NEUROTECHNOLOGY

EEG Applications

This module focuses on BCI Applications that are using EEG since it is the cheapest and most mature technology available. You'll soon see that a wide variety of applications can be built with them.

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NeuroEntertainment

Neurogaming

Emotiv and NeuroSky are two companies which has developed games to go along with their eeg headset, however it seems as though Emotiv has stopped selling them. If you are interested in playing brain controlled games, you can start with Neurosky. Otherwise you might try your luck in finding some open source games.

References

- **NeuroSky store (http://store.neurosky.com/collections/apps/games)**
- **Brain Fighta, an open source eeg game (https://github.com/NeuroTechX/BrainFighta)**

NeuroToys

There have been multiple manufacturers of BCI toys going back to the mid 2000's. Here are some of the more popular ones.

References

- **Puzzlebox has various devices BCI devices (https://puzzlebox.io/)**
- **There are also Star Wars-themed toys! (http://starwarsscience.com/product/the-force-trainer-ii-hologram-experience/)**

Art

Multiple people have use EEG's for art and music generation. Below are a few example of some these projects.

References

- **Axon Art Collective. A Series of projects doing brain controlled art and music (http://axonartcollective.com/)**
- **Manipulating water with eeg (https://creators.vice.com/en_us/article/vvygzm/eunoia-seeking-enlightenment-by-tracking-brainwaves)**
- **EEG Visulization tool (http://naotohieda.com/muse/)**

Virtual Reality

Due to the design of VR headsets, there are been an interest in integrating eeg into them. This can help to enhance the experience for the user, as well as provide a hands free approach to interact with the virtual world.

There are a few companies who have been interested in bring EEG data with VR headsets as seen below.

References

- **Neurosky's article on the subject (http://neurosky.com/2016/04/a-new-virtual-reality-the-rise-of-vr-headsets-eeg/)**
- **Article on Mind Mazet (http://www.theverge.com/2015/3/3/8136405/mind-maze-mind-leap-thought-reading-virtual-reality-headset)**
- **DG Lab's VR Zen Headset (https://www.cnet.com/news/this-vr-headset-is-designed-to-let-you-find-your-zen/)**
- **Neurable (http://neurable.com/)**

Security

Brain based authentication

EEG Biometrics is a growing field which looks at how we can use your eeg activity to be able to identify someone. Similar to one's fingerprint, your brain activity can be used as a form of authentication. The most common forms of Brain Authentication are using resting state brain activity or a visual evoked potential task. For more information on Brain Based Authentication, check out this DEF CON talk.

References

- **Brain Based Authentication (https://www.youtube.com/watch?v=frAhjtnvkqs)**

Biofeedback Therapy

Anxiety

Neurofeedback can be an effective method of handling anxiety. Similar to the methods used in mindfulness practices, alpha and theta training is done in order to put the person in a more relaxed state of mind.

References

- **Neurofeedback for mood and anxiety disorder (https://www.ncbi.nlm.nih.gov/pubmedhealth/PMH0070200/)**
- **Treatment of Anxiety disorder with neurofeedback (http://www.sciencedirect.com/science/article/pii/S1877042811018465)**

Sleep Improvement

Sleep research has been using EEG's for a long time. Recently, startups have been leveraging consumer grade eeg designs to measure the quality of your sleep.

References

- **https://iwinks.org/ (https://iwinks.org/)**
- **ttps://neuroon.com/sleep-tracking/ (https://neuroon.com/sleep-tracking/)**
- **http://sleepshepherd.com/ (http://sleepshepherd.com/)**

ADHD

Although a controversial **use case (http://journals.sagepub.com/doi/abs/10.1177/155005940904000311)**, there are many neurofeedback clinics and few companies who have created solutions to help manage ADHD.

References

- **http://www.akiliinteractive.com/ (http://www.akiliinteractive.com/)**
- **Attentiv (http://attentiv.com/)**

PTSD

PTSD neurofeedback has been studied for over **25 years (http://charleston.braincoretherapy.com/wp-content/uploads/2014/01/PENISTON-PTSD.pdf)**. A lot of the studies focus on getting the participants to generate alpha wave activity which is associated with being in a relaxed state. Most articles which were reviewed suggest that neurofeedback should be use in combination with other treatments.

References

- **Alpha-Theta Brainwave Neuro-feedback for Vietnam Veterans (http://onlinelibrary.wiley.com/doi/10.1111/acps.12229/full)**
- **Neurofeedback as an adjunct therapy for treatment of PTSD (http://journals.sagepub.com/doi/abs/10.1177/1039856217715988)** *

Cognitive Training

Performance Optimization

This series of articles discuss how you can you use Neurofeedback as a mechanism to optimizing performance. This is a good series of articles to start with if you want a high level overview.

