Game Sound Technology and Player Interaction:
Concepts and Developments

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Chapter 13

Player–Game Interaction Through Affective Sound

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ABSTRACT

This chapter treats computer game playing as an affective activity, largely guided by the audio-visual aesthetics of game content (of which, here, we concentrate on the role of sound) and the pleasure of gameplay. To understand the aesthetic impact of game sound on player experience, definitions of emotions are briefly discussed and framed in the game context. This leads to an introduction of empirical methods for assessing physiological and psychological effects of play, such as the affective impact of sonic player-game interaction. The psychological methodology presented is largely based on subjective interpretation of experience, while psychophysiological methodology is based on measurable bodily changes, such as context-dependent, physiological experience. As a means to illustrate both the potential and the difficulties inherent in such methodology we discuss the results of some experiments that investigate game sound and music effects and, finally, we close with a discussion of possible research directions based on a speculative assessment of the future of player-game interaction through affective sound.

INTRODUCTION

Digital games have grown to be among the favourite leisure activities of many people around the world. Today, digital gaming battles for a share of your individual leisure time with other traditional activities like reading books, watching movies, listening to music, surfing the internet, or playing sports. Games also impose new research challenges to many scientific disciplines – old and new – as they have been hailed as drivers of cloud computing and innovation in computer science (von Ahn & Dabbish, 2008), promoters of mental health (Miller & Robertson, 2009; Pulman, 2007), tools for training cognitive and motor abilities (Dorval & Pepin, 1986; Pillay, 2002), and as providers of highly immersive and emotional environments for their players (Ravaja, Turpeinen,

Saari, Puttonen, & Keltikangas-Järvinen, 2008; Ryan, Rigby, & Przybylski, 2006). Gaming is a joyful and affective activity that provides emotional experiences and these experiences may guide how we process information.

Regarding emotions, Norman's (2004) definition is that emotion works through *neurochemical* transmitters which influence areas of our brain and successively guide our behaviour and modify how we perceive information and make decisions. While Norman makes a fine distinction between *affect* and *cognition*, he also suggests that both are information-processing systems with different functionality. Cognition refers to making sense of the information that we are presented with, whereas affect refers to the immediate "gut reaction" or feeling that is triggered by an object, a situation, or even a thought. Humans strive to maximize their knowledge by accumulating novel, but also interpretative information. Experiencing novel information and being able to interpret it may be a cause of *neurophysiological* pleasure (Biedermann & Vessel, 2006). Cognitive processing of novel information activates endorphins in the brain, which moderate the sensation of pleasure. Thus, presenting novel cues in a game environment will affect and mediate player experience and in-game learning. This is an excellent example of how cognition and affect mutually influence each other, which is in line with modern emotion theories (Damasio, 1994; LeDoux, 1998; Norman, 2004). Norman (2004) proceeds to define emotion as consciously experienced affect, which allows us to identify, who (or what) caused our affective response and why. The problem of not making a clear distinction between emotion and affect is further addressed by Bentley, Johnston, & von Baggo (2005), who recall Plutchik's (2001) view on emotion as an accumulated feeling which is influenced by context, experience, personality, affective state, and cognitive interpretation. They also explain that user experience for desktop software or office-based systems is more dependent on performance factors while, for digital games,

user experience depends much more on affective factors. Affect is defined as a discrete, conscious, subjective feeling that contributes to, and influences, an individual's emotion (Bentley, et al., 2005; Damasio, 1994; Russell, 1980). We will revisit this notion later in the text.

In addition, Moffat (1980) introduced an interesting notion about the relationships between personality and emotion, which are distinguished along the two dimensions: *duration* (brief and permanent) and *focus* (focused and global). For example, an emotion might develop from brief affection into a long-term sentiment or a mood that occurs steadily might become a personality trait. The two dimensions can be plausibly identified at a cognitive level, making a strong case for the relation between emotion, cognition, and personality both at the surface and at a deep, structural level.

Psychophysiological research shows that affective psychophysiological responses elicit more activity (on facial muscles such as corrugator supercilii, indicating negative appraisal) and higher arousal when people have to process unpleasant sound cues (e.g., bomb sounds), which shows that sound cues can be used in games to influence players' emotional reactions (Bradley & Lang, 2000). Sound and music are generally known to enhance the immersion in a gaming situation (Grimshaw, 2008a). To music has been attributed also a facilitation of absorption in an activity (Rhodes, David, & Combs, 1988), and it is generally know to trigger the *mesolimbic* reward system in the human brain (Menon & Levitin, 2005), allowing for music to function as a reward mechanism in game design and possibly allowing for reinforcement learning (Quilitch & Risley, 1973). The recent explosion of interactive music games is a testament to the pleasure-enhancing function of music in games. Examples for interactive music games are *Audiosurf* (2008), the *Guitar Hero* series (2005-2009), *SingStar* (2004), or *WiiMusic* (2008). They make heavy use of reinforcement learning, as both positive

and negative reinforcement are combined when learning to play a song on *Guitar Hero* (2005) for example (for a comprehensive list of interactive music games see the list at the end of this chapter). Hitting the button and strumming with the right timing leads to positive reinforcement in the way that the guitar track of the particular song is played back and suggests player finesse, while a cranking sound acts as negative reinforcement when the button and strumming are off. Such reward mechanisms that foster reinforcement learning are a very common design element in games (see Collins, Tessler, Harrigan, Dixon, & Fugelsang, 2011). Applying them to diegetic composition of music is new and warrants further study as sound and music effects in games are currently not studied with the same scientific rigour that is present for example in the study of violent digital game content and aggression (Bushman & Anderson, 2002; Carnagey, Anderson, & Bushman, 2007; Ferguson, 2007; Przybylski, Ryan, & Rigby, 2009).

