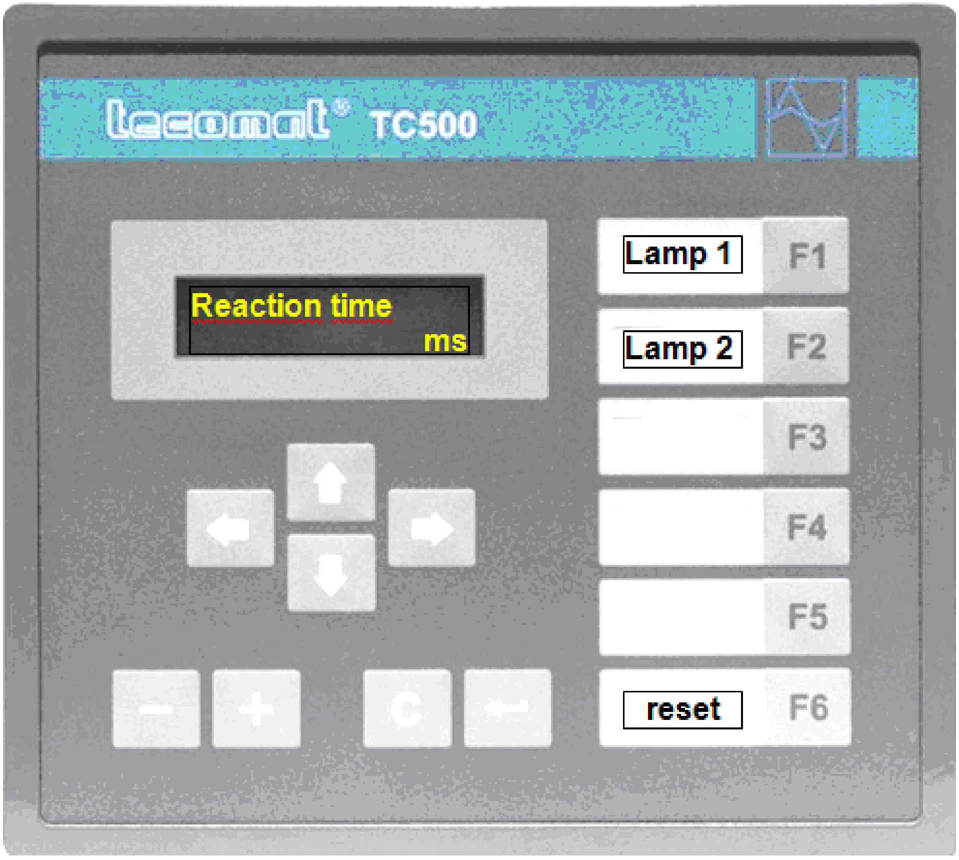


Figure 5.2: User interface of RT measurement

Record list appendix

Task: Measurement of Reaction Time (RT)

Table for results:

	Person 1				Person 2				Person 3			
No.	B	D	C	DA	B	D	C	DA	B	D	C	DA
[1]	[ms]	[ms]	[ms]	[ms]	[ms]	[ms]	[ms]	[ms]	[ms]	[ms]	[ms]	[ms]
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
std												

B - basic reaction time
D - reaction time with two direct choices
C - reaction time with two confused choices
DA - reaction time with divided attention

LAB 4. Fechner's Law Verification

Goal

Verify Fechner's law in the field of acoustic. Make this verification for three given ranges.

Theory

Gustav Theodor Fechner (1801–1887) was a German scientist, psycho-physicist and E. H. Weber descendant.

Fechner's law [14] description:

- The dependence of sense impression on the intensity of stimulus is logarithmic.
- The sense impression is proportional to the logarithm of the stimulus intensity.
- The sense impression increases according to arithmetic series whereas the stimulus has to increase according to geometric series.

$$p = k \cdot log(S), \tag{6.1}$$

where the p stands for percept (sense impression), k for constant and S for intensity of stimulus.

The principle of Fechner's and Weber's laws are integrated into Weber–Fechner law, which is directly used in acoustics. Weber–Fechner law can have the form of a differential equitation

$$dp = k\frac{dS}{S}, \tag{6.2}$$

and after its resolution we obtain the equitation in the form of:

$$p = k \cdot ln(\frac{S}{S_0}), \tag{6.3}$$

Where S_0 is the absolute threshold of the stimulus (minimal perceived value of the stimulus).

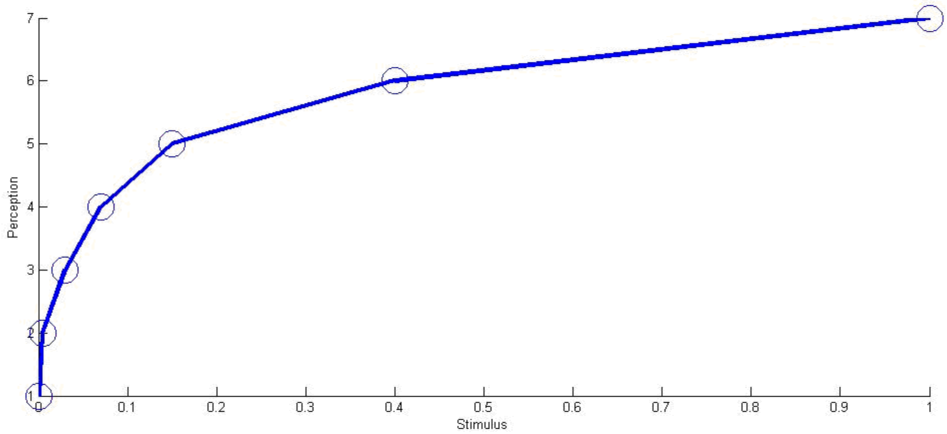


Figure 6.1: Dependence of sense impression on the intensity of stimulus

Practical application

Weber-Fechner law is used for evaluating noise level in acoustics, according to the Sound Intensity Level [5] (L_I, measured in db) equation

