

Efficient tongue-computer interfacing for people with upper-limb impairments

**Ph.D. Lecture**

**by**

**Hector Alejandro Caltenco Arciniega**

**Wednesday 1 June 2011**

This thesis is based on Hector Alejandro Caltenco Arciniega's research work at:

**Center for Sensory-Motor Interaction (SMI)**

**Department of Health Science and Technology**

**Aalborg University**

**Denmark**

To fulfil the requirements for the Ph.D. degree, Mr Hector Alejandro Caltenco Arciniega has submitted the thesis: Efficient tongue-computer interfacing for people with upper-limb impairments to the Faculty Council of Medicine at Aalborg University.

The Faculty Council has appointed the following adjudication committee to evaluate the thesis and the associated lecture:

**Ph.D. John Paulin Hansen**  
**Århus University**  
**Denmark**

**Associate Professor Ian Scott MacKenzie**  
**York University**  
**Canada**

**Chairman:**  
**Associate Professor Winnie Jensen**  
**Center for Sensory-Motor Interaction**  
**Denmark**

**Moderator:**  
**Associate Professor Erika Spaich**  
**Center for Sensory-Motor Interaction**  
**Denmark**

The Ph.D. lecture is public and will take place on:

**Wednesday 1 June 2011 at 13:00**  
**Center for Sensory-Motor Interaction – Room No. E3-109**  
**Fredrik Bajers Vej 7 D-3**  
**9220 Aalborg East**

# **Programme for Ph.D. Lecture on**

**Wednesday 1 June 2011**

**by**

**Hector Alejandro Caltenco Arciniega**

Efficient tongue-computer interfacing for people with upper-limb impairments

Chairman: Associate Professor Winnie Jensen

Moderator: Associate Professor Erika Spaich

13.00 Opening by the Moderator

13.05 Ph.D. lecture by Hector Alejandro Caltenco Arciniega

13.50 Break

14.00 Questions and comments from the Committee.  
Questions and comments from the audience at the  
Moderator's discretion

16.00 (No later than)  
Conclusion of the session by the Moderator

After the session a reception will be arranged.

# Efficient tongue-computer interfacing for people with upper-limb impairments

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**Hector Alejandro Caltenco Arciniega**

## **Abstract**

An efficient interface between a user and a computer system that ensures a correct degree of control and a correct interpretation of the user's wishes is vital for human computer interaction. Because the available motor functions of people with tetraplegia are scarce, they may not have the ability to efficiently control standard input devices, such as keyboard or mouse. They may need a computer interface requiring a minimum number of physical operations or movements. Therefore computer interface designers often minimize the number of keys or functions available for use. In many cases this leads to single switch interfaces, in which the user can only press one button, resulting in slow and tedious interaction. However, a fair amount of operations can still be allowed in computer interfaces for some people that still have complete mobility and control of complex manipulators, such as tongue and eyes in case of individuals with spinal cord injury. The objectives of this Ph.D. research are to research methods for designing an accurate and efficient inductive tongue-computer interface (ITCI), which ensures a sufficient degree of control and a correct interpretation of the user's wishes. In order to design efficient tongue-computer interfacing methods for people with movement disabilities, several studies were performed.

In the first study, a web survey collected potential users' opinions of their current computer interfaces. Also their desirable applications for future independent control of assistive devices were assessed. The study provided valuable insight on what should be done and what should be avoided when designing computer interfaces, as well as helped to prioritize alternative applications to interfaced by the ITCI. In the second study, tongue-selectivity experiments were used to evaluate intra-oral target selection performance. The results helped to determine the appropriate number of intra-oral targets and their optimal location. The third study evaluated functionality of the ITCI as a text-input and pointing device. Character selection and target pointing and tracking exercises were performed over three consecutive training sessions. From this study, it was clear that it was necessary to improve the accuracy of sensor selection for text-input with the ITCI. Therefore a fourth study evaluated three different feedback types that improve the accuracy of text-input: visual feedback, tactile feedback and mouse-pointer feedback (using an on-screen keyboard). Visual feedback was selected as the default typing feedback method for further studies and further development of the ITCI. The fifth and final study evaluated typing and pointing performance of the ITCI over an 18-session training regime dispersed over a period of two months. This study was also used as an iterative design process of tongue-computer interface software that extends the functionality of the ITCI. The software provides visual and auditory feedback for sensor selection and command acknowledgement. It also provides the text prediction capabilities that improve text-input.

In summary, results from the studies showed that the ITCI is a feasible way for people with severe upper-limb impairments to control a personal computer. Tongue-computer interfacing show promising results as an alternative text-input and mouse-pointer control method for individuals with severe physical disabilities. Motor learning evidence support the notion that the tongue can rapidly learn novel motor tasks, and the viability of using the tongue to control personal computers.