Kingston University London

LONDON CREATIVE & DIGITAL FUSION COLLABORATION AWARD SCHEME

METHODOLOGIES FOR USING BIOFEEDBACK DATA IN USER EXPERIENCE (UX) AND USABILITY STUDIES

PROJECT REPORT V1.0

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PROJECT OVERVIEW

"When people play games, they have an experience. It is this experience that the designer cares about. Without the experience, the game is worthless"; Jesse Schell.

Understanding what makes a good experience could be the difference between success and failure. The application of traditional User Experience testing methods are not fully effective for video games testing since gamers are seeking ‘fun’ and ‘immersion’ rather than task efficiency. When totally immersed a gamer describes a sense of presence as being cut off from reality to such an extent that the game was all that mattered. In the past few years new techniques with origins in psychological analysis have been introduced to shed more light on the experience dynamics of gaming, where the user feedback is more at an emotional level. The continuous representation of emotion is a powerful evaluative tool that can be easily combined with proven usability techniques, such as observational analysis and player interviews. Given a time series of emotional output, researchers can identify interesting features, such as a sudden increase or decrease in an emotional state, then investigate the corresponding underlying trigger in post testing analysis and interviews.

The research will focus on formulating a commercially applicable methodology to improve digital media user research (gaming, retail, web) by adapting easy-to-use and setup commercial biometric tools/utilities (EEG, EMG, EDA, HR, kinetic activity) combined with proven HCI testing techniques and innovative digital video/data capture utilities/software. The methodology will be refined to be fit-for-purpose with usability testing against different digital content, game genres, design criteria, and participants. This project will seek to review, refine, and create new UX and Usability methodologies to effectively incorporate user physiological (Biofeedback) data to provide greater insight on user emotional and behavioural preferences related to digital media.

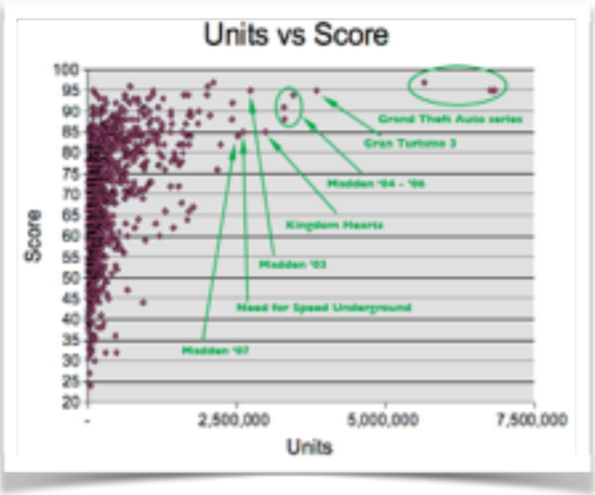
Using this data bespoke algorithms were postulated to provide real-time emotional event triggers, which form the basis of participant video-cued recall analysis; exploring the rationale behind the event.

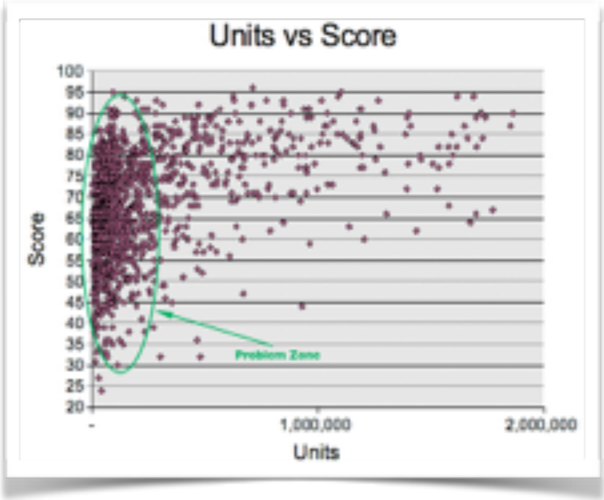
The project will further propose effective ways in which to present test results/data such that the right level of information is available to the designer/producer at each stage of the design process.

The project is intended to enable a new growth business opportunity for the SME (Seren) to support the evolution of the UK Games Industry and globally leading the field in complex UX testing.

The Relationship between game reviews, usability, and success

When users make comments in game reviews, blogs, or forums, it it very rare for a technical reason to be mentioned as a key reason for a bad review, usability / user experience is almost always the most significant factor. Why is it so important to get good reviews? Reviews drive sales and build brand identity / loyalty, which is important to drive repeat sales.





The graphs above clearly demonstrate that better reviewed games sell more units. Games with good reviews can fail (high score, low sales), e.g. the graph on left shows 19 games sold > 2M units, and only 1 game had metacritic (www.metacritic.com) score < 80%. However, it is difficult for badly reviewed games to do well, e.g. no game with metacritic score over 60% sold > 1 million units. Strong motivation for game developers to get a metacritic score above 60%.

This means it is even more important for the game industry to understand their users and what makes a game successful, and in particular how to achieve the best user experience. Key to that is testing the game design early and often in the development process, and including this testing as an integral part of the games design process. This has implications for the testing methodology to be effective, flexible, and with relevance to the games design.

USE OF PSYCHOPHYSIOLOGICAL TECHNIQUES IN GAMES RESEARCH

Problems with current usability testing methods

The application of traditional User Experience Human Computer Interaction (HCI) testing methods such as Heuristic Evaluation, Think-aloud protocol, interviews & focus groups, eye-tracking, and work-based task analysis metrics are not fully effective with video games testing as this is the focus of recreational and not functional interaction. In contrast to information applications such as e-commerce web sites or productivity software, video game software does not operate solely ac-

Productivity	Games
Task completion	Entertainment
Eliminate errors	Fun to beat obstacles
External reward	Intrinsic reward
Outcome-based rewards	Process is its own reward
Assumes technology needs to be humanized	Assumes humans need to be challenged
Intuitive	New things to learn
Reduce workload	Increase workload

cording to the general usability principles of task efficiency or ease of use. While productivity software is primarily created with functionality in mind, video games are designed for creating pleasurable and 'fun' experiences, which can stimulate cognitive and emotional processing. HCI methods apply to certain aspects of games, such as menus, navigation, and on screen information, but it is important to recognise that successful video games provide a different kind of experience. Satisfaction from task completion is a different quality than having fun. Measures of game quality focus more on positive emotional responses than on negative ones. Unlike productivity, offering a certain outcome and complexity well within user skills makes a game boring not satisfying. Gameplay requires goals that are difficult rather than easy to achieve. Testing to make something as simple as possible removes the very things that characterise a good game experience. A user experience target with 100% success rate eliminates some of the aspects that makes a game fun and immersive.

gamers seek 'fun' and 'immersion' rather than task efficiency

Observation

Observation involves watching the player interact with the game and picking up cues from their facial expressions and body language. A major benefit to using observation sessions is that they are relatively easy to conduct, and can potentially provide a rich source of data. However, whilst analysis can be performed 'live', understanding behaviour requires precise interpretation and, unless the video data is captured and reviewed, important events can be missed by researchers. In addition the presence of observers can bias results, and salient events can potentially slant interpretation. The technique is probably the most widely used in games testing due to the simplicity and success in highlighting major UE issues.

Think Aloud

A commonly used extension to observation is think-aloud or verbal reporting which involves the player describing their actions, feelings and motivations during gameplay. The aim is to get inside the players' thinking processes 'in the moment', potentially revealing unobservable details and providing researchers with immediate feedback. However, it is unprompted and many participants find it unnatural, which can affect the gameplay experience. However if the timing aspect of the game is integral to the game mechanic, then such talking will affect this. It is now widely accepted that for most video games 'think-aloud' techniques cannot effectively be used within game testing sessions because of the disturbance to the player and ultimately the impact they have on game play.

Heuristic Evaluation (HE)

This technique can be used to help identify game-specific usability problems throughout the development cycle as it is applicable to both mockups and prototypes, and it can be used to evaluate most games. However it does not address engagement and playability or emotional aspects of games; i.e. is a game fun. HE suffers with problems of subjective interpretation and is dependent on the selection and application of appropriate heuristics principles.

Interviews and Questionnaires

Interviews and questionnaires are frequently used to analyse player experience. They are generalised, convenient, and amenable to rapid statistical analysis, yet they only generate data when a question is asked, and interrupting gameplay to ask a question is disruptive. When users provide information after the play-test, rather than continuously throughout its course, their responses reflect the finished experience and therefore important issues may not be identified. The technique is also open to group biases (anchoring, social pressure, saliency, etc.).

Emotion in gaming; Immersion and Flow

Immersion

Brown and Cairns (2004) research identified three distinct levels of immersion. The first level of immersion was dubbed "engagement". To enter this level the gamer needed to overcome the barrier of gamer preference. The gamer needed to invest time, effort and attention in learning how to play the game and getting to grips with the controls. From engagement the gamer may be able to become further involved with the game and enter the second level of immersion, dubbed "engrossment", by overcoming the barrier of game construction. Game features needed to combine in such a way that the gamer's emotions were directly affected by the game and the controls became "invisible". The gamer is now less aware of their surroundings and less self aware than previously: "A Zen-like state where your hands just seem to know what to do, and your mind just seems to carry on with the story". From engrossment the gamer may be able to become further involved with the game, by overcoming the barriers of empathy and atmosphere, and enter the highest level of immersion, dubbed "total immersion". In total immersion gamers described a sense of presence, being cut off from reality to such an extent that the game was all that mattered. "When you stop thinking about the fact that you're playing a video game and you're just in a virtual world".

These broad findings indicate that immersion has the following features:

- Lack of awareness of time
- Loss of awareness of the real world
- Involvement and a sense of being in the task environment

Overall immersion can be defined as a “gradual, time-based, progressive experience that includes the suppression of all surroundings (spatial, audiovisual, and temporal perception), together with attention and involvement within the sense of being in a virtual world”

The implications for user research are that measuring immersion would require a real-time understanding of the users emotional state and relating this to the actual gameplay interactions.

When totally immersed a gamer describes a sense of presence as being cut off from reality to such an extent that the game was all that mattered

This is something that would be very difficult to achieve using purely quantitative analysis (as this does not include any emotional element), post-experience interviews (as this relies heavily on the recall of emotions), or think aloud techniques (as this would disrupt progression through the immersive states).

Psychophysiological Techniques

In the past ten years new techniques with origins in psychological analysis have been introduced to shed more light on the experience dynamics of gaming, where the user feedback is more at an emotional level, rather than the task-based efficiency of most HCI testing. Several studies have concentrated on quantitative measurement of these emotional aspects in gaming, in particular the concept of measuring ‘Fun in gaming’, along with identifying player ‘immersion” and ‘flow’ during the game experience.

Current methods for evaluating entertainment technologies. Evaluators have a lot of choice depending on their goals.

