UNIVERSITY OF BIRMINGHAM

Universität zu Köln
Medizinische Fakultät

Internship report about Computational Neuroscience in Birmingham from March to August 2015

Supervisor
Dr. Di Luca
M.DiLuca@bham.ac.uk

Intern
Robin Gutsche
Matrikelnummer: 5818656
r.gutsche@smail.uni-koeln.de

Table of contents

1. Application

I preferential applied for English speaking countries to improve my English. Actually I applied for the UK and the USA. Normally I contacted the group leader of different research groups. First I thought about which field of neuroscience I was most interested. I was really interested in cognitive neuroscience. After I was clear about in which field of neuroscience I wanted to do my internship, I searched for several research groups for cognitive neuroscience and especially for computational neuroscience. Particularly I was interested in how neuroscientists and computer scientist work together and what their every day research looks like. After some Skype Interviews with different researchers I applied for, I decided to go to Birmingham the second biggest city in the whole UK. Unfortunately the costs of living are very high that I recommend for students who want to go to the UK really should think about how to fund six months abroad, especially if you are not able to get a scholarship as in my case.

Despite of missing skills in statistic, programming and psychology, which I highly recommend for every student, who wants to do an internship in computational neuroscience, I decided to choose the research group of Dr. Massimiliano Di Luca for computational neuroscience and cognitive robotics at the University of Birmingham, in which I pass my internship from March to the end of August.

2. Description of the research group

2.1 Research focus

The research group led by the lecturer in computational neuroscience Dr. Di Luca is a research laboratory of the University of Birmingham and is called TIME Lab (Time and Interaction in Multisensory Environments). The research group consist of approximately 10 to 15 researchers. Most of them were PhD students or Master Students with either a background in psychology, neuroscience or computer science.

The research group focus on studies of the human perception means it focus on how human perception and action can be quantitatively described through computational models. The goal is to understand how the brain combines multisensory information for perception and action. The areas of research include multisensory interaction, time perception and haptic. All the sensory modalities are in focus of interest apart from the smell sensory modality.

Some of the research areas are “Temporal factors in multisensory integration” and “Perceptual recalibration”, means for example an audio-visual stimulus differs considerably. The light and sound have big differences in their physical propagation velocity. So how do we perceive sensory signals into one correct coherent multimodal percept? Which mechanism does our brain use to combine information across separate sensory channels into synchrony?

Another research area is "Visual-haptic interaction" which aims to understand illusions like the "Rubber-Hand Illusion", where arise the feeling that a rubber hand belongs to one`s body or the "Out of Body Illusion", where for example participants having the illusion of owning a stranger´s body and being located in that body´s position in the room. Apart from the illusions, visual-haptic research focus also on completely basic research like how do we perceive roughness vs. smoothness or hard vs. soft? And can we use the knowledge from this research and use it for example to transfer the feeling of roughness into a virtual reality?

2.2 Projects of the research group

Some interesting projects of some members of the lab I like to mention. For example one of the PhD students was doing an EEG project about the temporal recalibration effect, which is the adaptation of synchronicity perception between stimuli from different modalities to previous asynchrony presentation. The classical temporal recalibration experiments apply an adaptation phase lasting for several minutes. This type of recalibration has been linked to gradual phase shifts of entrained neural oscillations. However she wanted to show that recalibration can take place far more rapidly, on a trial-to-trial basis. By doing a simple audio-visual TOJ task (a temporal order judgment task about judging which stimulus came first) and recording the EEG Signals, she wanted to show that for the neural basis of this type of recalibration, a gradual adaptation mechanism does not seem feasible.

Another quite interested experiment from one PhD student was also an audio-visual TOJ task. But in this case subjects judged a change in the trajectory of a moving visual stimulus preceded or followed the onset of a brief sound. In one condition the two events took place at an unpredictable time, while in another condition there was a cue indicating the location of the change in trajectory, leading to a predictable timing of the event. He could show that such a spatial cue led to a better performance in temporal order judgments and suggest that the brain is capable of exploiting spatial cues for the prediction of stimulus timing and this can improve the precision of temporal order judgments.