References

- **EEG Neurofeedback for optimizing performance 1 (http://www.sciencedirect.com/science/article/pii/S0149763413002248#bib0700)**
- **EEG Neurofeedback for optimizing performance 2 (http://www.sciencedirect.com/science/article/pii/S0149763413002716)**

- **EEG Neurofeedback for optimizing performance 3 (http://www.sciencedirect.com/science/article/pii*/S0149763414000700)**

Brain Ageing

One of the more common services which neurofeedback clinics provide is to combat brain ageing. Researchers have found that you can identify certain biomarkers in QEEG to predict future cognitive decline as well as the onset of Alzheimer's.

References

- **Video games for cognitive enhancement - Adam Gazzaley Lab (http://gazzaleylab.ucsf.edu/wp-content/uploads/2014/09/Anguera_Nature_2013-Video-game-training-enhances-cognitive-control-in-older-adults.pdf)**
- **QEEG neurofeedback for Dementia (http://journals.sagepub.com/doi/abs/10.1177/1550059415590750)**
- **Beta and gamma neurofeedback on memory and intelligence in the elderly (http://www.sciencedirect.com/science/article/pii/S030105111300152X)**
- **Attential Training via neurofeedback in ageing bring (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5346575/)**
- **QEEG in Aging and evolution of Dimentia (http://onlinelibrary.wiley.com/doi/10.1196/annals.1379.008/full?wol1URL=/doi/10.1196/annals.1379.008/full&identityKey=c38f7acf-fae1-4f16-b3bb-d5a6f7e0fca9)**
- **Ref-6 (http://www.jpreventionalzheimer.com/1665-a-personalized-12-week-brain-fitness-program-for-improving-cognitive-function-and-increasing-the-volume-of-hippocampus-in-elderly-with-mild-cognitive-impairment.html)**

Early Development

Most articles looking into the use of EEG as a Neurofeedback tool for early development tend to focus using it for treatment of ADHD. However, there might be other use cases as well.

References

- **Cognitive Training enhances brain connectivity (Measured via MEG) (http://www.jneurosci.org/content/35/16/6277)**
- **EEG and behavioral changes after neurofeedback treatment in learning disabled children (https://www.ncbi.nlm.nih.gov/pubmed/14521276)**
- **ADHD and neurofeedback: a double-blind feasibility study (https://link.springer.com/article/10.1007/s00702-010-0524-2)**
- **EEG neurofeedback of SMR and beta frenquency for treatment of ADHD (https://www.ncbi.nlm.nih.gov/pubmed/6487671)**
- **Study on the effects eeg neurofeedback on children with ADD and learning disabilities (https://link.springer.com/article/10.1007%2FBF02214148?LI=true)**
- **Use of QEEEG-Neurofeedback for children with a history of abuse and neglect (http://www.tandfonline.com/doi/abs/10.1300/J184v10n04_02)**

Mindfulness

At a consumer level, mindfulness is one of the most common use case for EEG neurofeedback. Here are a few research articles as well as products that currently exist on the market.

References

- **Muse Research (http://www.choosemuse.com/research)**
- **NeuroSky's mindfulness app (https://store.neurosky.com/products/mindfulness)**
- **Neurophysiology review on Neural Oscillations and Mindfulness (http://www.sciencedirect.com/science/article/pii/S0149763415002511)**
- **Alterations in brain activity produced by mindfulness meditation (http://journals.lww.com/psychosomaticmedicine/Abstract/2003/07000/AlterationinBrain%20andImmuneFunctionProduced.14**

Accelerated Learning

The use of neurotechnology to accelerate learning is one of the subjects that remains of high interest, especially to **DARPA (https://www.darpa.mil/program/targeted-neuroplasticity-training)**. Here are some potential use cases of how you can use eeg to speed up your learning.

References

- **Use of B-Alert's EEG to create "Accelerated Learning" (http://www.advancedbrainmonitoring.com/neurotechnology/applications/accelerated-learning/)**
- **Memory consolidation theta neurofeedback (http://www.sciencedirect.com/science/article/pii/S0301051113002214)**
- **Non-invasive Brain biomarkers for cognitive-motor performance assement (https://link.springer.com/content/pdf/10.1007/978-3-642-21852-1.pdf#page=178)**

Enhanced creativity

One potential use case of neurofeedback training could be used to improve creativity. There has been a growing interest in exploring theta/alpha training. Based on the eeg paradigm which are being study, there is probably a lot of similarity to mindfulness training.

