# Chapter 14
# Applying Game Mechanics to Networked Music HCI Systems

**Anıl Çamcı, Cem Çakmak and Angus G. Forbes**

**Abstract** We discuss the use of game mechanics as a means to facilitate collaboration in networked music performances. We first look at core concepts of gaming and how these relate to musical creativity and performance. We offer an overview of various perspectives towards game mechanics and rule systems with examples from video games and musical practices. We then describe audiovisual software that we developed in order to study the integration of game-like elements and mechanics into networked music performance. Finally, we offer the results of a preliminary user study conducted using this system in private and public performance contexts. We observe that imposing various game mechanics upon a networked performance affects the nature of the musical collaboration as well as the audience's attentiveness towards the performance.

## 14.1 Introduction

Previous research has shown that reward mechanisms can be used to influence multi-agent systems toward collaborative behavior (Raffensperger 2013). This is often used in multiplayer video games, where players in remote locations collaborate with or compete against each other in pursuit of a common virtual goal, such as completing a campaign or obtaining resources. Such goals in music performance would be harder to delineate; even if we were to enumerate sensations, such as pleasure or closure, as desirable outcomes of a musical experience, the subjective nature of these sensations would make them hard to quantify as shared goals across multiple agents. However,

A. Çamcı (✉)
University of Michigan, Ann Arbor, USA
e-mail: acamci@umich.edu

C. Çakmak
Rensselaer Polytechnic Institute, Troy, USA
e-mail: cakmao@rpi.edu

A. G. Forbes
University of California, Santa Cruz, USA
e-mail: angus@ucsc.edu

© Springer Nature Switzerland AG 2019

S. Holland et al. (eds.), *New Directions in Music and Human-Computer Interaction*, Springer Series on Cultural Computing, https://doi.org/10.1007/978-3-319-92069-6_14

in a non-traditional performance environment, such as those encountered in music HCI applications, extra-musical constructs and rule-based systems can be used to establish narrative goals that can shape the nature of music-making.

Although co-location of performers in physical space is considered a prerequisite of group music, networked music allows musicians in remote places to engage in collaborative activity (Alexandraki and Akoumianakis 2010). Over the last decades, research into networked music has primarily focused on addressing technical limitations, such as latency and transmission quality. Despite significant advancements made in these areas, some level of latency is understood to be intrinsic to networked music due to the simple fact that signals take time to travel through a network. A latency-accepting approach integrates the inherent delay of networks into the musical interaction (Renaud et al. 2007). However, the lack of physical co-location among performers is still considered a primary challenge for networked music.

Over the last decades, multiplayer video games have proven to be successful platforms for stimulating competitive and collaborative behavior in networked settings. As a result, various technical and aesthetic characteristics of computer gaming are adopted in networked instruments (Rudi 2005; McKinney and McKinney 2012). Moreover, many music HCI applications foster social and collective experiences by promoting collaboration and competition (Jordà et al. 2007). In this article, we discuss the use of game mechanics in networked music as a means to facilitate collaboration across remote participants. Looking at core elements of games, such as rule and reward systems, we explore common traits between games and music. We then describe a music HCI system that we have designed to study the integration of game mechanics into networked collaborative performance, and to investigate how this integration affects the dynamics of the performance. Finally, we offer an evaluation of a series of user studies conducted with this system in private and public performance contexts.

## 14.2 Game, Rules, and Music

Playing a game and making music are similar in many ways. But before highlighting the similarities between the two, we will first focus on what constitutes a game. Here are two dictionary definitions of the word "game":

1. A form of competitive activity or sport played according to rules.
2. An activity that one engages in for amusement. (Game, n1 2017).

On the surface, these two definitions draw a distinction between competitive (e.g. baseball) and amusing (e.g. 'the floor is lava') games. However, in most cases, these definitions can be interchanged or even amalgamated. A baseball game is often played for amusement, and 'the floor is lava' is based on rules that can impose competition among its participants. We could therefore consolidate these definitions to suggest that a game is a competitive activity that one engages in for amusement by following a set of rules.

