A Deep Dive Into Brainwaves: Brainwave Frequencies Explained

We've all experienced that magical feeling of being hit with 'a brainwave'. That moment of newfound clarity, shift in perspective or a novel idea. And typically, it seems to appear out of nowhere. In between sips of coffee, while out for a walk, or simply indulging your dog in a good belly rub.

While "a brainwave" can be a figure of speech to describe our thoughts, scientists and clinicians can use literal brainwaves, measured on the head, to help understand the functioning of the human brain. As it turns out, the key to having more of these 'aha' moments lies in understanding the science behind brainwaves. Neuroscientists have been studying brainwaves – the popular name for the field of electroencephalography – for nearly a century.

WHAT ARE BRAINWAVES?

The brain has billions of neurons, and each individual neuron connects (on average) to thousands of others. Communication happens between them through small electrical currents that travel along the neurons and throughout enormous networks of brain circuits. When all these neurons are activated they produce electrical pulses – visualize a wave rippling through the crowd at a sports arena – this synchronized electrical activity results in a "brainwave".

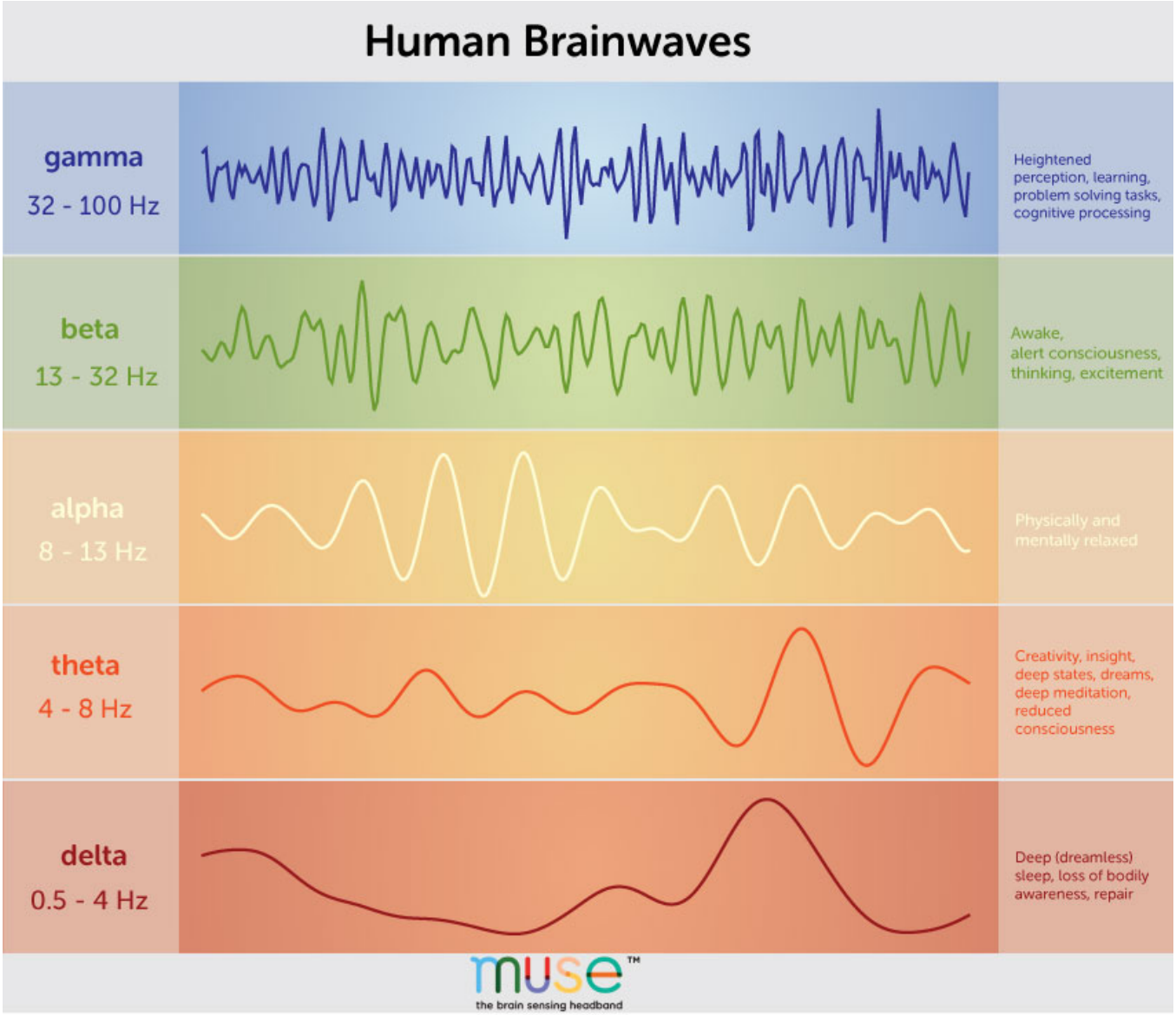
When many neurons interact in this way at the same time, this activity is strong enough to be detected even outside the brain. By placing electrodes on the scalp, this activity can be amplified, analyzed, and visualized. This is electroencephalography, or EEG – a fancy word that just means electric brain graph. (Encephalon, the brain, is derived from the ancient Greek "enképhalos," meaning within the head.)