3. My tasks

3.1 My tasks during the internship

In the first weeks of my internship I needed to read lot´s of papers to get in the topic and get acquainted with MATLAB. After having some conservations with everyone of the research group about their projects and their research aims my supervisor gave me my own project. My regular working hours was very flexible. Sometimes there was a day you came early in the morning and leave late in the evening but sometimes you have few to do because everyone of your lab is very busy. A regular meeting was on Monday, for planning the program for the following week, and on Friday, the Lab meeting where everyone of the Lab attended.

3.2 The role of vision for perception of human body properties

Introduction:

We investigated how we perceive the softness of a human body. We can judge the softness of somebody else's body or of our own body by pushing against it with our finger and by the integrating two sources of information one from the finger, the other from the touched location. But what happens if somebody else would press his or her finger against us? Do we judge about the properties in the same way like someone else does?

Touch is part of the haptic system. Information about the properties arrive the cognitive processing system about cutaneous receptors in the skin (Tactile information) and kinaesthetic receptors in muscles, tendons and joints (Proprioceptive information) [1]. Normally pressing against an object's surface allows us to assess softness by combining force and indentation information, which primarily is a judgement about compliance and related to the Law of Hook [2]. Results found by S.J Bolanowski et al. [3] showed significant differences in estimating the size of a ball either using tactile information of the finger or by the forearm. This effect could be described due to different tactile sensitivity of the finger and the forearm. So we expected differences in the softness perception between two individuals. Moreover humans usually integrate haptic and visual information resulting in a visual dominance [4]. Thus we expected a difference for participants performing the tasks in no view versus in full view.

Procedure:

Experiment 1.

To answer these questions 42 female undergraduate students of the University of Birmingham (aged 18 to 29) participated in the experiments. Only female participants took part in the experiments to exclude possible gender biases (i.e. females might expect the skin of a male to be harder). They were all compensated 6£/hour for their time. Participants were instructed to wash their arms and hands before the beginning of the session and dry them throughout. The experimenter then marked 10 points on each participant left forearm. Points were arranged in two parallel lines at intervals of 4 cm. The points indicated the location that participants were asked to touch while performing their judgment.

The experiment started with a practice task. Each participant sat at a table in front of the experimenter while the other participant waited outside the room. Each participant assessed the softness of 5 cubic and cylindrical composite silicon objects [5] by gently pushing down on them with the right index finger. Participants were required to find the cylinder among a series of 9 that was most similar in softness. There was no restriction on task time. They wrote down which cylinder approximated the object to be judged. Cylinder were 3 cm in diameter and 3 cm in height, and were composed of different ratio of 9 so to achieve the following Young's moduli: 46.9, 52.6, 59.8, 61.6, 73.8, 82.3, 102.6, 144.9, 146.0 kPa. Cylinders were washed and immersed in warm water to approximate body temperature, so to prevent biases in perceived compliance [6]. They were then dried and lightly powdered with chalk to reduce stickiness.

After the practice task, two participants sat at a table facing each other at an arm length distance. The experiment lasted roughly 40 minutes. Participants performed three types of judgments, whose order was counterbalanced across participants:

- Touch other; They assessed the softness of the other participant's left forearm by gently pressing the right index finger against it
- Being touched; They assessed the softness of their own left forearm while the other participant pressed the right index on it
- Touch other; They assessed the softness of their own left forearm by pressing their right index finger against it

Participants were divided in three groups of 14 participants with different viewing conditions.

- Full view; One group performed the tasks in full view. A partition positioned across the table, prevented participants to see each other's responses.

- No vision; A second group had the view of the interaction prevented using a paper disk with a hole where the touching finger was inserted. The paper sheet was fitted as much as needed so as to prevent the view of the deformation without making contact with the surface being touched. Participants who were being touched were blindfolded.
- Occluded control; To control that participants in the full view condition didn´t just compare the visible indentation of the cylinder to the one of the forearm, the view of the interaction of the finger with the cylinders was prevented using a screen attached on the vertical partition so to occlude the top of the cylinder.

Results:

Results are analysed by using an one-way repeated measures ANOVA.
Surprisingly we didn´t find a difference between touching someone else or touching yourself. Results are very similar with no significant bias for every experimental set-up [No-vision: p=0,742, tstat=0,336, sd=13,250; Full-view: p=0,578, tstat=-0,570, sd=16,125; Control: p=0,832, tstat=0,216, sd=9,269].
More interestingly, we found a large bias for blindfolded participants during the being-touched condition. The being-touch condition shows a significant difference between participants with or without vision input, stating that blindfolded participants perceive themselves to be harder [p=0,001; tstat=-5,122; df=13; sd=14,385]. This effect disappears for participants performing the being-touch condition in Full view [p=0,979; tstat=-0,027; df=13; sd=14,518].