The philosopher Mark Rowe defines a game as “an abstract object (either a sequence or a goal) which is designed to have no instrumental value; the realization or pursuit of which is intended to be of absorbing interest to participants or spectators” (1992). This interpretation, without incorporating the concept of competition, highlights a lack of instrumental value in games. Instrumental value is considered the antithesis of intrinsic value, which is often deemed a trait of musical activity (Blacking 1969). Musical activity and game playing can therefore be similar by virtue of relying on intrinsic value. However, Rowe draws a distinction between the arts and games by arguing that artistic activity inherently aims to produce “a work or a product in a way that games do not” (1992); while it is this product that renders an artistic activity pleasurable, with games, “it is the activity of playing which gives enjoyment, either directly to participants or vicariously to spectators” (Ibid.). It could however be argued that many musical practices, and especially those that involve improvisation, thrive on a similar focus on the in-the-moment appreciation of the process rather than a fixed product.

Rowe’s emphases on the intrinsic value and the absorbing qualities of games are common amongst theorists. For instance, the historian Johan Huizinga describes the broader concept of *play* as an activity that is intentionally outside of ordinary life, and one that utterly absorbs the player without requiring an external material interest (1955). Huizinga also emphasizes that play can proceed only according to rules. Similarly, the philosopher Bernard Suits calls attention to the importance of rules when he describes *playing a game* as a “voluntary attempt to overcome unnecessary obstacles” using only the means that are permitted by a prescribed set of rules (2005). Various music theories can be regarded as rule systems, where culturally imposed guidelines for music-making constitute a framework for creative activities of intrinsic value. Furthermore, formal rule systems are commonly used in generative music (Friberg 1991; Lerdahl and Jackendoff 1985). Musikalisches Würfelspiel, an early example of generative music-making, is a game where dice rolls are used to determine the order in which pre-composed snippets of music should be played. In the 20th century, this technique was framed as “aleatoric music,” and practiced by composers such as John Cage, Charles Ives, and Henry Cowell. The concept of “game piece,” as coined by the composer John Zorn, relies on a similar idea of controlled improvisation. While clear-cut objectives similar to those in games may not be apparent in these practices, a general sense of indeterminacy can be described as an aesthetic goal. Furthermore, the artificial goal of a game is considered to be of less importance than the experience towards achieving this goal (Salen and Zimmerman 2003). The feelings of surprise and amusement, which are intrinsic to the game experience, are also prevalent in music.

Game rules can be regarded as delineating a “limiting context” within which decision-makers try to achieve objectives (Abt 1987). This context is often referred to as a *game world*, where rules are used to cue players into imagining this world (Juul 2011). A similar sense of immersion is inherent to musical experiences on the basis of the context set by the particular decisions involved in a musical composition or performance. Accordingly, many musical practices are capable of prompting listeners to imagine alternative worlds (Çamcı 2016). While many qualities of gameplay are comparable to that of musical activity, there are more explicit theories that characterize gaming as a creative activity in itself. The game designer Ernest Adams, for instance, describes gaming as a form of self-expression in the style of a "constrained creative play", where the decisions made by players are indicative of their style (2013). Similarly, Salen and Zimmerman define play as a "free movement in a rigid structure" (2003). A game can therefore can be conceived as a medium for creativity through the use of rules as a means for "tremendous amounts of emergent complexity" (Ibid.).

## 14.3 Game Mechanics

The term *mechanics* is defined as "the way in which something is done or operated" (Mechanics, n1 2017). In the context of games, mechanics serve to connect the players' actions with the goals of the game (Sicart 2008); they determine "what the players are able to do in the game-world, how they do it, and how that leads to a compelling game experience" (Rouse and Boff 2005). Looking more specifically at video games, a *core mechanic* is described as the algorithmic implementation of a game's rules in the form of a symbolic and mathematical model that determines the challenges and the actions afforded by the game (Adams 2013). The researcher Miguel Sicart more broadly defines video game mechanics as a collection of methods invoked by the players as they interact with the game world (2008). Some of the functions of game mechanics include operating the internal economy of the game, presenting active challenges, accepting player actions, detecting victory or loss, and controlling the artificial intelligence (Adams 2013).