In addition to the reinforcement learning techniques in game design, another design feature is what Bateman (2009, p. 66) calls *toyplay*, facilitating the motivation of playing for its own sake. Toyplay denotes an unstructured activity of play guided by the affordances of the gameworld and is largely of an exploratory nature (Bateman, 2009; Bateman & Boon, 2006) being similar to games of emergence (Juul, 2005, p. 67) and unstructured and uncontrolled play termed "paida" (Caillois, 2001, p. 13). Many music games work completely without a narrative framing and derive the joy of playing simply out of their player-game interaction. For example, *Audiosurf* (2008) eliminates most design elements not necessary for the interaction of the player with the game, which is essentially the production of music by "surfing" the right tones. The colourful representation of tones and notes is a visual aesthetic that drives the player to produce music. A simple concept brought to stellar quality in games such as *Rez* (2001) or *SimTunes* (1996), which truly appeal to the toyplay aspect of gaming. Therefore, toyplay

elements and reinforcement learning techniques are two design methods most pronounced in music interaction games and that drive affective engagement with sound and music.

With recent efforts in the field of human-computer interaction (Dix, Finlay, & Abowd, 2004), the sensing and evaluation of the cognitive and emotional state of a user during interaction with a technological system has become more important. The automatic recognition of a user's affective state is still a major challenge in the emerging field of affective computing (Picard, 1997). Since affective processes in players have a major impact on their playing experiences, recent studies have emerged that apply principles of affective computing to gaming (Gilleade, Dix, & Allanson, 2005; Hudlicka, 2008). The field of affective gaming is concerned with processing of sensory information from players (Gilleade & Dix, 2004), adapting game content (Dekker & Champion, 2007) – for example, artificial behaviour of non-player character game agents to player emotional states – and using emotional input as a game mechanic (Kuikkaniemi & Kosunen, 2007). However, not much work has been put into sensing the emotional cues of game sounds in games (Grimshaw, Lindley, & Nacke, 2008), let alone in understanding the impact of game sound on players' affective responses.

We start by discussing general theories of emotion and affect and their relevance to games and psychophysiological research (for a more general introduction to emotion, see Cunningham, Grout, & Picking's (2011) chapter on *Emotion, Content & Context*). For instance, we suggest it is emotion that drives attention and this has an important effect upon both engagement with the game and immersion (in those games that strive to provide immersive environments). Immersion is an important and current topic in games literature – rather than attempt to define it (that is attempted elsewhere in this book); we limit ourselves to a brief overview of immersion theories and their relationship to theories of emotion, flow,

and presence before discussing empirical studies and theoretical stratagems for measuring player immersion as aided by game sound. Once we can understand under what sonic conditions immersion arises, we can then design more precisely for immersion.

THEORIES OF EMOTION

Psychophysiological research, affective neuroscience as well as affective and emotive computing are supporting the assumption that a user's (or in our case a player's) affective state can be measured by sensing brain and body responses to experienced stimuli (Nacke, 2009). Emotions in this sense can be seen as psychophysiological processes, which are evoked by sensation, perception, or interpretation of an event and/or object which is referred to in psychology as a stimulus. A stimulus usually entails physiological changes, cognitive processing, subjective feeling, or general changes in behaviour. This is of general interest, since playing games includes all sorts of virtual events taking place in virtual environments containing virtual objects.

Emotions blur the boundaries between physiological and mental states, being associated with feelings, behaviours and thoughts. No definitive taxonomy has been worked out for emotions, but several ways of classifying emotions have been used in the past. One of the first and most prominent theories of emotion is the James-Lange theory, which states that emotion follows from experiencing physiological alterations: The change of an outside stimulus (either event or object) causes the physiological change which then generates the emotional experience (James, 1884; Lange, 1912).

The Cannon-Bard theory offered an alternative explanation of the processing sequence of emotions, stating that, after an emotion occurs, it evokes a certain behaviour based on the processing of the emotion (Cannon, 1927). Thus, the percep-

tion of a certain emotion is likely to influence the psychophysiological reaction. This theory already tries to account for a combination of cognitive and physiological factors when experiencing emotions, in which case an emotion is not purely physiological (i.e. it is separate from mental processing). Another important emotional concept is the two-factor theory of emotions which is based on empirical observations (Schachter & Singer, 1962) and considers emotions to arise from the interaction of two factors: cognitive labeling and physiological arousal (Schachter, 1964). In this theory, cognition is used as a framework within which individual feelings can be processed and labeled, giving the state of physiological arousal positive or negative values according to the situation and past experiences. These theories have spawned modern emotion research in neurology and psychophysiology (Damasio, 1994; Lang, 1995; LeDoux, 1998; Panksepp, 2004) which is gathering evidence for a strong connection between affective and cognitive processing as underlying factors of emotion in line with the definition of Norman (2004) which we initially provided.