References

- **modulating slow waves EEG to enhance musical performance (http://journals.lww.com/neuroreport/Abstract/2003/07010/Ecological_validity_of_neurofeedback__modulation.6.aspx)**
- **A theory of alpha/theta neurofeedback to improve creative performance (https://link.springer.com/article/10.1007/s10339-008-0248-5)**

Rehabilitation

Stroke Recovery

Neurofeedback provides a potential opportunity to help patients recover from Stroke via neurofeedback. One case study, where on a 55 year old male had increased left-side activity within the 4-7 Hz range, used a neurofeedback therapy which aimed to decrease that frequency as well as increase activity within in the 15-21 Hz range in the sensorimotor and speech areas of the brain. By the end of the treatment the patient had improved speech and the depression and anxiety were gone.

References

- **Effects of EEG based neurofeedback training on memory function of post-stroke victims (https://jneuroengrehab.biomedcentral.com/articles/10.1186/s12984-015-0105-6)**
- **Neurotherapy for stroke rehabilitation (https://link.springer.com/article/10.1007%2FBF01474514?LI=true)**
- **The role of biofeedback in Stroke Rehabilitation: Past and Future Directions (http://www.tandfonline.com/doi/abs/10.1310/tsr1404-59)**

Addiction

The use of EEG biofeedback has been a subject of interest all the way back to the 1970's. There are some interesting connections in the change of eeg activity and drug dependency and the potential of eeg neurofeedback to help treat substance use disorders. This may allow for future neurofeedback products to be created.

References

- **EEG Biofeedback for Addictive Disorder (https://link.springer.com/article/10.1007/s10804-005-7030-z)**
- **EEG Biofeedback as a Treatment for Substance Use Disorders (https://link.springer.com/article/10.1007/s10484-007-9047-5)**
- **QEEG analysis of crack cocaine dependence (http://www.tandfonline.com/doi/abs/10.1300/J069v15n04_03)**

Rett Syndrome

Neurofeedback may provide a potential therapy to help those with Rett syndrome. Although it will not provide a complete relief, it can still help patients to manage its symptoms and have a better quality of life.

References

- **Cognitive training modifies eeg bands in those with Rett syndrome (http://www.sciencedirect.com/science/article/pii/S0891422216300099)**

Diagnostics

Concussion

Research has shown that there are noticeable changes in EEG oscillations after brain injury. This leads to the potential of creating eeg diagnostics. Current solutions like Brainscope, don't actually predict if a concussion is present. However it does provide some preliminary insight to clinicians so that they can determine if a person should get a PET/MRI scan.

References

- **Change in neural oscillations bands of mild traumatic brain injury patients (http://ieeexplore.ieee.org/document/7319994/?arnumber=7319994)**
- **Head injury assessment tool by Brainscope (http://brainscope.com/products/)**
- **EEG changes in mild traumatic brain injury in athletes (http://www.sciencedirect.com/science/article/pii/S0304394004015034)**

Alzheimer's

A growing body of evidence suggests that EEG analyses can be used in the early detect of Alzheimer's and may even allow for the diagnosis for different dementia subtypes. Most of the research has been done in academic environments, however there could be the potential to develop low cost medical testing devices.

References

- **Development of EEG Biomarkers for Alzheimer's Disease (http://www.advancedbrainmonitoring.com/EEGbiomarkersforAlzheimersDisease)**
- **EEG in patients with Alzheimer's (http://www.sciencedirect.com/science/article/pii/S138824570400015X)**

Epilepsy

Epilepsy is a disorder that affects over 50 million people worldwide, with 80% of cases coming from developing countries. There are some great opportunities in developing a low cost Epilepsy diagnostic with EEG's and which would help those that may not have the resources to properly test for the disorder.

Ressources

- **Epilepsy seizure detection using eeg time-frequency analysis (http://ieeexplore.ieee.org/document/4801967/?arnumber=4801967)**
- **Epilepsy care in developing countries (http://onlinelibrary.wiley.com/doi/10.1111/j.1535-7511.2010.01362.x/full)**
- **TeleEEG. a company which provides eeg analysis for epilepsy in poor countries (http://www.teleeeg.org/)**
- **Automated diagnosis of epileptic EEG using entropies (http://www.sciencedirect.com/science/article/pii/S1746809411000838)**