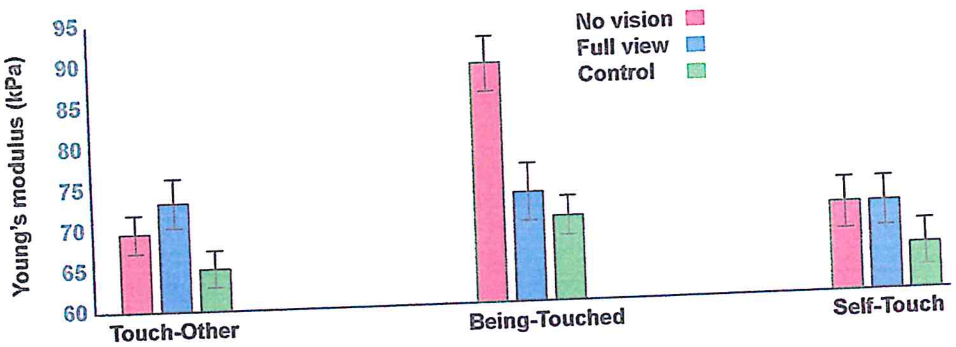

Figure 1. y-axis: Young´s modulus of the cylinders matched to the forearm across the 10 sampling points. Error bars are s.e.m. x-axis: The touch-other and the self-touch condition are perceived similar with no significant bias for every experimental set-up. The being-touch condition shows a significant difference between blindfolded participants and participants with full view of the interaction.

Conclusion:

As the results show, there is no difference between the self-touch condition and the touch-other condition. In other words, participants judge their own softness pretty much as someone else would do even despite from the different sensory sources.

To prove the finding that the visual input changes the softness perception of external touch to one owns body leading in a softer perception we run experiment 2.

Procedure:

Experiment 2.

The second experiment tested the immediate comparison of being-touched with vision and without. Participation was not in pairs. After the practice task (see Experiment1), the examiner (RG, male) touched 14 participants' left forearm (see Experiment1) either by covering the interaction of the touching finger with the paper disk or not. View of the interaction with the cylinder was prevented using the screen. The order of the two conditions was counterbalanced across participants. All in all the second experiment took about 10 minutes.

Results:

Results are analysed by using an one-way repeated measures ANOVA. We found again a significant difference between conditions as lack of vision leads to an increase in stiffness perception for exactly the same touched area and with the same applied force [p=0,012; tstat=4,829; sd=12,85]

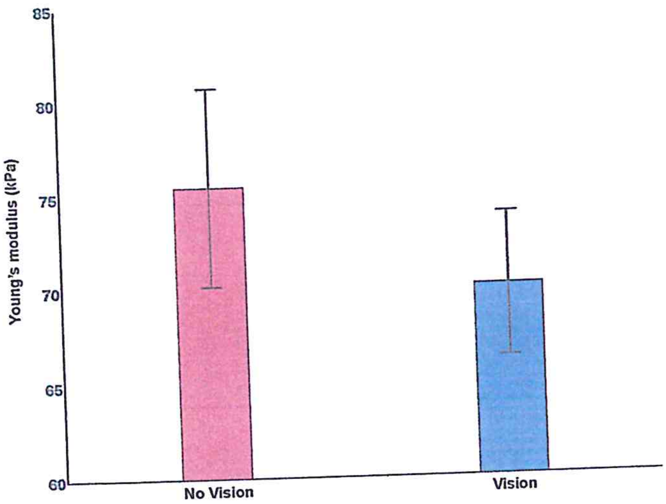

Figure 2 y-axis: Young´s modulus of the cylinders matched to the forearm across the 10 sampling points. Error bars are s.e.m.x-axis: red bar shows the no-vision condition; blue bar shows the vision condition.

Discussion:

Our results highlights the role of vision and lead to the assumption that vision is needed to determine material properties. We reason that an accurate estimation of softness requires force and indentation information. Our results imply that the person being touched acquires information about the amount of indentation only through vision and that a lack of vision leads to the reliance on prior assumptions, with an underestimate of indentation that leads to the perception of a harder body.