Measuring Immersion and Flow

A key component amongst the studies investigating the measurement of fun, is the identity of immersion and flow in gaming. The main proponent in achieving this is the use of psychophysiological testing methods. Commonly used methods are Electroencephalogram (EEG), facial EMG, Electrodermal Activity (EDA), cardiovascular activity including heart rate HR, and heart rate variability (HRV) are all used to present a method of modelling user emotional state, based on a user's physiology. For users interacting with complex emotional systems or technologies, such as video games, digital media, and interactive art, modelled emotions are a powerful tool because they exhibit the following benefits:

- capture usability and playability through metrics relevant to the ludic experience,
- account for user emotion,
- are quantitative and objective,
- and are represented continuously over a session.

Electroencephalogram (EEG)

EEG is the detection of electrical activity in the brain (Alpha, Beta, Theta, and Delta brainwaves):

Alpha wave power increases have been associated with cortical inactivity and mental idleness as well as attentional demand.

Beta wave activity is most evident in the frontal cortex and is connected to cognitive processes, decision making, problem solving and information processing.

Theta wave activity seems to be connected to daydreaming, creativity, intuition, memory recall, emotions, and sensations.

Whilst Delta waves are most prominent during deep sleep and could be associated with unconscious processes, such as trance.

The use of EEG in game research is currently quite spase, perhaps due to the complicated nature of the signal, which combined with a complex stimulus produces a range of methodological challenges.

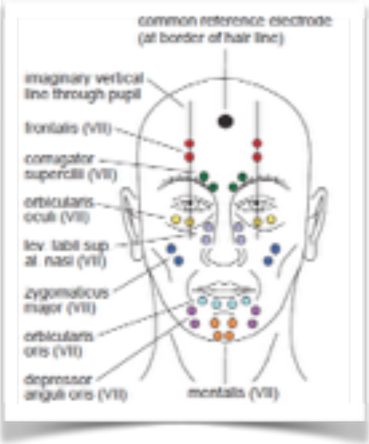
Electrodermal activity (EDA)

Galvanic skin response (GSR) now more commonly referred to as Electrodermal Activity (EDA) is a linear correlation to arousal and reflects both emotional responses as well as cognitive activity. For most people, if you experience emotional arousal, increased cognitive workload or physical exertion, your brain sends signals to the skin to increase the level of sweating. You may not feel any sweat on the surface of the skin, but the electrical conductance increases in a measurably significant way as the pores begin to fill below the surface.

Easily measured and relatively reliable, EDA has been used as an index for those who need some measurable parameter of a person's internal "state". As in EEG, there is not a clear understanding of what the measures reflect. Physiology, the EDA reflects sweat gland activity and changes in the sympathetic nervous system and measurement variables. Measured from the palm or fingertips, there are changes in the relative conductance of a small electrical current between the electrodes. The activity of the sweat glands in response to sympathetic nervous stimulation (Increased sympathetic activation) results in an increase in the level of conductance. There is a relationship between sympathetic activity and emotional arousal, although one cannot identify the specific emotion being elicited. Fear, anger, startle response, orienting response and sexual feelings are all among the emotions which may produce similar EDA responses. The sympathetic nervous system (SNS) responds to positive emotion or to anticipation of something exciting that is about to happen, the skin is mainly innervated by the SNS, making it an ideal place to measure sympathetic arousal.

Emotion has two main dimensions: arousal, ranging from calm to excited, and valence, ranging from negative to positive. Anger, for example, is likely to be highly arousing and negative in valence, while delight is likely to be mildly arousing and very positive in valence. While there is no perfect measure of arousal or valence, good approximations can be obtained by measuring arousal from the sympathetic nervous system (EDA) and valence from facial expressions (EMG).

Electromyography (EMG)



On the face, EMG has been used to distinguish between positive and negative emotions. EMG activity over the brow (corrugator supercilii : frown muscle) region is lower and EMG activity over the cheek (zygomaticus major : smile muscle) is higher when emotions are mildly positive, as opposed to mildly negative. Facial EMG is generally recorded with small surface electrodes positioned around specific muscles playing a prominent role in the expression of elementary emotions, like happiness, surprise, anger, sadness, fear, and disgust (see diagram opposite and table below).

Elementary emotions	Muscles involved	Produced actions
Happiness	• Orbicularis oculi • Zygomaticus major	Closing eyelids Pulling mouth corners upward and laterally
Surprise	• Frontalis • Levator palpebrae superioris	Raising eyebrows Raising upper eyelid
Fear	• Frontalis • Corrugator supercilii • Levator palpebrae superioris	Raising eyebrows Lowering eyebrows Raising upper eyelid
Anger	• Corrugator supercilii • Levator palpebrae superioris • Orbicularis oculi	Lowering eyebrows Raising upper eyelid Closing eyelids
Sadness	• Frontalis • Corrugator supercilii • Depressor anguli oris	Raising eyebrows Lowering eyebrows Depressing lip corners
Disgust	• Levator labii superioris • Levator labii superioris alaeque nasi	Raising upper lip Raising upper lip and wrinkling nasal skin

Game Evaluation Questionnaire (GEQ)

A questionnaire (Game Evaluation Questionnaire or GEQ) has been developed to enable testers to measure; immersion, tension, competence, flow, negative affect, positive affect, and challenge. The GEQ was developed around the following aims:

- Broad
- Easily applicable
- Robust
- Agnostic to the type of game, platform, or gamer
- Sensitive to changes in game interface, content and setting
- Reliable
- Valid

It was derived from existing game experience literature using related existing experience questionnaires and conceptualisations of game experience through focus groups. It takes the form of two large scale surveys with factor and scale analysis, and is used as a subjective self-report measurement after a player has completed a specific game, or at intervals during the gameplay.

THE IMPORTANCE OF ATTENTION

In a recent paper presented at the Games Developer Conference 2012 by Richard Lemarchand; Lead games designer at Naughty Dog, he puts forward the observation that Attention, not Immersion is better way to improve game testing. His findings are based on the games testing as part of the very successful Uncharted series of Sony Playstation games.

His observation is that immersion, in the context of TV-based video games, is too narrow to explain the reality of playing a video game and the different ways in which game designers create experiences that get and hold our attention. Suggesting this and can point us in the wrong direction when we're trying to analyse video games, especially if we start talking about being immersed in gameplay.

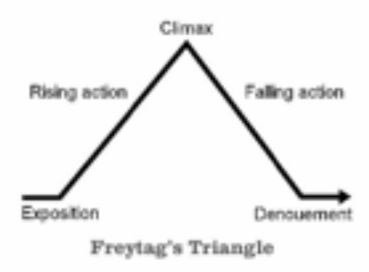
In his view a better approach is to observe 'getting attention' and 'holding attention'; "Video games entrance us by getting our attention, and then they give us what we'd call a compelling experience, by holding our attention". Loosely defined as the cognitive process of paying attention to one aspect of the environment while ignoring others, attention is one of the most widely studied and discussed subjects within the field of psychology. Different aspects of attention can have influence on gameplay.

Attention Bottleneck

This is based on the premise that the human mind can only pay attention to one thing at a time. In a multi-player environment players often attempt to steal attention by creating diversions and harassment. It is an important consideration for games designer as players will often have lots of pieces of different information to keep track of e.g. health, ammo, where the enemies and threats are etc. the designer has to take care not to overwhelm the player with attention overload.

Vigilance

The modern psychological understanding expands on this single premise to also consider our unconscious minds which are always monitoring the world for the arrival of important new information, this has been termed Vigilance. However we all suffer from something called 'vigilance fatigue', which means that, after the first fifteen minutes of paying close attention to something, we become much more likely to miss new relevant information if the sensory footprint of the new information is small or weak. This is what drives the concept of pacing in movie making and the shapes of stories often referred to as Freytag's Triangle of dramatic structure. In video games this is often handled with rotations in tone and intensities of visual activity.



Reflexive Attention

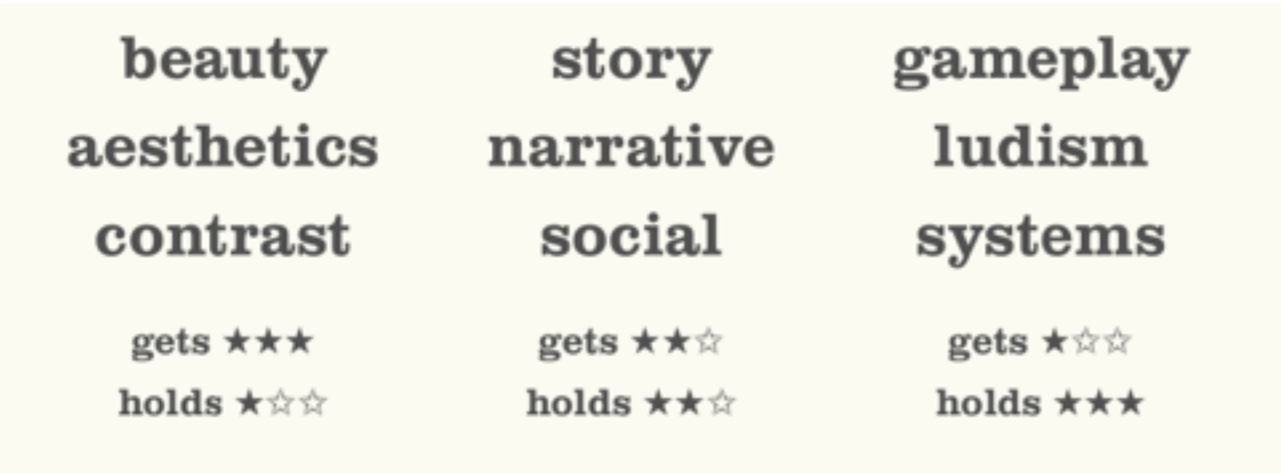
Big changes in the visual field exploit what is called the 'orienting reflex' which unconsciously attracts players attention to the screen. Sudden loud sounds and motion have the same affect, as do the mention of your name, anything that threatens your survival, and anything new and different. This takes place at the back and sides of the brain and is mostly connected with Delta and theta brainwave activity.

Executive (voluntary) attention

This is the attention that we're in charge of, which we choose to direct which we have 'executive control' over. Executive attention is one of a group of executive functions which also include problem solving and take place primarily in the front of the brain mostly concerned with Alpha and Beta brainwave activity.

Getting & Holding Attention

He goes on to conclude that the confusion around what 'immersion' and 'engagement' mean can be simply defined by saying: good video games get and hold our attention using a mix of the elements; Beauty, Story, and Gameplay as explained in the slide below:



Using this insight high-lights the potential opportunity in measuring the getting and holding of attention, and the different types of attentive behaviour as important aspects to be considered in the development of a video game testing methodology.

THE METHODOLOGY

Earlier research presented a theoretical methodology for the application of biometric feedback in game testing using a combination of psychophysiological techniques with more qualitative methods such as interviews using GEC, video analysis, and game tracking techniques.

“The continuous representation of emotion is a powerful evaluative tool that can be easily combined with other evaluative methods, such as video analysis. Given a time series of emotional output, researchers can identify interesting features, such as a sudden increase or decrease in an emotional state, then investigate the corresponding time frame in a video recording”

Using a variety of psychophysiological measures together with questionnaires present a viable research approach to gain a better understanding of the underpinnings of the subjective gameplay experience.