$$L_I = 10 \cdot log_{10} \frac{I}{I_0}, \tag{6.4}$$

where I is the sound intensity, measured in Wm^{-2} and I_0 is the reference sound intensity, measured in Wm^{-2}.

Tools

PC with LabView
Loudspeaker

The procedure of the experiment

1. Start the LabView program.

2. Try to change values (using potentiometers) in LabView application form to create a sequence of acoustic signals where all samples have an equal volume distance from the previous and the next sample (the increment of intensity should sound constant).

3. Everyone in the group will set three sequences:

   - The first of them is from 0 to 1/10 of maximum.
   - The second one is from 0 to 1/3 of maximum.
   - And the third is from 0 to maximum.

4. Export data to MS Excel.

Evaluation

Measured data should be evaluated accordingly:

1. Draw a suitable regression curve (with minimal error) for each range. It should be similar to figure 6.1.

2. Obtain the regression curve (and identify parameters of Fechner's law equation).

3. Discuss the differences dependent on the range.

Record list appendix

Task: Fechner Law Verification

Table of results for 1/10 of range:

No.	Volume [%]		
	Person A	Person B	Person C
1			
2			
3			
4			
5			
6			
7			
8			

Table of results for 1/3 of range:

No.	Volume [%]		
	Person A	Person B	Person C
1			
2			
3			
4			
5			
6			
7			
8			

Table of full range results:

No.	Volume [%]		
	Person A	Person B	Person C
1			
2			
3			
4			
5			
6			
7			
8			

LAB 5. Weber's Law Verification

Goal

Draw the dependence of total weight and discrimination threshold graphically and solve the k_w constant by the minimal square method (use Excel). Calculate the measurement error.

Theory

Ernest Heinrich Weber (1795–1878) was a German physician who is considered one of the founders of experimental psychology. Weber's law states that the just-noticeable difference between two stimuli is proportional to the magnitude of the stimuli [14]. That means that the Just-Noticeable Difference (JND) between two weights is approximately proportional to the mass of the weights as follows:

$$\Delta I = k_w \cdot I, \tag{7.1}$$

where I is a base intensity (Total weight), ΔI is the discrimination threshold (Weight difference) and k_w is constant (Weber Fraction). The relation between Weber's law and Fechner's Law was described in Fechner's Law.

Practical application

Control panels using different sound or light volumes as a part of indication must use volume differences that are bigger than the JND. Otherwise the passed information will not be understandable.

Tools

Web application for the measurement of the Weber fraction in the field of acoustics
Digital scale
Plate
Set of base weights (metal cylinders)
Set of difference weights (plastic cylinders)

The procedure of the experiment

1. The experimental person (EP) holds a given base weight (plate and metal cylinders) in hands and closes his eyes.

2. The experimentalist (E) adds and removes the small weight units (plastic cylinders) called difference weights and EP has to decide if the weight increases or decreases. After every three changes E removes the plate from EP and give it back to him with random (different or same) amount of plastic cylinders

3. The experiment starts at the minimal value of the difference weight and continues by increasing the difference weight (add/remove more weight units together when E fails to detect correctly the change 3 times in row).

4. The aim is to find out the discrimination threshold (minimal recognizable weight difference) for every base weight.

5. Minimal recognizable weight difference has to be confirmed repeatedly (at least three times in row).

6. Three different base weights (plate only with 2 metal cylinders, plate with 4 metal cylinders, plate with 6 metal cylinders) are used.

7. Experiment should be repeated for every person in a group.

8. Experiment results have to be recorded and evaluated in a suitable software.

Notes

- EP should stand and his/her elbows should not touch the body, legs or furniture.

- E should start the incrementation with one cylinder and continue with two or more cylinders only if it is sure that EP is unable to recognize the difference correctly.

- E should test the discrimination threshold from the lowest value (one cylinder) up to more cylinders, not in the opposite order!

Evaluation

- Estimate the Weber Fraction for every person and given base weight.
- Estimate the standard deviation of estimated Weber Fractions for every person.
- Results of evaluation could be organized in table like:

	k_w for bw 1	k_w for bw 2	k_w for bw 3	std
Person name				

Where constant k_w stands for Weber Fraction - according to mentioned theory, bw stands for base weight and std is standard deviation of all three estimated Weber Fractions.

Record list appendix

Task: Weber Law

Tables for measured data:

	Δw for bw 1 [g]	Δw for bw 2 [g]	Δw for bw 3 [g]
Person 1			
Person 2			
Person 3			
Person 4			

Note: bw stands for base weight.