From Emotions to Experience

Modern emotion research typically uses one of two taxonomies which try to account for emotions as either consisting of a combination of a few fundamental emotions or as comprising different dimensions usually demarked by extreme characteristics on the ends of the dimensional scales:

1. **Emotions comprise a set of basic emotions**. In the vein of Darwin (1899) who observed fundamental characteristic expressive movements, gestures, and sounds), researchers like Ekman (1992) and Plutchik (2001) argue for a set of basic discrete emotions, such as fear, anger, joy, sadness, acceptance, disgust, expectation, and surprise. Each basic emotion can be correlated to an individual

physiological and behavioural reaction, for example a facial expression as Ekman (1992; Ekman & Friesen, 1978) found after studying hundreds of pictures of human faces with emotional expressions

2. **Emotions can be classified by means of a dimensional model**. Dimensional models have a long history in psychology (Schlosberg, 1952; Wundt, 1896) and are especially popular in psychophysiological research. Wundt (1896) was one of the first to classify "simple feelings" into a three-dimensional model, which consisted of the three fundamental axes of pleasure-displeasure (*Lust-Unlust*), arousal-composure

(*Erregung-Beruhigung*), and tension-resolution (*Spannung-Lösung*). A more modern approach and currently the most popular dimensional model was suggested by Russell (1980). His circumplex model (see Figure 1) assumes the possible classification of emotional responses in a circular order on a plane spanned by two axes, emotional affect and arousal. The mapping of emotions to the two dimensions of valence and arousal has been used in numerous studies (Lang, 1995; Posner, Russell, & Peterson, 2005; Watson & Tellegen, 1985; Watson, Wiese, Vaidya, & Tellegen, 1999) including studies of digital

Figure 1. The two-dimensional circumplex emotional model based on Russell (1980)
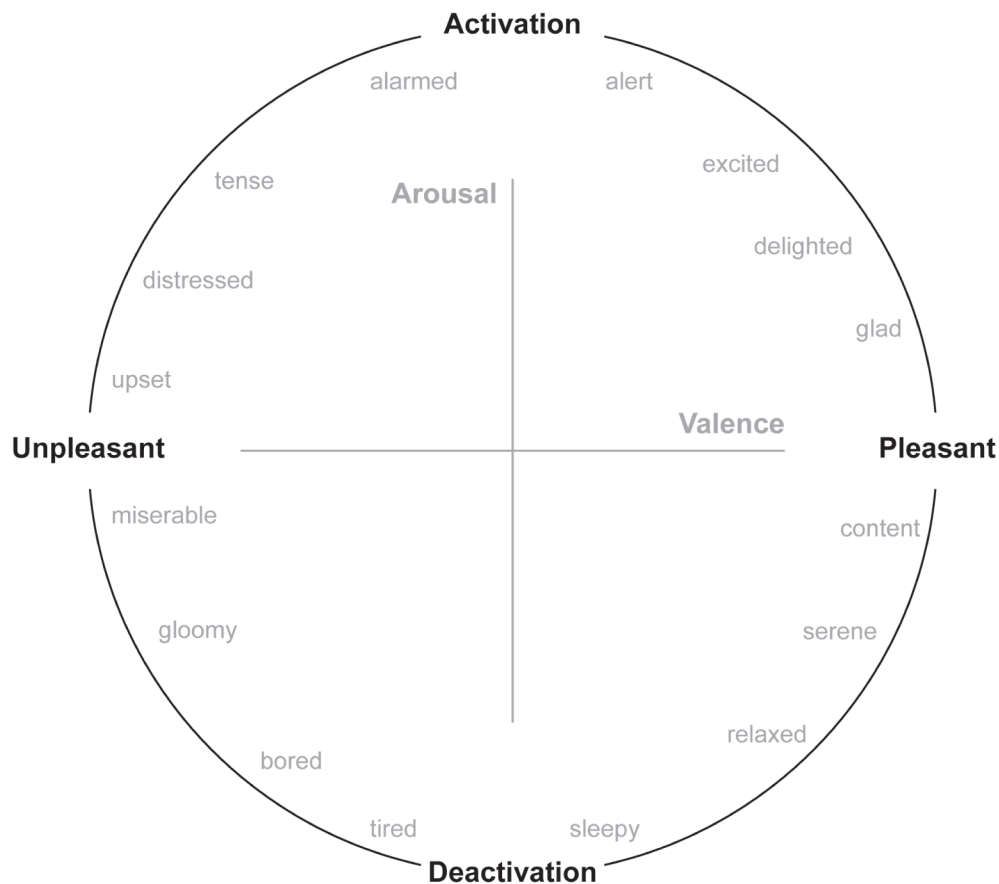
games (Mandryk & Atkins, 2007; Nacke & Lindley, 2008; Ravaja, et al., 2008).

The current popularity of dimensional models of emotion in psychophysiology can be explained by the fact that Wundt (1896) was one of the first researchers to correlate physiological signals, such as respiration, blood-pressure, and pupil dilation with his "simple feelings" dimensions. Bradley and Lang (2007) note that discrete and dimensional models of emotion need not be mutually exclusive but, rather, these views of emotion could be seen as complementary to each other. For example, basic emotions can be classified within affective dimensions. Finding physiological and behavioural emotion patterns as responses to specific situations and stimuli is one of the major challenges that *psychophysiological* emotion research faces currently. However, new evidence from *neurophysiological* functional Magnetic Resonance Imaging (fMRI) studies supports the affective *circumplex* model of emotion (Posner et al., 2009), showing neural networks in the brain that can be connected to the affective dimensions of valence and arousal: in this case, affective pictures were used as stimuli. The measurement of emotions induced by sound stimuli in a game context is, however, more complex. To identify how a certain sound, or a game element in general, is perceived, a subjective investigation is necessary, usually done after the experimental session. Gathering subjective responses in addition to psychophysiological measurements of player affect allows cross-correlation and validation of certain emotional stimuli that may be present in a gaming situation. This 'after-the-fact' narration is not, however, without its self-evident problems. A further major challenge remains the distinction between auditory and visual stimuli within games, as many games evoke highly immersive, audio-visual experiences, which can also be influenced by setting, past experiences, and social context.