### *14.3.1 Economy Mechanics*

Most games rely on an internal economy as a core mechanic. The internal economy of a game manages the creation, exchange and depletion of resources in a quantifiable manner (Adams 2013). Especially in creativity games, the economy limits the player in a way that provides a structure for the player's creative actions (Ibid.). This may be the reason why the game designer Greg Costikyan describes games as a form of art where players make decisions towards managing resources in pursuit of a goal (1994). In this pursuit, obstacles prevent the user from achieving their goal; these obstacles lead to *conflict*, which is "an intrinsic element of all games" (Crawford 1984). Accordingly, Salen and Zimmerman frame their definition of a game as "a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome" (2003). A common method of introducing conflict into games is to allow players to manipulate other players' resources to restrict their ability to act (Adams 2013). Often referred to as a survival system, this internal economy forces players to be mindful of both their and other players' actions.

### 14.3.2 Game Interface and Agency

The interface of a video game serves several purposes: it mediates between the player and the mechanics by offering the player a limited control over the game. Common interactions include navigating the game world and manipulating entities in it, monitoring and controlling inventory, and communicating with other agents. Through such actions, the interface helps the player gain a sense of *agency*, which is described as “the satisfying power to take meaningful action and see the results of our decisions and choices” (Murray 1997). The game interface can also include feedback systems such as mini-maps and indicators. Indicators can range from icons and power bars to plain text (Adams 2013).

### 14.3.3 Conflict Mechanics in Music

Going back to our earlier definition of a game as “a competitive activity that one engages in for amusement by following a set of rules,” the quality that appears to differentiate games from music could be highlighted as the sense of competition integral to games. However, there are many musical traditions that similarly rely on competition. For instance, in Turkish minstrel tradition, two musicians compete as they take turns in improvising lyrics accompanied by *saz* playing. The musical duel proceeds in the form of a conversation, where musical lines and lyric narratives evolve in each turn. At the end of the duel, the audience determines the winner in a similar fashion to the rap battles that are common in modern hip-hop music.

In another form of musical competition, musicianship contests have been used to promote virtuosity among performers in solo and group contexts. While competition in an artistic field is controversial by nature due to a lack quantitative measure for the intrinsic values of an artwork, contests have been deemed a valuable pedagogical tool in music education (Rohrer 2002). Moreover, research has shown that even under competitive pressure, musicians identified their efforts as significantly more cooperative than did athletes, while athletes recognized their activities to be much more competitive than did musicians:

> The competitive situation is one in which reinforcement is prescribed on the basis of a subject’s behavior relative to that of other individuals; while the cooperative or less-competitive situation involves working in harmony to achieve a mutually agreeable end. The person engaged in competition is concerned with winning, while the goal of winning need not be present under cooperative conditions (Coleman 1976).

### 14.3.4 Mechanics of Music Video Games

Video games are primarily ocular experiences, where sonic events often serve to augment the visuals. Most modern video games provide an option to turn down sound effects and music whereas doing the same to the visuals would render the game unplayable. In *music video games*, however, sound is the primary medium; it can function as both a product of the gameplay (i.e., as a result of successful interactions) or an indicator of game mechanics (i.e., as a means to provide interaction cues). Music video games often comprise a combination of sounds and visuals, whereas games that have little to no visuals are labelled as *audio games*. These games rely exclusively on spatial, temporal and spectral properties of sound for gameplay and interactivity. Popular examples to audio games are bit Generations' *Soundvoyager*[1] and Kenji Eno's *Real Sound: Kaze no Regret*,[2] which was primarily designed for visually-impaired players.

