Engineering Psychology

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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.
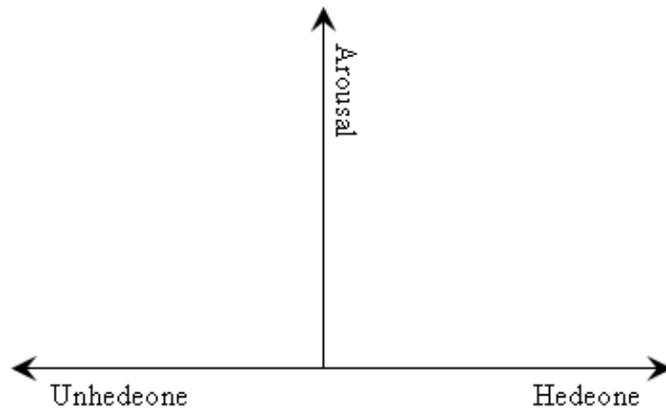
Record list

Task name: ....

Name of experimental person: ....

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

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

Arousal

Unhedeone   Hedeone

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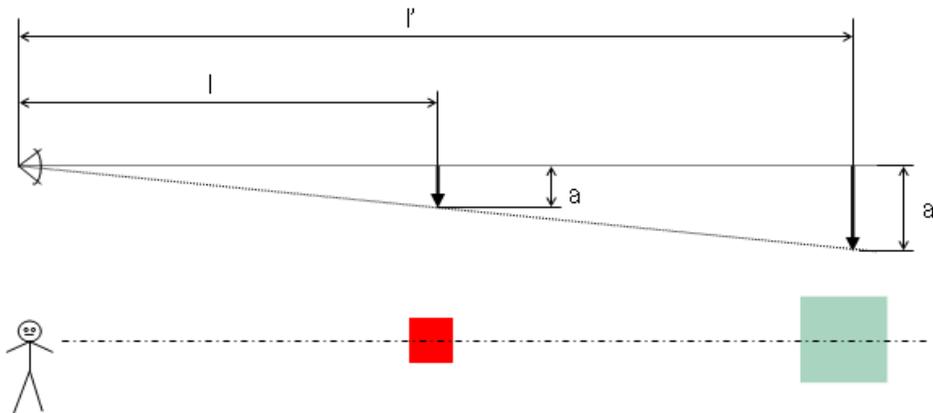
$$\frac{l'}{a'} = \frac{l}{a} \tag{3.1}$$

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.
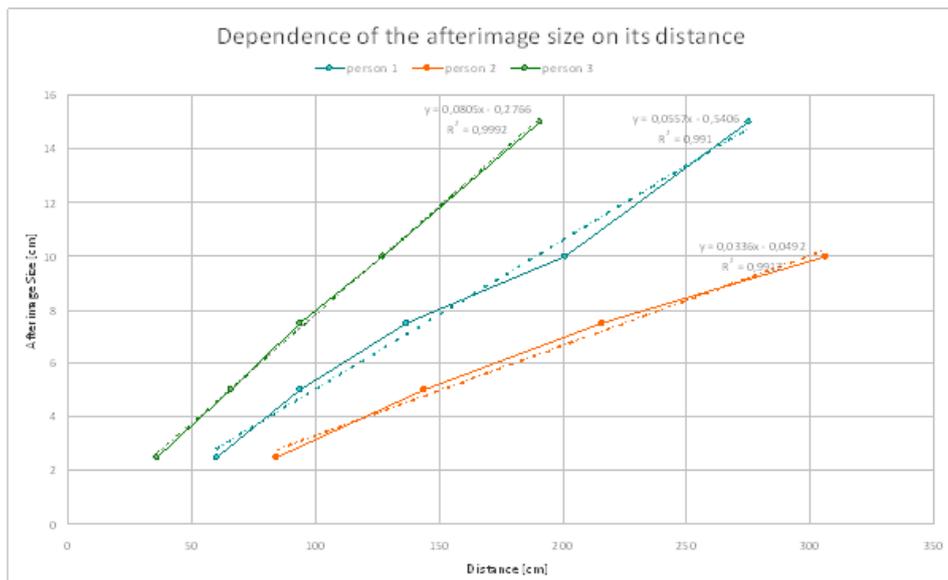
Example of experiment evaluation is shown on Figure 3.2.

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 end – 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 read 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 the 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.)
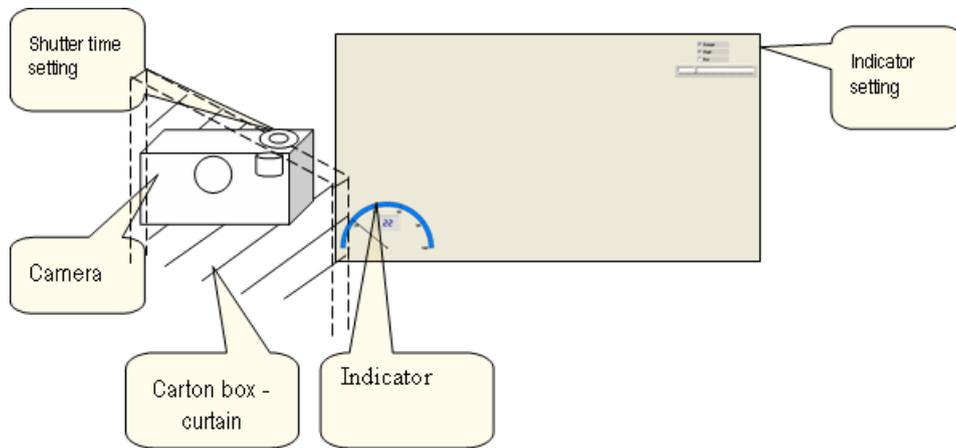
Figure 4.1: Schema of the task

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).