Moving out of the Laboratory

Moving away from the more controlled environment of laboratory testing to an environment closer to the real world was integral to the methodology and to improvements in detecting more issues, and provide more accurate response from users on the gameplay. This is especially true when considering children and teens as test subjects, and also when looking to evaluate immersion, flow and fun in games which by its very definition is achieved when users “loose sense of time and awareness of the real world with involvement and a sense of being in the task environment”. It can be argued that testing in an unfamiliar or sterile environment such as the laboratory will have an affect on whether the user is able to loose their sense of the real world to the same extent they would in a more natural environment, making the task of measuring immersion and flow more difficult.

Interpretation & Presentation

The methodology also considered the need on how to best present the wealth of data and analysis resulting from biometric feedback, captured video, game metrics, and user interviews. Further improvements in the interpretation and presentation of key data is necessary to establish an effective way to communicate results to a wider and multi-discipline audience.

Purpose & Relevance

The resent research into psychophysiological testing has recognised the need to look at the relationship between the testing purpose and game development process. This covers aspects such as the scope of testing, use for specific elements of gameplay, and integration into an agile design process.

METHODOLOGY DEFINITION

The methodology draws on the research findings into techniques used for measuring immersion and flow in video games, taking the agreed philosophy that reliance on a single measurement is prone to error, and that combining proven techniques to create a multi-modal picture or journal of events is likely to yield the best results. This presents certain technical and interpretation challenges. The method seeks to address this by starting from the premise that the user is still key to determining the underlying rationale behind an emotional event at a given time, using technology simply as a way to highlight in real-time positive or negative emotional events experienced whilst the user is playing the video game in a natural uninterrupted way possible. It is not seeking to analyse the raw biofeedback data in order to establish a cause or explanation of the emotional state, but to use this data as triggers to focus the post game interview questions. In this way the equipment used can be more simple, less expensive, and of commercial quality (i.e. subject to commercial product design processes making them smaller and more easier to use). The researcher is then able to use these triggers as key points to discuss with the user directly after the gameplay has finished, combined with reviewing video playback of the on-screen event can help stimulate user recall of the underlying rationale driving the emotion at that point in time and in the gameplay.

Non disruptive testing

A key part of the methodology is the use of portable and non disruptive biofeedback measuring equipment to support the objective of user testing in more natural environment and with minimal interference in the game play experience. The recent growth of 'quantified-self' wearable consumer electronic product category has seen the combination of physiological sensors such as EEG, HR, and movement into commercially designed products with focus on portability, comfort, and wireless data capture.

NeuroSky Mindwave (EEG)

This is a simple and easy to operate portable EEG tool to safely measure brainwave signals and monitor the users attention levels; providing PC and mobile software to give simple readings of attention and relaxation. It also comes with a developer toolkit to support development of specific applications and tools to capture Alpha, Beta, Theta, and Delta brainwave data. The headset operates wirelessly via bluetooth to a PC or mobile device so no cables are required allowing greater freedom of movement and comfort, making it applicable to use in gaming or a field environment. It is also suited to measuring multi-player or social gaming and different game interaction methods, since the player is free to move in the normal way they would when playing a game.

Brainwave Type	Frequency range	Mental states and conditions
Delta	0.1Hz to 3Hz	Deep, dreamless sleep, non-REM sleep, unconscious
Theta	4Hz to 7Hz	Intuitive, creative, recall, fantasy, imaginary, dream
Alpha	8Hz to 12Hz	Relaxed, but not drowsy, tranquil, conscious
Low Beta	12Hz to 15Hz	Formerly SMR, relaxed yet focused, integrated
Midrange Beta	16Hz to 20Hz	Thinking, aware of self & surroundings
High Beta	21Hz to 30Hz	Alertness, agitation
Gamma	30Hz to 100Hz	Motor Functions, higher mental activity

NeuroSky Mindwave Results

Initial testing using the Mindwave headset during a 30 minute video game session using several highly acclaimed (Metacritic.com scores above 80) PS3 video games from different genres, with sequences that users had chosen due to previous positive experience as being extremely exciting and fun to play. Each gameplay session was observed and recorded and the time noted when subjects appeared to reach high levels of immersion or focus within the 30 minute session.

During each of the sessions the output of the Mindwave headset was monitored using the Unity Technologies “Visualize” application which presents brainwave frequency data as both a series of coloured bar charts and as a spider graph indicating the relative degree of Delta, Theta, Low Alpha, High Alpha, Low Beta, High Beta, Low Gamma, and High Gamma frequencies present at that moment in time. The application also includes an algorithm to interpret the brainwave data into a percentage level of Attention and Meditation achieved.

The Visualize data was captured as a continuous screen recording during the session along with the video recording of the user activity and video game screen. Reviewing the user activity video and conducting post game interviews identified key moments during the gameplay when the user felt most immersed and focused in the game, correlating this to the Visualize data at that time revealed the Mindwave indicating a high percentage attention score and corresponding high Beta brainwave readings. The evaluation revealed a greater than 80% correlation between high focus/ immersion events identified from user gameplay video / post game interviews and the brainwave data captured using Visualize at that time.

The key mental states that the Mindwave is able to easily differentiate are attention focus (high Beta wave activity) and relaxation (high Alpha and Theta wave activity), although other states could be interpreted from a more detail analysis of the Mindwave frequency data.

The initial testings indicated that whilst the Mindwave headset is applicable for use in gameplay testing within a more natural environment, and able to provide key event triggers of a heightened emotional state (attention or relaxation), the design of the Mindwave with the single frontal electrode meant that after 15-20 minutes of use it became uncomfortable to participants, which resulted in some tendency to adjust the headset resulting in that segment of the data capture to be null and void. The setup of the Mindwave was also prone to bluetooth pairing problems - prolonging the initial set-up time and allowing the participant to become agitated. Whilst the continual on screen recording of the Visualize EEG data presentation tool was sufficient to observe key trends in brainwave activity (visual patterns of spider graph and the needle levels for attention and meditation) it was not sufficient to allow a greater degree of analysis in relation to specific brainwave activity, time spent in each brainwave pattern and the direct coloration to the other biofeedback measurements, and on screen game play.

MyndPlay Brainband

This is a product that is based on the same sensor, data analysis, and electronics as the Mindwave product but commercially targeted as a more relaxation product, as such the design of the headset is more comfortable for long periods, being a flexible headband construction. The data analysis tools available with the product also provide a much greater range of options:

- Real-time live feed activity screen with time markers
- Real-time bar graphs of frequency activity
- Blink recording and sensitivity adjustment
- Record, Save and playback raw brainwave data
- Attention/Meditation and Zone indication levels
- Built in Analytic's tool
- Export of raw Brainwave data to CSV function

EDA or GSR Measurement

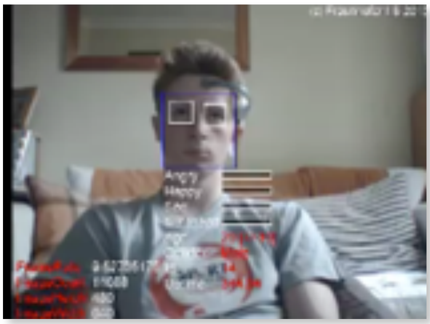
Advances in EDA measurement equipment have also adopted wireless technology leading to much greater comfort and freedom of movement for the participant, to extent that users become unaware of the measurement device, enabling several hours of test data to be captured (user can wear the device all day), and greater support for in field testing.

Other commercially available GSR products share some of the same characteristics (easy to set-up, use, and including PC tools to present and record the data). As EDA is now a well proven and reliable technique in measuring arousal, less disruptive equipment are able to respond to a users change in emotional state and present this as a measurable output, whilst allowing the testing to be conducted over longer periods, or in a more natural gaming environment.

The output of the GSR provides a visual indication of the users level of arousal e.g. excitement or boredom.

Facial Tracking as Alternative to Facial EMG

With the increased power in computing it is now easy to use simple cameras connected to a PC running facial tracking software to not only recognise peoples' faces, but to apply facial EMG analysis to provide an indication of the persons emotion. One such software application is: SHORE™ - Sophisticated High-speed Object Recognition Engine developed by the Fraunhofer Institute:



Analysis of; Gender, Facial expression („Happy", „Surprised", „Angry", „Sad"), Open / closed eyes, Open / closed mouth. Without the need to use physical electrodes attached to the face enables easier field testing and less interference to the natural gameplay experience. The software is also able to track and monitor multiple faces on the screen so is ideal for multi-player games. It is also possible to use the software to analyse pre-recorded video of the facial movements, such that if equipment is only available to record the players face during the testing, this can be later analysed for emotional content.

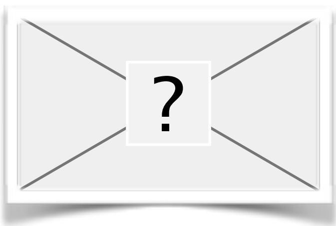
Facial expressions are generated by contractions of facial muscles that deform facial elements such as eyelids, eyebrows, nose, lips and skin texture. Facial tracking software extract discriminative information about the deformation of these facial elements from a discrete set of locations in the face, the discriminative information is then fed into a classification algorithm to recognise the facial expression.

Sensor technology, application and use

To ensure that the biofeedback data generated from EEG, EDA and facial EMG was reliable, robust, and simple enough to allow easy setup, operation, capture, and data analysis, each sensor type was investigated in terms of the different properties, challenges, application, and available options in order to select the best possible combination for an effective methodology.

EEG

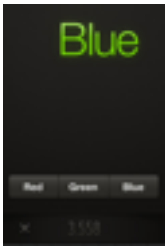
In selecting to use the Neurosky technology further research was conducted to ensure it was capable of providing the necessary sensitivity and responsiveness required. A study by Katie Crowley, Aidan Sliney, Ian Pitt, Dave Murphy [Evaluating a Brain-Computer Interface to Categorise Human Emotional Response] evaluated NeuroSky's Mindset headset as a minimally invasive method of measuring the attention and meditation levels of a subject. Two psychologically-based tests (The Stroop test and The Towers of Hanoi) were conducted to assess the suitability of the headset to measure and categorize a user's level of attention and meditation.



The Stroop Colour-Word Interference Test (Stroop, 1935) is a well-known psychological test of selective attention, cognitive flexibility and processing speed, often utilised as a psychological or cognitive stressor. The assessment requires the subject to name the colour that is displayed and not the word i.e. to identify the colour stimulus and not the word stimulus.

The paper concludes that “ The data collected from the headset during the Stroop and Towers of Hanoi tests clearly demonstrate NeuroSky’s suitability as a minimally invasive means of measuring the attention and meditation level of a subject. Both tests in this study show that the attention and meditation datasets outputted by the headset clearly indicate when a subject undergoes a change in these emotions.”

In evaluating the performance of the Neurosky technology, I conducted my own version of the Stroop colour test on 3 volunteers (including myself) to establish the effectiveness of the sensor to measure selective attention and cognitive flexibility and how well this is transferred to recording software (via the Visualise application). The results confirm the findings in the paper that an increased attention level is consistently observed when the user is attempting to name the colour and not the word that randomly appeared using an iPad App (EncephalApp - Stroop Test).



However the Visualise utility proved difficult to establish the brainwave nature associated with the increased cognitive load.

