Applications and novelties of the TeamFlow mental training and measurement system

In recent years, cheap and simple dry electrode EEG devices have become widespread and popular**,** with the potential to make EEG-based applications faster, more convenient, more mobile and more massively available. Particularly in areas where results can be achieved with a minimum number of channels, but where less invasiveness and faster setup are important factors.

In the current research application, we present a visual and auditory ***neurofeedback-based mental training system*** developed for individual and group training and assessment. The system is based on a neuroscience background of cognitive abilities and exploits specific algorithms for learning development and the advantages of .

The Muse software uses dry electrode EEG devices for individual and group synchronous applications. Radio (Bluetooth) data transmission provides subjects with freedom of location during relaxation and various indoor and outdoor activities. Device validation: ***[1] [2] [3]***

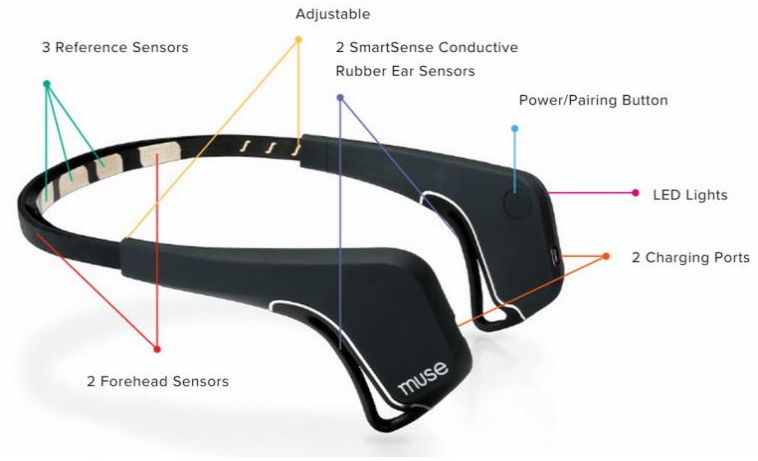

Figure 1.

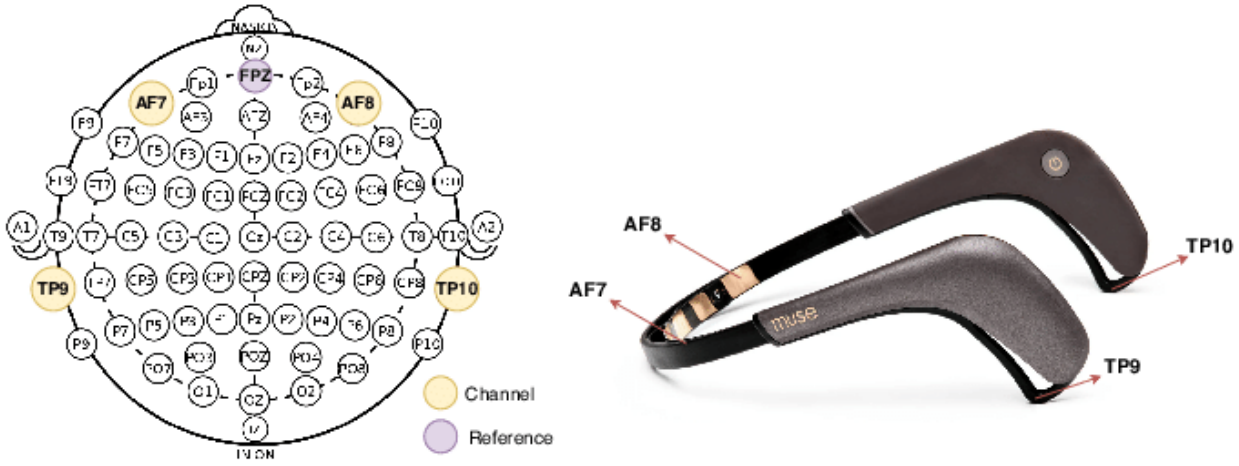

Figure 2. *Allocation of Muse channels in the 10-20 system.*

The TeamFlow system is backed by decades of development, testing, trials and academic application (more than 50,000 measurements) (even before the Muse EEG).

The app aims to improve cognitive skills and self-awareness, such as concentration, decision-making and coordinated teamwork, at individual and - as a first at international level - group level. Both in the individual target categories (*Measurement, Focus Enhancement, Decision Development, Stress Reduction,*

Recreation/Regeneration) and in the group target categories (*Measurement, Team Building, Competitive Spirit*), various modular neurofeedback lessons support the skills to be developed as well as general purpose, non-feedback measurements.