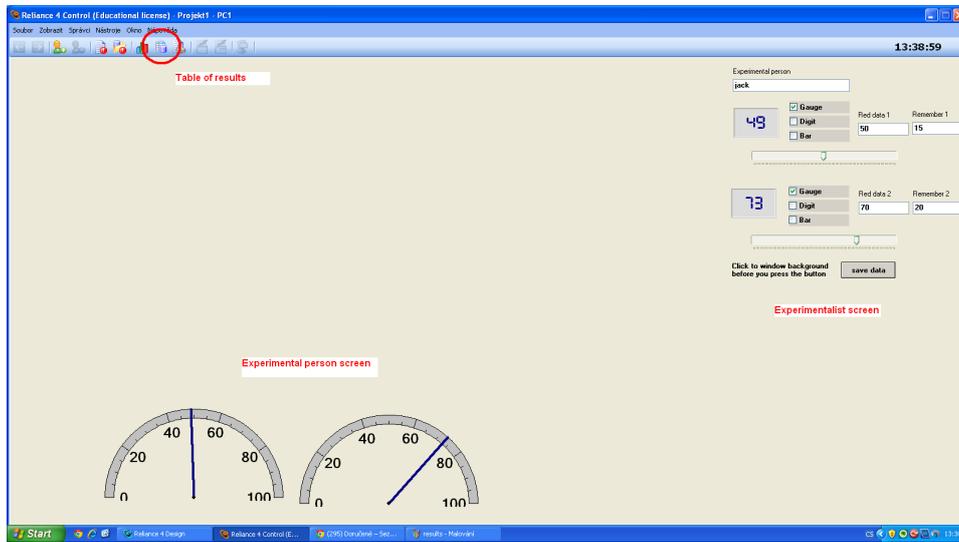2. Experimentalist sets the values on both observed instruments. He changes the values whenever the experimental person tries to read the values (also when the experimental person doesn't recognize the values).

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 in 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 ten 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!

16
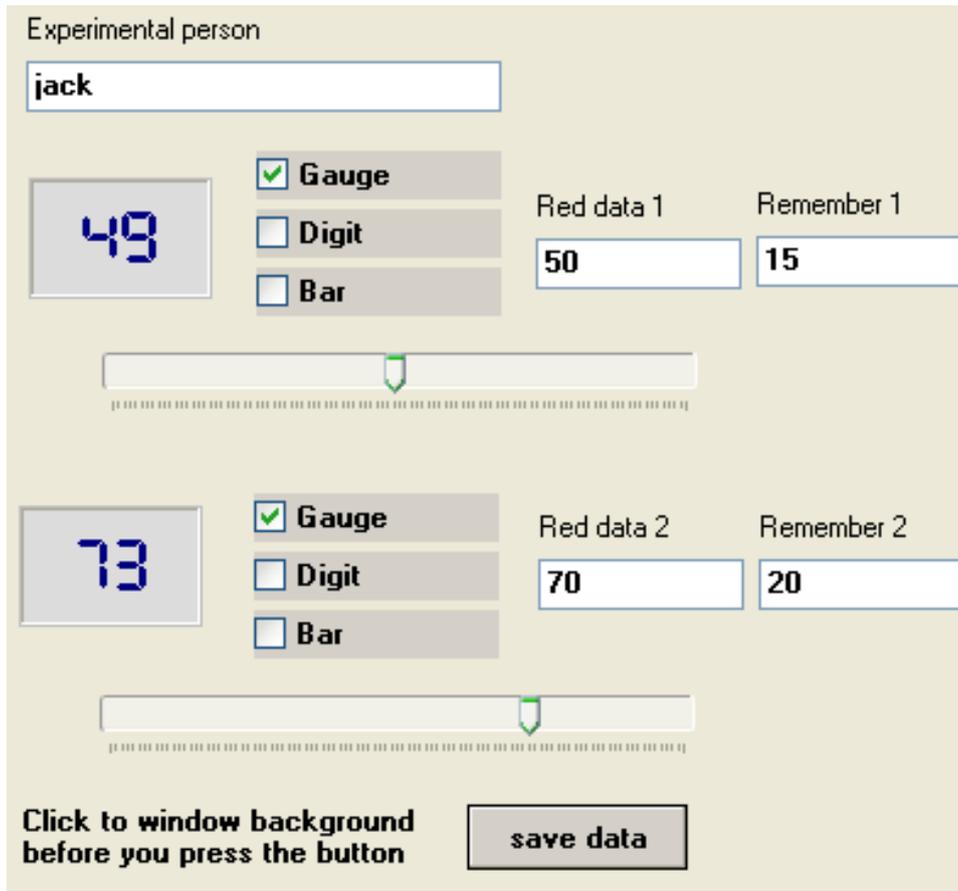
Figure 4.3: Interface for experimentalist

- 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
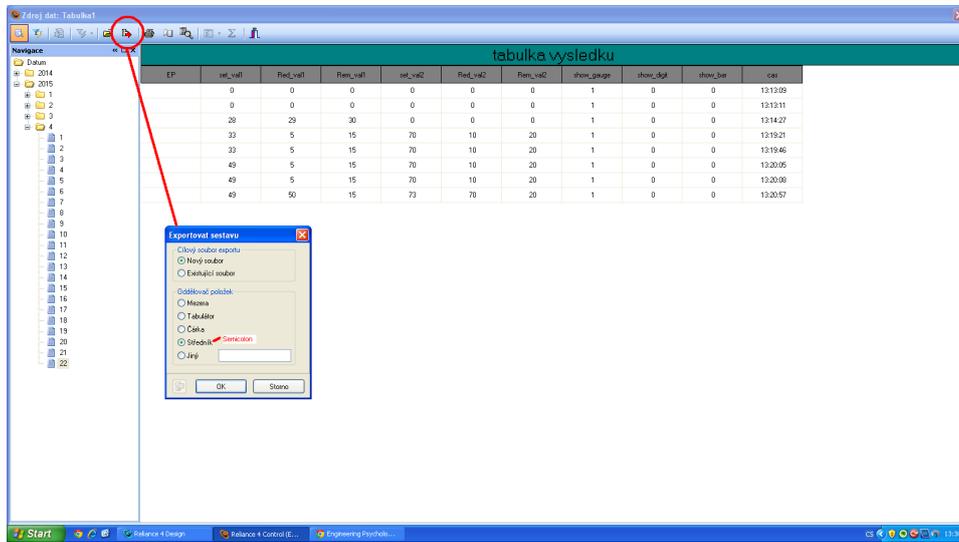
Figure 4.4: Database of measured values

	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 4.5: Bar chart of example results

