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Design and Evaluation of Surprises in Simulation

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Thesis Report

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Abstract

This study presents a framework for designing surprises in simulation, and also methods and techniques for assessing their effects. The framework for designing surprises provides a categorization of surprises (task-(in) dependent cue-based, narrative-based or mixed). Assessing the effects of surprises is relevant for the design of training scenarios to tailor them to the target audience. The aim of this study was to examine:

- Does exposure to surprises lead to improved handling of surprises?
- Is a simple EEG (i.e. electroencephalogram) device useful for measuring players' mental states in gaming situations?
- Are there any differences between the framework's surprise types?

A training scenario was developed, using a serious computer game called VBS2 (i.e. Virtual Battlespace 2), in which the player acted as an undercover agent who had to perform a series of actions in order to save an island's commercial supplies from terrorists. The scenario was implemented in two similar versions (each divided in four phases): the EC (i.e. Experimental Condition) version containing ten surprising events (i.e. SEs) and the CC (i.e. Control Condition) version containing only the last three SEs. After introductory game phases (i.e. Phase A & B), the gameplay started at phase three (i.e. Phase C) were seven SEs introduced only for the EC, before a common phase (i.e. Phase D containing three SEs). The assessment included the use of EEG, post-game questionnaire and in-game measurements for timings and performance scores. EEG was applied to investigate the short-term (seconds) and long-term (minutes) surprise effects.

A key expectation was that the EC group would be less disturbed during task-performance in Phase D than the CC group, which would result to faster and more correct responses. Since players' attention is considered to increase when surprised, it was also expected that their mean amplitude power (i.e. M.A.P.) values in the (Low, Mid and High) Beta bands would be higher during regular gameplay than in baseline, and also higher during surprising than regular gameplay. Moreover, since surprises are considered to temporarily stir up the players, it was expected that the players' M.A.P. value in Delta band would lower during surprising events. In addition, it was expected that the EC group would reach higher M.A.P. values at Alpha band during the last three SEs (of Phase D) compared to the CC group, since its emotional response to surprises should lower by forming a line of expectancy for SEs, and hence allow it become more relaxed. Furthermore, it was expected that the cue-based surprises would produce the aforementioned effects in Delta band more intensely than the narrative-based ones and that post-game questionnaire results would also align with this effect.

Results on the in-game measurements confirmed that EC was faster and more correct than CC during Phase D, even though no differences were found on the post-game questionnaires regarding players' disturbance by surprises during task-performance. A difference between the two conditions in Phase D was found in the EEG data, showing that EC was higher in the Alpha band than CC during the last three SEs. This means that EC group was more relaxed, which possibly allowed to reach better reactions, and thus become more efficient. Considering the Beta bands, no differences were found among surprising and regular gameplay. Yet, baseline Beta band M.A.P. values were found to be lower than both surprising and regular gameplay. Another important finding was the consistent drop in Delta M.A.P. values, which probably suggests a standard mental response pattern for short-term effects. The post-game questionnaire results showed differences between cue-based and narrative surprises in startle, surprise and confusion effects, but this finding was not reflected by differences in the players' Delta band M.A.P. values.

Chapter 0: Introduction

The motivation behind this study was to provide an innovative approach in designing and evaluating surprising effects within the virtual context of a serious computer game. As result, this study provides future potential in new forms of aviation training, so that aircraft pilots can be exposed to surprising situations that will challenge their level of performance and help them acquire crucial mental readiness when crisis situations emerge. A small discussion over each chapter of the present study follows.

The first chapter presents the theoretical background on which a "framework for surprises" is developed. This framework provides necessary tools in order to properly understand the nature of surprises and thus categorize them with respect to their individual characteristics. Hence, surprises from all the categories are implemented in the context of a serious computer game. In addition, the framework includes the assessment of the surprise effects by using a simple, of-the-shelf EEG device (NeuroSky's Mindwave Mobile). This chapter also introduces the research questions and hypotheses.

The second chapter discusses the used method for implementing the framework's design and assessment of surprises. Considering the design of surprises, it is described how a game scenario was developed (using VBS2) in two different versions, the EC and CC, in order to implement the various surprise types. Moreover, it is explained how the players' reactions to the implemented surprises were assessed by using EEG, post-game questionnaires and in-game indicators for logging timings and performance scores.

The third chapter provides the results. This includes multiple independent samples T-tests, one-way ANOVA's, box plots and error bars with respect to the raw data provided from the EEG measurements, the questionnaires and the in-game indicators.

The fourth chapter provides a discussion that wraps up the results by providing a general overview to the reader.

The fifth chapter provides a summary of the most important conclusions from this study. While further research is needed in order to verify any result, this study explored the possibilities to perform emotion interpretations through an EEG device as well as the potential of the implemented techniques for gaming and simulation purposes.

Chapter 1: Introduction and Research Questions

1.1 Introduction

Surprise is a complex phenomenon with physiological and psychological elements and depends considerably on situational meaning and therefore the personal background of the surprised person. What counts as a surprise, often defined as inconsistency between predicted and observed outcome (e.g., Ranasinghe & Shen, 2008), differs between individuals. What is considered to be a surprise for one person, does not need to be a surprise for another person, or it may differ in experienced intensity (ranging from insignificant to huge or even life threatening), depending on the persons experience and sensitivity to external input. A surprise can have valences such as positive, neutral, or negative, and can be pleasant or unpleasant (Frijda, 1986).

A surprising event can trigger a variety of responses such as startle, surprise, confusion, stress, panic, shock, and even trauma. Startle is physiological response to a sudden event and usually last for a couple of seconds. Startle may result in biological reflexes such as eye blinks, body movements, increased heart rate, goose bumps, and biochemical changes. Startle and surprise do not always concur. A well-known startle reaction without surprise comes with seeing a balloon being pricked. The loud noise does not happen unexpectedly, and yet the observer will blink the eyes. Surprise can also come without a startle effect. Receiving a call from your car dealer informing you that your broken car is repaired two days earlier than planned, may surprise you, but is not likely to induce a startle effect. Surprise therefore involves interpretation, a cognitive process in which the event is compared to memory. This process is mostly automatic and may last a few seconds. Finding explanations and possibly solutions for the surprise could last from a split second to lifelong, depending on the valence and relevance the surprise has to a person, and on the competence of the person to deal with the surprise. When the surprise is intense, the immediate phase of finding explanations will go together with feeling confused or even stress or panic when under time pressure or in danger. Confusion is the state of being bewildered or unclear in one's mind about something. When the surprise event includes extreme violence, danger, injury, or loss of life, it may result in shock and grow into a trauma. In this report, the focus is on the first three response types: startle, surprise, and confusion and will suggest an approach to design scenarios with a potential to induce these responses. This approach can be used to enable the following training functions:

1. Learn to deal with surprises in order to enable realistic training,
2. Enhance the learning effects.

1.2 Learning to deal with surprises in order to enable realistic training

Certain operational situations require immediate action to ensure safety of vehicle and crew or to ensure the mission goals can still be met. Emergency situations in aircraft are obvious examples, as well as unforeseen enemy behavior or other hazards to a mission plan. The training goal is to ensure that effects of startle, surprise, and confusion are known, recognized, and dealt with in such a way so that their effect become as short as possible and not lead to extreme reactions such as shock or panic, while practicing to analyze the situation and take appropriate actions (according to procedures or contingency plans).

Surprising events are useful in providing a context for acquiring complex competencies such as (tactical) decision making, prioritizing, maintaining situational awareness, and coordination under time pressure, threat or novel situations. These competencies need to be flexible and adaptive to a wide variety of new situations. Surprise here may be life threatening, but can and will often be more subtle, disturbing task execution only slightly. Most learning theories, such as associative learning and connectionist learning models, state that an unforeseen, unpredicted outcome is the basis for learning. With more experiences, the new association is strengthened and gets more stable. Providing the same event in the same environment again, may lead to learning, but will not generate the desired far transfer of the learning product into a real and less predictable professional world. The very nature of realistic training, provided in a rich environment that contains realistic elements of objects, human behavior, and processes, therefore depends on the surprise and variation quality of events or features.

1.3 Enhance learning effects

Conditions in which learning takes place (light, music, drug use, etc.) may affect learning positively, in particular when the performance on a test or in an operational situation is taken under the same conditions. A surprising event, not directly related to the learning task, can also provide for a learning enhancing condition (Van der Spek et al., 2013; Ranganath & Reiner, 2003).

1.4 The need to improve simulated surprises

With these two vital functions of surprising events in training, it is remarkable that the majority of training, including simulation and serious gaming, only provide for highly predictable training setups and scenarios (cf. Burki-Cohen, 2010). Improvement of scenarios is expected to benefit by applying a training perspective on when and how to use

surprises and variation. This perspective depends on understanding which elements (in simulation and gaming) can induce surprise as well as an understanding of how surprises work for individuals or groups with the same level of experience. Because surprise effects are related to the personal background and experience of the trainee, a generic theory of surprise effects may not be sufficient to realize the required improvement. A framework for optimal use of surprises will have to measure the effects either a) during the scenario design phase in which prototype test results are used to increase or decrease the surprising effect of the event or variation, or b) during the scenario run, using real time feedback of scenario effects on trainees to change the scenario events or settings either automatically or by advising instructors. The next section provides a framework for using surprise effects in this way. The framework intents to support the practitioner (instructor, scenario designer), whilst not necessarily the research community.

1.5 Framework for designing and measuring surprise effects

Enhancing the design for surprises can be achieved by following design principles and by adapting the scenario based on knowing the effects the surprise has on trainees. The latter requires application of techniques to measure surprise effects. Therefore, we describe a framework for measuring the effects of surprises first and subsequently design principles for surprising events.

1.5.1 Measuring surprise effects

The effects of surprises can be measured in several ways by using various means. Recent progress in biofeedback technology promises measurement of different physiological responses concurrently and then correlates them in a unified analysis frame in order to reach robust conclusions about the surprising effects (Murugappan et al., 2010). For example, the physiological responses of a trainee in a serious gaming context can be measured by using electroencephalogram (EEG), galvanic skin response (GSR), eye blinks, eye-tracking, facial expressions, heart-rate, etc. (Chanel et al., 2006). In addition, the trainee's behavior can be evaluated by comparing his/her in-game task performance (response times, game scores) before and after the surprising events. Additionally, trainees can provide self-ratings on perceived impact of surprising events by using questionnaires.

For practical training purposes, not all these measures can be taken simultaneously. An optimal and practical selection is yet to be found. Furthermore, the use of easy to apply, inexpensive measurement tools are critical for application on a wide scale. In the last

decade, several commercial products for measuring heart rate, eye gaze, and EEG seem to comply with these requirements.

EEG probably provides the richest measurement of mental state and is therefore the first to explore in the framework. The human brain generates electricity that can be measured on the scalp surface in microvolts by applying electrodes. Electric output can be found in wavelengths from 0.1 to 100 Hz. This brainwave spectrum is categorized into meaningful bandwidths or brainwave types. Each type has been found to indicate certain psychological states. What is more, each brainwave type is characterized by its amplitude. The more neurons that work in synchrony, the larger the amplitude of the electrical oscillations measured in microvolts. In other words, amplitude indicates the intensity (i.e. power) of the electrical signal at each brainwave type. In a certain interval of time, the mean amplitude power (i.e. M.A.P.) at each brainwave band can be calculated in order to define the mental condition within this time period in general.

The most common brainwave types discussed in EEG literature are Delta, Theta, Alpha, Beta and Gamma (Hondrou & Caridakis, 2012; Berger, 1929). However, a variety of EEG devices (e.g. intrusive or non-intrusive with one or more electrodes) are available in the retail market and each manufacturer independently defines the frequency range of these brainwave bands/types for their products. For example, Emotiv defines Delta band for wavelengths ranging from 0.5 to 4 Hz (cf. Emotiv Inc., 2011), while NeuroSky defines its range from 0.1 to 3 Hz. Moreover, a more detailed classification of the brainwave types might occur (Dressler, 2004), providing in this way additional brainwave types, such as Mu (i.e. μ ranging for 7.5 to 12.5 Hz) or SMR (ranging for 13 to 15 Hz), each defining very specific psychological states not described by the aforementioned brainwave bands (Amzica & Da Silva, 2010; Arroyo et al., 1993).

Also, depending on the hardware used, one, four, or more positions on the scalp can be measured, limiting or extending the scope of measurement and potential use. Measuring more positions is attractive, but comes with a price. It increases the level of complexity in analyzing data, and might also lead to more intrusive measurement to the trainee. For a practitioner oriented framework, this is a high price to pay. Hence, this study focus on using a simple, non-intrusive and one-channel EEG device, called Mindwave Mobile (manufactured by NeuroSky). This device provides a more explicit classification of the Beta band by splitting it into three different brainwave types: Low, Mid and High Beta. Each of these brainwave types interpret into a very specific mental state. Figure 1 illustrates all bandwidths, as provided from NeuroSky, along with their respected mental interpretation (cf. NeuroSky Inc., 2009).

Brainwave Types

Brainwave Type	Freq. Range	Mental States and conditions
Delta	0.1 Hz to 3 Hz	Deep, dreamless and non-REM sleep, daydreaming
Theta	4 Hz to 7 Hz	Intuitive, creative, recall, fantasy, imaginary, dream
Alpha	8 Hz to 12 Hz	Relaxed, but not drowsy, tranquil, conscious
Low Beta	12 Hz to 15 Hz	Relaxed yet focused, sensorimotor response
Mid-range Beta	16 Hz to 20 Hz	Thinking, aware of self and surroundings
High Beta	21 Hz to 30 Hz	Alertness, agitation
Gamma	30 Hz to 100 Hz	Higher mental activity, motor function

Figure 1 - Brainwave types and their respectful mental states and conditions

By using NeuroSky's Mindwave Mobile, an electrode can be applied on the left prefrontal cortex (position Fp1 according to the International 10-20 system (Jasper, 1958)), while embedded algorithms on its ThinkGear chipset can perform artifact correction (electricity generated by muscle movements, e.g. eye movements). The prefrontal cortex (i.e. PFC) is the cerebral cortex which covers the front part of the frontal lobe and it contains Brodmann areas 9, 10, 11, 12, 46, and 47 (Brodmann, 1909). In details, that would include the dorsolateral prefrontal cortex, the anterior prefrontal cortex, the orbitofrontal area and the pars orbitalis (which is part of the inferior frontal gyrus). Among others, these areas are involved in significant brain functions such as in working memory, decision making, emotion processing, behavior control, strategy change response, planning and selective attention. In general, the PFC is responsible for executive and higher cognitive functions. Therefore, this part of the brain is the most promising for measuring (short-term and/or long-term) effects that surprises (as well as other emotions) trigger in the brain. Moreover, the frontal activation/emotion intensity models (Davidson et al. 1979; Dawson, 1994; Schmidt, 1999; Schmidt & Fox 1999) argue that the greater the frontal activation, the more intense is the emotional experience. However, surprising effects can also be investigated in other parts of the brain, such as the parietal and anterior cingulate cortex (O'Reilly et al., 2013).

Due to frontal EEG asymmetry (LeMay, 1977), the left and right parts of the PFC have a different response to emotions with different valence (Davidson, 1993; Fox 1991; Heller, 1993). The right PFC is usually linked to negative emotions such as disgust, fear, sadness which are associated behaviorally to withdrawal (Coan et al., 2001, Dawson et al., 1992). Moreover, right frontal asymmetry measures are predictor of empathic concern (compassion and concern), a relationship that is mediated by feelings such as sadness (Tullett et al., 2012). In addition, right PFC is also associated specifically with the adjustment of inferential learning on the basis of unpredictability (i.e. surprising events) (Fletcher et al., 2001). On the other hand, left PFC is usually linked to positive emotions such as joy and happiness which are associated behaviorally to approach (Coan et al., 2001; Davidson et al., 1985; Harmon-Jones & Allen, 1998). It is vital to underline here that

surprises can have any valence (positive, negative or neutral), and thus they can accordingly be (partially) linked to the left or right PFC. Hence, surprises can behaviorally associate to withdrawal or approach. This remark coincides with the fact that surprises may induce a fight-or-flight response (Cannon, 1932). What is also important to note is that, individual differences in frontal asymmetry are present in humans from early age and predict their reactivity to emotional challenges (Davidson & Fox, 1989).

Since each frequency band has a special meaning (provided by the manufacturer) regarding the mental state of the wearer, certain interpretations might occur considering how human brains function before and after being surprised. For this reason, M.A.P. oscillations in all brain frequency bands must be explored in order to investigate differences in intensity of these mental states. If consistent EEG findings reveal specific mental reactions to surprising events, then it will be possible to confirm our hypotheses for the existence of certain EEG patterns and/or trends for surprises.

1.5.2 Design for surprises

Designing surprising events can be done in a variety of ways. We distinguish two design approaches:

1. Initial design with bottom up surprises, using sensory elements
2. Initial design with top down surprises, using cognitive, narrative elements

The bottom up and top down surprises relate to the general information processing model (Newell & Simon 1972) of receiving information through senses – processing information in working memory – retrieving information from long term memory (and integrating new information to existing knowledge structures) – generate actions by motoric actions (for an information processing model dedicated to game development, see Van der Spek, Van Oostendorp & Wouters, 2011). A bottom up surprise is generated by providing unexpected sensory input, while a top down surprise is generated by providing cognitive inconsistencies (to long term memory) or narrative surprises.

1.5.2.1 Bottom up surprises

Visual and auditory cues in the virtual environment can be used in order to create a bottom-up surprise. In the case of visual cues, the surprise of visual stimuli can be more or less salient, determined by features like the local luminance contrast, the color contrast, the orientation and direction of motion. Moreover, the flickering of a color (especially red) in some parts of an image where it used to be stationary black can also be surprising and

trigger the player's attention (Itti & Baldi, 2005). Beside the visual cues that can be used in order to generate bottom-up surprises from the virtual environment, a scenario or game developer can also use auditory cues. Any sudden and unexpected change of tonality, loudness, pitch etc. of voices, music, sounds and noises can cause surprise to the player. Figure 2 summarizes some of the basic visual and auditory surprising factors.

Bottom-up surprises

Visual cues	Unexpected and sudden changes in: • local luminance contrast • color contrast(red/green, blue/yellow – chromatic channels), • orientation of motion • direction of motion, • flickering	*Example:* *An unexpected explosion*
Auditorial cues	Unexpected and sudden changes in: • pitch • loudness • tonality • rhythm • timbre/melody of voices • music • sounds and noises	*Example:* *A sudden scream*

Figure 2 - Overview of visual and auditorial cues which stimulate surprises

1.5.2.2 Top down surprises

Top-down surprises can be created by building surprises from a narrative or by addressing the personal knowledge base of the trainee(s). For example, assume reading a book in which the main character starts dating a person. The information related to this event becomes surprising when it is coupled to the reader's knowledge in the long-term memory, for example that the person dated is the sister of the person's wife. As result, the surprise may trigger a physiological reaction such as facial expressions or to give a cry.

A well-known example of how a designer can create a surprising narrative is provided by Brewer and Lichtenstein (1981), a narrative in four sentences:

Butler puts poison in wine.
Butler carries wine to lord Higginbotham.
Lord Higginbotham drinks wine.
Lord Higginbotham dies.

There is no surprise in this narrative, but if the first sentence is removed, the death of Lord Higginbotham comes as a surprise because the reader will be ignorant of the poison.

A narrative in a (game) scenario can either be light or heavy. In the case of a light narrative, there will be a strong environmental storytelling (Jenkins, 2004) from which the surprise events may potentially pop-up by destabilizing the player's visual prediction over the observed outcome. In the case of a heavy narrative (McQuiggan et al., 2008) there will be a rich plot/story, in which, by leaving out important information or an important event, a subsequent event may become unexpected and thus surprising. See Figure 3 for examples of surprises from light and heavy game narratives.

Top-down surprises

Light narrative **(background storyline)**	Changes of: • weather, • indicators, • items, • characters, • environment, etc.
Heavy narrative	Leaving out an important event or information related to the game objectives or the characters participating in the storyline.

Figure 3 - Overview of narrative types that stimulate surprises

To sum up, surprises can be elicited from the narrative, from cues, or from a combination of narrative and cues (i.e. mixed surprises). Together they form a surprise capacity of a game or scenario. The personal knowledge base can also be considered as a surprise capacity (Gonzalez, 2005). People do not have the same surprise capacity and ability to regain or maintain an optimal state capacity for surprises in long-term. The range of surprise capacity differs between people for various reasons, primarily related to demographic characteristics such as education, previous experiences, age, gender etc. Also, the current physiological and psychological state in which someone is when being surprised is a factor. In other words, it is also depended to one's current state of consciousness. For example,

someone is more prone to surprise while daydreaming (i.e. while being in a decreased or altered state of consciousness). For more details see subsection 1.9.

Game or scenario developers aiming for a high surprise impact should design the events preceding the surprises in such a way that the trainee gets into a relaxed state before being exposed to the surprise event. The surprising events must be genuine and unprecedented, and trainees should not have prior knowledge about it. For example, our three sentence Higginbotham narrative would come less as a surprise when it was announced as an Agatha Christie story.

Lastly, the surprising event can either be related to a task or a procedure that is being executed by the trainee at the moment or not. In other words, a surprise event can be either task-dependent or task-independent. It is expected that these surprise types will have different impact on trainees.

It is assumed that the impact of surprise event, either task dependent or task independent, is a function of a) the surprise capacity range of individuals, b) the surprise capacity range of cues, and c) the surprise capacity range of the narrative.

As a result, we distinguish six different categories of surprises a game or scenario designer can create surprises:

1. ***task-independent cue based surprises*** (e.g. while the player is about to perform a task, he/she suddenly hears a Non-Playing Character (NPC), in a nearby dark alley, screaming loudly out of pain),
2. ***task-independent narrative based surprises*** (e.g. while the player is heading towards a target location to complete a task, he suddenly receives a call that his house has been robbed),
3. ***task-independent mixed surprises*** (e.g. while the player is trying to gather some supplies for his mission, a nearby fellow NPC which was supposed to aid him/her on the task, suddenly gets on fire and starts screaming),
4. ***task-dependent cue based surprises*** (e.g. while a player opens a chest to reveal its treasure, a fire trap disarms and causes an explosion which destroys all the content),
5. ***task-dependent narrative based surprises*** (e.g. while the player is heading to a certain location in order to complete a task, he/she gets informed that this location has changed) and
6. ***task-dependent mixed surprises*** (e.g. by the time a player reaches a mission target, the target gets destroyed by a sudden explosion caused by a bomb that a fellow NPC set, whom until this point of the mission was considered to be a friend or ally)

1.6 Usefulness of EEG for measuring surprise effects

The framework presented above requires considerable work to ensure it is useful and valid. We have started this by exploring the potential of measuring mental states during a simple VBS2 based scenario containing a variety of surprising events. Mental state was measured by EEG equipment for the consumer market, the Mindwave Mobile, a non-intrusive EEG headset from NeuroSky. The main reason for choosing this specific device was its simple configuration, since it only uses one single dry electrode on the left frontal scalp plus a reference point to the left earlobe. Data transfer is wireless. Hence, this allows non-EEG experts to use it in training applications, without having the constrictions and complexities that an expensive and advanced intrusive EEG device would pose.

1.7 Implementation of framework

As simulation mean for implementing the frameworks' various surprise types a serious game called VBS2 was used. A training scenario was therefore developed in two similar versions, the EC and CC versions. The scenario was divided in four phases in order to meet the requirements of this experiment. The first two phases (i.e. Phase A & B) have an introductory purpose to the game and they are common for both versions. Their goal is to learn the basic movement keys and the required action-set to the players. The regular gameplay starts at Phase C. At this point, the scenario differentiates the two versions, since seven SEs are introduced for the EC, while no surprises exist for the CC. This is because, we want to examine whether being exposed to prior surprises can lead to an improved handling of surprises at a later stage. This later stage would be phase D, which is common again for both versions and it introduces the same three SEs. The surprises were set within the missions in a random order considering their type. An overview for the two versions is provided in Figure 4. More details can be found in subsection 2.3.

	Phase A	Phase B	Phase C	Phase D
EC	Learning basic movement keys	Learning available action-set	Surprising gameplay with seven SEs	Surprising gameplay with three SEs
CC	Learning basic movement keys	Learning available action-set	Regular gameplay with no SEs	Surprising gameplay with three SEs

Figure 4 - Overview from the two version of the training scenario

1.8 Short-term and Long-term Effects of Surprises

As described in subsection 1.1, surprises can trigger a variety of responses, such as startle and confusion, in addition to the surprise response itself. These responses may vary in intensity and duration for each individual person even when the surprising stimulus is the same. This is because each individual person has a different mental capacity for surprises, majorly determined by its demographic characteristics (e.g. previous experiences) and its current state of consciousness (e.g. daydreaming). Therefore, the duration of these responses can be examined within a short period of time from the moment the person has been exposed to surprise (i.e. short-term effects such as startle), but also for a longer period of time (i.e. long-term effects) since the surprising event leads the person to update its knowledge schema for its environmental surrounding (i.e. a continuously surprising environment can create an anticipation for more surprises in the future). However, since the duration of these (short-term and long-term) responses cannot be strictly predefined within specific time-frames due to the previously mentioned individual differences, only an approximate selection of time-frames can be made. For the purposes of this study the time-frames to relate these responses are selected in a moderate fashion, and they are expected to include every non-extreme prolonged response. Hence, the time-frames were short-term effects are examined follow:

- 0-3 seconds from the moment the SE was triggered relates to a time-frame were startle effects can be explored
- 3-5 seconds from the moment the SE was triggered relates to a time-frame were surprise effects can be explored
- 5-8 seconds from the moment the SE was triggered relates to a time-frame were confusion effects can be explored

However, not all the implemented SEs are expected to necessarily introduce startle, surprise or confusion effects due to the fact that some of them might not generate all the aforementioned responses. Thus, this selection of time-frames will not be used in order to perform comparisons with respect to the responses they are associated with, but instead they will be used in a way so that short-term surprise effects are investigated within these particular time intervals in general. Hence, EEG effects for all the surprising events are to be examined within these time-frames in order to confirm our hypotheses (see subsection 1.11) for general mental response patterns to surprises. As for the long-term effects of surprises, the different game phases will be used as time periods for comparing prior mental states (i.e. consciousness state during Phase C in EC version) to later ones (i.e. consciousness state during Phase D in EC version). This is because it is expected that the mental state of players that have already been exposed to a surprising environment will be shaped in such a way so that they will be able to handle surprises more efficiently in the

future. This means that they will be less disturbed in the future when exposed to surprises and hence their task-performance will be less affected by the incoming surprising events.

1.9 Altering Consciousness States by using Surprises

According to Niedermeyer (Niedermeyer, 1994), three main components enter into the definition of consciousness: vigilance (I am awake), mental states (I am thinking) and selective attentiveness (I do attend to). In EEG terms these components would translate into low M.A.P. value in the Delta band and high M.A.P. value in the Beta bands. However, these are also the expected EEG effects for surprises (as described in 1.11). Therefore, it can be assumed that surprises can affect consciousness itself. But, consciousness has many states, such as the decreased or altered state of consciousness (e.g. when daydreaming or under alcohol) (Bundzen et al., 2002) the normal state of consciousness and some other higher states of consciousness. For example, transcendental consciousness is a higher state of consciousness, described as deeply restful yet fully alert (Mason et al., 1997). Surprise can be regarded as a key to achieve transitions from lower to higher states of consciousness, but it can also lead to unconsciousness if the initial (short-term) shock cannot be handled effectively by the brain. By observing the power spectrum plots (see Appendix D) for the short-term surprise effects, one can easily realize that in all cases the power spectrum curve initially drops across all the frequency bands. This means that the players become more wakeful (depicted by the drops in low frequency bands such as Delta and Theta) in order to achieve maximum sensory information absorption. Physiological reactions and facial expressions such as the increase of noradrenaline and pupil dilation from surprises (Preuschoff et al., 2011) can confirm such a hypothesis. In addition, they concurrently become less thoughtful and incapable for higher mental functioning which results to drops in high frequency bands such as Beta and Gamma). If the shock is extremely strong, these effects can even lead to fainting (i.e. unconsciousness), since the frontal lobe activity (which is where most researchers locate consciousness (Tassi & Muzet, 2001)) will decrease close to minimum. On the other hand, if this initial shock/astonishment is overpassed, then long-term surprise effects can be further investigated. These long-term effects can be associated to a transition in a higher state of consciousness than the one the surprised person was before being exposed to the surprise.

1.10 Research Questions

There are three research questions. First, the instructional usage of surprises in gaming for learning to deal with surprises (see subsection 1.2) is investigated:

1) Does exposure to surprises lead to improved handling of surprises?

In order to answer this question, it must be explored how an extensive exposure to surprises affect the players' task performance. In other words, how fast and correct they perform actions/tasks in a scenario where many surprising events take place (i.e. Experimental Condition or EC) compared to a scenario where only few surprising events take place (i.e. Control Condition or CC).

Second, it was an excellent chance to test the usefulness of the measurement toolset, and more specifically the usefulness of a simple EEG device such as NeuroSky's Mindwave Mobile for assessing the players' mental state when being exposed to surprises. This refers to both short-term and long-term psychophysiological effects of surprises. Especially in gaming situations this is more challenging to investigate due to side-effects and unmeasured in-game factors.

2) Are simple EEG devices useful for mental state measurements in gaming situations?

Third, the quality of surprises can also be examined. For example, which surprise type produce the expected EEG effects on VBS2 players and at which extend? Which surprises were perceived as more intense by the players? Also, is it possible to detect a mental response pattern to surprises in general? Thus, findings from questions as such may possibly aid the scenario developer during design revision process.

3) Are there any differences between the framework's surprise types?

1.11 Hypotheses

With respect to the research questions, the following hypotheses were formulated.

1) Considering the first research question, it is expected that the more the players are exposed to surprise events, the more they will mentally adapt in perceiving SEs and thus the more efficient they will become during task performance when finally a new surprising event occurs. The learning process behind this relates to a desensitization process and the formation of a coping strategy (Wolpe, 1958). Hence, it is expected that:

1a) The EC group will be less disturbed when surprised during task-performance in Phase D compared to Phase C and also less than CC group in Phase D. For this reason, the results from the post-game questionnaires will be analyzed.
1b) The EC group will be faster than the CC group during Phase D. Thus, the respected logged timings will be analyzed.

1c) The EC group will be more correct than the CC group during Phase D. For this purpose, the according logged in-game scores will be analyzed.

2) The second research question investigates the possibility of measuring both short-term and long-term surprise effects in a gaming context, by using a simple EEG device. EEG short-term effects will only be examined for SEs during the EC mission, since only there all the surprise types are introduced. Within the short-term effect time frames (as described in subsection 1.8) from the moment the SEs are triggered, it is expected for the M.A.P. value of Delta band to decrease. This is because surprises are regarded to stir up the players, which means that the players' vigilance increases and hence they transit into a more wakeful state. Also, since surprises are considered to heighten the players' attention and lead to better memory formation (Ranganath & Reiner, 2003) in a prolonged period of time, it is expected that the two groups will increase their Beta band levels, at least when first encountering surprises. That would be Phase C for the EC group and Phase D for the CC group. However, this prediction is also examined for regular gameplay (i.e. Phase C for CC group), due to the fact that the gameplay itself might introduce unmeasured surprise effects to the players. The EC group is expected to partially or fully recover to its baseline Beta band values during Phase D, since by then it should have already formed a line of expectation for SEs. Hence, the EC group is expected to respond less emotionally to forthcoming surprising stimuli. This means decreased cortical activation for the players, which during wake state (i.e. while being conscious) connects to an increased Alpha band activity (Benca et al., 1999). In other words, the EC group is expected to become more relaxed during surprise events in Phase D. All the above can sum up to the following hypotheses.

2a) Beta bands mean amplitude power will be higher during regular gameplay (i.e. Phase C for CC group) than in rest condition (i.e. baseline).
2b) Beta bands mean amplitude power will be higher during surprising gameplay (e.g. Phase C for EC group) than in regular gameplay (i.e. Phase C for CC group) and thus also than in rest condition (due to hypothesis 2a).
2c) Mean amplitude power in Delta band will be lower than baseline during surprising events, within the 3, 5, 8 sec. timeframe just after being triggered.
2d) Alpha band mean amplitude power will be higher for the EC group than the CC group during surprising events in Phase D, within the 3, 5, 8 sec. timeframe from the moment they are triggered.

A summary of the above EEG expectancies, the reasoning behind them along with the mental interpretation can be found in Table 1.

Reasoning	**Expected EEG effects**	**Mental interpretation**
Increase of attention	High Beta bands M.A.P.	High attention, agitation, thoughtfulness and relaxed yet focused
Increase of vigilance	Low Delta band M.A.P.	Non-sleepy, vigilant, not unconscious
Less emotional response after being exposed to many SEs	High Alpha band M.A.P.	Relaxed, but not drowsy, tranquil, conscious

Table 1 – Summary table for EEG expectancies along with their respected mental interpretations

3) In order to use mental state measurements as input to design revision process, it must first be confirmed whether the expected EEG effects are detected or not. For example, when examining whether the implemented surprises are producing the expected EEG effects (as described in hypothesis 2), it should be noticeable which surprise types confirm them. From this, it should be possible to classify whether a surprise (or a surprise type) can be regarded as strong or weak, and hence this can work as a guideline for the instructor redesign the according SEs. However, different surprise types might also trigger different mental reactions, due to the fact that they are part of a different cognitive process (i.e. bottom-up or top-down surprises). The intensity or valence of the SEs might also suggest a variety of oscillations in the brain frequency bands. For example, stronger surprise types are expected to produce more intense EEG effects. With respect to our prior findings (Georgiadis, Van der Pal, Van Oostendorp & Veltkamp, 2013) and based on the fact that narrative-based SEs are more difficult to be well-introduced in a 20-25 min. gameplay, it is expected that the cue-based SEs will produce more intense short-term EEG effects than the narrative-based ones. This means that it is expected for the cue-based SEs to decrease the Delta band M.A.P. of the player more than the narrative-based ones. At the same time, it is expected that the players will rate the cue-based SEs on the post-game Questionnaire to be more surprising, startling, confusing and disturbing during task performance than the narrative-based ones. Summarizing we have the following hypothesis.

3a) Cue-based SEs are expected to produce more intense short-term EEG effects than the narrative-based ones. In other words they are expected to produce lower Delta band M.A.P. values, while they will also receive higher ratings from the players in the post-game Questionnaire for surprise, startle, confusion and disturbance during task-performance.

Chapter 2: Method

2.1 Introduction

This study aims to develop and test a framework for designing surprises in the virtual context of a simulation or computer game, while also methods for assessing their impact to the players mainly by using an EEG device.

2.2 Participants

Twenty people aging from 19 to 33 participated in this experiment (10 in EC and 10 in CC). Assignment to conditions was balanced to sex and game experience. Thus, each group of participants contained an equal number of experienced (7) and inexperienced (3) players both in First-Person Shooter (FPS) games and generally in computer games.

2.3 Materials

This section describes all the used materials both for constructing the game missions and for the final assessment in order to give an answer to the research questions.

2.3.1 Materials for Game Construction

The (EC & CC) missions of this experiment (along with the game's narrative and the different surprise types) were developed by using the VBS2 Editor from Bohemia Interactive Studios.

2.3.1.1 Missions Narrative

A game scenario was created to provide the six surprise types (described at 1.5.2.2) by using the VBS2 editor from Bohemia Interactive. In this scenario, the player acted as an undercover agent whom had to perform a series of actions in order to save an island's commercial supplies from terrorists. The gameplay was set as single player, action-based in a non-military setting using a linear, simple scenario that was playable even for participants unexperienced to first person shooter games.

Two different versions of the same mission were implemented. The first, called "Experimental Condition or EC" contains 10 surprising events (SE). The second, called "Control Condition or CC", follows the same narrative, except this time only three surprising events are included, those of Phase D. The narrative of these two versions is divided in 4 phases:

Phase A: This is the introduction phase where the player learns how to navigate into the virtual world by using the standard gaming control keys for moving around in the virtual environment).

Phase B: This is the learning phase where the player learns about his mission and how and which types of actions he can perform:

- Social actions = Hello action, Get info action, Heal action
- Vehicle actions= Load trucks, Sit in vehicle as driver, drive vehicle, repair vehicle
- Toggle Lights actions = turn on/off the lights of a big shed.

The participant is given guidance (prompts, cues) on the actions to perform. By performing some actions without surprises, we assume the participant will learn to perform the actions while setting a baseline of expectations on the task and the environment.

Phase C: For the EC this is the surprising events phase, where the player has to perform actions which are introduced by different types of surprising events (seven SEs in total). On the other hand, Phase C is different for the CC as it does not contain any SEs. This is because:

- We want to measure the impact that prior surprises of Phase C, may have on SEs and actions in Phase D (only for the EC group).
- We want to measure the differences between EC and CC groups during Phase D.

The surprising events are introduced in EC mission as cinematics of certain time duration. On the other hand, in the case of the CC mission, the same cinematics of the same duration are again introduced, only this time the surprising stimulus is completely removed. That is because no default timing differences should exist between the two missions.

Phase D: This is the last "undercover mission" phase, where the player has to perform a series of actions in order to complete the mission successfully. This phase is identical for both EC & CC, since both contain the same (three) SEs. This is, to

evaluate the differences between the EC and CC, considering that EC had prior SEs during Phase C while CC did not.

The participant is given limited guidance during Phase C & D as it is considered that he/she should already be aware of the possible actions he/she can perform from Phase A & B. Below an overview (see Table 2) of the aforementioned approach is presented.

	Phase A	Phase B	Phase C	Phase D
EC		actions	SE1 - actions - SE2 - actions - SE3 - actions - SE4 - actions - SE5 - actions - SE6 - actions - SE7 - actions	SE8 - actions - SE9 - actions - SE10 - actions
CC		actions	actions	SE8 - actions - SE9 - actions - SE10 - actions

Table 2 - The game missions separated in different phases

The next table (see Table 3) illustrates the number of SEs, from each type, used in the EC mission:

Type of surprise	No. used in mission
Task-independent cue-based SE	2
Task-independent narrative-based SE	1
Task-independent mixed SE	1
Task-dependent cue-based SE	1
Task-dependent narrative-based SE	3
Task-dependent mixed SE	2

Table 3 - No. of surprises included in the mission per category

The complete narrative used for the mission can be found in Appendix E: Game's Narrative of the Small Project: Learning how to deal with surprises (Georgiadis, Van der Pal, Van Oostendorp, Veltkamp, 2013).

2.3.1.2 Scripting on VBS2

In order to develop the VBS2 game mission, it was necessary to use the VBS2 scripting language (C family). The scripting had to be implemented both in-game and out-game. In-

game scripting commands are rougher, but in some cases they are more simplistic and straightforward. This type of scripting is usually used by the developers in order to directly manipulate individual units in a mission. However, in-game scripting is not proper for creating the general framework of the mission. Out-game scripting on the other hand, is more laborious but still it is essential for creating a professional-like mission. For example, it allows the developers to organize their mission by providing instructional slideshows to the players. In many cases, the instructional pattern used by the creators of VBS2, were also used in the EC & CC missions so that the participants could be guided more effectively. The code can be found in Appendix D: Code of the Small Project: Learning how to deal with surprises (Georgiadis, Van der Pal, Van Oostendorp, Veltkamp, 2013).

2.3.2 Materials for Assessment

Three different ways where used in order to make the necessary measurements for the purposes of the experiment. One was done by measuring mental states with the use of an EEG device, while the others were in-game assessment (point system, time measurements) and a Likert-scale post-game questionnaire (engagement, surprise / startle / confuse / distraction from tasks).

2.3.2.1 EEG Assessment

By using key-strokes all the critical moments of the missions (such as the surprising events and the different phases of the missions) were stamped within the EEG recorded data. This allowed us to mark the data into very specific time moments of major interest in order to further analyze them. For example, the EEG data recorded directly after the surprising events was analyzed in three time periods: three, five and eight seconds after the time stamp, respectively related to startle, surprise and confusion effects (as described in 1.8). In general, the EEG data was collected with a sampling rate of 128 Hz. Data was recorded by using NeuroSkyLab. After collecting the EEG data, EEGLAB was used in order to plot the power spectra and the mean (amplitude) power of each individual frequency bandwidth for all the time-stamped events of the game missions. The whole process for extracting the EEG data can be found in the Capita Selecta: EEG Technical Exploration (Georgiadis, Van der Pal, Van Oostendorp, Veltkamp, 2014). Moreover, statistical analysis on the extracted EEG data was performed by using the IBN SPSS Statistics 21. Multiple T-Tests were performed as one-tailed or two-tailed (with regard to the initial hypothesis statements) independent-samples T-Tests (with equal variances not assumed). In addition, one-way ANOVA's using Games-Howell for post-hoc analysis was also used.

2.3.2.2 In-game Assessment

Considering the in-game assessment, a simple and straightforward point system was used in order to register the players' correctness by measuring their total score (+100 points for every correct action). The players were receiving according feedback for their correct actions during the whole mission, while they could also see their total score from the respected in-game score indicator (at the upper-left part of the screen). In detail, the players were receiving textual feedback from in-game instructors (i.e. non-playing characters) considering which actions they should take until Phase C. During Phase D however, no instructions were given to the players and thus they had to understand on their own which actions could provide them more points. The scoring system worked automatically for both score logging and in-game feedback. For example, in order to get points the player could load some supply boxes on trucks in order to get more points. By the moment the action was taken through the respected action menu, the box coordinates were changing and it was attached on the truck. At the same time the player was awarded with 100 points which were consequently added to his/her total score. For this reason, according scripting was needed in VBS2 Editor. Moreover, the players' timings (from both EC and CC groups) were logged separately for completing each of the four phases, as also their overall time for completing the whole mission. The begging and ending of each phase was marked in the EEG data files, with the manual press of the respected key-strokes (e.g. for Phase A the keystroke was "a", etc.). The timings were logged with milliseconds precision (i.e. ms). Multiple T-Tests were performed as one-tailed independent-samples T-Tests with equal variances assumed.

2.3.2.3 Post-game Questionnaire

Besides the in-game assessment, a post-game questionnaire was also used. This questionnaire was used in this experiment as a self-rating questionnaire for the four dimesions a) surprise, b) startle, c) confusion and d) distraction from task during the experienced surprising events. A 7-point Likert-type scale was used for this reason, ranging from "not at all" to "very much" concerning the intensity of the players' experience for all four dimensions. A screenshot was presented beside each SE question, illustrating a respected scene moment from the SE along with a short description of the respected surprising event. At the end of this questionnaire, some demographic related questions were also posed considering sex, age and gaming experience of the players. The questionnaires used for both the EC and CC groups can be found at the appendix section of the present report (Appendix A and B respectively).

2.4 Apparatus

The mission was made by using the VBS2 Editor (version 1.6) which was created by Bohemia Interactive Studios. The game was played on a Dell Alienware AURORA_4 desktop computer using an Intel(R) Core(TM) i7-4930K CPU @ 3.40 GHz, with a 27" widescreen monitor, a NVIDIA GeForce GTX 680 graphics card, and a large Alienware headset. The mission ran smoothly on a maximum detail (of 2560x1600) and lighting settings. All the VBS2 audio settings (SFX, Music etc.) where set at the maximum in order to get advantage of larger differences in loudness of the auditorial cues used in mission. Lastly, a 64-bit version of Windows 7 Professional was used as operating system.

In addition, Neurosky's Mindwave Mobile was used for collecting the EEG data. This EEG device consists of the ThinkGear AM (TGAM) EEG sensor PCB module, a dry-electrode and an ear-clip. Embedded within the TGAM, is the TGAT chip, which is a fully integrated single chip EEG sensor. The chip is programmed with NeuroSky eSense, A/D, amplification off head detection, and noise filtering for EMG and 50/60Hz AC powerline interference.

Finally, a powerful PC was used for EEG data analysis. The PC was configured with 12 cores and 128Gb RAM to allow for 12 parallel calculations using Matlab.

2.5 Experiment setting

The experiment took place at the facilities of NLR and more specifically at the "Serious Games Room". The aforementioned used desktop computer was placed in such a way so that the participants couldn't be easily distracted by any external visual noise. Before the players started the mission, some initial instructions were given in order to overcome minor technical inconsistencies. During the mission, the players where supervised, in order to see their gameplay behavior, their reactions on the SEs and also to provide them with some help in case of a bug or a technical inconsistency. For the users that where totally unexperienced with computer games a bit of extra help was provided, but always with respect to not affect their final scores.

2.6 Procedure

After fitting NeuroSky's Mindwave Mobile to the participants head, they were asked to wait while remaining calm and inactive in order to perform a 5 minute baseline recording. When done, few verbal instructions related to the gameplay were given to the participants. After this, the participants started playing the mission (either EC or CC) while concurrent EEG recordings were performed. After completing the mission, the participants were

handed with a questionnaire that they had to fill in order to complete the experimental process. Playing the game took about 25 minutes. The total session lasted about 45 minutes. The whole experimental procedure is illustrated in Fig. 5.

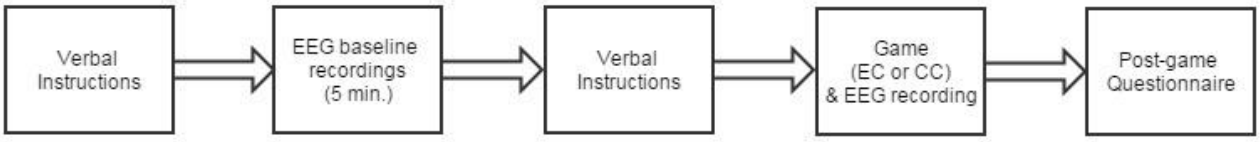

Figure 5 - Experimental Procedure

Chapter 3: Results

3.1 Introduction

In this chapter, all the EEG, questionnaire and in-game results collected during the experiment are presented. Graphs illustrating EEG results can be found in Appendix C, while the raw EEG data can be found in Appendix D.

3.2 Results

All the results are presented in order of the hypotheses (see section 1.11). Before performing any statistical analysis over the collected EEG data, all the outliers were removed by finding the according upper and lower limits (Iglewicz et al., 2001) for the amplitude range of each brain frequency band (formula for finding the limits provided at Table 4). This is because the amplitude range of each brain frequency bands was not provided by manufacturer (only the frequency range was provided as depicted in Figure 1).

Formulas for upper and lower limits	Upper limit = (75 Percentile) + (2.2 * (75 Percentile – 25 Percentile))
	Lower limit = (25 Percentile) - (2.2 * (75 Percentile – 25 Percentile))

Table 4 - Formula for finding the upper and lower limits of each frequency band in order to remove the outliers

The found upper and lower limits follow in details for each brainwave frequency band at Table 5. The lower limits were all found negative and thus the lower limit for all the frequency bands was set to 0 by default. This is because brain activity cannot be negative.

Brain freq. bands	**Delta**	**Theta**	**Alpha**	**Low Beta**	**Mid Beta**	**High Beta**	**Gamma**
Upper limits	1279.8572	31.2872	13.9760	5.5917	9.9510	4.4397	0.1059

Table 5 - Upper limits for all the frequency bands as found

3.2.1 Compatibility of EC and CC Groups

Before presenting results from the game mission, it is vital to first examine the pre-game mental state of the players in order to create a baseline for the two groups. While EEG can be expected to differ between individuals, no differences are expected between the EC and CC groups in a rest situation (baseline), and the same holds for gender and game experience.

However, the statistical analysis revealed a significant difference between the two groups in Theta band. Gender (and/or gaming experience) differences were also found in the baseline recordings, with the female participants being more aroused (i.e. having higher M.A.P. values) than the male ones in Mid Beta and Gamma bands. When comparing the mental state between the males of EC and CC groups, statistical significant differences were found in Theta, Alpha and Low Beta bands. The M.A.P value for each band was found by averaging the M.A.P. values of all the participants from each group (see Table 6). See Table 7 for a summary of statistically significant baseline results.

Brain freq. bands	Delta	Theta	Alpha	Low Beta	Mid Beta	High Beta	Gamma
EC group M.A.P. value in baseline	431.75	15.62	5.84	2.37	3.76	1.54	0.028
CC group M.A.P. value in baseline	357.56	12.91	4.93	2.06	3.83	1.71	0.032
Males' M.A.P. value in baseline	314.52	11.84	4.47	1.92	2.82	1.19	0.019
Females' M.A.P. value in baseline	458.00	15.42	6.02	2.40	4.70	2.05	0.040

Table 6 – M.A.P. values of each brain freq. band for both groups and also for males/females during baseline

Therefore, in subsequent analyses, the players' M.A.P. values at all brain frequency bands during gameplay phases are corrected for the baseline M.A.P. values at all brainwave frequency (see Table 6) of their group separately. Players' M.A.P. values that were found to be outliers in either baseline or during the game phases are removed from the analysis.

Variables from baseline	df	t	Sig. (2-tailed)	Mean	Std. Deviation
Comparing baseline of EC to CC group in Theta band	15.766	2.391	0.030	EC: 15.6226	EC: 5.9436
				CC: 10.2060	CC: 4.0007
Female to male comparison in Mid Beta band	9.178	2.796	0.020	F: 4.6953	F: 1.3905
				M: 2.8179	M: 1.2930
Female to male comparison in Gamma band	7.224	2.748	0.028	F: 0.0402	F: 0.0173
				M: 0.0188	M: 0.0117
Comparing EC to CC males in Theta band	6.858	2.787	0.028	EC: 15.6347	EC: 6.9574
				CC: 8.0471	CC: 1.8650
Comparing EC to CC males in Alpha band	7.903	2.695	0.028	EC: 5.9398	EC: 2.6847
				CC: 2.9909	CC: 1.0831
Comparing EC to CC males in Low Beta band	7.872	2.768	0.025	EC: 2.4389	EC: 0.9240
				CC: 1.3975	CC: 0.3696

Table 7 - Summary table of all statistically significant findings from baseline recordings

3.2.2 Effects on Task-Performance by Exposure to Surprises

This subsection introduces the results considering hypothesis 1 and thus also research question 1. The effects on the players' task-performance were assessed in a twofold way. Firstly, post-game questionnaires were used in order to perceive the participants' after-game impressions, and secondly in-game measurements were used in order to record their actual performance in terms of time and score (for correct actions).

3.2.2.1 Disturbance on Task-Performance

This subsection refers to hypothesis 1a. Considering the results (see Figure 6) of the players' self-ratings at the post-game questionnaires considering disturbance during task-performance, no statistically significant differences ($p>.05$) occurred. Therefore, our initial hypothesis that the EC group will be less disturbed during task-performance in Phase D compared to Phase C was not confirmed. Similarly, no differences ($p>.05$) were found among the two groups during Phase D.

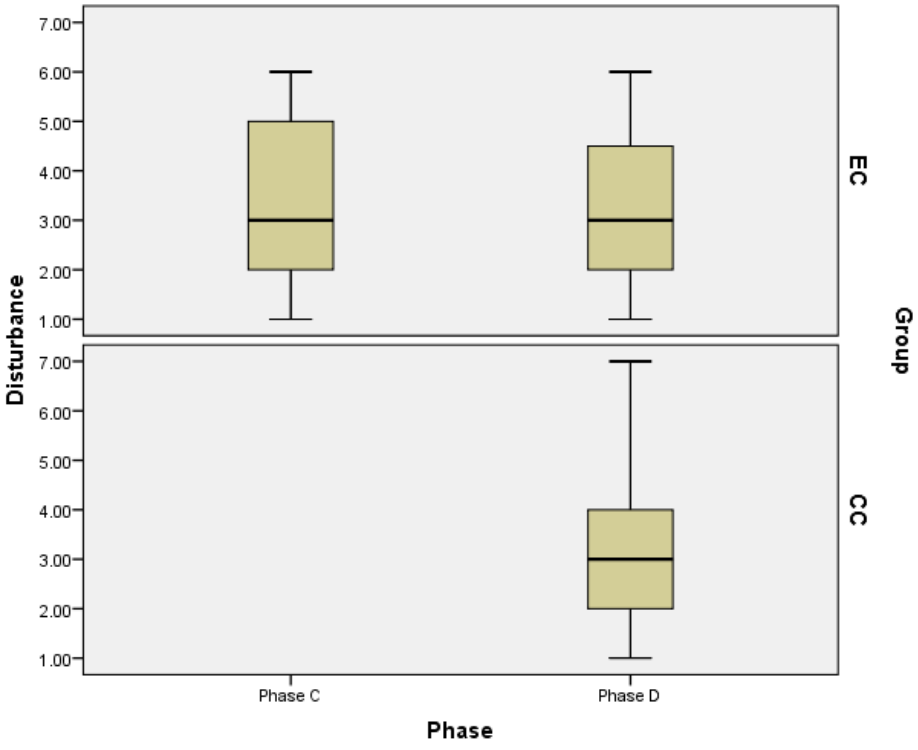

Figure 6 - Boxplot illustrating players' ratings on disturbance during task-performance from the SEs

3.2.2.2 In-Game Scores

This subsection refers to hypothesis 1b and 1c. Statistical significance was found during Phase D (see Figure 7), concerning the timings ($p < .01$) and the performance scores ($p < .05$) of the two groups, with the EC group being faster and more correct than the CC group (Note: At the bottom error bar at Figure 7 only one horizontal line appears because that is the maximum score that could be achieved at Phase D). For more details on the statistical results see Table 8. For a more detailed presentation of the raw data during Phase D see Appendix D.

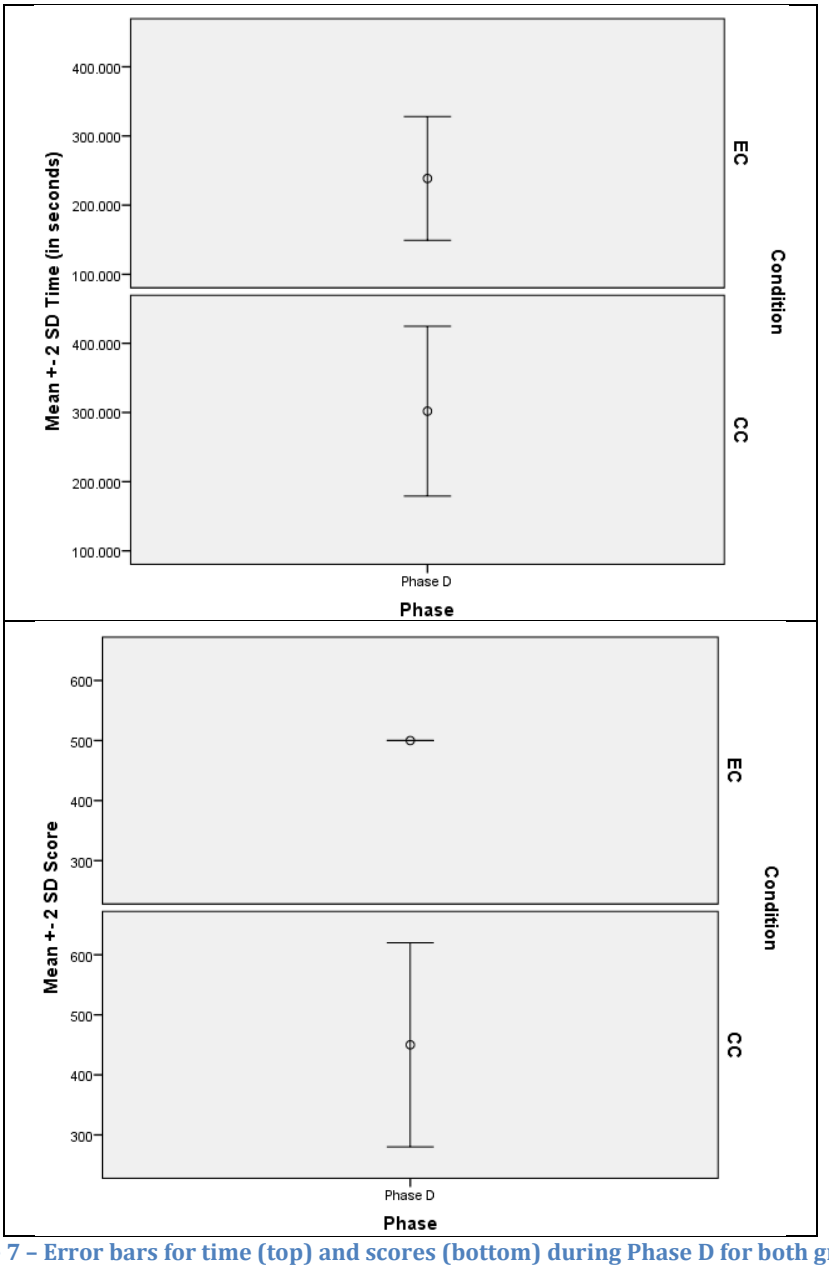

Figure 7 – Error bars for time (top) and scores (bottom) during Phase D for both groups

Variables from Phase D	df	t	Sig. (1-tailed)	Mean	Std. Deviation
Comparing timings of EC group to CC group	18	2.637	0.0085	EC: 238.5	EC: 44.7437
				CC: 301.8	CC: 61.3572
Comparing scoring of EC group to CC group	18	1.861	0.0395	EC: 500	EC: 0.000
				CC: 450	CC: 84.984

Table 8 - - Summary table of statistically significant findings of time and in-game scores at Phase D

3.2.3 EEG Effects of Surprises

Results for EEG effects from the implemented surprising events on the participants are presented in the following subsections. These results concern hypothesis 2 and the according research question 2.

3.2.3.1 Comparing Regular Gameplay to Baseline at Beta Bands

The results in this subsection refer to hypothesis 2a. When performing a statistical analysis on the CC group, comparing its Phase C to its baseline (Low, Mid & High) Beta band M.A.P. values, statistically significant results ($p<0.5$) were detected in Low Beta and Mid Beta bands (see Table 9). No statistically significant difference occurred in High Beta band though.

Variables from Phase C & Baseline (CC group)	df	t	Sig. (2-tailed)	Mean	Std. Deviation
Comparing CC Phase C to baseline in Low Beta	11.308	2.063	0.0315	Ph. C: 2.69	Ph. C: 1.11
				Base: 1.75	Base: 0.70
Comparing CC Phase C to baseline in Mid Beta	10.567	1.811	0.0495	Ph. C: 4.86	Ph. C: 2.18
				Base: 3.10	Base: 1.63

Table 9 - Statistically significant findings from comparing CC groups' M.A.P. values from Phase C with baseline

3.2.3.2 Comparing Surprising Gameplay to Regular Gameplay at Beta Bands

The results in this subsection refer to hypothesis 2b. When comparing the M.A.P. values of EC group to the ones of CC group during Phase C in the Beta bands no statistically significant results ($p>0.5$) occurred (see Figure 8).

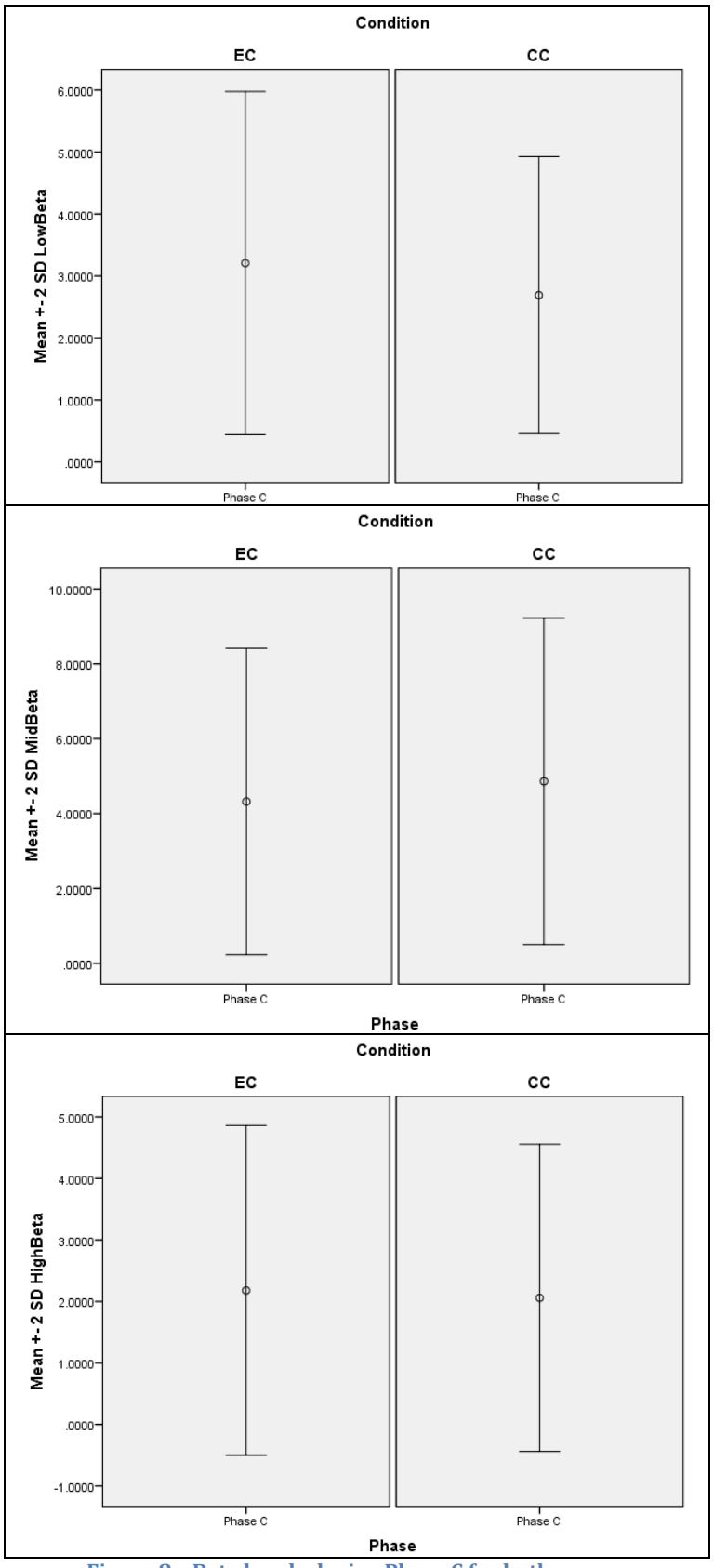

Figure 8 – Beta bands during Phase C for both groups

Even though no differences are found in the Beta bands between regular and surprising gameplay (as described above in this subsection), when comparing the Beta M.A.P. values of all the surprising phases of the gameplay for both conditions (i.e. Phase C & D for EC group and Phase D for CC group) to their respected baseline Beta M.A.P. values, we do find additional statistical significant differences (see Table 10). The appearance of a significant statistical finding ($p<0.5$) in High Beta (connected to alertness/agitation) for the CC group, when comparing its M.A.P. values in phase D to its baseline M.A.P. values is noticeably interesting, since this is the first time that a statistically significant difference is found in this particular band.

Variables	df	t	Sig. (1-tailed)	Mean	Std. Deviation
Comparing EC Phase C to baseline in Low Beta	14.775	1.630	0.062*	Ph.C: 3.20	Ph.C: 1.38
				Base: 2.37	Base: 0.83
Comparing EC Phase D to baseline in Mid Beta	10.725	1.623	0.067*	Ph.D: 5.49	Ph.D: 2.68
				Base: 3.75	Base: 1.50
Comparing CC Phase D to baseline in Low Beta	13.864	3.182	0.0035	Ph.D: 3.24	Ph.D: 1.30
				Base: 1.75	Base: 0.70
Comparing CC Phase D to baseline in Mid Beta	10.745	2.710	0.0105	Ph.D: 6.11	Ph.D: 2.79
				Base: 3.10	Base: 1.63
Comparing CC Phase D to baseline in High Beta	14.513	2.262	0.020	Ph.D: 2.58	Ph.D: 1.29
				Base: 1.39	Base: 0.94

weak effect

Table 10 - All statistically significant findings from comparing surprising gameplay to baseline for both groups

3.2.3.3 Short-term Effects at Delta Band

This subsection's results connect to hypothesis 2c. Therefore, a comparison was needed between the Delta M.A.P. values of the ten SEs in EC version within the given short-term effect time-frames (i.e. 0-3, 3-5 and 5-8 seconds) and the Delta M.A.P. baseline values of EC group.

A one-way ANOVA using Games-Howell for post-hoc analysis showed that the mean of the baseline M.A.P. values (Mean: 431.74, Std. Deviation: 318.38) is statistical significantly higher [$F(1, 9) = 14.971$, $p=0.004$] than the mean of the ten SEs M.A.P. values (Mean: 158.71, Std. Deviation: 234.59) in Delta band for the time-frame of 0 to 3 seconds. A boxplot illustrating the two variables follows in Fig. 9.

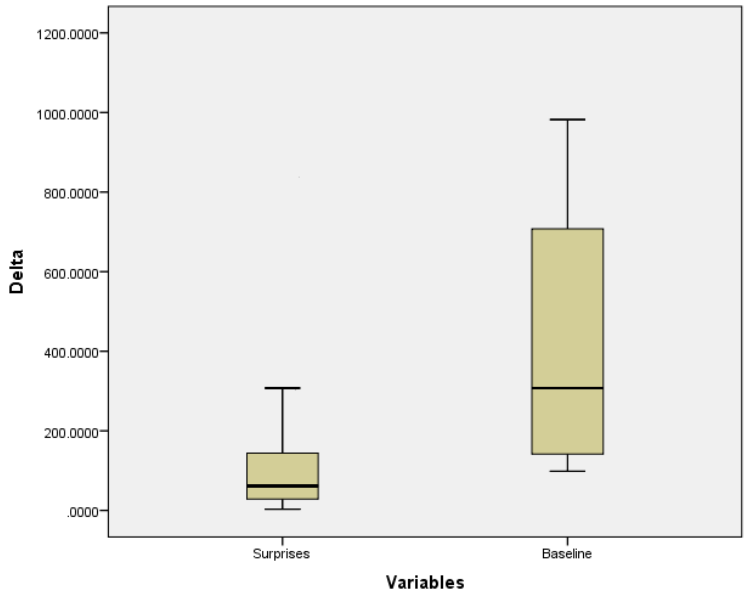

Figure 9 - Boxplot illustrating the Delta Band M.A.P. values for SEs and Baseline within the 0-3 sec. time-frame

A one-way ANOVA using Games-Howell for post-hoc analysis showed that the mean of the baseline M.A.P. values (Mean: 431.74, Std. Deviation: 318.38) is statistical significantly higher [F (1, 9) =5.353, p=0.046] than the mean of ten SEs M.A.P. values (Mean: 139.57, Std. Deviation: 232.34) in Delta band for the time-frame of 3 to 5 seconds. A boxplot illustrating the two variables follows in Fig. 10.

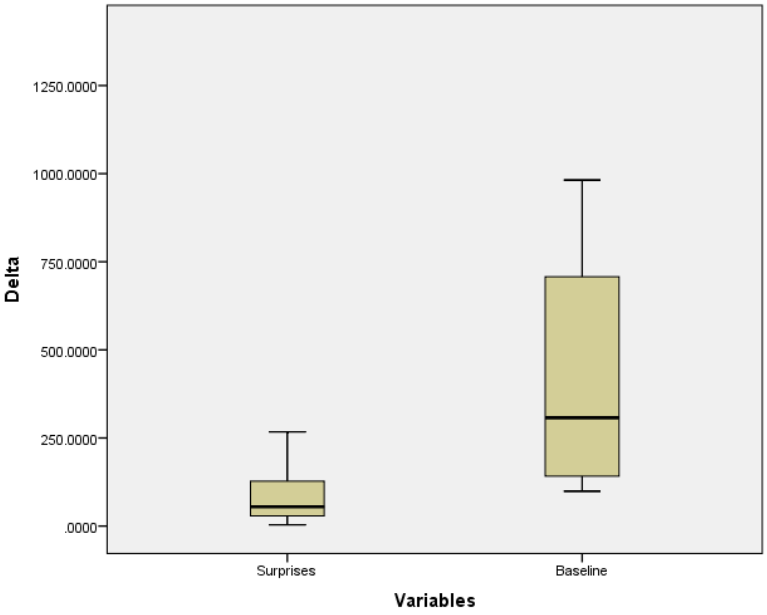

Figure 10 - Boxplot illustrating the Delta Band M.A.P. values for SEs and Baseline within the 3-5 sec. time-frame

A one-way ANOVA using Games-Howell for post-hoc analysis showed that the mean of the baseline M.A.P. values (Mean: 431.74, Std. Deviation: 318.38) is statistical significantly higher [F (1, 9) =28.179, p=0.000] than the mean of ten SEs M.A.P. values (Mean: 117.18, Std. Deviation: 154.05) in Delta band for the time-frame of 5 to 8 seconds. A boxplot illustrating the two variables follows in Fig. 11.

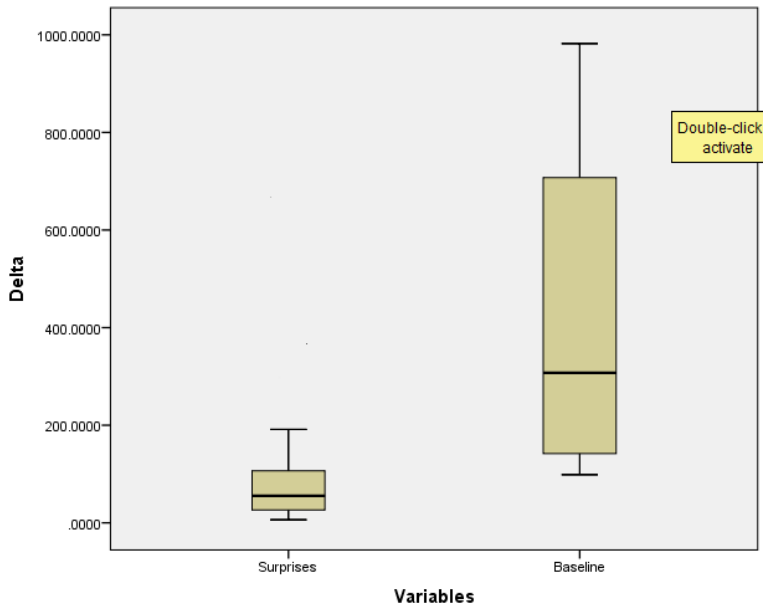

Figure 11- Boxplot illustrating the Delta Band M.A.P. values for SEs and Baseline within the 5-8 sec. time-frame

3.2.3.4 Short-term effects at Alpha band during the last three SEs (combined)

This subsection's results relates to hypothesis 2d. Results from EEG Data related to statistical differences between the two groups during the last 3 common SEs of Phase D, has shown a statistically significant difference (p<.05) in Alpha, with the EC group being higher in M.A.P. values than the CC group during the first 3 seconds. This means that EC group was more relaxed when encountering surprises at Phase D than the CC group. The results follow at Table 11.

Variables from last 3 common SEs	df	t	Sig. (1-tailed)	Mean	Std. Deviation
Comparing EC to CC in Alpha (0-3 sec.)	50.123	2.079	0.0215	EC: 5.2093	EC: 3.0727
				CC: 3.6353	CC: 2.5003

Table 11 - Summary table from summary comparison of last three common SEs between EC and CC groups

3.2.4 EEG Effects of Different Surprise Types

The results of this subsection relate to hypothesis 3a. Differences in short-term EEG effects and differences from the post-game Questionnaire ratings were examined among different surprise types of the framework. More specifically this would include the comparison between cue-based and narrative-based SEs.

Considering the differences in short-term EEG effects, and more specifically in Delta band, no statistically significant results ($p>0.5$) emerged from comparing cue-based surprised to narrative-based ones. An according boxplot illustrating this finding can be seen in Fig. 12.

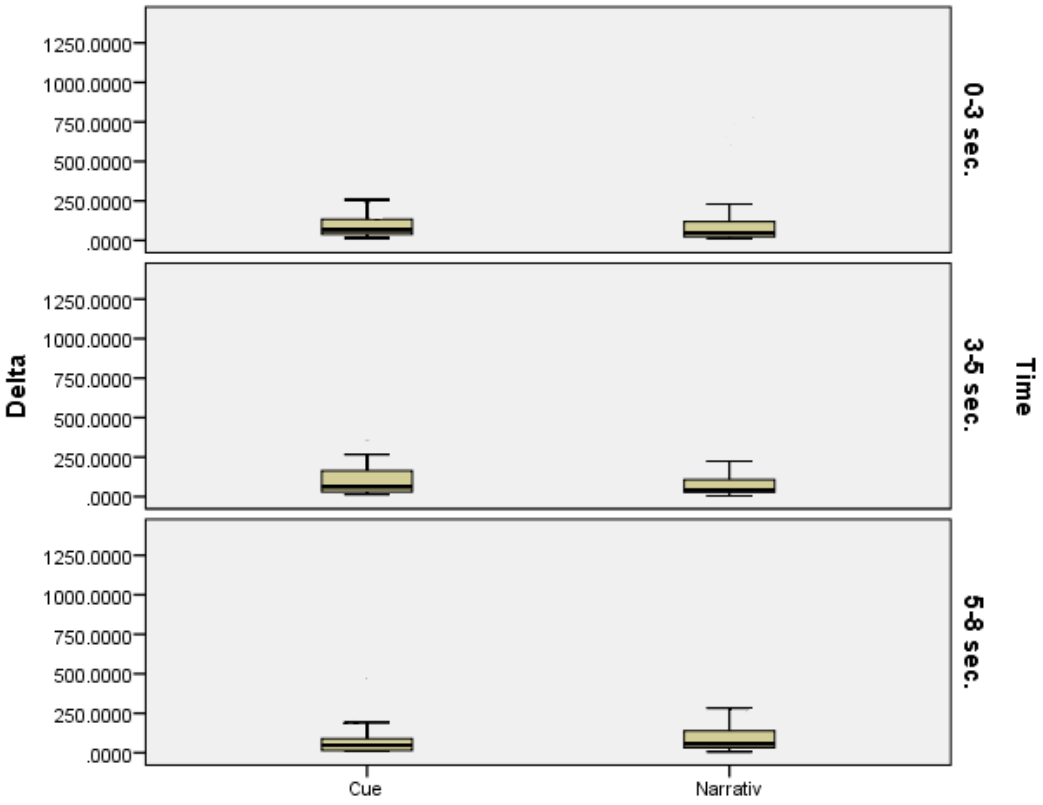

Figure 12 – Boxplot for Differences in Delta band between cue and narrative based SEs within all the given time-frames

However, the post-game questionnaires indicate otherwise, since the participants stated to be more surprised, startled and confused during the cue-based surprises. No statistically significant difference was found though for disturbance during task performance. A detailed table illustrates all the above findings (see Table 12).

Variables of SE categories from post-game Questionnaire	df	t	Sig. (1-tailed)	Mean	Std. Deviation
Comparing cue-based to narrative-based in surprise	83.413	2.050	0.0215	Cue: 4.9211	Cue: 1.3432
				Nar: 4.3000	Nar: 1.4880
Comparing cue-based to narrative-based in startle	74.581	2.965	0.002	Cue: 4.1316	Cue: 1.8912
				Nar: 2.9800	Nar: 1.6841
Comparing cue-based to narrative-based in confusion	79.550	2.175	0.0165	Cue: 4.3158	Cue: 1.8759
				Nar: 3.4400	Nar: 1.8643

Table 12 - Statistically significant results from post-game Questionnaire among cue and narrative based SEs

Chapter 4: Discussion

Considering the research question of whether exposure to more surprises leads to an improved handling of surprises, measurements were performed in three ways, feedback from the EEG, post-game questionnaire ratings and in-game measurements. The results have shown that even though the EC participants stated not to feel less disturbed during their task-performance when exposed to more surprises compared to the CC group, they performed better in means of performance score and time during Phase D. When looking for additional EEG differences between the two groups during the surprising events within the 0-3 sec. time-frame from the moment the last three common SEs were triggered, a difference was also detected between the EC and CC groups in the Alpha band. This means that the EC group (which was exposed to more surprises) felt more relaxed than the CC group during the very first seconds in which they had to act in Phase D. This fact probably helped the EC group maintain a better level of instant or reflex reactions towards the surprising gameplay, which consequently helped in achieving higher in-game scores.

Based on the literature, it was already known that surprises cause a heightening of attention. In EEG terms this relates to the Beta bands which are responsible for alertness, agitation, thoughtfulness etc. Thus, a boosting of the Beta bands was expected. This expectation was indeed confirmed when comparing the surprising phases to the baseline of each individual group. However, no differences were found when comparing regular gameplay to surprising gameplay, since regular gameplay also boosted the Beta bands in a very similar way. Therefore, the boosting of the Beta bands was not confirmed to be strongly connected to the surprising events, but instead it might be related to regular gameplay conditions were actions take place. It is also possible that unmeasured factors, such as ingenious surprises from the game itself, might have further affected the final results.

In addition, a drop in the Delta band was also expected within the 0-3, 3-5 and 5-8 sec. time-frames, since surprises are considered to stir up the players, i.e. awake them. This hypothesis was confirmed for all the given time-frames and for all the surprising events. Therefore, an EEG trend for the surprises was detected, based on which a distinction between well and bad implemented surprises can be made. This can be used for revising/redesigning the ones that are not affective, and also for recognizing strong surprising events within a game-play.

Furthermore, different EEG short-term effects for different surprise types were observed. More specifically, when comparing cue-based SEs to narrative-based SEs, the cue-based were found to be more surprising, startling and confusing. No difference however was found in the Delta band, since both the surprise types produced the expected M.A.P.

decrease in this band. For these results no strong arguments can be made, however a controversy between the post-game questionnaire and the EEG data is observed. This is because it should be the case that, the more intense a surprise type is (according to the post-game questionnaire) the more intense the EEG effects would also be. Since the EEG results confirm our hypothesis, the problem should probably focus in the post-game questionnaire assessment which does not align with the EEG findings. Hence, the validity of our assessment toolset is to be put at test, and especially the post-game questionnaire and the accuracy it provides.

This experiment was also an excellent chance for us to test our materials, both the ones that were used for the game construction and the ones that were used for the assessment. Considering the materials for the game construction, we got fruitful feedback from the participants regarding the gameplay and the implemented SEs. As for the tools used for the assessment it is important to mention that the use of EEG provided a new scope in the analysis of players' mental states. However, what could also help in that direction is an eye-tracking device and a camera for recording facial expressions. The eye-tracking device would allow the observation of the participants' reaction to cue-based (visual) surprises. Moreover, the recording of facial expressions during the surprising events could help in matching to standard facial expressions for surprise as part of a post-game assessment for their physiological state. Additionally, more biofeedback devices (such as GSR) could also be used, with the trade back however of possibly decreasing the players' immersion and natural response. It could also be useful to examine other promising parts of the brain such as the right PFC since in the current scenario setting only surprises of neutral and negative valence were implemented.

In addition, the questionnaires could be more extensive by considering demographic related questions, so that participants could be categorized in more coherent groups in order to avoid statistically significant differences during the baseline recordings. For example, in this experiment a default difference was found in relation to the baseline between the EC and CC groups in the Theta band, which means that there were indeed participants (even of the same gender / gaming experience) which were using their fantasy and imagination (and/or daydreaming) in a totally different way. This observation coincides with the remark about individual differences in consciousness state. The statistical difference between the two groups in the Theta band was mainly caused by a difference between the males of the two groups. Differences were also found between the females and males of the two groups, so we should probably examine separately male from female and not in mixed groups. Now, it is not fully understandable whether the differences are caused by demographic differences or by differences in consciousness states (or other unmeasured factors). The usefulness of the questionnaires is also put into test, since the 3-points Likert scales on gaming experience seem to be insufficient. Maybe broader scales

and some additional questions regarding the gaming experience could provide a better insight or even another system for measuring/classifying gaming experience. It is important to mention that even though the EEG results and the in-game measurements (fully or partially) confirmed our hypotheses, the results from the post-game questionnaire never seemed to align with those findings.

Chapter 5: Conclusion

This study presented an outline for a framework of techniques to optimize scenario design for training that requires trainees to deal with new situations with a desired and highly personal level of impact to the trainee's mental state. The framework consists of two major parts: 1) a design guide for implementing various surprise types in a virtual environment, 2) an assessment toolbox for measuring the trainees' responses before, during and after their exposure to surprising events, which were implemented in a serious computer game according to the framework's design guide.

The study mainly focused on testing the usefulness of one technique that has powerful potential in measuring mental states: EEG. The results indicate that a simple, commercial of the shelf tool that is easy to use in standard training situations, is sensitive to differences between surprising events, time effects, and individuals. Also, using the data recording and analysis software is at present not a simple task, and limited information is provided by the manufacturer.

No matter the complexity that EEG measurement introduced in this experiment, it helped in answering the posed research questions, even though some of the initial hypotheses were not fully confirmed. Our hypotheses (see 2a and 2b) for the Beta bands were confirmed when comparing regular and surprising gameplay to baseline M.A.P. values, but it was not confirmed when comparing regular game play to surprising gameplay at each other. An important finding that confirmed our hypothesis (see 2c) is the trend for surprises' short-term effect in Delta band, and more specifically its M.A.P. value decrease within the 0-3, 3-5 and 5-8 sec. time-frames from the moment the SEs were triggered. The most significant finding however derives from hypothesis 2d, were a short-term effect in boosting of Alpha band after being exposed to many surprises was observed as expected. This means that the players responded emotionally less to forthcoming surprising stimuli which consequently was depicted by their relaxed and more conscious mental condition. So, this is probably why the also managed to become more effective during task performance and thus score higher and act faster (as confirmed by the results from hypothesis 1b). Comparing surprise types (see hypothesis 3a), and more specifically cue-based to narrative based SEs showed that, no statistically significant difference occurred in the Delta band even though differences were detected on the players' ratings in the post-game questionnaire for surprise, startle and confusion. Similarly, the post-game questionnaire results for hypothesis 1a didn't align with the in-game measurement findings for hypothesis 1b. Therefore, doubts have risen for the usefulness of the post-game questionnaire, at least as it formed currently.

The usefulness for instructors and scenario designers of the post hoc analysis is currently low. More study is needed to determine the full potential of the technique and the validity of measuring the intended mental states. This will require mentally more compatible participant groups, a revision of the assessment tool-box especially for making more specific gaming profiles of the participants and lastly further improvements in the EEG data collection and analysis.

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Appendix

Appendix A: EC group Questionnaire

QUESTIONNAIRE

This study investigates what kind of events may have a surprising effect in some way or the other.

In this questionnaire, you are asked about 10 events in the game. Your answers are important to our research questions.

Please do read questions carefully, try to remember the situation and the effect it had on you.

Be honest in your answers. They only relate to the effect as you perceived it. As such they cannot be correct or incorrect!

Definitions

Surprise is a brief mental state that results from experiencing an unexpected event. Surprise occurs when a specific event or situation does not match with your expectations. Surprise can vary in intensity and appreciation. You may consider a surprise being negative, neutral or positive.

Startle is a physiological response to sudden event, such as sudden noise or sharp movement. Startle is a primarily a biological reflex and may include body movements or eyeblinks. A startling event can be unexpected, but not necessarily (think of a balloon that is about to be perched).

Confusion is the state of being bewildered or unclear in one's mind after experiencing a surprise, where the mismatch with your expectations can not easily be understood. Confusion is related to the process of trying to regain understanding of the situation.

Please describe the 3 events in this game that surprised you mostly

a)

b)

c)

1. This snapshot comes from an event that happened during your game play:

Short Description: While walking, Vincent hears a sudden loud horn, followed by a red moving arrow.

a) Do you remember the event in the snapshot above? Yes / No

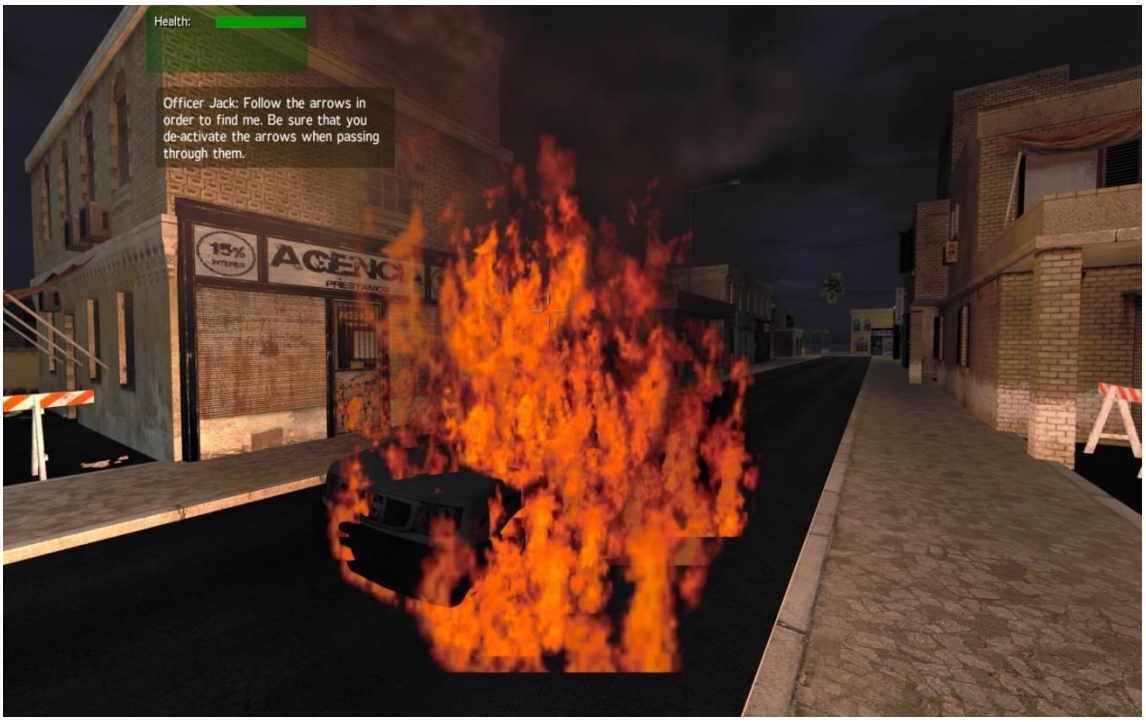
b) Please indicate how you experienced this event in terms of surprise, startle and confusion (circle the number of your choice):

	not at all	very little	little	moderate	above moderate	much	very much
This event surprised me:	1	2	3	4	5	6	7
This event startled me:	1	2	3	4	5	6	7
This event confused me:	1	2	3	4	5	6	7

c) Please indicate if the event caused any disturbance to performing your actions (e.g., pausing your actions while trying to understand what was going on, not knowing what to do, doing the wrong thing; doing irrelevant things):

	not at all	very little	little	moderate	above moderate	much	very much
This event disturbed my actions :	1	2	3	4	5	6	7

2. This snapshot comes from an event that happened during your game play:



Short Description: While driving, Vincent gets ejected from the vehicle, since it gets into flames.

a) Do you remember the event in the snapshot above? Yes / No

b) Please indicate how you experienced this event in terms of surprise, startle and confusion (circle the number of your choice):

	not at all	very little	little	moderate	above moderate	much	very much
This event surprised me:	1	2	3	4	5	6	7
This event startled me:	1	2	3	4	5	6	7
This event confused me:	1	2	3	4	5	6	7

c) Please indicate if the event caused any disturbance to performing your actions (e.g., pausing your actions while trying to understand what was going on, not knowing what to do, doing the wrong thing; doing irrelevant things):

	not at all	very little	little	moderate	above moderate	much	very much
This event disturbed my actions :	1	2	3	4	5	6	7

3. This snapshot comes from an event that happened during your game play:

Short Description: Cinematic shows a child sabotaging (exploding) part of the market's supplies.

a) Do you remember the event in the snapshot above? Yes / No

b) Please indicate how you experienced this event in terms of surprise, startle and confusion (circle the number of your choice):

	not at all	very little	little	moderate	above moderate	much	very much
This event surprised me:	1	2	3	4	5	6	7
This event startled me:	1	2	3	4	5	6	7
This event confused me:	1	2	3	4	5	6	7

c) Please indicate if the event caused any disturbance to performing your actions (e.g., pausing your actions while trying to understand what was going on, not knowing what to do, doing the wrong thing; doing irrelevant things):

	not at all	very little	little	moderate	above moderate	much	very much
This event disturbed my actions :	1	2	3	4	5	6	7

4. This snapshot comes from an event that happened during your game play:

Short Description: NPC shouts and shoots at the direction of a goat.

a) Do you remember the event in the snapshot above? Yes / No

b) Please indicate how you experienced this event in terms of surprise, startle and confusion (circle the number of your choice):

	not at all	very little	little	moderate	above moderate	much	very much
This event surprised me:	1	2	3	4	5	6	7
This event startled me:	1	2	3	4	5	6	7
This event confused me:	1	2	3	4	5	6	7

c) Please indicate if the event caused any disturbance to performing your actions (e.g., pausing your actions while trying to understand what was going on, not knowing what to do, doing the wrong thing; doing irrelevant things):

	not at all	very little	little	moderate	above moderate	much	very much
This event disturbed my actions :	1	2	3	4	5	6	7

5. This snapshot comes from an event that happened during your game play:

Short Description: Wacko guy wild dancing under the loud sound of a metal music song.

a) Do you remember the event in the snapshot above? Yes / No

b) Please indicate how you experienced this event in terms of surprise, startle and confusion (circle the number of your choice):

	not at all	very little	little	moderate	above moderate	much	very much
This event surprised me:	1	2	3	4	5	6	7
This event startled me:	1	2	3	4	5	6	7
This event confused me:	1	2	3	4	5	6	7

c) Please indicate if the event caused any disturbance to performing your actions (e.g., pausing your actions while trying to understand what was going on, not knowing what to do, doing the wrong thing; doing irrelevant things):

	not at all	very little	little	moderate	above moderate	much	very much
This event disturbed my actions :	1	2	3	4	5	6	7

6. This snapshot comes from an event that happened during your game play:

Short Description: A strong sandstorm destroys the island's electrical generators and street lamps.

a) Do you remember the event in the snapshot above? Yes / No

b) Please indicate how you experienced this event in terms of surprise, startle and confusion (circle the number of your choice):

	not at all	very little	little	moderate	above moderate	much	very much
This event surprised me:	1	2	3	4	5	6	7
This event startled me:	1	2	3	4	5	6	7
This event confused me:	1	2	3	4	5	6	7

c) Please indicate if the event caused any disturbance to performing your actions (e.g., pausing your actions while trying to understand what was going on, not knowing what to do, doing the wrong thing; doing irrelevant things):

	not at all	very little	little	moderate	above moderate	much	very much
This event disturbed my actions :	1	2	3	4	5	6	7

7. This snapshot comes from an event that happened during your game play:

Short Description: Truck steps into booby traps while heading to a “safe” location.

a) Do you remember the event in the snapshot above? Yes / No

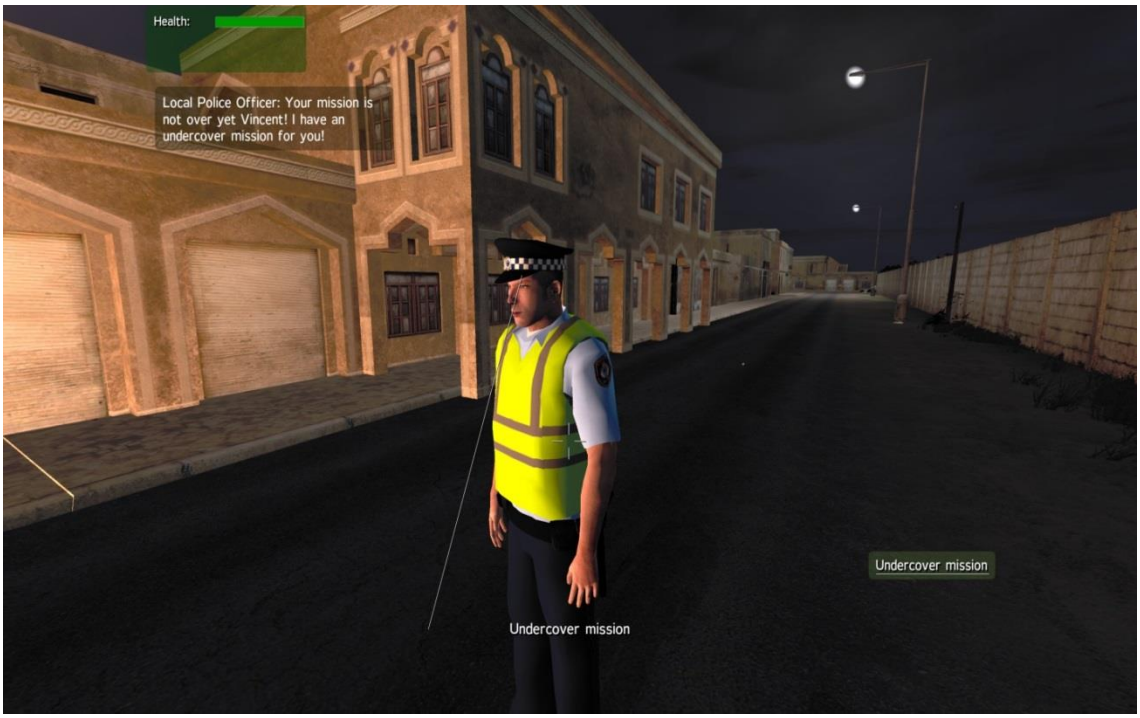
b) Please indicate how you experienced this event in terms of surprise, startle and confusion (circle the number of your choice):

	not at all	very little	little	moderate	above moderate	much	very much
This event surprised me:	1	2	3	4	5	6	7
This event startled me:	1	2	3	4	5	6	7
This event confused me:	1	2	3	4	5	6	7

c) Please indicate if the event caused any disturbance to performing your actions (e.g., pausing your actions while trying to understand what was going on, not knowing what to do, doing the wrong thing; doing irrelevant things):

	not at all	very little	little	moderate	above moderate	much	very much
This event disturbed my actions :	1	2	3	4	5	6	7

8. This snapshot comes from an event that happened during your game play:



Short description: After asking policeman to “Finish mission” he reveals an extra “Undercover mission”.

a) Do you remember the event in the snapshot above? Yes / No

b) Please indicate how you experienced this event in terms of surprise, startle and confusion (circle the number of your choice):

	not at all	very little	little	moderate	above moderate	much	very much
This event surprised me:	1	2	3	4	5	6	7
This event startled me:	1	2	3	4	5	6	7
This event confused me:	1	2	3	4	5	6	7

c) Please indicate if the event caused any disturbance to performing your actions (e.g., pausing your actions while trying to understand what was going on, not knowing what to do, doing the wrong thing; doing irrelevant things):

	not at all	very little	little	moderate	above moderate	much	very much
This event disturbed my actions :	1	2	3	4	5	6	7

9. This snapshot comes from an event that happened during your game play:

Short Description: Guards get distracted by sudden blackout caused from sandstorms (Street lamps fall).

a) Do you remember the event in the snapshot above? Yes / No

b) Please indicate how you experienced this event in terms of surprise, startle and confusion (circle the number of your choice):

	not at all	very little	little	moderate	above moderate	much	very much
This event surprised me:	1	2	3	4	5	6	7
This event startled me:	1	2	3	4	5	6	7
This event confused me:	1	2	3	4	5	6	7

c) Please indicate if the event caused any disturbance to performing your actions (e.g., pausing your actions while trying to understand what was going on, not knowing what to do, doing the wrong thing; doing irrelevant things):

	not at all	very little	little	moderate	above moderate	much	very much
This event disturbed my actions :	1	2	3	4	5	6	7

10. This snapshot comes from an event that happened during your game play:

Short Description: While reaching the last shed, a green flash screen appears followed by male screaming sounds.

a) Do you remember the event in the snapshot above? Yes / No

b) Please indicate how you experienced this event in terms of surprise, startle and confusion (circle the number of your choice):

	not at all	very little	little	moderate	above moderate	much	very much
This event surprised me:	1	2	3	4	5	6	7
This event startled me:	1	2	3	4	5	6	7
This event confused me:	1	2	3	4	5	6	7

c) Please indicate if the event caused any disturbance to performing your actions (e.g., pausing your actions while trying to understand what was going on, not knowing what to do, doing the wrong thing; doing irrelevant things):

	not at all	very little	little	moderate	above moderate	much	very much
This event disturbed my actions :	1	2	3	4	5	6	7

Please provide any comment or suggestion to the study below. This may improve future studies!

Please answer the following personal data

Sex M / F

Age …….

Experience with first person shooters

0 hours

1-20 hours

More than 20 hours

Experience with other video games / apps

0 hours

1-20 hours

More than 20 hours

Appendix B: CC group Questionnaire

QUESTIONNAIRE

This study investigates what kind of events may have a surprising effect in some way or the other.

In this questionnaire, you are asked about 3 events in the game. Your answers are important to our research questions.

Please do read questions carefully, try to remember the situation and the effect it had on you.

Be honest in your answers. They only relate to the effect as you perceived it. As such they cannot be correct or incorrect!

Definitions

Surprise is a brief mental state that results from experiencing an unexpected event. Surprise occurs when a specific event or situation does not match with your expectations. Surprise can vary in intensity and appreciation. You may consider a surprise being negative, neutral or positive.

Startle is a physiological response to sudden event, such as sudden noise or sharp movement. Startle is a primarily a biological reflex and may include body movements or eyeblinks. A startling event can be unexpected, but not necessarily (think of a balloon that is about to be perched).

Confusion is the state of being bewildered or unclear in one's mind after experiencing a surprise, where the mismatch with your expectations can not easily be understood. Confusion is related to the process of trying to regain understanding of the situation.

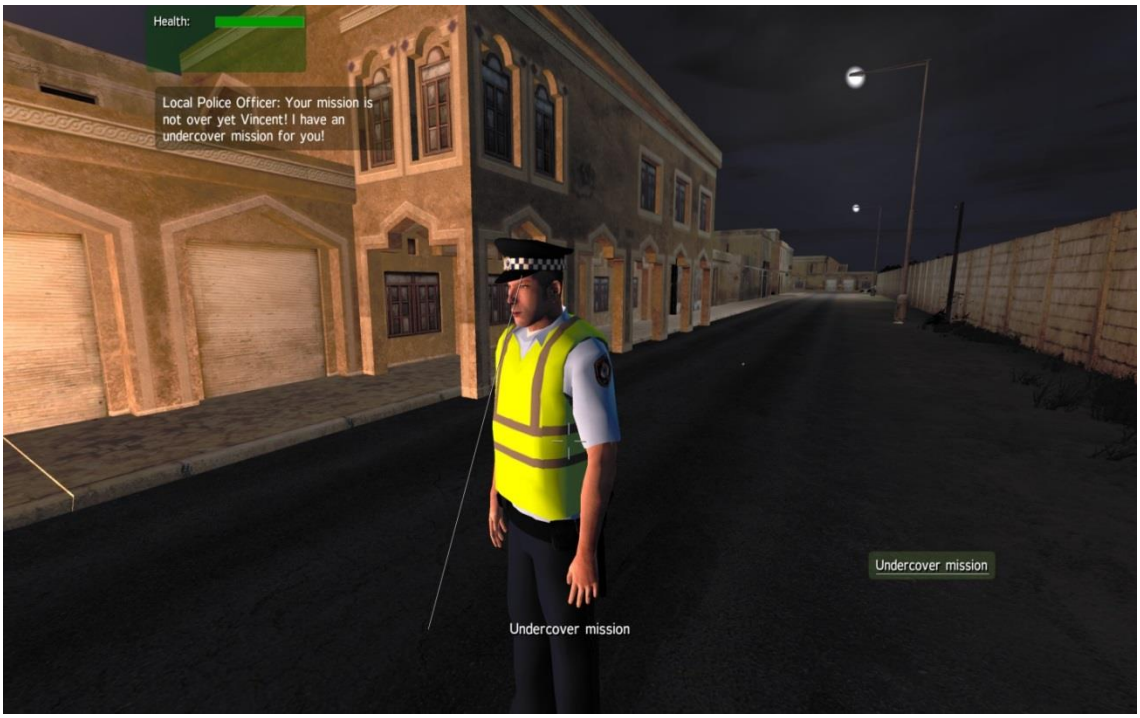
Please describe the 3 events in this game that surprised you mostly

d)

e)

f)

11. This snapshot comes from an event that happened during your game play:



Short description: After asking policeman to "Finish mission" he reveals an extra "Undercover mission".

d) Do you remember the event in the snapshot above? Yes / No

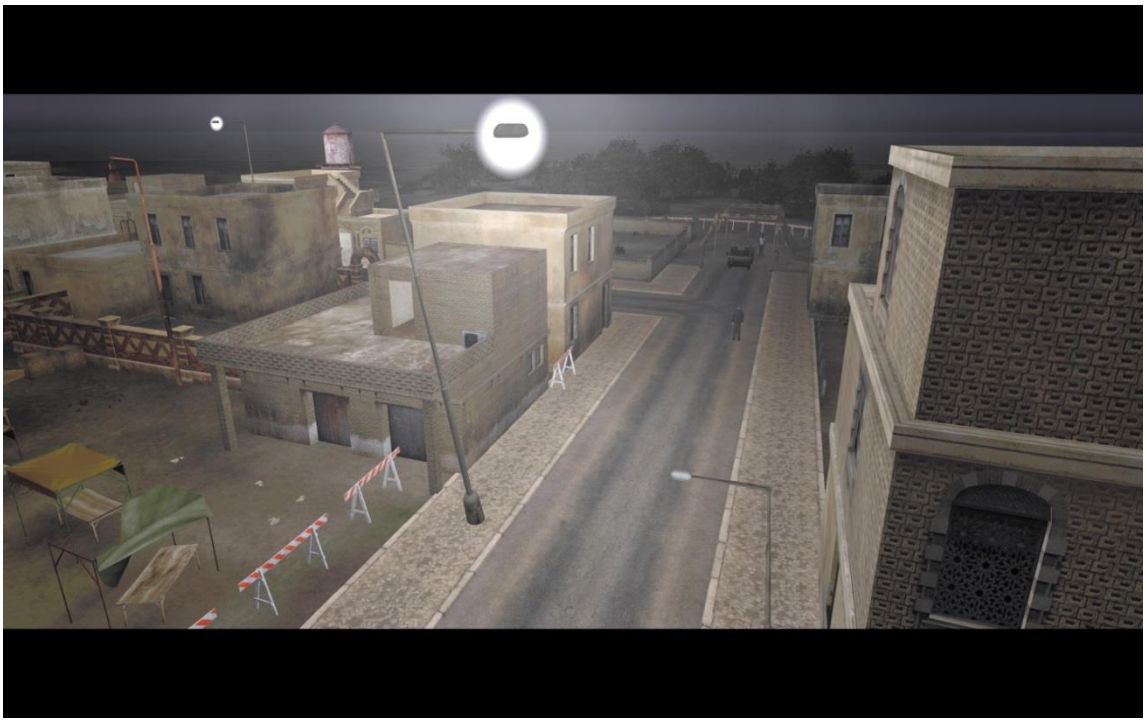
e) Please indicate how you experienced this event in terms of surprise, startle and confusion (circle the number of your choice):

	not at all	very little	little	moderate	above moderate	much	very much
This event surprised me:	1	2	3	4	5	6	7
This event startled me:	1	2	3	4	5	6	7
This event confused me:	1	2	3	4	5	6	7

f) Please indicate if the event caused any disturbance to performing your actions (e.g., pausing your actions while trying to understand what was going on, not knowing what to do, doing the wrong thing; doing irrelevant things):

	not at all	very little	little	moderate	above moderate	much	very much
This event disturbed my actions :	1	2	3	4	5	6	7

12. This snapshot comes from an event that happened during your game play:



Short Description: Guards get distracted by sudden blackout caused from sandstorms (Street lamps fall).

a) Do you remember the event in the snapshot above? Yes / No

b) Please indicate how you experienced this event in terms of surprise, startle and confusion (circle the number of your choice):

	not at all	very little	little	moderate	above moderate	much	very much
This event surprised me:	1	2	3	4	5	6	7
This event startled me:	1	2	3	4	5	6	7
This event confused me:	1	2	3	4	5	6	7

c) Please indicate if the event caused any disturbance to performing your actions (e.g., pausing your actions while trying to understand what was going on, not knowing what to do, doing the wrong thing; doing irrelevant things):

	not at all	very little	little	moderate	above moderate	much	very much
This event disturbed my actions :	1	2	3	4	5	6	7

13. This snapshot comes from an event that happened during your game play:

Short Description: While reaching the last shed, a green flash screen appears followed by male screaming sounds.

a) Do you remember the event in the snapshot above? Yes / No

b) Please indicate how you experienced this event in terms of surprise, startle and confusion (circle the number of your choice):

	not at all	very little	little	moderate	above moderate	much	very much
This event surprised me:	1	2	3	4	5	6	7
This event startled me:	1	2	3	4	5	6	7
This event confused me:	1	2	3	4	5	6	7

c) Please indicate if the event caused any disturbance to performing your actions (e.g., pausing your actions while trying to understand what was going on, not knowing what to do, doing the wrong thing; doing irrelevant things):

	not at all	very little	little	moderate	above moderate	much	very much
This event disturbed my actions :	1	2	3	4	5	6	7

Please provide any comment or suggestion to the study below. This may improve future studies!

Please answer the following personal data

Sex M / F

Age …….

Experience with first person shooters

0 hours

1-20 hours

More than 20 hours

Experience with other video games / apps

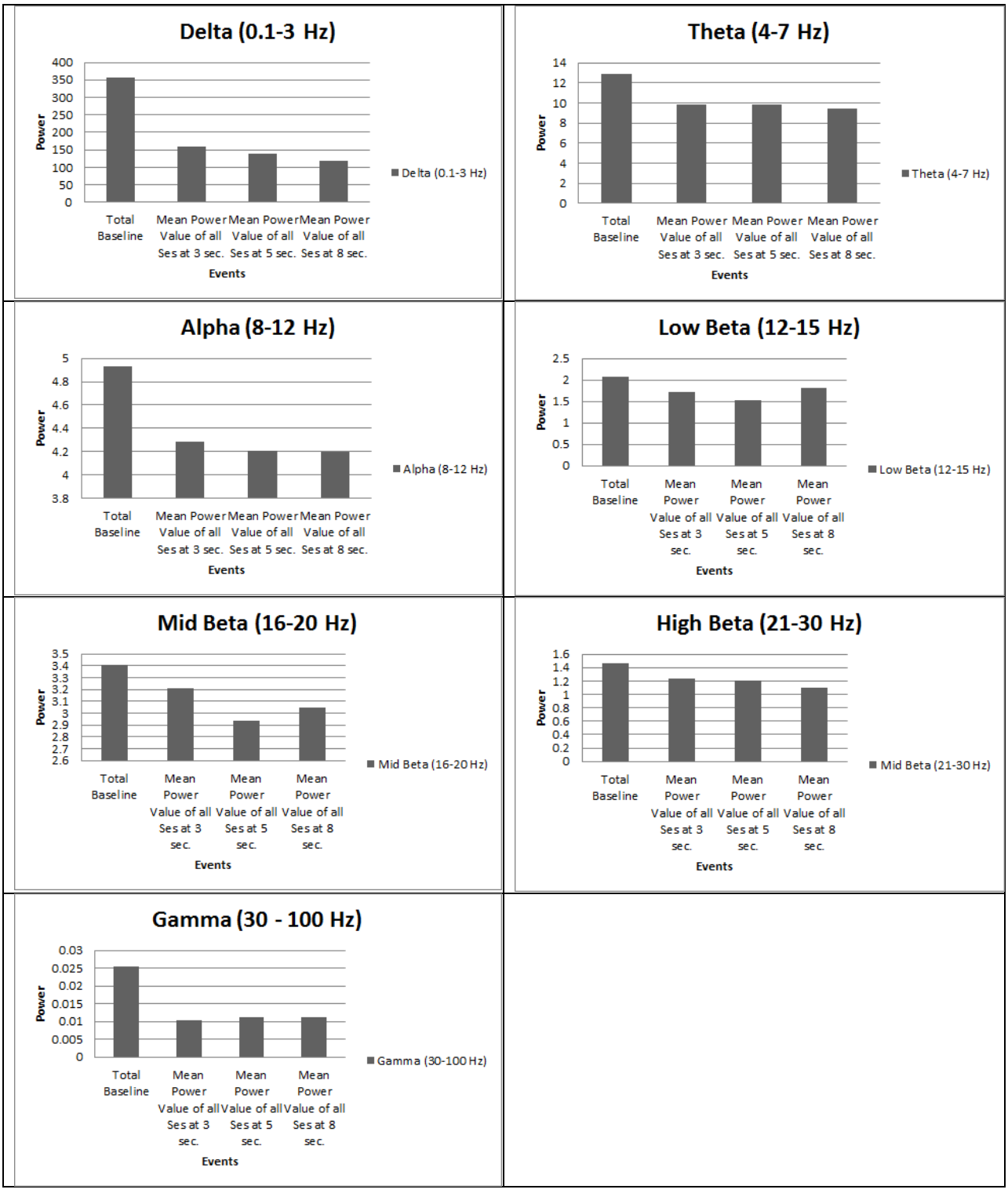
0 hours

1-20 hours

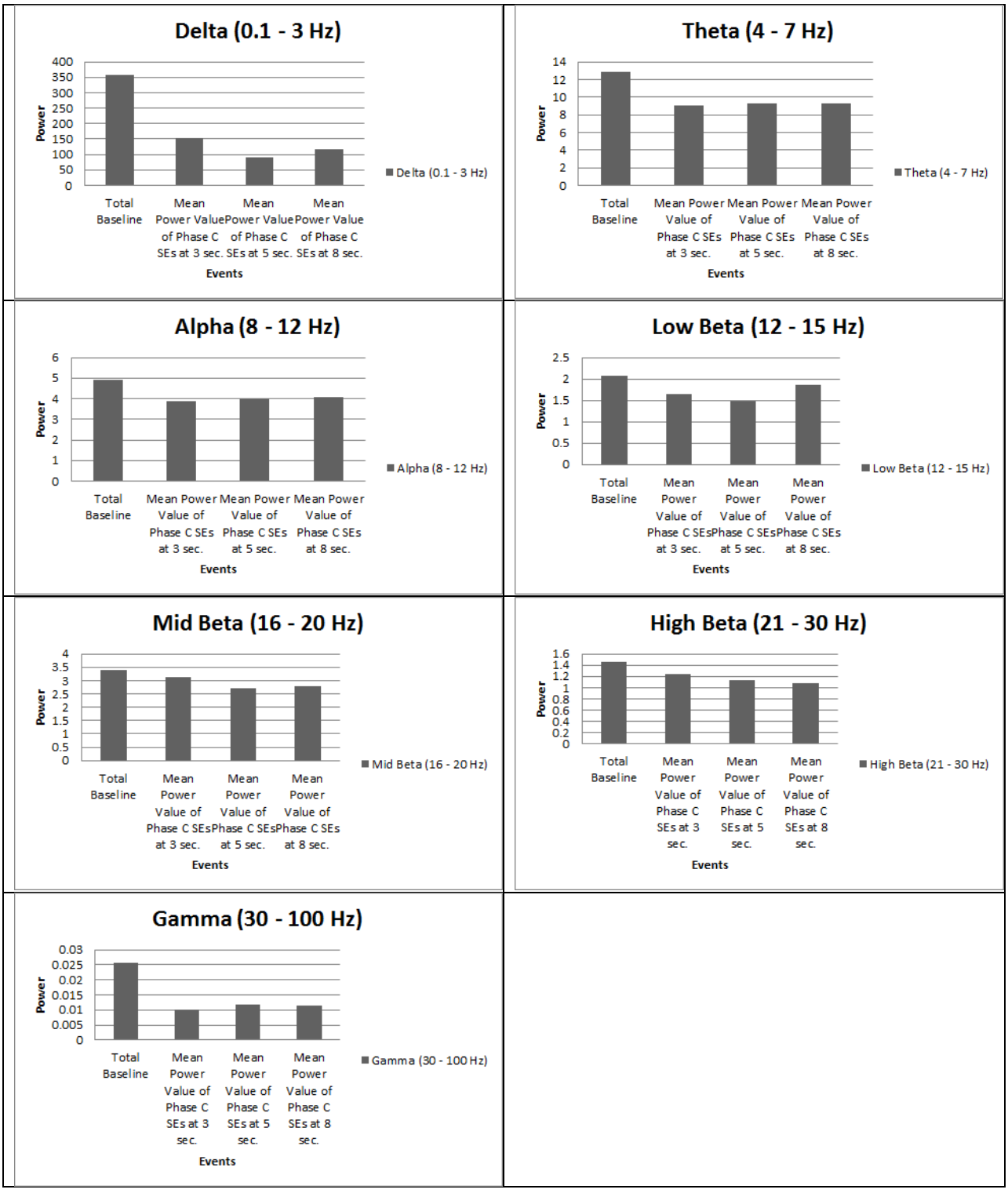
More than 20 hours

Appendix C: Bar Charts from EEG results

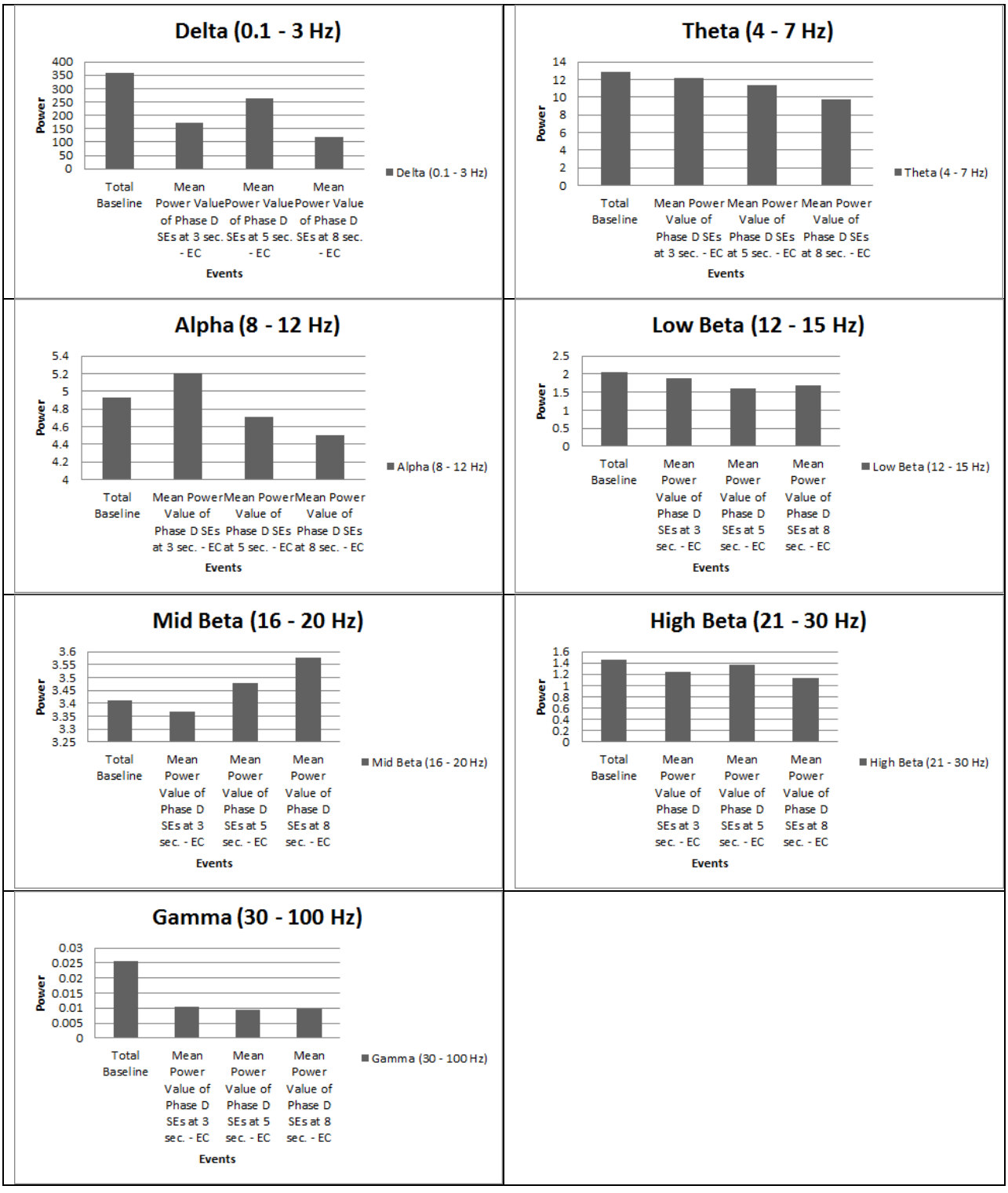
For all the SEs in EC all the bands



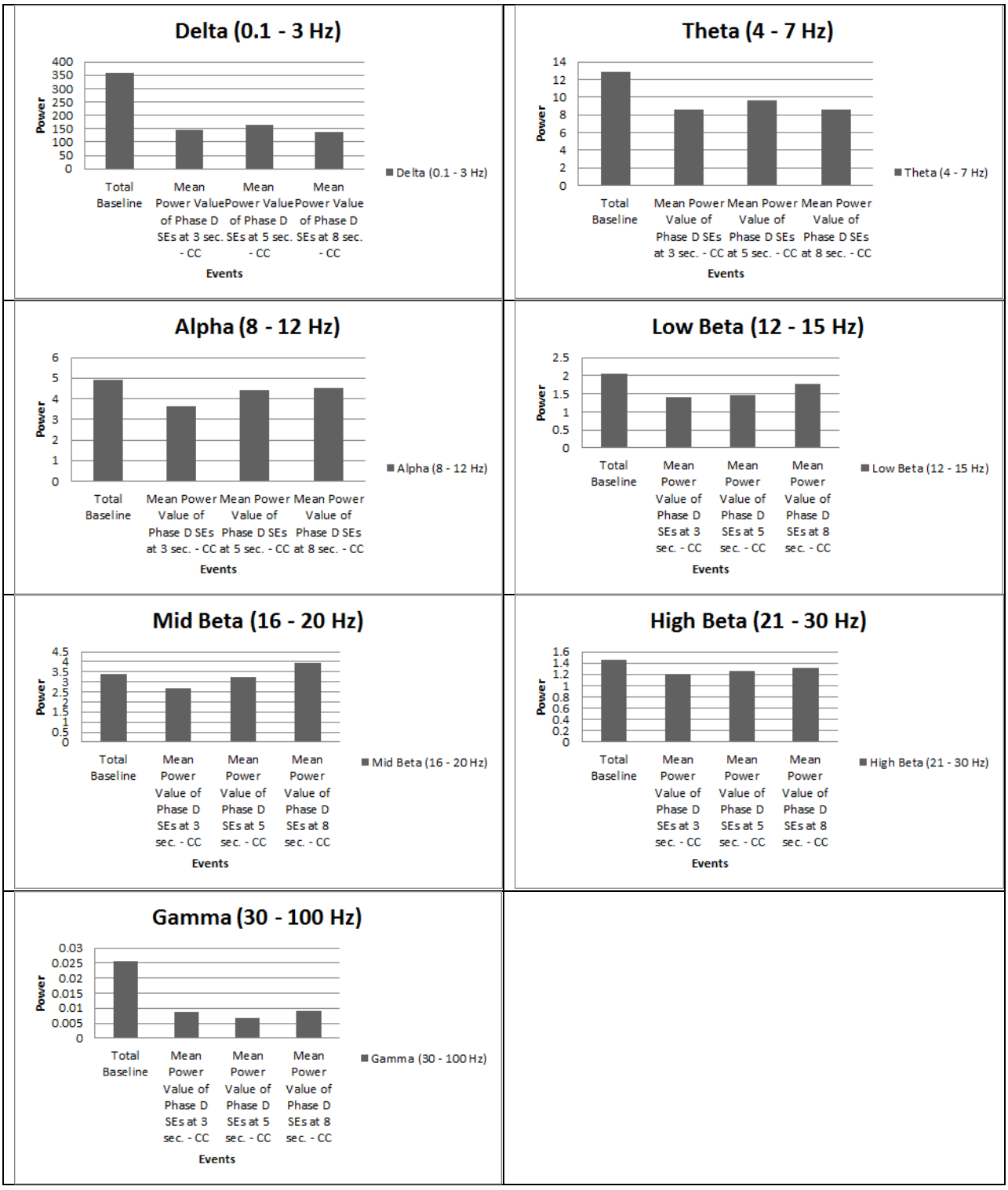
For the SEs in Phase C – EC



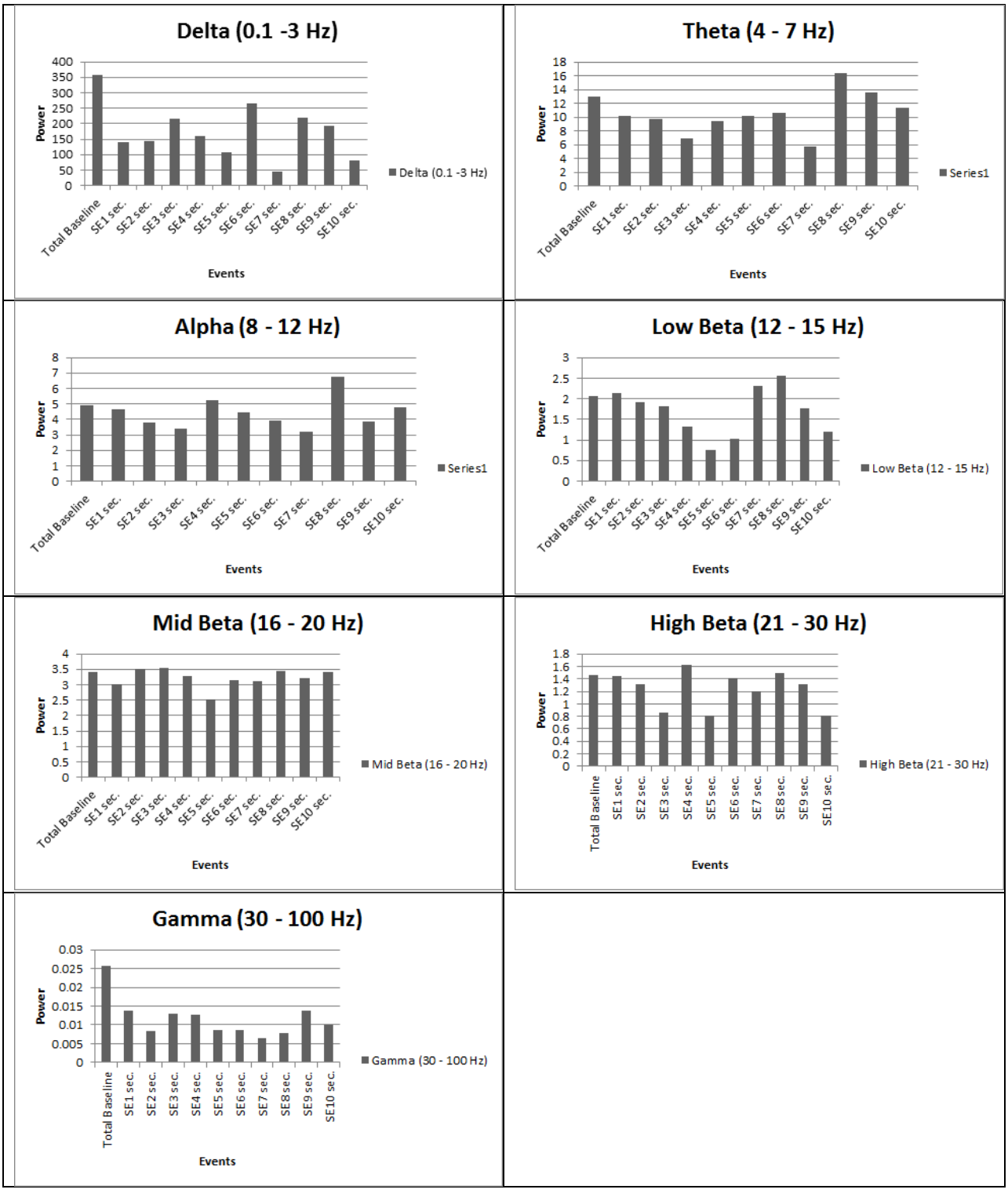
For the SEs in Phase D – EC



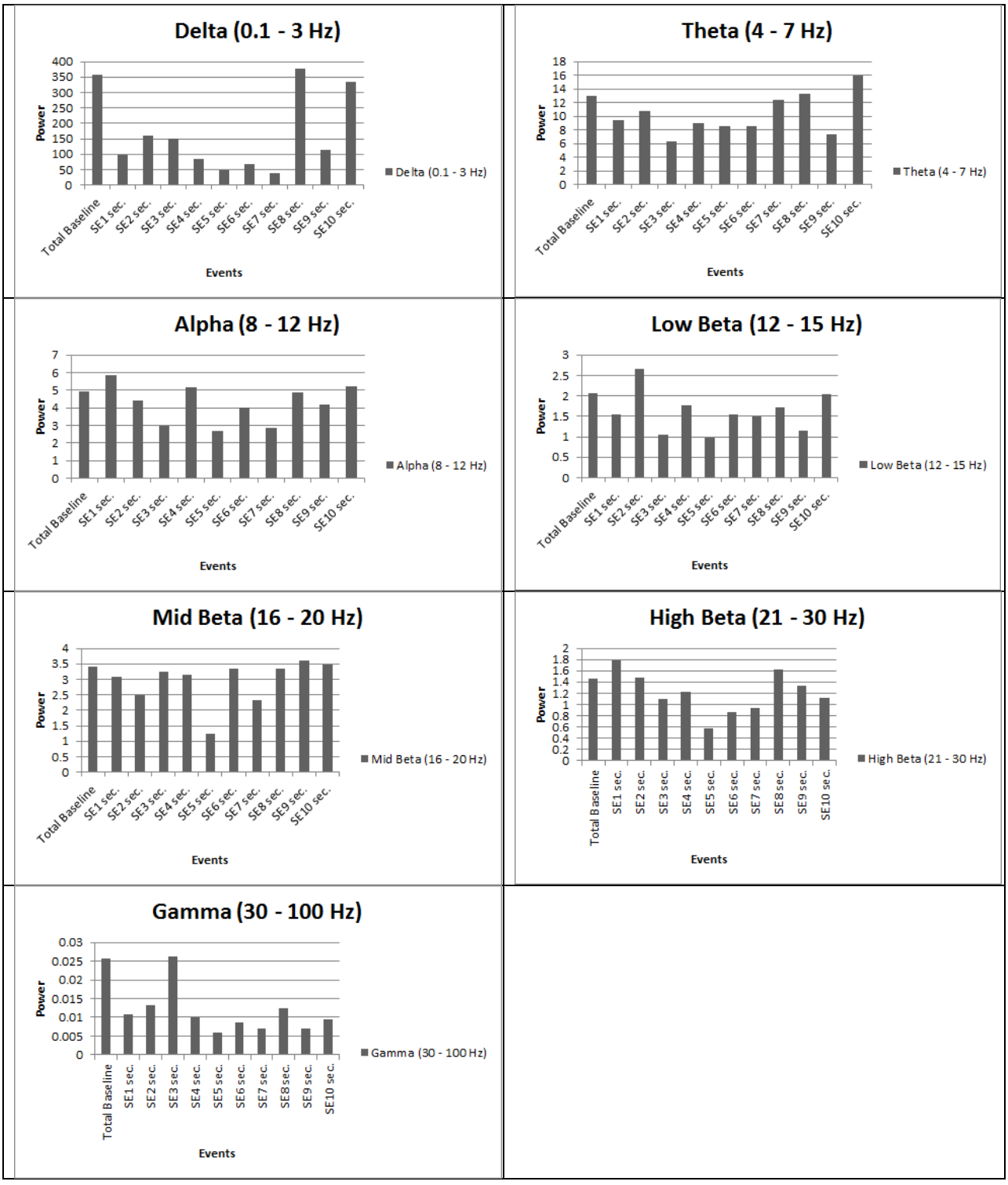
For the SEs in Phase D – CC



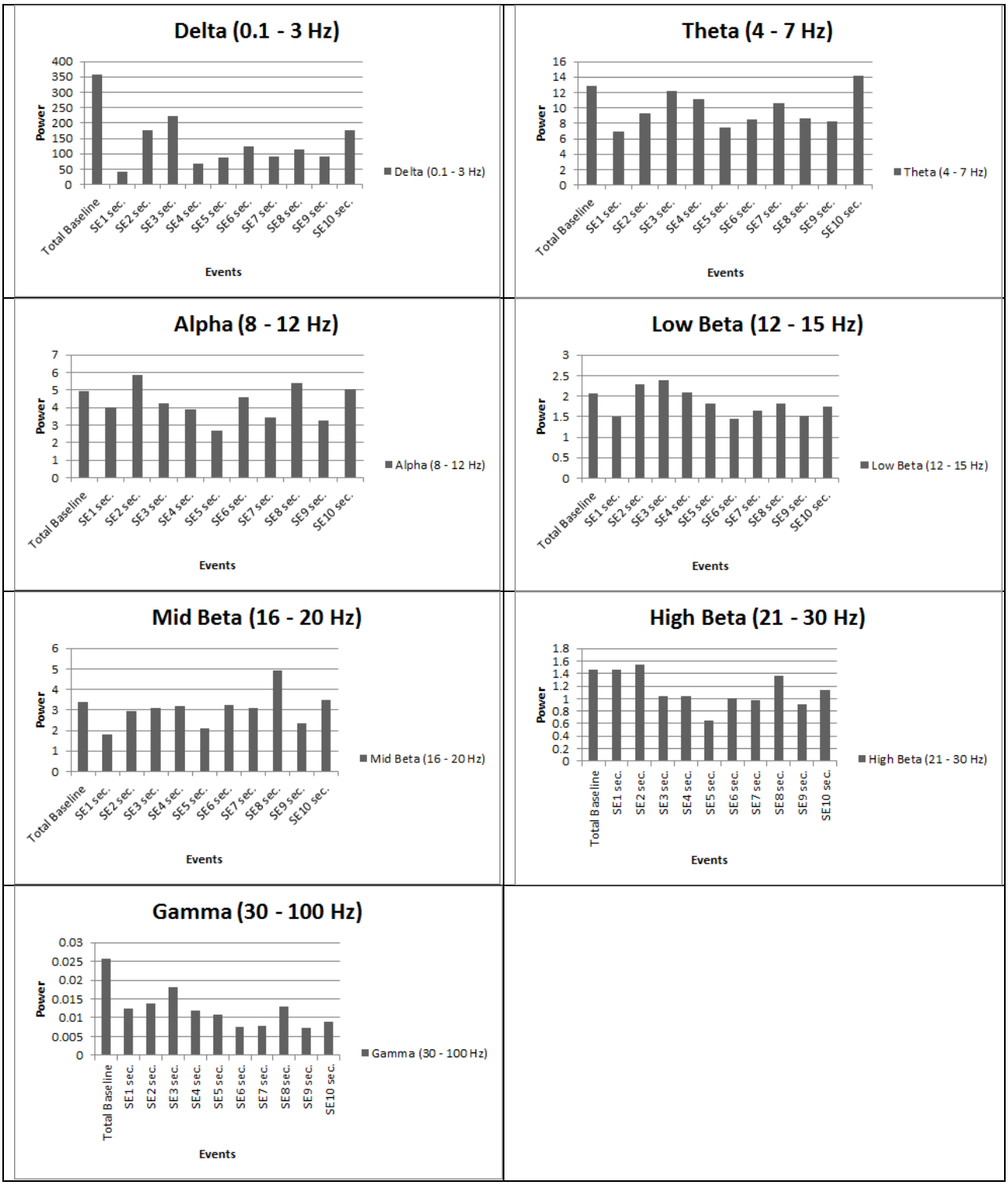
All bands for EC SEs at 3 sec.



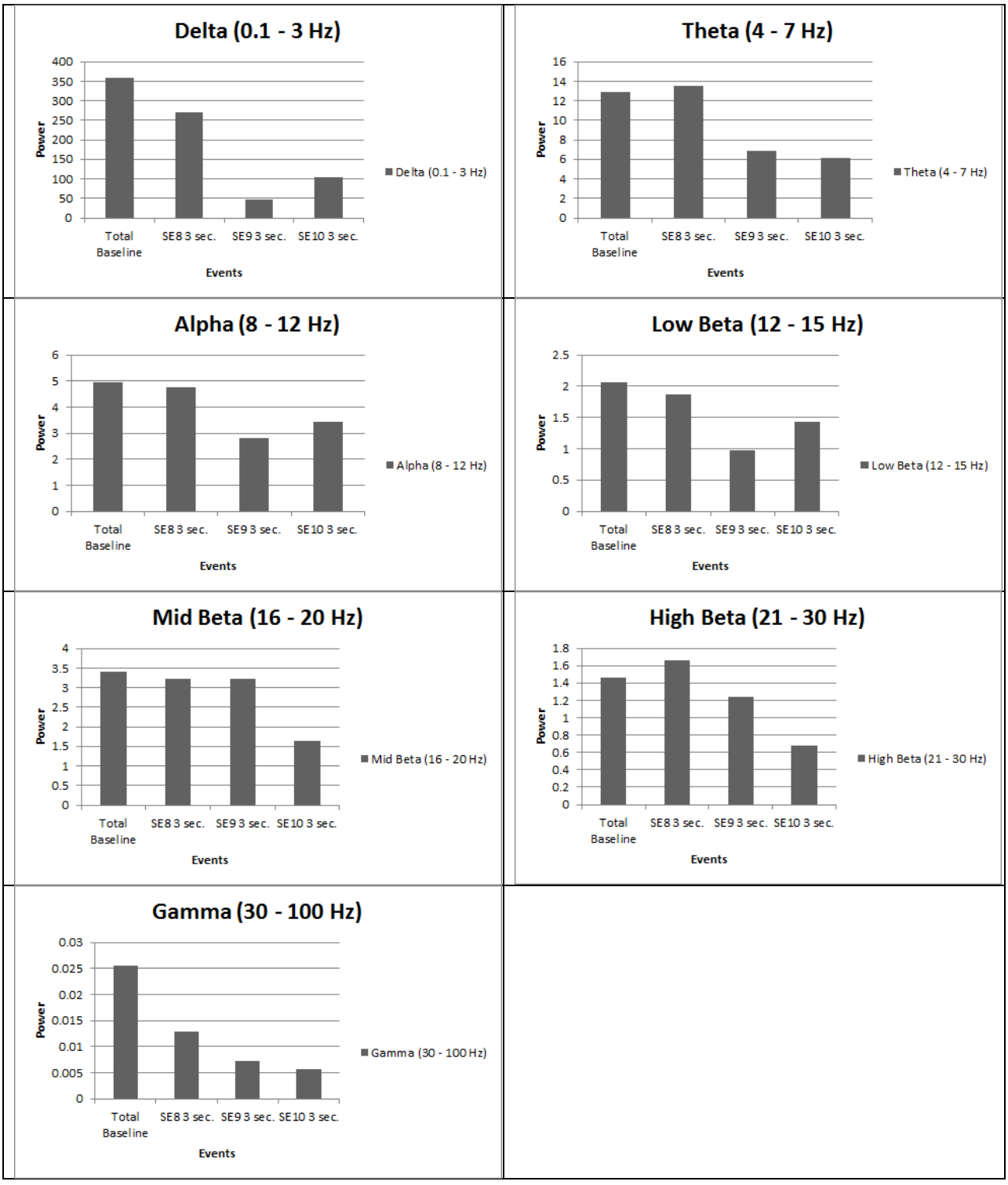
All bands for EC SEs at 5 sec.



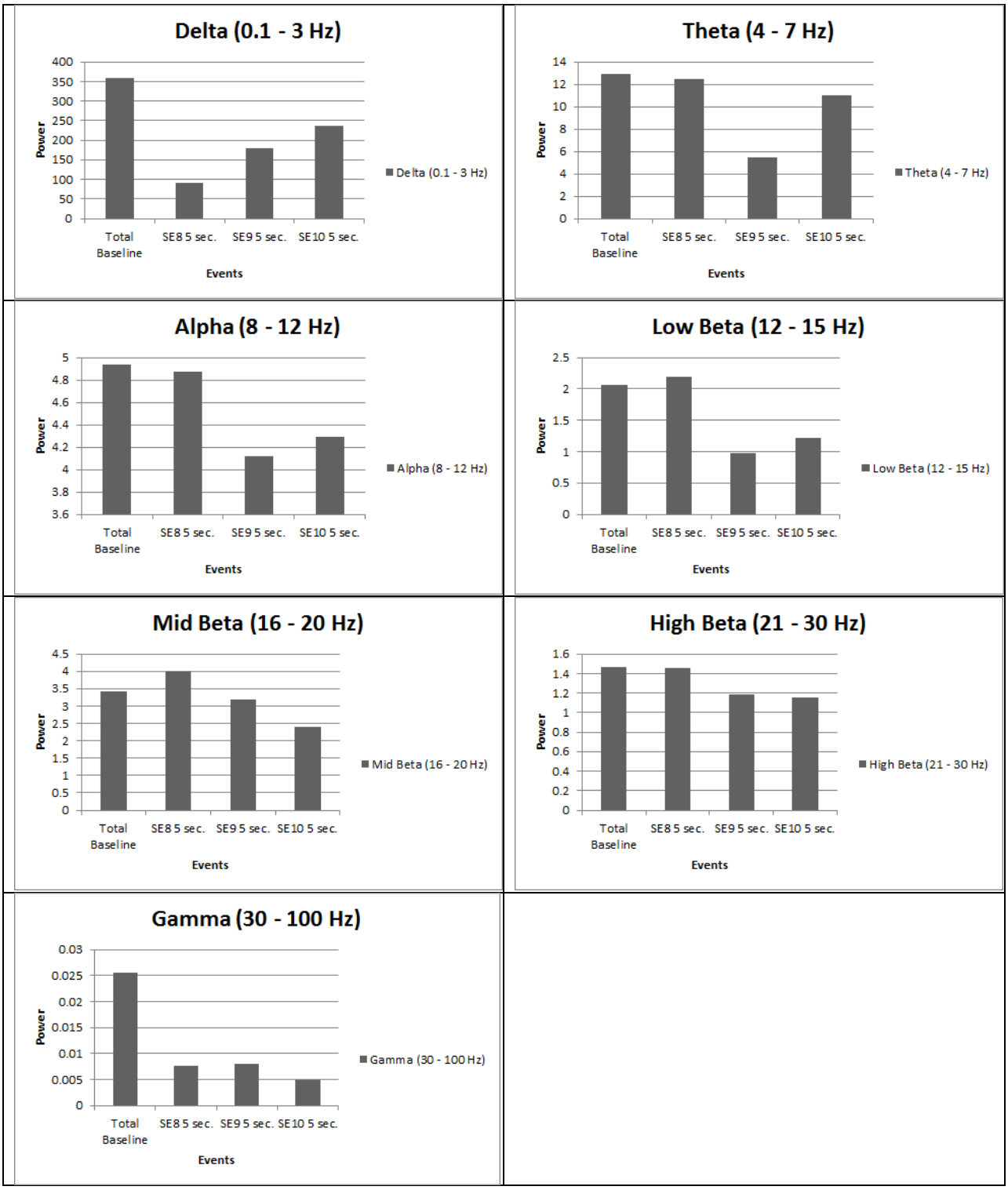
All bands for EC SEs at 8 sec.



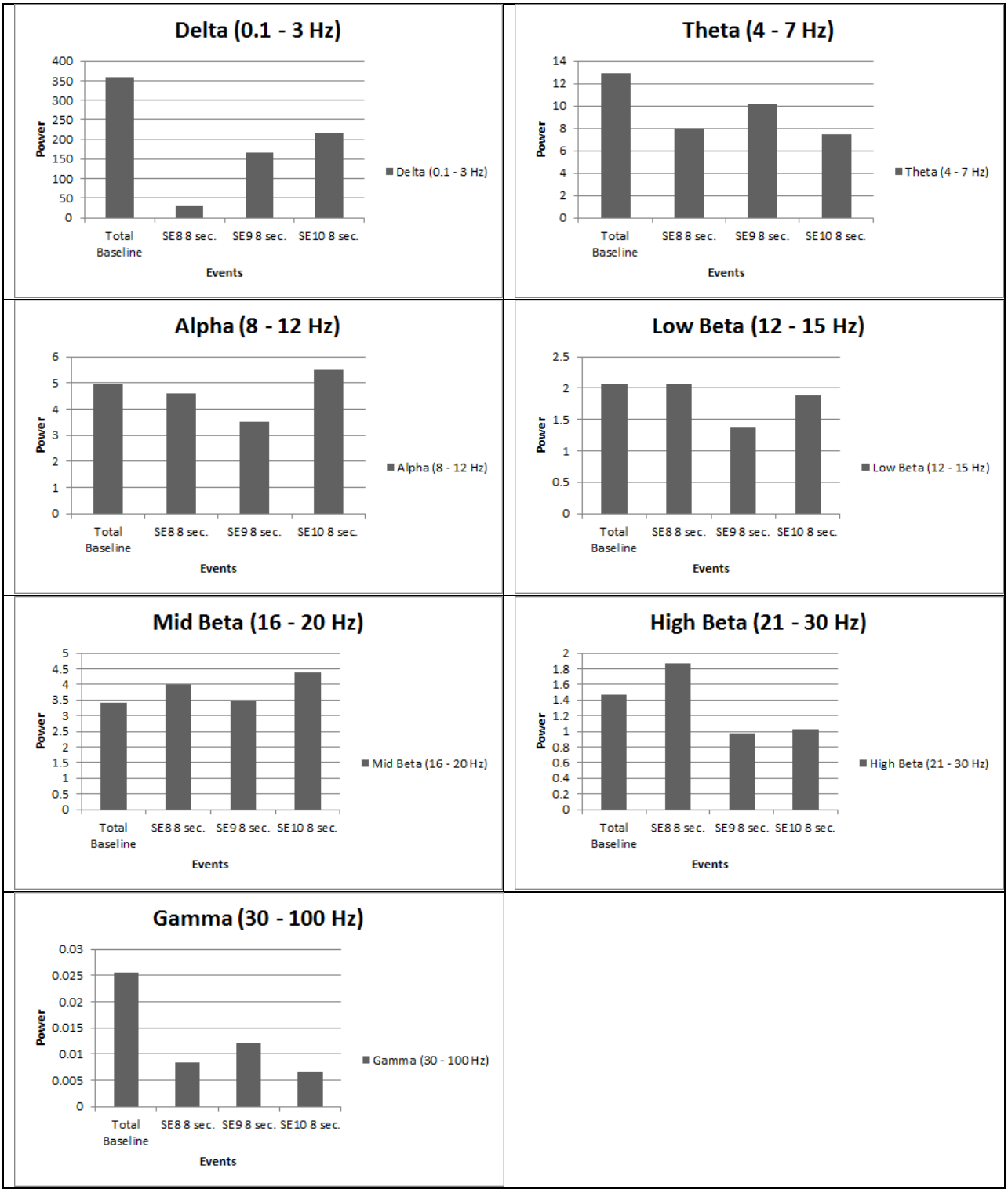
All bands for CC SEs at 3 sec.



All bands for CC SEs at 5 sec.

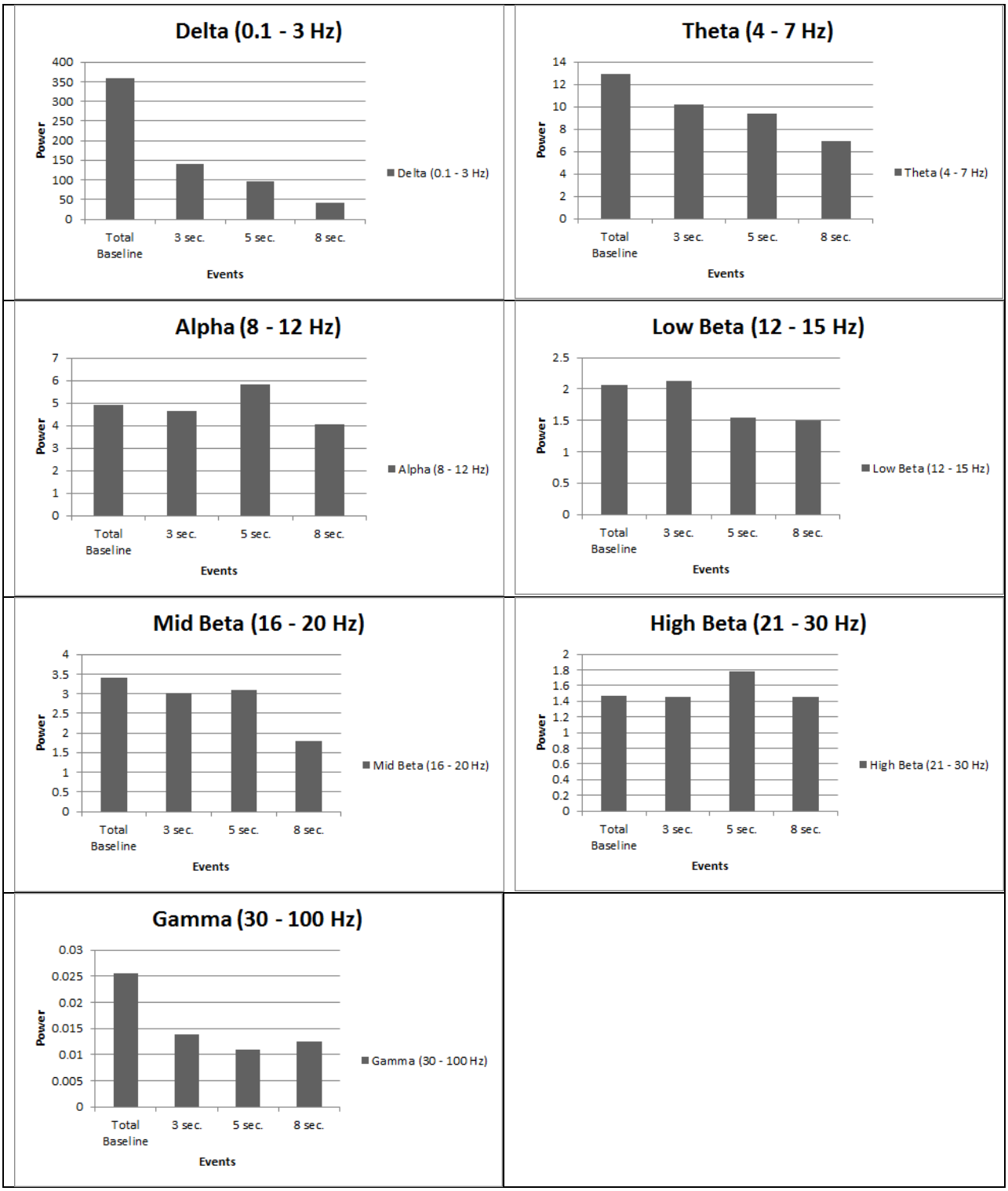


All bands for CC SEs at 8 sec.



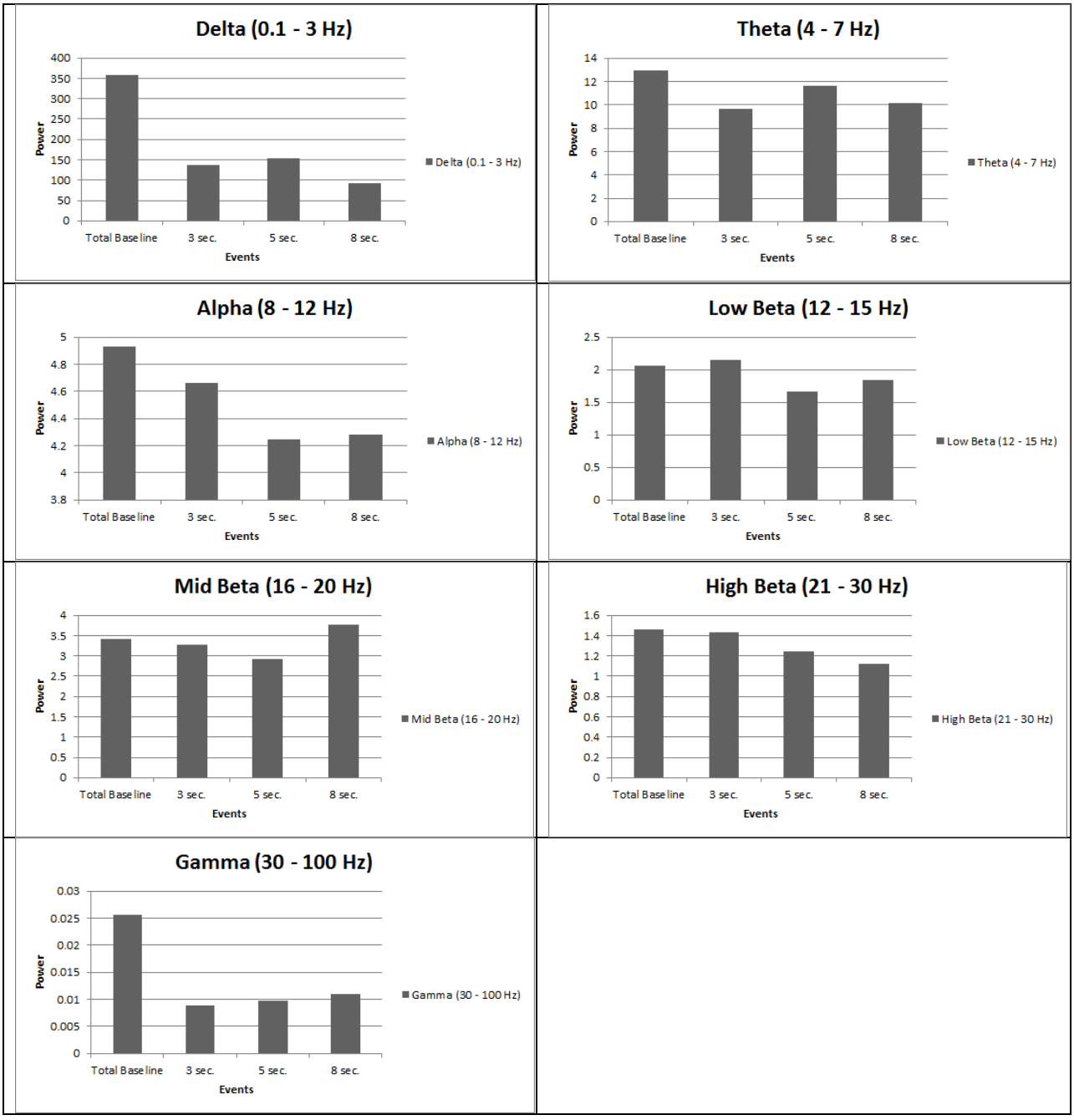
Mean Power of Task-dependent cue-based SE

SE1 - EC	**0→3**	140.2231	10.2163	4.6534	2.1299	3.0231	1.4506	0.0138
	3→5	96.8598	9.3909	5.8445	1.5448	3.0965	1.7793	0.0109
	5→8	40.6950	6.9252	4.0346	1.5012	1.7888	1.4607	0.0125



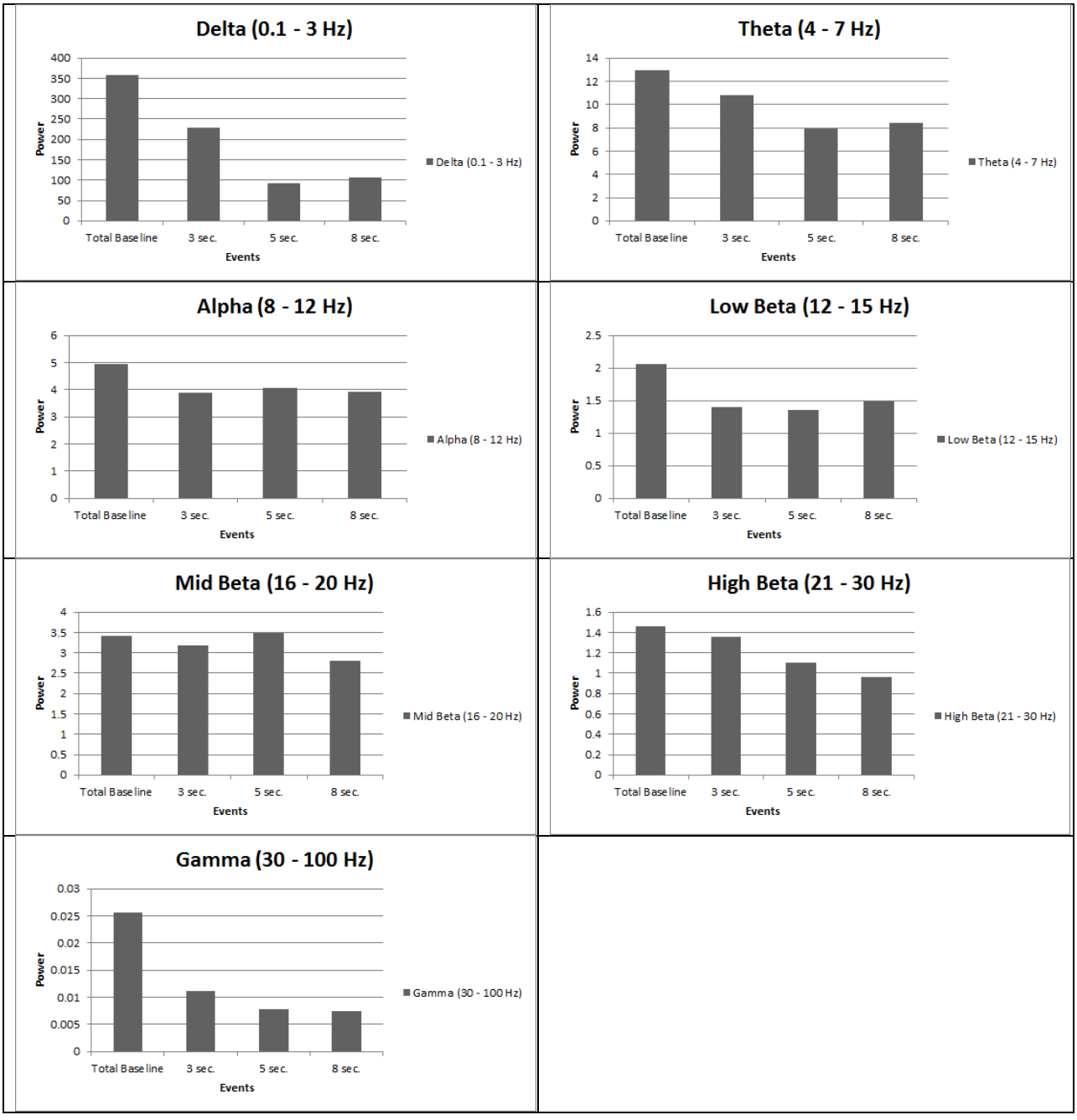
Mean Power of Task-dependent narrative-based SE

SE4, SE 7, SE 8 - EC	**0→3**	136.7490	9.6442	4.6632	2.1485	3.2780	1.4350	0.0089
	3→5	153.8077	11.6607	4.2432	1.6661	2.9245	1.2476	0.0097
	5→8	91.8842	10.1652	4.2803	1.8425	3.7575	1.1245	0.0109



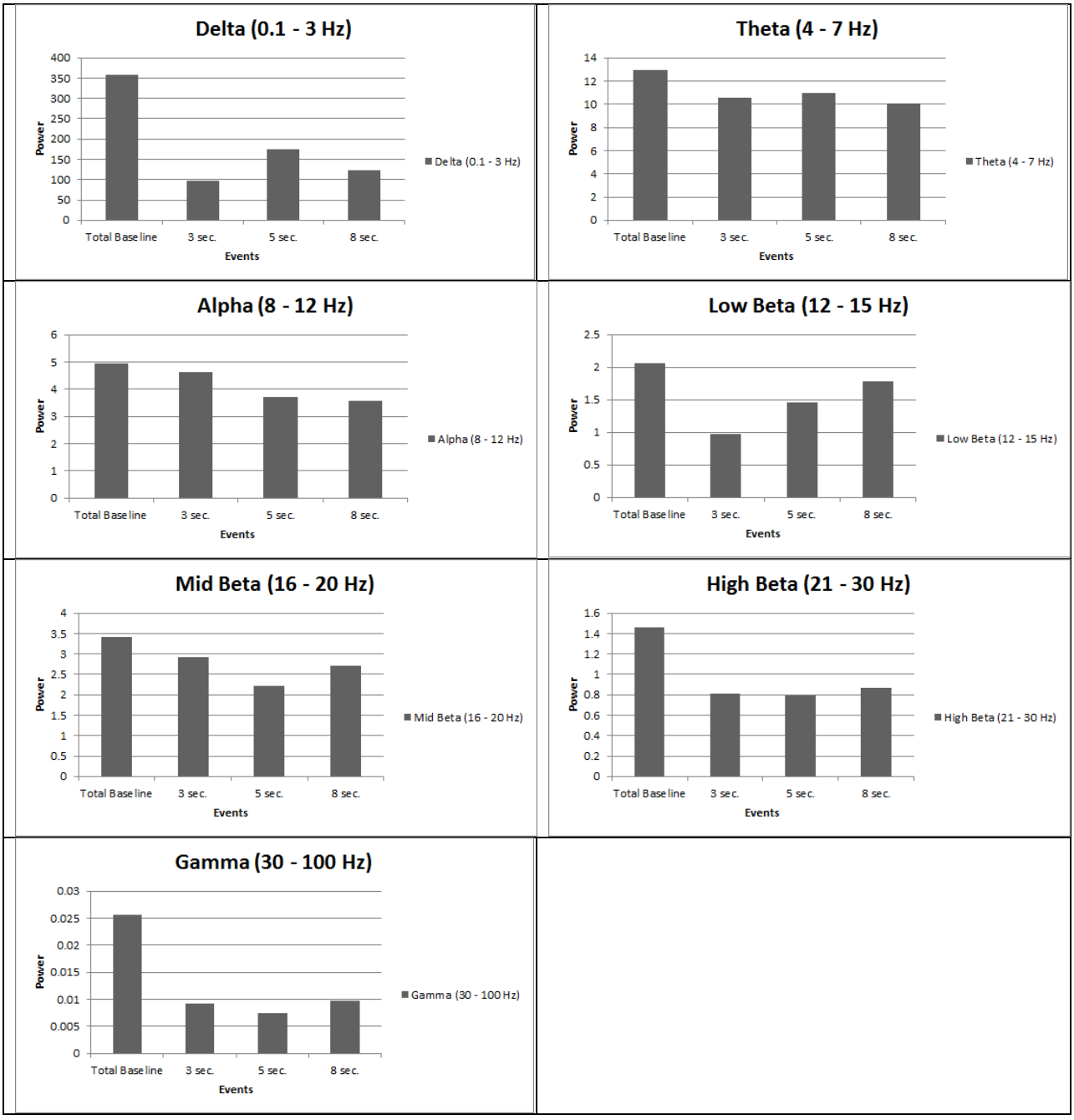
Mean Power of Task-dependent mixed SE

SE6, SE 9 - EC	**0→3**	228.8598	10.8342	3.8984	1.3968	3.1755	1.3606	0.0111
	3→5	92.4711	7.9278	4.0783	1.3502	3.4853	1.1064	0.0078
	5→8	106.3955	8.3942	3.9217	1.4884	2.7936	0.9586	0.0074



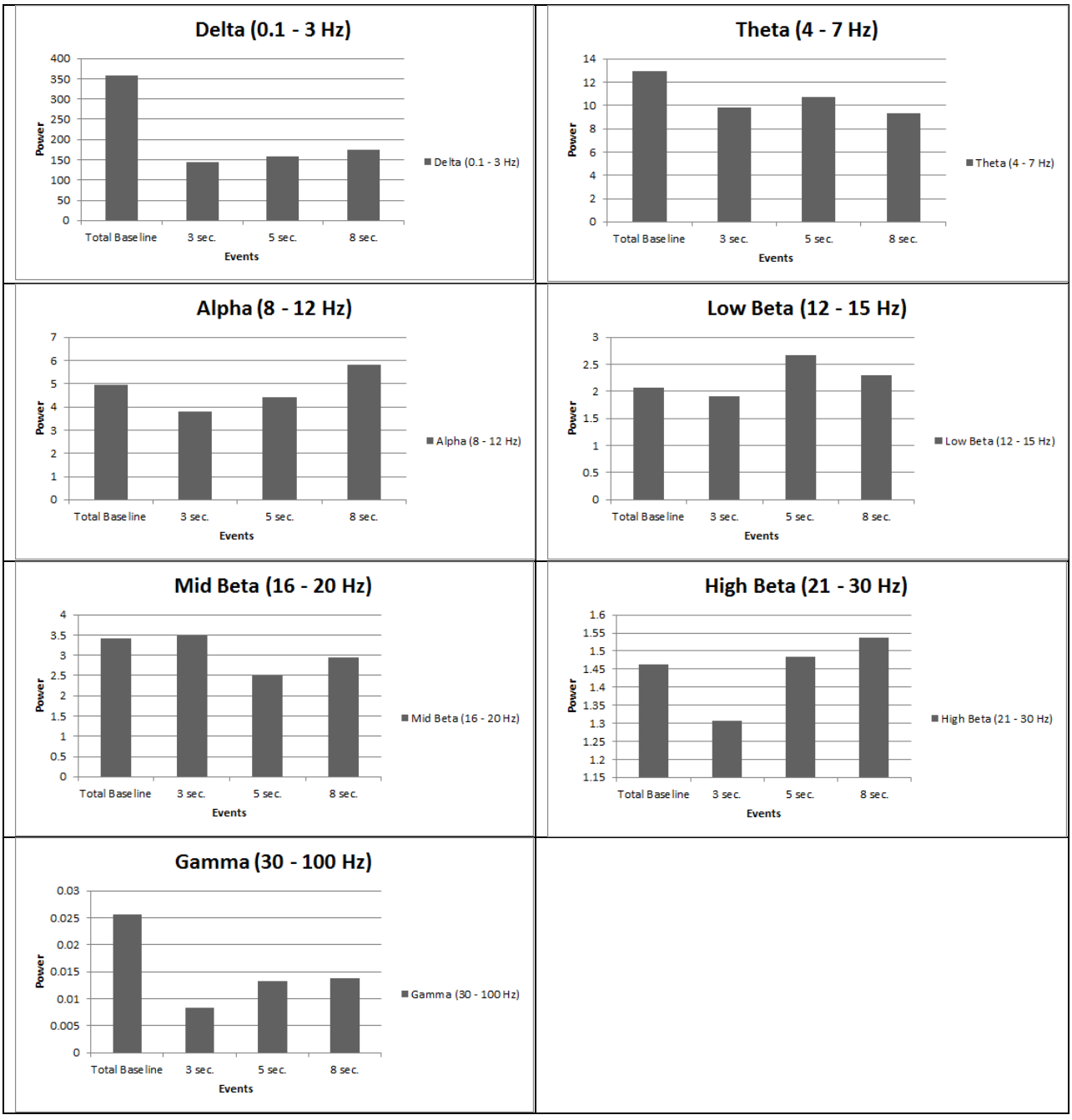
Mean Power of Task-independent cue-based SE

SE5, SE10 - EC	**0→3**	97.3353	10.5850	4.6154	0.9738	2.9210	0.8119	0.0092
	3→5	175.1523	10.9719	3.7186	1.4568	2.2152	0.7931	0.0074
	5→8	122.2952	10.0815	3.5795	1.7803	2.7012	0.8691	0.0098