While audio games utilize sound as the sole medium for communicating the game's progression, music video games can situate sounds as the creative goal of the game. Furthermore, such games can reverse the causal relationship between competition and creativity observed in musical contests as described earlier. While musicianship contests often promote virtuosity as a means to prevail in a competition, music video games can use competitive challenges as a means to drive creativity. For instance, in *Fract OSC*,[3] musical exploration constitutes the primary mechanic of the gameplay: as a player explores the sandboxed virtual environment of the game, their primary goal is to unlock a music synthesizer. By solving puzzles, the player creates new timbres and harmonic structures. Unlike most survival-based video games, "mistakes" in *Fract OSC* often result in re-spawning without a resource penalty. In such a system where conflict mechanics serve to drive musical creativity, exploration and creation supersede competition and winning.

Conforming to Rowe's definition of games, sequential activity and timing is of importance to most video games. Many 2D platformer and 3D shooter games use visual rhythm and precise timing as core mechanics without any musical outcomes. Rhythm and timing, which are fundamental elements of music-making, are also utilized in music video games. Popular examples to these are music performance simulators, such as *Guitar Hero* and *Rock Band*, where players use "toy instruments" to perform sequential interaction tasks with the purpose of filling in parts in popular songs. These games are based on rhythm challenges that test the player's "ability to press the right button at the right time" (Adams 2013), in a somewhat similar fashion to musicianship contests that promote virtuosity. Although musical activity is the central theme in these games, they are criticized for lacking the spontaneity and originality of "total musical engagement" (Miller 2009).

Using Coleman's dichotomy between competition and cooperation in gameplay, we can identify music video games that rely on collaboration rather than conflict. *Plink*,[4] developed by Dinahmoe Labs, is an online game where a player can partake in musical improvisation with other players who are randomly assigned to the same session. As a player clicks on a horizontally flowing timeline, they trigger

[1] https://en.wikipedia.org/wiki/Bit_Generations#Soundvoyager.

[2] https://en.wikipedia.org/wiki/Real_Sound:_Kaze_no_Regret.

[3] http://fractgame.com.

[4] http://dinahmoelabs.com/plink/.

events with the instrument that has been assigned to them. The Y-axis position of the player's mouse determines the instrument's pitch. All the sound events and pitches are quantized to predetermined values so the events triggered by individual players adhere to a strict temporal grid and note scale. A popular interaction among users is *chasing* each other's cursors, which results in the repetition of musical patterns between instruments, akin to the call-and-response technique in music performance.

## 14.4 A Case Study: *Monad*

So far, we have discussed the similarities between gameplay and collaborative music-making in terms of their reliance on implicit and explicit rule systems, agency and communication, and intrinsic value gained through creative activity. Besides these conceptual similarities, networked music HCI systems also share many technical similarities with video games in terms of the media used for interaction, graphical user-interfaces (GUIs), and network topology. Furthermore, the fundamental reliance of both domains on computers result in comparable work-flows. Given such similarities, and the evident success of video games in supporting online collaboration, we have designed *Monad*, an audiovisual software that implements some of the intrinsic elements of video games in a networked music HCI system. With *Monad*, we aim to explore the use of game mechanics to drive collaboration among remote agents of a networked performance.

Similar to multiplayer games, a collaborative musical performance is inherently a shared experience between multiple agents. Parlett explains that a game relies on a set of equipment, and a series of rules by which the equipment is manipulated to achieve the winning conditions (1999). In *Monad*, audiovisual structures represent the primary equipment of the game. Through musical collaboration governed by an internal economy mechanic, the users manipulate these structures. The internal economy introduces an element of conflict based on survival. This element of conflict in *Monad* serves to drive creativity by encouraging an engagement with the ongoing collaboration over the manipulation of the equipment. Together, the GUI and the mechanics of *Monad* set up the "limiting context" that prompts players to achieve musical objectives.