Thus, we suggest that for measurement of emotional responses to game sound, three broad strategies are available for a full, scientific comprehension of player experiences. This means that there are at least three ways of understanding the emotional player experience in games (each illustrated by a particular stratagem) but the third, being a combination of the previous two, is likely to be the most accurate:

1. As objective, context-dependent experience – Physiological measures (using sensor technology) of how a player's body reacts to game stimuli can inform our understanding of these emotions
2. As subjective, interpreted experience – Psychological measures of how players understand and interpret their own emotions can inform our understanding of these emotions
3. As subjective-objective, interpreted and contextual experience – Inferences drawn from physiological reactions and psychological measures allow a more holistic understanding of experience.

One of our primary research goals is to understand gaming experience, which has been connected to positive emotions (Clark, Lawrence, Astley-Jones, & Gray, 2009; Fernandez, 2008; Frohlich & Murphy, 1999; Hazlett, 2006; Mandryk & Atkins, 2007), but also to more complex experiential constructs like, for example, immersion (Calleja, 2007; Ermi & Mäyrä, 2005; Jennett, et al., 2008), flow (Cowley, Charles, Black, & Hickey, 2008; Csíkszentmihályi, 1990; Gackenbach, 2008; Sweetser & Wyeth, 2005) or presence (Lombard & Ditton, 1997; Slater, 2002; Zahorik & Jenison, 1998). Thus, we will provide an overview of the current understanding of immersion, flow and presence in games and then provide suggestions as to how this could be measured using objective and subjective approaches.

IMMERSION, FLOW, AND PRESENCE

In the fields of game science, media psychology, communication and computer science, many studies are concerned with uncovering experiences evoked by playing digital games. There is a lot of work directed towards investigating the potentials, definition, and limitations of immersion in digital games (Douglas & Hargadon, 2000; Ermi & Mäyrä, 2005; Jennett et al., 2008; Murray, 1995). A major challenge of studying immersion is defining what exactly is meant by the term "immersion" and how does it relate to similar game experience phenomena such as flow (Csíkszentmihályi, 1990), cognitive absorption (Agarwal & Karahanna, 2000) and presence (Lombard & Ditton, 1997; Slater, 2002).

From Immersion to Flow and Presence

In a very comprehensive effort, Jennett et al. (2008; Slater, 2002) give an extensive conceptual overview of immersion. According to their definition, immersion is a gradual, time-based, progressive experience that includes the suppression of all surroundings (spatial, audio-visual, and temporal perception), together with attention and involvement mediating the feeling of being in a virtual world. This suggests immersion to be an experience related to cognitive processing and attention: the more immersive an experience is, the more attentionally demanding it is (see Reiter, 2011 for a discussion of attention and audio stimuli). One could hypothesize that emotional state drives attention (Öhman, Flykt, & Esteves, 2001) and therefore, the more affective an experience is, the more likely it is to grab individual attention and consequently to immerse the player. Thus, immersion would be elicited as the result of an action chain that starts with affect. This prompts an emotional response that influences attention and, as a consequence, leads to immersion. It remains to be shown whether, and how, affective responses of players influence immersion and what measures of player affect are most suitable to evaluate immersion.

Immersion is seen in some literature (Sweetser & Wyeth, 2005) – based on qualitative analysis – as an enabler of a fleeting experience of peak performance labeled flow (Csíkszentmihályi, 1990; Nakamura & Csíkszentmihályi, 2002). Flow is a little understood, but often-used experiential concept for describing one kind of game experience. Some examples from game studies and human-computer-interaction literature try to use flow for analyzing successful game design features of games (Cowley et al., 2008; Sweetser & Wyeth, 2005). However, originally, flow was conceived by Csíkszentmihályi (1975) on the basis of studies of intrinsically motivated behaviour of artists, chess players, musicians, and sports players. This group was found to be rewarded by executing actions *per se*, experiencing high enjoyment and fulfilment in the activity itself rather than, for example, being motivated by future achievement. Csíkszentmihályi describes flow as a peak experience, the "holistic sensation that people feel when they act with total involvement" (p. 36). Thus, complete mental absorption in an activity is fundamental to this concept, which ultimately makes flow an experience mainly found in situations with high cognitive loading accompanied by a feeling of pleasure. According to a more recent description from Nakamura and Csíkszentmihályi (2002), it should be noted that for entering flow, two conditions should be met: (1) a matching of challenges or action opportunities to an individual's skill and (2) clear and close goals with immediate feedback about progress. Flow itself can be described through the following manifested qualities (which are admittedly too fuzzy for a clear evaluation using subjective or objective methods): (1) concentration focuses on present moment, (2) action and consciousness merge, (3) self-awareness is lost, (4) one is in full control over one's actions, (5) temporal perception is distorted, and (6) doing the activity is rewarding

in itself (Nakamura & Csíkszentmihályi, 2002). Flow even shares some properties with immersion, such as a distorted temporal perception and lost or blurred awareness of self and surroundings.