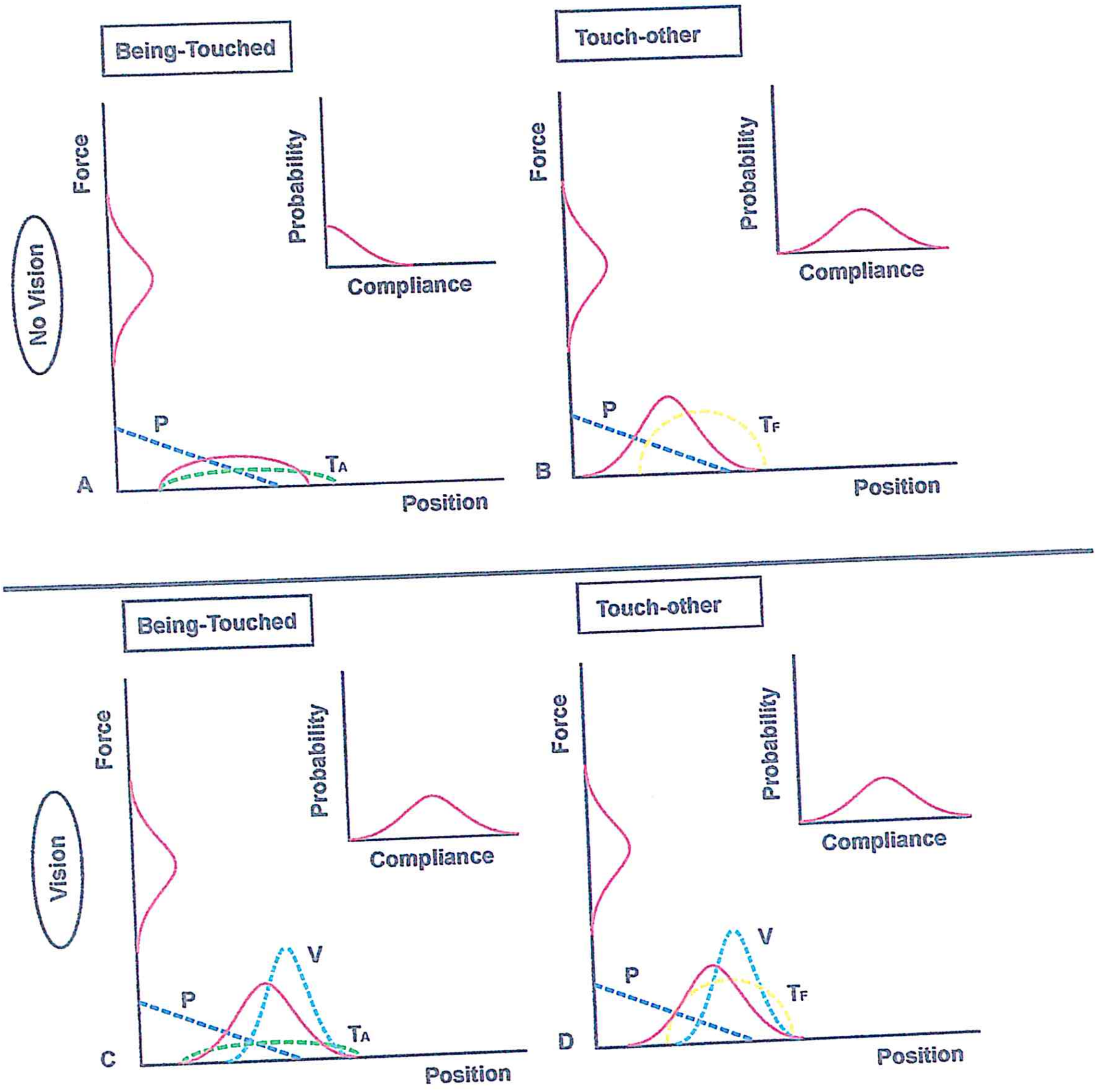

Figure 3 The prior assumption (P=information that the material doesn´t change) are available for every condition. Tactile information is perceived to the touch of the Arm (TA), has the lowest sense for the position, and the touch of the Finger (TF). The Vision Input (V) gives the best information about the position. The different integration of the sensory modalities in every condition leads to a different combination of Force, which is always the same, and position, thus to a different compliance.

