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Implications of Interactivity: What Does it Mean for Sound to be “Interactive”?

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Abstract and Keywords

This article appears in the *Oxford Handbook of New Audiovisual Aesthetics* edited by John Richardson, Claudia Gorbman, and Carol Vernallis. This chapter explores concepts of interactivity as they relate to sound production in video games. A guiding assumption of the chapter is that interactivity is a definitive paper of new digital aesthetics in general and gaming in particular. And yet, the question of interactivity has not been addressed with sufficient stringency in scholarly research. At the heart of the chapter are these questions: What makes interactive sound different from noninteractive sound? Where does *interacting with* sound fit into our understanding of our experience of sound and music in media? How do we begin to approach interactive sound from a theoretical perspective? The implications of interactivity are examined, specifically the notion of sound as a feedback device and as a control mechanism. . In these ways the chapter works toward a more comprehensive understanding of sounds in new media contexts that addresses their particularity in interactive contexts rather than resting on previous assumptions about the primacy of sounds as narrative devices.

Keywords: video games, interactivity, feedback, control mechanisms, sound production, digital aesthetics, new media

Video games, mobile phones, and other modern digital media alter the traditional relationships between creator and consumer, audience and performance when the audience takes a participatory role in instigating sound events. When using such media audiences may, through their actions, be responsible for evoking sounds, selecting them, altering or shaping them, or creating new sounds, thus playing an active role in the composition of their own soundscapes. This active role of the audience raises interesting questions about the ways in which we theorize sound in media. What does it mean to interact with sound? Who is the audience, and who is the creator of such co-creative, interactive sonic constructions? How does interacting with sound change our relationship

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to that sound? How do we begin to discuss these changes in relationship? As I tried to work through these questions, I asked a group of students in a music class at McGill University to consider the diagram in figure 32.1. Each corner of the triangle represents a different relationship a participant has to music or sound design: creation, performance, and reception.[1]

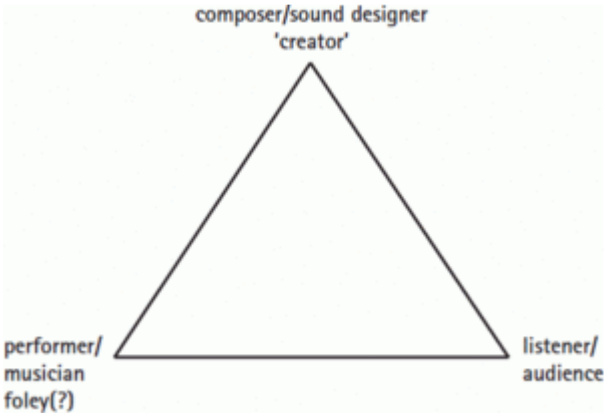

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Figure 32.1 : Relationships to music and sound design.

The students and I agreed that there is considerable overlap among these positions. A composer generally performs the music while in the process of composing, and of course he listens to it as well. A performer will listen to a song as she plays, to time her part or to catch mistakes. A listener may choose to sing harmony or play air guitar along with a piece of music, thus becoming, in part, creator (or at least orchestrator) (p. 573) and performer (even if a silent one). In other words, these roles cannot be considered entirely distinct. Nevertheless, the diagram helps us discuss the impact of interactivity on our traditional ways of perceiving our relationships to sound and music.

I asked the students where they would place interactive video game sound on the diagram. If a player can create the overall soundscape through her game play or rearrange the music cues based on her characters’ movements by changing instrumentation or sequencing, or by triggering generative music parts, is she not in some way the creator of the overall sound experience? If she is constantly “performing” sound by triggering the emitter of that sound (pushing buttons, swinging the Wii remote) or altering sonic events through action, is she not also part performer? And if she is listening to the sounds as she plays (critical for some games), is she a listener/audience as well? Again, we can never consider these roles as separate, but if there is considerably more overlap among them than in most other forms of music and sound, where do our interactions with game sounds belong on the diagram? Ultimately most of the students decided that interactive sound belongs somewhere in the middle of the triangle, but the longer we discussed the problem, the more the corners of our triangle became rounded, and we entered into John Cagean discussions of what it means to create art/music, especially in light of the often nonlinear, aleatory, and generative nature of game sound.

