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SPECIAL ISSUE

Tuning, Not Training, the Brain for Sport

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In using neurofeedback with athletes one must consider both the uniqueness of the athlete and the purpose of the training. Our clinical experience suggests that using single hertz frequencies for assessment allows for the fine tuning of the training. For example, rather than training all athletes with alpha (8–12 Hz), you may find that the athlete who typically has high amplitude at 8 Hz needs to be made aware of when the 8 Hz is beneficial during competition but also that it may inhibit intensity and quality of performance during practice. Contrarily, the athlete with typically high amplitude at 12 Hz may be a great 'practice animal' but does not perform as well in competition. The ability to identify and change the states needed for different sport purposes is the goal of 'tuning' neurofeedback.

The use of biofeedback/neurofeedback for performance enhancement has progressed as the equipment and knowledge have advanced. Initially, owing to limitations in data collection, frequency bands were used (e.g., alpha 8–12 Hz) in recording and training the brain. The more traditional approach to training both downstream biofeedback (heart rate, temperature, electrodermal, muscle) and neurofeedback (theta, alpha, and beta) was to increase or decrease the response to the theoretical position of more or less is better. For example, alpha was to be trained up while theta and beta were trained down. In some cases, the training was recommended to continue until a norm was obtained. Interestingly, no norm for athletes for any of the modalities was ever published (to our knowledge), and the published norms were generally based on clients with pathologies and a comparative healthy population, clinical recommendations, or practitioners' best guesses.

We suggest that it is no longer sufficient to train the person to a preset frequency band, whether that is alpha enhance, or theta and beta inhibit. One can obtain more specific information from 1 Hz frequencies, or by using multiple site quantitative electroencephalography (EEG) with interactions among many sites and frequencies. Training can be tailored to the individual's brain; for example, if slow wave content occupies 2.5–6 Hz as opposed to 4–8 Hz, thresholds can be modified to make training more targeted to the individual in front of you. Since fewer clinicians use multiple sites for training, we are illustrating in this article the benefits of using 1 Hz bands, focusing on the traditional alpha band at site Cz to assess and tune the brain of athletes.

There are at least two issues that must be considered when tuning the brains of athletes: the athlete and the goal. The first is that athletes are different from the population from which most clinical data are obtained, and they also are different from the norm that is established from these subjects/patients (Wilson & Peper, 2011).

An example of difference in athletes was found (Wilson & Shaw, 2011) when clinical data suggested that very elite athletes had higher amplitude 10 Hz than less elite athletes (see Figure 1). Babiloni et al. (2010) and Yarrow, Brown, & Krakauer (2009) substantiated these findings doing research using full cap QEEG, noting several differences between elite athletes, lesser skilled athletes, and "normals." Thus, the skill level of the athlete is also a factor.

The second consideration is that the goal or purpose of training/tuning the brain of an athlete is not to "normalize" or have the person enter a stable state of relaxation or focusing, but rather to produce the mental conditions necessary to perform at maximum during dynamic competitive stress. Athletes themselves may not always know what mental state yields maximum results. For example, Harkness (2009) noted, in his biofeedback work with assisting Abhinav Bindra to the first Olympic gold medal for India, that Bindra felt that training the T3 alpha helped him to shoot calmly during the heat of competition, but the results indicated that he broke world records by up-training with 15–18 Hz at Cz. What feels good may be from years of doing something one way, but it may not always be the best strategy Another example that shows the complexity of mental states is that mental states for elite performance may have to be adjusted for the particular sport. Rifle shooters were reported (Hatfield, Haufler, & Spaulding, 2006) as shooting better when enhancing alpha

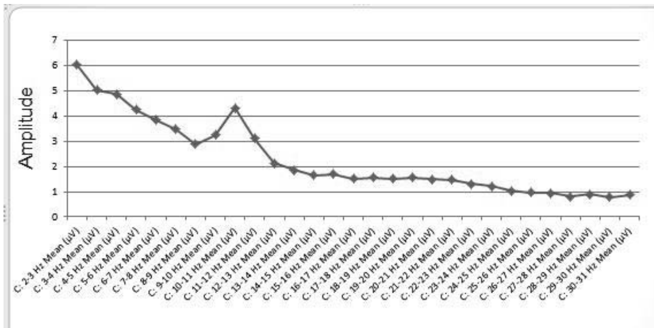

Figure 1. Higher alpha results from athletes from swimming, tennis, baseball, figure skating biathlon.

