

Towards a European Jurisdiction based on Brain Computer Interfaces

Martin Glettler Thomas Grechenig

Abstract—As demonstrated in our recent work “Improving the accuracy in person lineups and identification via brain-computer interfaces“ we used brain computer interface technology to distinguish between known and unknown persons faces when presented to a witness as a set of stimuli. The classifiers are built using the BCI2000 framework, a multi-purpose research software. In this paper we will extend this approach and explore the potential of our “BCI based analytic proof” in detail at the example of Austria, a jurisdiction in the European Union.

Keywords—BCI, Brain computer interface, BCI2000, P300, Evoked Potentials, Improving Accuracy in person lineups, Eye-Witness, BCI based Jurisdiction

I. Introduction

„The anvil of the law has always resounded to the striking iron of science“[1]

Over the last two decades, brain-computer interfaces (BCI) have emerged as a new frontier in assistive technology since they can provide an alternative communication channel between a user’s brain and the outside world. We filter and modify this approach, and have demonstrated that it is possible to distinguish between known and unknown subjects when presented as stimuli. To evaluate how this approach could be used in European jurisdiction, we benchmark the concept of a BCI based analytic proof against the federal law of Austria, an EU Member State.

II. Electroencephalography

Based on the facts and rules for already approved technology in criminal trials we must compare the BCI technology in detail to existing solutions like a polygraph.

Martin Glettler
Technical University Vienna
Austria

Thomas Grechenig
Technical University Vienna
Austria

A. Technical aspects

BCI based classification can be accomplished by measuring specific features of the user’s brain activity that relate to his/her intent to perform the control. From the technical aspect, our BCI approach is based on EEG and is therefore limited by all aspects that apply to clinical EEG setups. EEG does not measure changes in blood flow in the brain, nor does it measure the metabolic rate. Instead, it records the electrical current produced by brain activity measured via electrodes attached to the subject’s scalp. This approach can only record electrical activity occurring near the scalp and cannot probe deeper into the depths of the skull and brain.[2]

EEG lacks the spatial resolution and specificity of PET (Positron emission tomography) but has a better temporal resolution, and is better at detecting the nuanced timing differences of measured brain activity which is crucial for P300 experiments. An EEG based BCI is a computer-based method for interpreting EEGs which pass through a series of signal processing algorithms and are classified based on numerous features such as frequency, events, or localization. BCIs can identify specific patterns of electrical activity associated with brain diseases or neurological disorders, such as slow brain waves associated with dementia.

A specific type of brain activity is termed a “neurological phenomenon”. As an example, when a particular movement such as right index finger flexion is performed, or only imagined, the specific neurological phenomena that correspond to that action is generated. Those features are then filtered and translated into signals that are used to control devices, or result in a classification like yes/no, true/false or in this domain „perpetrator recognized“.

B. BCI based Identification

Since the process of identification itself is subject to various influence factors like prejudgments, stress or even misleading and too detailed descriptions by police-officers, this may result in false positives, and false convictions.[13] The positive aspect of the BCI approach is: it is involuntarily, and remains unaffected by conscious decisions since it is based on the P300 paradigm, an infrequent or particularly significant auditory, visual or somatosensory stimuli interspersed with frequent or routine stimuli evokes a positive peak at about 300ms after the stimulus is received.

III. Austrian criminal law

To gain better insight and to be able to estimate the potential of BCI based trials in Austria / Europe, it is useful and necessary to identify the major influence factors in this legislation. Austria is a democratic, federal republic and its public constitution is based on old structures. The Austrian legal system consists of public law, private law and criminal law. Through the Constitutio Criminalis Theresiana, which came into effect in 1768, Austria had a uniform, substantive criminal and criminal proceedings law. In 1804, a new law came into effect, which was amended in 1852 and remained valid till 1974 where the StGB (Strafgesetzbuch) came into effect. Substantive criminal law is the branch of public law that defines criminal acts and sets out the respective criminal penalties.

Within the concept of criminal law, one differentiates between judicial criminal law and administrative criminal law depending on whether the criminal law is to be enforced by the courts or by the administrative authorities. Thus we focus on judicial criminal law. The requirements of culpability correspond to an arbitrary, factual, unlawful and culpable behavior (the act must be linked to the offender) which serves as the entry point where a BCI based analytic approach could be used.