3.3 Weighting of tactile and proprioceptive information for softness perception

Introduction:

Humans make frequent contacts with objects to interact with them, explore them, and ascertain their properties. As mentioned in "The role of vision for perception of human body properties" the brain estimates information about softness by combining the force and position using the integration of tactile information and proprioceptive information [7,8]. Humans are best in discriminating between two conditions when using the tactile modality and the proprioceptive modality together. We wanted to investigate in what way and how the brain weights this information. We expected that there is a difference in the efficiency of the two modalities. We suggest that tactile information have a larger effect to our judgement about softness for deformable objects than proprioceptive does [2] and for rigid objects it will be the other way around [9]. We suggest that humans making frequent use of tactile sensing, which makes us more, accustomed to it.

Procedure:

To answer these questions we used a Force Dimension Delta Haptic device, measured the proprioceptive modality, a Phantom Force Feedback Haptic Device and the silicon cylinders of Young moduli, which measured the tactile modality (see Experiment1). Silicon Objects softness and the Delta Haptic device stiffness ranged from 1-7 stimuli.

Students of the University of Birmingham were instructed to assess the softness of the presented rubber cylinders. One cylinder was placed on the Delta Device. The participants then explored the cylinder by using their right index finger applying a lightly pressure. During the haptic exploration the finger was connected to the Phantom Haptic Device, which recorded the forces used, specify the position and helped performing the haptic movement correctly. After exploring the first stimulus the experimenter removed the first cylinder and placed a second cylinder on the Delta Device. The participants repeated the procedure and report which of the two stimuli perceived to be softer. The experiment consisted out of 4 Blocks each with 56 trial-pairs.

Students had to decide which of two presented cylinders appear to be softer under four different conditions. The conditions were: soft object as stiffness varies, hard object as stiffness varies, soft spring as object varies and a hard spring as object varies.

To exclude that only haptic and proprioceptive information were used, participants were blindfolded, prohibiting visual cues, and wear headphones, prohibiting auditory cues.

Results:

Unfortunately the haptic devices were not reliable and data were useless. Therefore we had to discontinue the experiment for the internship. Results will show different Point of Subjective Equality (PSE) and Just Noticeable Difference (JND) for the difference between a hard versus a soft object and hard versus soft spring and give an explanation about how the brain weight tactile versus proprioceptive information and how it integrate and combine these information. This experiment will be completed in the future, therefore I may come back to finish the experiment.

3.4 ERP evidence for tactile softness versus hardness perception

Introduction:

We investigated the peripheral neural mechanism implicated in softness and hardness perception. As mentioned in 3.2 "The role of vision for perception of human body properties" a cutaneous input about tactile information is necessary for a softness discrimination of deformable surfaces. Cutaneous perception for the glabrous skin of the human hand is realised by four peripheral mechanoreceptor populations. Fast adapting units (FA), responding to a transient change in the stimulus and slow adapting units (SA), responding to a sustained stimulation. These FA and SA units are further differentiated in small, well-defined receptive fields (Type 1) and large, poorly differentiated fields (Type 2). The afferent fibres terminate in the dermal and subcutaneous layers of the skin [10].

La Motte and Srinivasan [11] speculated on the involvement of various mechanoreceptors populations and especially the SA1 units in the neural processing of softness and hardness. There have been fMRI studies about the haptic processing of hardness. S. Lederman et al. [12] found a contralateral activation in the postcentral gyrus (PCG) and bilateral activation in the parietal operculum, which suggest an activation of the insula and the somatosensory cortex during hardness tactile perception. However there is no published work about an EEG study on the neural processing of softness and hardness. There have been many studies to roughness perception using an EEG recording. Ballesteros et al. [13] found involvement of the N1-P2 complex, which is generated by the neural populations of the somatosensory cortex, and found also an activation of the left insula.

Therefore we expect also a difference between hardness and softness perception for the N1-P2 complex and also similar areas of neuronal activation.

Procedure:

For that participants sit in a chair in front of a Delta haptic device with their hand resting comfortably on a desk. They were blindfolded and introduced only to attend to the stimulus and to move as few as possible. An object was placed on the haptic device performing a gently touch to the fingertip of the fingers (index, middle and ring finger) of the participant. Every trial was repeated 100 times for every condition with the same force and the same contact time. After one condition the experimenter changed the object on the haptic device. The object placed on the haptic device was a soft object, a medium object or a hard object.