	Base weight 1	Base weight 2	Base weight 3
Weight [g]			

LAB 6. Measurement of Electro-Dermal Activity (EDA)

Goal

Find out the difference in the SRL (skin resistance level) in different mental states (relaxation, stress etc.).

Theory

Our skin on the fingers is very sensitive to an actual mental state. High EDA values correlate with high arousal [4]. According to the same study, the EDA values also correlate with a given task difficulty and frustration.

It happens because skin responds with opening and closing its pores when the mental state changes. This causes the skin resistance (conductivity) to change. The skin response is delayed. You can measure only the states that you can induce yourself. It can be: sleepiness (or relaxation), solving of a complicated mental task, tiredness (after hard work) etc.

The types of electro-dermal activitiy are: SRR – skin resistance response, SRL – skin resistance level, SCR – skin conductance response, SCL – skin conductance level, SPR – skin potential response, SPL – skin potential level. Our experiment is designed for the measurement of SLR.

Practical application

The measurement of electro-dermal activity is widely used for the evaluation of the psychological state of operators with high responsibility.

Tools

Couple of Ag-AgSO4 electrodes
LabJack measuring device with Bridge circuit
PC with measurement software (LabView)

Principle of measurement

For the measurement we use the half-bridge circuit shown in Figure 8.1, described by the following equation

$$R_v = R_k \frac{U_v}{U_{Ref} - U_v}, \tag{8.1}$$

where R_v is the skin resistance, R_k is the 150kΩ compensating resistor, U_{Ref} is the reference potential and U_v is the measured electrical potential between electrodes.

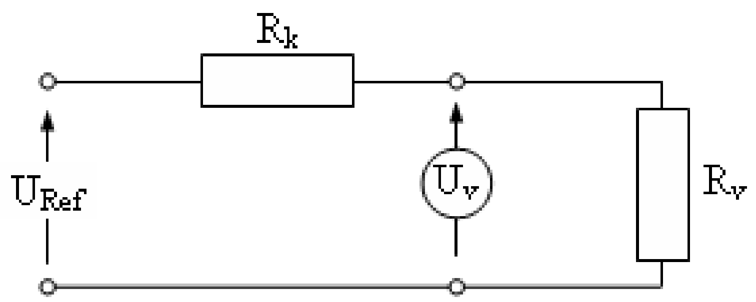


Figure 8.1: Half-bridge measurement circuit

The procedure of the experiment

1. Start the program SkinResistance.exe (Figure 8.2).
2. Place the electrodes on the experimental person's (EP) fingertips (Figure 8.3), check the proper contact of the electrodes.
3. EP should not to see the computer screen with the graphs during the experiment!
4. Measure the skin resistance level (SRL) in the following phases :
    a Reference state - non affected (your actual state - sitting with no effort).

b Relaxation state (close your eyes, think of something pleasant . . .).

c During the resolution of tests on imagination capabilities (i.e. shape composing), executive functions (i.e. trial making or U-drawing) or attention (i.e. Bourdon). There are good results with SUDOKU solving.

d During physical activity (ten squats or jumps).

e Scare state. EP closes his eyes. Experimentalist pinches or pokes EP with a pencil (gently!) suddenly at random intervals. The reaction should occur very quickly, just before the physical contact. You can mark each "attack" in the graph using the <Marker> button. Be careful during this phase! The aim is to scare, not to injure!!!

5. Each phase must take at least 3 minutes to achieve a sufficient gap for skin response.

6. Use <Marker> button to indicate boundaries between experiment phases. Press the button for a few seconds and release again – the blue mark should appear in the graphs.

7. During the measurement you can change the axes' limits in the graphs without affecting the data (Figure 8.2).

8. Export the measured data into Excel using <Export data from "Skin Resistance" chart> button and save exported file. There are three columns in the exported file – time [s], SLR [kOhm] and Marker [1: button pressed, 0: button released]. Generate Scatter graph from Excel data. Use Time as X axis, SLR as primary Y axis and Marker as secondary Y axis. Analyze the data.

9. Repeat this procedure for every person in the group.

Evaluation

Verbal description of the mental states by the EP (introspection – how do you feel), by the experimentalist (exterospection – what you observe) and description of graph of the skin resistance level. Describe the difference between mental states in SRL. Graph obtained from used software with detail notes and description is part of the laboratory report.