In detail, the StPO (Österreichische Strafprozessordnung) - the Austrian code of criminal procedure defines where we need to focus on the paragraphs which deal with the means, production and interpretation of evidence and the process which regulates the procedure to bring forward incriminating evidence:

A. Examination of the accused under section §164 StPO

Define Authorities inform the accused person about the crime and the charges against him/her, while there is an option to plead no contest, during an examination there is no option to talk to a lawyer. While this is a common paragraph it doesn't stand against the BCI approach, since it does not limit the technological aspects of this process, nor does it limit the procedure itself apart from the fact that violence or coercive must not be used to force an admission.

B. Hearing of the witness under section §160 - §163 StPO

Define The most important technological aspect of the hearing of a witness deals with remote sessions, when the person is not able to/ or can't testify in court (i.e. in cases like child abuse). This solves a trivial problem: location. A major influence factor for any successful and high quality BCI measurement is the environment itself. (clinical/lab). The BCI measurement must not be disturbed by any radiation, noise, unpredictable interruptions, or public attendance of any third

parties. To ensure acceptable results and limit the error rate, a suitable environment must be granted. This paragraph §160-§163 could be the entry point to contribute BCI measurements in court via a remote session.

The second important finding deals with person lineups, in paragraph §163 where a group of persons may be shown to the witness. Any identification must be testified, any known subject must be reported, and the circumstances must be told. There exist detailed studies of the efficiency of such person lineups and the overall process.[10] In Austria the process must be documented in written form and may be supported by imaging procedures. This is important because the „mapping of active regions of the brain“ is an imaging procedure and part of the BCI approach. The third fact that may help to establish the BCI approach is part 2 of 3 in §163 where all stated information in §163 applies for „Einsicht in Lichtbilder und der Anhörung von Stimmproben „ (to view pictures or hear audio-recordings of voices). In terms of BCI this correlates exactly to visual and audio stimuli which are presented during recording a BCI dataset.

C. Expertise - under section §125-§127 StPO

The improvement of justice with the aid of Expert Witness [11] is a traditional valid method once special expert knowledge which is not available in court or its personnel pool, and it is appreciable for the trial, or the hearing of evidence. There is a list of available experts which may be contracted. This paragraph is necessary to enable BCIs in court since the knowledge to build, measure, interpret, and control a BCI experiment is at expert level and must not be done by novices.

D. Judicial inspection and crime reconstruction under section §149 StPO

Judicial inspection refers to sense perception of an item or process or their documentation by images or audio recordings. The procedure itself can be ordered by the prosecutor or the court and is valid evidence. Presenting these images or audio recordings in court may serve as the basis to broaden this approach for the result of the BCI analysis, which produces a documentation of responses of the persons brain to such material. [9] Does he react to the scene in an appropriate manner or is it most likely that the subject has never been there, or does not show any signs of recognition (places/items/scenes).

IV. Analysis

There are a few paragraphs which lead to the conclusion that it would be possible in theory, to produce evidence by the use of the BCI analytic proof approach. To build a more stable basis we wider the thesis by referring to the so called “Grundsatz der freien Beweiswürdigung“ §14 StPO, - the principle of the optional consideration of evidence. Due to an

inaccurate translation and for the purpose of completeness this paragraph states:

„Ob Tatsachen als erwiesen festzustellen sind, hat das Gericht auf Grund der Beweise nach freier Überzeugung zu entscheiden; im Zweifel stets zu Gunsten des Angeklagten oder sonst in seinen Rechten Betroffenen.“ [14]

This tells that it's up to the court to decide whether a demonstrative evidence may be used or not. There are no rules which define exactly what may be used and what must be excluded. Today based on this paradigm, a lot of trials started to use evidence based on new technology (i.e. Email and digital-signatures)

This approach of demonstrative evidence is not new in other countries, since in 1962 W.P.Mahle stated in „Medico-Legal Aspects of the Electroencephalogram that EEG is „a newcomer to the field of demonstrative evidence“. His approach was solely based on EEG as a method to proof the effects of brain injuries at the courtroom instead of x-rays medical drawings or scale models. But still it was used to support the testimony of medical experts. In comparison to our BCI approach, the method itself but not an expert would help the witness to testify by brain wave analysis and serve as a scientific proof. In the US, the Federal Evidence Rule 702 states:

„If scientific, technical, or other specialized knowledge will assist the trier of fact [jury] to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise.“

, and was amended in 2000 by:

- the testimony is based on sufficient facts or data..
- the testimony is the product of reliable principles and methods
- the witness has applied the principles and methods reliably to the facts of the case