Record list appendix
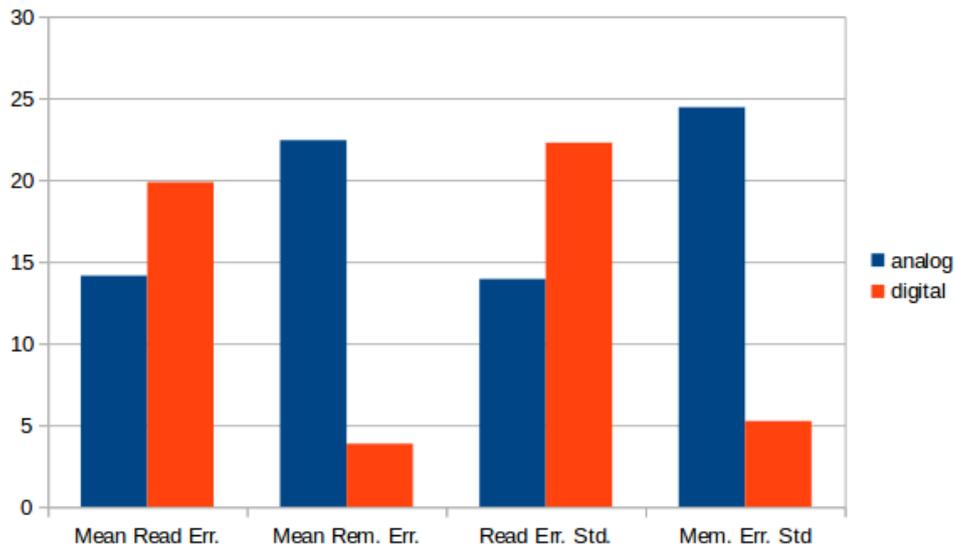
Task: Evaluation of the influence of the Type of Indicator on Memory
Person:

Read error = abs(Set - Read)
Remember error = abs(Previous Read - 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. Or you can write a short text message instead of gaming. When you are done the task 7 - Car Driver Analysis, you should use same distractor (game or text messaging).

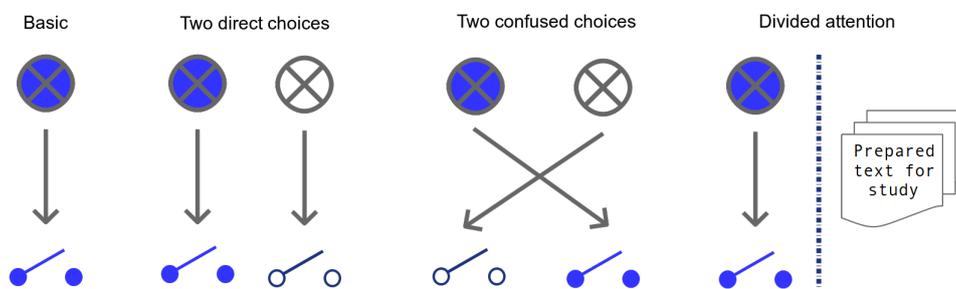Op. Measure RT with special conditions (tiredness, exhaustion, sleepiness etc.).

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	D - B	C - B	DA - B
	[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:

No.	Person 1				Person 2				Person 3			
	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

Discusion

Compare results (especially from 1. and 4. subtask – basic reaction time
(B) and reaction time with distraction (DA)) with results of the laboratory
task 7 – Car Driver Analysis. Discus similarity and differences.

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:

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

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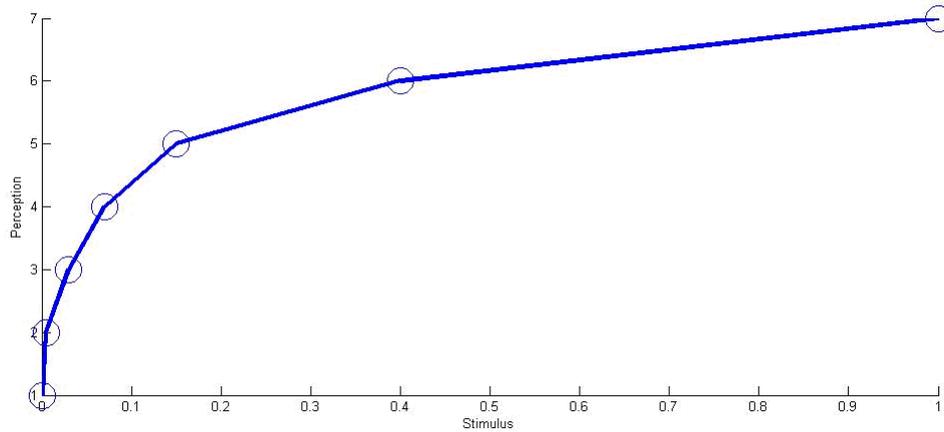

Figure 6.1: Dependence of sense impression on the intensity of stimulus

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

$$L_I = 10 \cdot log_{10}\frac{I}{I_0},$$ (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).

Note : If it's not clear enough, here's a step by step description of the procedure :

Before you begin, the difference of volume between 1 and 2 will already be set. Therefore, your task will be to change the volumes of samples 3 to 8. Listen to the sequence (only 1 and 2 at first) and try to set the volume of 3 so that the increment in volume sounds constant to you (i.e. the increment in volume is the same between 2 and 3 and between 1 and 2). Repeat this step for the next samples (until you reach number 8) In the end, the increase of the volume should sound linear to you throughout the whole sequence.

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 (metal circles)

The procedure of the experiment

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

2. The experimentalist (E) adds and removes the small weight units (metal circles) called difference weights and EP has to decide if the weight increases or decreases.

3. The experiment starts at the minimal value of the difference weight (smallest circles) and continues by increasing the difference weight (add/remove bigger weight units /or more biggest weight units together if needed/ 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, plate with 2 metal cylinders, plate with 4 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 weight addition with smallest circle and continue with bigger one only if it is sure that EP is unable to recognize the difference correctly.

- E should test the discrimination threshold from the lowest value (smallest circles) up to bigger circles, 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* stands for 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

$$R_v = R_k \frac{U_v}{U_{Ref} - U_v},$$ (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.
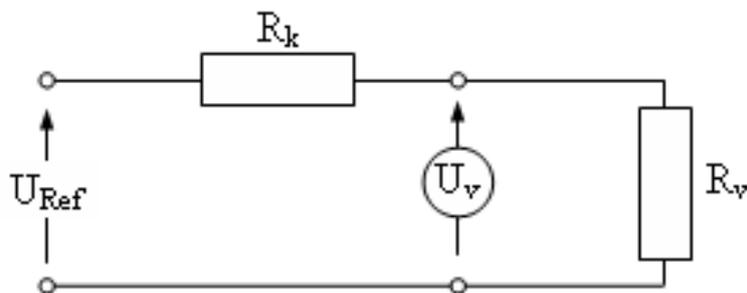