4.What did I learn? Which insights did I get?

During the internship you get many impression about very different areas of cognitive neuroscience. For sure it´s a very useful experience working in a research group. I could get a good impression of Cognitive Neuroscience and it´s methods used in areas like audio-visual experiments, haptic research and also EEG studies. Furthermore I could get an impression of how computer scientist and neuroscience could be combined and using the knowledge for robotics or virtual reality. A quite exciting part was the presentation of the results from the "The role of vision for perception of human body properties" project at the results at the WIPI Conference (Workshop on Interpersonal Postural Interaction) the 22/06/2015 in front of many experienced researchers. I am also writing my first paper which hopefully get´s public and not forgetting I improved my English language. A quite interesting experience I would like to mention is the Pint of Science Festival, which was from 18/05/2015 to 20/05/2015. At the Pint of Science Festival experienced researches give a talk about their research focus to the public in a pub. During two talks visitors had the chance to run some small experiments as participants. For that I helped out as a Science Busker, which means to run these experiments and to explain the visitors about the experiments. It was a nice atmosphere and something I highly recommend.

5. Conclusion

To have a short resume about my internship, I would recommend this kind of internship for everyone who is interested in cognitive neuroscience methods.

However it would be useful to have a stronger background in psychology, cognitive science or computer science because you will be much time on your own, means you have to look up many techniques you will use which takes you a lot of time.

One of my main goals was to improve my English that I´d say I truly achieved.

Furthermore it was very helpful for my further academic career to get a good overview of cognitive neuroscience and the connection to computer science.

These insights in the daily work of a researcher in cognitive neuroscience should really help me finding the right research area, which I am going to choose.

All in all the internship was a great experience nevertheless it´s hard to say if it really fits to the background of a student of neuroscience.

In the end I want to thank my research group under the leadership of Dr. Di Luca. Everyone of research group was very friendly and very helpful. A special thank goes to Dr. Di Luca who made this internship possible for me and try to integrate me as best as possible in his research.

6.References

1. Lederman S. J, Klatzky R. L. (1987), Hand movements: A Window into Haptic Recognition, Volume 19, Issue 3, Pages 342–368
2. M. A. Srinivasan, R. H. LaMotte (1995), Tactual discrimination of softness, Journal of Neurophysiology, 73(1), 88-101
3. S.J Bolanowski, R.T. Verrillo, F. McGlone (2003), Passive, active and intra-active (self) touch, Behavioural Brain Research 148 (2004) 41-45
4. Ernst MO & M. S. Banks (2002), Humans integrate visual and haptic information in a statistically optimal fashion, *Nature* 415, 429-433
5. Di Luca M, Ernst MO (2010), Learning to use an invisible Visual Signal for Perception, Current Biology 20, 1860-1863
6. Sullivan A. H. (1927), The cutaneous perceptions of softness and hardness, Journal of 1Experimental Psychology, 10(6), 447-462.

7. Kuschel M, Di Luca M, Buss M and Klatzky R.L (2010), Combination and Integration in the Perception of Visual-Haptic Compliance Information, 234 IEEE Transaction on Haptics, VOL. 3, NO. 4
8. Lederman S.J, Klatzky R.L (1990), Haptic classification of common objects: Knowledge-driven exploration, Cognitive Psychologie Volume 22, Issue 4, Pages 421–459
9. Di Luca M, Knoerlein B, Ernst M.O, Harders M (2011), Effects of visual–haptic asynchronies and loading–unloading movements on compliance perception, Brain Research Bulletin Volume 85, Issue 5, Pages 245-259
10. Vallbo A.B, Johansson R.S (1984), Properties of cutaneous mechanoreceptors in the human hand related to touch sensation, Human Neurobiology 3:3-14
11. Lamotte R.H, Srinivasan M.A, Lu C, Klusch-Petersen A (1994), Cutaneous neural codes for shape, Canadian Journal of Physiology and Pharmacology, 72(5): 498-505, 10.1139/y94-073
12. Servos P, Lederman S, Wilson D, Gati J (2001), fMRI-derived cortical maps for haptic shape, texture, and hardness, Cognitive Brain Research 12, 307–313
13. Ballesteros S, Muñoz F, Sebastián M, García B and Reales J (2009), ERP evidence of tactile texture processing: Effects of roughness and movement Soledad, Third Joint Eurohaptics Conference and Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems