BCI: Entertainment's Brain Hacking Tool

for Control & Monitoring

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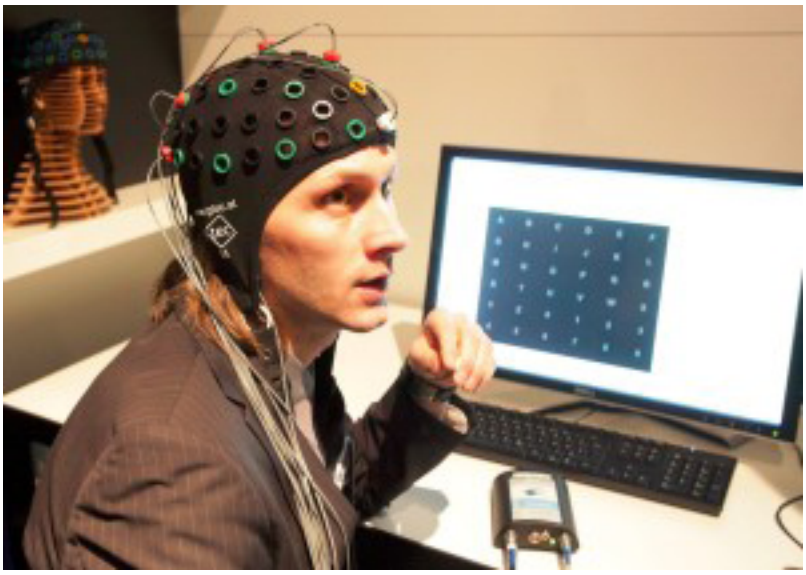
At times, BCI gets a bad rap from the entertainment industry. Take video gaming, for example. Some have the opinion that BCI is "too slow" for gamers and impacts the speed and flow of the game. It takes users time to properly prepare themselves to enter into a certain mental state, slamming the brake pedal down on the action and intensity of the game. Controlling mental states can also get pretty tiring over the course of a particularly long gaming session. These views have only been reinforced by the traditional, and more limited, perception of how the technology can be utilized and by some of the early consumer products that deployed BCI in its traditional sense—for rudimentary control.



So far, BCI-enabled partner products on the market have only leveraged NeuroSky's Attention or Mediation algorithms. These algorithms work well in control applications since users can consciously steer these mental states with a little practice. Past use cases have centered heavily on telekinetic experiences for moving objects. Nevertheless, these two algorithms, along with others, can also be used in monitoring applications. Let's take a closer look at control and monitoring use cases for BCI and EEG biosensor technology, and how they can be applied to the Entertainment market.

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BCI as a Controller

BCI as a controller harkens back to some of the earliest uses for BCI as a communication interface tool to aid the severely physically handicapped. For quadriplegics, learning to communicate with a computer empowered them to become more independent and productive individuals. The early BCI hardware was complex, time-consuming to set up, messy and expensive, yet enabled its users to have at least a crude ability to move a cursor across a screen by controlling mental state levels. The ability to use brainwaves to map and select objects on a computer screen was to later become the traditional view of how BCI could be applied as a controller device, and eventually evolved into telepathic control uses in entertainment products.

Many BCI algorithms are normalized to output some range of real-time values (e.g. 0-100). So, how can algorithms like Attention, Meditation, Mental Effort, and others, be used in a control context?

First, let's talk about object selection. Objects that we wish to control through BCI are typically selected through a mouse, game controller, touch screen, keyboard or more simply by the application software without any user intervention. Once the object is selected, there are two possible scenarios for what action the object executes:

- Fixed Action Object – Some objects have a single action "hard-coded" into their behavior. For example, a ball may always be programmed to roll or a bird may always be programmed to fly. For these types of objects, once they are selected, the BCI controller is used to execute the action.
- Multiple Action Object – Some objects may have multiple action options assigned to them by the developer. For example, using one of the manual control methods

discussed, the player would first select the object then select a particular action to take place from a menu. The player might select a racing car and have an option menu to move forward or move in reverse. Once the action has been selected, the BCI controller is used to execute the action.

Now, there are some different BCI control models that can support interesting variations to how actions are actually performed (and the list is not exhaustive). These control definitions are modeled by the developer within the application layer. Most of the BCI-enabled toys (Mindflex, Force Trainer, Puzzlebox) and video games on the market today utilize almost exclusively the Single Sliding Scale model (see below). Therefore, there remains quite a bit of unused real-estate when it comes to employing additional control models as we explain will see below.

- Single Sliding Scale – The object in question (e.g. a toy car) has an assigned action (e.g. move forward) whose intensity of that action (e.g. speed) is a function of the magnitude of the mental state assignment (e.g. higher attention gets mapped to faster speeds). The action is driven through a sliding scale of mental intensity (from 0 - no movement to 100 - fastest movement).
- Toggle Switch (ON-OFF) – An ON-OFF action can be applied by setting threshold limits (upper and / or lower). For example, raising Attention above 90 toggles the action from ON-to-OFF or OFF-to-ON, depending on its current state. Turning on and off a light bulb with your mind can become possible in this way. Note: we recommend that the action takes place only as the mental state rises above the threshold level (not when exiting the threshold level). The next time the threshold level is reached, this would toggle the switch.

- Timed Toggle Switch (ON-OFF) – When a user's mental state falls within some pre-defined range (e.g. 40-60, > 80, < 20, etc.), a timer starts. If the conditions continue to be met after some preset time duration, the action takes place (ON). Otherwise, no action takes place (OFF). This requires the player to maintain a mental state within some range before enabling an action For example, the developer may require the user to remain relaxed above a level of 60 for at least 20 seconds before she is transported (moved) from one dimension to the next.
- Multiple Sliding Scales – this control mode performs just like the single sliding scale, except multiple actions can be assigned and the intensity of each action is derived from the range within the scale. In the example, below, if the user enters a meditation range from 31-70, the object will begin to skip. The speed or intensity of the skipping will vary (31 is slowest while 70 is fastest).

Meditation Range	Object Action	Min Intensity	Max Intensity
0—30	Hop	0	29
31—70	Skip	30	69
Greater than 70	Run	70	100

- Multiple Toggle Switches (ON-OFF) – a developer may wish to use a mental state for multiple ON-OFF-type actions. For example, suppose the following actions are mapped to the Meditation algorithm for avatar control. Any time the user is within a particular meditation range, the action takes place (ON). Once outside of that same range, the action stops (OFF) and a new action (depending on the range) is assigned. Note: action intensity is not applicable.

Meditation Range	Object Action
0—10	Do Nothing
11—30	Hop
31—70	Skip
Greater than 70	Run

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- Multiple Timed Toggle Switches (ON-OFF) – a combination of both the Multiple Toggle Switches and Timed Toggle Switch approaches. This control technique requires the user to maintain a set range of mental state output for a particular duration (hold timer) in order to enable the action (ON). The action continues as long as the user stays in the range. If the user falls out of the range, the action is disabled (OFF) and a new action (per the new range) timer starts.

Meditation Range	Object Action	Timer (Hold Time)
0—30	Hop	3 seconds
30—70	Skip	5 seconds
Greater than 70	Lie Down	10 seconds

BCI as a Monitor

BCI's traditional use case (control / telepathy) has limited its true potential for entertainment uses and locked developers onto a single use case mindset for some years. Part of NeuroSky's mission is to educate the market about this misconception that has artificially limited BCI's growth into toys, gaming, music, art, theatre, film and video.

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In the BCI world, the counter-part to control is monitoring. In monitoring, the user is simply engaged with the entertainment media and not attempting to consciously control any mental states. In fact, some algorithms do not even work well in control applications simply because they cannot be adequately controlled (try to create a drowsy or a happy feeling, for instance). Many of these types of algorithms work best strictly in monitoring situations. By applying monitoring to the BCI experience, the player engages naturally with the media as if in a non-BCI experience. In this way, BCI overcomes much of the criticism attributed to its so-called negative influences during the engagement. The Necomimi ("Cat Ears") product is a classic use of BCI in a monitoring role.

> Monitoring neither slows down the experience nor tires the player.

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Monitoring can be used in two primary ways:

- Real-time - Utilizing the data as a real-time feedback mechanism (neurofeedback) in conjunction with the application to determine its next course of action
    - Dynamic / re-configurable media experiences
    - Real-time player status (inattentive, high work load, possible fatigue)

An example of this would be to monitor a player's reaction to an intense event (e.g. excessive shooting or explosions) and adjust (up or down) the graphical intensity of the event (or change the layout or venue entirely) if the player's reaction does not align with the developer's expectations.

- Post-process - Capturing the mental / emotional data of the player throughout the media engagement for post-processing and big data mining
    - Player profiling, segmentation and trending
    - Ranking game quality and experience

An example of this would be to analyze which media segments or entire media experiences (games, films, music) had the greatest impact to the user as a tool to better granulate advertising, promotional messaging, user targeting and product design.

BCI as Both Controller and Monitor

Combine control with monitoring and suddenly BCI becomes an extremely powerful tool. Using control more sparingly and in more natural contexts (e.g. to cast a spell in order to exorcise demons, cross a dangerous bridge by staying relaxed) reduces any negative impacts on game speed and player fatigue. Meanwhile, simultaneously leveraging the monitoring benefits lends an additional secondary value to the overall experience and better justifies the rationale to use and develop BCI-enabled entertainment products.

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NeuroSky: Pioneers in Consumer BCI Technology

NeuroSky's mission is the proliferation of consumer EEG technology into mainstream use cases by enabling our partners to design and manufacture wearable BCI devices. Some NeuroSky highlights include:

- Consumer Brain-Computer Interface (BCI) technology pioneer
- First EEG biosensor chip launched in 2007
- EEG biosensors, algorithms & wearable BCI peripheral manufacturer
- Core technology (B2B) enabler ("Intel Inside" Model)
- Largest consumer BCI developer / OEM partner community in the world
- Broad vertical market (entertainment, health/wellness, education) applicability

Do you have an idea for an entertainment device that can make use of BCI technology as a controller or monitor? Contact NeuroSky today to set up a discovery call. We can help provide you with the tools you need to bring your product to the market.

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