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Although we arrived at no definitive answers, it was clear from our discussion that most scholarship on music and sound design privileges a single perspective at any given time (usually that of the composer), often disregarding the performers’ and audience’s complementary roles in a piece of music or sound design. Thus, when it comes to a type of sound or music that fits somewhere in the middle of our triangle, there is little scholarship to develop an understanding of interactive sound, nor is there adequate language to discuss the participant’s active role in the sonic experience. In this chapter I explore the differences between interactive and noninteractive sound, focusing on video games, although I also refer to contemporary digital slot machines because they have some common features.

(p. 574) This chapter raises several central questions. What makes interactive sound different from noninteractive sound? Where does *interacting with* sound fit into our understanding of our experience of sound and music in media? And how do we begin to approach interactive sound from a theoretical perspective? Elsewhere[2] I have begun to explore video game sound by drawing on film theory. Indeed, other scholars have also approached game sound from a film-theoretical framework,[3] although this has certainly not been the only approach taken.[4] In some ways film theory is an obvious starting point from which to discuss game sound, as games share many qualities of films. Like films, games usually have a narrative and contain cinematic sequences,[5] and cross-marketing (as well as coproduction) has also grown between the game and film industries. Recent scholarship has adapted useful concepts from the study of film sound and music to the study of games.[6] But as I have argued, film theory seems to fall short in many respects when applied to game sound; notably, film studies does not account for the sound that is directly controlled by the player and for the distinctly different experience that this embodied control of sound involves. I contend that to study interactive sound we need to expand our scholarly horizons and look farther afield to computer science, interaction design, and cognitive psychology, all of which have dealt for some time with the phenomenon of interactivity with sound and other modalities.

Defining Interactivity

Defining interactivity is a tricky business, because of the variety of types of interaction with media texts that can occur. In *The Language of New Media* Lev Manovich states, “All classical, and even more so modern, art is ‘interactive’ in a number of ways. Ellipses in literary narration, missing details of objects in visual art, and other representational ‘shortcuts’ require the user to fill in missing information.” [7] We can argue that a (p. 575) paperback book is interactive on a psychological level. Indeed, Manovich and others have

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argued that the act of *participating* or *active reception* is the same as interacting. It may therefore be best to think of interactivity as a spectrum of activities, from the psychological to the physical. However, we can also say that although we *act* with a book, it does not respond to our actions: it does not *interact* with us. There is no feedback from the book based on our actions. Those actions do not alter the book, merely our perception of it, and therefore we lack control or agency over the book. For the purposes of this chapter, then, I suggest that a book is not interactive because it lacks two fundamental elements: control and feedback.

Interactivity need not take place only between a user and a text (e.g., a reader and a book), of course. A variety of different types of interactivity characterize media such as video games, even including interpersonal interactions mediated by a game.[8] For example, in online multiplayer games, players interact with each other through speech or play virtual instruments in ad hoc or planned jam sessions. More widescale interactions may also occur, including the social and cultural interactions that take place on a much vaster and temporally longer scale. For example, a game’s plot or aesthetics may inspire a movie director, or fans may modify (“mod”) and then spin off a new series of fan-authored games. These may be released as official versions, based on the modifiable game engines and code provided by the original game’s manufacturer, or “hacked” versions of games, such as *Kaizo Mario* (also known as *Asshole Mario*),[9] a fan modification of *Super Mario World* (Nintendo 1990) designed to be nearly impossible to play. All of these works may then become part of a larger cultural dialogue about games, film, art, and so forth. Although these types of interactions are culturally significant and interesting, they lie outside the scope of this chapter.

Here I focus on the interactivity between a game and the player(s), which might range from game content or events based on in-game parameters, where the player has little control; to generative or artificially intelligent content; to interaction with prefabricated scripts; to entirely open, unscripted interaction in a multiplayer game. A game may be fluid in its degrees of interactivity and may afford different degrees of interactivity at different times. The correspondence between action and speed of the response to the player, the number and types of characteristics that the player can exert control over or modify in a game, as well as the number and type of inputs that afford agency all influence the degree to which a game is interactive.[10]

As discussed previously, many theorists, particularly outside of the humanities, agree that central to the idea of interactivity are *feedback* and *control*. As Bert Bongers notes, (p. 576) “Interaction between a human and a system is a two way process: control and feedback.... The system is controlled by the user, and the system gives feedback to help the user to articulate the control, or feed-forward to actively guide the user.”[11] Here,

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then, I use the term “interactive” with this idea of control and action as the core, to refer to physically acting, with agency (control), with media that in some way respond to the action (feedback). The rest of this chapter explores what feedback and control mean in our understanding of sound in media such as video games.

Implications of Interactivity: Sound as Feedback

Sound in nature provides us with continuous feedback. We constantly receive information about the status of our surroundings, from the state of the weather to the direction of moving objects and approaching dangers. It is not surprising, then, that when it comes to games (which may aspire to some degree of verisimilitude), sound has continued to fulfill this same role. Over time music has also been developed in games (perhaps to a lesser extent) to provide feedback to the player, from signaling enemies nearby to indicating the character’s status.

Most sound in early video games was designed specifically to provide feedback to the player to indicate that he had taken an action (fired a gun, jumped, bumped into a wall), that he had earned points, or that there was a change in game-state (e.g., he was beginning a new level). Sonic feedback or prompts were also used to alert the player to take an action: that her spaceship was under attack, that an encounter with an enemy was imminent, or that time was running out. An item in *Electronic Games* in July 1983 advised the player of Adventure Vision’s *Super Cobra*: “Super Cobra makes use of a range of sound effects to enhance the play. Listen to these special tones since they frequently warn you of what type of enemy the helicopter will face next.”[12] About Adventure Vision’s *Space Force*, the same guide notes: “Pay close attention to the sound effects. The approach of alien ships are [*sic*] signaled by alien cannon fire. This alerts you to be prepared to shoot.”[13]

I have defined *dynamic audio* in games as audio that reacts to changes in the game-play environment *or* in response to a user.[14] I distinguish two types of dynamic audio: *interactive* (sound events occurring in reaction to game play, which respond to (p. 577) the player directly) and *adaptive* (sound that reacts appropriately to game play and even anticipates it, rather than responding directly to the player). Adaptive audio is closely related to interactive audio in that it is preemptively interactive, implying that there will be a response from the player (after the sound event has taken place). As this chapter discusses feedback, it may be useful to consider interactive and adaptive audio as a series of events that are generated by the system (adaptive audio) or the player (interactive

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audio). A *player-generated event* is an event that the player initiates, such as the click of a mouse or the pressing of a controller button, and hence is *interactive*. Interactive sound is primarily player-generated; the player initiates an event through an input device (button, controller), and there is a system-controlled response. A *system-generated event* is initiated by the software, such as a timer running out or a spaceship flying overhead at random intervals. System-generated events tend to be adaptive audio events. We could say, then, that interactive audio is always in some form of causal relationship with an event and with a player.

Games map sound to events in a number of ways and for a variety of purposes. Sometimes, for variation in sound effects, an entire collection of sounds might be mapped to a single event; only one sound file from the collection connects to the event at run-time. For example, to make sure I don't hear the same gunshot shell casing fall the same way every time I shoot a weapon, there may be a folder of shell-casing-fall sounds from which a single one is randomly selected. Thus, when I shoot the weapon my action can create a slightly different sound each time. As noted previously, the mapping of sound to an event in video games has historically been motivated to provide immediate feedback to the player, either directly in response to a player action or to instigate one. Turning the sound off in a video game can be detrimental; in fact, there is ample objective evidence that having the sound on enhances the ability to play the game.[15]

Today's game sound typically provides many types of feedback to the player.[16] These fall into seven overlapping categories:

1. *Preemptive attention and alert sounds*: Preemptive sounds are usually a call to attention ("you need to take an action"). For example, they can be musical cues that serve as a warning that an enemy is around the corner and that you need to pull out your sword. Notably, in games *acousmatic sound*—that is, sound with no clear origin visually—may inspire the player to look in the direction of a sound, to "incite the look to go there and find out."[17] The term was first adopted from (p. 578) ancient Greek usage by French composer Pierre Schaeffer and was later used by Michel Chion to describe sounds in film that have no visible source onscreen. Even if we cannot compel the camera to go where the sound seems to come from, we mentally look there. Acousmatic sound is actually far more pronounced in games, as sound gives the player cues to head in a particular direction or to run the other way. And unlike in film, preemptive and alert sounds prompt an active response from the listener. When your character is dehydrated and running out of health points, the sound of a waterfall may draw you in one direction, whereas adjacent gunfire might scare you away. These cues (particularly acousmatic sounds) provide the most information about the environment.

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2. *Confirmation sounds*: Confirmation sounds verify that an event has been carried out (“you have taken an action”). Most player-generated sound effects in video games are confirmation sounds: “you have taken a step,” “you have jumped up,” “you have fired your weapon.” Because these player-generated sounds are mapped to input events (button presses, etc.), they tend to be repetitive. Contemporary game sound designers therefore often spend a lot of time making variable sound effects for these events, as in the shotgun shell casing example. Footstep sounds are now often randomly selected from a series of samples or even generated in real time using a variety of synthesis methods.

3. *Status feedback*: A status sound is an often continuous sound or musical cue that provides information about status (“you are taking an action”). In a game, such sounds commonly take the form of health status information, notably when the player is running out of health (e.g., a steady beeping or sped-up musical cue) or is temporarily invincible.

4. *Navigation and orientation*: Navigation sounds and music indicate where the player is in a level or the larger game matrix. Spatial sound, for example, gives feedback about proximity or direction of objects, and occlusion effects can provide feedback about barriers. Music and ambient sound help to tell you where you are in the game (both in terms of environment and the overall game matrix).

5. *Peripheral information*: In addition to the more direct feedback in the game, sounds can provide input about the brand, the genre or style, and aesthetic information. This is particularly notable when the game uses recognizable intellectual property such as music. Familiarity with a television show, film, person, place, musical act, or sport is likely to entice players to various slot machines, for example. “Players may find [them] more enjoyable because they can easily interact with the recognizable images and music they experience.”[18]

6. *Affective feedback*: Sound in games can provide feedback of an affective nature. For example, music in a game, particularly musical leitmotifs, can give information about the state of your own character or nonplaying characters in a (p. 579) game. In addition to providing feedback about the emotional states of characters, sound and music can influence the player, through what has been termed *mood induction*. This sound “changes how one is feeling, while communication of meaning simply conveys information. One may receive information depicting sadness without him or herself feeling sad.”[19] Game music commonly deploys tempo for mood induction; different musical genres can also affect the player’s success rates. Yamada studied the impact of different genres of music on the player (in addition to playing without music) and found “that the no-music condition showed the best rate of success. Moreover, a ‘mixed’ musical excerpt added ‘unpleasantness’ to the game and, in turn, resulted in

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a negative effect on the success rate. Increasing the speed increased the ‘potency’ of the game, but did not affect the success rate, systematically.”[20]

7. *Reward and punishment*: Reinforcement sounds (positive and negative) are very common in video games and provide feedback to the player about the consequences of her actions. Digital slot machines are a clear example. Sound effects govern a variety of reward and feedback systems in slot machines.[21] You can hear coins falling into the hopper—even though credits are usually substituted for physical coins in today’s machines. These false coin sounds can portray wins much larger than the actual win, giving deceptive feedback to the player. Of course positive, winning sounds are key to the machines, and sounds of losing are rarely heard, emphasizing positive experiences over negative ones. Verbal reinforcement also takes place: computer-generated voices tell players that they are “cool” or “a genius.” Parke and Griffiths note that verbal reinforcement is designed to raise self-esteem, give hints and guidance, and even provide friendship or company.[22]

Sonic rewards are also fairly common in video games. They have considerably more losing sounds than slot machines—think of the sounds for player character death. Winning sounds—gaining points, gathering a special object, and so on—are of course very common and offer sonic rewards to the player. When it comes to casual games (games usually consumed in short time periods, with a smaller barrier to entry and less involvement), some games go over the top with reward sounds and, as do slot machines, (p. 580) aim more at making the player feel good about playing the game than providing any critical feedback about status or location.

Implications of Interactivity: Sound and Control

The other key element of interactivity is control. Because the player has some control over many of the audio events in video games, she participates in that sound. The player directly triggers some sound events through her input device, and her actions nearly always affect the overall soundscape of the game. Often she may have a gestural interaction with that sound. From an arbitrary button-press to more sophisticated racket swings of the Wii remote, the player has a unique physical and gestural connection to the sound events. These technological changes alter the player’s relationship to that sound. This self-produced sound distinguishes the game experience from that of most other media, which often disconnect the player from her physical self, and the sonic events do not respond to her physical actions.