One way that EEG 'brainwaves' convey information is in their rate of repetition. Some oscillations, measured on the scalp, occur at more than 30 cycles per

second (and up to 100 cycles per second!) These cycles, also called frequencies, are measured as Hz, or hertz, after the scientist who proved the existence of electromagnetic waves.

When looked at this way, brainwaves come in five flavours, each of which corresponds to a Greek letter. As we'll see, these different brainwaves correspond to different states of thought or experience. While there are many other ways to analyze brainwaves, many practitioners of a field called neurofeedback rely on dividing brain oscillations into these five categories.

Some of these brain oscillations are more easily detectable on specific parts of the scalp, corresponding to the parts of the brain just below. The brain has many specialized regions which correspond to different processes, thoughts, and sensations. Particular oscillations often reflect distinct regions and networks in the brain communicating with each other.



THE 5 MAIN TYPES OF BRAINWAVE FREQUENCIES

Different patterns of brainwaves can be recognized by their amplitudes and frequencies. Brainwaves can then be categorized based on their level of activity or frequency. It's important to remember, though, that brainwaves are not the source or the cause of brain states, or of our experiences of our own minds – they're just some of the detectable reflections of the complex processes in the brain that produce our experience of being, thinking, and perceiving.

- Slow activity refers to a lower frequency and high amplitude (the distance between two peaks of a wave). These oscillations are often much larger in amplitude (wave depth). Think: low, the deep beat of a drum.

- Fast activity refers to a higher frequency and often smaller amplitude. Think: high pitched flute.

Below are five often-described brainwaves, from fastest activity levels to slowest.

GAMMA BRAINWAVES

- Frequency: 32 – 100 Hz
- Associated state: Heightened perception, learning, problem-solving tasks

Gamma brainwaves are the fastest measurable EEG brainwaves, and have been equated to ‘heightened perception’, or a ‘peak mental state’ when there is simultaneous processing of information from different parts of the brain. Gamma brainwaves have been observed to be much stronger and more regularly observed in very long-term meditators including Buddhist Monks.

BETA BRAINWAVES

- Frequency: 13-32 Hz
- State: Alert, normal alert consciousness, active thinking

For example:

- Active conversation
- Making decisions
- Solving a problem
- Focusing on a task

- Learning a new concept

Beta brainwaves are easiest to detect when we're busy thinking actively.

ALPHA BRAINWAVES

- Frequency: 8-13 Hz
- State: Physically and mentally relaxed

Alpha brainwaves are some of the most easily observed and were the first to be discovered. They become detectable when the eyes are closed and the mind is relaxed. They can also often be found during activities such as:

- Yoga
- Just before falling asleep
- Being creative and artistic

THETA BRAINWAVES

- Frequency: 4-8 Hz
- State: Creativity, insight, dreams, reduced consciousness

According to Professor Jim Lagopoulos of Sydney University, "previous studies have shown that theta waves indicate deep relaxation and occur more frequently in highly experienced meditation practitioners. The source is probably frontal parts of the brain, which are associated with monitoring of other mental processes."