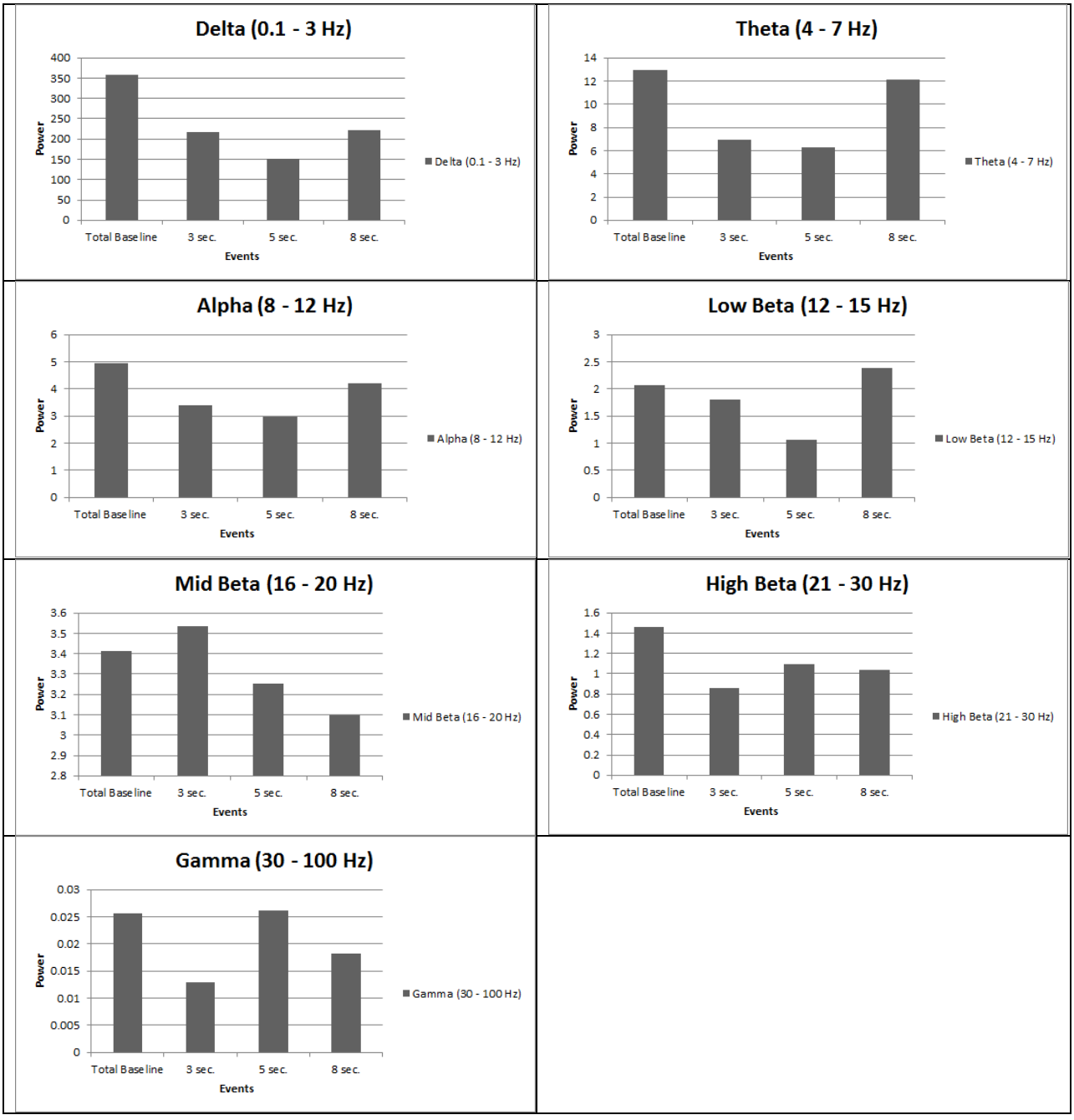
Mean Power of Task-independent narrative-based SE

SE2 - EC	**0→3**	144.7806	9.7823	3.8157	1.9061	3.4945	1.3081	0.0083
	3→5	158.6151	10.6910	4.4158	2.6592	2.5030	1.4848	0.0133
	5→8	175.4463	9.3293	5.8279	2.2884	2.9491	1.5381	0.0138



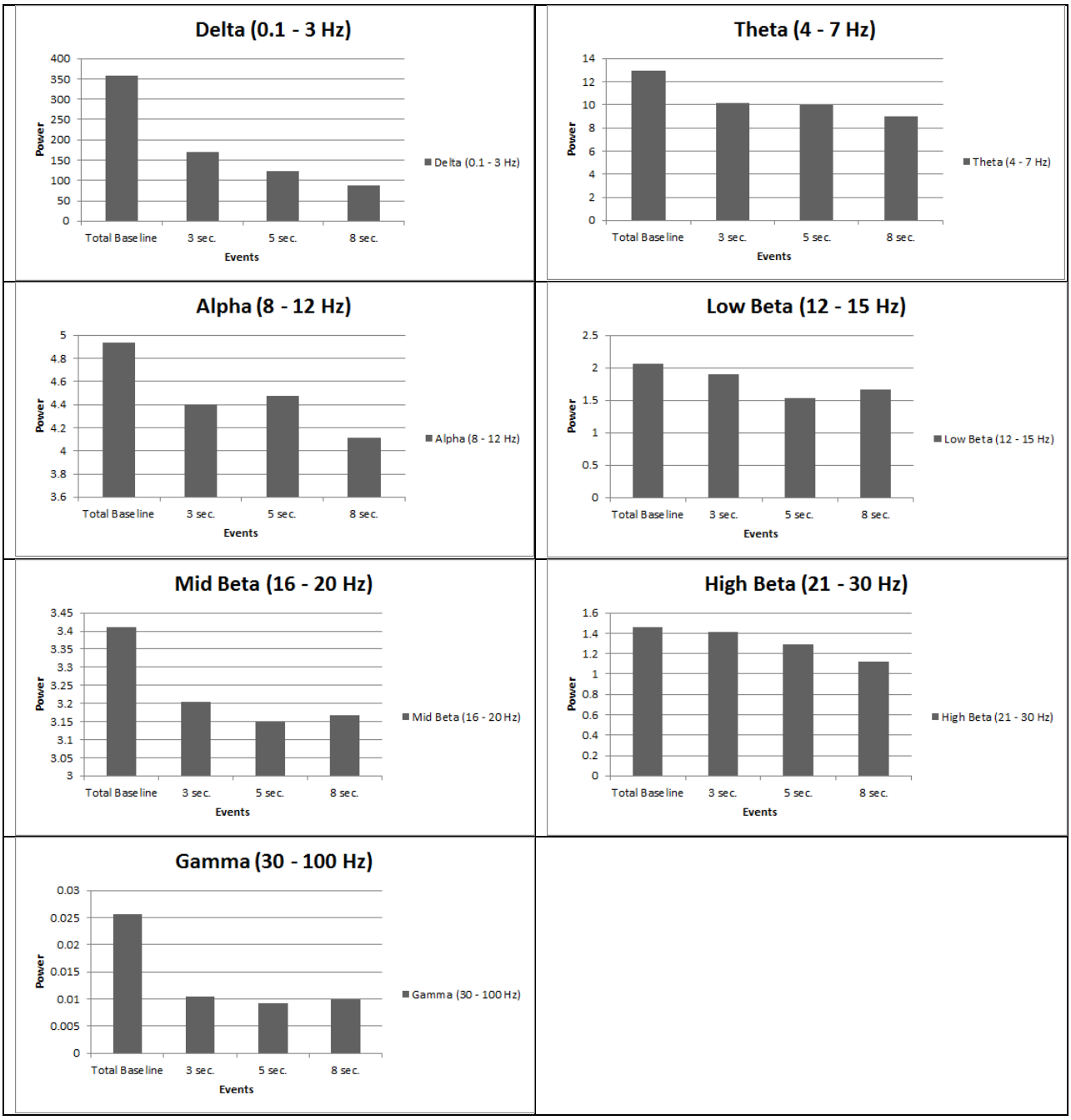
Mean Power of Task-independent mixed SE

SE3 - EC	**0→3**	216.7282	6.8960	3.4120	1.8085	3.5343	0.8564	0.0130
	3→5	151.4628	6.2960	2.9580	1.0573	3.2535	1.0974	0.0262
	5→8	221.5953	12.1354	4.2172	2.3917	3.0980	1.0411	0.0182



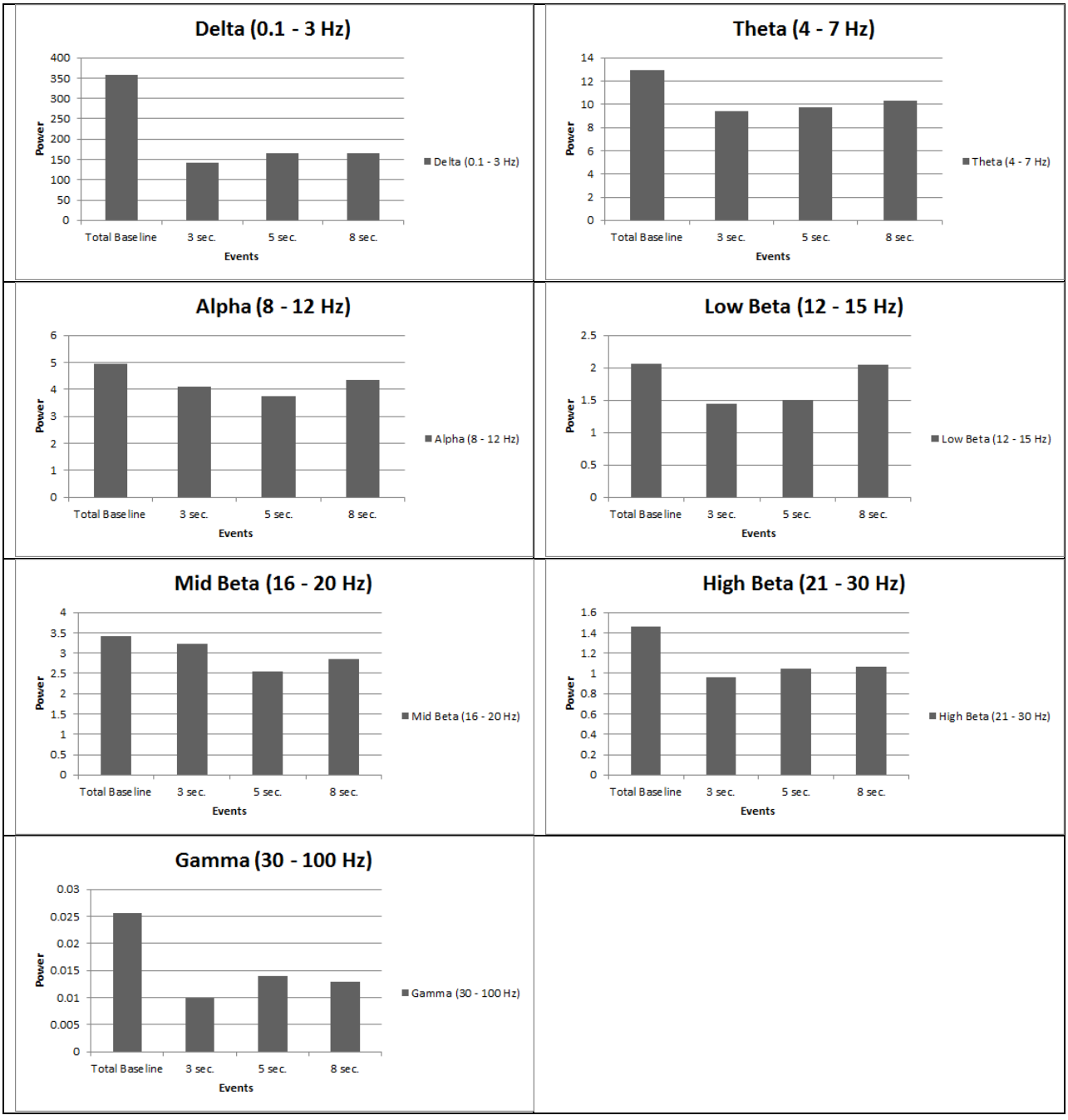
Task-dependent SEs - EC

SE1, SE4, SE6, SE7, SE8, SE9 - EC	**0→3**	169.1103	10.1433	4.3972	1.8948	3.2032	1.4124	0.0105
	3→5	122.8278	9.9888	4.4774	1.5360	3.1495	1.2938	0.0093
	5→8	87.8122	8.9959	4.1157	1.6615	3.1671	1.1195	0.0100



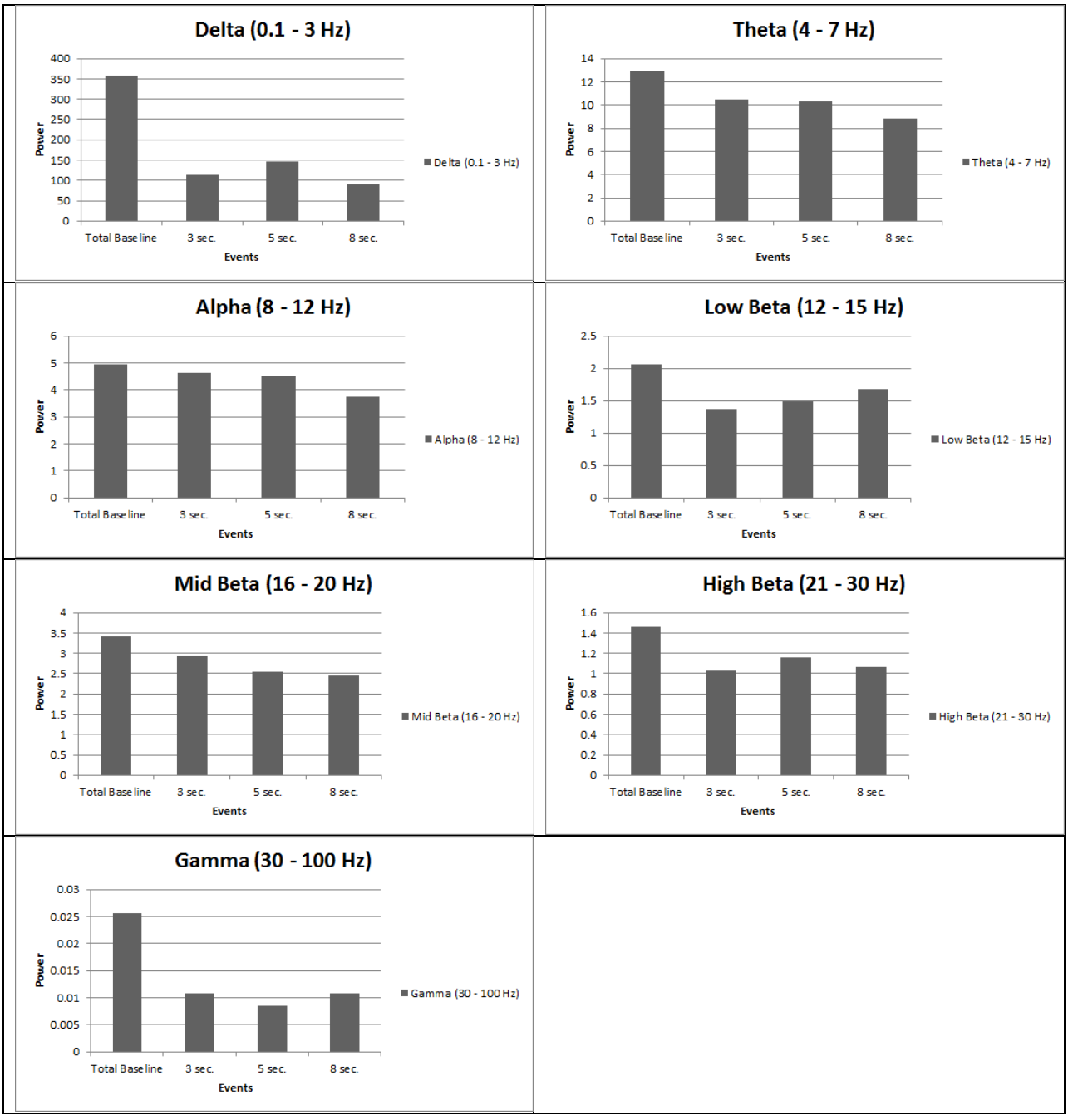
Task- independent SEs -EC

SE2, SE3, SE5, SE10 EC	**0→3**	142.4267	9.3960	4.1146	1.4514	3.2188	0.9596	0.0100
	3→5	164.9205	9.6927	3.7474	1.5066	2.5481	1.0478	0.0139
	5→8	165.8527	10.3269	4.3557	2.0507	2.8422	1.0677	0.0129



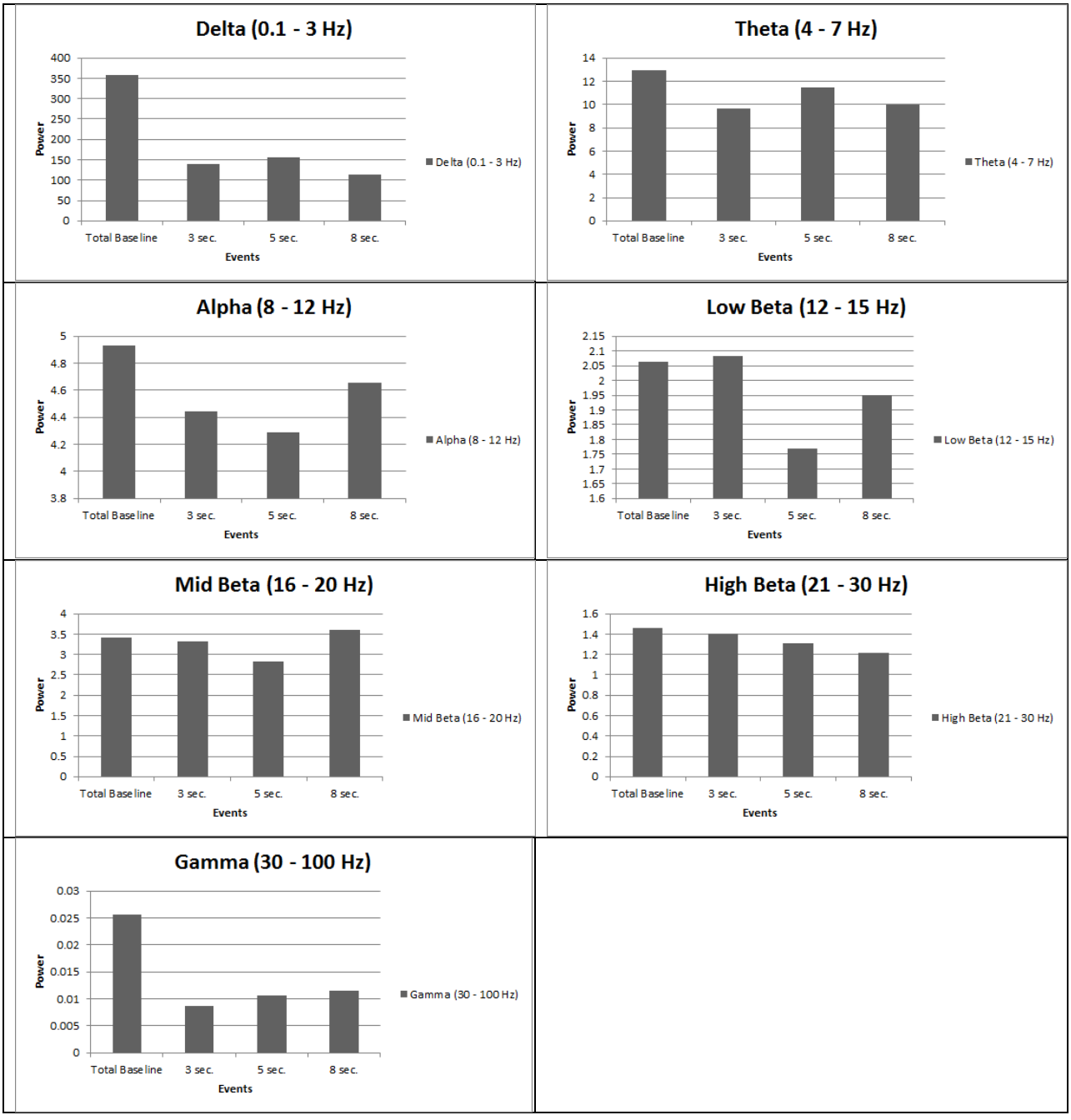
Cue-based SEs –EC

SE1, SE5, SE10 EC	**0→3**	113.2197	10.4432	4.6289	1.3740	2.9550	1.0400	0.0108
	3→5	147.1907	10.3395	4.5060	1.4839	2.5541	1.1584	0.0086
	5→8	89.6551	8.8190	3.7433	1.6806	2.4457	1.0663	0.0108



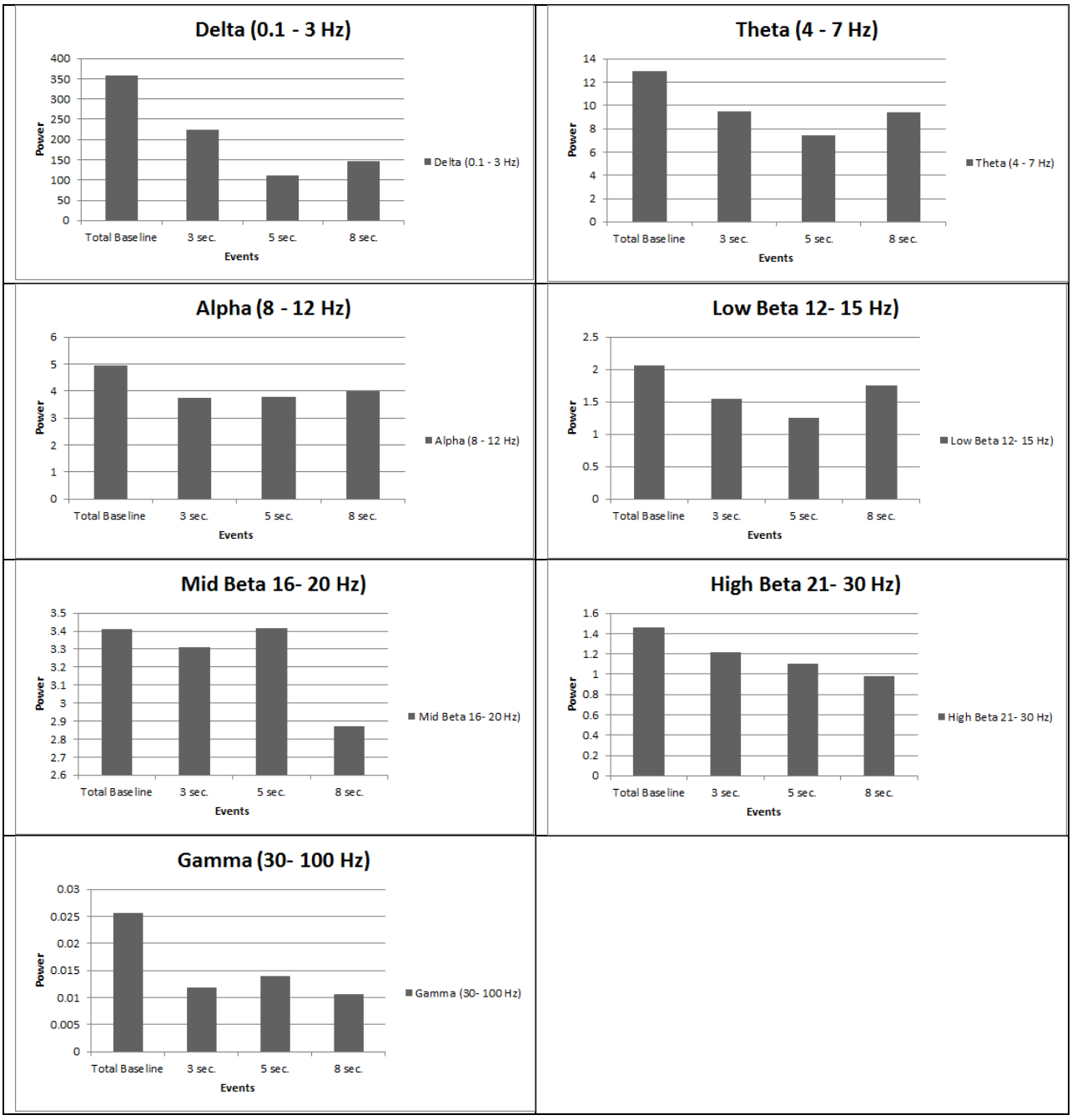
Narrative-based SEs -EC

SE2, SE4, SE7, SE8 EC	**0→3**	138.8626	9.6808	4.4453	2.0830	3.3261	1.4025	0.0087
	3→5	155.1070	11.4391	4.2876	1.7679	2.8351	1.3053	0.0106
	5→8	113.3104	9.9619	4.6567	1.9509	3.6003	1.2139	0.0116



Mixed SEs –EC

SE3, SE6, SE9 EC	**0→3**	224.8159	9.4710	3.7421	1.5438	3.3084	1.2165	0.0118
	3→5	111.4327	7.4443	3.7767	1.2593	3.4166	1.1037	0.0139
	5→8	146.1196	9.3642	3.9899	1.7465	2.8725	0.9800	0.0107



Appendix D: All EEG, Questionnaire and in-game score data

Baselines - EC (≈5 min. recording with a sampling rate of 128Hz. Then, band pass filtered with respect to Nyquist frequency restrictions i.e. Lower edge=0 and Higher edge=55)

Participants	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Participant 1	982.1181	14.1125	4.5669	2.1632	4.1907	1.7561	0.0192
Participant 2	332.3804	12.7475	5.7825	2.2369	5.6384	1.9454	0.0116
Participant 3	135.5204	9.4062	4.5025	1.8459	3.2533	1.1290	0.0290
Participant 4	141.7901	9.8735	3.1734	1.3074	1.8908	0.6361	0.0166
Participant 5	253.0076	16.5423	10.9526	3.9308	11.7308	6.4126	0.1564
Participant 6	707.4769	30.0911	8.0330	2.7897	3.6283	1.2681	0.0270
Participant 7	98.6621	19.8147	8.5551	2.9735	6.5429	2.3956	0.0616
Participant 8	532.1116	15.0897	4.2299	3.2221	3.4947	2.9333	0.0374
Participant 9	282.5814	12.8556	3.7470	1.5356	2.5795	0.9028	0.0200
Participant 10	851.8260	15.6929	4.9053	1.7400	2.5859	0.8755	0.0265
Avg. Value	**431.7475**	**15.6226**	**5.8448**	**2.3745**	**4.2134**	**2.0254**	**0.04053**

* Highest value per frequency band .
** Lowest value per frequency band .

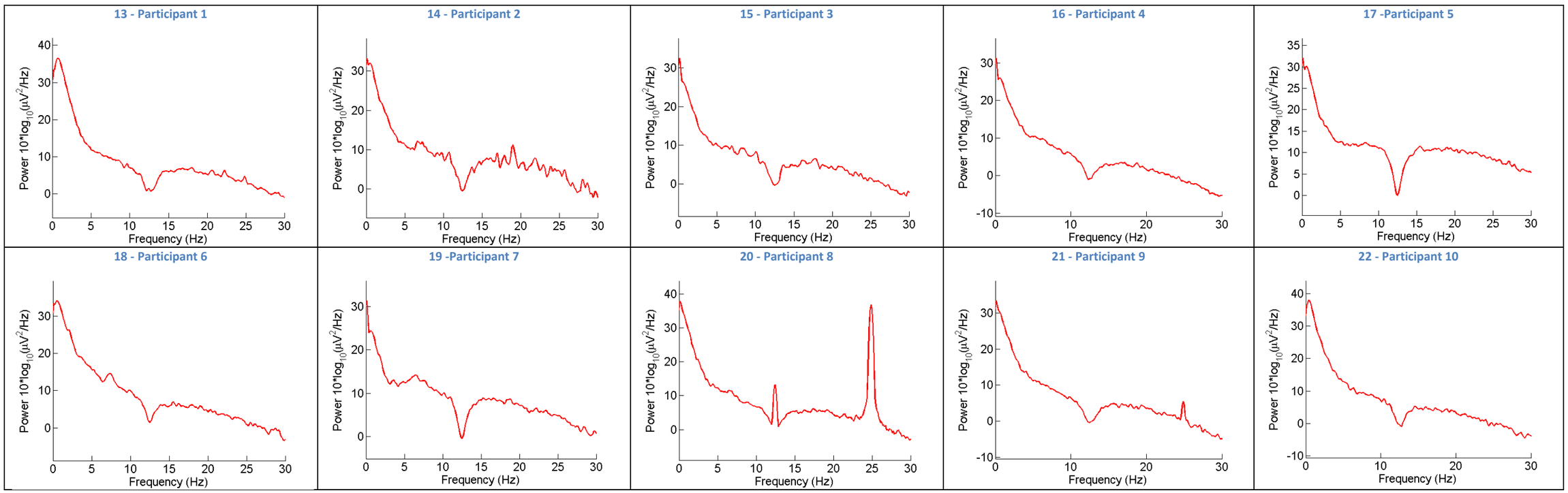


Figure 13 - Power spectrum plots of the participants in the EC.

Baselines - CC (≈5 min. recording with a sampling rate of 128Hz. Then, band pass filtered with respect to Nyquist frequency restrictions i.e. Lower edge=0 and Higher edge=55)

Participants	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Participant 11	984.5682	17.5873	6.5762	2.1797	4.4011	1.8196	0.0529
Participant 12	186.2202	8.5371	2.4626	1.2740	1.7021	0.6072	0.0066
Participant 13	148.5060	12.3135	6.5148	3.2801	5.8875	3.5417	0.0419
Participant 14	252.6500	10.1567	4.5905	1.7819	3.1864	1.2058	0.0399
Participant 15	251.5694	15.8302	6.1808	2.2941	4.5703	1.8866	0.0459
Participant 16	167.4026	5.5551	2.5009	1.4211	2.7446	1.2333	0.0143
Participant 17	163.9618	6.2555	2.9445	1.2095	1.8030	0.7837	0.0093
Participant 18	118.3373	10.4838	4.4171	2.0061	4.3048	1.9318	0.0134
Participant 19	148.6224	7.1512	2.0487	1.0781	1.3284	0.5145	0.0073
Participant 20	411.9583	8.1904	1.9724	1.0124	1.0725	0.4436	0.0058
Avg. Value	**283.3796**	**10.2060**	**4.0208**	**1.7537**	**3.1000**	**1.3968**	**0.02373**

* Highest value per frequency band .
** Lowest value per frequency band .

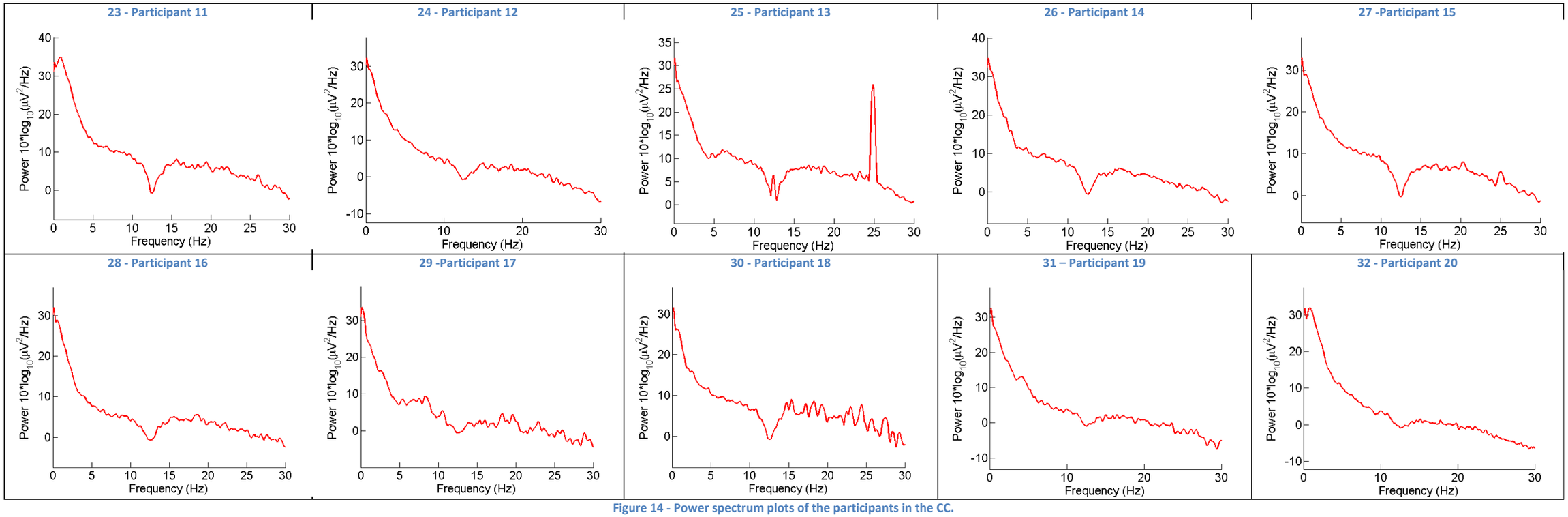


Figure 14 - Power spectrum plots of the participants in the CC.

	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Avg. Value from both EC & CC	357.5635	12.91434	4.9328	2.0641	3.8268	1.7111	0.0321

Gameplay - EC

Participants	Time (sec.)	Score	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Participant 1	1102.915	1600	1397.6000	25.8189	9.7551	3.7904	8.3866	3.2034	0.0508
Participant 2	1106.108	1700	171.8824	13.7315	6.7235	2.5428	5.4103	2.3936	0.0423
Participant 3	877.195	1600	243.9936	11.8847	4.7245	1.9315	3.7315	1.3320	0.0096
Participant 4	1355.758	1700	336.3318	20.4823	6.8018	2.2088	3.9026	1.3010	0.0091
Participant 5	1044.823	1500	237.2225	19.7820	11.7749	3.9199	10.7067	4.6791	0.0316
Participant 6	1214.860	1800	233.9916	16.2874	9.0910	2.7953	6.7793	2.2683	0.0142
Participant 7	1304.102	1700	703.3101	48.6805	15.5082	4.6968	11.0223	3.9913	0.0246
Participant 8	1165.752	1800	304.8049	18.7149	6.4260	2.6472	4.7892	1.7092	0.0090
Participant 9	1334.054	1800	576.9263	32.9213	29.1808	8.8635	27.2477	7.1316	0.0279
Participant 10	1014.808	1400	1113.8653	38.8082	6.8410	1.9594	3.2392	0.9916	0.0121
Avg. Value	**1152.037**	**1660/1900**	**531.9929**	**24.7112**	**10.6827**	**3.5356**	**8.5215**	**2.9001**	**0.0231**

* Highest value per frequency band .
** Lowest value per frequency band .

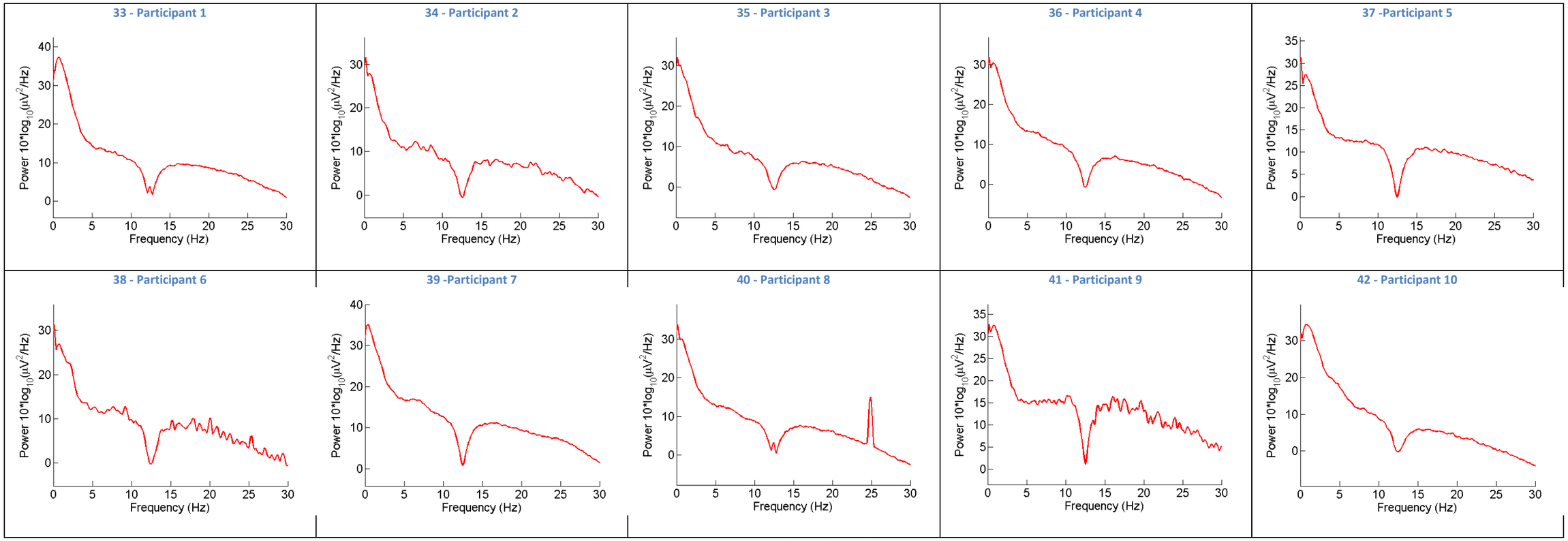


Figure 3 - Power spectrum plots of the participants in the EC Gameplay.

Gameplay - CC

Participants	Time (sec.)	Score	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Participant 11	1550.138	1600	3218.1418	49.7309	18.9458	8.4650	12.9041	4.6222	0.0700
Participant 12	1087.304	1800	220.3933	12.5324	6.2359	2.4370	6.0661	2.2315	0.0139
Participant 13	1148.195	1800	190.5826	13.5624	8.2729	3.0926	7.1963	3.1190	0.0140
Participant 14	1130.178	1600	116.0436	12.4508	7.9718	2.6109	6.1609	1.9668	0.0096
Participant 15	1698.765	1700	159.8932	19.4929	9.8335	3.4331	8.3280	3.2251	0.0162
Participant 16	1052.733	1700	889.9474	17.9400	8.3855	3.2751	7.6500	3.0166	0.0290
Participant 17	998.801	1400	896.9891	29.5777	7.7891	2.7254	3.8974	1.2111	0.0156
Participant 18	1450.029	1800	288.3297	36.3058	13.4100	4.0153	10.9196	4.0201	0.0295
Participant 19	1218.454	1300	119.1855	8.2300	3.3673	1.5886	2.3616	0.7687	0.0060
Participant 20	1385.546	1800	373.4803	9.7874	3.2708	1.6436	2.4864	0.9649	0.0084
Avg. Value	**1272.014**	**1650/1900**	**647.2986**	**20.9610**	**8.7482**	**3.3286**	**6.7970**	**2.5146**	**0.0212**

* Highest value per frequency band .
** Lowest value per frequency band .

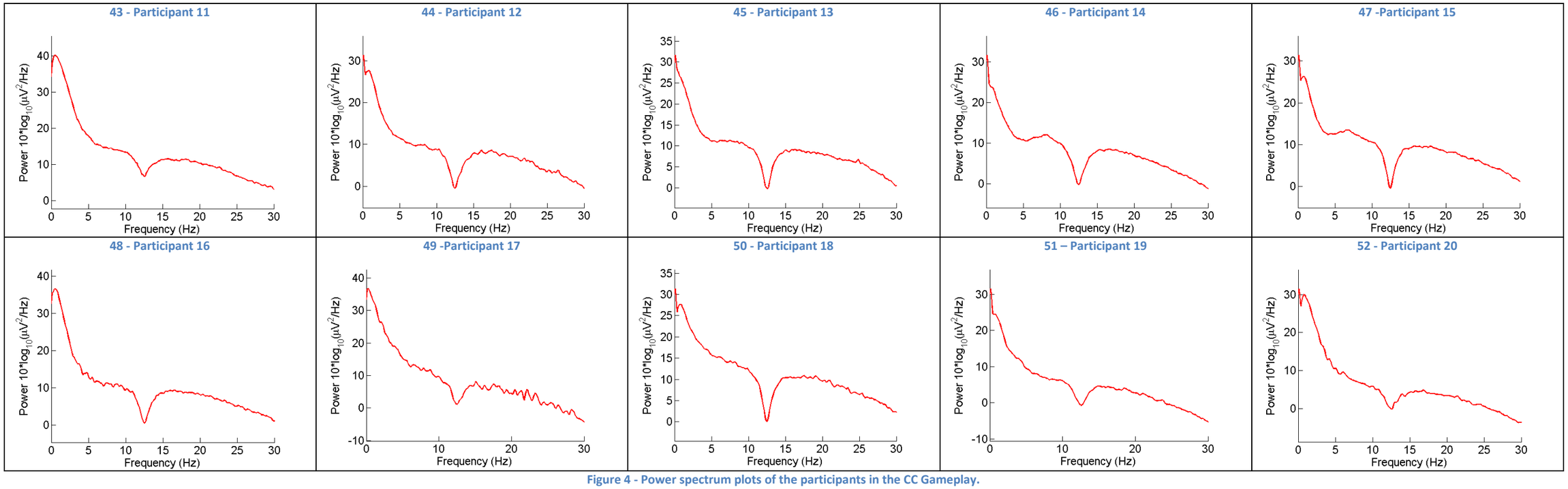


Figure 4 - Power spectrum plots of the participants in the CC Gameplay.

Gameplay Phase A - EC

Participants	Time (sec.)	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Participant 1	61.619	1748.0565	15.4791	7.0286	2.8129	6.0947	1.9065	0.0288
Participant 2	69.859	200.7308	19.4569	16.4064	3.2738	8.7383	3.1602	0.0124
Participant 3	51.153	100.0544	6.8009	2.6179	1.3727	2.2053	0.7607	0.0078
Participant 4	134.425	901.4110	33.2336	8.3041	2.1173	4.4859	1.8766	0.0221
Participant 5	78.517	123.4228	20.9796	12.4382	4.4990	13.5662	6.4713	0.0359
Participant 6	111.905	314.3003	11.3475	6.2902	1.8645	5.1260	1.9820	0.0107
Participant 7	127.456	198.6914	15.8563	5.6506	2.4357	5.0947	2.6455	0.0140
Participant 8	111.631	662.6202	10.2508	2.5800	2.0068	2.1975	1.0843	0.0110
Participant 9	119.680	337.6700	7.5864	3.3094	1.5376	2.5589	0.8781	0.0050
Participant 10	76.569	356.9730	12.7123	4.1744	1.4417	2.1272	0.6537	0.0087
Avg. Value	**94.281**	**494.3930**	**15.3703**	**6.8799**	**2.3362**	**5.2194**	**2.1419**	**0.0156**

* Highest value per frequency band .
** Lowest value per frequency band .

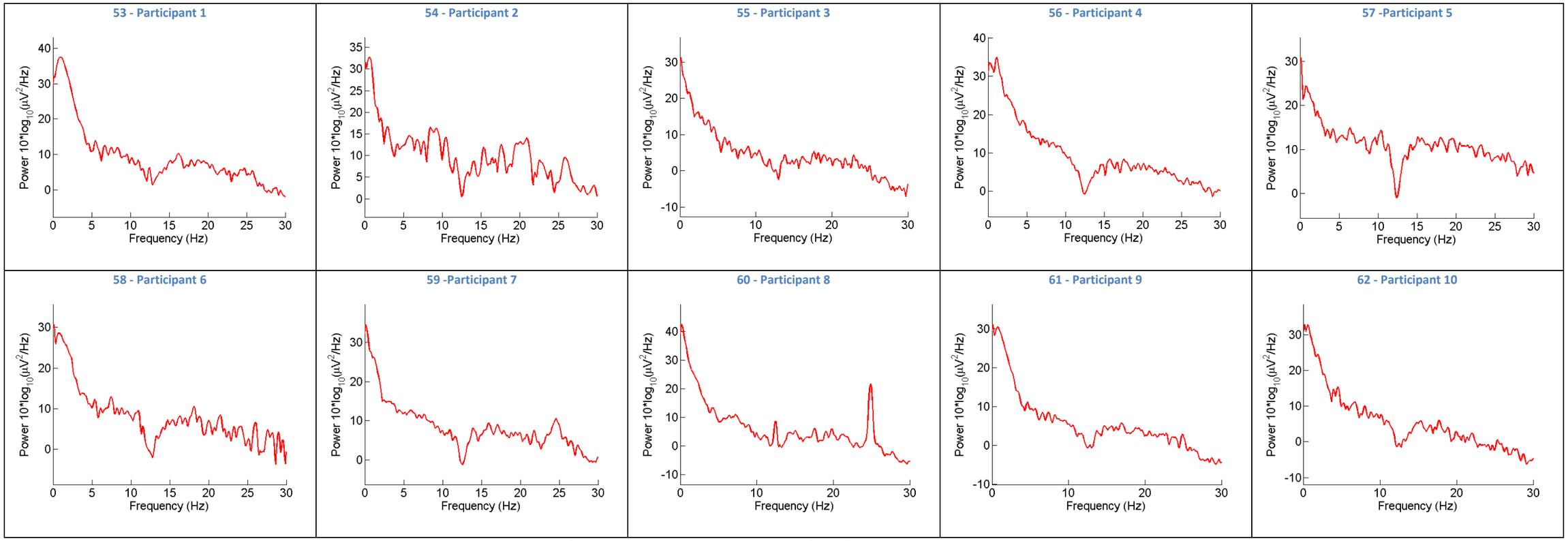


Figure 5 - Power spectrum plots of the participants in the EC Gameplay Phase A.

Gameplay Phase A - CC

Participants	Time (sec.)	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Participant 11	116.449	2251.1341	37.0057	14.0728	5.2919	16.4460	7.8522	0.0483
Participant 12	92.358	113.3476	8.1032	3.0228	1.5525	2.2503	0.8271	0.0061
Participant 13	99.139	119.6042	11.8430	6.6773	2.3009	4.7107	2.1199	0.0089
Participant 14	88.112	190.2352	14.2439	6.6449	2.6585	5.6883	2.3111	0.0155
Participant 15	124.270	172.5222	8.5855	4.3259	1.6767	3.2944	1.5171	0.0090
Participant 16	78.479	207.5633	5.9792	3.2880	1.4679	2.7248	1.1515	0.0075
Participant 17	37.374	1647.5649	27.3642	7.4820	1.6093	1.7700	0.5643	0.0060
Participant 18	137.030	153.4258	16.2390	9.3173	3.4402	7.9897	2.4629	0.0121
Participant 19	92.056	202.4101	8.4806	2.8152	1.4667	2.1153	0.8246	0.0076
Participant 20	112.176	460.7809	6.9424	2.7604	1.2169	1.9633	0.8348	0.0069
Avg. Value	**97.744**	**551.8588**	**14.4787**	**6.0407**	**2.2682**	**4.8953**	**2.0466**	**0.0128**

* Highest value per frequency band .
** Lowest value per frequency band .

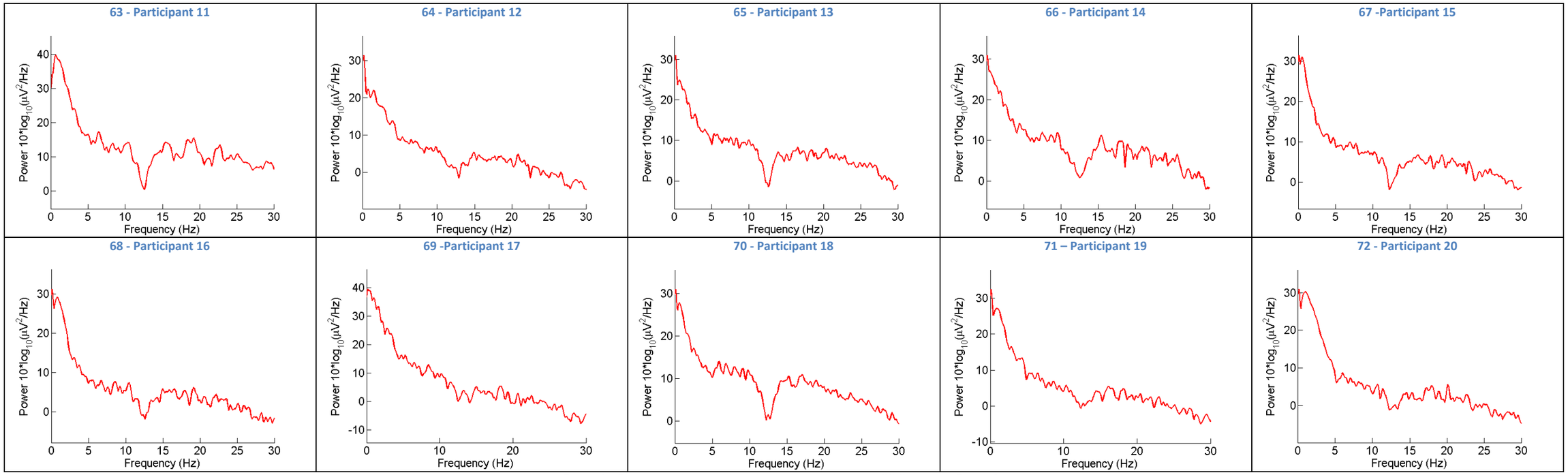


Figure 6 - Power spectrum plots of the participants in the CC Gameplay Phase A.

	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Avg. Value from both EC & CC (Phase A only)	523.1259	14.9245	6.4603	2.3022	5.0574	2.0942	0.0142

Gameplay Phase B - EC

Participants	Time (sec.)	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Participant 1	286.806	1179.3780	23.4293	9.3522	3.9627	7.4980	2.9478	0.0485
Participant 2	301.845	309.3041	17.6447	6.2154	3.5866	8.1653	2.9320	0.0164
Participant 3	188.848	601.8925	13.6350	4.0194	1.8698	3.3562	0.8606	0.0066
Participant 4	341.017	507.0250	24.0543	10.4716	2.7797	7.1459	1.9316	0.0134
Participant 5	296.862	250.6412	32.6439	19.7891	6.0277	17.1991	7.0644	0.0465
Participant 6	409.964	223.9440	17.5737	8.4946	3.1472	6.3258	2.2095	0.0121
Participant 7	327.139	629.8129	25.1462	9.2031	3.4634	7.7843	3.1037	0.0237
Participant 8	343.716	375.7559	13.1034	4.2840	2.3454	3.3329	1.2040	0.0090
Participant 9	378.766	418.9491	17.4563	6.3621	3.1997	6.8798	2.1385	0.0099
Participant 10	313.179	1068.5329	40.1354	7.6898	1.9124	2.6252	0.7240	0.0106
Avg. Value	**318.8142**	**556.5235**	**22.4822**	**8.5881**	**3.2294**	**7.0312**	**2.5116**	**0.0196**

* Highest value per frequency band .
** Lowest value per frequency band .

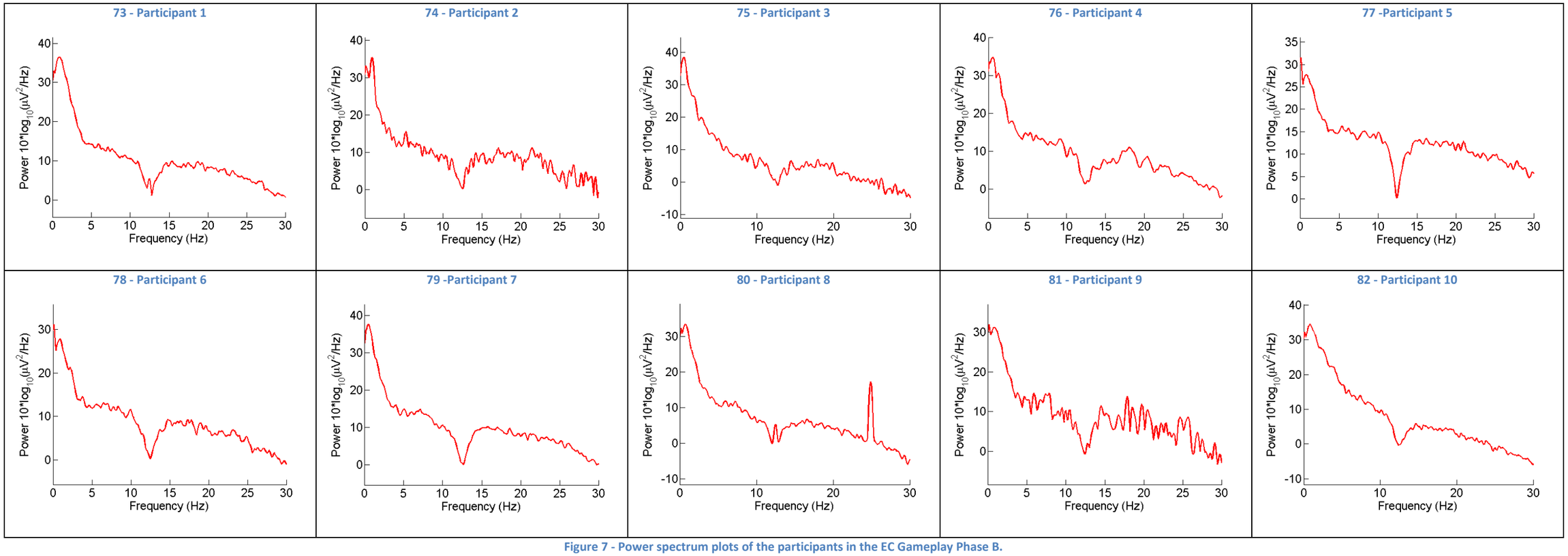


Figure 7 - Power spectrum plots of the participants in the EC Gameplay Phase B.