Figure 8.1: Half-bridge measurement circuit

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.
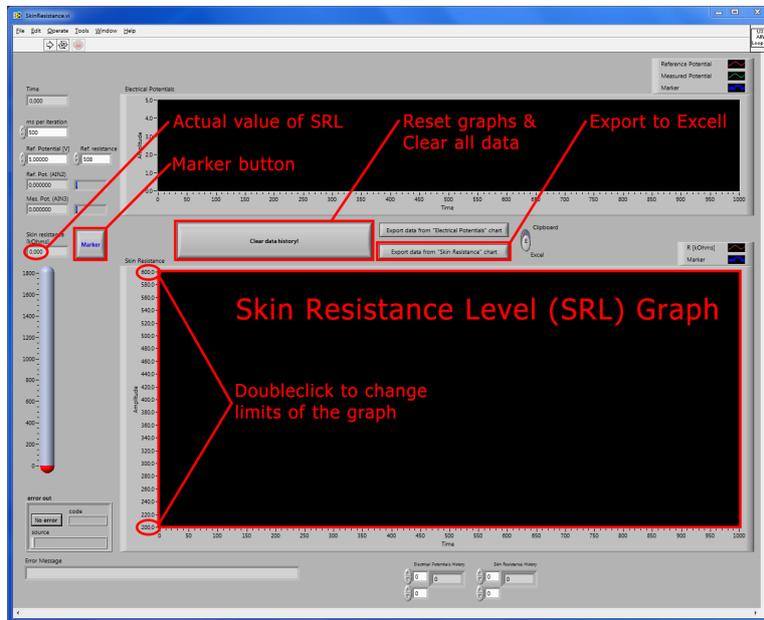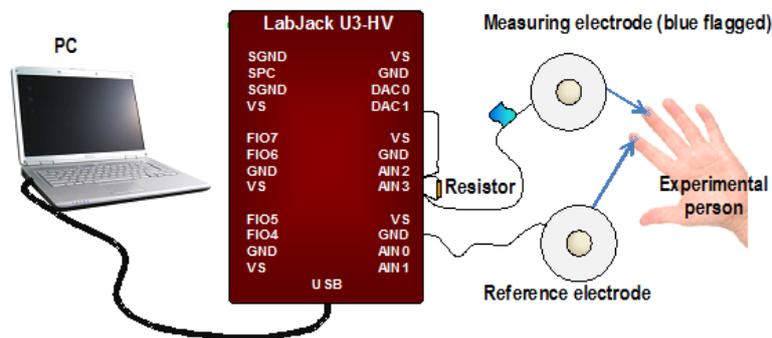
Figure 8.2: User interface of software "Skin Resistance"

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 accounts (cvut_111, cvut_109) 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 communicates with experimented person using phone (Skype). Second experimentalist monitors the amount of faults the driver makes and notes the times of important events. Before starting the experiment, the driver realizes a training ride (without recording). Then he drives first comparative round without disturbance. In the second round the Observer makes a call with the driver and has a conversation with the driver (must hold head set as "cellphone"). 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:
Start testing lesson Career:City driving Click on "START".

Car control	
Steering wheel	Steering
Paddles (behind steering wheel)	Look left/right
Gear shift lever	Shift up/Down
Left pedal	Brake
Right pedal	Throttle
Upper left/right button	left/right turn signal
Lower left button	Engine
Lower right button	Neutral
Keyboard	
L	Parking lights/Headlights
B	Seat belt
SPACE	Hand brake

Press "back", then open Career:Penalty statistics. (Do NOT change profile!). Roll down, expand your rides and capture your driving statistics.

Experiment phases

Experiment person gives a signal to experimentalist before the start of each phase (using the camera or the phone). Experimentalist records duration of each phase and type of finishing (succesfully finished, crash with other car, crash with peasant etc.). NOTE: If you finish lesson succesfully, the software doesn't record your time.

1. Training round (before experiment is started).

2. One round without distraction. (Record your roud time. Leave lessson and start again in order to record your statistics.)

3. One round with a call without hands-free (EP holds the phone in hand). (Record your roud time. Leave lessson and start again in order to record your statistics.)

4. One round with a call using hands-free (experimentalist holds the phone next to EP's ear). (Record your roud time. Leave lessson and start again in order to record your statistics.)

5. One round with a writing short text message with your full home address. When you are done the task 3 - Measurement of Reaction Time (RT), you should use same distractor (game or text messaging). (Record your roud time. Leave lessson and start again in order to record your statistics.)

6. One round without distraction (for comparison). (Record your roud time. Leave lessson in order to record your statistics.)

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).

Discussion

Compare your results with results of the laboratory task 3 – Measurement of Reaction Time (RT). Especially with subtask 1. and 4.– basic reaction time (B) and reaction time with distraction (DA).

Record list appendix

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

Comparative, Total Time, Score:			
Event	Penalty	Time	Description of event, subject response etc.

With phone, Total Time, Score:			
Event	Penalty	Time	Description of event, subject response etc.

Hands-free, Total Time, Score:			
Event	Penalty	Time	Description of event, subject response etc.

Comparative, Total Time, Score:			
Event	Penalty	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.
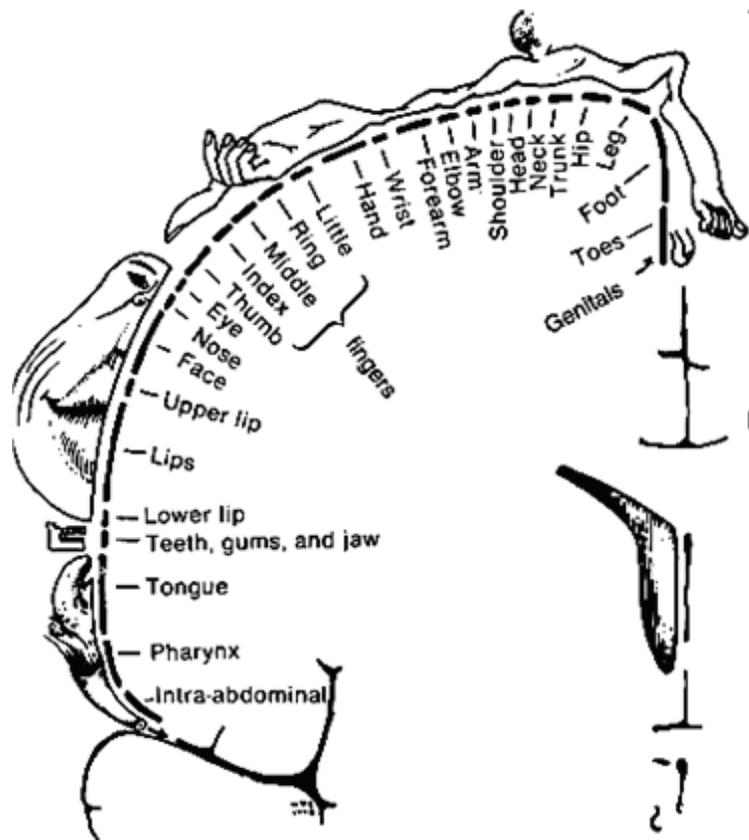
Figure 10.1: Dependence between the skin surface and the brain surface – gyrus postcentralis