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Chion proposes the term “ergo-audition” to refer to how we hear ourselves taking an action, noting that “this concept extends the concept of feedback to incorporate the subjective experience of one’s impact on the world.”[23] One might argue that in everyday life we have a greater connection to self-produced sounds because we have a deeper understanding of their causes and effects. For example, I draw on the sounds of my fingers tapping on my keyboard as I type to determine if I managed to hit the keys, and I know that the harder I hit the keys, the louder the sounds will be. The connection between the physical action and the sonic reaction is arguably much stronger when it comes to self-produced sounds. Indeed, this control over sound events is vital to our perception of sounds in the environment. For instance, when given control over noise, people are more likely to accept sound, as anyone who has control over his own stereo as opposed to a neighbor’s will attest. Even the *illusion* of control over a sound alters the ways in which we perceive it. [24]

Many of today’s video games offer options for customizing sound elements, including music, voice-over, and sound effects. Though not all games are completely flexible, it is increasingly the case that they allow for some degree of customization beyond the volume or equalization found in most audio playback devices. The customization of sound, however, may not always be a conscious attempt to alter sounds. For example, you may (p. 581) customize the overall soundscape through your choice of avatar or weapon. If you choose a tiny elf as your avatar, different sound effects are likely to accompany it than if you choose a giant ogre, so the sonic experience of the game will depend on your choice. You may also customize the overall playback of sounds, as many games allow players to enter menu or options screens and individually adjust the volume (thus overall mix) of sound effects, ambient levels, speech, and music.

Moreover, modern game consoles like the Xbox 360 allow users to insert their own music into games as they play. Some games even allow the player’s input music to directly impact the level maps of the game, such as *Vib Ribbon* (SCEI, 1999) and *Phase* (Harmonix Music Systems Inc., 2007). Advertising research suggests that we have a different relationship to media that we select than to media chosen for us, which implies that we may have a different relationship to games than to media for which we cannot customize sound.[25] A pilot study recently carried out by one of my students on players’ selection of music in games found that players consciously choose music to alter their affective state —for example, to relieve anxiety—as well as to increase their immersion. Players could in fact change their anxiety levels by using their own music rather than the precomposed game music. A particularly important finding is that their personal music choices could alter their game-play tactics, notably speed of play. But perhaps most relevant to the discussion here is that players’ control over music influenced their enjoyment of the game.[26]

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Our study also found that familiar music controlled by the player could be used to help her overcome frustration and increase her immersion. This phenomenon might be best described using Csikszentmihalyi’s concept of *flow*, characterized by concentration on the task at hand, a sense of control, merging of awareness and action, temporal distortion, and a loss of self-consciousness.[27] It may be the case that control over music and sound in general leads to a more immersive experience, because we become a part of the process rather than being external to it, although this remains unexplored. Roccheso and Bresin argue, “The possibility of using continuous interaction with sounding objects allows for expressive control for the sound production and, as a result, to higher engagement, deeper sense of presence, and experiential satisfaction.”[28]

Although research into the effect that control has on video game players remains limited, there has been some research into control—and the illusion of control—when it comes to playing modern video slot machines. Modern slot machines bear many (p. 582) similarities to video games, and the industries share game designers as well as composers. Until the 1990s, slot machines had fairly standard mechanical or electromechanical reels and parts. The digitization of slot machines has brought considerably more complex elements to slot machine game play. Many of these elements have been adapted from video games; for example, cut scenes, bonus rounds, secret functions, and specialist plays[29] are designed to increase what the industry calls “time on device.”[30] A simple bonus or increased (illusory) skill component leads to an increased psychological involvement on the part of the player.[31] Control is key to the player’s involvement, and many elements are designed to give players the illusion of control (e.g., by presenting a choice even when the outcome is predetermined). Players are far more engaged and will spend longer on the game when they feel that they have some control over the outcome. Some of these elements of game play are hinted at by the sound (as in the *Simpsons* EGM, in which Krusty the Clown says, “Here’s a clue for ya, Jack.”).[32] We can extrapolate the findings from slot machine research to video games and make the assumption that the more control a player has, the more engaged he becomes. When it comes to sound, this *could* mean that players are more engaged with the sound, which could have implications in areas such as memorability and branding.