Gameplay Phase B - CC

Participants	Time (sec.)	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Participant 11	469.711	3310.2675	42.3543	19.2101	8.1566	9.6019	4.6439	0.2439
Participant 12	275.958	270.5689	17.9786	8.7852	2.9640	7.8640	2.8286	0.0480
Participant 13	302.835	129.5646	13.1833	10.5474	3.5316	9.5310	4.2253	0.0171
Participant 14	257.967	115.0730	9.5463	4.8760	1.8285	3.7397	1.1153	0.0068
Participant 15	404.456	95.0177	14.5838	7.1232	2.8229	6.1007	2.5318	0.0111
Participant 16	293.521	2529.5742	31.7581	14.7523	5.6907	23.5779	7.8563	0.0472
Participant 17	240.878	1458.6426	21.8696	3.9198	1.3667	1.5663	0.4452	0.0091
Participant 18	417.184	157.4908	24.0689	14.4372	4.5283	10.9958	3.7353	0.0192
Participant 19	345.243	130.0402	7.2182	2.9238	1.4330	2.0541	0.7724	0.0073
Participant 20	409.200	464.6110	8.8097	2.6268	1.1848	1.7136	0.7420	0.0187
Avg. Value	**341.6953**	**866.0851**	**19.1371**	**8.9202**	**3.3507**	**7.6745**	**2.8896**	**0.0428**

* Highest value per frequency band .
** Lowest value per frequency band .

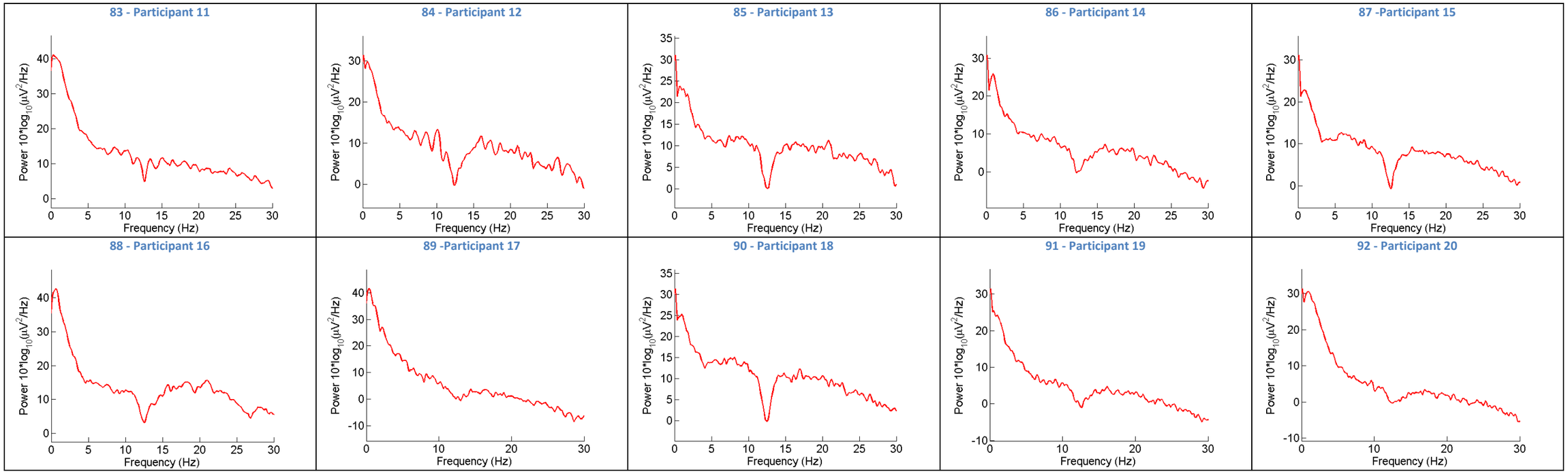


Figure 8 - Power spectrum plots of the participants in the CC Gameplay Phase A.

	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Avg. Value from both EC & CC (Phase B only)	711.3043	20.8097	8.7542	3.2901	7.3529	2.7006	0.0313

Gameplay Phase C - EC

Participants	Time (sec.)	Score	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Participant 1	498.493	1100	1038.4122	34.9624	13.2468	4.3856	11.3467	4.0310	0.0546
Participant 2	500.914	1200	207.4395	21.4840	17.2883	5.0805	12.8004	5.2645	0.0243
Participant 3	464.872	1100	191.6035	12.9916	5.0183	1.9968	4.0212	1.4606	0.0123
Participant 4	556.376	1200	176.4972	13.4803	4.3198	1.6362	2.9547	1.0914	0.0082
Participant 5	423.479	1000	233.0188	18.2519	13.5936	4.3794	13.4410	6.9448	0.0442
Participant 6	482.369	1300	187.3622	13.6749	6.0434	2.1130	3.8292	1.2599	0.0084
Participant 7	578.735	1200	548.7874	51.3046	17.5092	4.9386	12.4247	4.0946	0.0271
Participant 8	478.897	1300	142.9801	17.2957	6.2724	2.5895	4.6171	1.6269	0.0095
Participant 9	573.817	1300	392.8727	15.1587	8.8719	3.3098	8.1621	3.0567	0.0192
Participant 10	446.071	900	302.5967	15.4500	3.9558	1.6436	2.3425	0.8163	0.0083
Avg. Value	**500.402**	**1160/1400**	**342.1570**	**21.4054**	**9.6119**	**3.2073**	**7.5939**	**2.9646**	**0.0216**

* Highest value per frequency band .
** Lowest value per frequency band .

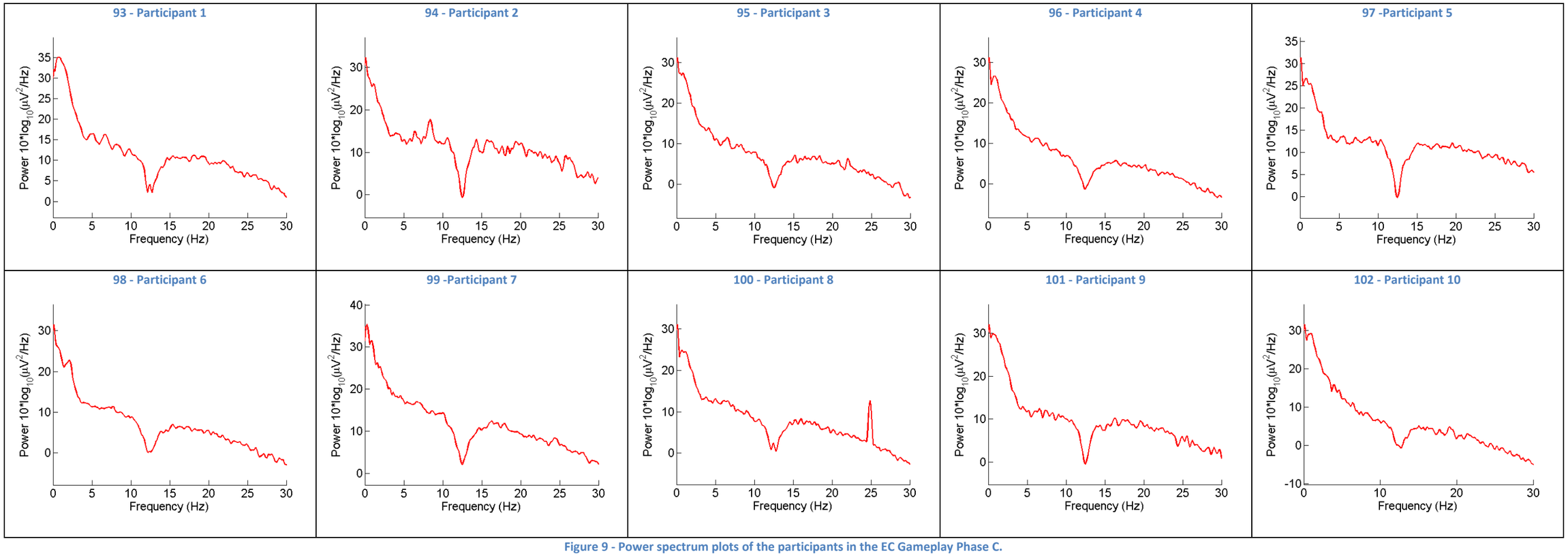


Figure 9 - Power spectrum plots of the participants in the EC Gameplay Phase C.

Gameplay Phase C - CC

Participants	Time (sec.)	Score	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Participant 11	619.077	1200	4143.6638	118.7032	28.2718	11.4227	15.0188	5.4716	0.2976
Participant 12	462.775	1300	107.8806	9.4936	5.1576	1.9882	5.0363	1.3987	0.0280
Participant 13	492.185	1300	132.5944	13.2386	7.7915	2.9301	6.9187	2.9630	0.0150
Participant 14	550.835	1300	74.4541	11.1184	7.2106	2.4159	5.6536	1.8768	0.0087
Participant 15	723.913	1200	118.9894	16.9986	8.5546	3.0127	7.7506	2.9613	0.0174
Participant 16	442.547	1200	1757.8133	70.5501	22.1621	6.6166	10.4757	4.3293	0.0402
Participant 17	460.949	1100	265.2866	9.4247	4.0815	1.4460	2.0069	0.7237	0.0103
Participant 18	580.542	1300	482.4096	34.1910	13.6890	5.0858	11.4467	4.7781	0.0393
Participant 19	483.842	800	124.7341	9.0327	4.6319	2.8018	4.4516	1.2772	0.0075
Participant 20	548.334	1300	355.7259	12.3258	3.9361	1.8438	2.2197	0.9327	0.0233
Avg. Value	**536.500**	**1200/1400**	**756.3552**	**30.5077**	**10.5487**	**3.9564**	**7.0979**	**2.6712**	**0.0487**

* Highest value per frequency band .
** Lowest value per frequency band .

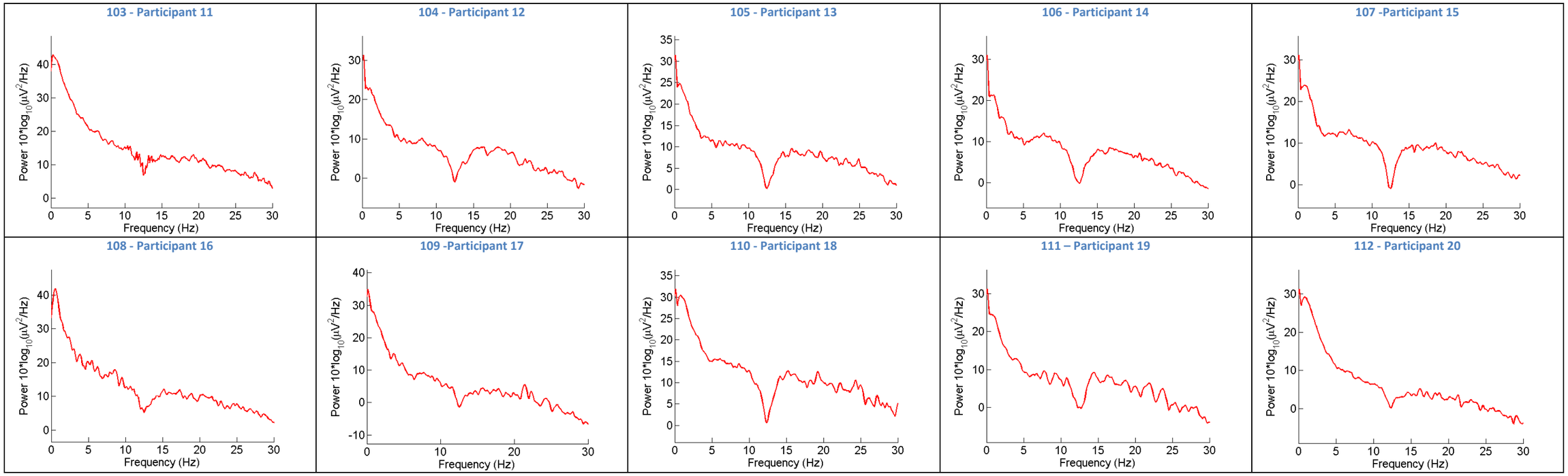


Figure 10 - Power spectrum plots of the participants in the CC Gameplay Phase C.

Gameplay Phase D - EC

Participants	Time (sec.)	Score	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Participant 1	255.997	500	1580.6218	29.5774	9.7854	3.7163	9.2205	3.8544	0.0686
Participant 2	233.490	500	147.4974	5.9426	2.1422	1.1362	1.5060	0.5142	0.0048
Participant 3	172.322	500	295.0841	11.1516	4.2045	1.8630	3.8403	1.1554	0.0078
Participant 4	323.940	500	364.6054	19.7111	7.8874	3.1244	5.2991	1.5848	0.0108
Participant 5	245.965	500	196.4031	14.9064	8.2574	2.8478	6.6785	2.6139	0.0175
Participant 6	210.622	500	264.2163	34.7799	40.9376	8.4073	33.4882	10.2793	0.0407
Participant 7	270.772	500	251.1110	32.7252	12.2188	3.4107	8.2922	3.4968	0.0155
Participant 8	231.508	500	554.4568	27.1761	9.2802	3.6293	6.4090	2.3554	0.0141
Participant 9	261.791	500	570.3846	34.5011	20.1424	11.4773	20.5671	4.6463	0.0211
Participant 10	178.989	500	399.7651	11.5209	4.1429	1.5774	2.7251	0.8442	0.0105
Avg. Value	**238.539**	**500/500**	**462.4145**	**22.1992**	**11.8998**	**4.1189**	**9.8026**	**3.1344**	**0.0211**

* Highest value per frequency band .
** Lowest value per frequency band .

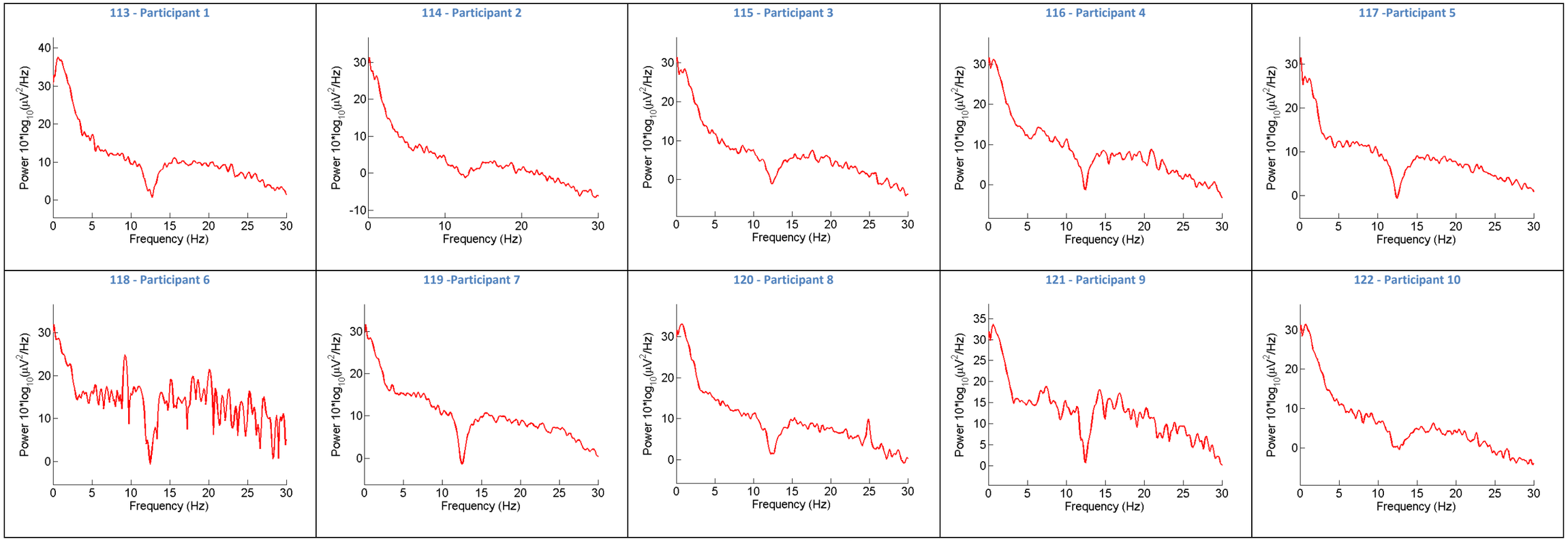


Figure 11 - Power spectrum plots of the participants in the EC Gameplay Phase D.

Gameplay Phase D - CC

Participants	Time (sec.)	Score	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Participant 11	344.901	400	2057.9170	38.0948	18.2663	5.3812	17.8754	6.5093	0.1072
Participant 12	256.213	500	205.2386	16.2549	9.6471	3.2550	8.3065	3.1258	0.0517
Participant 13	254.036	500	115.4763	14.4448	7.7378	2.9276	6.8073	2.7804	0.0107
Participant 14	233.264	300	103.0390	15.5909	9.1120	2.9654	7.1865	2.3757	0.0123
Participant 15	446.126	500	330.3571	15.1926	8.7142	3.1320	8.7811	3.9143	0.0240
Participant 16	298.184	500	420.1303	11.7208	7.5365	3.0677	8.1435	3.4008	0.0223
Participant 17	259.600	300	377.3830	7.5241	2.6245	1.0873	1.3505	0.3656	0.0043
Participant 18	315.273	500	278.4306	28.2725	12.0971	3.8615	10.3355	4.1945	0.0336
Participant 19	297.313	500	114.0808	8.1054	3.8507	1.7490	2.3464	0.8175	0.0057
Participant 20	313.736	500	931.0538	41.8188	7.8031	5.0640	6.0368	2.3164	0.0775
Avg. Value	**301.864**	**450/500**	**493.3107**	**19.7020**	**8.7389**	**3.2491**	**7.7170**	**2.9800**	**0.0349**

* Highest value per frequency band .
** Lowest value per frequency band .

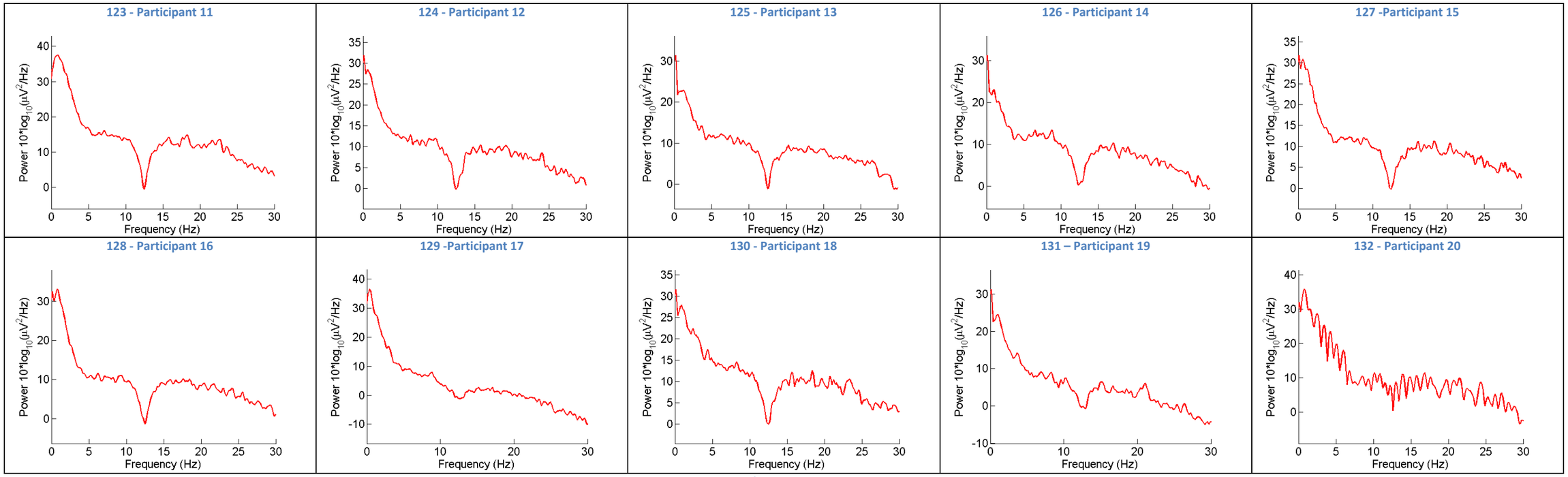


Figure 12 - Power spectrum plots of the participants in the CC Gameplay Phase D.

Instructions - EC (combined measurements from 5 different textual instructions; cut-down to a standard duration for each of 8 sec.)

Participants	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Participant 1	995.5922	19.3575	10.1036	4.1866	7.1032	3.2759	0.0495
Participant 2	266.6383	18.5701	15.5432	2.0812	5.9668	2.1078	0.0195
Participant 3	1240.3865	57.6652	9.9212	4.2908	4.7047	2.3612	0.0338
Participant 4	82.0680	17.8635	5.8829	1.9954	3.5257	1.2496	0.0093
Participant 5	148.8735	28.9713	14.5796	4.8281	17.6139	6.1644	0.0309
Participant 6	101.8628	11.6986	5.0753	2.5291	4.8900	1.7607	0.,0120
Participant 7	121.5318	23.8057	9.1781	3.8363	7.9486	3.0221	0.0106
Participant 8	124.5967	11.2508	4.7683	2.0919	4.9177	1.8303	0.0066
Participant 9	1032.6573	33.2676	9.3386	2.3836	3.8852	1.6187	0.0302
Participant 10	597.7663	20.1143	6.1675	1.7847	2.0751	0.7035	0.0103
Avg. Value	**471.1973**	**24.2564**	**9.0558**	**3.0007**	**6.2631**	**2.4094**	**0.0223**

* Highest value per frequency band .
** Lowest value per frequency band .

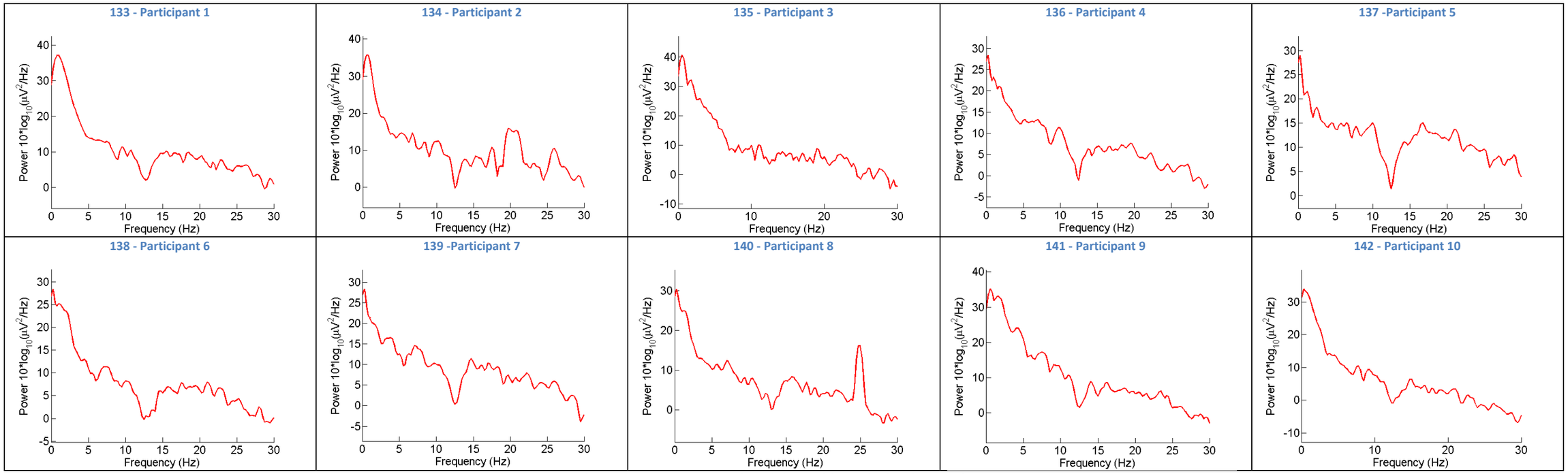


Figure 13 - Power spectrum plots of the participants in the EC Instructions.

Instructions - CC (combined measurements from 5 different textual instructions; cut-down to a standard duration for each of 8 sec.)

Participants	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Participant 11	2306.5983	38.0927	14.1898	4.3730	10.8320	3.7017	0.0802
Participant 12	100.2891	6.9826	3.2300	1.4697	2.7179	0.9552	0.0292
Participant 13	75.8586	12.1610	9.5943	3.0313	5.8376	3.1943	0.0124
Participant 14	107.5495	10.6621	12.0064	1.9875	6.4962	2.3184	0.0143
Participant 15	41.1161	8.4616	5.8311	2.2259	5.4925	1.7056	0.0085
Participant 16	55.3731	8.3927	4.5663	1.9739	3.6001	1.5255	0.0091
Participant 17	1984.3688	18.2809	3.4261	1.0987	1.4267	0.3082	0.0066
Participant 18	101.7405	34.1757	8.9485	2.7080	6.4473	1.9024	0.0098
Participant 19	212.4012	10.6514	4.4767	1.7261	3.2839	1.2491	0.0079
Participant 20	867.0034	9.8834	3.5204	1.5536	2.9338	1.0665	0.0208
Avg. Value	**585.2299**	**15.7744**	**6.9790**	**2.2148**	**4.9068**	**1.7927**	**0.0199**

* Highest value per frequency band .
** Lowest value per frequency band .

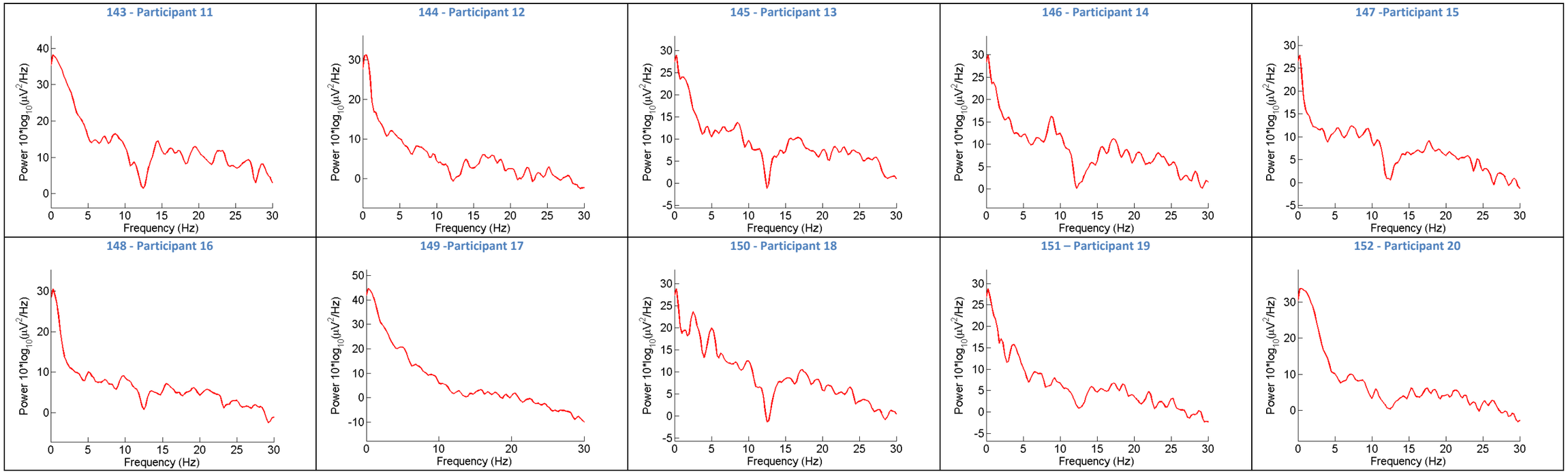


Figure 14 - Power spectrum plots of the participants in the CC Instructions.

	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Avg. Value from both EC & CC (Instructions)	528.2136	20.0154	8.0174	2.6078	5.5849	2.1011	0.0210

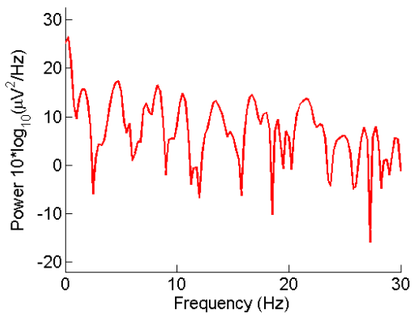
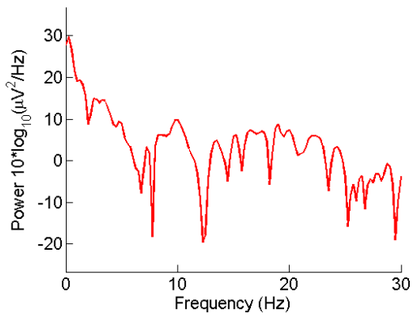
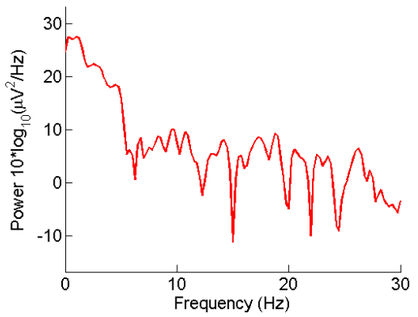
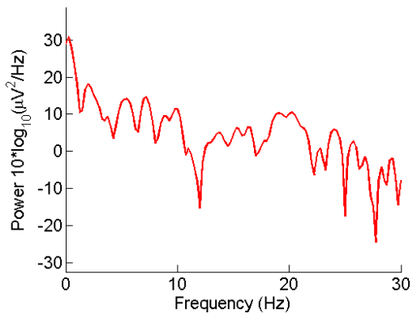
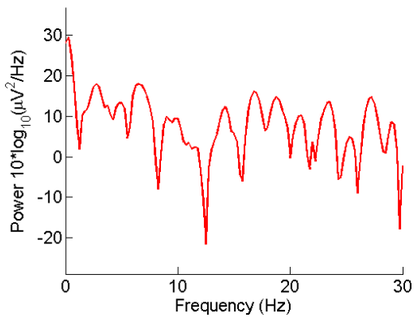
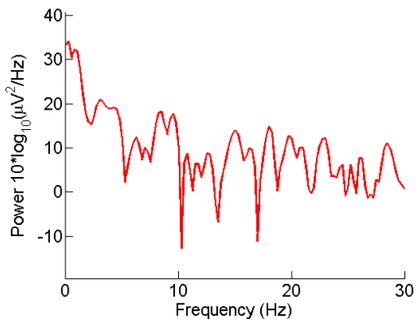
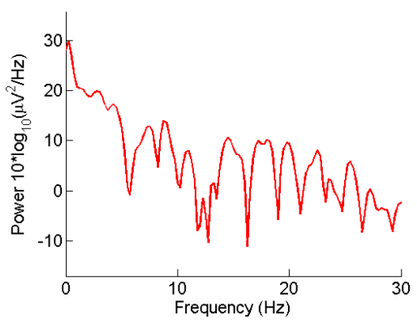
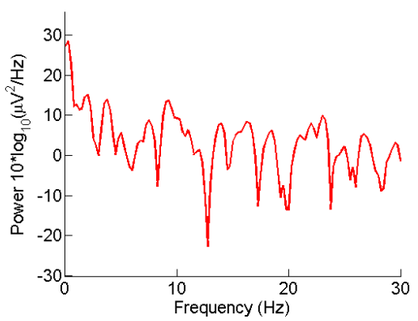
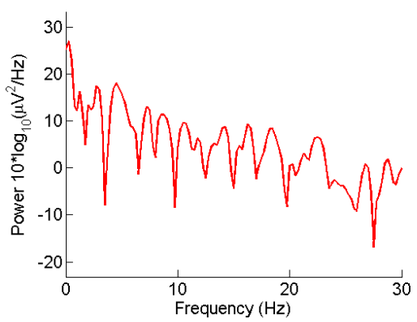
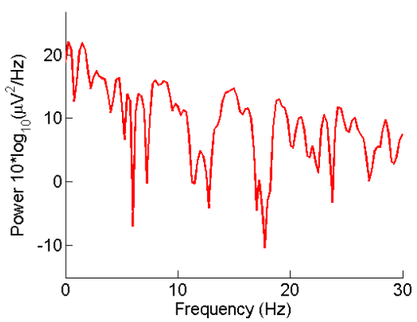
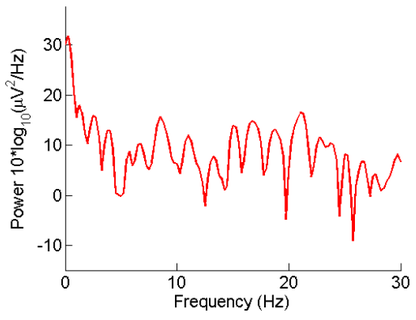
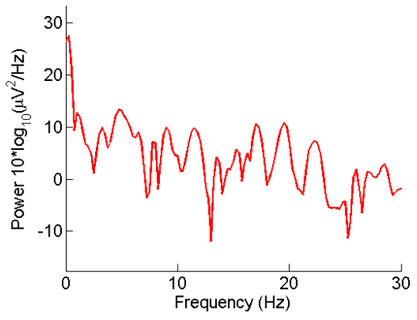
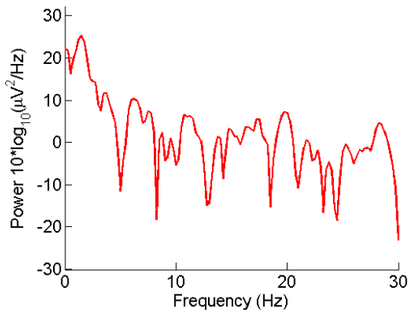
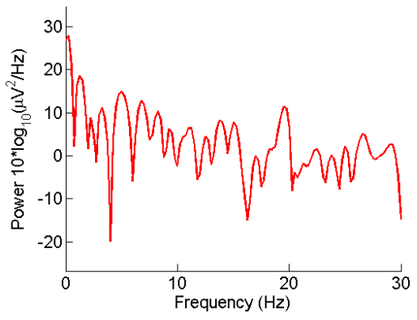
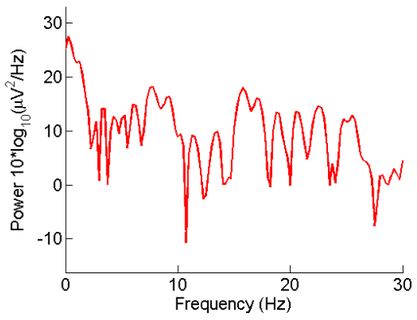
Gameplay SE1 (task dependent cue-based surprise) - EC

Participants	Duration	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Participant 1	**0 → 3**	15.4856	8.4598	5.0317	7.6426	5.9700	2.4531	0.0222
	3 → 5	251.9162	13.5705	9.1388	3.3108	5.1758	2.8883	0.0250
	5 → 8	63.6319	3.5191	9.6422	2.6332	10.2312	3.6775	0.0250
Participant 2	**0 → 3**	65.7665	2.1699	3.4576	0.5339	3.6221	0.5427	0.0029
	3 → 5	142.5115	8.0496	4.0687	1.6957	3.3160	0.9446	0.0040
	5 → 8	11.2284	11.0094	3.7391	0.8947	4.1227	0.8092	0.0055
Participant 3	**0 → 3**	307.4637	11.0070	5.4833	2.7862	3.6816	1.0057	0.0039
	3 → 5	22.2242	1.4391	4.0891	0.6312	0.8469	1.2142	0.0116
	5 → 8	92.4212	2.2921	0.9521	0.3561	1.4462	0.4341	0.0094
Participant 4	**0 → 3**	69.7796	9.3760	2.8703	1.7113	3.5509	0.4650	0.0038
	3 → 5	30.9600	12.7852	4.6195	2.5450	2.1213	0.6349	0.0043
	5 → 8	14.5733	7.6743	2.1488	2.3366	0.9941	0.8678	0.0043
Participant 5	**0 → 3**	31.5341	18.6612	2.9365	1.7008	14.9780	2.7605	0.0327
	3 → 5	66.7278	12.8298	10.6203	6.2244	2.9374	4.1920	0.0335
	5 → 8	66.4694	13.8699	9.4464	2.0977	11.1719	3.7217	0.0396
Participant 6	**0 → 3**	283.2840	17.3971	4.4824	1.6105	2.3476	1.4095	0.0486
	3 → 5	267.3650	10.4835	7.0194	5.8636	2.7714	3.7479	0.1119
	5 → 8	46.0547	5.8923	5.5404	0.8209	1.6695	1.8619	0.0193
Participant 7	**0 → 3**	467.8028	10.5867	12.7588	3.5388	4.4372	3.7686	0.0144
	3 → 5	64.6114	13.5769	12.2291	1.8488	6.9871	2.5681	0.0072
	5 → 8	39.5489	10.8787	14.4393	1.6684	19.2852	4.8290	0.0106
Participant 8	**0 → 3**	33.2709	2.8974	2.3210	2.4956	0.9220	1.1216	0.0038
	3 → 5	72.2835	2.6680	4.2247	0.9401	2.0394	0.5450	0.0036
	5 → 8	47.9237	8.1582	1.4977	1.9183	2.0269	0.6608	0.0027
Participant 9	**0 → 3**	26.6006	3.3049	1.5457	1.2825	1.0012	0.5824	0.0029
	3 → 5	33.1405	7.3079	0.9829	0.6933	1.1531	0.5746	0.0034
	5 → 8	11.4995	4.7281	2.0467	1.7445	0.9991	0.6172	0.0027
Participant 10	**0 → 3**	101.2435	18.3033	5.6464	3.5092	1.6751	0.3969	0.0029
	3 → 5	16.8580	11.1986	1.4527	0.6932	3.6163	0.4830	0.0052
	5 → 8	13.5990	1.2302	1.2981	0.5418	1.2634	0.4957	0.0058
Avg. Value	**0 → 3**	**140.2231**	**10.2163**	**4.6534**	**2.6811**	**4.2186**	**1.4506**	**0.0138**
	3 → 5	**96.8598**	**9.3909**	**5.8445**	**2.4446**	**3.0965**	**1.7793**	**0.0210**
	5 → 8	**40.6950**	**6.9252**	**5.0751**	**1.5012**	**5.3210**	**1.7975**	**0.0125**

* Highest value per frequency band .
** Lowest value per frequency band .

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7	Participant 8	Participant 9	Participant 10	Avg. Value
Surprise	3	2	4	5	3	4	4	5	5	6	4.1
Startle	6	1	5	5	2	4	5	3	3	5	3.9
Confusion	4	1	2	5	4	2	3	6	6	4	3.7
Disturbance	3	2	3	6	6	1	5	2	6	2	3.6

Participants' ratings on the effects of the SEs from the questionnaires

153 - Participant 1	154 - Participant 2	155 - Participant 3	156 - Participant 4	157 -Participant 5
				
				
				

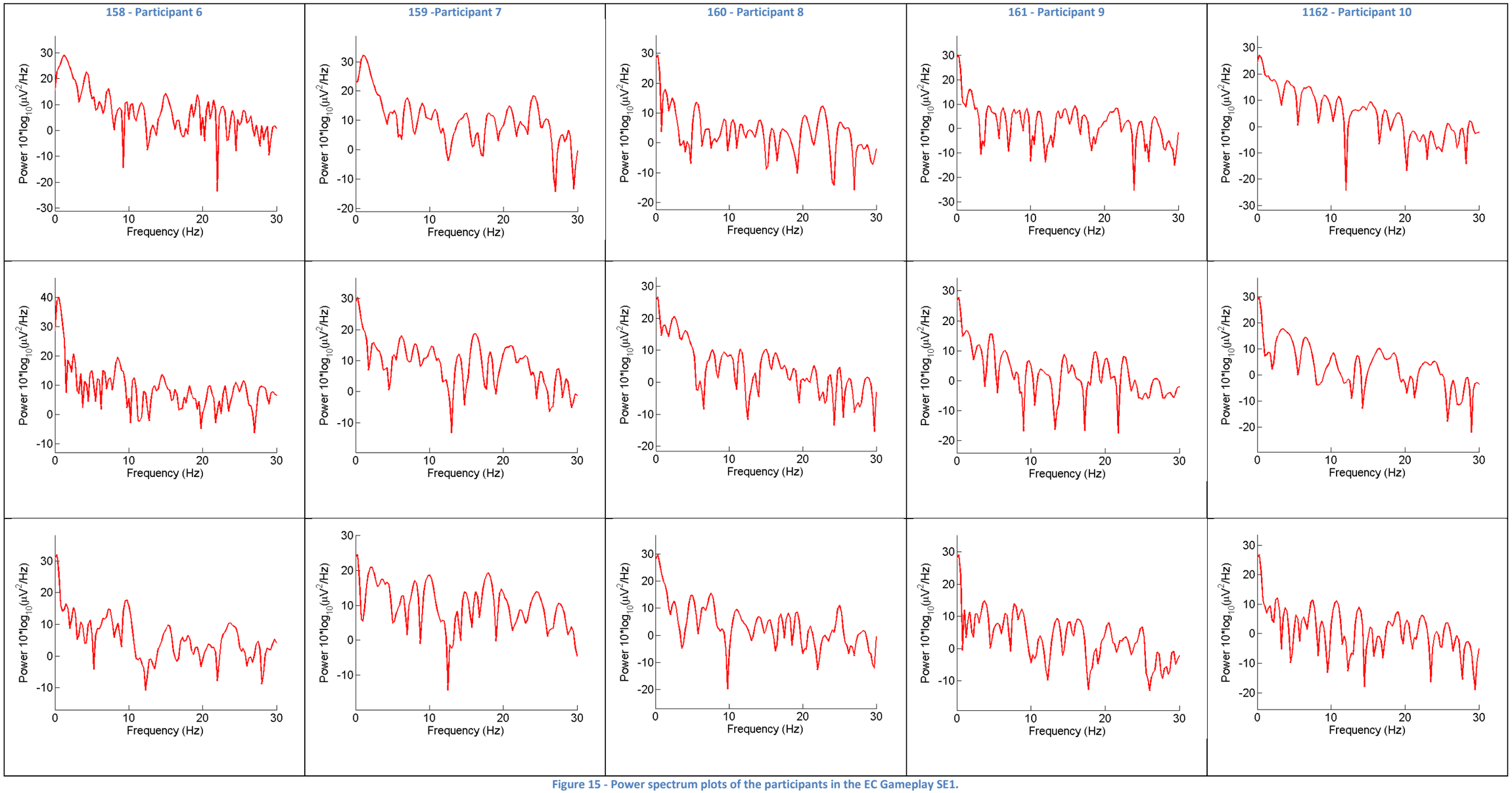


Figure 15 - Power spectrum plots of the participants in the EC Gameplay SE1.

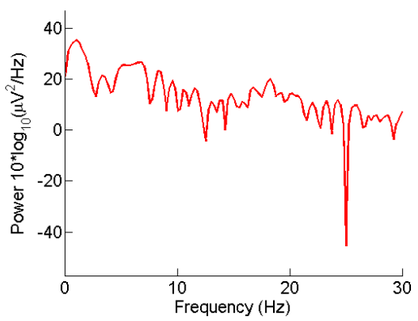
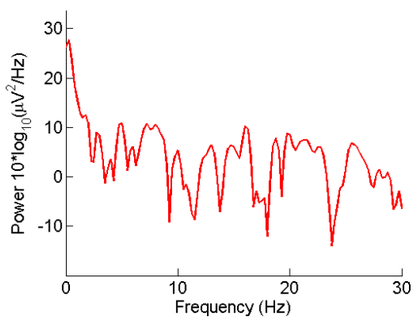
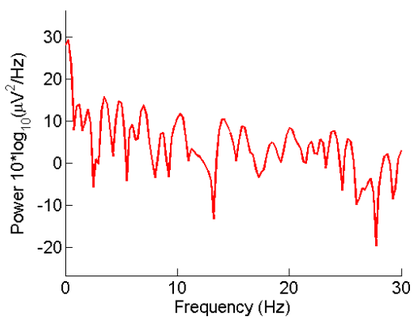
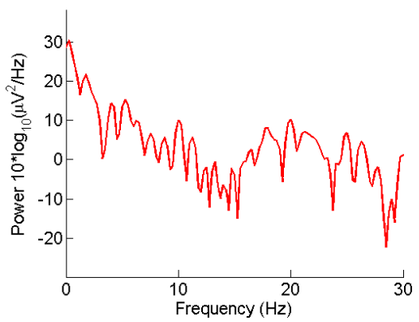
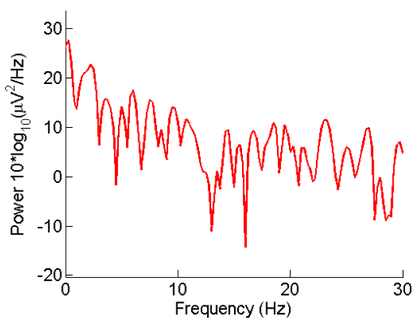
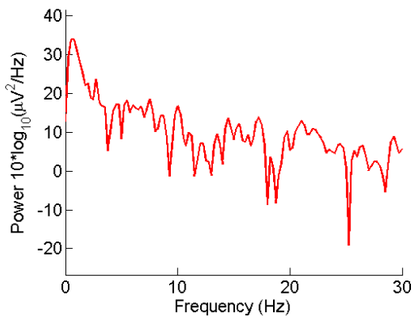
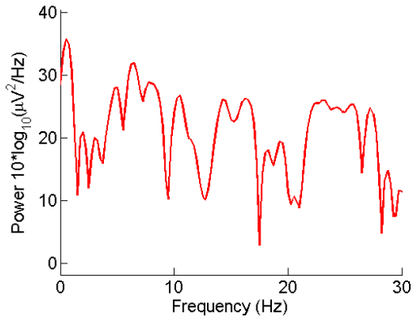
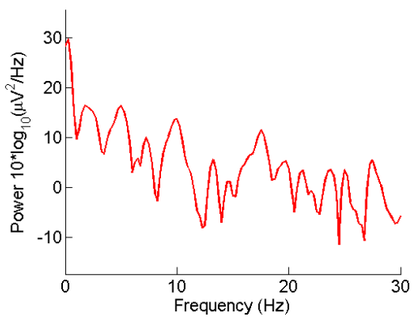
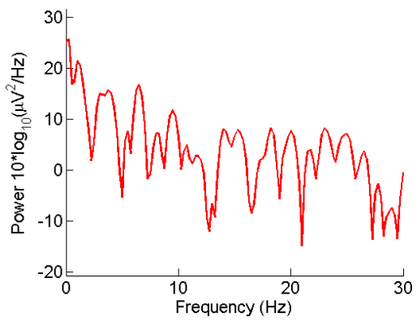
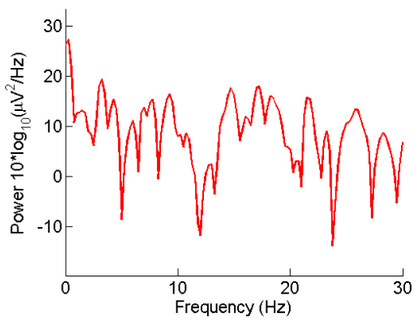
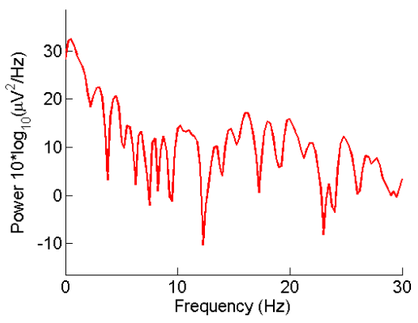
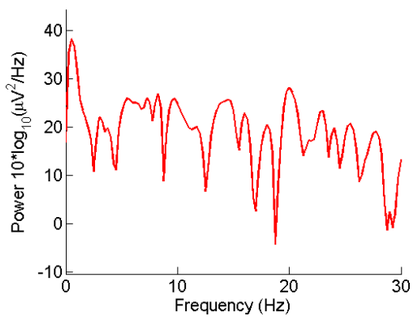
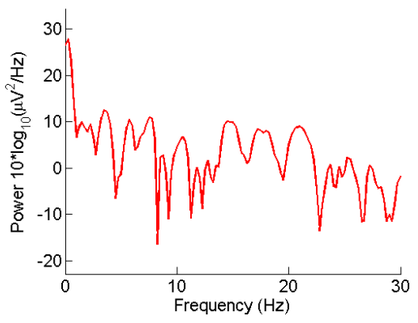
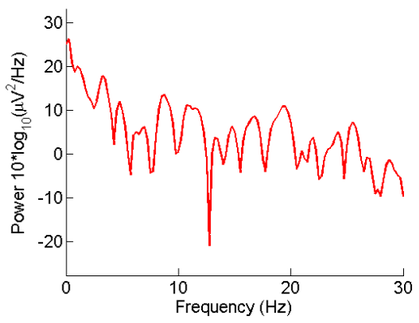
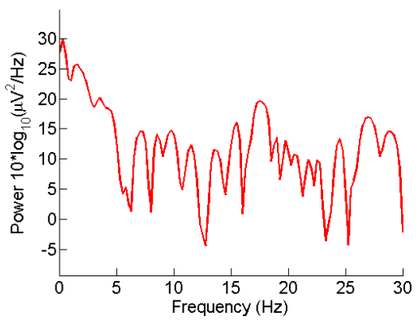
Gameplay SE2 (task-independent narrative-based surprise) - EC

Participants	Duration	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Participant 1	**0 → 3**	563.7679	257.7181	30.4464	5.5604	29.0406	2.5031	0.1395
	3 → 5	406.5364	37.9566	7.7620	4.4541	3.2121	2.7874	0.0560
	5 → 8	403.6476	21.5312	9.0620	3.7589	12.2627	2.9696	0.0309
Participant 2	**0 → 3**	22.4549	3.5717	1.0840	1.8470	1.0874	1.2258	0.0064
	3 → 5	207.6011	553.3726	158.4101	68.8792	66.3637	106.2035	0.1269
	5 → 8	338.4207	156.2922	142.3015	103.6327	28.0529	28.0404	0.1071
Participant 3	**0 → 3**	13.1423	6.0123	3.2184	1.7243	1.5488	0.8467	0.0072
	3 → 5	46.1547	10.9325	4.2396	0.7639	4.2035	0.6701	0.0088
	5 → 8	13.8129	2.3570	0.8358	1.6091	2.5860	0.5103	0.0058
Participant 4	**0 → 3**	117.9918	10.3000	1.6989	0.2485	2.2706	0.6248	0.0085
	3 → 5	27.1479	6.3617	3.1378	0.8618	1.2608	0.9197	0.0053
	5 → 8	46.9314	3.1350	7.5448	0.9531	4.3074	0.7876	0.0046
Participant 5	**0 → 3**	103.7946	9.3234	8.1870	1.1968	4.7630	1.8136	0.0131
	3 → 5	20.8257	5.2030	5.2930	4.3079	19.0479	3.9797	0.0242
	5 → 8	269.6035	9.5803	13.3411	3.1124	24.3609	8.4642	0.0546
Participant 6	**0 → 3**	112.2762	5.5631	4.5813	0.8328	2.9890	0.5662	0.0052
	3 → 5	75.3990	2.4171	3.7340	2.0129	0.6080	0.3557	0.0053
	5 → 8	28.1556	2.9905	5.1307	2.1333	1.0953	0.3505	0.0022
Participant 7	**0 → 3**	108.9070	9.6124	6.7074	1.4606	12.0601	2.2648	0.0217
	3 → 5	79.6129	8.0319	3.1687	6.9384	4.5801	1.3851	0.0077
	5 → 8	282.0532	18.7076	6.0281	1.1817	4.7746	3.2840	0.0085
Participant 8	**0 → 3**	16.8748	11.6667	2.0556	0.7932	1.9560	0.9941	0.0025
	3 → 5	12.1947	11.7356	3.4230	2.2459	11.8089	2.0337	0.0046
	5 → 8	31.5373	10.7428	3.8276	3.1538	4.4584	2.9268	0.0033
Participant 9	**0 → 3**	341.4100	27.0946	2.8416	2.4823	8.3146	1.4334	0.0023
	3 → 5	72.4742	15.6166	5.2301	1.5020	1.5110	0.7895	0.0045
	5 → 8	283.3903	9.4356	5.0055	1.2938	2.4384	1.0271	0.0043
Participant 10	**0 → 3**	47.1864	4.8966	3.9674	2.9148	5.0267	0.8085	0.0076
	3 → 5	638.2047	25.2294	3.7544	0.8460	2.1458	0.4424	0.0032
	5 → 8	56.9106	5.4836	1.6756	3.3997	0.9833	0.4485	0.0098
Avg. Value	**0 → 3**	**144.7806**	**34.5759**	**6.4788**	**1.9061**	**6.9057**	**1.3081**	**0.0214**
	3 → 5	**158.6151**	**67.6857**	**19.8153**	**9.2812**	**11.4742**	**11.9567**	**0.0247**
	5 → 8	**175.4463**	**24.0256**	**19.4753**	**12.4229**	**8.5320**	**4.8809**	**0.0231**

* Highest value per frequency band .
** Lowest value per frequency band .

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7	Participant 8	Participant 9	Participant 10	Avg. Value
Surprise	6	2	6	5	4	5	6	6	4	6	5.0
Startle	5	1	4	6	2	4	5	5	4	3	3.9
Confusion	6	1	6	5	2	4	6	6	5	3	4.4
Disturbance	5	1	4	6	3	2	6	2	3	2	3.4

Participants' ratings on the effects of the SEs from the questionnaires

163 - Participant 1	164 - Participant 2	165 - Participant 3	166 - Participant 4	167 -Participant 5
				
				
				

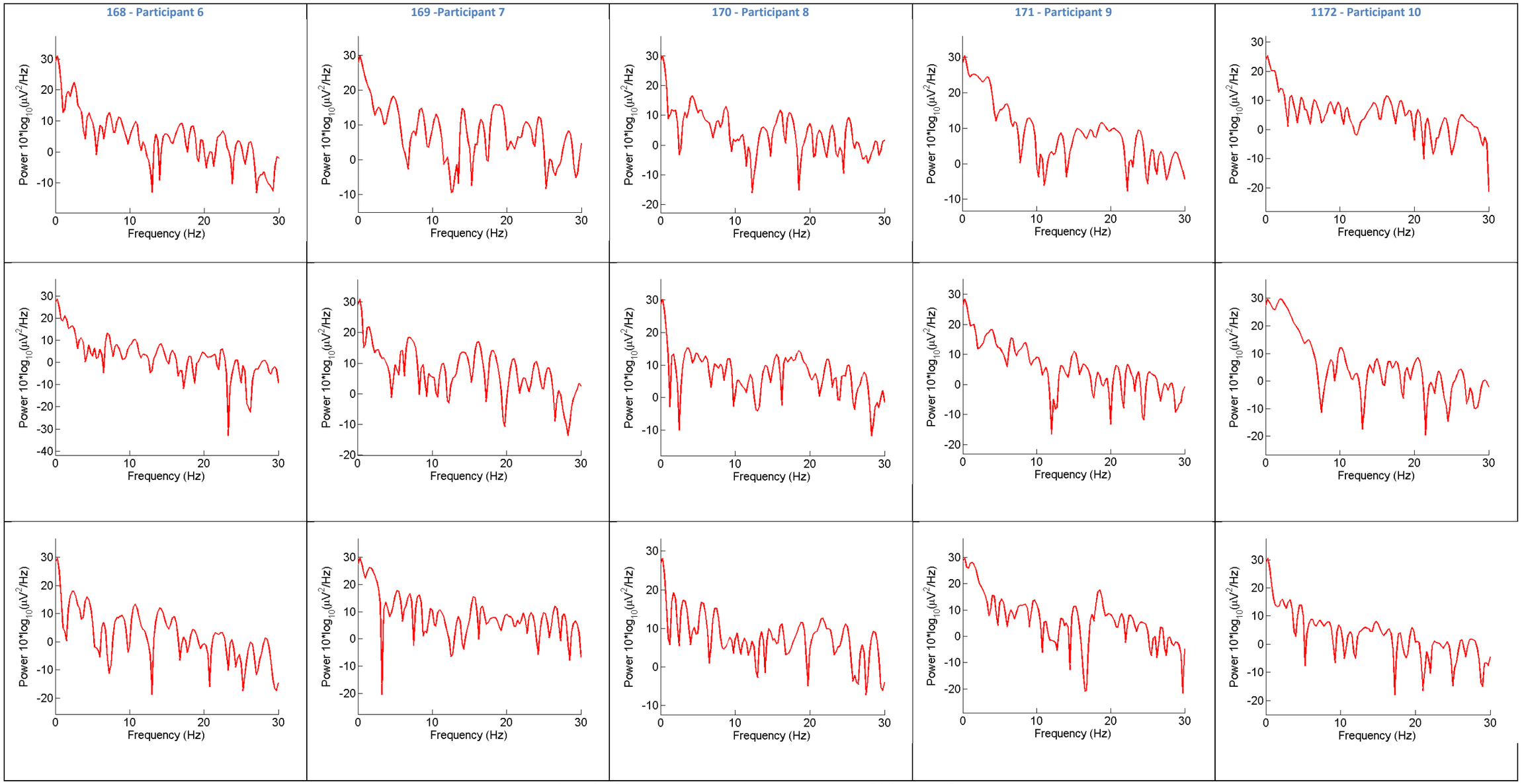


Figure 16 - Power spectrum plots of the participants in the EC Gameplay SE2.

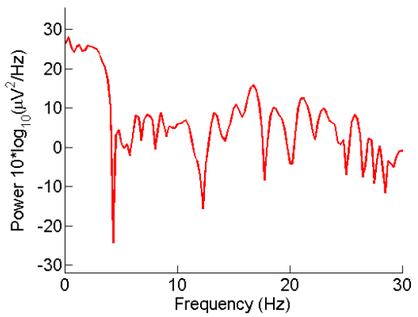
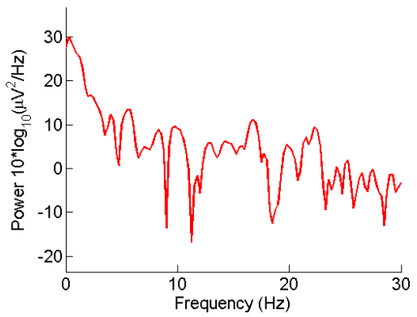
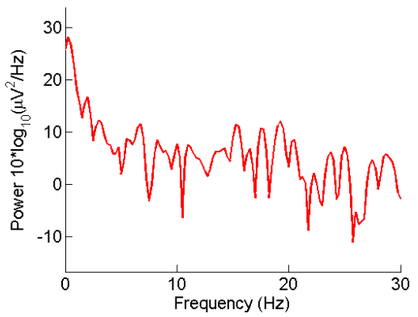
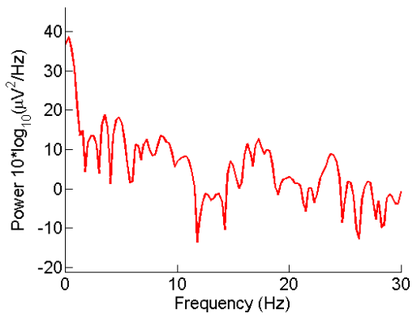
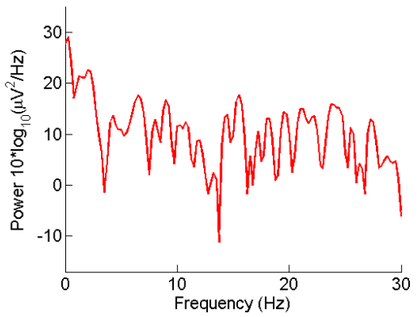
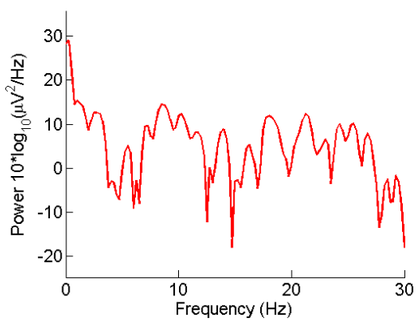
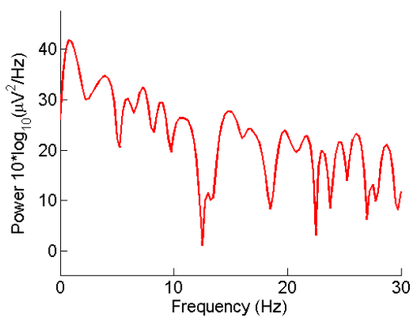
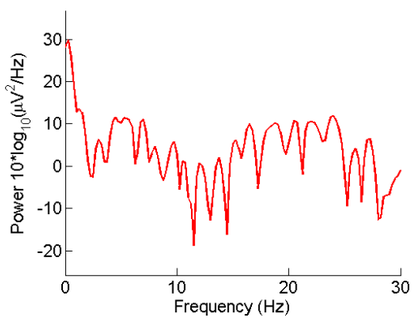
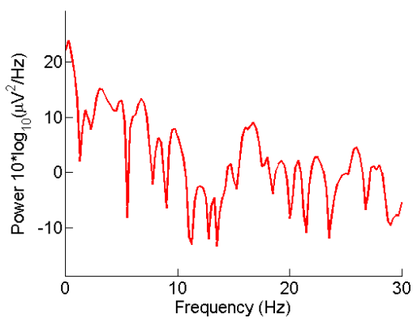
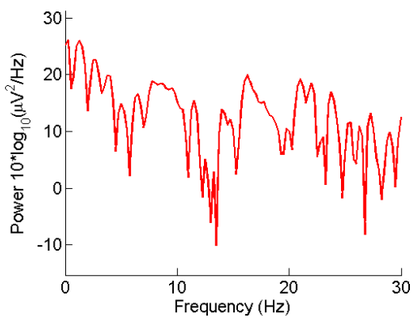
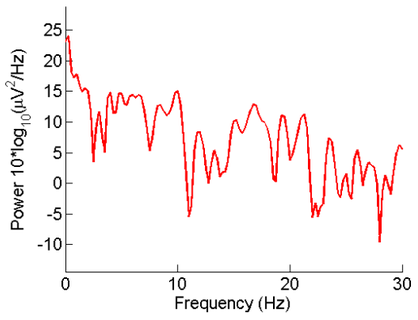
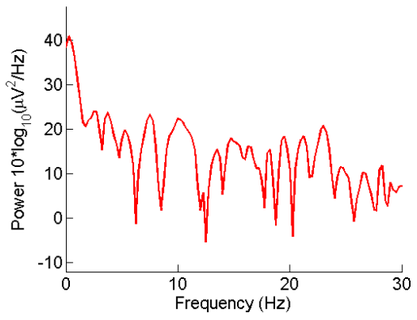
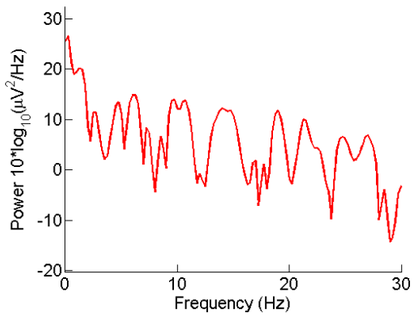
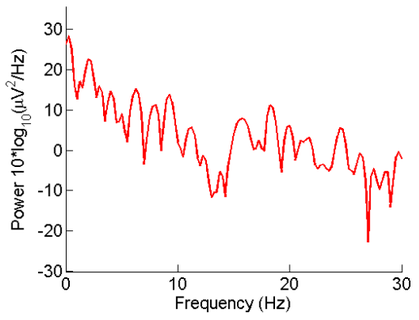
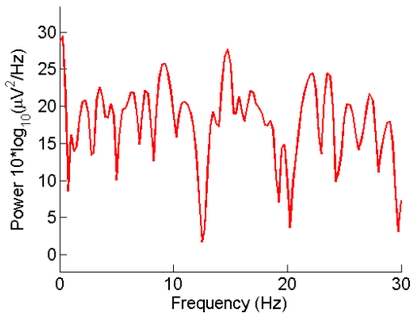
Gameplay SE3 (task-independent mixed surprise) - EC

Participants	Duration	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Participant 1	**0 → 3**	349.0797	1.0578	2.6511	1.6028	5.8324	1.4505	0.0172
	3 → 5	32.0194	0.6346	11.4615	0.9904	3.3028	1.8394	0.0399
	5 → 8	29.9197	22.4867	7.1151	2.1934	7.7957	1.2899	0.0272
Participant 2	**0 → 3**	161.0140	6.1203	1.7593	2.8601	1.3777	0.6830	0.0069
	3 → 5	3766.1351	683.8404	335.6232	37.7878	85.3009	46.6564	0.0945
	5 → 8	633.8051	26.9891	37.5549	10.7773	15.0941	8.8511	0.0574
Participant 3	**0 → 3**	53.3643	5.4930	3.3601	2.9844	4.3919	1.1086	0.0166
	3 → 5	12.9921	8.0200	0.6331	0.3294	4.2044	1.6132	0.0061
	5 → 8	43.7953	13.1784	6.4659	5.4625	1.7098	1.1476	0.0087
Participant 4	**0 → 3**	80.2700	11.7829	5.0999	0.6943	4.7771	0.7472	0.0107
	3 → 5	18.2153	8.7142	1.0749	0.3111	1.9429	0.5792	0.0037
	5 → 8	80.4100	8.7798	3.2483	0.2214	2.2134	0.4301	0.0043
Participant 5	**0 → 3**	127.7380	20.4645	10.5233	2.4043	5.3246	7.0227	0.0236
	3 → 5	146.4904	16.4695	29.6546	2.8839	21.9778	7.1904	0.0793
	5 → 8	61.1585	74.8315	107.1892	37.0089	52.1538	55.5161	0.2086
Participant 6	**0 → 3**	96.1584	6.6601	0.7534	0.6030	0.7447	0.2416	0.0016
	3 → 5	62.2784	3.2534	1.9282	0.7163	2.0816	0.5288	0.0017
	5 → 8	32.2025	8.0033	2.9365	1.2420	1.1045	0.5018	0.0039
Participant 7	**0 → 3**	1166.2120	54.3192	15.8656	3.6974	5.6923	5.2361	0.0276
	3 → 5	997.9245	59.8095	26.1315	1.8019	6.0733	2.4714	0.0201
	5 → 8	698.0393	101.0700	17.9759	3.3483	6.1019	1.9061	0.0252
Participant 8	**0 → 3**	22.7922	2.9818	4.0803	1.5612	3.1269	1.3531	0.0052
	3 → 5	34.5626	6.0169	3.0720	0.8846	5.5532	0.5776	0.0068
	5 → 8	47.6431	4.2121	4.7321	0.8818	1.2873	0.9325	0.0052
Participant 9	**0 → 3**	19.7557	3.7890	0.9980	0.8716	2.9084	0.7162	0.0069
	3 → 5	29.1507	3.1915	2.0441	0.3465	1.7839	0.7493	0.0034
	5 → 8	18.2459	1.2981	0.8053	1.3441	1.4734	1.0799	0.0119
Participant 10	**0 → 3**	90.8977	3.7144	1.4828	0.8059	1.1669	0.5513	0.0138
	3 → 5	29.5315	4.0675	0.4925	1.2513	1.0855	0.4205	0.0060
	5 → 8	570.7336	261.9091	179.3088	4.4402	14.1041	9.1198	0.0204
Avg. Value	**0 → 3**	**216.7282**	**11.6383**	**4.6574**	**1.8085**	**3.5343**	**1.9110**	**0.0130**
	3 → 5	**512.9300**	**79.4018**	**41.2116**	**4.7303**	**13.3306**	**6.2626**	**0.0262**
	5 → 8	**221.5953**	**52.2758**	**36.7332**	**6.6920**	**10.3038**	**8.0775**	**0.0373**

* Highest value per frequency band .
** Lowest value per frequency band .

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7	Participant 8	Participant 9	Participant 10	Avg. Value
Surprise	3	3	2	6	2	3	5	3	2	4	3.3
Startle	5	1	2	6	1	3	3	4	3	5	3.3
Confusion	5	2	3	5	1	2	3	3	2	3	2.9
Disturbance	5	1	1	5	1	3	4	1	2	1	2.4

Participants' ratings on the effects of the SEs from the questionnaires

173 - Participant 1	174 - Participant 2	175 - Participant 3	176 - Participant 4	177 -Participant 5
				
				
				

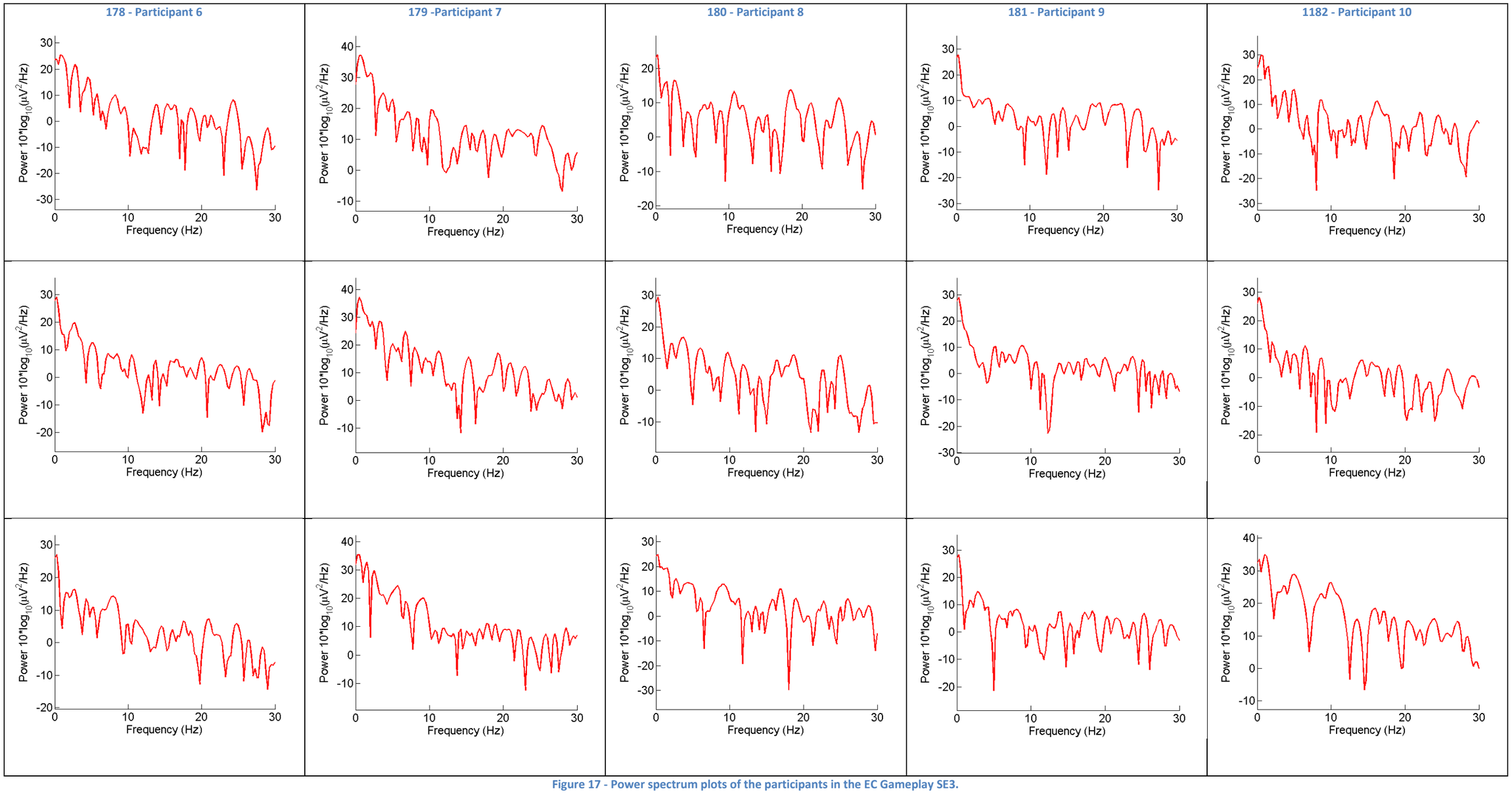


Figure 17 - Power spectrum plots of the participants in the EC Gameplay SE3.

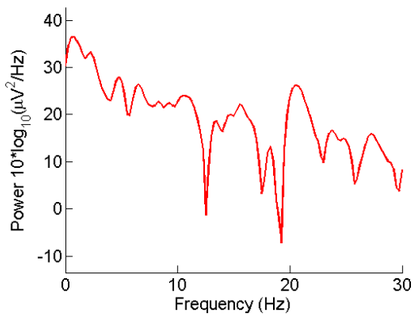
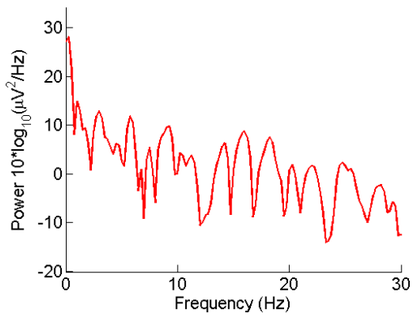
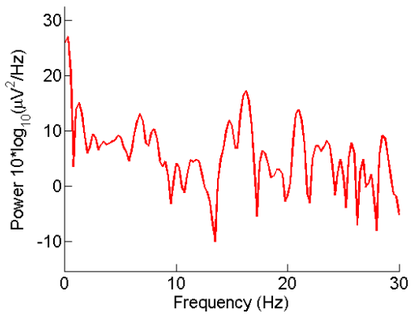
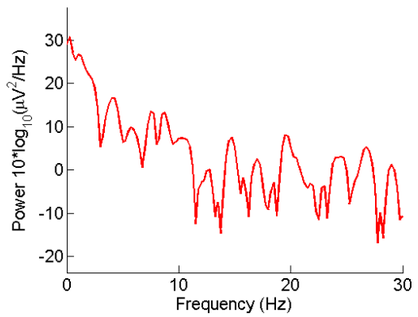
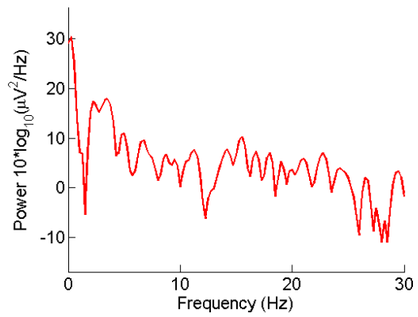
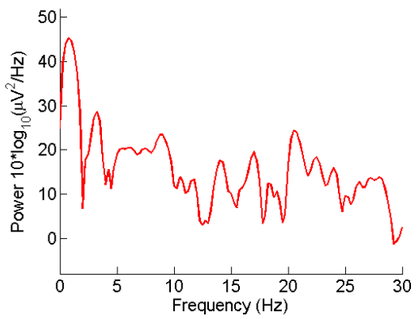
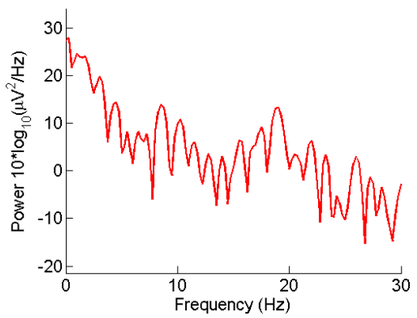
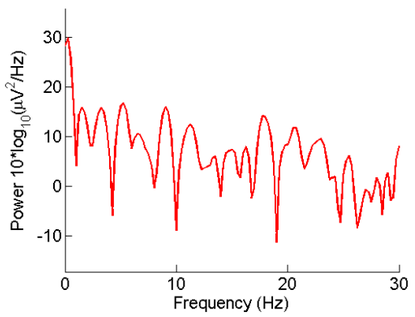
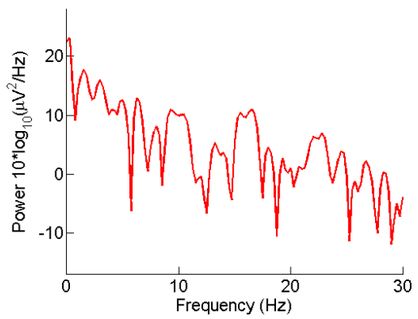
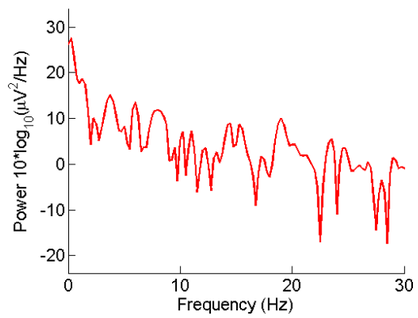
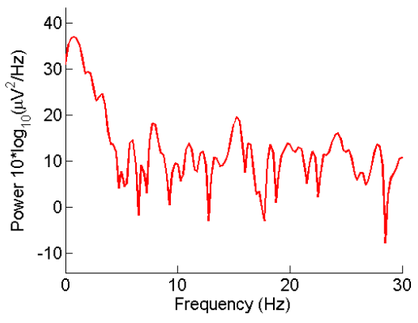
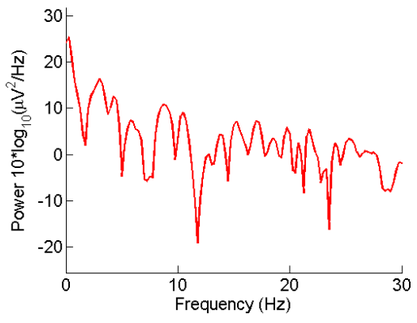
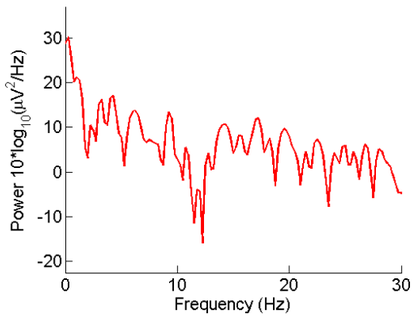
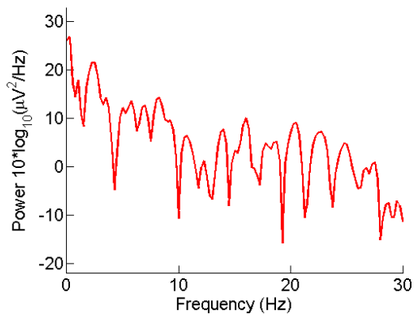
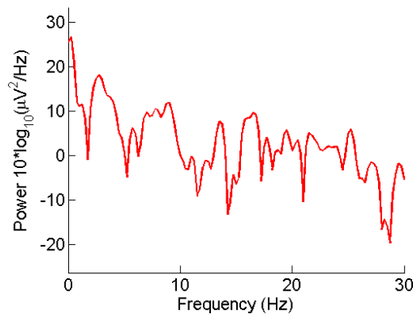
Gameplay SE4 (task-dependent narrative-based surprise) - EC

Participants	Duration	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Participant 1	**0 → 3**	2336.3714	295.8257	174.6226	30.3580	9.8752	20.3776	0.1385
	3 → 5	1451.5504	68.4607	43.3454	9.5523	12.8003	14.0649	0.1200
	5 → 8	1519.1883	6.9353	8.5054	8.2496	6.3074	8.2972	0.0609
Participant 2	**0 → 3**	15.4494	3.0622	2.6030	0.6333	1.1700	0.3698	0.0051
	3 → 5	167.0692	5.9246	5.1263	0.8072	4.5256	0.3639	0.0038
	5 → 8	19.6340	3.5564	2.2373	0.9646	1.9320	0.6786	0.0036
Participant 3	**0 → 3**	16.4890	7.0657	1.9274	1.4136	2.9850	2.0601	0.0241
	3 → 5	29.3514	10.4196	7.1455	2.5917	4.1530	1.4395	0.0082
	5 → 8	34.2042	11.6016	1.9072	2.6092	4.9176	1.5949	0.0090
Participant 4	**0 → 3**	230.2183	7.2318	3.5215	0.5517	0.6591	0.4715	0.0053
	3 → 5	32.8783	8.0433	4.2050	1.1300	1.8705	0.8822	0.0041
	5 → 8	57.8141	7.8307	3.0207	1.0177	1.3261	0.6250	0.0039
Participant 5	**0 → 3**	23.0293	5.0978	3.0558	1.7968	2.3768	0.9196	0.0047
	3 → 5	30.5663	5.7496	2.0977	1.8946	1.5176	0.5963	0.0034
	5 → 8	23.5182	2.3447	1.7539	0.7962	2.1058	0.6145	0.0040
Participant 6	**0 → 3**	39.0937	7.5256	14.8913	1.0449	1.4897	2.0655	0.0064
	3 → 5	40.0401	10.4809	3.4068	0.9414	5.3833	0.7614	0.0081
	5 → 8	167.0676	26.3116	3.8326	1.4809	2.9392	1.1742	0.0115
Participant 7	**0 → 3**	176.9845	28.2680	22.1161	5.7845	16.7231	3.8307	0.0542
	3 → 5	224.2480	41.2930	33.0159	1.1043	2.9171	1.6569	0.0256
	5 → 8	147.9493	29.9541	19.0765	4.5462	21.3703	1.4661	0.0105
Participant 8	**0 → 3**	875.7975	4.5792	7.9100	2.4386	13.6930	1.5310	0.0054
	3 → 5	75.2526	5.5823	3.4808	0.3708	0.4871	0.3797	0.0042
	5 → 8	24.0470	4.9402	2.2960	0.4111	2.1507	1.4605	0.0026
Participant 9	**0 → 3**	25.3148	13.6743	17.2643	8.9570	1.5061	2.2474	0.0038
	3 → 5	28.8371	17.6241	10.4949	3.9260	12.1945	2.4952	0.0098
	5 → 8	46.2015	42.5403	10.5800	5.0343	6.2766	1.3058	0.0045
Participant 10	**0 → 3**	24.2339	8.7625	2.6327	1.3848	6.0820	1.1445	0.0057
	3 → 5	120.5932	7.6021	17.3450	3.2141	4.2186	2.4550	0.0222
	5 → 8	94.2210	6.8371	1.0206	1.9729	0.8829	0.4120	0.0095
Avg. Value	**0 → 3**	**376.2982**	**38.1093**	**25.0545**	**5.4363**	**5.6560**	**3.5018**	**0.0253**
	3 → 5	**220.0387**	**18.1180**	**12.9663**	**2.5532**	**5.0068**	**2.5095**	**0.0209**
	5 → 8	**213.3845**	**14.2852**	**5.4230**	**2.7083**	**5.0209**	**1.7629**	**0.0120**

* Highest value per frequency band .
** Lowest value per frequency band .

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7	Participant 8	Participant 9	Participant 10	Avg. Value
Surprise	5	5	5	5	3	5	6	6	5	7	5.2
Startle	3	1	3	5	1	2	5	2	4	6	3.2
Confusion	5	1	6	5	2	5	2	5	7	7	4.5
Disturbance	3	1	3	4	1	No	4	4	3	5	3.1

Participants' ratings on the effects of the SEs from the questionnaires

183 - Participant 1	184 - Participant 2	185 - Participant 3	186 - Participant 4	187 -Participant 5
				
				
				

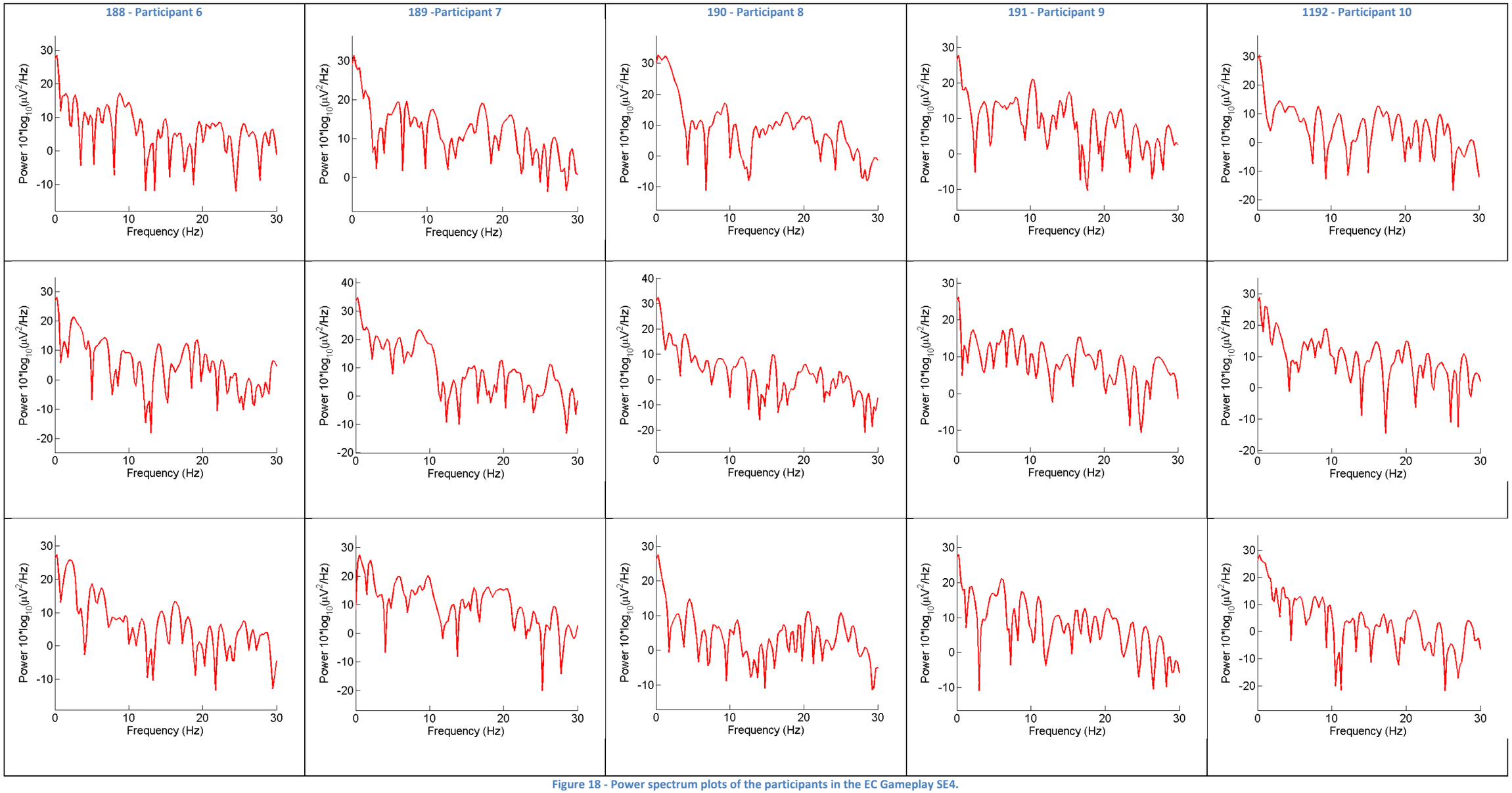


Figure 18 - Power spectrum plots of the participants in the EC Gameplay SE4.

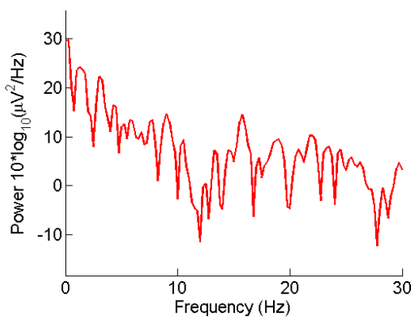
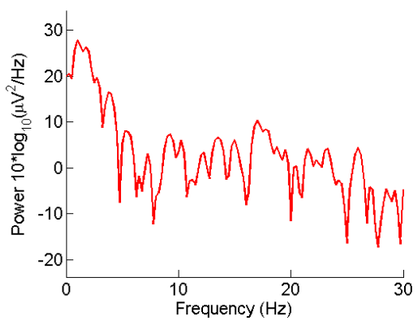
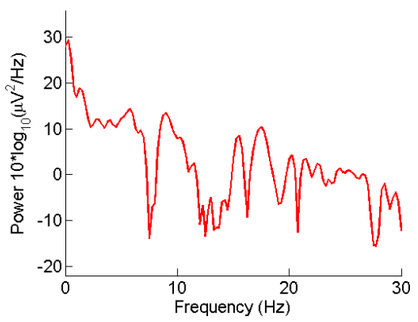
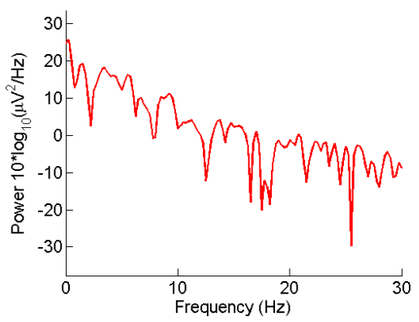
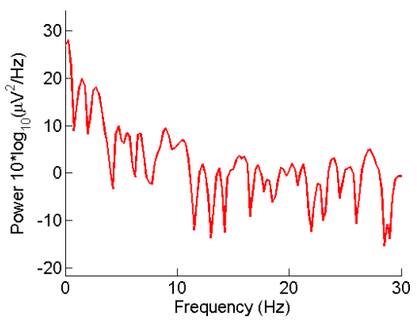
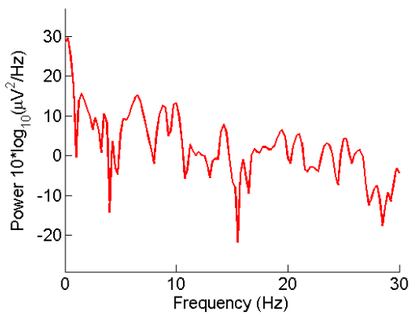
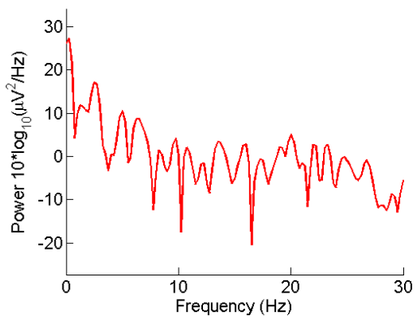
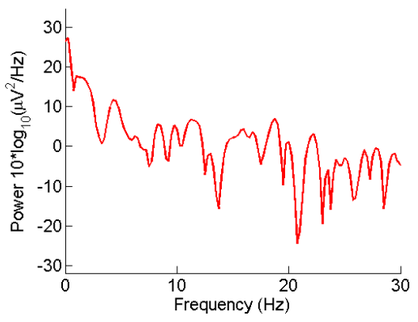
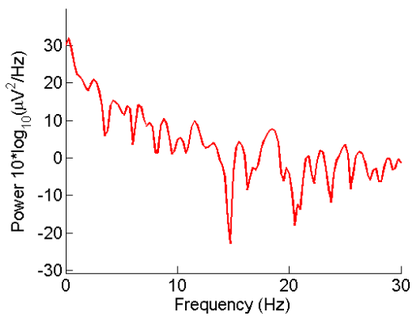
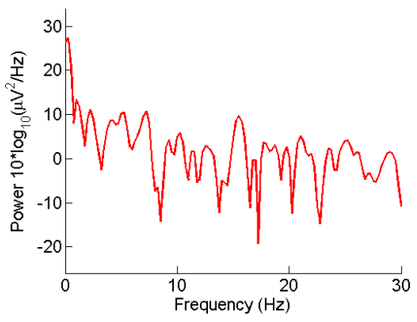
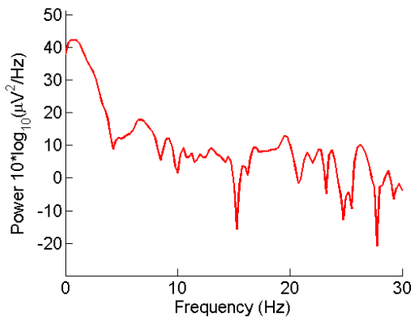
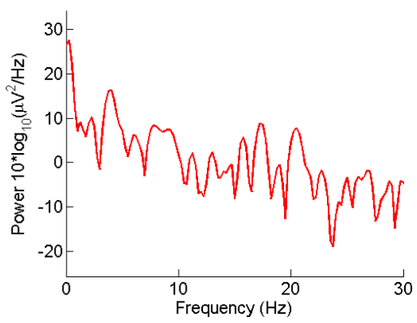
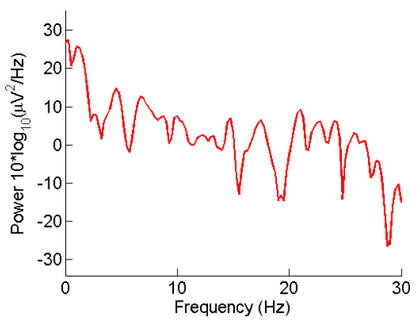
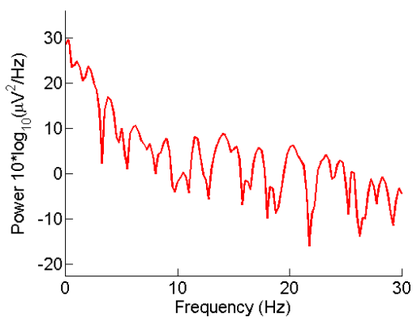
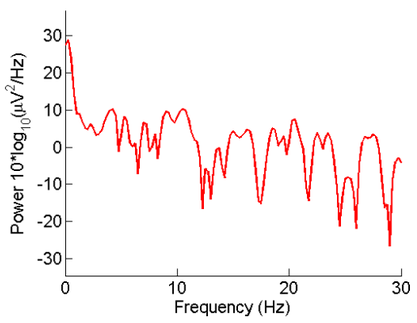
Gameplay SE5 (task-independent cue-based surprise) - EC

Participants	Duration	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Participant 1	**0 → 3**	85.9003	15.2406	3.0417	1.3849	2.9738	1.7896	0.0432
	3 → 5	24.2298	5.9749	3.7151	1.1833	1.3387	0.4165	0.0216
	5 → 8	6159.6805	23.1512	5.2911	4.7392	7.3825	1.2758	0.0655
Participant 2	**0 → 3**	212.8566	1.8480	1.2641	1.7550	3.0980	0.4143	0.0036
	3 → 5	25.3451	3.5601	0.6490	0.6593	0.5204	0.3114	0.0035
	5 → 8	12.1617	4.0028	1.6633	0.6400	0.8003	0.2034	0.0036
Participant 3	**0 → 3**	50.7266	14.3774	5.0270	0.1480	1.4821	0.5898	0.0056
	3 → 5	39.9162	3.1642	2.0683	0.3486	1.2710	0.2766	0.0025
	5 → 8	66.2034	6.0453	2.6256	1.5485	0.5436	0.5031	0.0039
Participant 4	**0 → 3**	31.5377	18.9570	3.9682	0.8413	0.1850	0.1871	0.0027
	3 → 5	181.2374	16.7176	3.6287	0.5655	1.0807	0.5830	0.0034
	5 → 8	191.6484	6.4827	1.6620	2.3234	0.7461	0.4366	0.0066
Participant 5	**0 → 3**	47.5986	3.5918	2.2595	0.4196	0.6475	0.5374	0.0054
	3 → 5	13.6738	4.6160	0.8320	0.5779	0.7134	0.7549	0.0029
	5 → 8	11.4165	1.9702	4.2191	0.2750	0.6829	0.2707	0.0027
Participant 6	**0 → 3**	46.9468	3.1418	3.9831	0.1379	2.9996	0.6232	0.0024
	3 → 5	55.4304	4.5921	2.1588	1.6623	2.4234	0.4037	0.0035
	5 → 8	20.9333	3.0452	1.1152	1.4894	1.5156	0.6808	0.0059
Participant 7	**0 → 3**	283.3474	14.6594	12.6706	7.7253	5.0750	0.9543	0.0069
	3 → 5	42.5664	10.3985	3.6342	3.5434	15.3325	1.3936	0.0099
	5 → 8	47.7413	42.8238	3.3852	3.1435	3.8440	1.0121	0.0068
Participant 8	**0 → 3**	257.2824	15.5803	7.2045	1.4486	1.3379	0.7215	0.0079
	3 → 5	59.3346	19.6957	4.5353	0.6155	1.2337	0.7023	0.0020
	5 → 8	89.8384	10.7778	3.8054	0.8769	3.3858	0.7866	0.0030
Participant 9	**0 → 3**	21.9078	10.2357	2.8209	0.3288	4.8293	1.7783	0.0034
	3 → 5	30.6502	13.5249	3.6620	0.3698	1.3698	0.4779	0.0056
	5 → 8	13.9270	4.7077	1.1027	2.3466	1.2785	0.7648	0.0055
Participant 10	**0 → 3**	45.1804	3.4383	2.3761	0.4388	2.6502	0.5282	0.0046
	3 → 5	15.4545	2.4753	1.6852	0.3656	1.2124	0.4038	0.0031
	5 → 8	323.9228	6.3639	1.9515	0.7789	0.6664	0.6027	0.0030
Avg. Value	**0 → 3**	**108.3285**	**10.1070**	**4.4616**	**1.4628**	**2.5278**	**0.8124**	**0.0086**
	3 → 5	**48.7838**	**8.4719**	**2.6569**	**0.9891**	**2.6496**	**0.5724**	**0.0058**
	5 → 8	**693.7473**	**10.9371**	**2.6821**	**1.8161**	**2.0846**	**0.6537**	**0.0107**

* Highest value per frequency band .
** Lowest value per frequency band .

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7	Participant 8	Participant 9	Participant 10	Avg. Value
Surprise	6	6	5	3	2	4	5	5	4	6	4.6
Startle	2	1	3	2	1	2	4	3	2	1	2.1
Confusion	6	2	4	2	3	3	3	5	5	7	4.0
Disturbance	5	1	5	2	6	3	5	3	3	2	3.5

Participants' ratings on the effects of the SEs from the questionnaires

193 - Participant 1	194 - Participant 2	195 - Participant 3	196 - Participant 4	197 -Participant 5
				
				
				

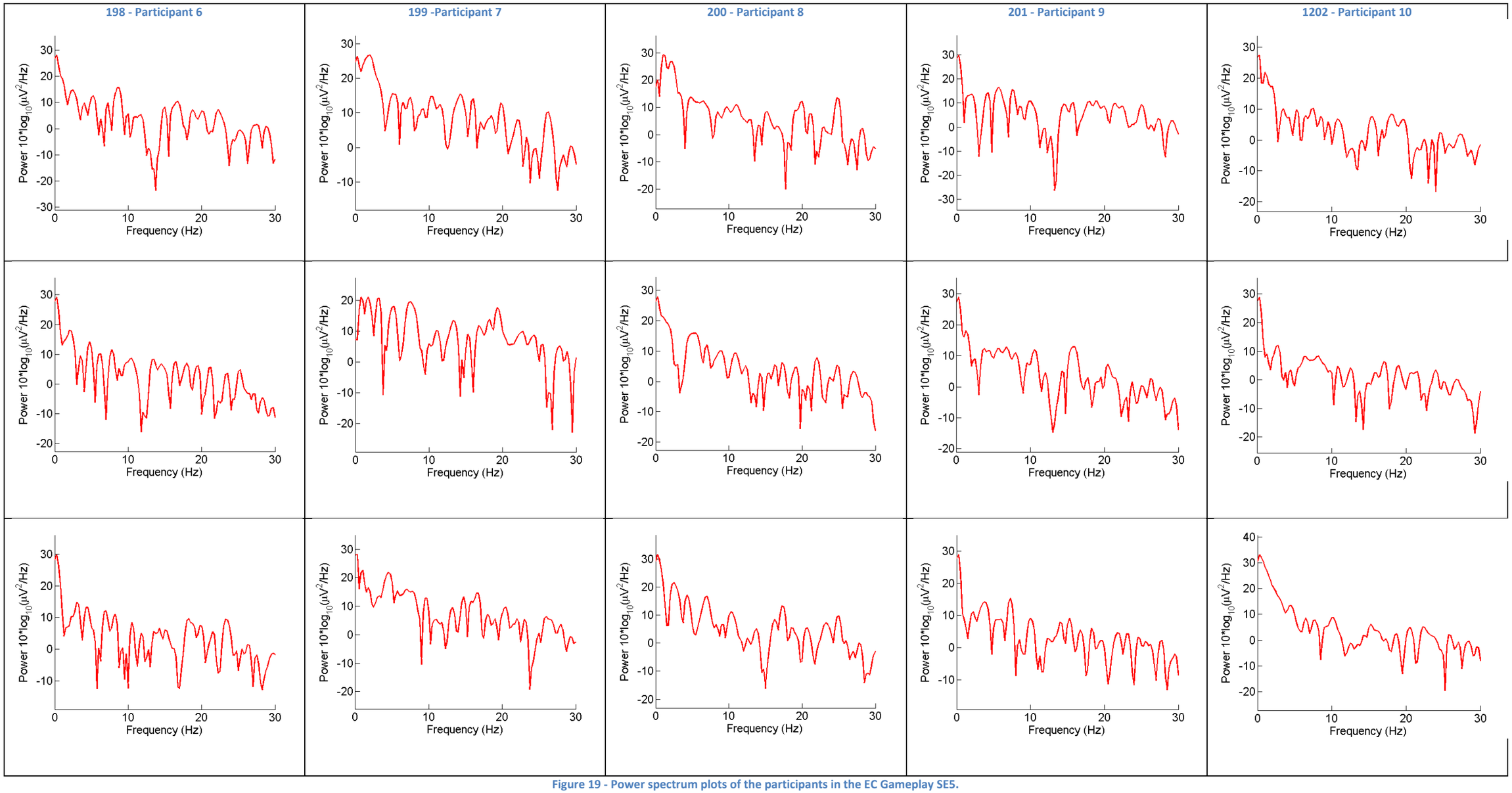


Figure 19 - Power spectrum plots of the participants in the EC Gameplay SE5.

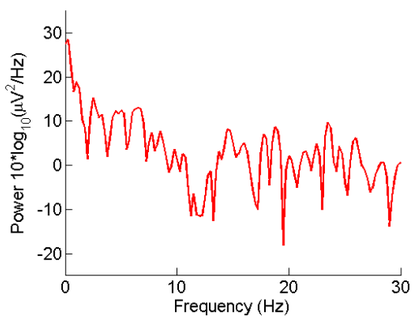
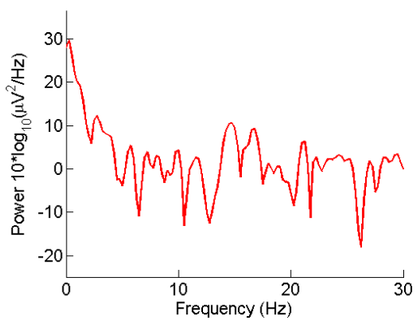
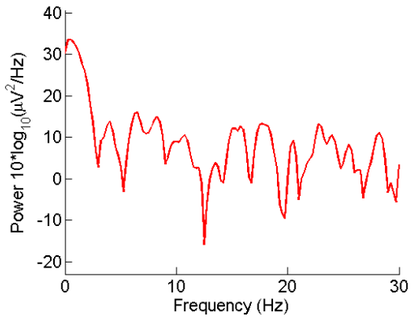
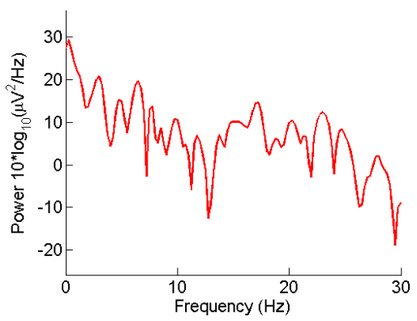
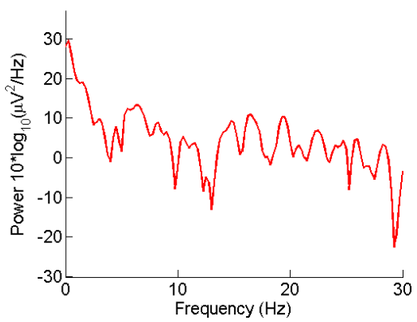
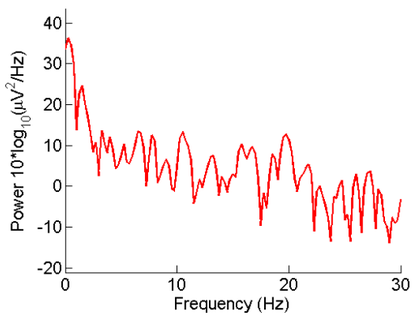
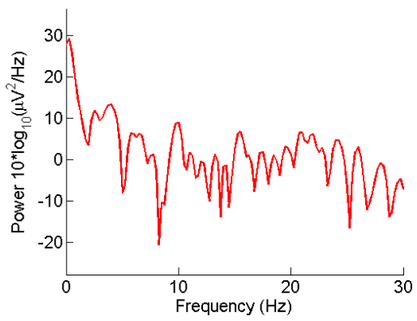
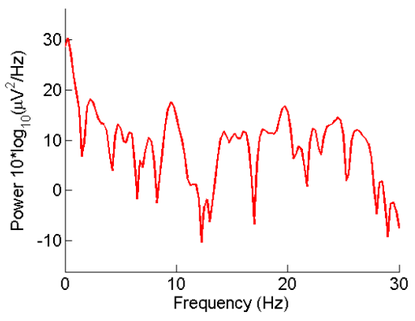
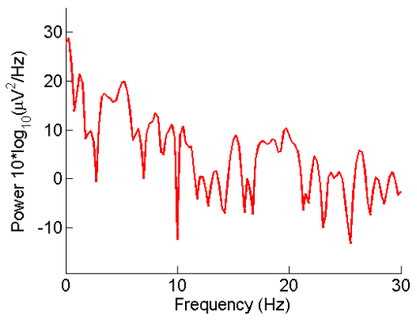
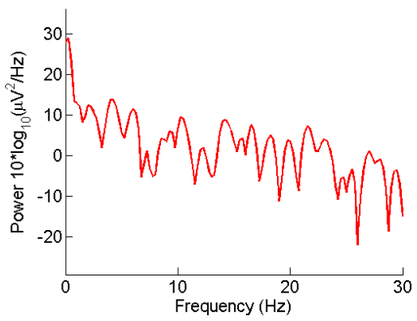
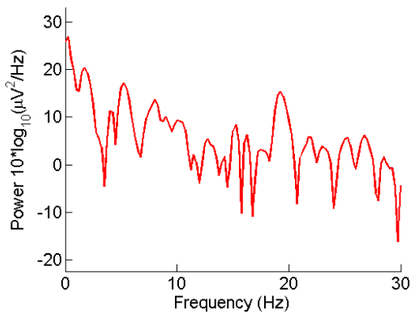
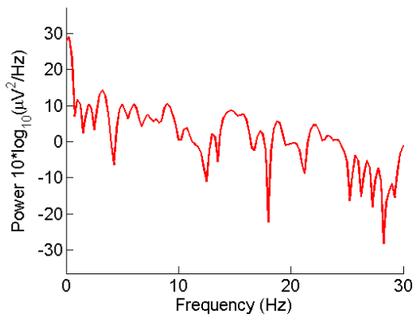
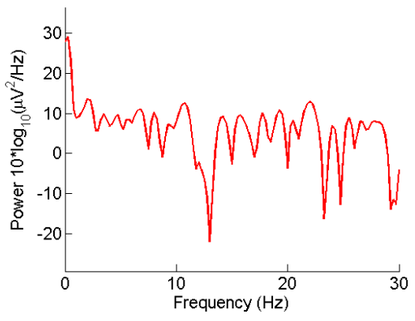
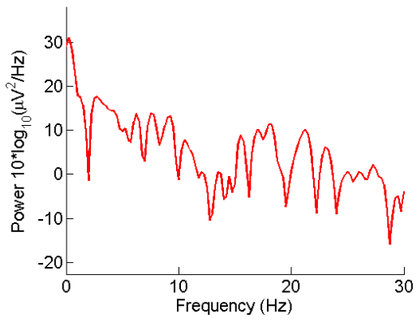
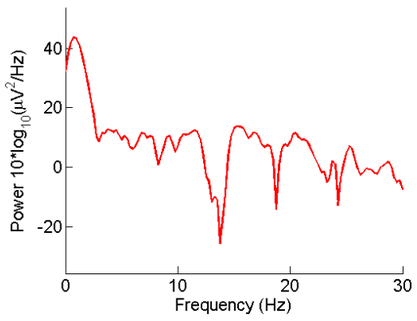
Gameplay SE6 (task-dependent mixed surprise) - EC

Participants	Duration	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Participant 1	**0 → 3**	29.8305	12.0793	0.8721	0.7879	0.9156	0.9899	0.0229
	3 → 5	126.5691	6.7109	2.8959	1.7571	2.8735	0.4187	0.0307
	5 → 8	58.7707	9.6743	4.8497	1.3394	3.3484	1.2232	0.0152
Participant 2	**0 → 3**	43.2480	0.7218	0.8558	0.7806	1.4062	0.9209	0.0061
	3 → 5	22.6324	2.4999	0.6786	0.3376	0.8245	0.5755	0.0029
	5 → 8	12.7172	4.3219	2.5120	1.2627	0.8761	0.2454	0.0036
Participant 3	**0 → 3**	331.9047	7.5820	6.6087	0.9498	2.9936	3.0121	0.0152
	3 → 5	67.2906	6.9242	6.3917	1.7717	9.6941	4.5416	0.0137
	5 → 8	21.5999	7.2268	4.2480	0.6700	3.9163	2.0544	0.0154
Participant 4	**0 → 3**	102.4965	23.4226	3.4639	1.4143	6.2077	1.2488	0.0041
	3 → 5	27.3156	25.2675	3.6831	0.6929	3.2487	0.6542	0.0058
	5 → 8	52.6425	10.9819	4.2893	0.4381	2.8655	0.7687	0.0038
Participant 5	**0 → 3**	61.2388	8.9332	2.0357	0.9182	3.7694	0.8289	0.0022
	3 → 5	24.4956	5.9888	2.1455	1.6692	1.1770	0.4866	0.0022
	5 → 8	1747.5766	9.0423	7.5480	0.2041	4.0367	1.0460	0.0076
Participant 6	**0 → 3**	28.4953	1.7703	3.2042	0.7441	2.0858	0.5159	0.0067
	3 → 5	127.1965	2.9593	5.5821	1.2687	3.7865	0.5863	0.0041
	5 → 8	32.3959	2.9749	2.4546	1.2749	3.7417	0.6443	0.0023
Participant 7	**0 → 3**	411.6489	54.8629	13.5298	8.5858	24.6347	3.1321	0.0073
	3 → 5	85.0595	45.4656	31.6657	2.1702	23.2692	1.9149	0.0108
	5 → 8	57.7937	10.5354	8.3432	2.1576	4.4256	1.2526	0.0073
Participant 8	**0 → 3**	1089.9332	21.9535	1.9128	0.9946	4.6790	1.4260	0.0099
	3 → 5	114.5385	5.9396	3.1961	0.7607	2.4396	1.6229	0.0032
	5 → 8	437.2369	7.6292	2.3553	3.0688	3.1856	1.0123	0.0102
Participant 9	**0 → 3**	7.4582	12.9796	3.0990	1.6241	2.3761	0.9235	0.0079
	3 → 5	25.4281	18.1834	9.0183	2.6496	2.9080	0.7057	0.0074
	5 → 8	438.9693	21.6787	7.3326	3.0200	4.4664	1.3900	0.0055
Participant 10	**0 → 3**	534.0836	6.4272	3.7956	1.1132	3.8286	1.0893	0.0037
	3 → 5	2159.6675	2.3822	2.2411	2.4939	3.2631	0.7607	0.0055
	5 → 8	11.4700	1.5021	1.7851	1.0677	1.7467	0.4220	0.0043
Avg. Value	**0 → 3**	**264.0338**	**15.0732**	**3.9378**	**1.7913**	**5.2897**	**1.4087**	**0.0086**
	3 → 5	**278.0193**	**12.2321**	**6.7498**	**1.5572**	**5.3484**	**1.2267**	**0.0086**
	5 → 8	**287.1173**	**8.5568**	**4.5718**	**1.4503**	**3.2609**	**1.0059**	**0.0075**

* Highest value per frequency band .
** Lowest value per frequency band .

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7	Participant 8	Participant 9	Participant 10	Avg. Value
Surprise	2	2	3	7	2	5	6	4	5	5	4.1
Startle	2	1	6	7	1	3	4	4	3	1	3.2
Confusion	3	1	5	7	1	3	6	4	6	2	3.8
Disturbance	2	1	6	6	1	3	4	2	3	1	2.9

Participants' ratings on the effects of the SEs from the questionnaires

203 - Participant 1	204 - Participant 2	205 - Participant 3	206 - Participant 4	207 -Participant 5
				
				
				

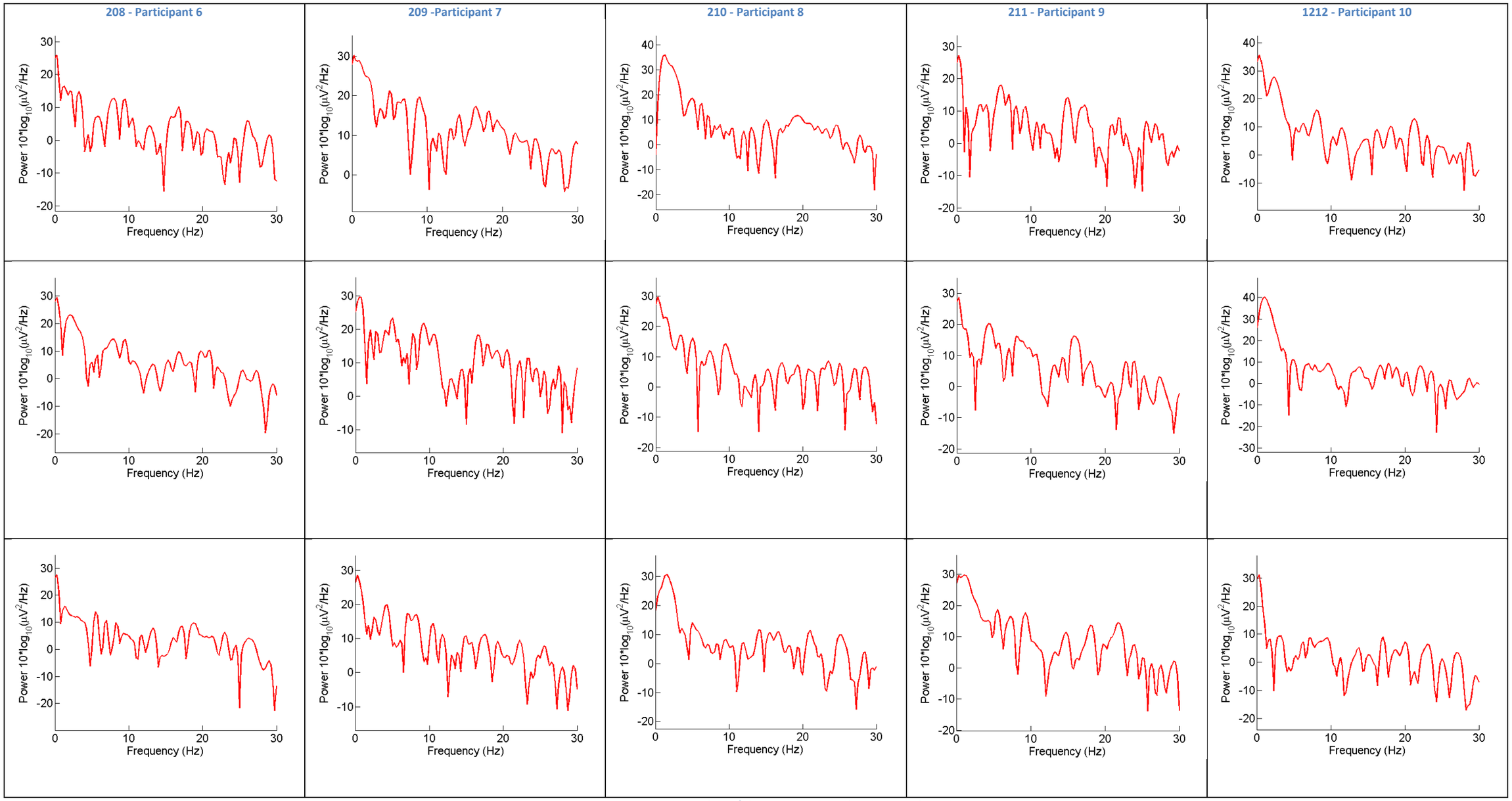


Figure 20 - Power spectrum plots of the participants in the EC Gameplay SE6.

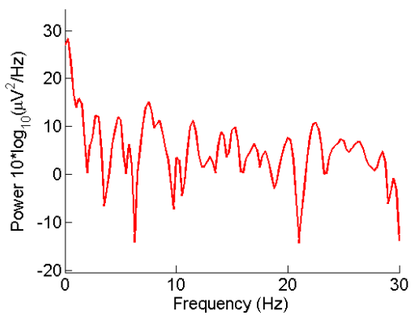
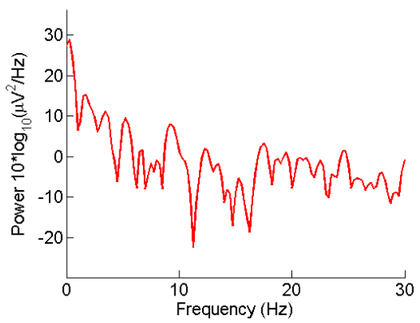
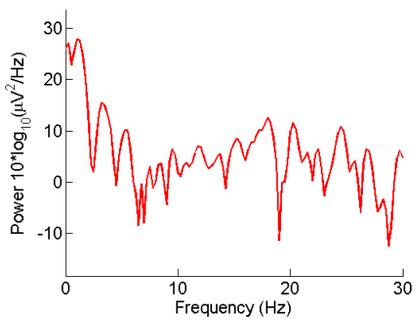
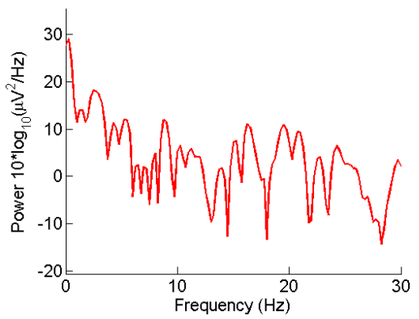
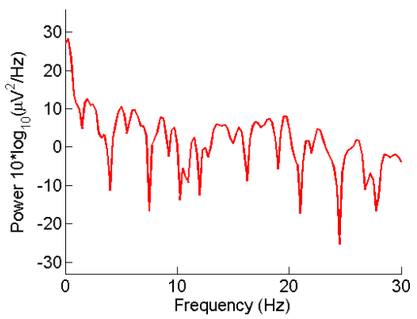
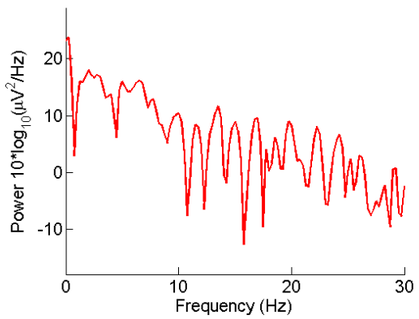
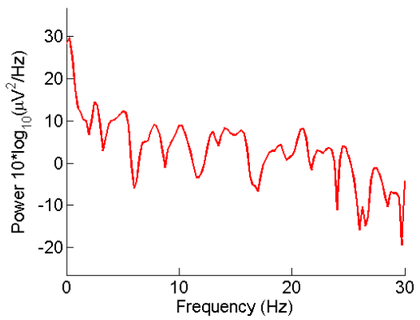
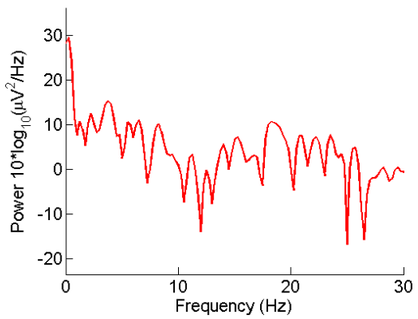
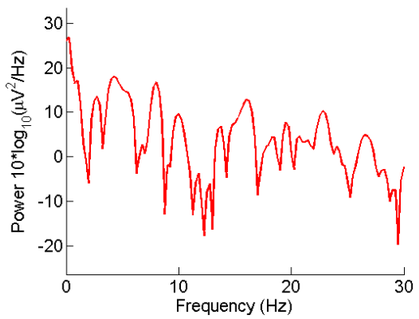
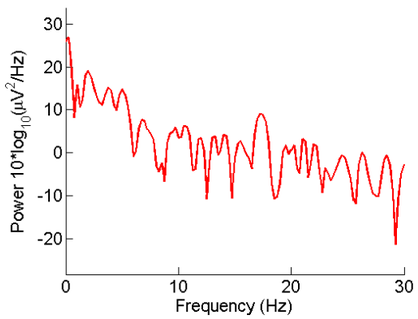
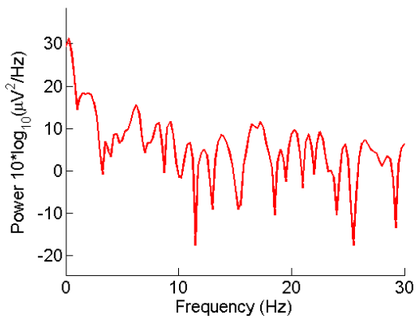
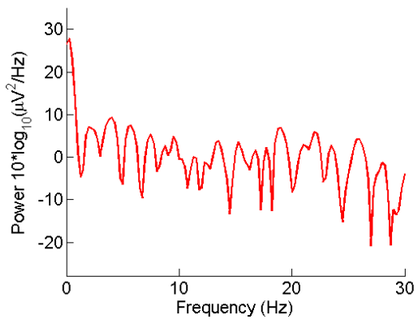
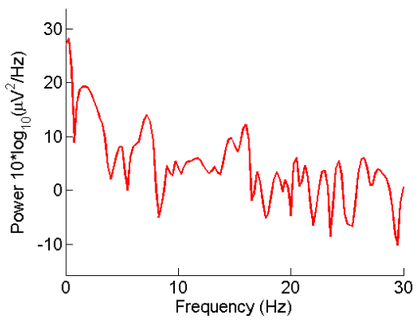
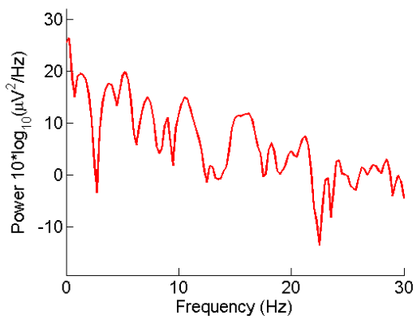
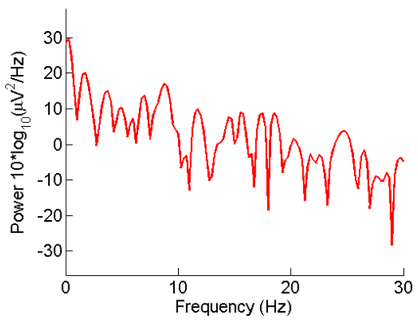
Gameplay SE7 (task-dependent narrative-based surprise) - EC

Participants	Duration	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Participant 1	**0 → 3**	21.5026	2.4411	2.7073	2.4870	1.9789	2.2033	0.0199
	3 → 5	36.6887	24.5628	4.0518	2.9907	2.3506	0.7512	0.0258
	5 → 8	87.6010	10.4362	2.1285	2.1236	3.1740	1.4512	0.0245
Participant 2	**0 → 3**	26.7712	1.3280	0.5985	0.3045	0.5490	0.2952	0.0022
	3 → 5	30.1970	3.5979	2.3450	3.8886	0.9923	0.4428	0.0055
	5 → 8	6.1995	1.2549	0.8621	0.6208	0.9455	0.4166	0.0056
Participant 3	**0 → 3**	70.1144	1.9716	2.0443	2.3140	4.1009	1.5410	0.0042
	3 → 5	18.0907	6.6723	1.4332	1.0125	3.4824	1.0541	0.0044
	5 → 8	68.3010	4.5585	2.0639	3.3295	1.1265	0.9330	0.0058
Participant 4	**0 → 3**	47.8970	4.1117	2.7192	0.4690	2.6497	0.6497	0.0029
	3 → 5	12.9452	11.3921	1.3099	0.6144	1.9908	0.9259	0.0037
	5 → 8	29.5854	24.2358	8.9221	1.4362	2.6949	0.8286	0.0022
Participant 5	**0 → 3**	21.4890	5.2661	0.9287	1.9072	2.4648	0.4290	0.0032
	3 → 5	39.7397	6.9494	1.4190	0.8268	1.0115	0.3083	0.0027
	5 → 8	31.7650	4.4833	3.5584	0.9828	0.9567	0.2265	0.0016
Participant 6	**0 → 3**	88.7880	9.1922	4.4926	4.0564	1.9657	1.9322	0.0116
	3 → 5	30.9739	7.7303	2.4131	0.9753	1.9406	0.8176	0.0075
	5 → 8	48.3199	8.8416	2.9392	0.8887	2.0373	1.2613	0.0053
Participant 7	**0 → 3**	24.2958	46.5678	6.1560	3.3250	3.9233	2.4882	0.0057
	3 → 5	38.6854	27.5930	20.1909	9.6403	11.5310	2.7934	0.0094
	5 → 8	254.8357	30.4887	18.1568	1.5185	9.0217	2.0271	0.0096
Participant 8	**0 → 3**	100.1131	51.7080	5.9048	1.8304	7.3749	1.2244	0.0036
	3 → 5	107.8051	17.0924	2.0124	0.8433	1.7209	0.9014	0.0032
	5 → 8	282.0966	7.1246	4.7902	2.7685	2.8929	1.2174	0.0084
Participant 9	**0 → 3**	12.3284	13.8947	3.9117	5.3146	4.2809	0.6899	0.0051
	3 → 5	37.0905	16.6820	8.8305	1.9443	6.4537	1.1664	0.0051
	5 → 8	32.3305	13.4829	4.8345	1.6848	7.8254	0.8364	0.0088
Participant 10	**0 → 3**	29.2516	7.6721	2.6305	1.1210	1.7887	0.5236	0.0060
	3 → 5	22.8356	1.2346	1.8045	0.4521	0.8411	0.1640	0.0020
	5 → 8	69.1013	1.7725	0.6113	1.1223	0.3859	0.4817	0.0051
Avg. Value	**0 → 3**	**44.2551**	**14.4153**	**3.2094**	**2.3129**	**3.1077**	**1.1977**	**0.0064**
	3 → 5	**37.5052**	**12.3507**	**4.5810**	**2.3188**	**3.2315**	**0.9325**	**0.0069**
	5 → 8	**91.0136**	**10.6679**	**4.8867**	**1.6476**	**3.1061**	**0.9680**	**0.0077**

* Highest value per frequency band .
** Lowest value per frequency band .

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7	Participant 8	Participant 9	Participant 10	Avg. Value
Surprise	5	2	6	6	2	3	5	3	5	5	4.2
Startle	3	1	5	6	1	2	4	4	5	3	3.4
Confusion	4	1	2	5	1	2	6	3	5	3	3.2
Disturbance	2	1	3	6	1	2	5	1	3	2	2.6

Participants' ratings on the effects of the SEs from the questionnaires

213 - Participant 1	214 - Participant 2	215 - Participant 3	216 - Participant 4	217 -Participant 5
				
				
				

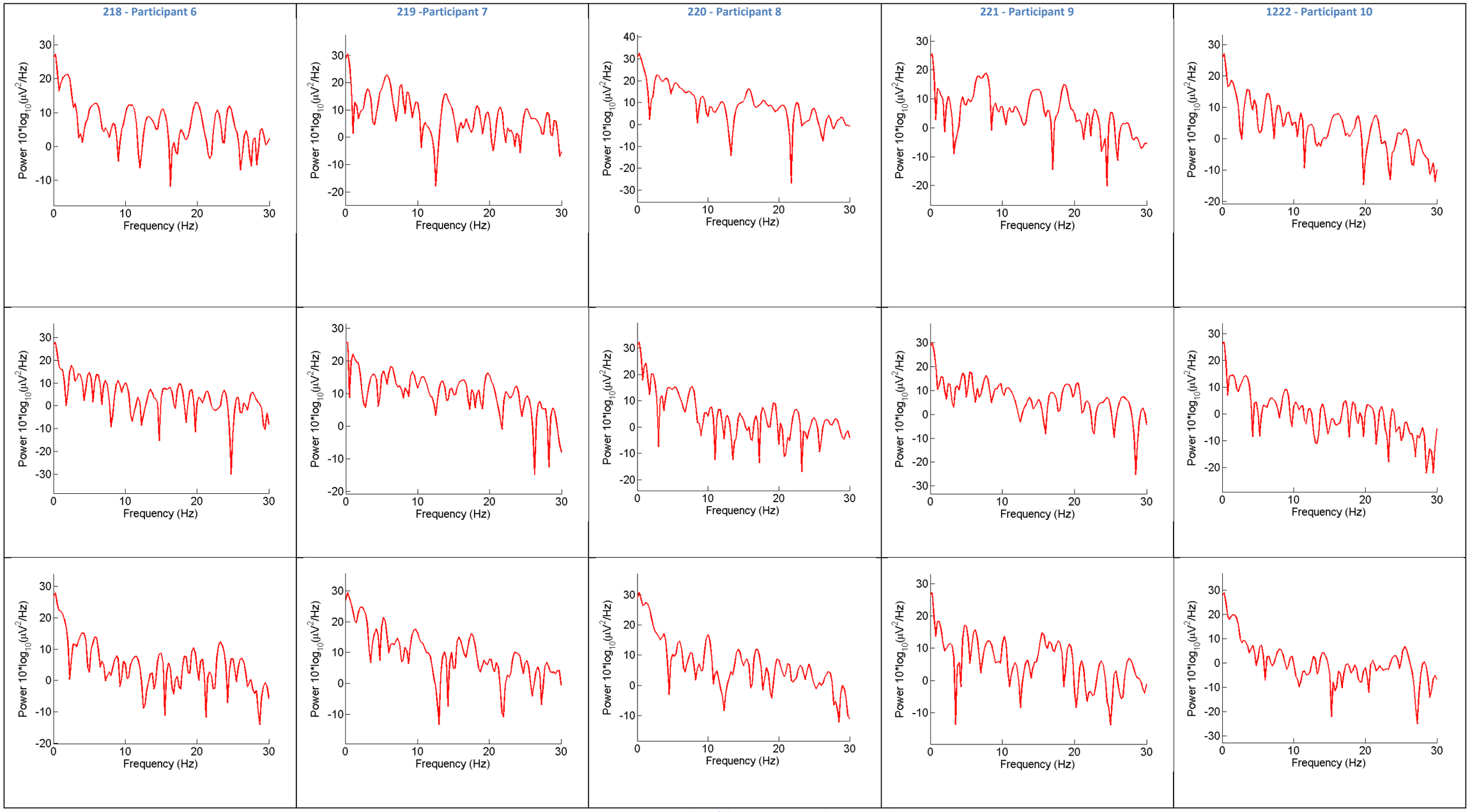


Figure 21 - Power spectrum plots of the participants in the EC Gameplay SE7.

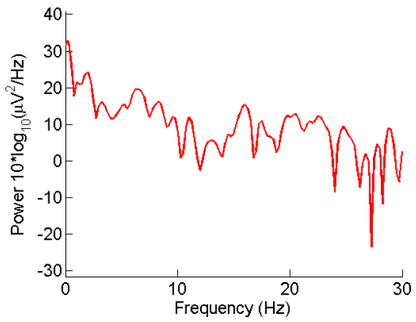
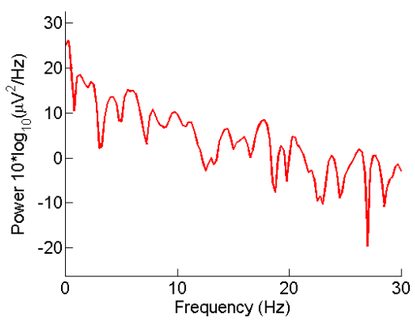
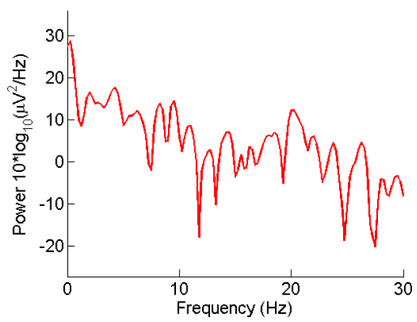
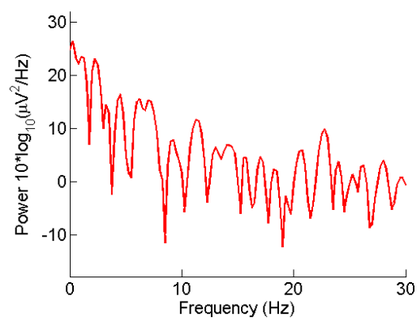
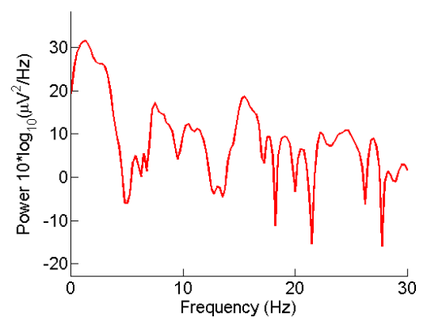
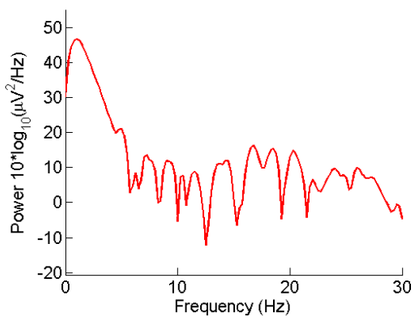
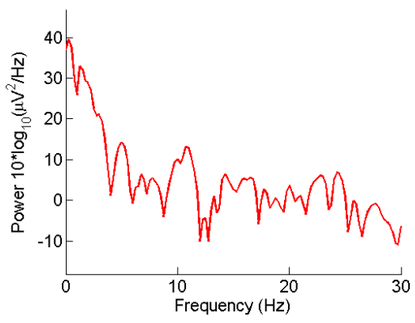
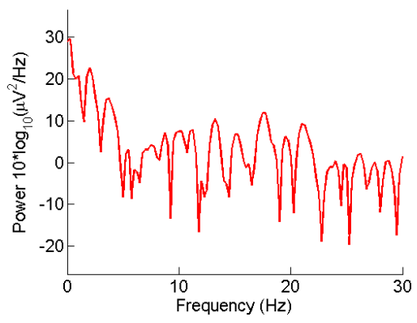
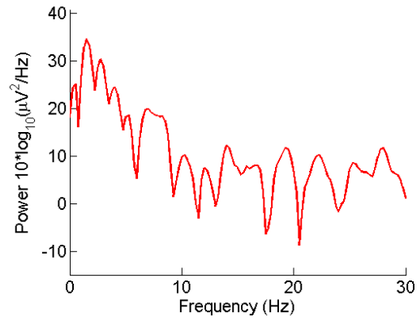
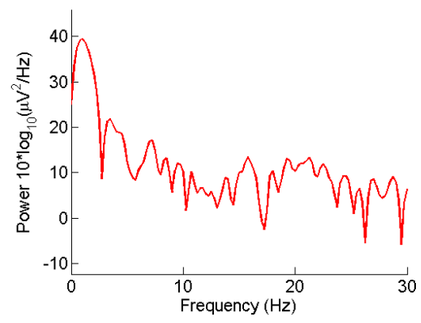
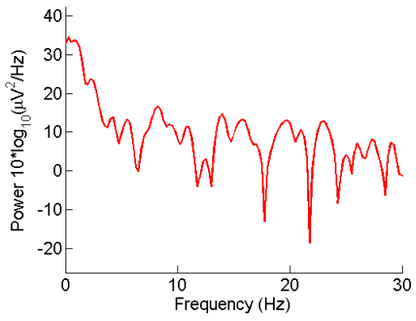
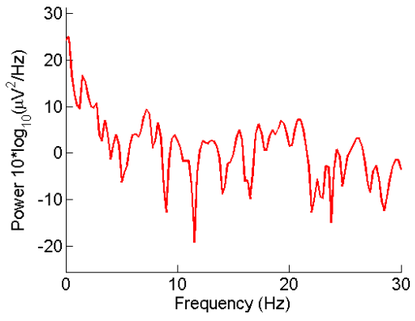
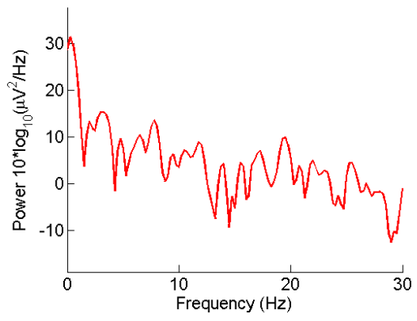
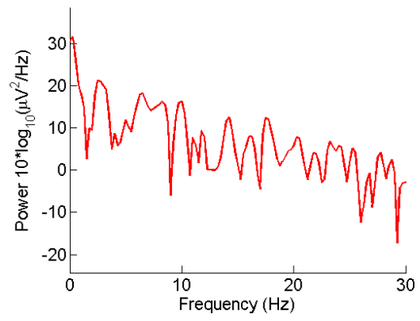
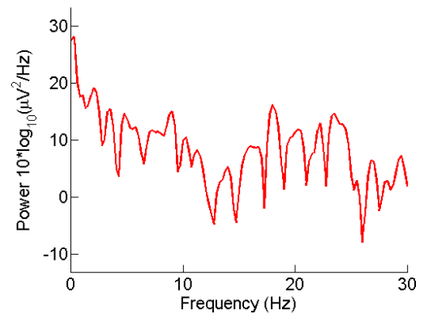
Gameplay SE8 (task-dependent narrative-based surprise) - EC

Participants	Duration	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Participant 1	**0 → 3**	145.2996	37.9500	8.1010	2.7208	5.8887	2.2766	0.0242
	3 → 5	16454.7699	19.5909	3.9239	3.1720	12.4914	3.0163	0.0229
	5 → 8	614.4590	6.8166	9.0291	4.9472	4.3939	2.4222	0.0221
Participant 2	**0 → 3**	48.6861	16.9766	5.7754	1.4906	1.6108	0.4228	0.0023
	3 → 5	921.0640	5.3732	4.2796	0.8849	1.1700	0.7420	0.0048
	5 → 8	22.7276	1.2931	0.5671	0.8482	1.6314	0.3916	0.0031
Participant 3	**0 → 3**	37.9586	15.3314	4.2806	1.6333	2.2478	0.4594	0.0050
	3 → 5	74.2394	0.9664	1.7869	1.1109	2.1844	0.4822	0.0086
	5 → 8	45.8395	4.6296	3.4447	0.7156	2.7515	0.6867	0.0081
Participant 4	**0 → 3**	118.0742	12.5365	2.5478	2.7752	0.6016	0.9947	0.0064
	3 → 5	574.5127	37.6803	5.9364	4.7244	3.7459	4.3781	0.0069
	5 → 8	55.4996	16.1601	7.4907	2.8420	3.1092	0.9308	0.0188
Participant 5	**0 → 3**	713.9110	1.2697	10.6966	1.3308	5.0156	2.4749	0.0092
	3 → 5	1519.0230	19.7496	7.3602	3.4499	5.5062	4.4574	0.0446
	5 → 8	59.3121	11.0110	8.2141	1.1121	8.1147	3.8347	0.0406
Participant 6	**0 → 3**	46.7311	5.9446	5.1087	1.0398	0.5871	0.3713	0.0040
	3 → 5	29.1701	2.5893	0.8014	0.7686	2.5224	0.5400	0.0041
	5 → 8	52.6405	4.3080	2.9551	0.4527	2.7919	0.3731	0.0046
Participant 7	**0 → 3**	114.8816	12.6701	8.9462	5.2255	4.8433	3.0264	0.0091
	3 → 5	84.1375	30.1358	13.0818	0.8039	5.7428	2.0850	0.0102
	5 → 8	65.6757	58.5984	10.3056	2.8499	8.5872	1.5224	0.0195
Participant 8	**0 → 3**	699.1955	16.1100	8.4996	1.5237	3.3420	3.6872	0.0053
	3 → 5	1265.2518	27.5079	5.5715	0.7778	2.2071	1.9244	0.0146
	5 → 8	128.2991	13.0514	4.5827	7.5651	5.9733	0.7173	0.0072
Participant 9	**0 → 3**	35.0739	29.1214	6.5210	5.4360	3.0921	1.0096	0.0079
	3 → 5	3.7211	7.7887	3.9800	0.7542	3.5198	0.8846	0.0052
	5 → 8	69.1422	3.6917	3.9859	0.9068	9.2393	2.1807	0.0045
Participant 10	**0 → 3**	1620.9222	41.5825	7.0220	2.4419	7.3345	0.2759	0.0042
	3 → 5	76.8234	6.2039	2.0251	0.6763	3.5823	0.5254	0.0017
	5 → 8	26.2546	16.6733	3.4091	1.6057	2.4753	0.5407	0.0027
Avg. Value	**0 → 3**	**358.0734**	**18.9493**	**6.7499**	**2.5618**	**3.4564**	**1.4999**	**0.0078**
	3 → 5	**2100.2713**	**15.7586**	**4.8747**	**1.7123**	**4.2672**	**1.9035**	**0.0124**
	5 → 8	**113.9850**	**13.6233**	**5.3984**	**2.3845**	**4.9068**	**1.3600**	**0.0131**

* Highest value per frequency band .
** Lowest value per frequency band .

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7	Participant 8	Participant 9	Participant 10	Avg. Value
Surprise	3	4	6	5	1	4	6	2	3	5	3.9
Startle	1	1	6	4	1	3	2	2	1	1	2.2
Confusion	2	2	3	5	2	3	3	3	2	1	2.6
Disturbance	1	1	6	3	3	3	4	2	2	1	2.6

Participants' ratings on the effects of the SEs from the questionnaires

223 - Participant 1	224 - Participant 2	225 - Participant 3	226 - Participant 4	227 -Participant 5
				
				
				

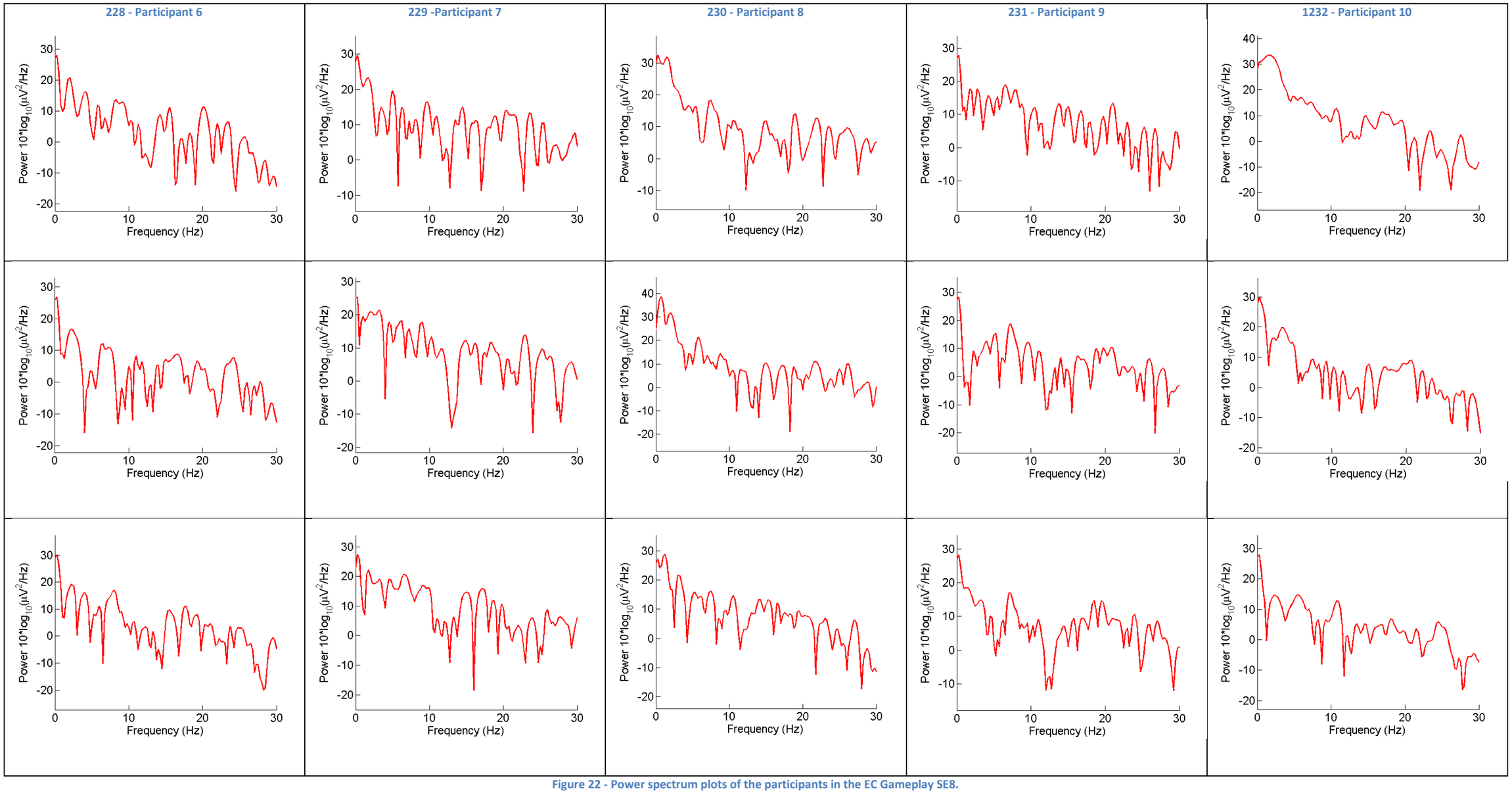


Figure 22 - Power spectrum plots of the participants in the EC Gameplay SE8.

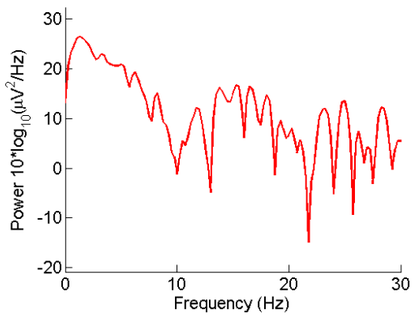
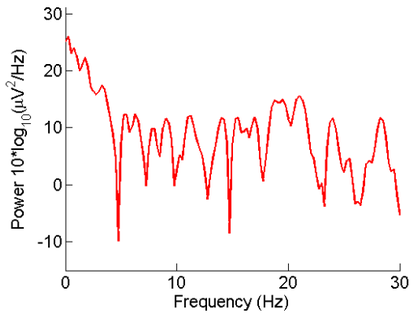
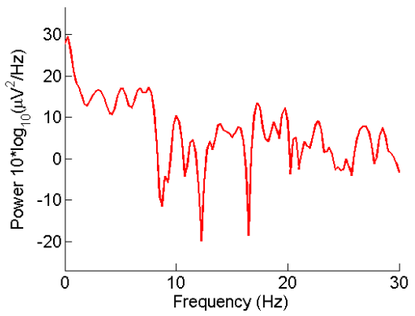
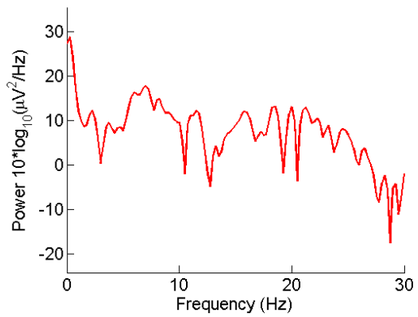
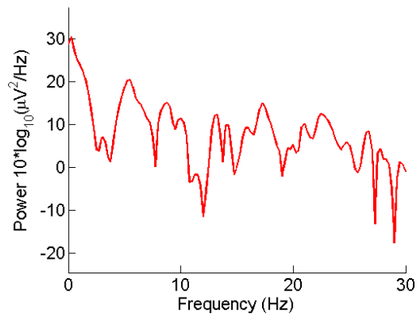
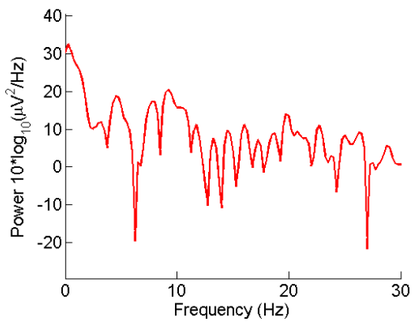
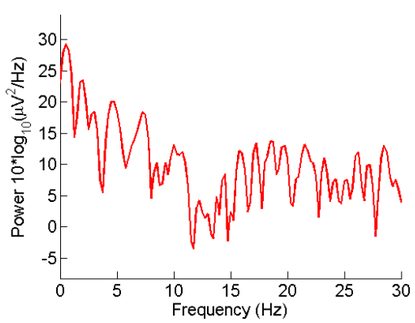
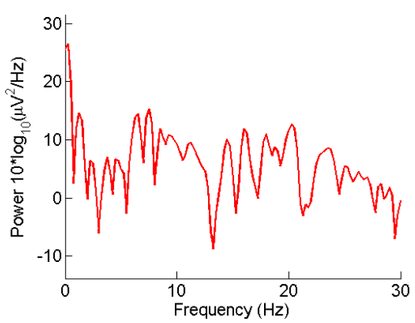
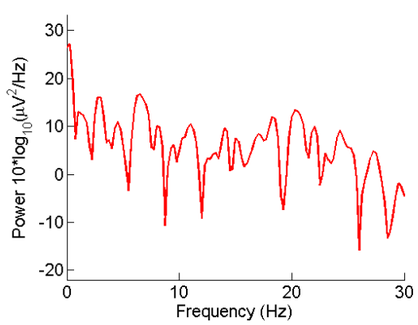
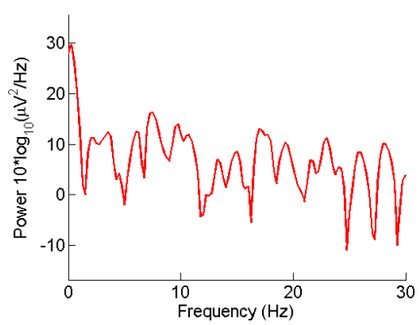
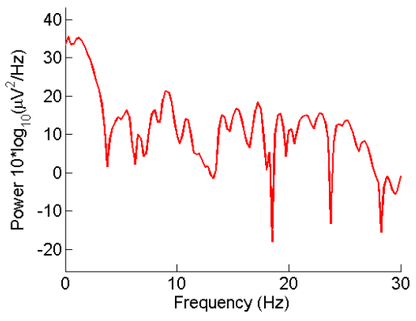
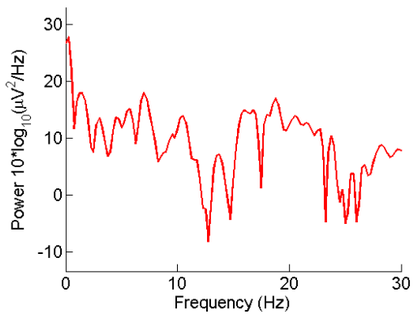
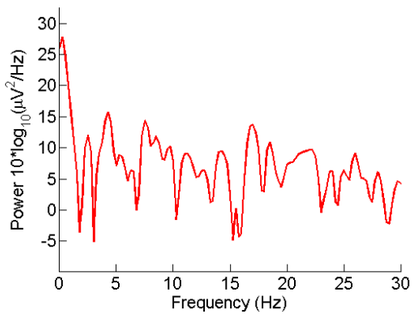
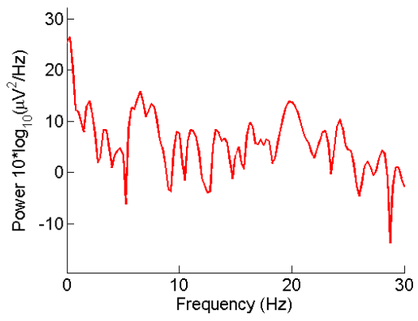
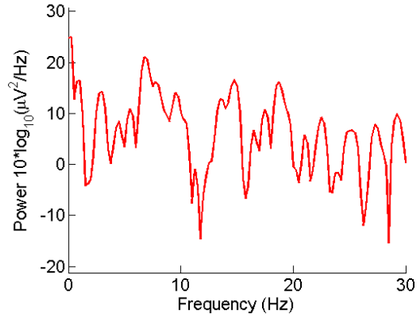
Gameplay SE8 (task-dependent narrative-based surprise) - CC

Participants	Duration	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Participant 11	**0 → 3**	263.5567	80.4689	5.1394	9.2228	11.0530	2.9459	0.0140
	3 → 5	127.8515	6.5961	24.2712	1.2726	3.7726	2.2247	0.0081
	5 → 8	1561.1345	14.4441	19.5214	4.1246	7.3607	4.1789	0.0322
Participant 12	**0 → 3**	120.9760	6.0885	5.8298	2.8229	10.8336	2.8738	0.0114
	3 → 5	159.9603	32.6440	6.4788	1.7906	9.3448	6.1374	0.0209
	5 → 8	35.9710	20.5504	8.3556	1.1418	19.6053	3.6887	0.0145
Participant 13	**0 → 3**	64.0737	28.3114	1.1297	1.6269	3.5636	1.8193	0.0036
	3 → 5	9.4283	4.8867	8.0465	1.7279	4.9455	1.8040	0.0057
	5 → 8	16.4462	6.2769	6.2101	4.1020	6.3536	2.9925	0.0044
Participant 14	**0 → 3**	23.3168	17.0770	10.2485	2.1207	6.3264	1.6482	0.0069
	3 → 5	18.3228	8.5842	3.2281	2.6788	3.5214	1.2403	0.0041
	5 → 8	17.2874	6.1245	2.4477	1.8796	5.3958	1.7526	0.0032
Participant 15	**0 → 3**	63.8866	40.7868	4.7903	3.3989	5.8067	2.3516	0.0100
	3 → 5	19.5238	3.6333	7.8855	2.3004	6.3843	2.2891	0.0067
	5 → 8	7.2238	9.3157	3.4957	7.2006	7.9722	1.5195	0.0055
Participant 16	**0 → 3**	652.8756	19.8740	8.9241	1.4457	2.0695	1.6885	0.0659
	3 → 5	105.7558	6.9674	4.0515	4.0176	1.3320	0.6220	0.0120
	5 → 8	85.9611	2.6570	2.6210	0.4668	1.1954	1.2918	0.0051
Participant 17	**0 → 3**	171.9934	7.5735	2.5513	2.2795	2.2300	0.4069	0.0033
	3 → 5	19.2439	2.5129	1.6302	1.2584	0.5587	0.2076	0.0021
	5 → 8	20.1463	2.4355	2.2624	0.3898	0.3298	0.2466	0.0014
Participant 18	**0 → 3**	1140.1747	17.3704	38.2757	5.8349	11.2313	1.6961	0.0061
	3 → 5	335.9104	29.8392	15.3698	3.6196	5.4887	3.1004	0.0105
	5 → 8	51.7171	223.2528	26.4053	2.5994	12.1020	1.9892	0.0097
Participant 19	**0 → 3**	201.5448	6.4120	1.8948	0.4480	1.1377	0.5108	0.0037
	3 → 5	13.6648	18.2091	1.7732	1.7771	2.1628	0.3161	0.0026
	5 → 8	14.3739	8.6462	5.2993	2.7737	1.8009	0.3307	0.0032
Participant 20	**0 → 3**	7.2401	5.4520	2.1423	0.7432	1.3961	0.6138	0.0042
	3 → 5	3791.4093	30.8820	5.9177	1.4797	2.6535	1.2968	0.0044
	5 → 8	29.8478	1.2878	6.1061	1.1417	1.6710	0.7513	0.0049
Avg. Value	**0 → 3**	**270.9638**	**22.9415**	**8.0926**	**2.9944**	**5.5648**	**1.6555**	**0.0129**
	3 → 5	**460.1071**	**14.4755**	**7.8653**	**2.1923**	**4.0164**	**1.9238**	**0.0077**
	5 → 8	**184.0109**	**29.4991**	**8.2725**	**2.5820**	**6.3787**	**1.8742**	**0.0084**

* Highest value per frequency band .
** Lowest value per frequency band .

	Participant 11	Participant 12	Participant 13	Participant 14	Participant 15	Participant 16	Participant 17	Participant 18	Participant 19	Participant 20	Avg. Value
Surprise	4	3	2	3	5	4	4	3	2	2	3.2
Startle	2	5	2	1	3	3	1	3	1	1	2.2
Confusion	2	5	1	1	4	5	1	2	1	3	2.5
Disturbance	1	4	2	1	4	4	3	2	2	1	2.4

Participants' ratings on the effects of the SEs from the questionnaires

233 - Participant 11	234 - Participant 12	235 - Participant 13	236 - Participant 14	237 -Participant 15
				
				
				

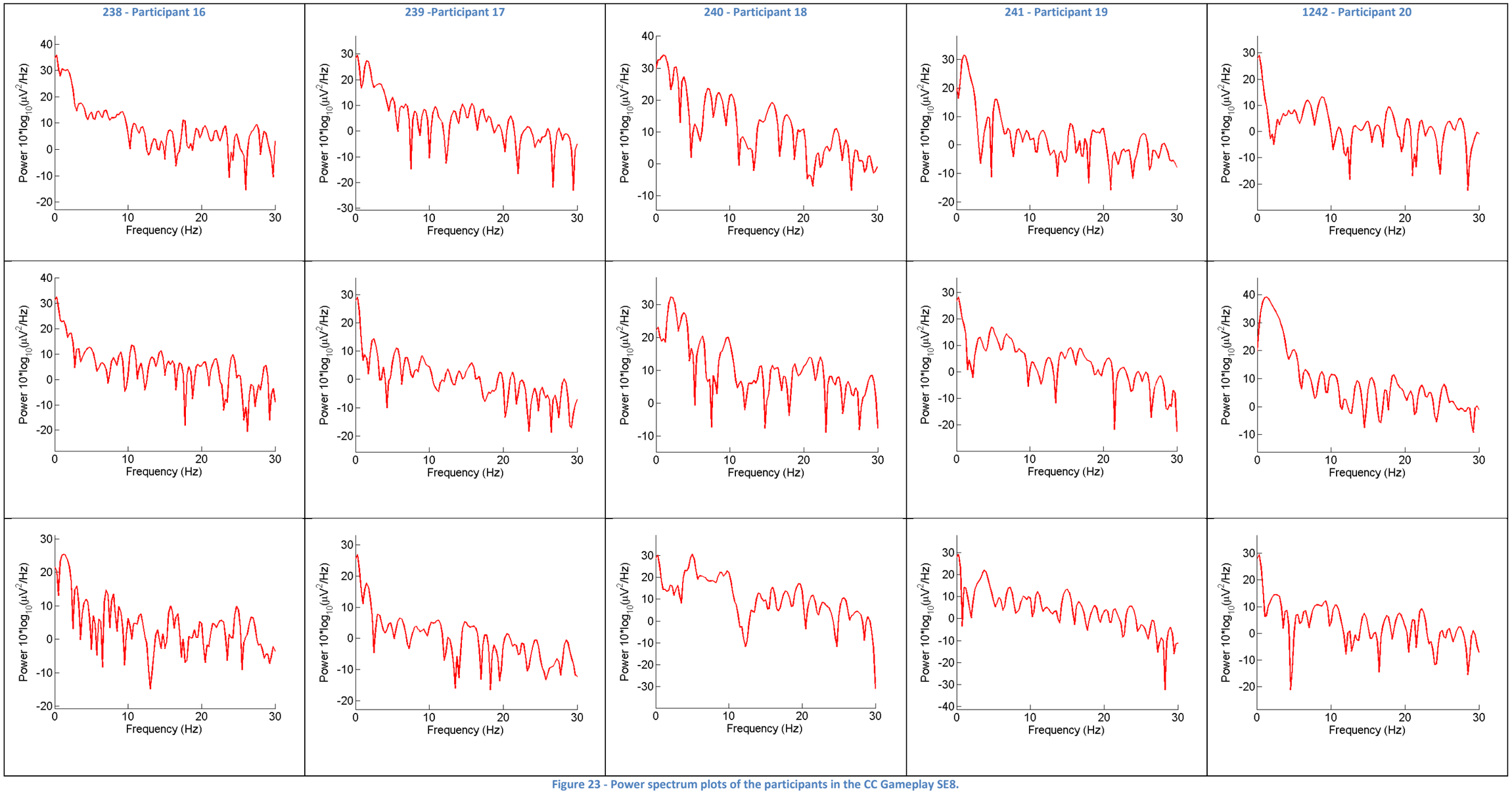


Figure 23 - Power spectrum plots of the participants in the CC Gameplay SE8.