Based on a machine evaluation of the results of the lessons completed, an AI "*robot coach*" will make an offer for personalised neurofeedback-based development lessons to be completed the following week. Progress can be measured, results can be compared to the performance of the subjects' activities (e.g. sports, law enforcement).

In addition to the primarily processed frequency ranges (delta, theta, alpha, beta, gamma and frequency coherence), the graph evaluation module of the system also takes into account derived data, *virtual mind-map modeling*, and dynamic parameters related to typical behavioral and response patterns (e.g., emotional reactions, stress severity, recovery ability).

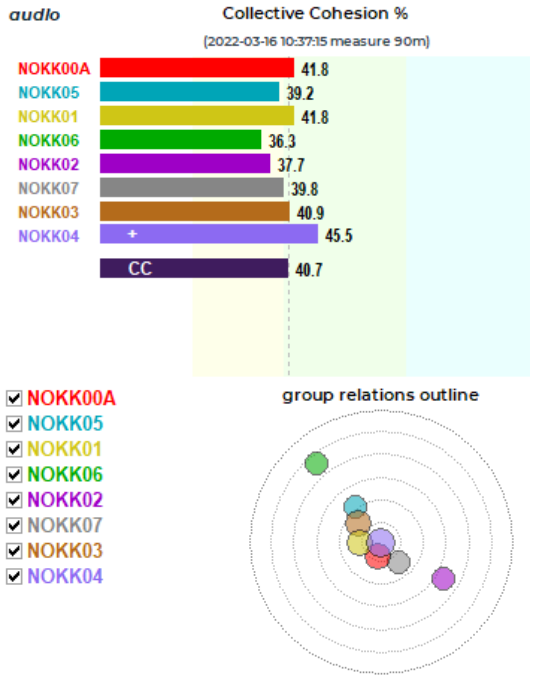

Figure 3. *Team cohesion, individual value added and sociometry*

The group evaluation (based on synchronous measurement of 2-8 people) is based on a significant number of empirical situational evaluations, e.g. the emergence of qualified roles at group level (leaders of armed forces teams, their supporters, etc.) or even the emotional-mental synchronizing effect of joke-telling at the level of a conversation. In the virtual mental space of the group, the attitude-attractors of the members can be well tracked.

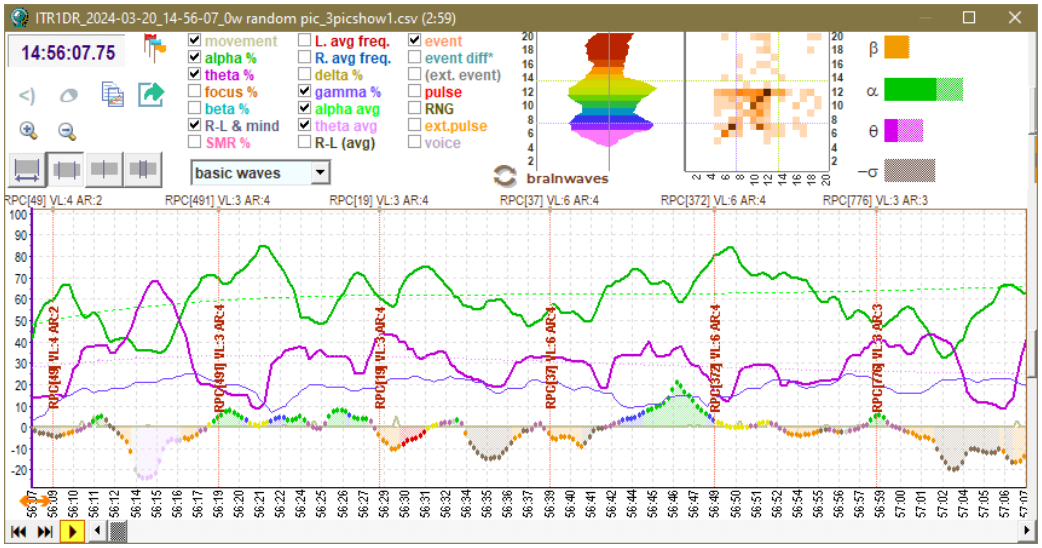

Figure 4 *Time series data section with event signals*

In addition to aggregated data, time series data (*with synchronous audio and video*) can be viewed and analysed against statistics of changes before or after event alerts.

Primary counted and derived numerical data can be exported for further analysis.

Previous application examples

Chess research, March 2018 **[4]**

Pilot research in decision sciences. We wanted to find out how chess players react to sharp situations and whether there is a difference in brain function when analysing strategic versus tactical chess moves.