Jennett et al. (2008) argue that immersion can be seen as a precursor for flow experiences, thus allowing immersion and flow to overlap in certain game genres, while noting that immersion can also be experienced without flow: Immersion, in their definition, is the "prosaic experience of engaging with a videogame" (p. 643) rather than an attitude towards playing or a state of mind. One important question in the discussion about flow and immersion is whether flow is a state or a process. Defining flow as a static rather than a procedural experience would be in contrast to the process-based definitions of immersion such as the *challenge-based immersion* of Ermi and Mäyrä (2005). This kind of immersion oscillates around the success and failure of certain types of game interactions. Another important differentiation between flow and immersion is that immersion could be described as a "growing" feeling, an experience that unfolds over time and is dependent on perceptual readiness of players as well as the audio-visual sensory output capabilities of the gaming system. Past theoretical and taxonomical approaches have tried to define immersion as consisting of several phases or components. For example, Brown and Cairns (2004) describe three gradual phases of immersion: *engagement*, *engrossment*, and *total immersion*, where the definition of total immersion as an experience of total disconnection with the outside world overlaps with definitions of telepresence, where users feel mentally transported into a virtual world (Lombard & Ditton, 1997). The concept of *presence* is also discussed by Jennett et al. (2008) in relation to immersion, but defined as a state of mind rather than a gradually progressive experience like immersion. If we assume for a moment that immersion is an "umbrella" experience, immersion could incorporate notions of presence and flow at certain stages of its progress. It remains, however, unclear

through what phases immersion unfolds and what types of stimuli are likely to foster immersive experiences. In what situations is immersion likely to unfold and what situational elements make it progress? When does it reach its peak and how much immersion is too much? More research is needed to investigate such questions, as well as a possible link between *high engagement* and *addiction*, as studied by Seah and Cairns (2008) or the differences between *high engagement* and *addiction* as suggested in a study by Charlton and Danforth (2004).

The SCI Immersion Model

Ermi and Mäyrä (2005) subdivide immersive game experiences into *sensory* (as mentioned above), *challenge-based* and *imaginative* immersion (the SCI-model) based on qualitative surveys. The elements of this immersion model account for different facilitators of immersion, such as, the experience of elements (in a gaming context) through which immersion is likely to take place. The three immersive game experiences Ermi and Mäyrä give implicitly provide different immersion models of static state and progressive experience. *Sensory immersion* can be enhanced by amplifying a game's audio-visual components, for example, using a larger screen, a surround-sound speaker system, or greater audio volume. If immersion is actually facilitated in this way, immersion would be an affective experience, as evidence points to the fact that enhanced audio-visual presentation results in an enhanced affective gaming experience (Ivory & Kalyanaraman, 2007). By jamming the perceptive systems of players (as a result of mental workload associated with auditory and visual processing of game stimuli), sensory immersion is probably also a facilitator of guiding player's attention (see Reiter, 2011). This strengthens the hypothetical link between attentional processing and immersive feeling found in related literature (Douglas & Hargadon, 2000) but, while the link remains, the cognitive direction is the reverse of

those discussed earlier. *Imaginative immersion* describes absorption in the narrative of a game or identification with a character which is understood to be synonymous with feelings of empathy and atmosphere. However, atmosphere might be an agglomeration of imaginative immersion and sensory immersion (since certain sounds and graphics might facilitate a compelling atmospheric player experience): the use of this term raises the need for a clearer definition of the concept of atmosphere and this is not provided by Ermi and Mäyrä (2005). If 'imaginative' refers mainly to cognitive processes of association, creativity, and memory recall, it is likely to be facilitated by player affect. However, individual differences are huge when it comes to pleasant imagination (this is probably a matter of personal preference), which would make it very difficult to accurately assess this kind of immersion using empirical methodology. The last SCI dimension, viz. *challenge-based immersion*, conforms closely with one feature of Csíkszentmihályi's (1990) description of flow. This is the only type of immersion in this model that suggests it might be progressive experience because challenge level is never simply static but is something that oscillates around the success and failure of certain types of interaction over time. If we assume now that immersion is linked to either successful or failed interactions in a game that are likely to strengthen or weaken the subjective feeling of immersion, we can try to establish the following relationship between game interactions and immersions. Given a number of successful interactions σ, a number of failed interactions φ, and incremental playing time τ, then two descriptions of the magnitude of immersion ι could be considered:

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        (1) For σ, φ > 0: If σ
> φ, then ι = σ/φ × τ.

        (2) For σ, φ > 0: If σ
≤ φ, then ι = σ/(φ × τ).
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These equations would suggest that the longer people play with a higher success than failure rate, the more immersed they would feel. If the failure rate is higher than the success rate, the feeling of immersion for players will decrease over time. Many sonic interactions in games are implicitly challenge-based because they require interpretation (or are understood from previous experience), but an example of explicitly challenge-based sonic interaction in games is given by Grimshaw (2008a) in his description of the *navigational mode* of listening (p. 32). It remains to be tested whether such an equation could account for immersion itself or whether this would only measure one aspect of the immersive experience. Ideally, such a ratio would be extended and combined with psychophysiological variables that measure a player's affective response over time.