In a *Monad* performance, remote players collaborate over the manipulation of a 3D structure, as seen in Fig. 14.1, which is a visual representation of a drone-based sound synthesizer. Rather than triggering individual sound events, players contribute to the sound output of the system by adding, changing, and removing visual patterns that drive the sound synthesis. Users can click-and-drag anywhere on the screen to rotate the structure and scroll to zoom in or out of it. This way the users can observe the structure from different perspectives, or become immersed in it. With respect to the axes defined by Hattwick and Wanderley for the evaluation of collaborative performance systems (2012), Monad offers a *centralized music system* that affords an *equality of control* across *interdependent performers* who contribute to a *homogeneous texture*. In Malloch et al.'s terms, *Monad* is a *rule-based performance*

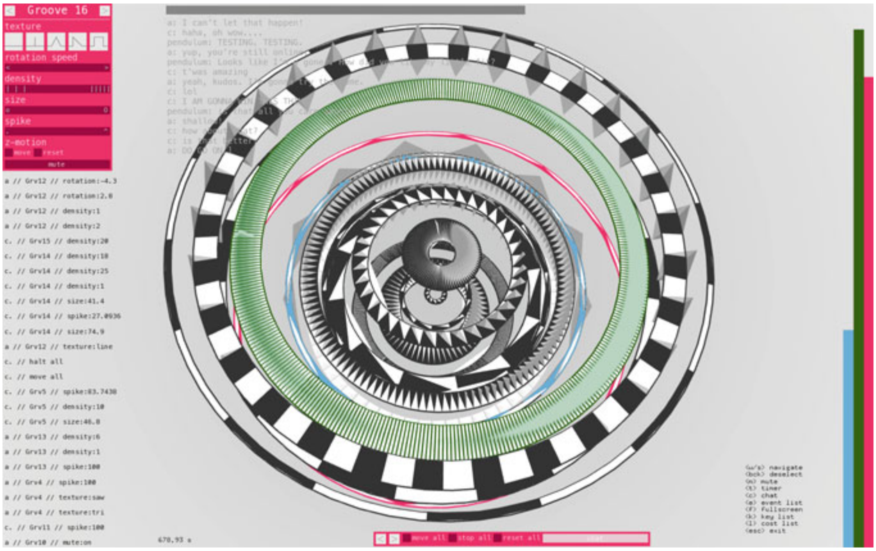


**Fig. 14.1** A screenshot of the *Monad* interface. On the top left is a GUI window that allows the user to manipulate a disc's timbral, temporal and dynamic characteristics. Beneath the GUI window, is a text stream that reports recent allocations of resources. A chat box on the top of the screen allows the player to send text-based messages; a chat stream that overlays the visuals can be turned on or off. On the right-hand side are the color-coded resource bars. Once a player's bar reaches zero, the player loses the game. The last remaining player becomes the winner

*system* (2006), where the users focus on controlling the process of manipulating a common visual structure.

### 14.4.1 Implementation

*Monad* is designed using *openFrameworks*,[5] an open source multimedia toolkit for creative coding. The audio in *Monad* is implemented using the *openFrameworks* add-on for the *Tonic* audio synthesis library.[6] The visual structures in *Monad* are inspired by Evgeny Sholpo's optical disc designs from the 1930s (Smirnov 2013). All players are able to add, remove, and manipulate various parameters of these rotating graphical objects to improvise electronic music. The discs can be set to rotate at LFO rates to create rhythmic elements, and at audio frequencies to synthesize sounds. The rotating nature of the visual elements in *Monad* is reminiscent of the researcher Nick Bryan-Kinns' music HCI application *Daisypone*, which allows novice users to collaborate

[5] openframeworks.cc.

[6] https://github.com/TonicAudio/ofxTonic.

on a rhythmic structure by adding sound event markers on a rotating digital sequencer (2004).