Separate tests were conducted using the MyndPlay brain-band, to establish if this would be a better option to use. On final analysis the Myndband proved more effective as a result of:

- ease of fit, setup and comfort for the participant (especially over prolonged periods of use)
- strength of signal and sensitivity having 2 electrode contacts
- data analysis tools that provide access to raw brainwave data, graphical analytics, data summary (on a session basis), and the tracking of attention / meditation / Zone indicators provided with the Neurosky chipset algorithms.

EDA

In exploring the different aspects of EDA measurement a number of challenges were encountered:

- placement of the EDA sensor
- wireless data capture

Sensor Placement

There are only certain areas of the human body where you can measure the sympathetic nervous response. The most commonly used and areas that provide the best sensitivity are on the finger tips, palm, or wrist. Other areas which are less responsive are on the upper arm, feet and back of the head. In order for the electrodes to pick up the changes in skin conductance they need to be in direct contact with the skin. Using the upper arm and feet was felt to be too intrusive for testing, similarly the back of head would need to be shaved to make this a viable location.Attention was focused on the fingers,

palm and wrist. As the player will be using their fingers to interface with the controller during video game play, this area was eliminated as providing too much impact on the gameplay experience. In performing evaluation EDA tests between the wrist and palm, the wrist was seen as the ideal location as it is easy and comfortable for user to wear during testing, and has no interference with the game play. Exploring different products that enable EDA measurement on the wrist two possibilities were found:

Afectiva Q-Sensor

This is a unit that has been developed by MIT for continuous monitoring of users GSR level, and whilst providing a comfortable wrist band it also uses wireless technology to transmit the data and has advanced data capture software. Unfortunately the £1000 cost and the fact that the product is no longer available meant that this could not be used.

Shimmer3 GSR development Kit

This provides a wearable wrist GSR measuring device with wireless capability, along with sensors that can be attached to the base of the finger, and supporting data analysis software. However due to the £1000 price for all the necessary device, sensors, wireless transmitter, and software this was outside the budget for this project. Also the need to still have the sensors located on the fingers presented usability issues with video game testing.

Thoughtstream USB

Whilst this device is not wireless and the electronics are quite bulky the sensors are easily placed on the uses palm and there is sufficient length of cable that the data processing unit can be clipped to users belt or on a sport arm band normally used to secure an iPhone to a users arm whilst exercising. The device is equipped with a USB interface which allows continuous and recorded monitoring of the GSR data. Future developments to make the device more usable are to house the sensors in a fingerless glove making it easier to put on. Re-housing the electronics directly into the arm band and fitting Bluetooth USB adaptors to provide wireless transfer of the EDA data to the PC.

Facial EMG

Whilst there are many different solutions available for facial recognition software, very few have the built-in algorithms to use face tracking data in providing EMG analysis. Fraunhofer Shore solution has been developed over several years and using a wide range of facial expression analysis and provide a free sample software which was sufficient for the needs of the video game testing. During early testing the accuracy and effectiveness of the facial EMG was dependant on a number of factors:

- camera image quality
- position of the face within the camera

Early testing was conducted using the Playstation eye camera, however the image quality and control aspects (ability to zoom or focus on specific area of the image) reduced the performance of the EMG data results. Different USB cameras were evaluated and it was found that those which supported a higher resolution and more natural image performed better. Also the ability to have software that can be used to fine tune the image in terms of the relative position of the participants face within the overall image and ability to set focus on the face area of the image, improved the sensitivity of the EMG results. The final camera chosen to use for the testing was the Microsoft LifeCam Cinema HD.

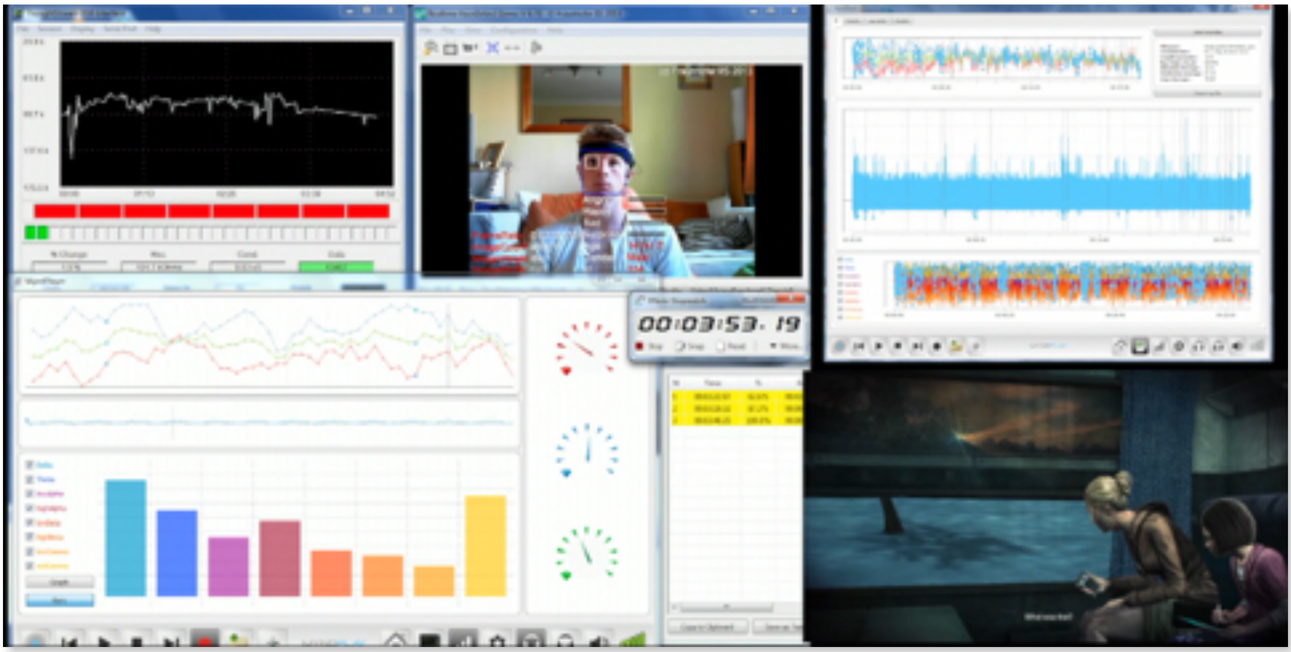
Capturing the data and continuous recording

The facial capture does not require expensive cameras and can easily be achieved using actual gaming equipment that may be present, or indeed used as part of the game, such as Sony Playstation Eye camera, or Microsoft Kinect. This data along with the Myndplay and GSR-Sensor output can be then be continuously recorded in real-time using standard screen capture software such as iShowU, for as long as an average user would play the game.

With the rise in Youtube videos and player walkthroughs commercial games console recording equipment are now widely available that capture the screen play in high definition. With normal video camera equipment it is also possible to record the players movements during the session.

Compiling the data for easy analysis

When capturing the real-time recording from each of the biofeedback data streams (EEG, GSR, and EMG), it is important to include a time reference marker, for the testing a free version of XNote stopwatch for PC was used. This can then be used to relate biofeedback events with in game activity and enable a compiled video edit of the session to be created by combining the biofeedback data screen capture with the video game sequence and user activity, the end result is a continuous time stamped recording of the players psychophysiological activity, in sequence with the actual game video output and player movements. A video frame from the combined results for a video game test session is shown below:



In addition to having a timer reference a mechanism was needed to allow the observer to easily record time-stamped event triggers that could then be used later during the video-cued recall interview stage to quickly refer to key biometric or game events This was achieved using the snap feature of the Xnote stopwatch which the observer could click on for each significant change in Biometric data:

- sharp rise or fall in EDA activity (indicting an increased arousal or return to relaxed state)
- the presence of a high facial EMG state e.g. Happy, sad, angry, surprised
- a high EEG reading for attention, relaxation, or zone

The methodology also provided a mechanism, via the Myndplay recording software to tag any significant video game player events directly against the recorded output for the players attention / relaxation / zone levels. This was used to capture specific in game aspects such as when a players character dies (fist person shooter) or car crashes (racing game) or level achieved, puzzle solved, fight won etc. This allows easy analysis of key in game events in relation to the users physiological state at that time and provides a means to track user levels of engagement / immersion against game design elements and level progression.

Test Session Protocol

The test session procedure for the methodology was evolved and refined by examining each step of the session flow definition, and understanding how this relates to previous and next steps, what can be done to streamline the procedure and that it enables the easy and quick set-up and implementation of the test session. The final test procedure document is provided in the appendix, the steps involved are:

Procedure

1. Welcome participant & explain purpose of the test

2. Ask participant to fill out and sign the consent form *[form listed in Appendix]*

3. Ask participant to complete pre-session questionnaire *[this is to establish a level of understanding of the participants video game experience, preferences, and if they have played the video game on test and what skill level they are. Also it establishes their mental alertness and tendency for game immersion. The questionnaire is shown in appendi]*

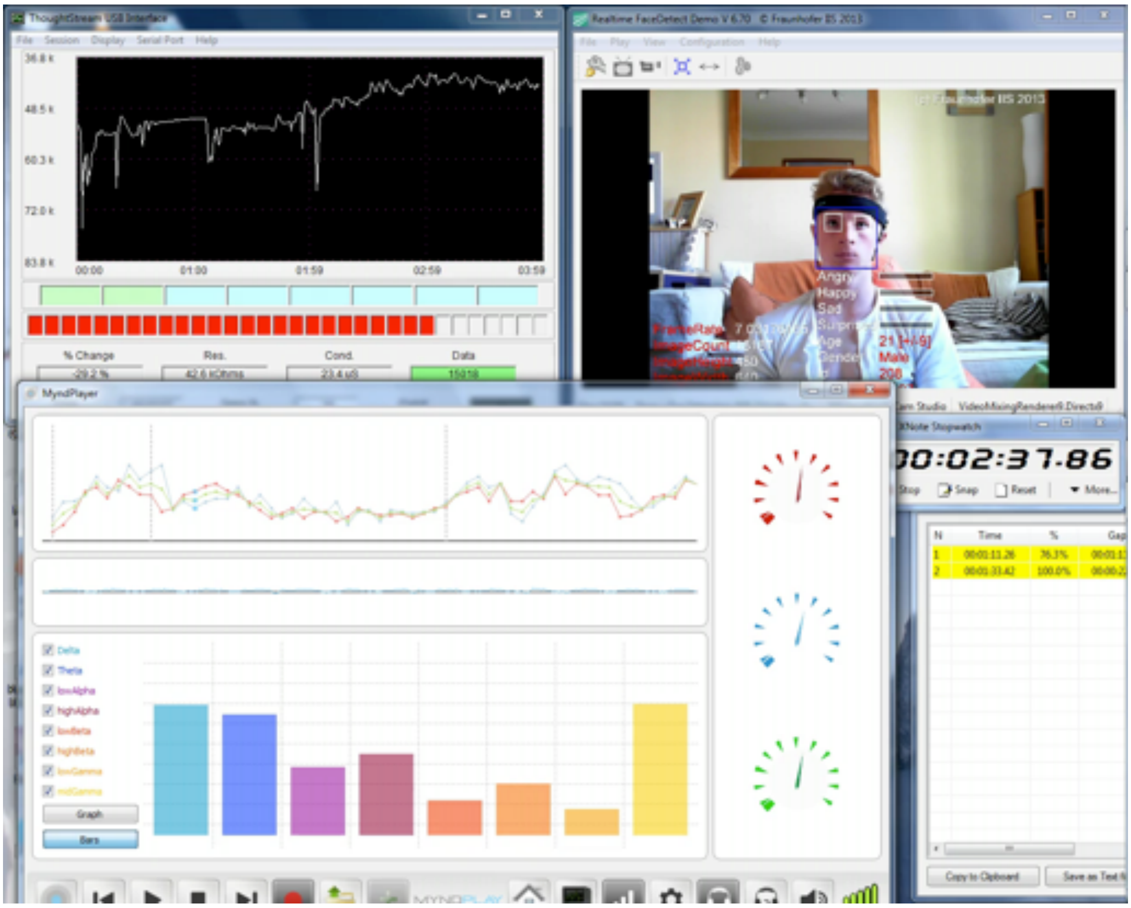
4. Measure & record participant Pre-session heart rate level; (using iPhone app) *[this is used to established their relative level of relaxation at the beginning and repeated at the end of the session.]*