Implications for Player-Game Interaction and Affective Sound

In the context of sound and immersion in computer games, other work investigates the role of sound in facilitating player immersion in the gameworld. A strong link between "visual, kinaesthetic, and auditory modalities" is hypothetically assumed to be key to immersion (Laurel, 1991, p.161). The degree of realism provided by sound cues is also a primary facilitator for immersion, with realistic audio samples being drivers of immersion (Jørgensen, 2006) similar to employing spatial sound (Murphy & Pitt, 2001) although some authors, as noted by Grimshaw (2008b) argue for an effect of immersion through perceptual realism of sound (as opposed to a mimetic realism) where verisimilitude, based on codes of realism, proves as effective if not more efficacious than emulation and authenticity of sound (see Farnell, 2011). Self-produced, autopoietic sounds of players, and the immersive impact that sounds have on the relationship between players and the virtual environment a game is played in, have been framed in discussions on acoustic ecolo-

gies in first-person shooter (FPS) games which provide a range of conceptual tools for analyzing immersive functions of game sound (Grimshaw, 2008a; Grimshaw & Schott, 2008). In an argument for physical immersion of players through spatial qualities of game sound (Grimshaw, 2007), we find the concept of sensory immersion reoccurring (Ermi & Mäyrä, 2005). The perception of game sound in this context is not only loading player's mental and attentional capacities but is also having an effect on the player's unconscious emotional state. The phenomenon of physical sonic immersion is not new, but has been observed before for movie theatre audiences and the concept has been transferred to sound design in FPS simulations and games (Shilling, Zyda, & Wardynski, 2002). In some cases, the sensory intensity levels of game sound may be such that affect really is a gut feeling as alluded to earlier in this chapter. Possible immersion through computer game sound may be strong enough to enable a similar affective experience by playing with audio only, as investigations in this direction suggest (Röber & Masuch, 2005).

PSYCHOPHYSIOLOGICAL MEASUREMENT OF EMOTIONS

As we have discussed before, a rather modern approach is the two-dimensional model of emotional affect and arousal suggested by Russell (1980, see Figure 1). Ekman's (1992) insight that basic emotions are reflected in facial expressions was fundamental for subsequent studies investigating physiological responses of facial muscles using a method called electromyography (EMG) which measures subtle reactions of muscles in the human body (Cacioppo, Berntson, Larsen, Poehlmann, & Ito, 2004). For example, corrugator muscle activity (in charge of lowering the eyebrow) was found to increase when a person is in a bad mood (Larsen, Norris, & Cacioppo, 2003). In contrast to this, zygomaticus muscle activity (on the cheek)

increases during positive moods. High obicularis oculi muscle activity (responsible for closing the eyelid) is associated with mildly positive emotions (Cacioppo, Tassinary, & Berntson, 2007). An advantage of physiological assessment is that it can assess covert activity of facial muscles with great sensitivity to subtle reactions (Ravaja, 2004). Measuring emotions in the circumplex model of emotional valence and arousal is now possible during interactive events, such as playing games, by covertly recording the physiological activity of brow, cheek and eyelid muscle (Mandryk, 2008; Nacke & Lindley, 2008; Ravaja, et al., 2008).

For the correct assessment of arousal, additional measurement of a person's electrodermal activity (EDA) is necessary (Lykken & Venables, 1971), which is either measured from palmar sites (thenar/hypothenar eminences of the hand) or plantar sites (e.g. above abductor hallucis muscle and midway between the proximal phalanx of the big toe) (Boucsein, 1992). The conductance of the skin is directly related to the production of sweat in the eccrine sweat glands, which is entirely controlled by a human's sympathetic nervous system. Increased sweat gland activity is related to electrical skin conductance. Using EMG measurements of facial muscles that reliably measure basic emotions and EDA measurements that indicate a person's arousal, we can correlate emotional states of users to specific game events or even complete game sessions (Nacke, Lindley, & Stellmach, 2008; Ravaja, et al., 2008). Below, we refer to several experiments analyzing cumulative measurements of EMG and EDA to assess the overall affective experience of players in diverse game sound scenarios.

Pointers from Psychophysiological Experiments

A set of preliminary experiments (Grimshaw et al., 2008; Nacke, 2009; Nacke, Grimshaw, & Lindley, 2010) investigated the impact of the sonic user experience and psychophysiological effects of