Conclusion

Feedback and control are two of the key distinctions that make interactive audio a unique experience for its audience. I have only touched on these issues here, hinting at what might be found by more empirical research into the impact of interactivity on audience experience. Both feedback and control, I have hypothesized, alter the relationship that an

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audience has with music or sound in interactive media. We have seen that feedback provides important information to the player about a variety of game elements, and that without sound, the player increasingly relies on visuals to gain that information. In the most vital cases, sound provides preemptive warnings to the player to take an action. Control over the sonic environment may immerse the player more deeply in the game.

Not only do feedback and control influence audience experience, but as I have suggested, production practices must also be different. The nature of a feedback-based medium means that sounds tend to be more repetitive, requiring considerations for (p. 583) variability. Player participation in some instances has meant that composers completely relinquish control to the player’s choice of music. Moreover, increased unpredictability in the overall soundscape must constantly be negotiated, as players may alter the overall aesthetic with a variety of choices in not only music but also sound effects and dialogue.

I began the chapter with a series of questions: What makes interactive audio different from noninteractive audio? Where does interacting with audio fit into our understanding of sound and music in media? How do we begin to approach interactive audio from a theoretical perspective? Drawing on research from a variety of disciplines, I have indicated some of the related literature that hints at methodologies as yet unexplored that may be particularly useful when it comes to interactive audio, such as advertising, interaction design, gambling studies, and cognitive psychology. Moreover, our understanding of not just interactive sound, but sound in audiovisual media in general, may be enhanced by expanding our scope of research into the areas that have been underutilized by scholars of music and sound in media. It is evident that we lack research into the influence that interactivity has on player experience as well as production practice. In particular, empirical research is needed in a variety of areas so that we may better understand what, exactly, it means to interact with sound.

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Notes:

(1) There is no real equivalent today to the musician/performer in the field of sound design. Perhaps the closest is the Foley artist, who creates sounds “live” in the studio. In the early days of film, the traps person was the closest to this role.

(2) Karen Collins, “An Introduction to the Participatory and Non-Linear Aspects of Video Games Audio,” in *Essays on Sound and Vision*, ed. John Richardson and Stan Hawkins (Helsinki: Helsinki University Press, 2007).

(3) For instance, Anahid Kassabian, “The Sound of a New Film Form,” in *Popular Music and Film*, ed. Ian Inglis (London: Wallflower, 2003); and Zach Whalen, “Play Along: An Approach to Videogame Music,” *Game Studies: The International Journal of Computer Game Research* 4, no. 1 (2004).

(4) See, for example, Mark Grimshaw, “The Acoustic Ecology of the First Person Shooter” (PhD diss., University of Waikato, 2007).

(5) See Karen Collins, *Game Sound: An Introduction to the History, Theory and Practice of Video Game Music and Sound Design* (Cambridge, Mass.: MIT Press, 2008), 5–6, for an expanded comparison of film and video game music and sound practice.

(6) In particular, for example, Michel Chion’s chapters on the audiovisual scene and phantom audiovisual in *Audio-Vision: Sound on Screen* (New York: Columbia University Press, 1994); and Philip Tagg’s approach to music semiotics in *Kojak: Fifty Seconds of Television Music* (New York: Mass Media Music Scholars’ Press, 2000).

(7) Lev Manovich, *The Language of New Media* (Cambridge, Mass.: MIT Press, 2001), 56.

(8) See Sally J. McMillan, “Exploring Models of Interactivity from Multiple Research Traditions: Users, Documents, and Systems,” in *Handbook of New Media*, ed. Leah A. Lievrouw and Sonia Livingston (London: Sage, 2002).

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(9) Douglas Wilson and Miguel Sicart, “Now It’s Personal: On Abusive Game Design,” in *Proceedings of Future Play 2010* Vancouver, Canada, May 6–7.

(10) See Matthew Lombard and Jennifer Snyder-Duch, “Interactive Advertising and Presence: A Framework,” *Journal of Interactive Advertising* 1, no. 2 (2001).