5. Ask Participant to get comfortable on the beanbag in front of the TV screen. Fit Myndplay headband on user - check comfort & signal working (PC Bluetooth drivers loaded correctly)

6. Fit EDA sensor to users palm of right hand (less involved in game control). Check signal and comfort. Record the ambient room temperature (necessary to calibrate EDA signal level). Perform EDA validation by asking participant to take 2-3 sharp intakes of breadth and check there is a corresponding rise in EDA response. If no response observed record participant as may be a EDA non-responder. *[a sharp intake of breadth is related to changes in the sympathetic nervous system which the EDA sensor is measuring - so acts as a validation the sensor is correctly fitted, data recording is OK, and importantly the participant is not a EDA non-responder which effects a small % of people where their sympathetic nervous system does not result in changes in the sweat glands. This would mean that the EDA data for this participant is not used as part of the biofeedback analysis]*

7. Arrange web-cam & launch face-detection software. Check that user face is occupying ~80% of screen and being tracked with good signal; recorded sex and age levels are accurate. Ask user to smile and give surprised look (mouth open). Check software is detecting the correct facial EMG response.

8. Launch and arrange software into pre-assigned quadrants on recording PC (EDA, EMG at top; EEG at bottom – select the Myndplay stats screen). Launch stopwatch app (XNote) and arrange to bottom right of screen (as shown below):



9. Launch screen capture software (ensure full screen capture mode, and audio is captured from web-camera, and the output folder is set as raw).

10. Launch the PS3 console game and navigate to the correct level, and start point for the session.

11. Open the Elgato games capture software on the Mac laptop. Check the game screen image is displayed and the capture settings are 720p.

12. Set-up external camcorder to record participant during the session (check power and storage capability is sufficient, and that audio levels are OK – have participant speak to confirm); start the recording now.

13. Start the Myndband software session recording, start the EDA software session recording.

14. Synchronise the start (hit buttons at the same time) of the Mac game capture recording, the PC screen recording software, and the Xnote stopwatch. Check time counter on both game capture software and PC capture software are in synch. *[It is important to have the time reference synchronised so that the recorded biofeedback data relates to the real-time game play actions, and the two video streams can be easily combined into a single time-line output during post-processing of the results]*

15. Ask participant to begin playing the game. They should be encouraged to relax and play in the normal way they would in their home environment.

16. Moderator records key game events during the playtest; e.g. when they get stuck, character dies or requires reset, or if they verbalize any positive or negative emotions. This is captured using the real-time mark feature of the Myndplay software in addition to any written notes.
17. Moderator records, using the snap function of the Xnote stopwatch, each significant Biometric (EDA, EMG, EEG) event, for later analysis.
18. After the specified duration of playtest has been reached the participant is asked to stop playing where they are in the video game.
19. Stop the screen recording, game capture, and camcorder.
20. Measure & record the participant post session Heart rate level (using same iPhone app)
21. The participant is asked to then complete the GEQ part 1 & 2 questionnaire on the laptop. Explain that part1 relates to the experience during playing the game and part2 to the experience after playing the game. *[THE Game Evaluation Questionnaire GEQ is used to understand if the user appeared to enter an immersive state during the session, and what their overall impression of the video game experience was - which is useful to supplement any biofeedback findings and analysis]*
22. Review the captured biometric event trigger log and Myndplay gameplay event log with the participant. Using the 'during game' questionnaire as prompts any significant event triggers and areas of game play are reviewed with the participant using post-session video-cued recall method where the participant is shown the video game capture at the noted times and asked to 'think aloud' as to what they were feeling at that time and why. Record the participant's audio responses using iPhone audio recorder.
23. Thank the participant and save all files. Transfer raw files to the external archive HDD within the specific participant folder ID for later post-processing and analysis.
24. Prepare the equipment and computers for next participant.

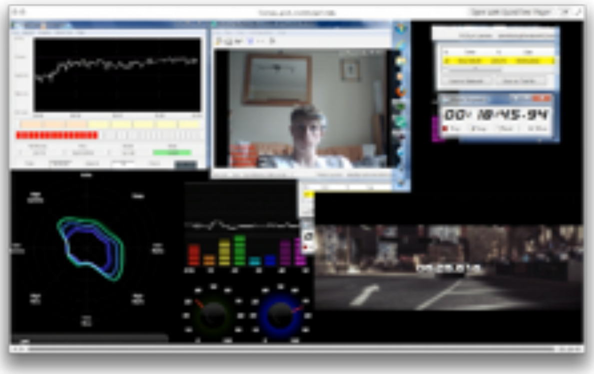
TEST SESSION RESULTS

The test protocol methodology was successfully used to playtest several video games from different genres. The play test sessions lasted up to 30 minutes and served to provide the following information:

- validation of the methodology design, test protocol and supporting test documents
- identification of key usability issues and overall game experience
- analysis of biometric data patterns against the GEQ results to determine levels of immersion and flow with the game experience
- input to further video game test designs to explore relationship between biometric data and game genre, meteoritic score, and game design elements

Testing with Grid2 (Racing game)

In order to evaluate the biofeedback methodology with a racing style video game, Grid2 (Metacritic score = 83) was selected as is represented a proven and successful game of its type and could be set-up so that the same circuit, car, level is experienced by each participant. This also enabled the testing to be easily repeated with the same participants but with variations in the test design, sensors, and protocol to help refine and establish the best testing parameters.

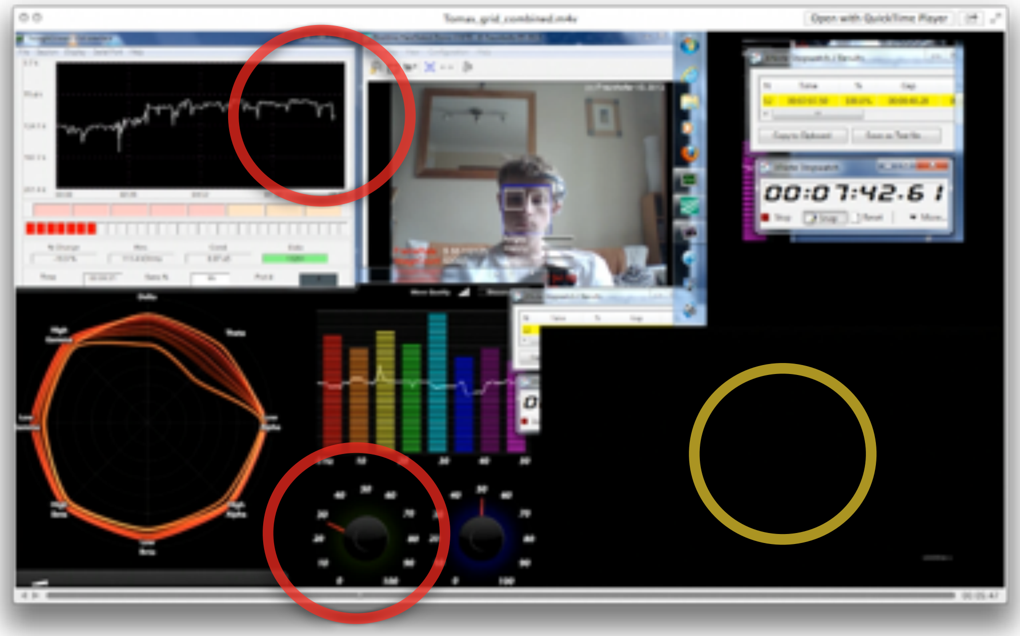


Grid2 Results

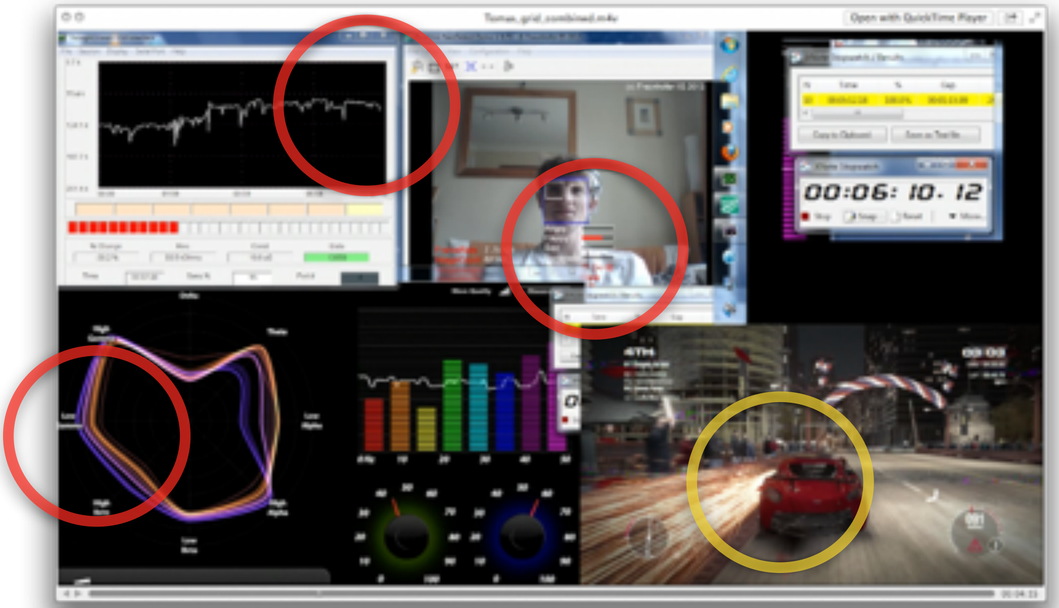
Participant					
Tomas	Duration	Observed Biometric events	Observed Gameplay events	EEG sensor	Video cued test Summary