*Monad* presents its players with a virtual "media space," as seen in Fig. 14.1. Media spaces link remote locations with audio and video connections in order "to create the metaphor of a seamless physical space for the purpose of collaborative work" (Gurevich 2006). Although such virtual environments can benefit from new approaches to user interaction and cross-modal representations (Çamcı et al. 2017), many media spaces fail to harness the imaginative potential of their medium:

> In spite of the recognition that technologies can create new modes of interaction, media spaces and many online virtual environments don't try to create new paradigms. For the most part, these try to imitate face-to-face interactions in a virtual world. This has led to criticism in the literature that network-based interactions are "unnatural" or inherently inferior to face-to-face interactions. Many are indeed unsatisfying, but this is most often attributable to the fact that these systems have not exploited the unique possibilities and opportunities of their underlying technologies. There still exists a pre-occupation with simulating real life; creating experiences that are "just like being there", when in fact we could be creating experiences that are entirely not otherwise possible when we are in the same room. (Gurevich 2006)

In one such example, where an unlikely experience is favored over those that simulate real life, Rob Hamilton and Chris Platz's *Carillon* involves multiple performers playing a giant carillon in a virtual environment (2016). Instead of interacting directly with the sound producing parts of the virtual instrument, performers control the movement patterns of these parts with body-based interactions. This is similar to *Monad*'s focus on the manipulation of sound producing sequences as opposed to triggering of singular sound events. This approach, which highlights timbral qualities of music over temporal ones (Çakmak et al. 2016), not only alleviates some of the latency and synchronization issues that are inherent to networked music systems, but also relieves players from an immediacy of sound-making. The players sculpt sounds over time collaboratively as they interact with various parts of the system. This is similar to live coding systems, where text-based instructions are used to manipulate the sound output over time.

The GUI window on the top left corner of the screen gives the performers control over the timbre, dynamics, effects, and temporal characteristics of the rotating disc that they are interacting with. Bars on the right-hand side of the screen indicates each user's remaining resources. When a user's color-coded bar reaches zero, the user is removed from the performance. The last user who remains in the game is declared the winner.

In a networked performance, the players are often deprived of the benefits of being physically co-located. The sense of immersion that a virtual system affords can therefore be used to instigate a feeling of being "in the zone," which is not only common to music performances, but also "an explicit goal of virtually all videogame design" (Miller 2009). This immersion serves to fulfil Huizinga's aforementioned characterization of games as being outside of ordinary life while utterly absorbing the user. Adams suggests that even using a 2D display, which is a common component of personal computers, a sense of immersion can be achieved by allocating the entirety of the screen space to a virtual environment and overlaying UI elements as semi-transparent windows (2013). This principal is followed in the design of the *Monad* view-port. The lack of a frame around the virtual structure implies a first-person interaction for the player. Parameter windows and resource indicators are overlaid onto the virtual space in the form of head-up displays.

On start-up, each user is assigned a color which is reflected in the UI elements, resource indicators, and various other parts of the visual structure that the user interacts with. Such consistency in color schemes is also known to contribute to the sense of immersion in games (Miller 2009). Furthermore, when a player makes changes to the visual structure, this becomes apparent in other player's window through the particular color assigned to the player who is making the change. The color coding therefore contributes to the player's agency in the performance.

The mappings between auditory and visual features in *Monad* has been designed to facilitate the perception of a cross-modal coherence. In order to achieve a tight audiovisual synchronization, all drawing and synthesis operations are handled by client nodes. Although the server maintains the momentary global state of the environment, the transmitted information consists only of numeric values pertaining to visual coordinates and synthesis parameters, putting minimal strain on the network.

The interactions between musicians during an improvisation can have significant impact on the resulting music. Furthermore, such interactions play a role in the audience's attentiveness, which can be negatively impacted in performances that rely on digital musical instruments (Berthaut et al. 2013; Blaine and Fels 2003). Especially in networked performances, the extra-musical interactions among performers can be lost; a common method to alleviate this issue is to implement a text-based chat system to facilitate the dialogue between performers (Alexandraki and Akoumianakis 2010; McKinney and McKinney 2012). Furthermore, performers use such systems to communicate with the audience as well. Accordingly, Monad utilizes a chat system that allows performers to submit text messages during the performance. These messages overlay the visuals in a semi-transparent fashion, as seen in Fig. 14.2, and can be turned on or off.