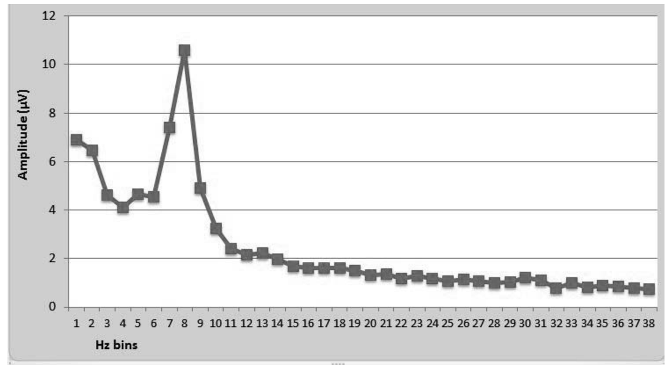

Figure 2. The profile of an athlete who represents 8 Hz dominance.

of the left hemisphere, and in some cases, quieting of the right hemisphere (8–12 Hz). In contrast, golfers showed no benefit from alpha state training but responded better to lessening frequencies in the beta band.

Regrettably, there has been insufficient research and clinical reporting to be able to recommend with any certainty what mental state is needed for elite performance and how to train for it. In the remainder of this article, we are presenting 1 Hz profiles that we often see in our clinical practice and how we believe they are related to the athlete's performance and guide our tuning of the athlete's mental state.

Single Hz Assessment

In addition to doing EEG assessment, we typically have the athlete's and coach's perception, mainly through paper-and-pencil inventories, of how they think and feel during practice, competition, and during critical moments in the event. The suggestions we make here are based on those inventories, which were taken when the athlete has performed well during practice or under competitive situations.

By moving from the alpha band (8–12 Hz) to single or dual Hz frequency bands, we feel we can better discern differences between the typical states of the athletes during practice and competition, or fine tune the findings. All measures are taken at Cz with the eyes open in a resting condition, which we find are repeatable across time unless there is a significant intervention or life event. The purpose of tuning alpha at Cz is to create the relaxation/energy state that is believed to be associated with a better, more automatic performance. Moving to another site, such as Pz, the goal may be to modify the information flow, specifically modifying the download speed of the brain.

Clinically, we have noted from paper-and-pencil measures that athletes who have increased amplitude in the lower alpha frequencies reported less anxiety/stress in competitive situations or critical moments compared to those who do not show this low alpha dominance. The latter group tend to report a greater problem in staying focused/motivated in long or dull practice settings. J. Gunkleman (personal communication, September 27, 2016) also suggests that individuals with low alpha dominance (e.g., 8 Hz) may be different from those who are 12 Hz dominant and that they should be tuned rather than merely trained to enhance alpha. He suggests that performers who have a higher magnitude of alpha at 8 Hz are typified by more difficulty practicing with intensity across time, but they perform well under stressful competitive conditions.

Natural 8 Hz Profile

Alan is typical of an 8 Hz profile (Figure 2). He is the athlete who drives the coaches nuts because they feel he does not practice seriously enough, and although he is a highly functioning member of a good university team, the coaches feel he will not be great because his practice habits are inconsistent.

Although Alan is not a great practice animal, he is tenacious during competition. Seldom does he lose focus, lack motivation, or become unduly stressed. He plays to his maximum regardless of the opponent or situation. Regrettably, coaches feel that his true potential will not be met because his practice is not consistent enough to create outstanding skills.