Participant					
Race 1	6m	11	12	MyndPlay Brainband	Good correlation between the biometric events and the observed events relating to cognitive activity resulting from crashes, overtakes, or restarts
Race 2	18m	25	11	Neurosky Mindwave	Biometric data also high-light emotional responses related waiting (for restart), frustrations, poor controller response, and excitement (improved cornering)

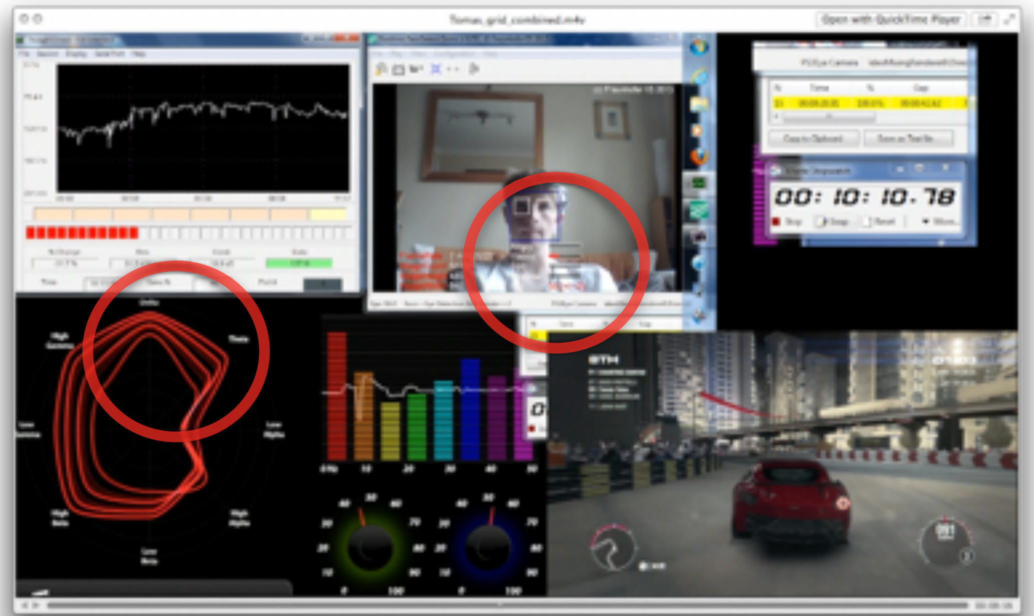
The testing was able to both establish good correlation of biometric events (increased EEG attention and or meditation levels and rise in EDA levels) with the gameplay observations for race start, car crashes, overtakes, reset function, and race finish). With the longer test session the methodology was able to provide double the amount of observable events, when interviewing the participant during the video cued recall analysis revealed more emotional level events related to the wait times (decline in attention and EDA levels):



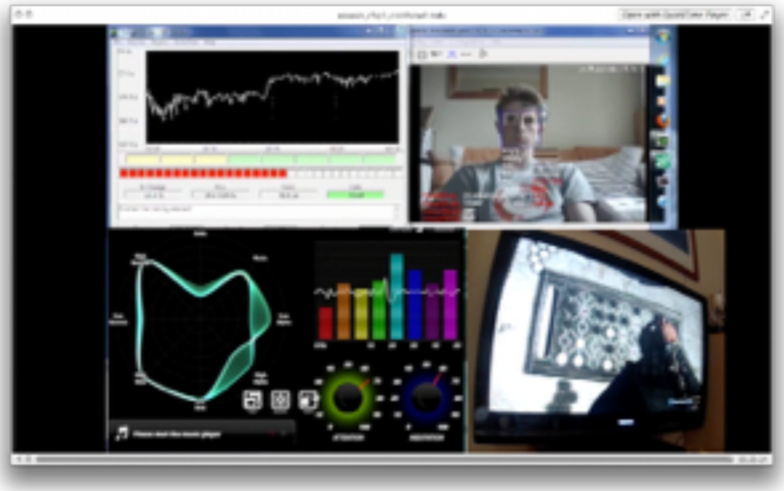
Unexpected controller response to player action i.e. steering, breaking and accelerating (rise in EDA level and high Beta and Gamma activity plus presence of happy or surprised EMG state):



and the player excitement experienced with improved learning of the car and controls reflected in improved cornering speeds and lap times (presence of Beta with Theta brainwave activity along with presence of happy EMG state):



Testing with Assassins Creed 3 (RPG game)

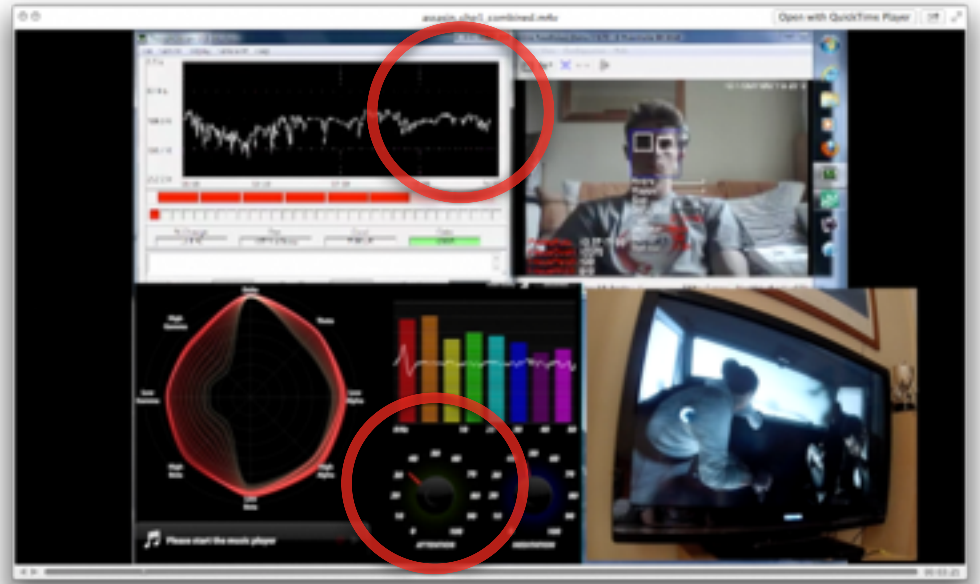


This game title was chosen to provide data on a RPG style game which had not been previous played by the participant, and to evaluate the first 30 minutes experience of a new game revenant to game design elements; story, cut-scenes, level build up, game mechanic introductions etc.

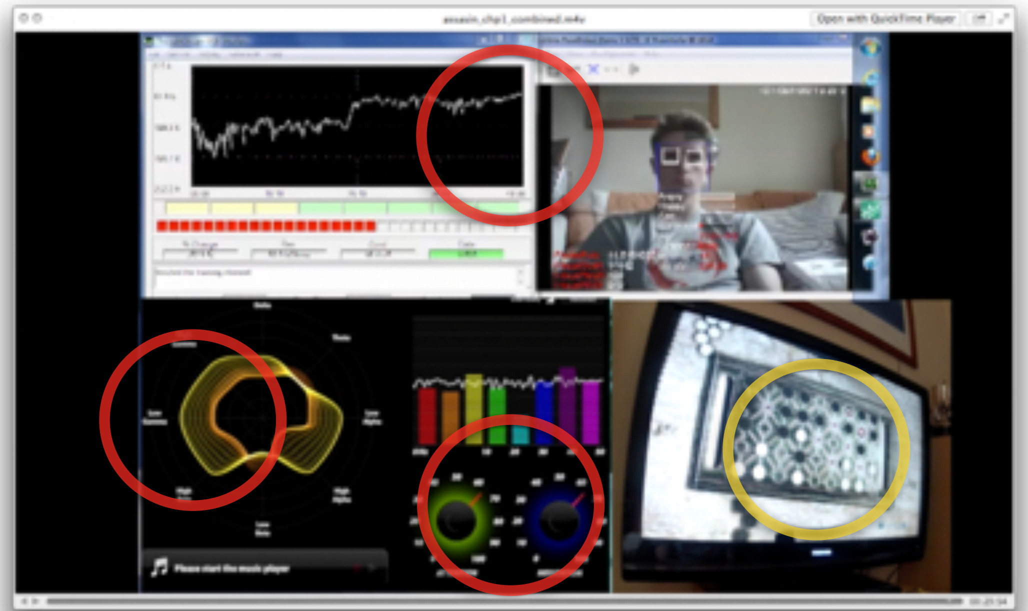
Assassins Creed 3 Results

Participant					
Tomas	Duration	Observed Biometric events	Observed Gameplay events	EEG sensor	Video cued test Summary
Results	30m	22	12	Neurosky Mindwave	The biometric events were able to capture elements of growing boredom with length cut scenes and growing frustration with the complexity of the first puzzle element, in addition to observed experiences

The testing was able to use the captured biometric events with the video cued recall to high-light a growing level of boredom with the extended cut scene at the start of the game (slow steady decline in EDA and attention levels after initial sharp increase related to the anticipation of playing the game):



Also the biometrics (via steady rise in EDA levels plus high Beta & high attention/meditation activity coupled with the video-cured recall analysis revealed a growing frustration surrounding the perceived complexity of the first puzzle test:



FIT WITH OBSERVATIONAL PLAYTESTING

Current Playtesting methodologies

The most common way of playtesting games within the video games industry is using Direct Observation, Verbal Reports, and Q&As. The main reasons for this are due to the relatively straightforward and simple way to conduct the play testing, and the relative success at high-lighting major usability issues. However the effectiveness often depends on the skill of the observer, is subject to bias and may not high-light emotionally driven usability issues, which often factor when players post reviews on the game experience.

Many of the larger game companies are also using sophisticated tracking software built into the prototype games to capture every detail about the on screen interaction such as kills, ammo used, path taken, achievements etc. to build up a detailed picture of where users seemed to encounter the most problems. Whilst this provides good feedback on the effectiveness of the game design and game elements, it does not provide information on how fun the game is, and how this might compare to other similar games.

Playtesting with Biofeedback

The biofeedback methodology outlined in the previous testing protocol section is designed to be used in conjunction with any of the above current play testing methodologies to provide additional insight into the users psychophysiological state and offer biofeedback event triggers, which can be used to supplement the direct observational analysis to uncover more usability issues, especially those that cannot easily be observed via human physical response and often relate more to emotional aspects of the game experience, whilst offering the ability to test in a players more natural environment without excessive intrusion.

Limitations and Commercial Requirements

In designing the current biofeedback methodology it is know to suffer from the following limitations:

- EDA measuring device and sensor could be less cumbersome and intrusive to more effectively fit with the methodology
- Conducting the testing session ideally requires two people as presently the on screen game information is captured separately to the biometric data and observing these two interfaces is best managed between two people
- There is quite a heavy cognitive load on the observer to manually track the biometric data for anomalies and to time stamp this via the Xnote interface and capture observational notes, in addition to manually monitoring and noting significant events during the game play.
- Initiating the time synchronisation of the data recording between the biometric data and the game play screen is manual process and subject to human error.

- creating a single time-synched video stream combining the biometric data readings along with the on screen gameplay action requires time intensive post-processing video editing.