### *14.4.2 Topology*

The topology of a network dictates what is communicated during transmission, the order in which the communication happens, and the direction of information flow. For example, a centralized network takes information from the players' input and sends it to a center of activity, where the data is analyzed (Weinberg 2005; Burk 2000). Decentralized systems, on the other hand, enable direct interactions between its participants but are limited by the computational capacity of each node. However, Rohrhuber argues that the network topology alone does not provide a complete representation of a network music system (2004). The causal topology of a networked performance becomes an integral aspect of the audience experience. In other words, solely focusing on the logical organization of the network cannot fully reflect the end product.

With *Monad*, we designed a network structure based on a server-client relationship. All users are clients with equal privileges, while the server, which is hosted on one of the performers' computer, maintains the shared environment. Upon starting the program, users are asked to enter the server's IP address and a unique nickname for their client. The server initially assigns equal resources to each node, and broadcasts each participant's details to the others. During the performance, the server continually reports the current state of the environment to every participant. Here, the server functions as a shared object that all clients are able to impose changes upon. Once individual clients receive the most recent change of game state from the server, the appropriate sounds and visuals are rendered on the client end. In addition to controlling the system state, the *Monad* server also maintains the allocation of resources and IP-based client identifiers, such as color labels and nicknames.

### 14.4.3 Intra-action

Musical instruments are most commonly designed for individual performers. Especially in traditional music practices, it is very rare for a performer to physically interfere with another performer's interaction with their instrument. There are indeed exceptions to this: for instance, African balafon music can require multiple musicians to play their parts on one instrument in a way that creates a single musical line. There are similar examples in contemporary western music as well: for example, in Stockhausen's 1964 composition *Mikrophonie I*, four musicians play a single tam-tam with various materials.

However, such collaborations among multiple performers using a single instrument is often impossible due to physical constraints of the instrument. Since there are no such constraints in virtual multimedia environments, the performers can intervene with each other's interactions with a musical interface much more easily. In fact, such interference is integral to many video games by way of promoting it as a means to survive in the game (e.g. by stealing resources from another user). In the context of music performance, Moore and Place describe this sort of activity as "intra-action" as opposed to interaction (2001). They describe that in an ensemble that engages in intra-activity, the performers collectively play an "inclusive instrument," which the individual members of the ensemble do not have complete control over. The authors therefore liken the role of the performer in this context to being part of an organism that functions via interdependencies among individuals who work towards a singular audio-visual entity. In that sense, *Monad* can be considered an intra-active "multi-user instrument," which according to Jordà must enable mutual interaction (2005). Berthaut and Dahl refer to such interaction as "concurrent collaboration" in the context of digital music ensembles (2016).

Recalling Parlett's delineation of games as relying on the manipulation of a shared equipment according to rules, we can argue that video games promote intra-active behavior among multiple agents. Such behavior, which is facilitated by virtual environments, hints at the unexplored possibilities of new game-based models for musical performance, where instruments are embedded with intra-active mechanics that can lead to increased competition and musical interaction. In *Monad*, by implementing a hierarchical equality between the concurrent collaborations between performers, we have enabled game-like intra-actions, where a performer can immediately complement or override another performer's actions.

### *14.4.4 Mechanics*

To evaluate the effects of a video game-like economy mechanic on networked improvisation, we developed two separate rewards mechanisms in two consecutive versions of *Monad*. In both mechanisms, musical collaboration relies on an internal economy, where every action that has a sonic outcome costs a certain amount of virtual resources. On startup, each player is allocated an equal amount of resources by the game server, which maintains the economy throughout the game.

In the first version of *Monad*, we implemented a client-driven reward system that relies on players to give each other points when they "like" what another player has done. Other players' most recent actions are displayed as a stream of events under the parameter GUI window on the left-hand side of a user's screen, as seen in Fig. 14.2. Clicking on an action label rewards points to the player who performed that action. In this system, the clients are in charge of the rewarding mechanism, thus their decision-making is critical to the internal economy. In Jarvinen's taxonomy of game mechanics, the principal mechanic here is one of "approval" (2008). Each player can explicitly approve of other players' actions to grant them resources that would further their participation in the game.Å

