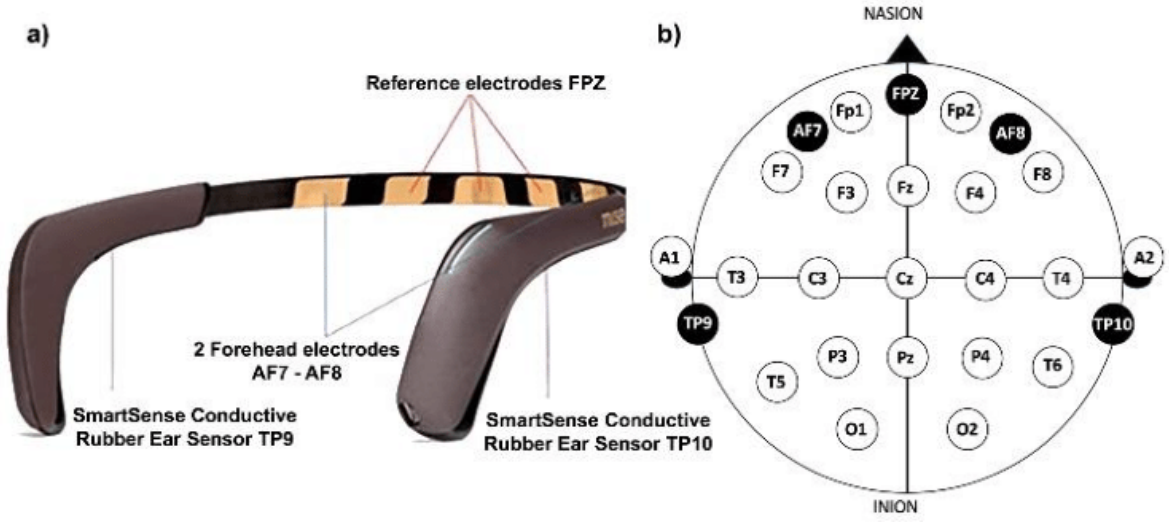
Muse 2 Headband Specifications (Neuronal Tracking)

Which features can be collected and extracted with this device?

The Muse 2 Headband has 4 electrodes (TP9, AF7, AF8, TP10) that allow for brain wave tracking at a 256 hz sample rate and 12-bit sample depth.



Source: https://doi.org/10.21014/acta_imeko.v10i4.1180

The Mind Monitor App can be connected to the Muse 2 Headband to record and extract brain wave data such as absolute wave values (Power Spectral Density), discrete frequency breakdown (Real-time Fast Fourier Transform), and unprocessed electric signals (Raw Microvolts) from its sensors. The variables collected by Mind Monitor are:

Variable	Description	Range / Units
TimeStamp	Date and Time	Year-Month-Day Hour:Minute:Second.Millisecond
Delta_{TP9,AF7,AF8,TP10}	Delta brainwaves, for each of the four sensors	Bels
Theta_{TP9,AF7,AF8,TP10}	Theta brainwaves, for each of the four sensors	Bels
Alpha_{TP9,AF7,AF8,TP10}	Alpha brainwaves, for each	Bels

	of the four sensors	
Beta_{TP9,AF7,AF8,TP10}	Beta brainwaves, for each of the four sensors	Bels
Gamma_{TP9,AF7,AF8,TP10}	Gamma brainwaves, for each of the four sensors	Bels
RAW_{TP9,AF7,AF8,TP10}	RAW brainwaves, for each of the four sensors	0.0 - 1682.815 uV
AUX_RIGHT	RAW brainwaves for the auxiliary USB sensor (not available with MU-01)	0.0 - 1682.815 uV
Accelerometer_{X,Y,Z}	Gravity. X = tilt up/down, Y = tilt left/right, Z = vertical up/down	g {-2:+2}
Gyro_{X,Y,Z}	Gyroscope motion over time (returns to zero)	degrees/second {-245:+245}
HeadBandOn	Basic data quality indicator: if the headband is on the head	1=True, 0=False
HSI_{TP9,AF7,AF8,TP10}	Data quality, for each of the four sensors (HSI=Horse Shoe Indicator)	1=Good, 2=Medium, 4=Bad
Battery	Battery charge percentage	%/100
Elements	Data markers such as Blink, Jaw_Clench, or numbered markers	