In order to make the biofeedback methodology work more effectively in a commercial environment with current direct observation techniques it would benefit from the following improvements:

- evaluation and design of more wearable wireless EDA sensor equipment to improve this part of the biofeedback testing
- explore or create specific software to combine the biometric data elements as well as the real-time data recordings and output from the game play - in order to reduce the need for time consuming post-processing activities
- create software which can automate the event triggers and capture associated time-stamp and observational metadata using logic which can track the specific biometric data components and create/log an event based on assigned threshold limits, adjusted according to the playtesting session. This would reduce the current high cognitive load, prior knowledge, and 2 person operation associated with the methodology in looking at several data feeds for significant biofeedback changes, as well as tracking the on screen game play events.
- create a single start operation to automatically time synch the data recording from the biometric suite and the gameplay on-screen video

TEST DESIGN (GOING BEYOND OBSERVATIONAL ANALYSIS)

Video Game Genre

With the test protocol established and evaluation of sensor technology, use, application and data capture to provide sufficient data modelling to observe changes in the psychophysiological state of a video game player during a normal (up to 30 minutes) gameplay session. The next step was to design a test programme that would help apply this test methodology to understanding the use and interpretation of biofeedback data as part of video game and complex user interaction testing. As a starting point it was clear to establish if there was significant variation in observed biofeedback results due to the type of video game being played. How would the identification of immersion, flow, and attention types vary between different video game genres. To understand this the testing methodology was applied to the most common game genres identified in the top 20 best selling games:

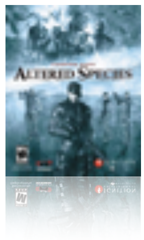
- First Person Shooter (FPS); Half-Life
- Action (survival); Last of Us
- Role Playing Game (RGP); Skyrim
- Car Racing games; Grid2
- Sport games; FIFA 13
- Visual aesthetics; Journey

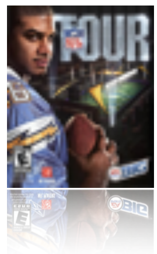
Metacritic score (good vs bad games)

In addition to genre the methodology was also used to test known positive and negative game examples as indicated by their Metacritic scores. (metacritic.com carefully curate a large group of the world's most respected critics, assign scores to their reviews, and apply a weighted average to summarise the range of their opinions. The result is a single number that captures the essence of critical opinion in one Metascore). In testing games which have overall positive reviews this established biofeedback references for a good gameplay experience (within that genre), and similarly those with overall low scores created a biofeedback reference where poor gameplay usability exists. These references where then analysed to look for patterns, trends, or key similarities in the biofeedback data that can provide clues or insight into common elements that exist for good and successful video games versus those traits that exist for poor and unsuccessful video games.

For each of the previous games tested against genre, an associated low Metacritic score game was also chosen for comparative testing:

- First Person Shooters (FPS); Rogue Warrior
- Action (Survival); Amy
- Role Playing Games (RPG); Vampire Rain: Altered Species
- Car Racing games; Fast & Furious: Showdown
- Sport games; NFL Tour
- Visual aesthetics; Vampire Rain: Altered Species

Game design elements

In addition the biofeedback methodology was used to test the effectiveness of specific game design aspects, using forums and blogs to identify elements that have know to be successful and those that have know to present problems for users:

- video game story (specifically cut scenes),
- visual style and graphics
- level progression & challenge
- game interaction clues or direction

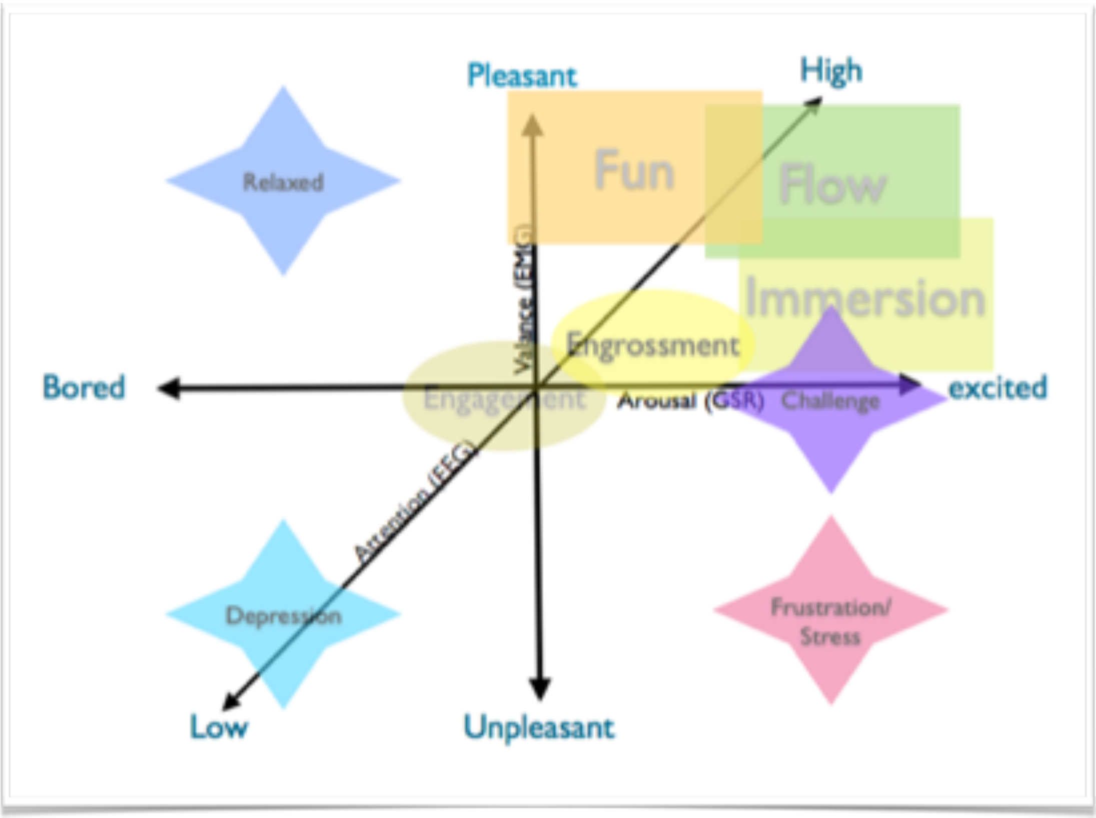
This was used to establish the effectiveness of the methodology and use of biofeedback data in the determination of successful game design elements, as well as being used to evaluate overall gaming experience.

ANALYSING THE RESULTS

It was clear with the large amount of data and information being produced from the biofeedback video game testing (30 minutes of captured video for EEG, EDA, EMG biometric data, plus on screen gameplay, and player observational session video), that a structured method to analysing and interpreting the results was necessary.

Pattern Template Method

In order to look for patterns it was first necessary to define a theoretical relationship between the biometric levels for EEG, EDA, EMG, and the understood psychophysiological state. With reference to my previous research which presented a mapping of biometric states for EDA / EMG / EEG to player mental state of Fun / Flow / Immersion / Engrossment / Engagement / Challenge / Frustration:



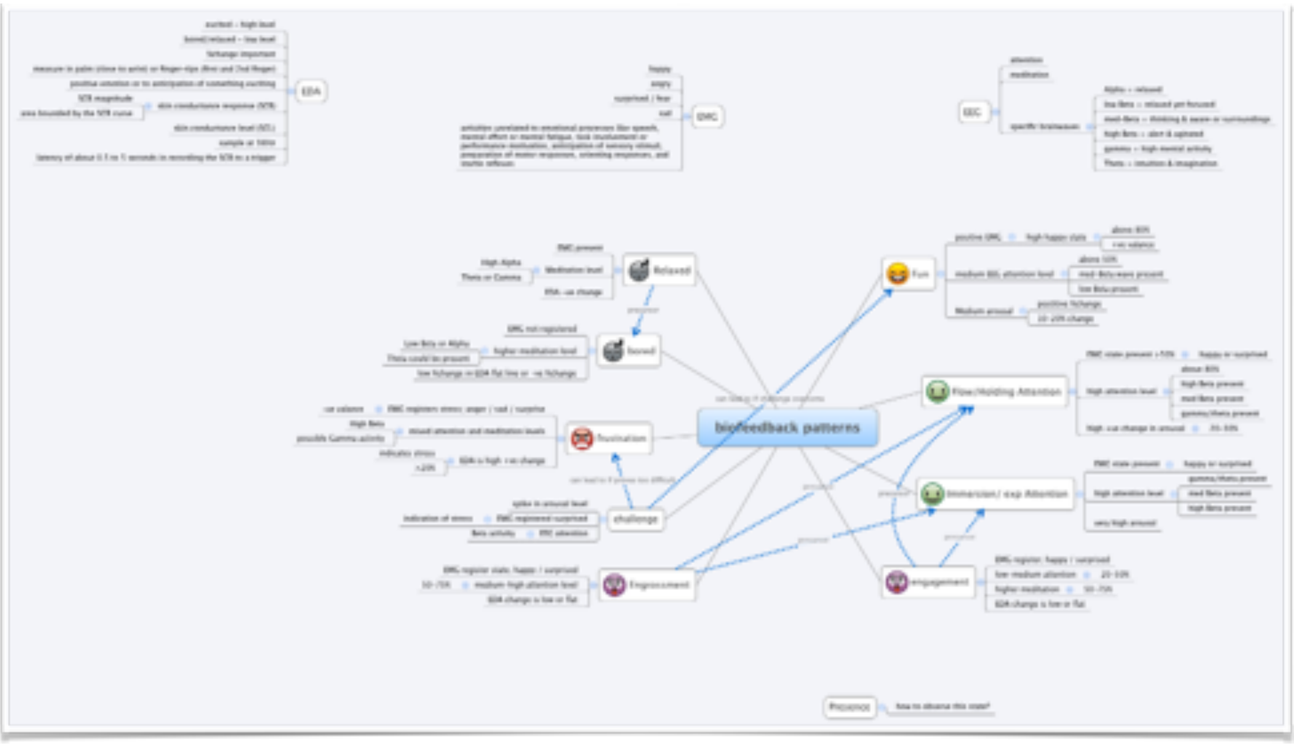
EDA/GSR (x-axis arousal); there is a well proven relationship between sympathetic activity and emotional arousal, although one cannot identify the specific emotion being elicited. Fear, anger, startle response, orienting response and sexual feelings are all among the emotions which may produce similar EDA responses, however an increase/decrease in EDA level can be associated with player excitement / boredom emotions.

EMG (y-axis valance); there is a clear understanding of the relationship with the facial muscle responses and the emotional valance levels ranging from unpleasant to pleasant.

EEG (z-axis attention); is the most difficult area to map, however there are understood relationships between various brainwave activity and human mental states and conditions as show in the table opposite. In addition combinations of brainwave activity can be related to cognitive load shown with attention and meditation levels.