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).
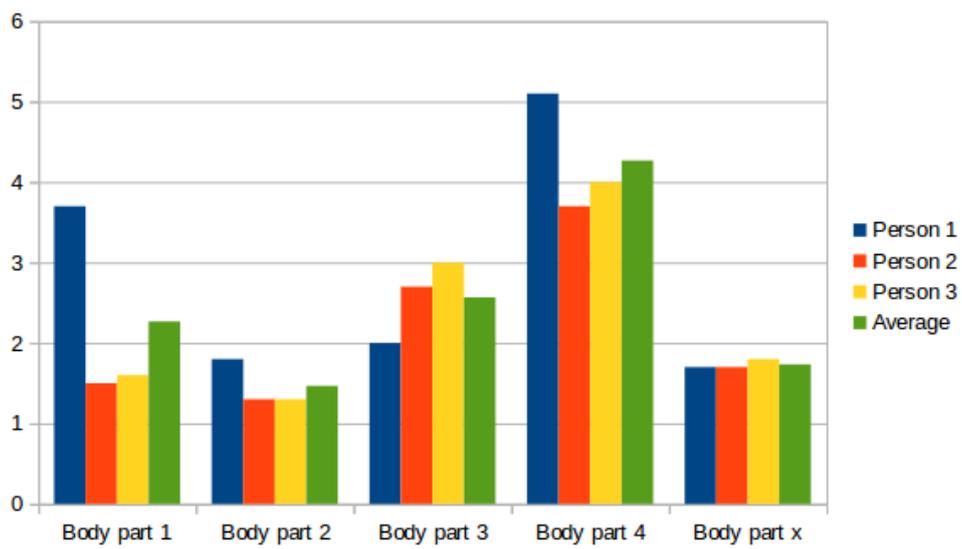
Figure 10.2: Bar graph of example values.

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 needs 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.
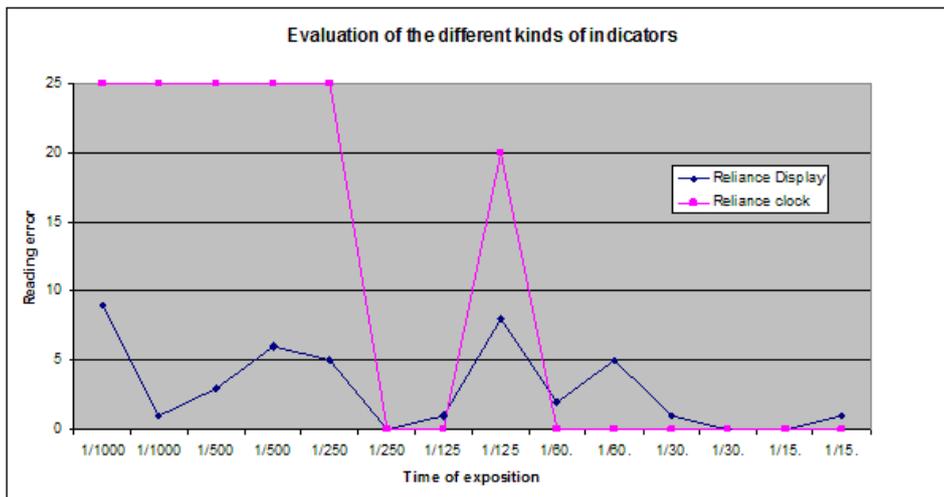
Figure 11.1: Graph of results

LAB 11. Emotion Recognition from Speech

Goal

The main goal will be to understand how it is possible to recognize emotion in speech (automatically). In order to do so, we will use EmoVoice, an already existing framework from the University of Augsburg. To understand the process better, and test its accuracy, you will execute the following steps :

a) Check the efficiency of a model using previously recorded speech ; b) Build a user-specific model and test it ; c) Evaluate emotion recognition from speech by a human operator.

Theory

As we saw in LAB. 6 with skin sensitivity, our body can react differently depending on our mental state. It is known that one's voice changes with the emotions felt. For instance, we can sometimes hear a tremble in a sad person's voice. For a few decades now, scientists have tried to find which features of speech characterize emotions. A review of studies regarding this matter can be found in section « Emotion recognition from speech ». The method used could be simplified as follows :

• From an extract of oral speech, find out which acoustic parameters seem to give information on the emotion felt at the time ; Note : In addition to acoustic features, it's also possible to use other speech features such as linguistic or discourse information.

• Build a classifier with these parameters ;

• Create an « emotional speech database » to train and evaluate the classifier (an emotional speech database is basically an ensemble of sentences that will induce specific emotions when read) ;

Nowadays, with the results of this studies it is possible to find programs reaching a significant accuracy in emotion recognition from speech. In this lab, you will use EmoVoice, a framework with a very user-friendly design. It's important to note that in this case we consider only acoustic features. For further information on how EmoVoice is built (for example which algorithms are used), please refer to section ≪ EmoVoice ≫ in the textbook.

Practical application

Like the measurement of electro-dermal activity, this technology could be used to evaluate the mental state of operators with high responsibilities. Furthemore, a wide range of applications can benefit from it, for instance it could lead to the improvement of voice-operated services.