It is evident that the Austrian law has no such standards or fundamentals to build on, but at the same time it isn't restricted by these definitions like Daubert Standard or Frye [12] where the rules how such evidence must be produced, and what quality aspects must be met - are defined in detail .e.g: "The Daubert Standard goes a step further than Frye and requires the forensic scientists to prove that the evidence is fundamentally scientifically reliable, not just generally accepted by his/her peers in the discipline"[3]

In such an environment of „not defined“ the principle of a BCI based analytic proof may also be misused and turned upside down, from an approach to proof that „something is true“, that recognition happened or that a specific reaction is shown, to a dark scenario where the absence of reaction to a scene, or the disability to react to P300 paradigm is used to defend a guilty perpetrator as described in the „Braunstein“-case from 2007 in which evidence produced by a PET system out of the defendant's brain was used in an attempt to show

that he was unable to have planned a sexual assault, which he did not contest committing, and so could not form an intent to commit the crime.

The Braunstein case is described as an attack which was planned with precision. Dressed as a firefighter on Halloween, Braunstein set off a smoke bomb in the lobby of a coworker's apartment building and then knocked on her door, claiming that he had come to assess the damage to her apartment. When the victim let him in, the perpetrator used chloroform to knock her out, stripped her, tied her to her bed, forced a pair of high-heeled shoes onto her feet and sexually assaulted her for the next 13 hours. His defense never contested that he had committed the assault. Rather than the expected insanity defense, however, his not-guilty plea was based on the contention that he was unable to form an intent to commit the crimes with which he was charged. The definitions of US crimes require that a defendant be found both to have committed the act in question and to have done so with intent.[4]

Another issue is called „marketplace dynamics“ where a method or procedure which is expensive and applied in court rapidly forms a type of „their own industry“. For example by describing economic forces and marketplace dynamics of neuropsychological practice, where 20% of all neuropsychologists reported involvement in forensic practice as a source of supplemental income while the average hourly fee charged for legal-related activities is 150% versus the average hourly assessment rate/treatment rates of neuropsychologists.[5]

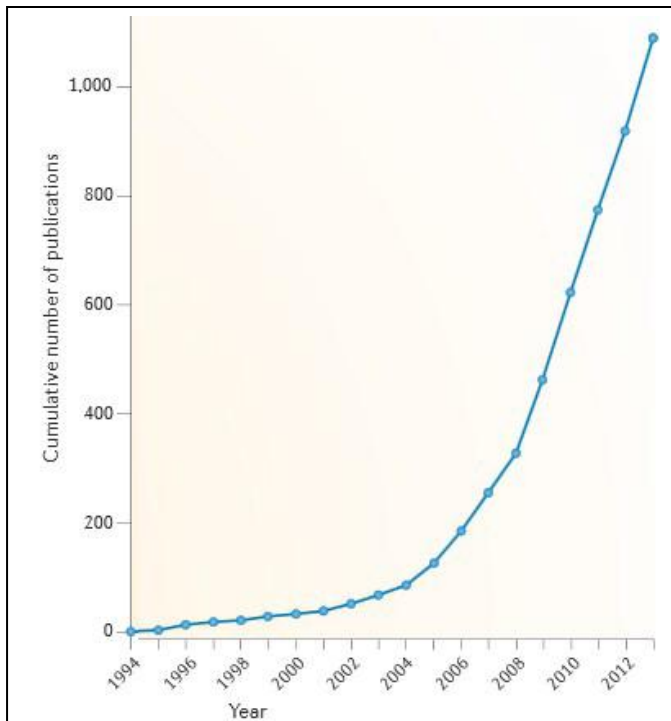
The BCI approach is not immune to this type of marketplace pressures. Well it's not based on an experts opinion. It uses systematic classification algorithms and mathematical filter models, but generates the need for „building such services“, BCI-centers with experts, scientific programmers and dedicated research scientists. These persons would be on a list (which already exists in Austria for other expertise) and would most likely be contracted on a regular basis due to the lack of experts in the field. The following graph gives a good insight how popular this topic is already, by displaying the cumulative growth in the number of 'law and neuroscience' publications between 2003 and 2013:

Figure 1. Cumulative growth in the number of 'law and neuroscience' publications between 2003 and 2013. [6]

Driven by the amount of activity worldwide we will probably see this trend continue over the next few years, which is highly desirable to drive growth and development in both sectors BCI's and Law.