game sound (i.e., diegetic sound FX) and music in an FPS game. They measured EMG and EDA responses together with subjective questionnaire responses for 36 undergraduate students with a 2 × 2 repeated-measures factorial design using sound (on and off) and music (on and off) as predictor variables with a counter-balanced order of sound and music presentation in an FPS game level.
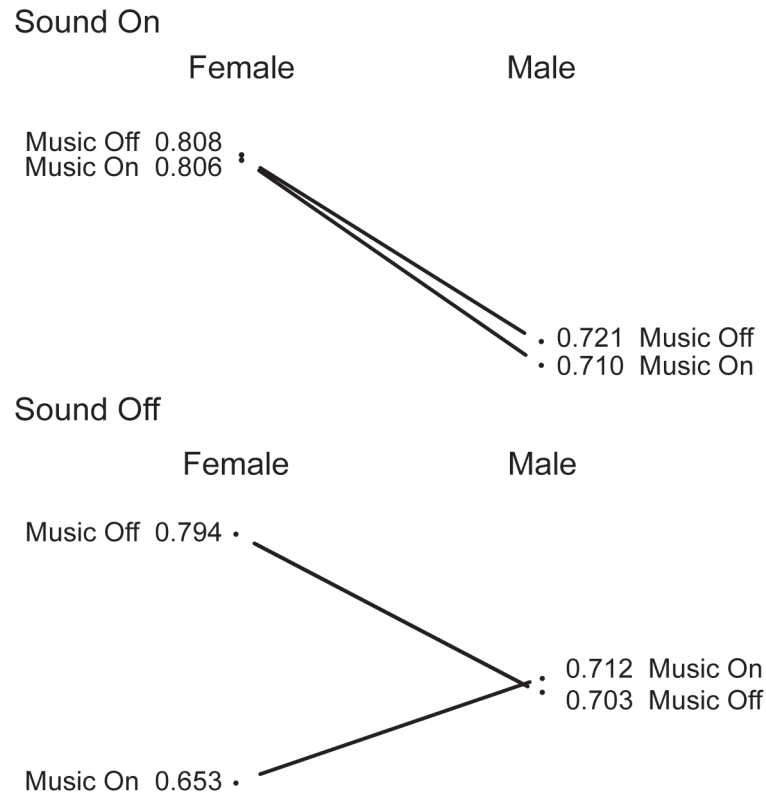
Among many results, two are particularly interesting: (1) higher co-active EMG brow and eyelid activity when music was present than when it was absent (regardless of other sounds) and (2) a strong effect of sound on gameplay experience dimensions (IJsselsteijn, Poels, & de Kort, 2008). In the case of the latter result, higher subjective ratings of immersion, flow, positive affect, and challenge, together with lower negative affect and tension ratings, were discovered when sound was present than when it was absent (regardless of music). The psychophysiological results of this study put the usefulness of (tonic) psychophysiological measures to the test, since the literature points to expressions of antipathy when the facial muscles under investigation are activated at the same time (Bradley, Codispoti, Cuthbert, & Lang, 2001). The caveat here is that the most common stimuli that have been used in psychophysiological research are pictures (Lang, Greenwald, Bradley, & Hamm, 1993). Using music, especially in a highly immersive environment such as a first-person perspective digital game, may lead to a number of emotions being elicited simultaneously and which might lie outside of the dimensional space that is being used in Russell's (1980) model. This opinion argues that a person's emotional experience is a cognitive interpretation of this automatic physiological response (Russell, 2003). But the bipolarity of the valence-arousal dimensions have been criticized before as the model is too rigid to allow for simultaneous (i.e., positive and negative) emotion measurements (Tellegen, Watson, & Clark, 1999). Using sound and music in a digital game is, however, a very ambiguous and complex use of stimuli and prior research has

suggested that the emotional responses to such complex stimuli can be simultaneously positive and negative (Larsen, McGraw, & Cacioppo, 2001; Larsen, McGraw, Mellers, & Cacioppo, 2004). Tellegen, et al. (1999) proposed a structural hierarchical model of emotion which might be more suited in this context by providing for both independent positive emotional activation (PA) and negative emotional activation (NA) organized in a three-level hierarchy. The top level is formed by a general bipolar Happiness-Unhappiness dimension, followed by the PA and NA dimension allowing discrete emotions to form its base. With this model, we could argue that the findings of Nacke et al. (2010) show an independent positive and negative emotional activation during the music conditions. This would, however, also indicate that the physiological activity is not a direct result of the sound and music conditions, but arguably of a combination of stimuli present during these conditions.

In addition, greater electrodermal activity was found for female players when both sound and music were off, while the responses for male players were almost identical (see Figure 2). The authors assumed music to have a calming effect on female players, resulting in less arousal during gameplay. For females, music was also connected with pleasant emotions as higher eyelid EMG activity indicated. Overall, the psychophysiological results from that study pointed toward a positive emotional effect of the presence of both sound and music (see also Nacke, 2009). Interesting in this context is that music does not seem to be experienced significantly differently on a subjective level, whereas sound was clearly indicated as having an influence on game experience. Higher subjective ratings of immersion, flow, positive affect, and challenge, together with lower negative affect and tension ratings when sound was present, paint a positive picture of sound for a good game experience (particularly so when music is absent).

The results discussed above are ones that run the gamut from expected (sound contributes

Figure 2. Results of electrodermal activity (EDA averages in log [µS]) from the Nacke et al. (2010) study, split up between gender, sound, and music conditions in the experiment (see also Nacke, 2009)

Sound On

Female   Male

Music Off 0.808
Music On 0.806

0.721 Music Off
0.710 Music On

Sound Off

Female   Male

Music Off 0.794

0.712 Music On
0.703 Music Off

Music On 0.653

positively to the experience of playing games) to the interesting and meriting further investigation (for example, gender differences in sound affect in the context of FPS games). Being the results of preliminary experiments, they typically provoke more questions than they answer and such results should, for the time being, be viewed in the light of several limiting factors. For example, the experiments provided audio-visual stimuli (not solely audio) and the sub-genre of game used – the FPS game – proposes a hunter-and-the-hunted scenario which, perhaps, might account for the gender affect differences noted. Another limitation that needs to be considered in psychophysiological research is the effect of familiarity with a particular game genre and a psychological mindset. Thus, a personality test and demographic questions regarding playing habits and behaviour

will help circumvent possible priming effects of familiarity or non-familiarity with games in the experimental analysis. In our experiments, personality assessments and demographic questionnaires were handed out prior to each study to factor out priming elements later in the statistical analysis. Finally, it is difficult to correlate objective measurements taken during gameplay with subjective, post-experiential responses and it may well be that such psychophysiological measurements are not the most optimal method for assessing the role of sound in digital games.