Tools

PC with EmoVoice Microphone

The procedure of the experiment

Note : See Fig. 1 and Fig. 2 for indications with "n°". a) Check the efficiency of a model using previously recorded speech An emotional speech database is already built in EmoVoice. The stimulus (sentences inducing emotions in the speaker) can be chosen in German, English, French or Italian. A recording of the German pack of sentences has already been made. You will use it to evaluate and train a model and then check its efficiency. The output you will get using this database is a positive emotion or negative emotion label. 1. In the EmoVoice interface, select project' emovoice' (n°1), user'user'and double-click on recording '2013-10-16_07-35-48.'You can see it's now loaded in the View panel. 2. In the Model panel (n°3), select the Evaluation (n°4) tab. Select method'ev-bayes'(check box're-extract features'on the far right) and run Evaluate Model. You can then see the result of the evaluation in the display box. Note : We choose to use the'ev-bayes'in our lab because it works better than the'ev-svm'method for real-time recognition. 3. In the Train/Run tab (n°5), click on Train Model. The model is now ready to use. In the next step, you will check its efficiency. 4. You will now test the model AND a human operator. You need to be prepared to say 20 sentences in the microphone. Everytime you will say one sentence, EmoVoice will display the label it has assigned to your speech (negative or positive). At the same time, please note the label you chose and ask your partner to write down the label he would choose, for each occurrence. Note : If you need some ideas for the sentences can choose them from the examples in the last page of the lab (try to choose 10 negative and 10 positive). 5. Once you are ready

for the test, select the trained model and start Run Selected Model. Say your sentences one by one and be careful to check that a label is displayed by EmoVoice after each time your read a sentence before moving on to the next one. 6. Write down or copy the results from EmoVoice.

b) Build a user-specific model and test it 1. In the EmoVoice interface, select project'emovoice'(n°1) and create a new user with your name. 2. In the Record panel (n°2), chose the language of the stimuli you want to use. 3. Click on Start Recording. The stimuli slides will begin to be displayed, start reading them. The recording will stop once you have read all the sentences. 4. Now it is necessary to extract the features from your speech recording to evaluate and train a new model with it. Select the recording you just made and repeat steps 2. to 6. from the instructions in paragraph a).

c) Evaluate emotion recognition from speech by a human operator. You can notice that this step was already realised during the tests in a) and b). You will use the notes of your partner as results for the evaluation.

FIG.1

FIG.2

Evaluation

Of course, we will assume that the accuracy of the label chosen by the person whose speech is evaluated is 100%, it is our reference. Therefore, our reference is not absolute, it is user-related. In our lab, we only used basic labels for emotions (negative or positive). However, in the case of more complex emotions, it can be hard to describe the feelings in one word (for an external person and even for the person who's expressing the emotions). To test your self-evaluation in a given situation, you can try this test, created by a research group from the University of Geneva : `https://www.unige.ch/fapse/emotion/demo/TestAnalyst/GERG/apache/htdocs/index.php` Now, with the results obtained in a) and b), evaluate the accuracy of the models and the human operator (in %). Compare the results and comment.

Note : if the stimuli you chose has an output of more than 2 labels (positive-passive, positive-active, negative-passive, negative-active), you can consider only the ≪ positive ≫ and ≪ negative ≫ part, since the already existing model was trained with only positive and negative.

Record list appendix

Example of a table of results for one model :

TABLE

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	

Examples of sentences

This is so unfair! Get out of here! You really get on my nerves. I could never imagine being so angry! I can't believe I'm always so unlucky! That's such bad luck! She makes me so mad! I don't want to see you again! My life is so tiresome. It often seems that no matter how hard I try, things still go wrong. Everybody is so friendly to me! I feel enthusiastic and confident now! This is the best movie I have ever seen! This is the best movie I have ever seen! I'm very content about my life. I got the new job! Isn't it beautiful? It's a great book! Blue is such a comforting colour. Never mind, keep going!

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 13.1) for the description of the structure properties, State diagram (Figure 13.4) for the description of the class's behavior and Sequence diagram (Figure 13.3) 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
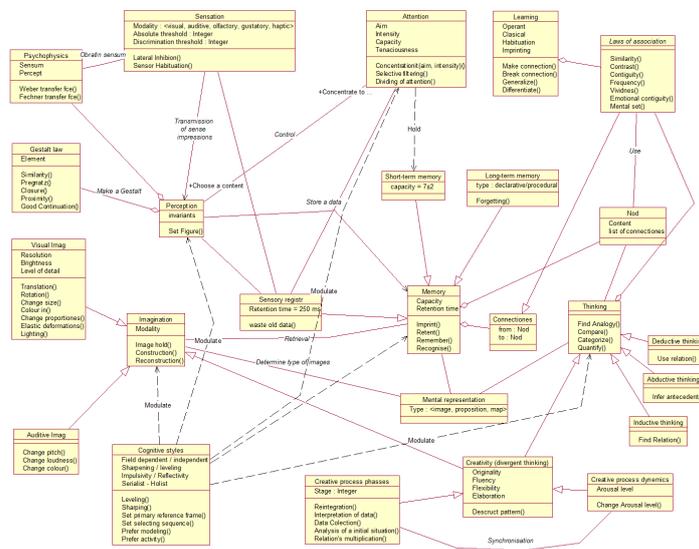
Figure 13.1: Structure of the cognitive functions described by the UML Class diagram.
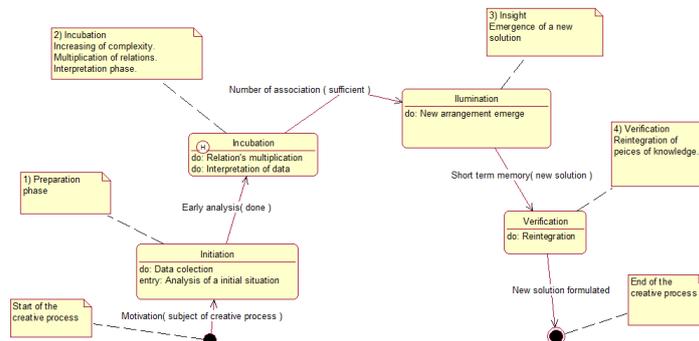

Figure 13.2: State diagram of the class Creative process phases

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 13.3) 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.
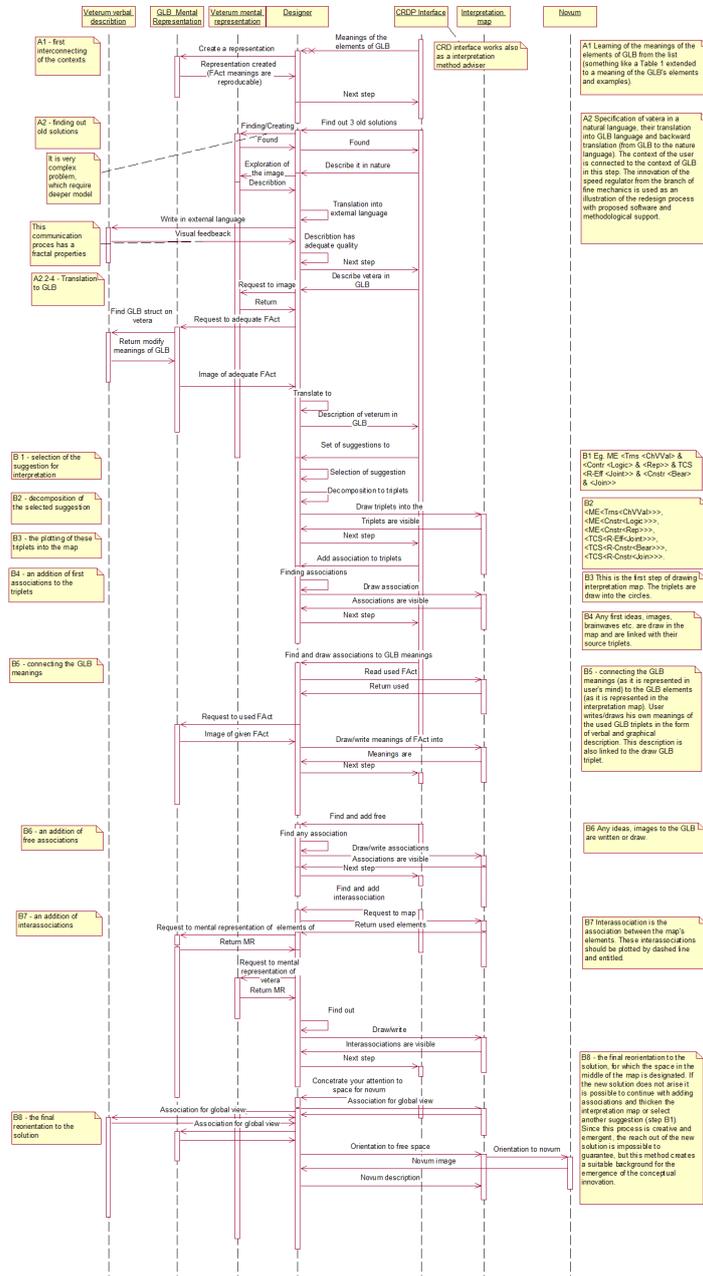
Figure 13.3: An example of sequence diagram - communication between user (designer) and CRDP software.

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.
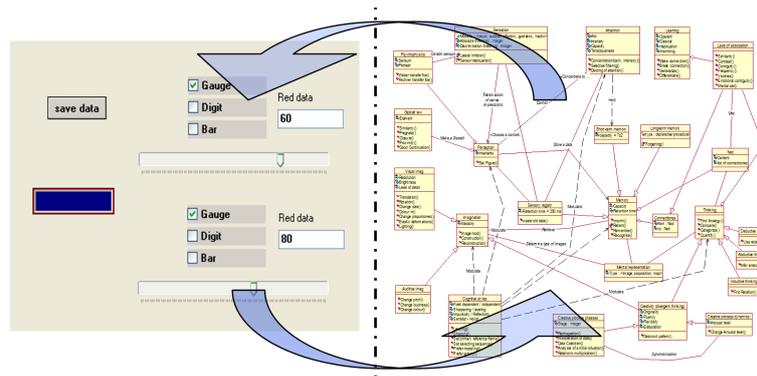

Figure 13.4: The interaction between proponed interface and model of human cognitive system.

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.

Emotion recognition from speech

Knowing the mental state of somebody could be useful for a lot of applications. For instance, we already stated in LAB. 6 that the measurement of the EDA was used for the evaluation of the psychological state of operators with high responsibilities.

It is also known that one's voice changes depending on their state. That is why there have been a lot of experiments in this field and some of them are still ongoing. The main goal of these works would be to be able to build a model of emotion recognition from speech, which hasn't been effectively done yet.

This kind of knowledge could then be used for different applications, for example :

- Improvement of voice command (for a better understanding of voice commands made by the user to the machine) ;

- Improvement of synthetic voice (so that it seems more human) ;

- Improvement of the service given by call centers ;

- New acting methods/tips for actors ;

- Communication for people in the autistic spectrum or with communication disabilities (for a better understanding of other people or creation of a new way to communicate feelings to others) ;

- Better understanding of some brain malfunctions ;

- Detection of stress and tiredness in operators (for example in conversations between pilots and control on the ground) ;

- ...

The situation today

In the following paragraphs, we'll detail further the results of some of the experiments that have been lead on the subject until now.

What are the methods used to figure out emotions in speech?

In the research papers reviewed, the experiments have been done on given extracts of oral speech, that can be from recorded conversations, actors' work, etc. Therefore, emotions are either simulated (by actors), forced (induced by the context) or natural.

One of the main problems is to find the acoustic features of speech that could be used as efficient parameters to decipher emotions, since the list is very long, as shown in Fig. 12.5.

Some experiments show that the "best" parameters can be different depending on the emotion. However, certain parameters seem to have shown significant results many times : prosodic (mainly the fundamental frequency F0), time-related, articulation or energy-related parameters for example.
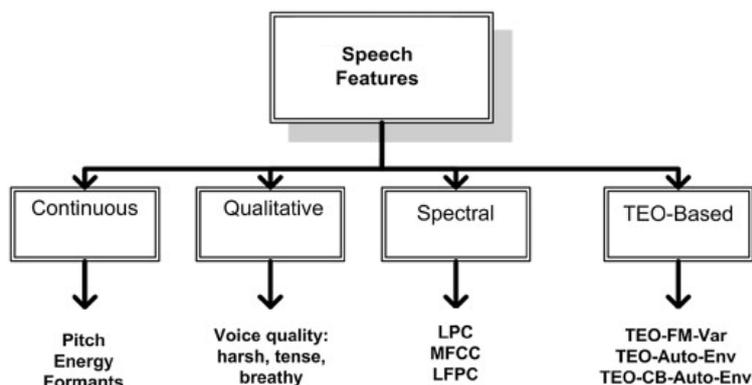

Figure 13.5: Example of parameters

Then, with the chosen parameters, a classifier has to be built.

After this step, there's a need to create what is called an Emotional Speech Database (many already exist and some of them are public) in order to train and evaluate the performance of the classifier. Usually they are built with simulated emotions from actors who have to read and act on a given number of sentences that will induce a certain emotion that can be categorized.

In addition to acoustic features, it's also possible to consider other speech features, like linguistic and discourse information. However, to use linguistic features, it's necessary to implement a word-recognition system too.

The basic architecture of an emotion recognition system can be seen in Fig. 12.6.
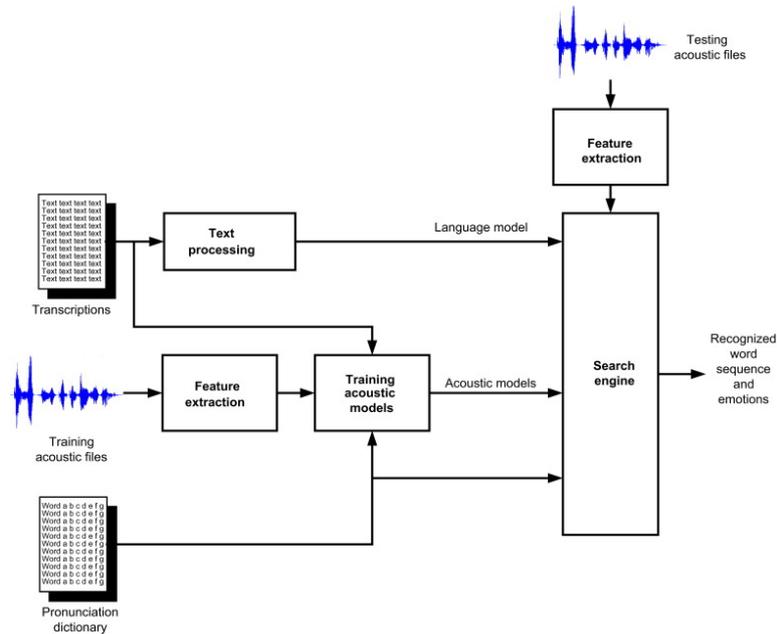
Figure 13.6: Architecture of a speech emotion recognition engine combining acoustic and linguistic information

Furthermore, note that the whole process can be done "off-line" or in real time (then it is called automatic).

Remarks

Nowadays, we can see from the experiments that it is not possible to reach a total accuracy for now. Furthermore, the efficiency will be significantly lower if the recognition is automatic and if the emotions analyzed are not "basic" ones (because the boundaries between subtle emotions is blurry). It also seems that acoustic features are the reference over linguistic information (maybe because the efficiency of the latest is lowered by the imprecision of word-recognition systems).

However, some simple solutions for emotion recognition in speech have been developed and made accessible to a broad audience. For instance, many Matlab algorithms have been written and put online (it is possible to find or ask for source codes of some of them on YouTube). Universities or research centers working on the subject have sometimes also made their work available. In the next paragraphs, we'll take a closer look at one platform in particular, called EmoVoice, a project from the University of Augsburg.

EmoVoice

In the words of its creators, EmoVoice is "a framework for emotional speech corpus and classifier creation and for offline as well as real-time online speech emotion recognition". It is built in a very user-friendly way : its interface is designed in way that enables non-experts to build their own emotion recognition system.

How does it work?

The emotion recognition system in EmoVoice uses only acoustic information and its basic architecture is similar to the one described in the last paragraphs and Fig. ? (without linguistic information). The emotional speech database is built with the help of the Velten mood induction technique. A set of sentences that should elicit a specific emotion in the reader is included. Also, EmoVoice already contains a database built with this sentences, made with the help of some students, but it is possible for the user to use this set (or even write other sentences) to create a new database. The emotions induced can be labelled as follow : positive-active, positive-passive, negative-active, negative-passive. These are designed from four emotions : joy, satisfaction, anger and frustration.
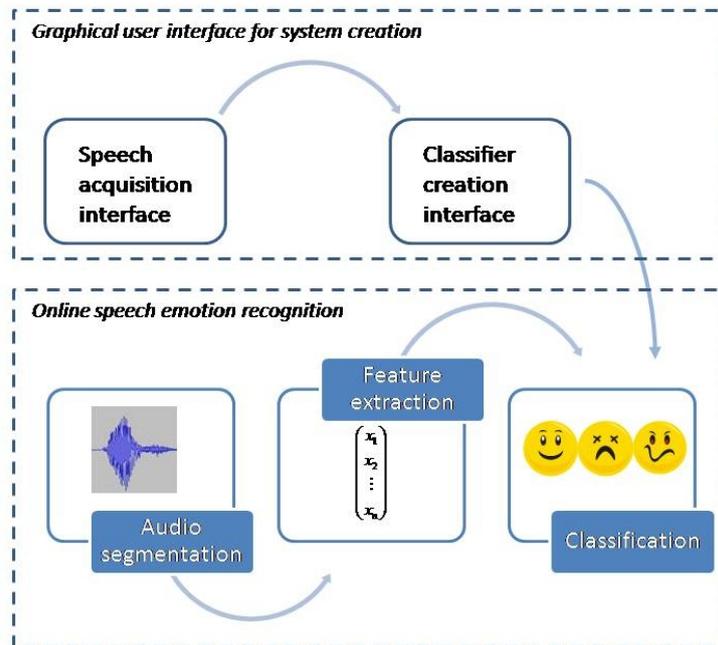

Figure 13.7: Architecture of EmoVoice : 3 steps

As seen in Fig. 12.7, there are three steps to fulfill for emotion recognition in speech :

Audio segmentation

Firstly, the speech extract has to be cut into segments that will be used as meaningful classification units. Since EmoVoice doesn't use linguistic information, there's no need to use a word-recognition software and the units don't necessary have to be words or utterances.

For this purpose, a *voice activity detection* (VAD) algorithm is used. This technique is used to detect the presence or absence of speech, and helps cutting the signal into segments that contain pauses of 200 ms maximum. This method has had positive results in similar contexts, it is fast and it seems there can be no change of emotion in the duration of one segment.

Feature extraction

The aim of this step is to find out which derived values from the acoustic signal are going to give useful information on the emotion expressed in one segment, so that the number of properties to use can be reduced : it will prevent the use of redundant properties or non informative ones.

Classification

There are two classification algorithms in EmoVoice : a Naïve Bayes (NB) classifier and a Support Vector Machine (SVM) classifier. The later has a higher classification rate and is widely used for offline emotion recognition but can only be used in real-time with a significant reduction of the number of features used, whereas the former works fast even with a high number of features.

External applications

EmoVoice can also be integrated into other applications, for instance in a humanoid robot or a virtual agent. For further information on this, please visit the project's page on the website of the University of Augsburg.

Sources - to write

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