We evaluated 10 chess players in three groups: women's top chess players (between 2200 and 2400 ELO points, 4 players), professional men's chess players (over 2500 ELO points, 3 players), amateur chess players (between 1800 and 2100 ELO points, 3 players).

The EEG system was complemented with synchronous heart rate measurement, a thermal camera and an eye-tracking device, as well as system-level integrated chess software.

The measured data can predict the quality of the decision up to 10 seconds before the decision. It can be seen when the dominance of the good decision pattern turns into the unfavourable one and the non-ideal decision pattern is made.

Based on the results and data samples, we also showed differences between the three groups.

Training: football/USA, August 2019

An afternoon was available to train a 24-man football team before their departure for an important match the next day.

Divided into six groups, they received short training in teams of four. During the exercises, some participants were observed to solve the task with different brainwave patterning behaviour than the majority of their peers.

Their coach confirmed the divergent patterns that emerged in the evaluation of the tasks, that the person who consistently supported the rise of his teammates throughout the game was the team captain. Thus, the coach received further objective confirmation that he had made the right decision in appointing the player as a quarterback. Further confirming feedback from the coach was that the players we marked with different brainwave patterning behaviours from the others in the separate groups during the evaluation were all playing the same position (defenders).

All the players who participated were enthusiastic about the training, to the point that some of them returned several times to try different mental tactics (focus on self, focus on others, focus on team). Despite the short practice time, they were able to repeatedly evoke the desired state of mind as a group and link it to their inner feelings through real-time feedback, creating greater alignment with their teammates.

According to their coach, they were up against a much stronger team than they had ever faced before and would have settled for a draw. This time, however, this team was mentally prepared and their experience in training had given them more confidence. They eventually won the match 2-0 against the stronger opponents.

Neurofeedback targeting lesson in pairs

New: a version of the previously existing individual targeting exercise, also individually assessed, but performed simultaneously and in a shared space for a pair. The lesson is called *"pair target", its* duration is 3 minutes, and it is recommended to be performed in a sitting position. The subject sitting on the left has the red target and the subject on the right has the blue target.

Neurofeedback "tools" for separate target acquisition on the targets shown in the virtual shooting range (Figure 5):

- the saturation of the alpha waves, characteristic of the resting state, which raises the aiming spike towards the centre of the target,
- the focus (coherent frequency image), which aligns the direction finder and the spike,
- or balancing the right and left hemispheres, which brings the lateral deviation to the centre.

Figure 5.

Therefore, the task for both subjects is: move the sight and the yellow target ball to the centre of your own target and keep it there as long as possible. Since optimal aiming is achieved with relaxed yet focused attention, the aim of the exercise is to test the subject's ability to aim calmly and maintain steady attention (aiming imitation movements are not required).

If you aim accurately and consistently, you will hear the sound of a gun firing from the right side. The software counts the number of virtual firing events, scoring them according to their start and number.

A pairs lesson, compared to an individual one, involves the potential motivation and distraction of each other, but most importantly the requirement that both of you focus on your own target.

Based on our previous experience, when compared to EEG measurements or tests of passive relaxation, this task, which requires focused attunement and feedback, better characterizes the subject's mental state. In addition, the dynamic factor of how quickly the subject is able to regain a focused state of consciousness in the event of a distraction or attention wandering can be assessed. In appropriate cases, it is also worthwhile to assess the results at the level of pairwise comparisons. Such specific ratings can be made by the evaluation software module.

This lesson should be used in a survey or research study in which a pair is asked to perform a coordinated and attention-demanding task under the pressure of the stressful situation before and/or after this neurofeedback exercise. Examples: professional exercises for armed forces, athletes, pilots or general surveys.

References

[1] Cédric Cannard, Helané Wahbeh, Arnaud Delorme
Validating the wearable MUSE headset for EEG spectral analysis and Frontal Alpha Asymmetry
IEEE conference, DOI: 10.1109/BIBM52615.2021.9669778

[2 Olave E. Krigolson, Mathew R. Hammerstrom, Wande Abimbola, Robert Trska, Bruce W. Wright, Kent G. Hecker and Gordon Binsted
Using Muse: Rapid Mobile Assessment of Brain Performance
2021 Jan 28. DOI: 10.3389/fnins.2021.634147

[3] Olave E. Krigolson, Chad C. Williams, Angela Norton, Cameron D. Hassall and Francisco L. Colino
Choosing MUSE: Validation of a Low-Cost, Portable EEG System for ERP Research
Frontiers in Neuroscience, 10 March 2017, DOI: 10.3389/fnins.2017.00109

[4] SportInno 2018 Conference presentation
The impact of chess on life