A. Admission of lie detectors

To force someone to participate in a lie-detector setup is prohibited by Article 6 I by the ECHR (European Convention on Human Rights). In Germany the first decision about the use of lie detectors in court dates back to 16.02.1954 where all lie detectors were banned in German trials by the BGH. They based the decision on the thesis that the German StPO §136a



StPO „geschützte Freiheit der Willensentschliesung und Willensbetätigung des Beschuldigten“ - a paragraph about free/declared-will is breached. In 1981 the German Bundesverfassungsgericht confirmed this approach once again, but had to deal with reactions. The approach to protect an accused persons human rights by banning lie detectors when the subject agrees to use it to testify his innocence was criticized. In 1998 (17.12) th BGH changed directions and stated that lie detectors are allowed to protect your freedom.

In Austria, there are two court decisions available at the OGH, where the first statement from 24.11.1966 interdicts the usage of lie detectors even if the subject demands for such a test, and they used the very same reasons like the once back than in Germany. Also in 1977 the OGH confirmed the decision again but never revoked it. Today's attitude hasn't changed much but comes down to the question if a system could be built that is 99.99% accurate. This question depends on, who tests the system, how is such a study built, and who's the beneficial.

B. *BCIs aren't lie detectors*

The polygraph, which measures activity of the peripheral nervous system to detect deception, has been the primary technical method for lie detection during the last century. Beginning with the Frye /US (1923) decision, most U.S. courts have expressed disapproval of polygraph-based evidence. The U.S. Supreme Court has noted the lack of consensus on the reliability and admissibility of the polygraph and courts remain largely hostile to its admission into evidence. A meta-analysis commissioned by the U.S. Department of Defense found the sensitivity and specificity of the polygraph to be 59 and 92% respectively.

The National Academy of Sciences report from 2003 laments the lack of definitive research on the accuracy of the polygraph under various conditions and estimates it to be in the vicinity of 75%; as high as 99% and as low as 55% depending on the setting (i.e., experimental vs. forensic), questioning format, the operator, and response classification rules. BCIs critically differ from the polygraph in that they measure the central (brain) rather than the peripheral (galvanic skin response, heart rate, blood pressure, and respiration) correlates of the nervous system activity. [7]

The BCI approach itself is different by nature, as it doesn't use any of the polygraphs features, nor does it use the same procedure. It's just the simplest next best thing that comes to people's mind when they have no idea what a BCI is. Its lies deep in the humans mind to compare the unknown to something similar in memory, but it's not helpful here and should be avoided. A polygraph uses two major sets of tests:

- 1) tests of the crime knowledge (indirect)
- 2) tests of comparison (direct)

The BCI approach analyzes responses to visual/auditory stimuli, e.g. by determining and analyzing the timing and frequency response to the P300 paradigm in a set of images or person lineups [8] and is not a questionnaire. The method is different, the equipment is different, the outcome is different, the measurement is different and the ability of humans to pretend a reaction in exact 300ms is very unlikely. In polygraphs, the Test-coordinator itself is very important in terms of - how are the sets of questions prepared, how is the sequence and so on. In BCIs the same experiment setup can be used for several test-subjects, and it is not bound to any specific technical operator.

The lie detector in the U.S. Customs and Border Protection system: Automated Virtual Agent for Truth Assessments in Real-Time- or AVATAR, is capable of detecting changes in your voice as additional features which indicate a lie and is stated to be 94% accurate. Well 94% accuracy may be suitable for border protection but not for court decisions and trials. Other studies indicate that the power of lie detectors is solely built upon their believe in its efficiency. A lie detector is used to generate evidence that X =false. A BCI approach can only detect that X = true, or undetectable.

Which implies that the best case process works (simplified) as: "P300 pattern detected" results in a

- classification: recognition found
- proof established.

The absence of a classification does not indicate that the perpetrator is not among the subjects, it just states that a classification was not possible, due to various reasons. The BCI analytic proof approach does not respond to lies and is not built to detect lies.

v. Conclusions

We have covered the most aspects of today's BCIs and compared them to the current law in Austria where several paragraphs have been identified which can serve as a basis towards a European jurisdiction powered by BCI technology. The possible downsides of this approach have been examined by examples from related domains. Furthermore the two major questions have been answered.