Brainwave Type	Frequency range	Mental states and conditions
Delta	0.1Hz to 3Hz	Deep, dreamless sleep, non-REM sleep, unconscious
Theta	4Hz to 7Hz	Intuitive, creative, recall, fantasy, imaginary, dream
Alpha	8Hz to 12Hz	Relaxed, but not drowsy, tranquil, conscious
Low Beta	12Hz to 15Hz	Formerly SMR, relaxed yet focused, integrated
Midrange Beta	16Hz to 20Hz	Thinking, aware of self & surroundings
High Beta	21Hz to 30Hz	Alertness, agitation
Gamma	30Hz to 100Hz	Motor Functions, higher mental activity

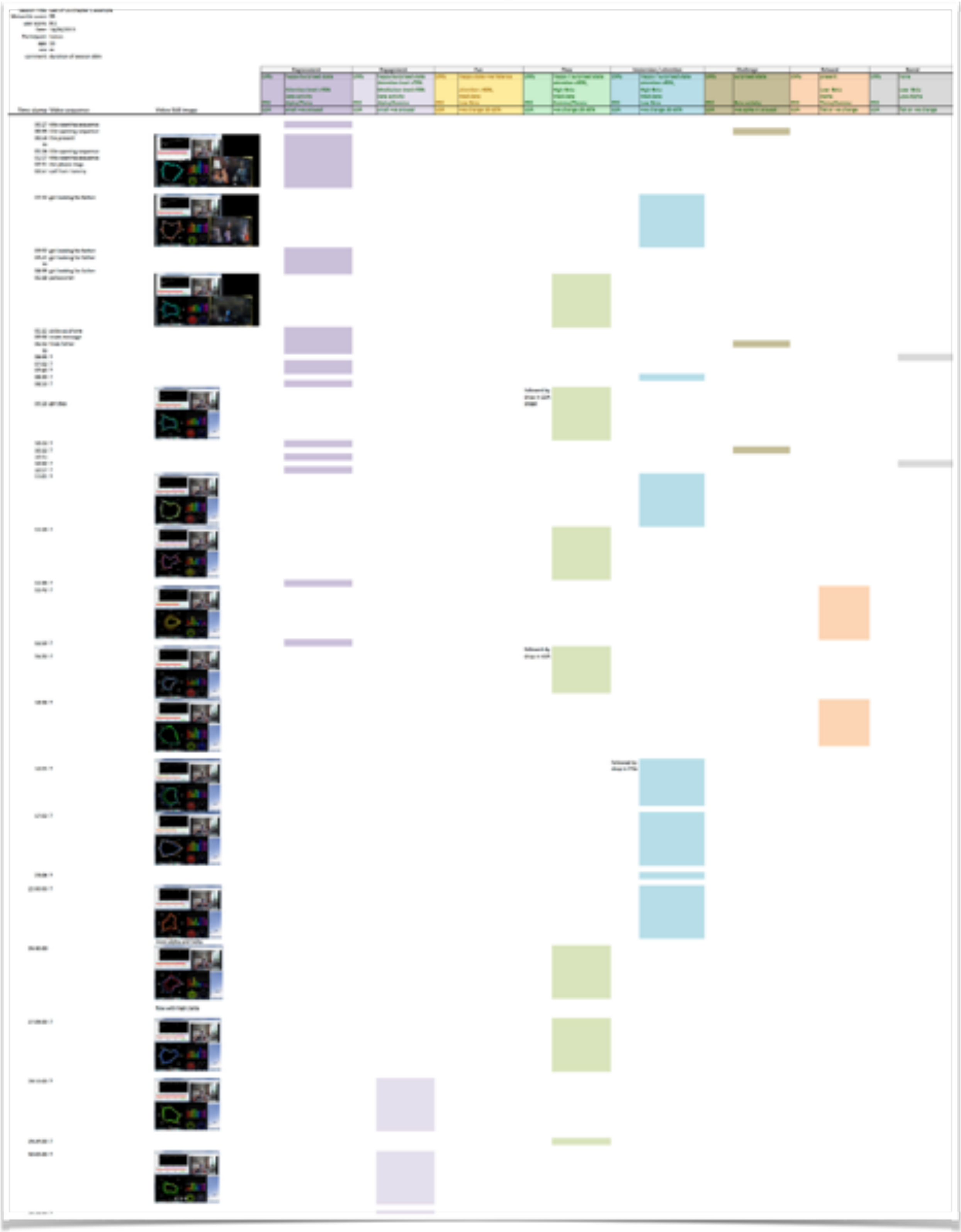
The mind map below shows the mapping of theoretical biometric conditions against the emotional state based on my previous research work (shown previously) and the understanding of how different biometric signals correspond to an emotional response.



Using this as a template I was then able to analyse the results from previous video game testing to establish when the biometrics conditions where being met (within certain parameters) against the corresponding mental state. This was able to show at what point during the game the player was perceived to be in a specific emotional state and relate this to the game play activity, any identified biometric event and video cued recall information. The analysis for Assassins Creed 3 is shown below.

This suggests that the player entered engrossment state followed by engagement state on 2 occasions during the first 10 minutes of game play and this was related to the anticipation of playing the 3rd game in the series (having experience of the previous 2) and the excitement delivered by the cut scene storey & visuals. However after about 2 minutes into the cut scene the player showed signs of entering bored state - suggesting that the cut scene may be to long. The player was also shown to enter a brief immersed state at the point where the cut scene reaches a climax, and for longer period once the player is actively involved in the training sequence.

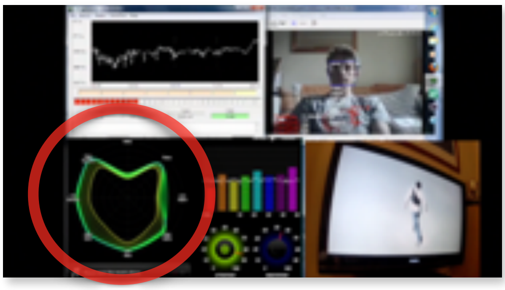
The analysis for Last of Us testing is shown below:



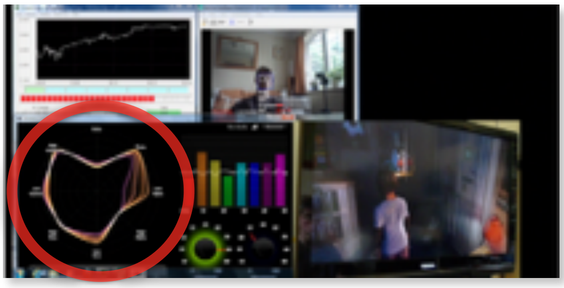
Using the same technique with the Last of Us game testing revealed that there are a number of occasions when the player mental state changes from engrossment to immersion and then flow as the story of the character is unfolding. This is then repeated several times suggesting that perhaps ‘vigilance fatigue’ is evident which is preventing sustained attention levels. It also indicates that the game introduces small periods of mental relaxed state which corresponds with the normal idea of story development.

A final area of this method that was explored is looking at similar EEG patterns captured using the Neurosky Visualise application for key mental states such as engagement / immersion / flow and if this is consistent between different game types and between different participants. Looking the the two previous examples where the same participant was testing two different style of games, focusing on the EEG patterns observed when the player was deemed to be in a state of immersion:

Assassins Creed 3 - immersion



Last of Us - Immersion



Whilst there is some correlation with the Beta and Gamma brainwaves shown on the left side, less consistency is shown with the Alpha brainwaves (shown on the right).

Last of Us (2nd participant) - immersion

Again there is some correlation with Beta and Gamma Brainwaves but insufficient overall to enable this to be a valid analytical method to easily assess EEG biometric results in relation to mental state.

Attention / Meditation level extraction

The adoption of the Myndplay brainband EEG device as part of the biofeedback methodology enabled the analysis of the EEG data in terms of attention, exploring some of the insights expressed in the GDC presentation from Richard Lemarchand which suggests observing the getting and holding of attention as a way to improve game testing.

Using the data available from the Myndplay analytical tools the average attention / meditation / and zone levels for the game testing session are accessible.

Data Processing Protocol

TEST SESSION RESULTS & ANALYSIS

Genre differences

Participant differences

Common patterns, trends, factors and traits

Emergence of a formula

CONCLUSIONS & INSIGHT

Toward Predictive testing & Algorithms

Use with Game Design

Further work

APPENDIX

c? eXperience

Information

Purpose: The purpose of this session is to understand how players respond to different video games by measuring player's biometric data along with the completion of game evaluation questionnaires in order to help improve video game design.

Tasks and duration: You will be asked to:

- tell us a little about yourself as a player;
- play a specific part/level of a video game whilst biometric data is captured;
- give us some feedback about your experience.

The session will last for approximately one hour and 15 minutes.

Right to withdraw: You may withdraw from the session at any time without prejudice or you need not answer specific questions if you choose.

Potential of risk or discomfort: This study has no side effects and will not impose any harm to you physically or mentally.

Anonymity/confidentiality: Your identity will be anonymous. All data will be stored using a participant number, and will only be used for the purposes of the research. All data that might identify individuals will be destroyed by December 1st, 2013, when we anticipate that the project and its publications will reach its completion. In the reporting of the project, no information will be released which will enable a reader to identify whom our participants were.

If you agree to participate in this study, please read and sign this consent form.

Informed Consent

Statement by participant # ……..

- I confirm that I have read and understood this information sheet and the invitation to participate.
- I understand:
  - the purpose, risks, and benefits of taking part in this session.
  - what my involvement will entail and any questions have been answered to my satisfaction.
  - that my participation is entirely voluntary, and that I can withdraw at any time without prejudice.
  - that all information obtained will be confidential.
  - that research data gathered for the study may be published provided that I cannot be identified.
- Contact information has been provided should I wish to seek further information from the investigator at any time for purposes of clarification.

Participant's Signature …………………………………… Date: …………………..

Statement by moderator

- I have explained this study and the implications of participation in it to this participant without bias and I believe that the consent is informed and that he/she understands the implications of participation.

Name of moderator: …………………………………………………………

Moderator's Signature …………………………………… Date: …………………

 Page 1

C?eXperience Ltd Game Evaluation Questionnaire Page 1 of 5

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Pre-test Questionnaire

Session title: ______________________________

Participant: ____________________ Date of Test (dd/mm/yy): __________

Age: __________ Moderator: ____________________

Sex (M/F): __________

Gaming Devices:	
Do you own an iPhone or iPad? [Y / N]	
Do you own an Android phone or tablet? [Y / N]	
Do you own a console? (Xbox 360 / PS3 /Nintendo) [Y / N]	

Roughly how many hours a week do you:	
play games on a mobile device?	
play games on a Console?	
play games on a computer?	

On average how long (hrs) do you play for, each time you use a console?	

Favourite Video games:	
What type/genre of video games do you like?	
Do you play video games online? [Y / N]	
In which room do you normally play console games?	

Today's test:	
Have you played the Video Game title on test today before?	
If yes how proficient are you? [novice <> intermediate < > expert]	

How mentally alert do you feel at the present time?

NOT ALERT		MODERATELY		FULLY ALERT

Do you ever become so involved in a video game that you lose all track of time?

NEVER		OCCAISIONALLY		OFTEN

How good are you at blocking out external distractions when you are involved in something?

NOT VERY GOOD		GOOD		VERY GOOD

C? eXperience

Session Title:
Objective:

UsaBio

Test Plan

Moderator: Carl Yates
E-Mail: carl@cyexperience.com
Phone: 07766 478521
Location: home
Version: 0.2

Test Plan 1