**Submission Summary**

**Paper ID:** 144  
**Title:** Fostering BCI interoperability  
**Abstract:**

**Background and Objective**

In the last decade, the number of groups involved in BCI research has increased tremendously. They have often tackled similar problems in different ways, generating a multitude of BCI systems that are incompatible with each other, even if they solve the same classes of problems.

The co-existence of several systems may represent a richness if, their parts could be made interchangeable or at least could cooperate. To achieve this goal, standardization is needed to:

1) lead to the adoption of a common BCI model, shared among BCI researchers with different backgrounds;
2) provide interchangeable modules, forming a BCI system (SW and HW) by means of the adoption of standard interfaces;
3) promote easy data sharing among different research labs;
4) allow for a reliable comparison among different systems (a well defined unambiguous metric assumed).

We are currently fostering a solution to the aforementioned issues as part of the planned activities of the TOBI project [TobiWeb], and seeking involvement of BCI groups from outside the project in the planning and implementation phase.

**Methods**

Defining an architecture is a different concept from implementing yet another BCI software. Our aim is to analyze common features of BCI existing implementations and synthesize general rules that would make implementations complying to the standard interoperable.

The approach we follow is based on three main cornerstones:

* Iteration: The development of a body of definitions, specifications, and guidelines will follow a top-down procedure, improving their granularity at each step. This approach allows for a gradual standardization of legacy implementations that are initially interconnected at a limited number of interfaces, and are then blended at a lower level.

* Consensus: The standardization procedure will avoid dominating opinions, with the aim of getting to a standard that is really taken up by the involved actors. This approach was primarily followed in the internal TOBI project committees, and is now being replicated in clustering meetings with representatives of other projects.

* Negotiation: As it is unrealistic that a slow consensus raising action can keep pace with the need for prompt solutions required by experimental research, standards must be open to incorporate new solutions (bottom-up approach). On the other side, when consensus is reached, developers who implemented solutions under loose standard specifications, will be invited to continue their development in agreement to the new ones.

**Results**

Five European BCI labs (based in: Lausanne, Switzerland; Berlin, Würzburg, Germany; Graz, Austria; Rome, Italy) participating in the TOBI project committed to using a shared common architecture for their experimentation.

First agreements were reached on:

* A logical framework, with a high level definition of the processing modules and a
fine grained definition of the interfaces between them (based on [Mason03]).
* The use of GDF files format [Schloegl06] for the exchange of raw EEG data. Additional features will be addressed through the use of an additional xml file.
* Specifications of interfaces downstream of data acquisition and feature translation, communication to applications.

Discussion and Conclusions
The proposed concept has strong implications both on the software engineering side, promoting the use of Component Based Development and Interface Definition Languages, and on the IPR side, allowing for a free choice by IPR holders on whether to disclose their source code, while keeping the overall architecture an open standard.
The establishment of standards would represent an important opportunity to join efforts within a fragmented research field and a milestone on the way to the development of fruitful interactions with other research fields (rehabilitation engineering, machine learning, human-computer interaction, neuropsychology, etc).

References

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Component based architecture, software infrastructure, consensus building, standard interfaces, exchangeability

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