(11) Bert Bongers, “Physical Interfaces in the Electronic Arts—Interaction Theory and Interfacing Techniques for Real-Time Performance,” in *Trends in Gestural Control of Music*, ed. Marcelo M. Wanderley and Marc Battier (Paris: IRCAM–Centre Pompidou, 2000), 41–70.

(12) Joyce Worley, “Adventure Vision: Inside the Hardware,” *Electronic Games* (July 1983): 116.

(13) Worley, “Adventure Vision,” 118.

(14) Collins, “Introduction to the Participatory and Non-Linear Aspects of Video Games Audio,” 265.

(15) See, for example, Kristine Jørgenson, “Left in the Dark: Playing Computer Games with the Sound Turned Off,” in *From Pac-Man to Pop Music: Interactive Audio in Games and New Media*, ed. Karen Collins (Aldershot: Ashgate, 2008).

(16) I take the first four areas from Alan Dix, Janet Finlay, Gregory Abowd, and Russell Beale, *Human-Computer Interaction* (London: Prentice Hall, 1998), 24. The last three are arguably “feedback,” but I believe they contribute to the communication (hence information/feedback) process and so include them here.

(17) Chion, *Audio-Vision: Sound on Screen*, 71, 85.

(18) Mark Griffiths and Jonathan Parke, “The Psychology of Music in Gambling Environments: An Observational Research Note,” *Journal of Gambling Issues* 13 (2005): 5.

(19) Cited in Annabel. J. Cohen, “Music as a Source of Emotion in Film,” in *Music and Emotion: Theory and Research*, ed. Patrick N. Juslin and John A. Sloboda (Oxford: Oxford University Press, 2001), 42.

(20) Masashi Yamada, “Can Music Change the Success Rate in a Slot-machine Game?” in *Proceedings of the Western Pacific Acoustics Conference* (Beijing, China, 2009).

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(21) See Karen Collins, Holly Tessler, Kevin A. Harrigan, Michael J. Dixon, and Jonathan Fugelsang, “Sound in Electronic Gambling Machines: A Case Study of Player Interaction,” in *Game Sound Technology and Player Interaction: Concepts and Developments*, ed. Mark Grimshaw (London: IGI Global, 2011).

(22) Jonathan Parke and Mark Griffiths, “The Psychology of the Fruit Machine: The Role of Structural Characteristics (Revisited),” *International Journal of Mental Health and Addictio n* 4 (2006): 171.

(23) Michel Chion, *Le Son: Traité d’acoulogie* (Paris: Editions Nathan, 1998), 79–86.

(24) See, for example, Julie Hatfield, R. F. Job Soames, Andrew J. Hede, Normal L. Carter, Peter Peploe, Richard Taylor, and Stephen Morrell, “Human Response to Environmental Noise: The Role of Perceived Control,” *International Journal of Behavioral Medicine* 9, no. 4 (2002).

(25) Paul A. Pavlou and David W. Stewart, “Measuring the Effects and Effectiveness of Interactive Advertising: A Research Agenda,” *Journal of Interactive Advertising* 1, no. 1 (2000).

(26) Andrew Wharton and Karen Collins, “Subjective Measures of the Influence of Music Personalization on Video Game Play: A Pilot Study,” *Game Studies: The International Journal of Computer Game Research* 11, no. 2 (2011).

(27) Mihalyi Csikszentmihalyi, *Flow: The Psychology of Optimal Experience* (New York: Harper Perennial, 1990).

(28) Davide Rocchesso and Roberto Bresin, “Emerging Sounds for Disappearing Computers,” in *The Disappearing Computer, Lecture Notes in Computer Science 4500*, ed. Norbert Streitz, Achilles Kameas, and Irene Mavrommati (Berlin: Springer-Verlag, 2007), 241.

(29) There are also, of course, some notable differences between video games and slot machines, the most obvious being the betting of money on the outcome, but effectively slot machines today are video games.

(30) Natasha Dow Schull, “Digital Gambling: The Coincidence of Desire and Design,” *The Annals of the American Academy of Political and Social Science* 597 (2005): 67.

(31) Parke and Griffiths, “Psychology of the Fruit Machine,” 176.

(32) Parke and Griffiths, “Psychology of the Fruit Machine,” 157.

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