In the past we have not always tuned the EEG of this 8 Hz athlete. Instead, considerable time has been spent creating motivating scenarios on the court during practice: less time in group drills, constant competition in drills, with higher ranked partners, graphs of success in each skill element. Perhaps we need to fine tune awareness of 8 Hz and provide training in the difference of 8 to 12 Hz. Some 8 Hz shooters were trained to recognize and change from 8 to 12 Hz and reported being more attuned to visual input of light/range conditions, and more aware of kinesthetic/

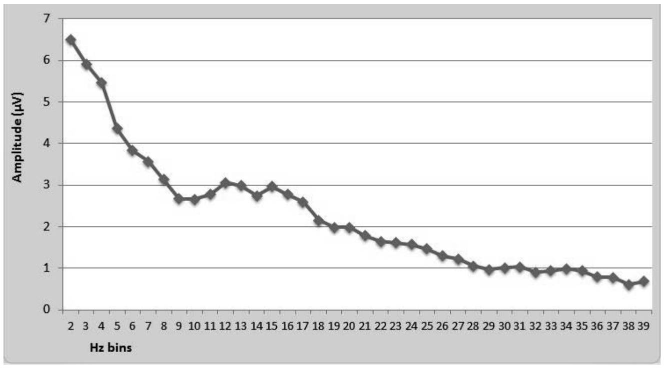

Figure 3. Typical profile of a natural 12 Hz athlete.

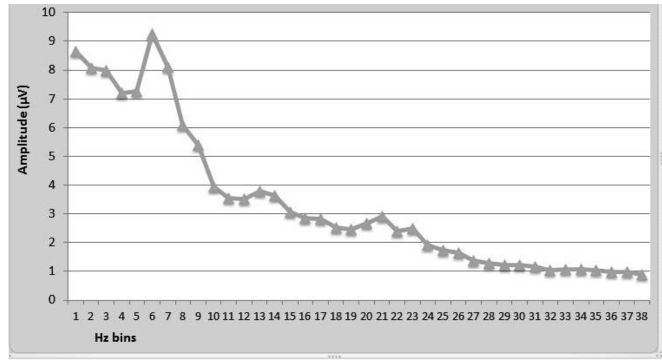

Figure 4. Profile of a gifted 10-year-old athlete with 12 Hz dominance complicated by elevated 6–7 Hz and elevated beta readings.

postural/tension, which in theory means they have the capacity to do something with that additional information. Individuals with 8 Hz are not so inundated with information that they might feel overwhelmed, which can happen to a 12 Hz athlete under competitive stress. The 8 Hz athlete gets boosted up into the sweet spot of information processing during competition. He or she feels dialed in and can rise to the occasion.

Site matters! If the electrode was at Pz when 8 Hz is dominant, then you are getting eight information packet downloads per second. When 12 Hz is dominant, then you are getting 12 downloads per second. More information can be better if you know what you are paying attention to. If you do not, more information can induce anxiety and produce unintended negative consequences. Hence tuning—both rewarding the 8–10 Hz and then the 11–12 Hz band independent from each other—creates discrete information processing states and also gives the athlete the capacity to shift between them.

Natural 12 Hz

Stan is an example of a typical 12 Hz dominant, highly skilled athlete (Figure 3).

Stan was known as the best practice athlete in the Academy: disciplined, focused, motivated, and always energized. The issue was that he was unable to perform anywhere near the same level in important competitions and would significantly tighten up during critical moments. Moreover, we suggest that the 12 Hz athlete may feel overwhelmed and may not know where to anchor attention. Being a 12 Hz natural athlete can be a gift, but the athlete may need to learn to shift dominant frequency, which is done through alpha tuning training. This can be done by increasing the 8–10 Hz band and feeling how it just takes the edge off the brain and processing is not draining/freezing the athlete. Just as the 8 Hz athlete needs to learn to "get up" neurally for training, the 12 Hz athlete needs to learn to "slow down" for competition.