FAQ on sensor conductivity and signal quality:

https://choosemuse.force.com/s/article/How-do-I-get-good-sensor-signal-quality-with-Muse?language=en_US

References:

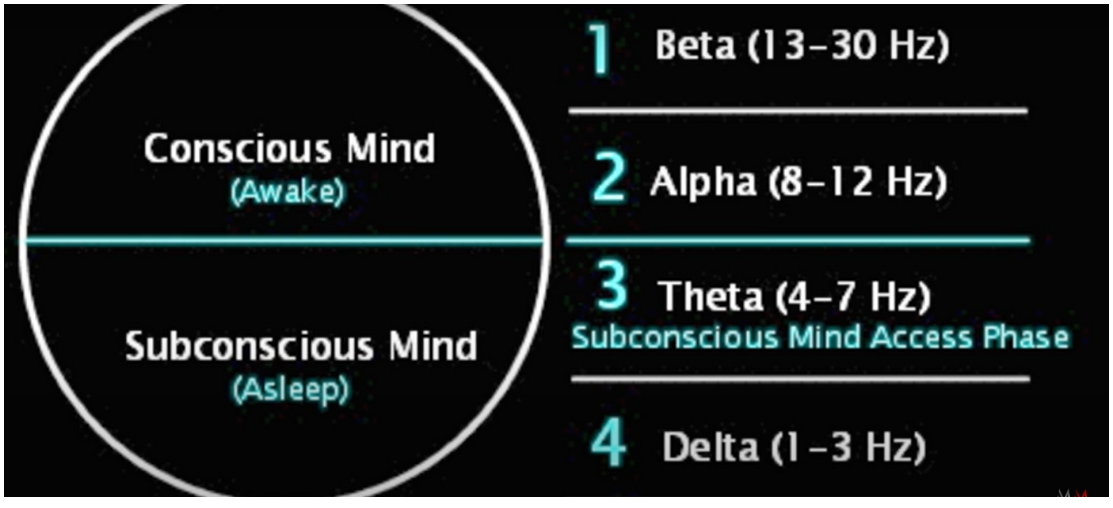
- https://choosemuse.com/muse-2/
- https://mind-monitor.com/#features

How are such features related to neuronal activity?

The human brain is made up of brain cells called neurons, which communicate with each other through electrical brain waves. The pattern of brain waves changes depending on one's level of consciousness and cognitive processing. For example, when one feels fatigued or dreamy, slower brain waves are likely dominant at that time.

Brain activity is generally characterized by a combination of brain waves. Depending on what one is doing at the time, a particular brain wave will be dominant over the others. There are five widely recognized brain waves, and the main frequencies and characteristics of human EEG waves are:

Band	Frequency	Brain State
Delta(δ)	1 - 4 Hz	Dreamless sleep (deep meditation)
Theta(θ)	4 - 8 Hz	Deeply relaxed, inward focused (drowsiness, vivid dreams)
Alpha(α)	7.5 - 13 Hz	Very relaxed, passive attention (thoughtful times, reflective, restful)
Beta(β)	13 - 30 Hz	Anxiety dominant, active, external attention, relaxed (busy mind)
Gamma(γ)	30 - 44 Hz	Concentration (higher levels of consciousness, problem solving)



Source: https://youtu.be/T7v9InRW9wk

References:

- https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/brain-waves
- https://www.goodtherapy.org/blog/psychpedia/brain-waves
- https://youtu.be/T7v9InRW9wk?t=580

How could we relate such features to learning?

There are multiple studies in the literature which relate neuronal tracking, with devices such as the Muse 2 Headset, to different learning activities and environments. Such studies seek to analyze brain waves to gain a deeper understanding on:

- Cognitive performance
- Focus and attention
- Emotion detection
- Auditory stimulation
- Visual stimulation
- Drowsiness

References:

- https://www.sciencedirect.com/science/article/pii/S2352710222005538
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- https://www.semanticscholar.org/paper/Muse-Headband%3A-Potential-Communication-Tool-for-Tian/a2da82b8ab3e26959c98db36e355321699e14fdd
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- https://www.frontiersin.org/articles/10.3389/fninf.2020.553352/full

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