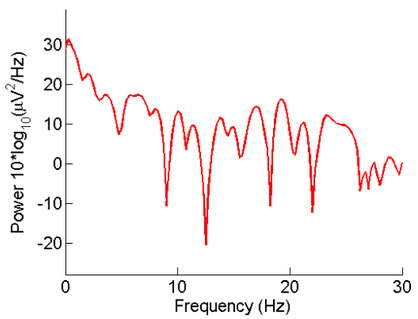
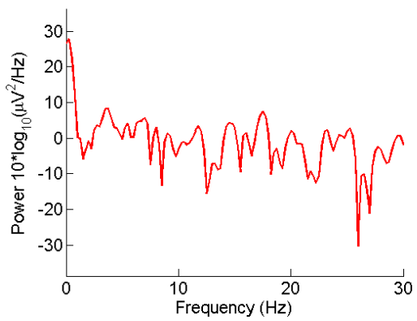
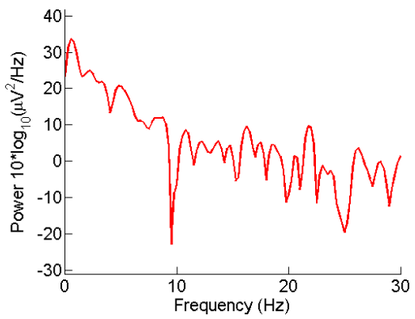
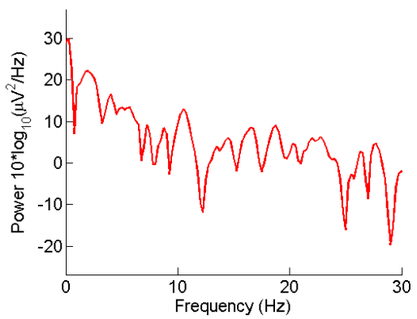
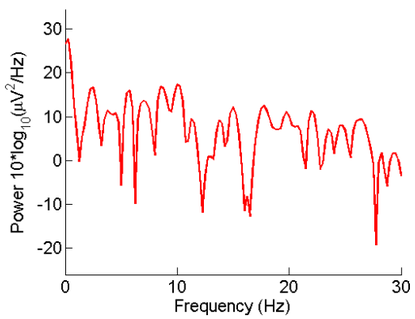
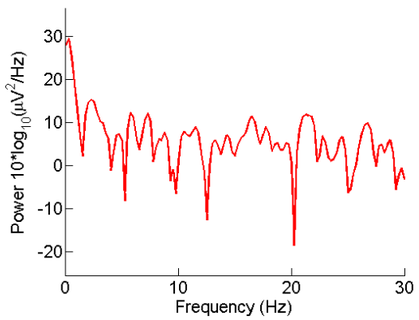
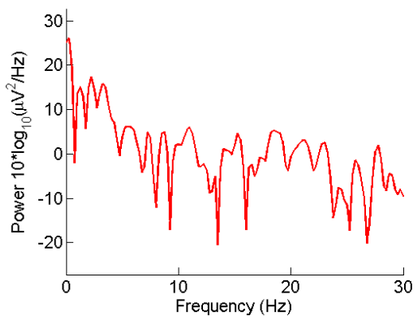
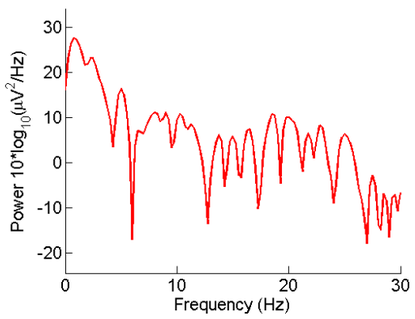
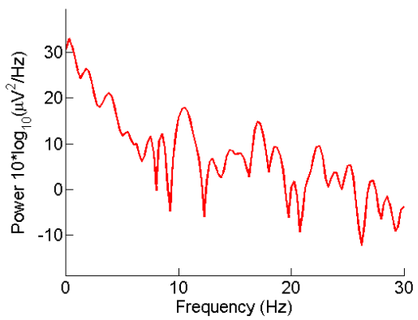
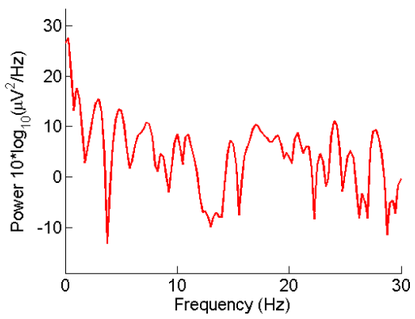
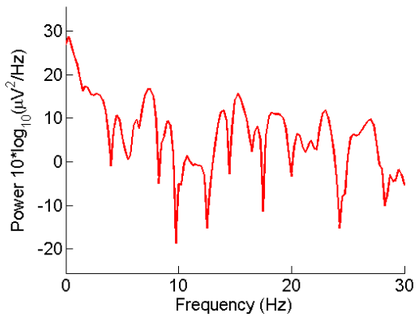
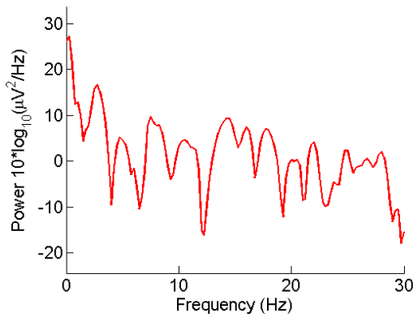
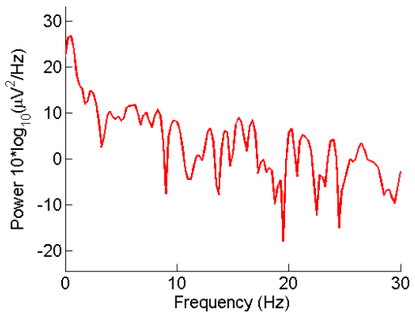
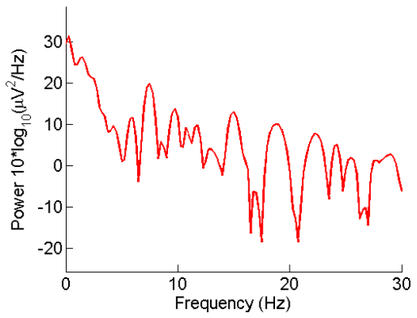
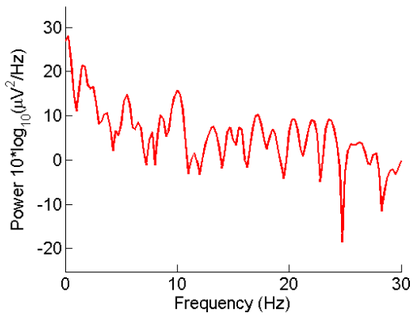
Gameplay SE9 (task-dependent mixed surprise) - EC

Participants	Duration	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Participant 1	**0 → 3**	256.7187	26.6527	5.3601	2.0162	10.7443	2.0667	0.0394
	3 → 5	31.2898	3.7717	2.8495	1.6811	4.5093	2.3364	0.0263
	5 → 8	94.2448	4.7989	0.9181	1.6509	4.3873	1.5709	0.0241
Participant 2	**0 → 3**	3.1716	1.7853	0.6671	0.3353	0.7416	0.2864	0.0023
	3 → 5	21.8491	2.1561	1.2236	0.3524	1.0103	0.2711	0.0046
	5 → 8	21.6324	0.7845	1.6417	1.6655	1.2169	0.4656	0.0048
Participant 3	**0 → 3**	484.7151	44.0791	1.9323	2.2328	1.5665	0.3979	0.0057
	3 → 5	255.8203	4.6859	6.7422	0.8284	2.4040	0.5304	0.0024
	5 → 8	55.1722	9.3129	1.8675	1.4187	0.6383	0.5682	0.0063
Participant 4	**0 → 3**	103.6526	13.1458	4.1618	1.3390	2.8375	0.7077	0.0065
	3 → 5	381.4233	14.3545	11.3875	2.7004	4.9979	0.9507	0.0033
	5 → 8	277.5602	3.7701	5.5199	2.0873	0.9739	0.9678	0.0022
Participant 5	**0 → 3**	19.5018	6.5339	14.9960	1.8211	3.7227	2.0801	0.0107
	3 → 5	22.0596	6.2983	2.4664	0.3307	5.6790	1.3145	0.0084
	5 → 8	61.5370	6.9731	5.0993	2.5771	2.4099	1.2114	0.0079
Participant 6	**0 → 3**	903.6580	33.7782	8.9584	7.1307	23.4292	3.9479	0.0537
	3 → 5	74.9998	10.5461	1.9536	0.7042	2.9118	0.8190	0.0056
	5 → 8	176.5551	4.0168	3.2487	1.8712	1.4278	1.0740	0.0083
Participant 7	**0 → 3**	17.8281	7.5581	3.3097	4.9307	4.9126	1.0224	0.0073
	3 → 5	27.3889	6.2852	5.1776	1.0712	5.6185	3.7259	0.0085
	5 → 8	62.4620	12.0240	7.1942	1.5435	3.0095	0.8833	0.0063
Participant 8	**0 → 3**	60.9690	16.1858	3.5585	1.5286	6.3879	1.4073	0.0048
	3 → 5	131.5766	5.0954	2.7563	0.8562	2.5655	1.9303	0.0046
	5 → 8	106.5005	16.3466	2.5479	0.7309	2.2556	0.6570	0.0051
Participant 9	**0 → 3**	28.5126	11.5932	5.0213	1.2733	3.9476	0.6881	0.0036
	3 → 5	40.9893	2.6605	3.5459	0.7179	3.7082	1.0289	0.0040
	5 → 8	25.8574	21.2231	1.3819	0.6406	5.7401	1.3238	0.0042
Participant 10	**0 → 3**	58.1299	4.8568	1.7230	0.3378	1.6048	0.5198	0.0028
	3 → 5	149.0279	17.9178	3.5533	2.1907	2.6006	0.3885	0.0028
	5 → 8	16.3976	3.0671	3.2975	1.0782	1.2031	0.3903	0.0029
Avg. Value	**0 → 3**	**193.6857**	**16.6169**	**4.9688**	**2.2946**	**5.9895**	**1.3124**	**0.0137**
	3 → 5	**113.6425**	**7.3772**	**4.1656**	**1.1433**	**3.6005**	**1.3296**	**0.0071**
	5 → 8	**89.7919**	**8.2317**	**3.2717**	**1.5264**	**2.3262**	**0.9112**	**0.0072**

* Highest value per frequency band .
** Lowest value per frequency band .

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7	Participant 8	Participant 9	Participant 10	Avg. Value
Surprise	4	4	7	6	4	3	3	6	3	5	4.5
Startle	3	1	2	7	2	2	3	3	3	1	2.7
Confusion	5	1	5	5	5	3	3	4	5	1	3.7
Disturbance	4	1	3	5	2	3	3	3	4	1	2.9

Participants' ratings on the effects of the SEs from the questionnaires

243 - Participant 1	244 - Participant 2	245 - Participant 3	246 - Participant 4	247 -Participant 5
				
				
				

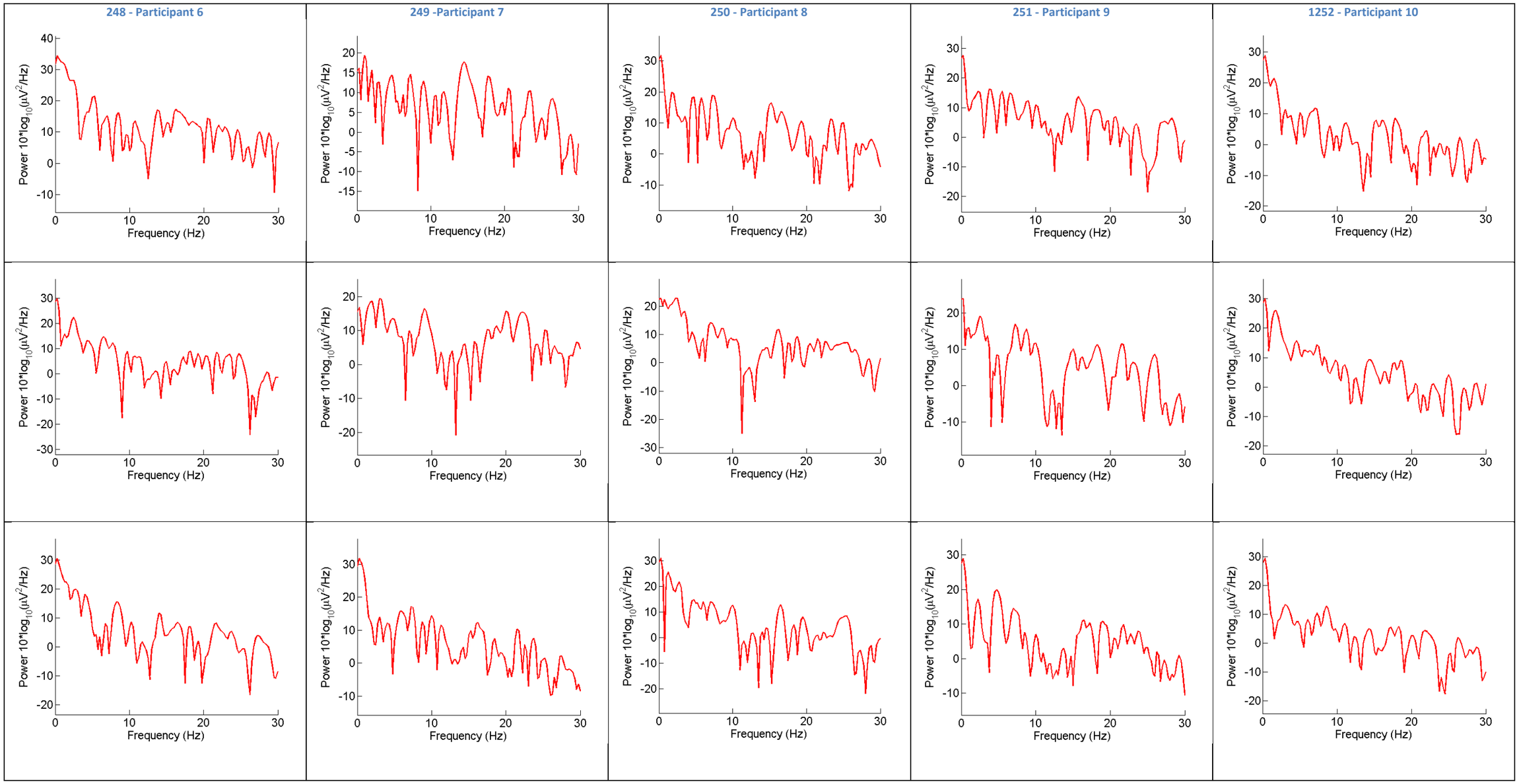


Figure 24 - Power spectrum plots of the participants in the EC Gameplay SE9.

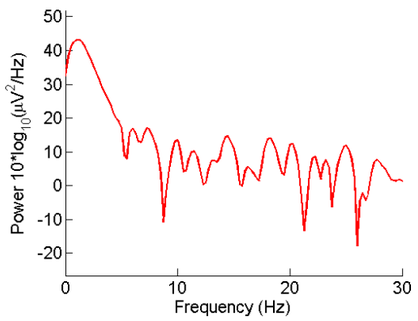
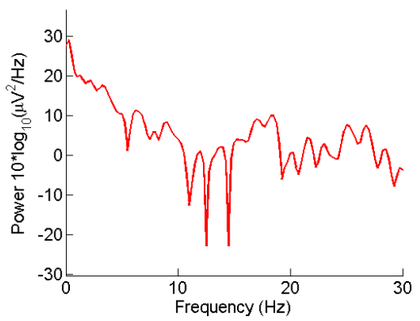
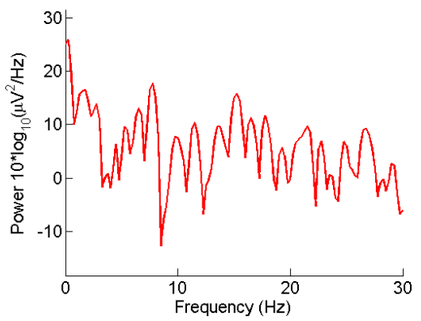
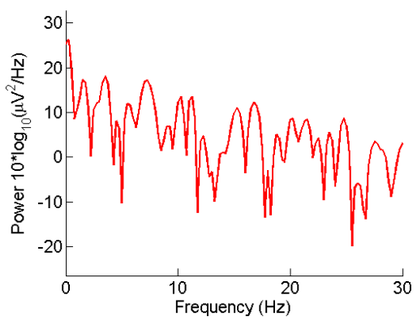
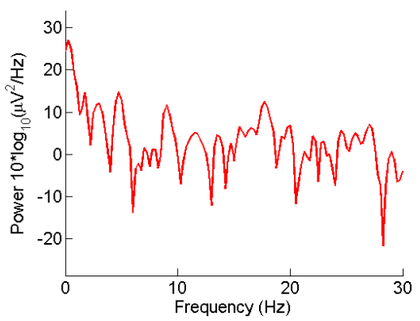
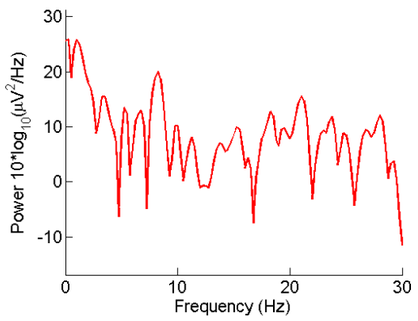
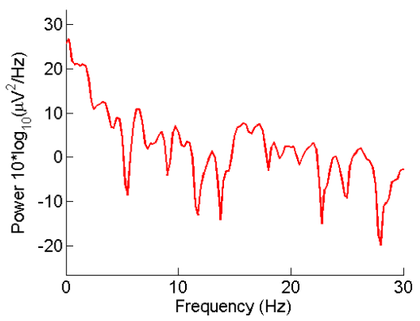
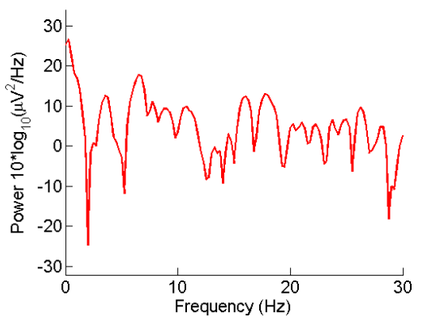
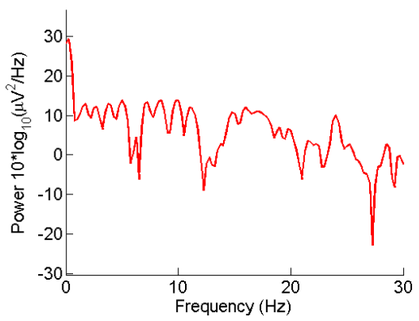
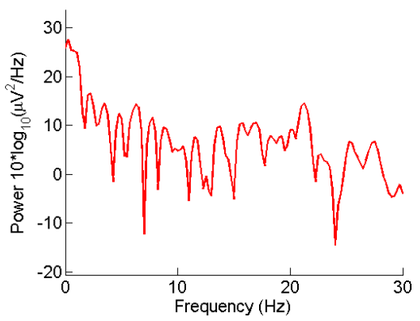
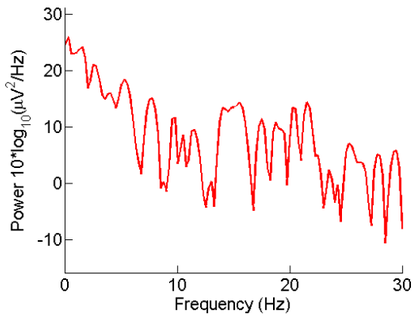
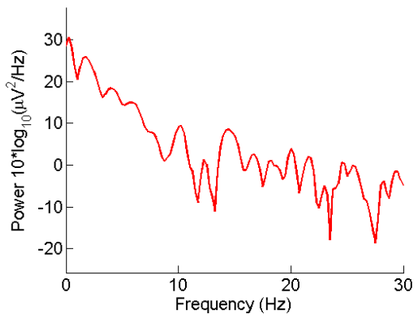
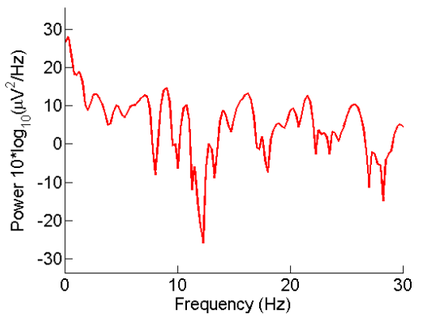
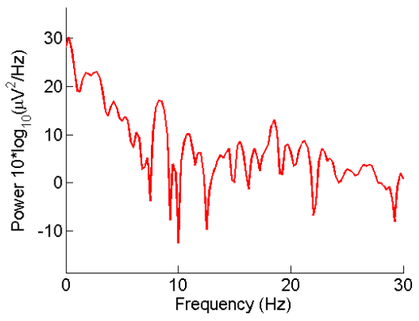
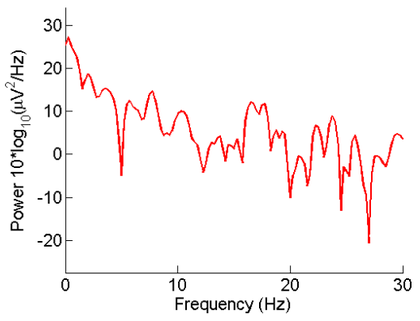
Gameplay SE9 (task-dependent mixed surprise) - CC

Participants	Duration	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Participant 11	**0 → 3**	9457.4870	33.9393	4.3908	6.5910	5.2246	1.8743	0.0251
	3 → 5	100.8870	6.3359	5.9318	2.3546	4.5711	4.1547	0.0160
	5 → 8	158.9415	17.3563	3.6779	3.3068	3.9671	1.8028	0.0121
Participant 12	**0 → 3**	108.0866	8.7068	1.4573	0.3516	3.3952	1.3956	0.0053
	3 → 5	74.9729	2.9338	1.2572	0.4741	2.1318	0.3904	0.0039
	5 → 8	280.2333	30.3793	1.7514	1.3066	0.9122	0.2859	0.0058
Participant 13	**0 → 3**	33.4536	5.0429	1.8162	2.7243	3.6066	1.6636	0.0061
	3 → 5	5.6676	4.2442	5.1326	0.5112	3.7728	1.3556	0.0071
	5 → 8	41.8665	8.7660	1.8461	0.7469	2.1632	1.6736	0.0057
Participant 14	**0 → 3**	20.7116	4.7215	3.9648	0.9128	1.6781	0.8464	0.0037
	3 → 5	22.7186	4.2984	10.4678	1.3504	6.5681	0.8801	0.0045
	5 → 8	201.2712	13.4720	4.2452	1.6464	4.1910	1.4821	0.0038
Participant 15	**0 → 3**	24.8096	2.1356	2.0511	0.8301	3.9512	0.9511	0.0071
	3 → 5	70.2902	7.8797	2.9343	1.7502	5.2050	1.4950	0.0067
	5 → 8	93.0759	7.0991	4.3796	1.2851	5.2390	0.8847	0.0093
Participant 16	**0 → 3**	46.2608	4.1977	6.1169	0.9471	5.3768	2.5085	0.0128
	3 → 5	1851.5247	9.2953	6.0297	0.3628	1.9106	1.3092	0.0251
	5 → 8	564.0064	7.4664	10.4374	1.7239	7.2631	1.8126	0.0248
Participant 17	**0 → 3**	9.6281	1.8572	1.4856	0.2089	1.0545	0.1463	0.0025
	3 → 5	1023.9755	1.7100	0.8972	0.7107	0.5060	0.1790	0.0017
	5 → 8	15.0824	2.0536	1.5381	0.4067	0.9930	0.1197	0.0022
Participant 18	**0 → 3**	79.5704	23.3049	4.0420	1.7357	6.5112	2.3519	0.0052
	3 → 5	232.4549	48.3462	22.5825	0.9429	5.0003	1.5168	0.0100
	5 → 8	286.0401	11.2006	5.5478	13.8770	7.8979	7.3043	0.0516
Participant 19	**0 → 3**	71.0813	6.5015	1.8490	0.5985	0.7814	0.4823	0.0029
	3 → 5	21.3505	10.7115	3.1125	0.9588	1.2386	0.1636	0.0023
	5 → 8	27.2958	1.1574	0.6186	1.4947	2.1000	0.3123	0.0023
Participant 20	**0 → 3**	24.8165	5.0496	0.9918	0.3950	0.6960	0.1971	0.0026
	3 → 5	54.2314	2.0626	1.2929	0.3838	1.0192	0.4480	0.0030
	5 → 8	8.9816	2.5086	1.0836	0.5437	0.1575	0.3716	0.0037
Avg. Value	**0 → 3**	**987.5906**	**9.5457**	**2.8166**	**1.5295**	**3.2276**	**1.2417**	**0.0073**
	3 → 5	**345.8073**	**9.7818**	**5.9639**	**0.9800**	**3.1924**	**1.1892**	**0.0080**
	5 → 8	**167.6795**	**10.1459**	**3.5126**	**2.6338**	**3.4884**	**1.6050**	**0.0121**

* Highest value per frequency band .
** Lowest value per frequency band .

	Participant 11	Participant 12	Participant 13	Participant 14	Participant 15	Participant 16	Participant 17	Participant 18	Participant 19	Participant 20	Avg. Value
Surprise	3	6	2	5	5	6	7	4	4	3	4.5
Startle	2	5	2	1	5	6	3	3	4	3	3.4
Confusion	1	5	1	1	4	6	5	3	3	4	3.3
Disturbance	1	5	3	1	3	4	5	4	3	1	3.0

Participants' ratings on the effects of the SEs from the questionnaires

253 - Participant 11	254 - Participant 12	255 - Participant 13	256 - Participant 14	257 -Participant 15
				
				
				

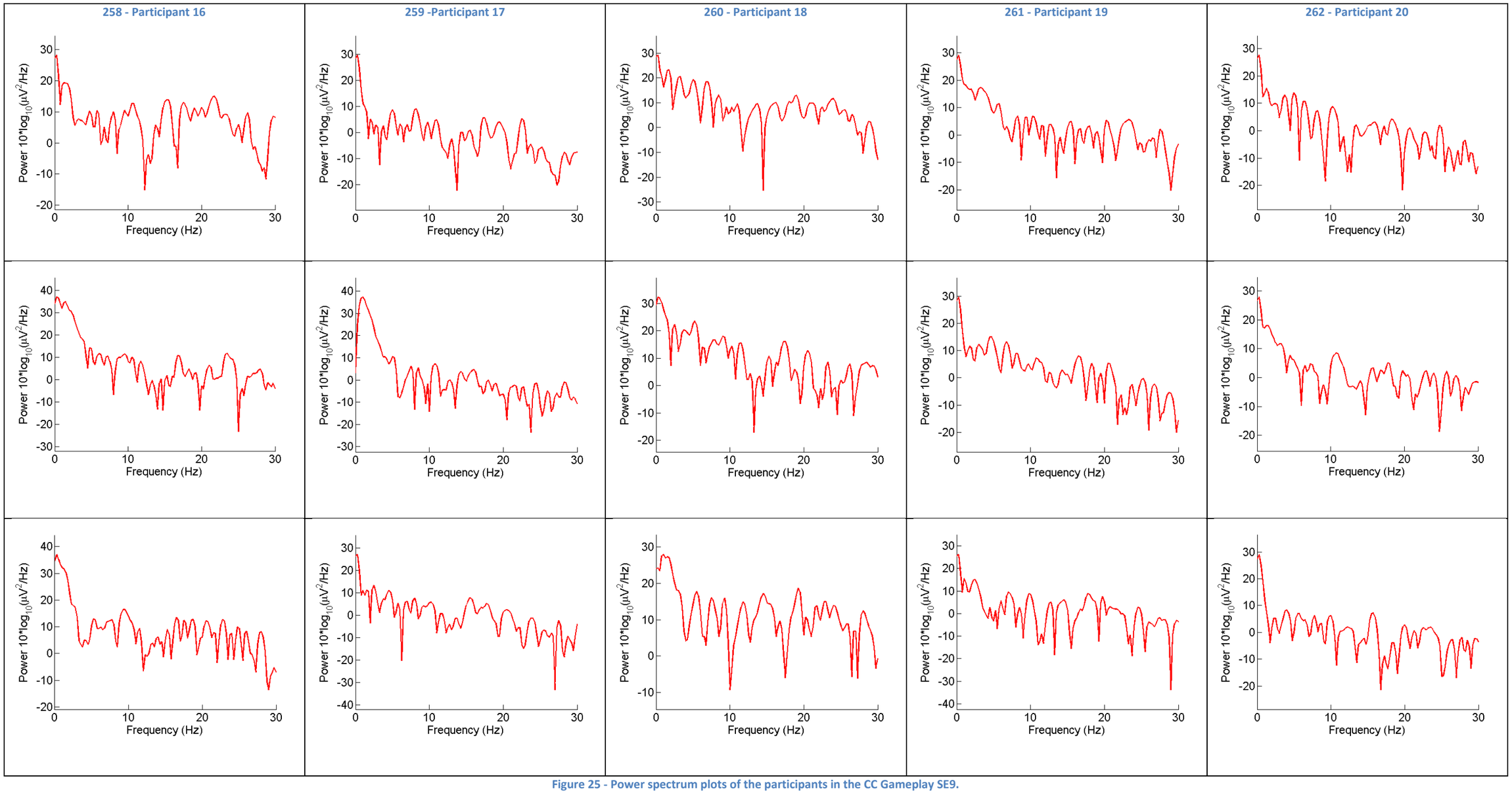


Figure 25 - Power spectrum plots of the participants in the CC Gameplay SE9.

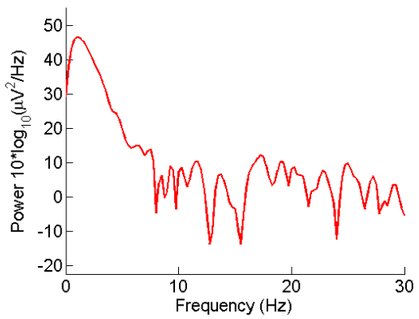
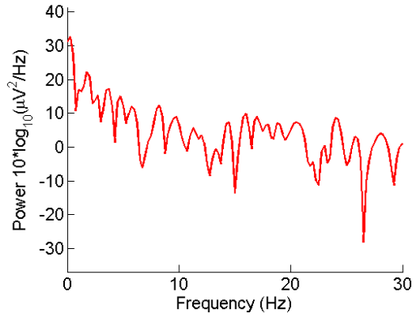
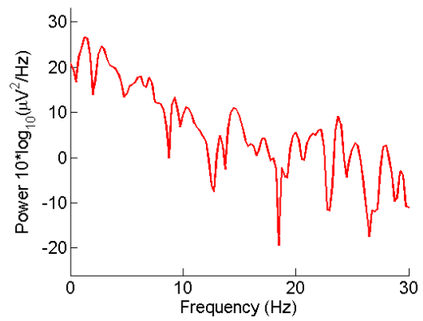
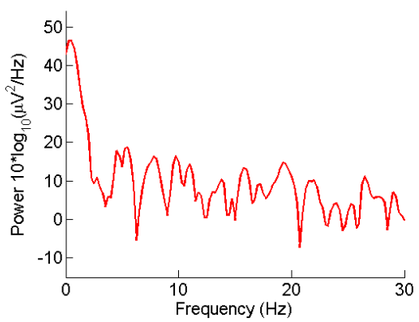
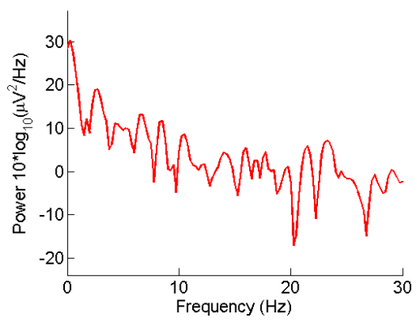
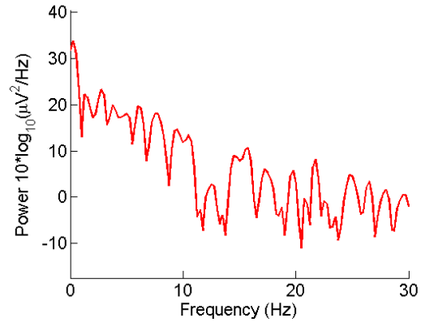
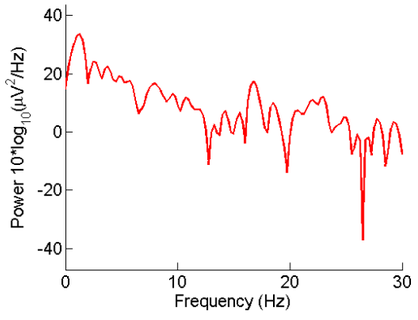
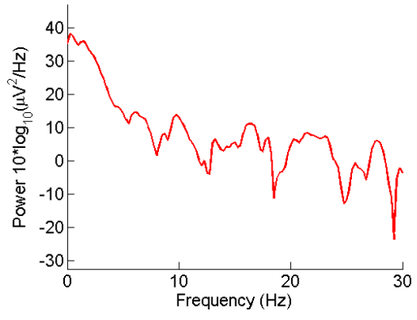
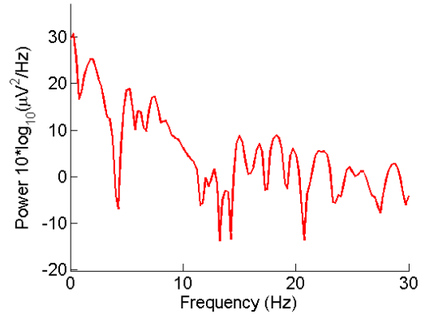
Gameplay SE10 (task-independent cue-based surprise) - EC

Participants	Duration	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Participant 1	**0 → 3**	19547.1800	61.5280	3.6749	0.8008	6.6145	1.5931	0.0348
	3 → 5	807.6736	13.4968	9.6423	3.2031	8.5252	2.5405	0.0360
	5 → 8	429.0698	31.4973	11.9936	1.3097	4.0105	1.2794	0.0201
Participant 2	**0 → 3**	-	-	-	-	-	-	-
	3 → 5	-	-	-	-	-	-	-
	5 → 8	-	-	-	-	-	-	-
Participant 3	**0 → 3**	77.1259	5.2726	2.9837	0.8859	3.1466	0.6087	0.0038
	3 → 5	54.8580	9.5381	2.5455	1.3026	1.0300	0.7184	0.0089
	5 → 8	2631.2231	25.2041	6.2893	1.7979	1.7971	0.8807	0.0108
Participant 4	**0 → 3**	142.4013	41.6883	6.8357	1.8498	0.8311	0.5771	0.0112
	3 → 5	161.8265	40.0489	6.1014	1.2034	1.0896	0.7540	0.0054
	5 → 8	189.5426	13.6935	3.3412	0.4879	2.4504	0.8902	0.0047
Participant 5	**0 → 3**	-	-	-	-	-	-	-
	3 → 5	-	-	-	-	-	-	-
	5 → 8	-	-	-	-	-	-	-
Participant 6	**0 → 3**	61.4230	8.1892	2.5598	1.0856	1.2237	0.1976	0.0032
	3 → 5	73.5060	25.6179	4.0579	0.9461	5.1103	0.6154	0.0016
	5 → 8	16.5410	0.8997	2.3339	1.0581	1.0360	0.2302	0.0017
Participant 7	**0 → 3**	88.3512	30.8047	12.6118	1.0589	6.5277	1.5997	0.0122
	3 → 5	874.6690	46.5315	15.6453	3.1355	12.4587	6.5530	0.0068
	5 → 8	57.9915	18.9927	15.2777	3.2681	9.4289	1.9404	0.0121
Participant 8	**0 → 3**	125.2850	20.2068	6.9464	1.9454	2.8643	1.2370	0.0054
	3 → 5	166.8062	386.9191	9.2032	4.4881	6.3617	2.0852	0.0072
	5 → 8	348.6932	44.6197	4.6368	3.2172	1.9901	1.6833	0.0042
Participant 9	**0 → 3**	57.6088	2.3738	1.8896	1.2935	4.9864	0.4119	0.0037
	3 → 5	400.9818	17.6664	3.4900	0.2680	1.3673	0.6848	0.0047
	5 → 8	4572.6548	19.6933	19.9642	1.1149	4.6792	1.5582	0.0121
Participant 10	**0 → 3**	19.2198	1.4429	0.9592	0.7318	1.1056	0.2647	0.0048
	3 → 5	124.5813	13.5394	1.6076	1.7842	0.7948	0.3610	0.0051
	5 → 8	14.7965	6.1923	1.8557	1.6296	2.3835	0.6444	0.0050
Avg. Value	**0 → 3**	**2514.8244**	**21.4383**	**4.8076**	**1.2065**	**3.4125**	**0.8112**	**0.0099**
	3 → 5	**333.1128**	**69.1698**	**6.5367**	**2.0414**	**4.5922**	**1.7890**	**0.0095**
	5 → 8	**1032.5641**	**20.0991**	**8.2116**	**1.7354**	**3.4720**	**1.1384**	**0.0088**

* Highest value per frequency band .
** Lowest value per frequency band .

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7	Participant 8	Participant 9	Participant 10	Avg. Value
Surprise	6	No	6	5	No	5	6	6	6	7	5.875
Startle	7	No	7	5	No	4	5	6	6	7	5.875
Confusion	6	No	7	6	No	4	6	6	6	7	6
Disturbance	6	No	6	5	No	3	6	3	4	5	4.75

Participants' ratings on the effects of the SEs from the questionnaires

263 - Participant 1	264 - Participant 2	265 - Participant 3	266 - Participant 4	267 -Participant 5
				
				
				

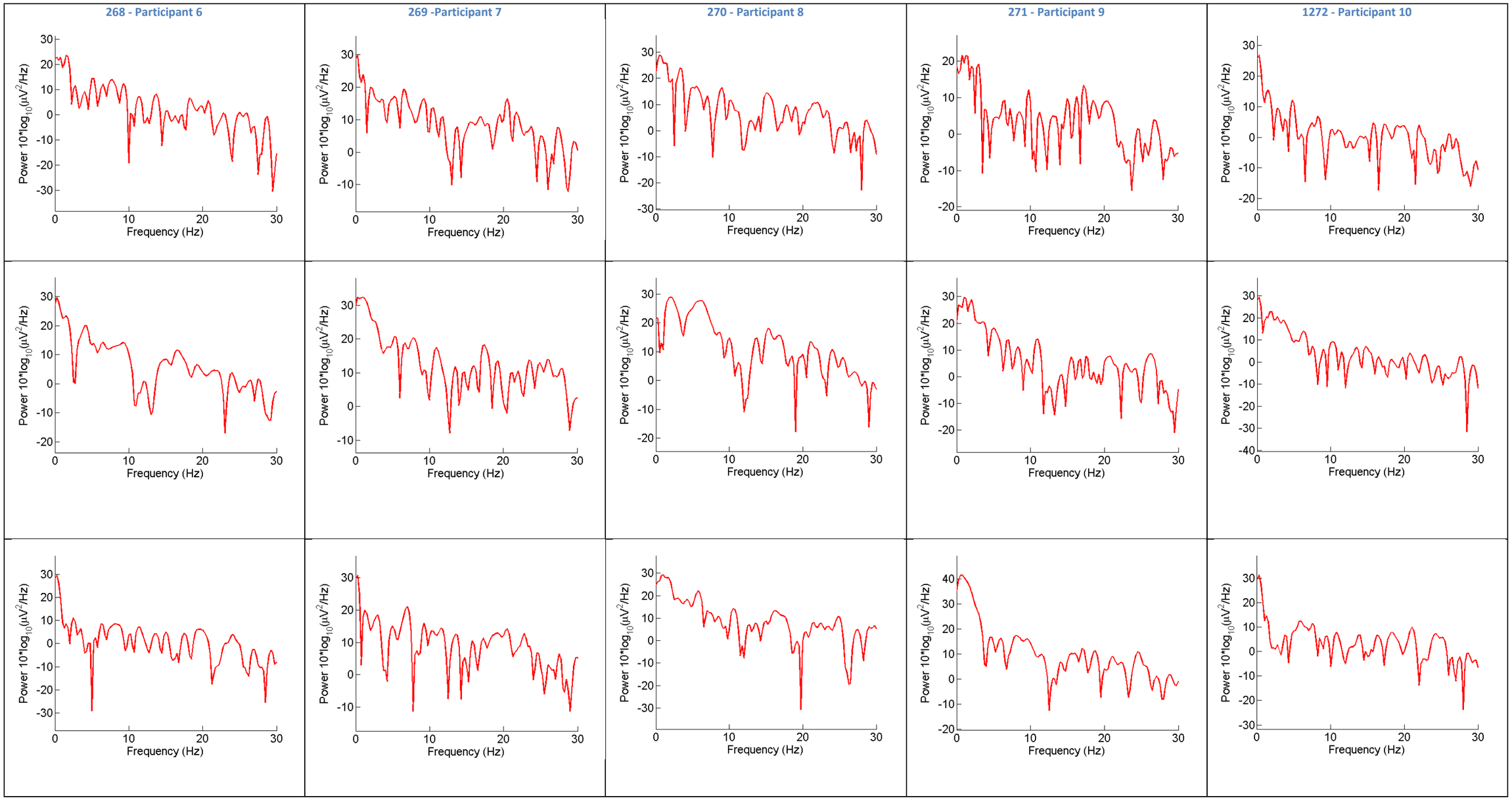


Figure 26 - Power spectrum plots of the participants in the EC Gameplay SE10.

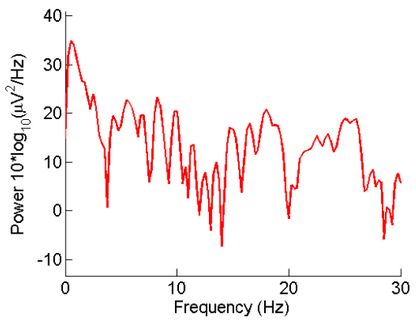
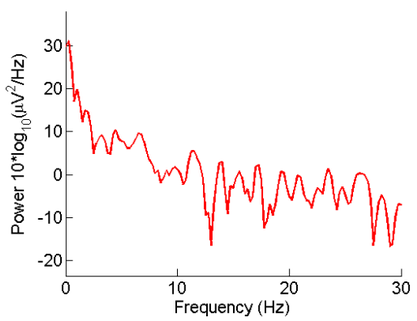
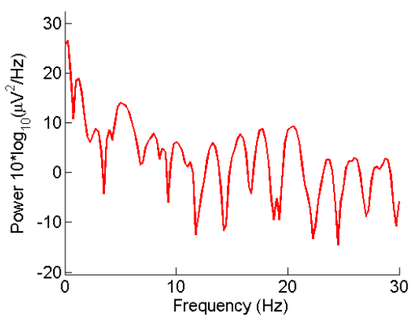
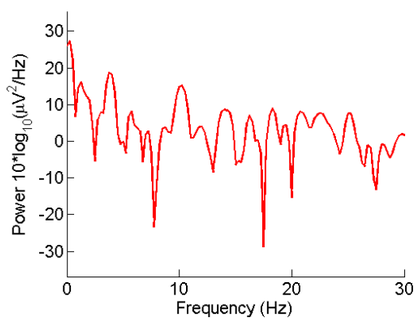
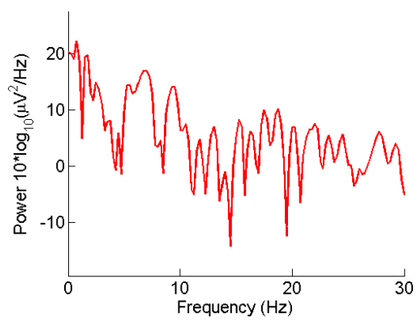
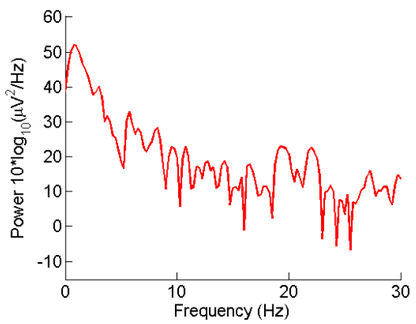
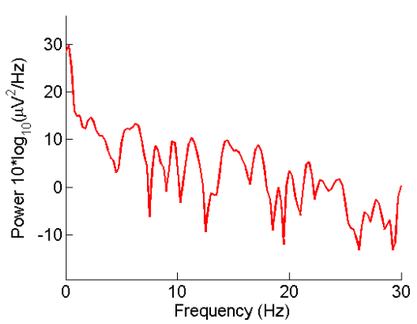
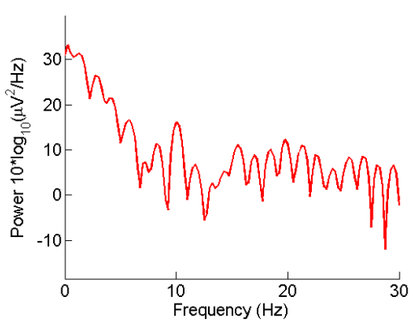
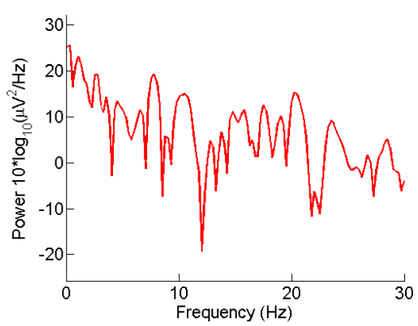
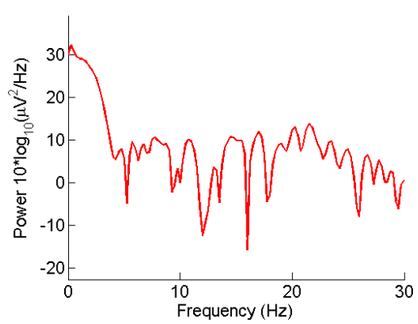
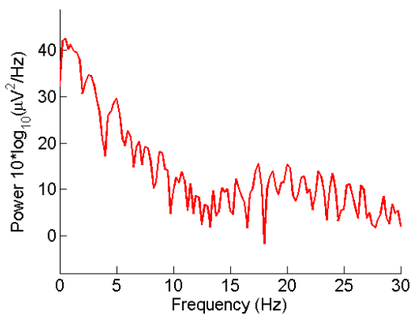
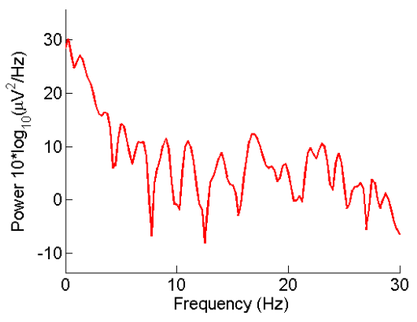
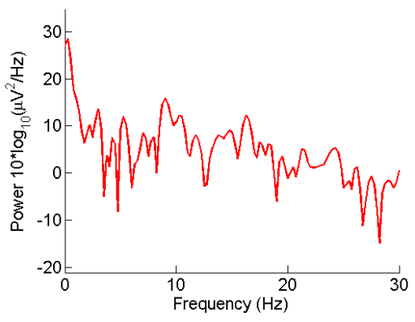
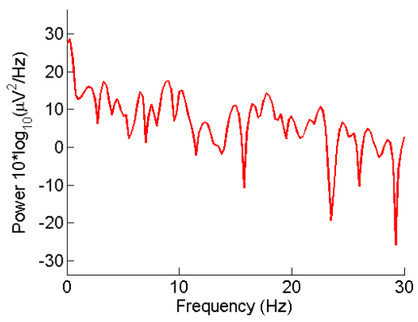
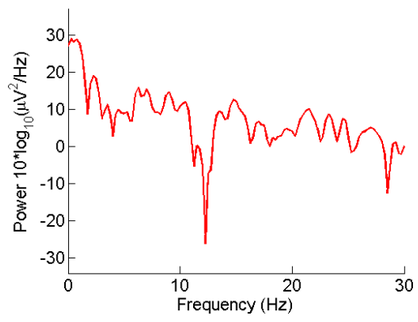
Gameplay SE10 (task-independent cue-based surprise) - CC

Participants	Duration	Delta (0.1-3)	Theta (4-7)	Alpha (8-12)	Low Beta (12-15)	Mid Beta (16-20)	High Beta (21-30)	Gamma (30-100)
Participant 11	**0 → 3**	561.7266	83.0003	19.9539	3.7627	35.5600	11.9707	0.2950
	3 → 5	3689.4635	362.2111	65.6394	31.9350	31.0516	10.6935	0.4768
	5 → 8	6027.2913	209.7744	14.1162	4.8054	9.3495	5.6094	0.1741
Participant 12	**0 → 3**	38.7277	6.5253	1.3045	0.3175	0.3807	0.2809	0.0045
	3 → 5	43.1858	9.4060	3.4714	1.5045	1.0844	0.4232	0.0036
	5 → 8	272.8399	9.7802	4.0344	1.9785	6.0145	1.9867	0.0118
Participant 13	**0 → 3**	23.5831	9.6167	1.5493	0.7779	1.0900	0.5522	0.0032
	3 → 5	716.1623	23.2511	5.5437	1.4436	4.4595	2.7664	0.0036
	5 → 8	23.8554	2.7534	8.9970	3.0892	2.8607	0.8233	0.0022
Participant 14	**0 → 3**	14.8917	1.9373	3.9953	1.8203	1.2200	1.1670	0.0074
	3 → 5	75.2180	9.5113	5.7105	1.7228	3.9618	0.9490	0.0078
	5 → 8	36.4486	8.6407	10.4100	2.2929	8.2155	1.0841	0.0068
Participant 15	**0 → 3**	40.1091	11.2003	3.7877	0.7046	2.5396	1.7440	0.0068
	3 → 5	602.5567	4.0116	3.1269	1.8192	4.6083	2.6980	0.0070
	5 → 8	132.3611	11.7855	6.3872	1.8712	2.2725	2.0014	0.0063
Participant 16	**0 → 3**	103.8680	4.1220	7.1980	2.0396	2.9142	0.8554	0.0049
	3 → 5	74.5421	6.8807	7.4728	1.1295	1.6974	0.9719	0.0055
	5 → 8	1249.61597	17.3063	10.9165	1.3022	8.5753	1.3304	0.0115
Participant 17	**0 → 3**	111.9672	5.0117	3.4169	1.3468	1.7506	0.0985	0.0042
	3 → 5	120.7536	2.9558	1.5915	0.1726	0.3951	0.1650	0.0016
	5 → 8	62.5396	1.7508	0.7533	0.3214	0.5251	0.3298	0.0025
Participant 18	**0 → 3**	112.0975	11.9068	6.9338	1.1999	1.9678	0.8498	0.0127
	3 → 5	1342.1963	16.5802	5.8454	1.4361	3.6141	1.8501	0.0093
	5 → 8	72.7002	9.2669	3.8458	0.8559	3.2569	0.8910	0.0093
Participant 19	**0 → 3**	15.5573	3.1363	1.4007	1.7969	1.6111	0.1129	0.0036
	3 → 5	17.6280	2.9122	1.9421	0.5670	1.0600	0.3795	0.0013
	5 → 8	50.9542	3.7489	1.2811	1.7816	0.7822	0.3123	0.0025
Participant 20	**0 → 3**	22.9021	1.6766	1.3889	0.5680	1.2784	0.4629	0.0042
	3 → 5	250.9942	23.8040	3.9480	1.1465	0.6720	0.2119	0.0034
	5 → 8	40.9938	2.3643	2.9142	0.5238	2.0434	0.5222	0.0068
Avg. Value	**0 → 3**	**104.5430**	**13.8133**	**5.0929**	**1.4334**	**5.0312**	**1.8094**	**0.0347**
	3 → 5	**693.2701**	**46.1524**	**10.4292**	**4.2877**	**5.2604**	**2.1109**	**0.0520**
	5 → 8	**796.9600**	**27.7171**	**6.3656**	**1.8822**	**4.3896**	**1.4891**	**0.0234**

* Highest value per frequency band .
** Lowest value per frequency band .

	Participant 11	Participant 12	Participant 13	Participant 14	Participant 15	Participant 16	Participant 17	Participant 18	Participant 19	Participant 20	Avg. Value
Surprise	5	7	3	5	6	7	7	5	4	4	5.3
Startle	3	6	3	5	5	7	7	4	5	5	5.0
Confusion	3	6	1	1	4	7	7	3	4	3	3.9
Disturbance	2	4	3	1	3	7	4	5	5	2	3.6

Participants' ratings on the effects of the SEs from the questionnaires

273 - Participant 11	274 - Participant 12	275 - Participant 13	276 - Participant 14	277 -Participant 15
				
				
				

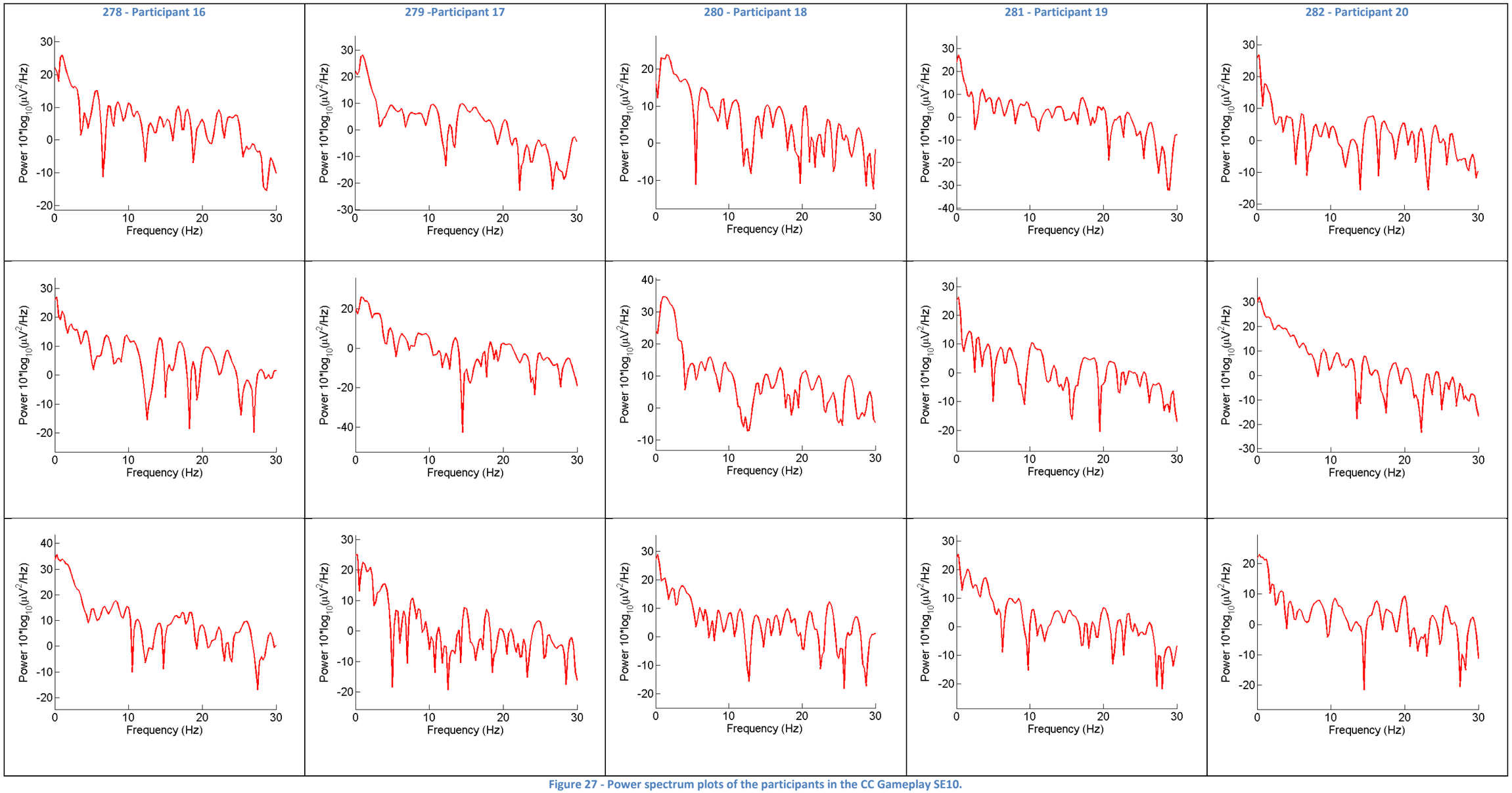


Figure 27 - Power spectrum plots of the participants in the CC Gameplay SE10.

Demographics from questionnaires

EC Group

Participants	Gender	Age	Experience with FPS games (specific)	Experience with computer games (general)
Participant 1	Female	29	1	2
Participant 2	Male	29	3	3
Participant 3	Male	21	3	3
Participant 4	Male	25	2	3
Participant 5	Male	26	3	3
Participant 6	Male	26	3	3
Participant 7	Female	24	1	2
Participant 8	Male	23	3	3
Participant 9	Female	25	1	1
Participant 10	Male	21	3	3
Avg. Value	**7 M/3 F**	**24.9**	**2.3**	**2.6**

CC Group

Participants	Gender	Age	Experience with FPS games (specific)	Experience with computer games (general)
Participant 11	Female	24	1	1
Participant 12	Male	22	2	2
Participant 13	Female	22	1	2
Participant 14	Male	26	3	3
Participant 15	Female	25	1	1
Participant 16	Male	20	2	3
Participant 17	Male	21	3	3
Participant 18	Male	33	1	3
Participant 19	Male	30	3	3
Participant 20	Male	27	3	3
Avg. Value	**7 M/3 F**	**25.0**	**2.0**	**2.4**