Also noted in Figure 3 is the increase in 15 Hz activity, which may be interpreted as constantly problem solving or possibly monitoring/guarding for events. This probably contributes to the athlete becoming overwhelmed.

Neurofeedback training included enhancing low alpha around 8–9 Hz and identifying when the state moved back up to 12 Hz. Significant time was also spent teaching the athlete awareness of his facial and shoulder tension and how to lessen this during actual play. He was trained to briefly increase 8–10 Hz independently from 11–12 Hz. He needed to learn what strategies were helpful in increasing lower alpha and resisting his natural tendency to increase high alpha, which at times can be associated with the feeling of drinking from a fire hose. Although his faster resting individual alpha peak suggests that he can take in more information at once—or performs more downloads per second—if his attention is not anchored appropriately, he may feel paralyzed by information overload under stress. He needs to learn to slow his processing down slightly, not to slow down his reactions, but to tune down his download speed, and hone in on the most important aspects of his competitive performance. An action cue word assisted him during competition.

Younger 12 Hz Peak with Other Peaks

Tammi is a 10-year-old, highly ranked player (Figure 4). Coaches rate her as one of the top players in the country in skill but very low on mental performance during competition. She becomes tense and angry during competition and performs poorly but knocks the socks off everyone in practice.

In addition to a 12 Hz peak, the 6–7 peak increase could be interpreted as attentional difficulties but may also include her young age and her brain development stage (her Index of Alpha Frequency is 9.2 at site Cz according to Thought Technology hardware/software [Thought Technology, Inc., Montreal, Canada]). Coaches and parents both report that although she can hyperfocus for a certain period of time, she then becomes a "space cadet," with people wondering what she is focusing on. Also of note are the high 22 and 24 Hz that we typically find in other athletes who have a busy brain: judge, evaluate, and ruminate. Tammi is very young, but she has had great international experience, success, and failure, which have generated unusually high expectations and pressure (thus, most likely the unusually high beta for her age).

Summary

We believe that more information can be obtained by including 1 Hz frequencies in your assessment and understanding generally what the frequency represents, and then associating the frequencies with the actual mental state needed during competition. Data of elite performers would be a welcome addition to the biofeedback/neurofeedback field. The examples of differences between natural 8 and 12 Hz dominant athletes suggest that the person who comes to the clinic needs to be fully assessed, along with the sport requirements, before beginning to tune the brain.

References

Babiloni, C., Marzano, N., Iacoboni, M., Infarinato, F., Aschieri, P., Buffo, P., … Del Percio, C. (2010). Resting state cortical rhythms in athletes: A high-resolution EEG study. *Brain Research Bulletin*, *81*, 149–156.

Harkness, T. (2009) Psykinetics and biofeedback: Abhinav Bindra wins India's first-ever individual gold medal in Beijing Olympics. *Biofeedback*, *37*, 48–52.

Hatfield, B. D., Haufler, A. J., & Spaulding, T. W. (2006). A cognitive neuroscience perspective on sport performance. In E. Acevedo & Ekkekakis (Eds.), *Psychobiology of physical activity* (pp. 221–240). Champaign, IL: Human Kinetics Press.

Wilson, V., & Peper, E. (2011). Athletes are different: Factors that differentiate biofeedback/neurofeedback for sport versus clinical practice. *Biofeedback*, *39*, 27–30.

Wilson, V., & Shaw, L. (2011). Clinical use of a one Hz bin electroencephalography (EEG) assessment to distinguish elite from less elite and typical from atypical athlete profiles. *Biofeedback 39*, 78–84.

Yarrow, K., Brown, P., & Krakauer, J. W. (2009). Inside the brain of an elite athlete: The neural processes that support high achievement in sports. *Nature Reviews Neuroscience*, *10*, 585–596.

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