CONCLUSION

In this chapter, we have given an overview of the emotional components of gameplay experience

with a special focus on the influence of sound and music. We have discussed the results of experiments that have made use of both subjective and objective assessments of game sound and music. After these pilot studies, and our discussion of emotional theories and experiential constructs, we have to conclude that the detailed exploration of game sound and music at this stage of our knowledge is still difficult to conduct because there are few comparable research results available and there is not yet a perfect measurement methodology. The multi-method combination of subjective and objective quantitative measures is a good starting point from which to create and refine more specific methodologies for examining the impact of sound and music in games.

Important Questions and Future Challenges

The important questions regarding game design that aims to facilitate flow, fun, or immersive experiences are: should tasks be provided by the game (i.e., created by the designer), should they be encouraged by the game environment, or should finding the task be part of the gameplay? The latter is rather unlikely, since finding only one task at a time sequentially might frustrate players and choosing a pleasant task according to individual mood, emotional, or cognitive disposition will probably provide more fun. Thus, instead of saying players need to face tasks that can be completed, it might be better design advice to provide several game tasks at the same time and design for an environment that encourages playful interaction. An environment that facilitates flow, fun, or immersion would provide opportunities for the player to alternate between playing for its own sake (i.e., setting up their own tasks) and finding closure by completing a given task.

Some of the future challenges here will include finding good experimental designs that clearly distinguish audio stimuli, while still being embedded in a gaming context, in order that the

measurements and results obtained remain valid and thus more readily informative for the design suggestions above. We also see a lot of potential in cross-correlation of subjective and objective measures in terms of attentional activation, such as the exploration of brain wave (that is EEG) data to find out more about the cognitive underpinnings of gameplay experience, by this means potentially separating experiential constructs from an affective emotional attribution and aligning them to an attentive cognitive attribution. Experiments might be designed to answer the question *does attention guide immersion or vice versa?* Others might investigate sound and affect in game genres other than FPS.

Potential of These New Technologies for Sound Design

Why go to all this experimental trouble? After all, most digital games seem to function well enough with current sound design paradigms. The answer lies in two technologies both having great potential for the future of sound design. The first is procedural audio and as other chapters here deal with the subject in great depth (Farnell, 2011; Mullan, 2011), we limit ourselves to highlighting the importance of the ability to stipulate affective-emotional parameters for the real-time synthesis of sound. It is generally accepted that a sudden, loud sound in a particular context (perhaps there is a preceding silence and darkness wrapped up in a horror genre context) is especially arousing. However, what is less understood is the role, for example, of timbre on affect and emotion and, in the context of digital games and virtual environments, immersion. Would it be effective to design an affective real-time sound synthesis sub-engine as part of the game engine where the controllable parameters are not amplitude and frequency but high-level factors such as fear, happiness, arousal, or relaxation? Perhaps these parameters could be governed by the player in the game set-up menu who might opt, for instance, for a more or less

emotionally intense experience through the use of a simple fader. This brings us to the second technology.

Although rudimentary and imprecise, consumer biofeedback equipment for digital devices (including computers and gaming consoles) is beginning to appear.[1] Pass the output of these devices (which are variations of the EMG and ECG/EKG technologies used in the experiments previously described) to the controllable parameters of the game sound engine proposed above and procedural audio becomes a highly responsive, affective, and emotive technology.[2] Furthermore, a feedback loop is established in which both play and sound emotionally respond to each other. In effect, the game itself takes on an emotional character that reacts to the player's affect state and emotions and that elicits affect responses and emotions in turn – perhaps the game's character might be empathetic or antagonistic to the player. This is the future of game sound design and the reason for pursuing the line of enquiry described in this chapter.

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KEY TERMS AND DEFINITONS

Affective Gaming: The research area exploring game designs and mechanics that evoke player emotions and affects.

Affective Sound: One auditory stimulus or multiple auditory stimuli (here in a gaming context) that evoke affect and emotion.

Audio Entertainment: An activity that involves the manipulation or reception of one sonic entity or multiple sonic entities that permits the users to amuse themselves.

Empirical Methods (Quantitative): The collection of quantitative data on which a theory can be based or which facilitates reaching a scientific conclusion.

Human-Centered Design: Also known as user-centered design (UCD) is a design philosophy that values the needs, wants, and limitations of users during each iterative step of the design process.

Human-Computer Interaction (HCI): The research area studying how people interact with computational machines.

Interaction Design: The creation and study of hardware devices and/or software that users can interact with.

Psychophysiology: A branch of psychology concerned with the way psychological activities produce physiological responses.

User Experience (UX): The field of study concerned with experience people have as a result of their interactions with products, technology and/or services.

User Studies: Experimental studies involving human participants to evaluate the impact of software or hardware on users.

ENDNOTES

[1]   For example, the *NIA*: http://www.ocztechnology.com/products/ocz_peripherals/nia-neural_impulse_actuator.

[2]   In terms of the creation of static sound objects, the future might see the sound designer being able to *think* sounds rather than having to *design* sounds.