Most frequently, theta brainwaves are strongly detectable when we're dreaming in our sleep (think, the movie Inception), but they can also be seen during :

- Deep meditation
- Daydreaming

When we're doing a task that is so automatic that the mind can disengage from it e.g. brushing teeth, showering. Research has also shown a positive association of theta waves with memory, creativity and psychological well-being. (5) (6)

DELTA BRAINWAVES

- Frequency: 0.5-4 Hz
- State: Sleep, dreaming

These are the slowest of all brainwaves, and are strongest when we are enjoying restorative sleep in a dreamless state. This is also the state where healing and rejuvenation are stimulated, which is why it's so crucial to get enough sleep each night.

HOW TO TRAIN YOUR BRAINWAVES

Is it possible to change how much we experience these different brainwaves, and the brain states and thought experiences associated with them? In short, yes.

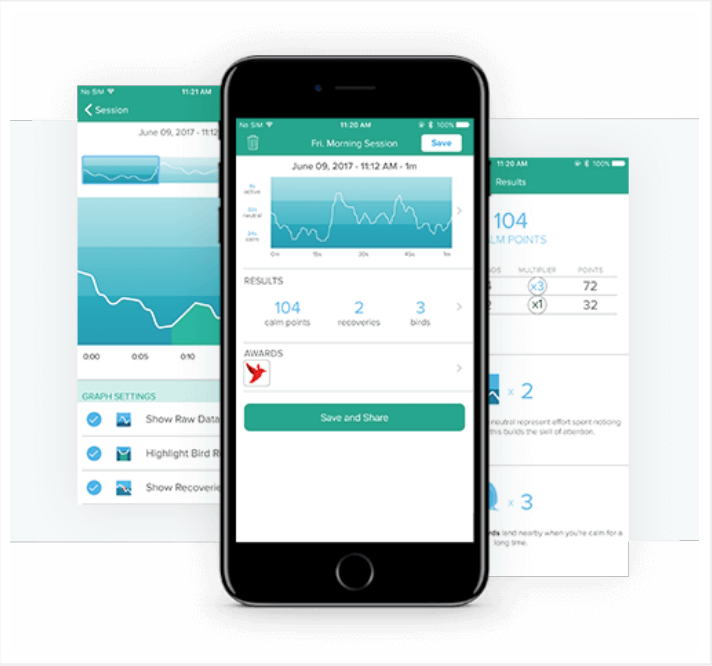
Conditioning and Neurofeedback

For decades, practitioners have engaged in training programs which are intended to reinforce the brain states which produce increases in certain brain oscillations, and decreases in others. The most common example of this, called neurofeedback, can utilize EEG or other brain sensing modalities.

Neurofeedback practitioners and clinicians find that immediate, direct feedback on brain states, whether in the form of sound, light, or even a video game, can produce changes in underlying behaviors and brain states that are reflected in brainwaves. This feedback seems to accelerate the learning process, by making brain states more apparent to the recipient.

Another important discovery in the recent history of neuroscience is the significant differences in brainwave characteristics of highly experienced meditators. Expert meditators not only have different resting-state brainwaves from non-meditators – they also seem able to control their brainwaves through voluntary thought control with greater ease than others.

So how do we start to improve our ability to control our brainwaves? **These brainwave-changing skills can be learned. Meditation deepens your ability to focus and control your attention.**



What Does Muse Do?

Using 7 finely calibrated sensors – 2 on the forehead, 2 behind the ears plus 3 reference sensors – Muse is a next-generation, state of the art EEG system that uses advanced algorithms to train beginner and intermediate meditators at controlling their focus. It teaches users how to manipulate their brain states and how to change the characteristics of their brains.

The Muse algorithm technology is more complex than traditional neurofeedback. In creating the Muse app, we started from these brainwaves

and then spent years doing intensive research on higher-order combinations of primary, secondary and tertiary characteristics of raw EEG data and how they interact with focused-attention meditation.

Muse has been tested and validated against EEG systems that are exponentially more expensive, and it's used by neuroscientists around the world in real-world neuroscience research inside and outside the lab.

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