- Is there a basis for the BCI analytic proof approach in the European jurisdiction example of Austria?
- Define the value of such BCI based evidence

At this stage the law of Austria isn't adapted to modern technology, but is flexible enough to allow such scenarios. The fact that it has been demonstrated in documented cases that technology like IP-tracking protocols, emails or digital signatures are used as evidence in court blazes the way for BCI technology based evidence. It's not a question of when will it be used in court, but how it will be used or misused. The technology itself is neutral, stable and reliable, but it needs a huge effort in research & development programs to establish a framework for scientific evidence which is accurate enough to be used in court.

References

- [1] H. W. Smith, Scientific proof, S. Cal. L. Rev. 16 (1942): 120
- [2] A. Teitcher, Weaving Functional Brain Imaging Into the Tapestry of Evidence: A Case for Functional Neuroimaging in Federal Criminal Court, 80 Fordham L.Rev. 355 (2011).
- [3] Jones, President's Editorial The Changing Practice of Forensic Science, 47 J.Forensic Sci. 437,437 (2002)
- [4] Paul S. Appelbaum, M.D., Law & Psychiatry: Through a Glass Darkly: Functional Neuroimaging Evidence Enters the Courtroom, Psychiatric Services 2009; doi: 10.1176/appi.ps.60.1.21
- [5] R. J. McCaffrey, A. D. Williams, J. M. Fisher, L. C. Laing, The Practice of Forensic Neuropsychology: Meeting Challenges in the Courtroom.
- [6] Owen D. Jones, Anthony D. Wagner, David L. Faigman and Marcus E. Raichl, Neuroscientists in court, 2013 Macmillan Publishers Limited, NATURE REVIEWS, Vol.14| Oct 2013| 735
- [7] Langleben, D. D., & Moriarty, J. C., Using Brain Imaging for Lie Detection: Where Science, Law, and Policy Collide, -Psychology, Public Policy, and Law. Advance online publication. doi: 10.1037/a0028841
- [8] M. Glettler, T. Grechenig, Improving accuracy in person lineups and identification via braincomputer interfaces, Natural Computation (ICNC), 2013 Ninth International Conference on. IEEE, 2013 doi:10.1109/ICNC.2013.6817991
- [9] Yarmey, A. D., Yarmey, A. L. and Yarmey, M. J. (1994), Face and voice identifications in showups and lineups. Appl. Cognit. Psychol., 8: 453-464. doi: 10.1002/acp.2350080504
- [10] F. Losel, D. Bender, 1992, Comparison of One-Person and Many-Person Lineups: A Warning Against Unsafe Practices; Influence of Eyewitness Observation and Photographic Presentation on the Identification of Persons in Lineups, From Psychology and Law: International Perspectives, P 275-291
- [11] Richardson, Orville, Improvement of Justice with the Aid of Science and Expert Witness, The. Wash. ULQ (1951): 498

- [12] Thatcher, Robert W., Carl J. Biver, and Duane M. North., Quantitative EEG and the Frye and Daubert standards of admissibility., CLINICAL ELECTROENCEPHALOGRAPHY CHICAGO-34.2 (2003): 39-53.
- [13] Gross, Samuel R., et al., Rate of false conviction of criminal defendants who are sentenced to death., Proceedings of the National Academy of Sciences 111.20 (2014): 7230-7235.

Resources: last accessed at 16.09.2014, 18:00:

- [14] [http://www.jusline.at/Strafprozessordnung_\(StPO\).html](http://www.jusline.at/Strafprozessordnung_(StPO).html)
- [15] <http://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=10002326>
- [16] http://www.zaoerv.de/59_1999/59_1999_4_b_1107_1132.pdf
- [17] http://www.zjs-online.com/dat/artikel/2011_6_504.pdf
- [18] <http://archiv.jura.unisaarland.de/Entscheidungen/pressem98/BGH/strafrecht/luegende.html>
- [19] <http://juris.bundesgerichtshof.de/cgi-bin/rechtsprechung/document.py?Gericht=bgh&Art=en&sid=3880f3efc32e18c3bc436660fba5ad71&nr=54661&pos=0&anz=1>
- [20] http://www.ris.bka.gv.at/JustizEntscheidung.wxe?Abfrage=Justiz&Dokumentnummer=JJT_19990415_OGH0002_01200S00034_9900000_000&IncludeSelf=True
- [21] http://www.ris.bka.gv.at/Dokument.wxe?Abfrage=Justiz&Dokumentnummer=JJT_19990415_OGH0002_01200S00034_9900000_000
- [22] <http://www.pnas.org/content/111/20/72306>