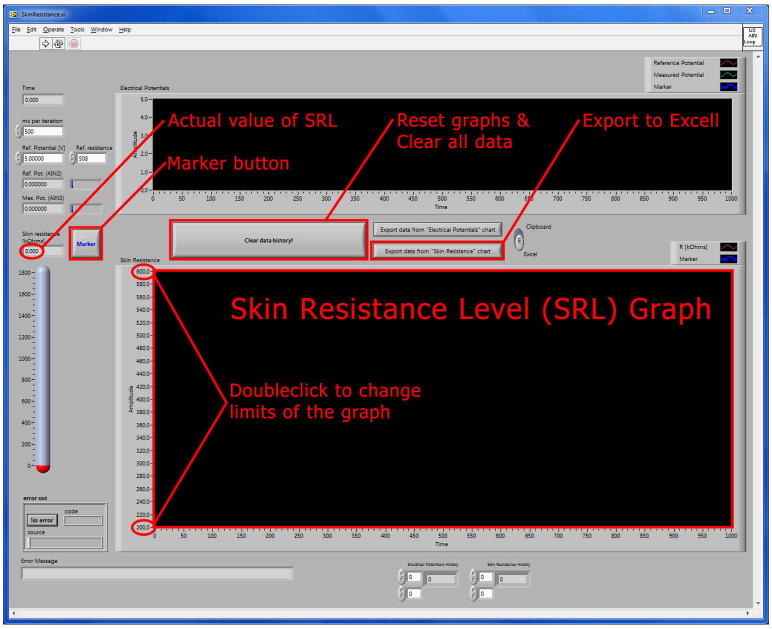


Figure 8.2: User interface of software “Skin Resistance”

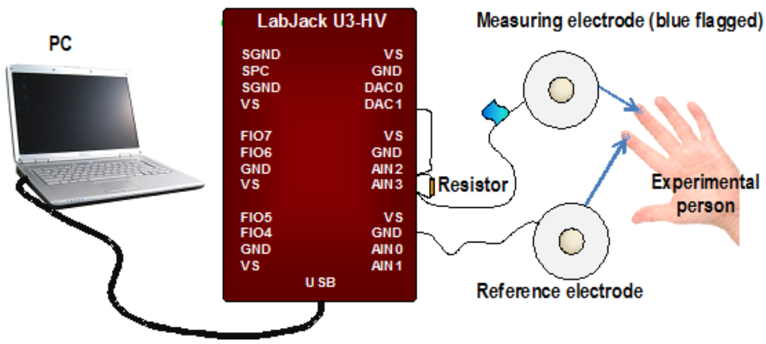


Figure 8.3: Placing of electrodes

Record list appendix

Task: Measurement of Electro-Dermal Activity (EDA)

Table for one person: ....

The marker description column should also contain the information, whether the marker time is related to one event, or the beginning of a state.

State	Time	Marker description

LAB 7. Influence of Phone Use on Driving Performance

Goal

Quantitatively and qualitatively evaluate the influence of phone use on driving abilities. Discover the quantitative difference in driving performance with/without distraction. Qualitatively find out what the operator (driver) does during the mobile phone ring and when he/she telephones.

Theory

Divided attention, Automatic controlled processes

Practical application

Machine operators have only a given amount of attentional capacity. If their task is complicated, their attention should not be used by other unnecessary processes.

Tools

Car driving simulator
2 skype accounts and headsets, phone (able to accept SMS or email)
Video with recording

Task description

Experimental person (EP) drives a car on the PC simulator. First experimentalist (Observer) takes the video record and notes the times of important events. Second experimentalist monitors the lap time and the amount of faults the driver makes (e.g. number of hit objects). Before starting the experiment, the driver realizes two or three training rounds. Then he drives a comparative round without disturbance. In the second round the Observer makes a call with the driver and has a conversation with the driver. In the third round the phone call is also realized, but the driver uses the hands-free set. Final round is without disturbances again.

Operating the program

The procedure of the experiment:

Use Training course No. 14: Throttle control 2 Click on “Go” or “Try Again” to start.

Car control	
Steering wheel	Steering
Left paddle (behind steering wheel)	Clutch (semi-automatic)
Gear shift lever	Shift up/Down
Left pedal	Brake
Right pedal	Throttle

Experiment phases

Experiment person gives a signal to experimentalist before the start of each phase (using the camera or the phone). Experimentalist records the starting time of each phase (see stopwatch in camera recording software).

1. Approx. three training laps (before experiment is started).
2. One lap without distraction. (Record your lap time and count of objects that you hit.)
3. One lap with a call without hands-free (EP holds the phone in hand). (Record your lap time and count of objects that you hit.)
4. One lap with a call using hands-free (experimentalist holds the phone next to EP’s ear). (Record your lap time and count of objects that you hit.)
5. One lap without distraction (for comparison). (Record your lap time and count of objects that you hit.)

Evaluation

Watch the recorded video and fill the table according to it. Make qualitative observations (what you noticed on the video). It is useful to focus your attention on the movements of the driver's eyes when he makes a mistake. Also analyze the quantitative results (relation between the use of phone with/without handset and the number of faults made by the driver).

Record list appendix

Task: Influence of Phone Use on Driving Performance
Table for one person: ....

Comparative, Number of faults:		
Event	Time	Description of event, subject response etc.

With phone, Number of faults:		
Event	Time	Description of event, subject response etc.

Hands-free, Number of faults:		
Event	Time	Description of event, subject response etc.

Comparative, Number of faults:		
Event	Time	Description of event, subject response etc.

LAB 8. Haptic Sensitivity

Goal

Check the difference in skin sensitivity on different parts of the body.

Theory

The skin surface feeling is projected into the human brain (cortex) [6] at the gyrus postcentralis. Here the tactile feeling becomes conscious. More sensitive parts of the human body take a larger area of cerebral cortex surface and vice versa. The largest areas of cortex are devoted to the hands and face. Neural density is very similar on the whole given gyrus.

Practical application

Tools

Tactile compasses
Ruler

The procedure of the experiment

1. One measurement starts at the minimal distance (0 mm) and ends when the experimental person (EP) feels two separated points.
2. Measure and record the resulting distance.
3. Repeat ten times on one body part with one EP.
4. Repeat steps 1) till 3) for different body parts (at least 4).
5. The whole experiment should be repeated for each person in a group.

6. Draw a bar graph (or a pie chart) of the haptic (tactile) sensitivity on the different body parts you tested (for individual persons and for mean values of all experimental persons).
7. On one given part of the body, make a measurement for open and closed eyes.

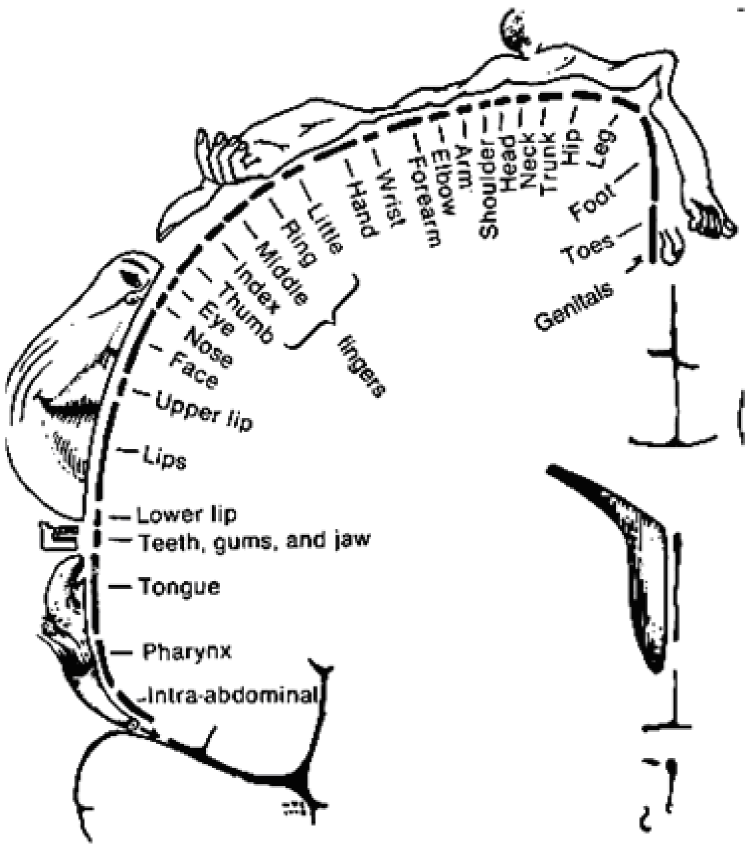


Figure 10.1: Dependence between the skin surface and the brain surface – gyrus postcentralis

Evaluation

Discuss individual and common differences in skin sensitivities. Discuss the influence of the open/closed eyes on skin sensitivity and express this difference in percentage. Make a bar graph of results (like example graph Figure 10.2).

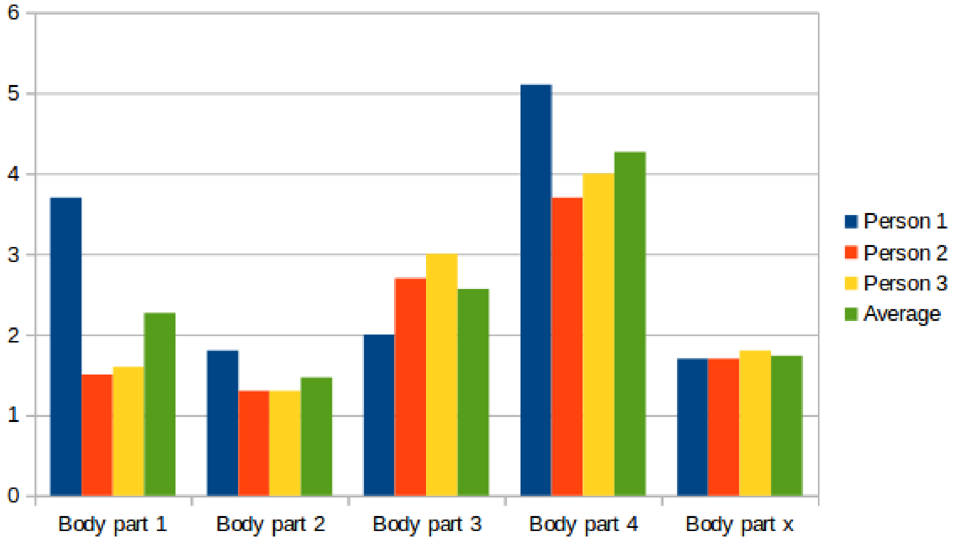


Figure 10.2: Bar graph of example values.

Record list appendix

Task: Haptic Sensitivity

Table for one person:

No	Body part 1	Body part 2	Body part 3	Body part 4	Body part 1 closed eyes
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
mean					
std					

Body part 1: ....
Body part 2: ....
Body part 3: ....
Body part 4: ....
Body part 5: ....

LAB 9. Readability of Different Kinds of Indicators

Goal

Find out which type of indicator is the most readable.

Theory

The readability of indicators has been an issue in engineering psychology since its beginning and is still relevant. Choosing the most suitable indicator for a given task can be a really complex problem - and from the visual perception point of view it is discussed in [15]. One of the criteria is the amount of time the operator need, to correctly get the information from the indicator.

Practical application

The ability to read values from an indicator and do it under time stress situation is very important in the field of operator control. Misreading the indicator can have huge consequences. Although the reading is always an outcome of an interaction between the operator and the interface – and the side of the operator is impossible to skip – we only deal with the interface part in this lab task. It justifies the fact that the look of the interface can have an influence in the process of designing technical systems.

Tools

Tachistoscop (electronically controlled exposition time by the camera shutter) with range 1/1000–1 second.
The set of instruments - displays, clocks and theirs equivalents realized by

computer interface and SCADA HMI Reliance - 4.2. (Start program Reliance 4 – Design, open Project1, Run project – F9)
Power pack and potentiometer.

The procedure of the experiment

Preparation

The value displayed on the given instrument (clock etc.) is shown by the experimentalist to the experimental person for a very short time. Arrange the observed instrument in front of the curtain (cardboard box with camera) in order to see it comfortably. Use the "B" shutter setting (permanently open) for this purpose.

Experiment

Experimentalist sets the value on the observed instrument. He changes the value whenever the experimental person tries to read the value (also when the experimental person doesn't recognize the value). Experimental person sets the shutter time. Use shutter time 1/1000, 1/500, 1/125, 1/30 and 1/4 only. Measure with every shutter time ten times! Measure for all members of your group!

Evaluation

Make a graph of the mean value of reading errors for all devices and exposition times (x-axis: exposition time, y-axis: reading error). E.g. 11.1 Make a verbal interpretation of the information from the graph. And on this basis evaluate specific properties of each given indicator type.

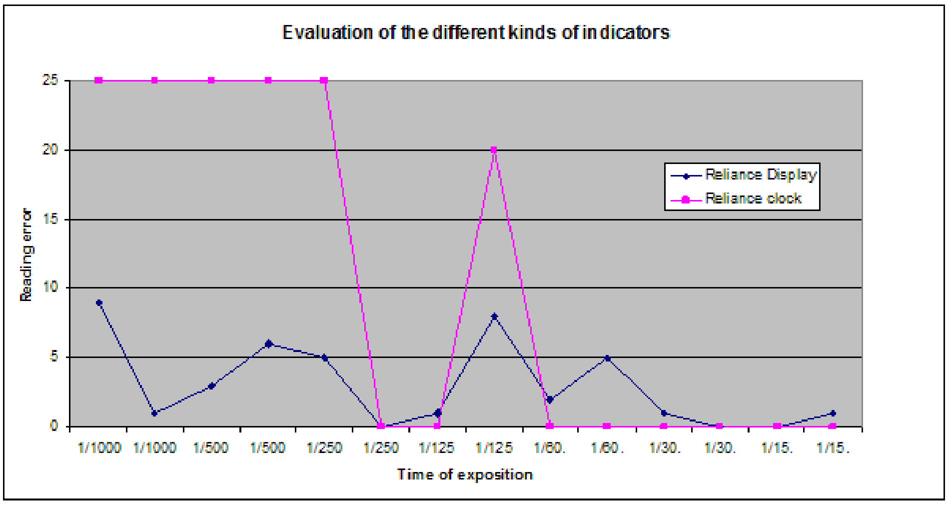


Figure 11.1: Graph of results

Application of Engineering Psychology Today

Design of HMI with cognitive model

This chapter is based on article [10]. The method deals with Human Machine Interface (HMI) and its design, which is based on the cognitive model of the HMI user. Designing a Human Machine Interface (HMI) is a process that is mastered routinely – especially in the case of the interface between a user and his personal computer, in its day-to-day use. In this paper, the approach which supports the design of a very special interface is outlined. This interface considers particular human attributes such as creativity. The global aim of this effort is to generalize this procedure and obtain a universal method for HMI design.

Software engineering standard UML (Unified Modeling Language) [2] is used for the modeling of the cognitive functions of the operator here. We use only three UML diagrams: Class diagram (Figure 12.1) for the description of the structure properties, State diagram (Figure 12.4) for the description of the class's behavior and Sequence diagram (Figure 12.3) for the description of interactions between classes. This model describes in the first place the user's cognitive processes (psychology part) e.g. perception, thinking, attention, memory etc.

The skeleton of the UML model arises from the process of the lexical analysis (e.g. [11]). The problematic field of human cognition has been described in nature language (e.g. [12] – better briefly) and the names of the classes were derived from the nouns (and nouns phrases) used in the text after the selection (the selection rules are a part of the OMT lexical analysis [11]). In a similar way, the names of the attributes were obtained from the adjectives. And associations and operations were obtained from the verbs and verbal phrases.

The statical structure of the described cognitive system is represented by the UML class diagram. This view comes from the lexical analysis and the

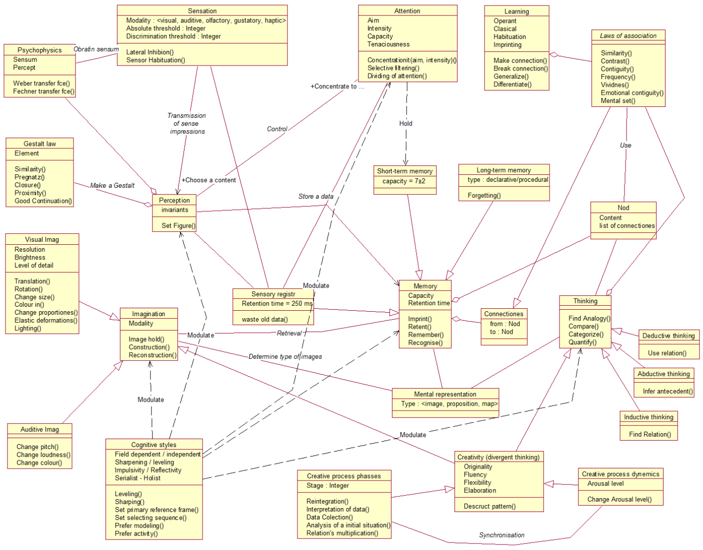


Figure 12.1: Structure of the cognitive functions described by the UML Class diagram.

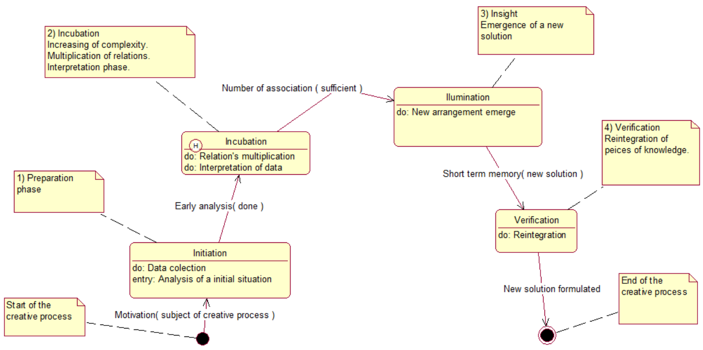


Figure 12.2: State diagram of the class Creative process phases

skeleton of this model was made on this basis. However this one contains uncovered logical spaces (inconsistencies) which have been resolved by the addition of the connecting pieces of knowledge.

For the description of the communication process, an UML sequence diagram (Figure 12.3) is used. The description of the creative phases was derived from the Deep neurobiology of E. Rossi [3]. The Sequence diagram notes a communication between classes. Since the UML model of cognitive functions is oriented to the field of redesign, the sequence diagram shows the process of communication between the user (designer) and the CRDP (Computer ReDesign Process) software.

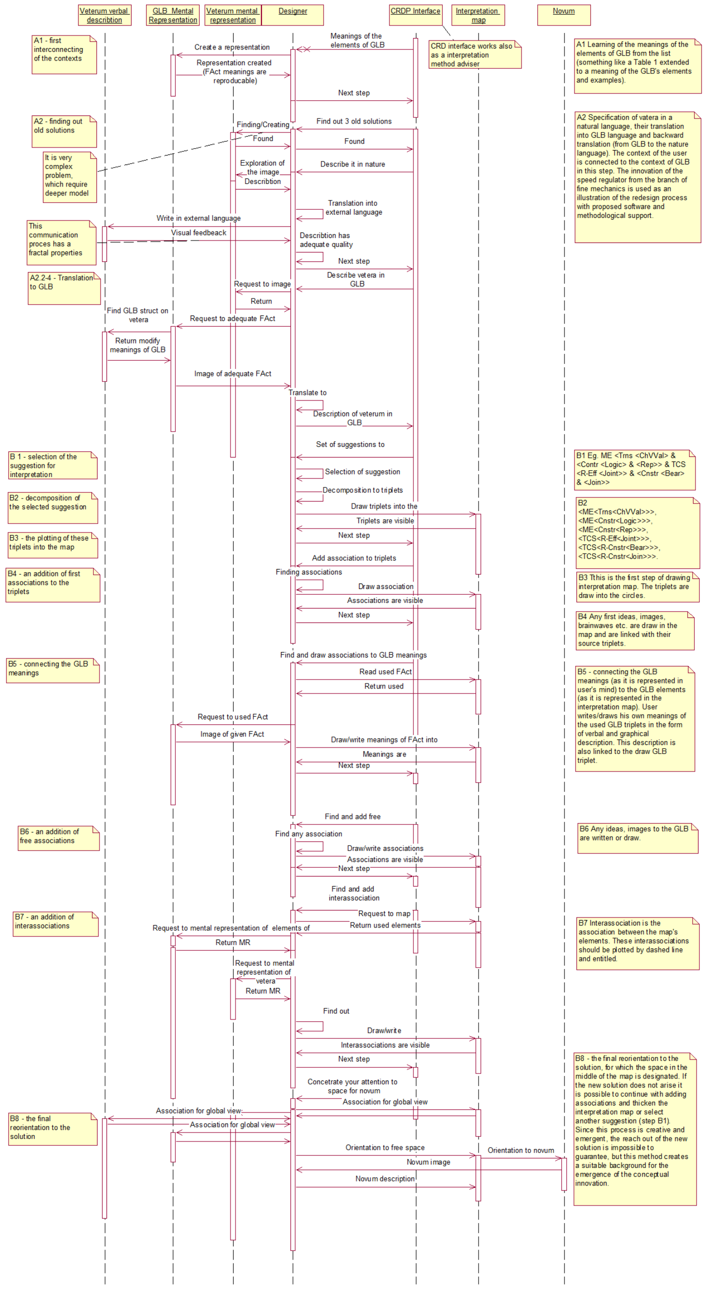


Figure 12.3: An example of sequence diagram - communication between user (designer) and CRDP software.

The cognitive method helps the Human Machine Interface (HMI) designer to develop the interface with respect to complex mental functions. The designer can allocate the cognitive functions displayed on the model to the arising interface and assure the usability of his HMI system for human operator.

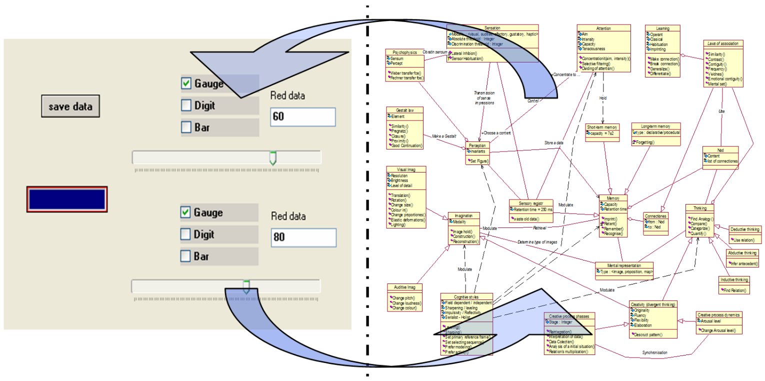


Figure 12.4: The interaction between proponed interface and model of human cognitive system.

The designer (of HMI) uses the cognitive model to see and to use the human natural capabilities (which are expressed for example as an operation and properties of the given classes). And in the process of description of the communication between user and HMI (computer), the designer can deeply elaborates the cognitive model, according to the incorporation of the new cognitive parts in the sequence model. The universal technique of HMI design can arise by the generalization of the above mentioned principles of the drafted method.

Bibliography

[1] Galton , Francis. An instrument for measuring reaction time. *Report of the British Association for the Advancement of Science*, 59:784 5, 1889.

[2] OMG Object Management Group . Unified modeling language: UML resource page.

[3] Rossi , E.L. The deep psychobiology of psychotherapy. In *Handbook of Innovative Therapy. 2ed Edition*, pages 155–165, NY: Wiley, 2007.

[4] Anders Drachen, Lennart E. Nacke, Georgios Yannakakis, and Anja Lee Pedersen. Correlation between heart rate, electrodermal activity and player experience in first-person shooter games. In *Proceedings of the 5th ACM SIGGRAPH Symposium on Video Games*, Sandbox '10, pages 49–54, New York, NY, USA, 2010. ACM.

[5] Frank Fahy. *Sound intensity.* E & FN Spon, London, 1995.

[6] Stuart Ira Fox. *Perspectives on human biology.* Wm. C. Brown Publishers, Dubuque, IA, 1991.

[7] J. D. Hoffman, J. D. Lee, and D. V. McGehee. Dynamic display of in-vehicle text messages: The impact of varying line length and scrolling rate. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, 50(4):574–578, October 2006.

[8] R. J. Irwin. EMMERTS LAW AS A CONSEQUENCE OF SIZE CONSTANCY. *Perceptual and Motor Skills*, 28(1):69–70, February 1969.

[9] James F. Juola, Alp Tiritoglu, and John Pleunis. Reading text presented on a small display. *Applied Ergonomics*, 26(3):227–229, June 1995.

[10] Jakub Jura and Jiří Bíla. Model of cognitive functions for description of the creative design process with computer support: Improving of the interpretation method for the computer conceptual re-design. In Ali

Sanayei, Ivan Zelinka, and Otto E. Rössler, editors, *ISCS 2013: Interdisciplinary Symposium on Complex Systems*, volume 8, pages 163–171. Springer Berlin Heidelberg, Berlin, Heidelberg, 2014.

[11] Andrea C Schalley. *Cognitive modeling and verbal semantics a representational framework based on UML.* Mouton de Gruyter, Berlin, 2004.

[12] Robert J Sternberg, Karin Sternberg, and Jeffery Scott Mio. *Cognition.* Wadsworth/Cengage Learning, Belmont, Calif., 2012.

[13] Derek Viita and Alexander Muir. Exploring comfortable and acceptable text sizes for in-vehicle displays. In *Proceedings of the 5th International Conference on Automotive User Interfaces and Interactive Vehicular Applications*, AutomotiveUI '13, pages 232–236, New York, NY, USA, 2013. ACM.

[14] Ernst Heinrich Weber, Ernst Heinrich Weber, Ernst Heinrich Weber, Helen E Ross, David J Murray, and Experimental Psychology Society. *E.H. Weber on the tactile senses.* Erlbaum (UK) Taylor & Francis, Hove, 1996.

[15] Christopher D. Wickens. *An introduction to human factors engineering.* Pearson Prentice Hall, Upper Saddle River, N.J, 2nd ed edition, 2004.

ČVUT v Praze

2015