In the second version of *Monad*, seen in Fig. 14.3, we implemented a server-driven reward system that functions independently of the players' explicit approval. Here,

**Fig. 14.2** Two screenshots from *Monad* version 1, which is based on the player-driven reward mechanism. On the left, the green player's screen shows a performance with 3 other players. The rotating disc that each player is currently interacting with is highlighted with the color they have been assigned. Below the GUI window on the top-left is a color-coded stream of actions performed by other players. The green player can click these boxes to reward other players for their actions. On the right, the green player has the visibility of the chat stream turned on. The conversation between the players streams over the visual structure

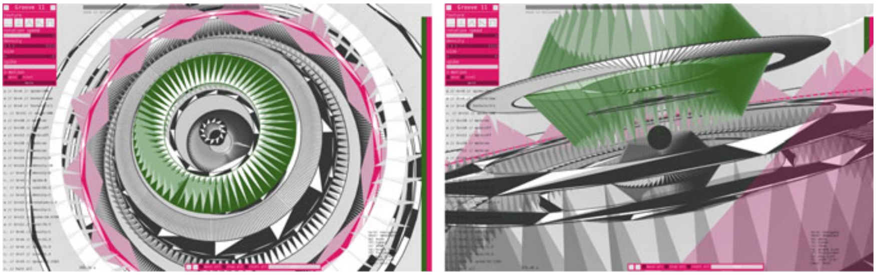

**Fig. 14.3** Two screenshots from *Monad* version 2 based on the system-driven reward mechanism. In this version, the system automatically rewards actions that are contiguous and similar to previous actions. A stream beneath the GUI window reports whenever the system rewards an action

the server keeps track of each player's actions, and assigns points to players who make changes that are analogous to previous moves by other players, similar to the *chasing* action observed between players in *Plink* as discussed earlier. This model is inspired by the call-and-response technique often used in musical improvisations, as well as in the aforementioned minstrel battle traditions. An action, such as changing the timbre or frequency of a rotating disc, is automatically rewarded when it's performed within 10 s of the action it replicates. This duration was inspired by the supposition that the human understanding of the "now" expires within a span of 5–9 s (Miller 1956). As a result, users are encouraged to pay attention to other performers, and to promptly respond in order to retain resources. Using Jarvinen's taxonomy, the principal game mechanic underlying this model is one of "imitation" (2008). An implication of this model is that a player can follow other players to earn points, or instead deviate from previous actions by spending resources to potentially create a new musical direction for the performance. The user can then engage in the call-and-response behavior to earn points, but now in a musical direction of their making.

Under both mechanics, the player invests a set amount of resources with each action; approval or imitation points that this action receives increase the player's resources, and therefore, their ability to remain in the game. In Rowe's terminology, this creates a sequence-driven game as opposed to a goal-driven one: instead of working toward an end-game goal, the players either win or lose within a continuous process of elimination. Each action that gains approval or imitation points earns the user twice the amount of resources spent to perform the action. As a result, both mechanics promote an element of risk-taking towards extending the longevity of participation.

## 14.5 Evaluation

### *14.5.1 User Study*

10 users with varying degrees of experience in networked music and video games participated in two studies conducted with each version of *Monad*. Each user was first asked to participate in an individual tutorial, where the UI and the mechanics of the game were described to them. This was followed by a brief two-player performance between the user and the supervisor of the study. The users were then asked to participate in a networked performance in groups that ranged from 3 to 5 players. These were private performances where a time constraint was not imposed. At the end of each performance, the users were asked to fill out a survey, which included Likert-scale (i.e. rated between 0: strongly agree and 5: strongly disagree) and free-form verbal questions. The users rated a set of statements that determined their background (e.g., “I am a musician”, “I often play video games”), the learning curve involved in performing with *Monad* (e.g. “Getting to learn the program was easy” and “I felt getting better as I played”), their relationship with other players (e.g. “Communication with others was easy,” “I felt competitive against other players,” and “I rewarded players due to their specific actions”), and their general experience (e.g. “UI controls were practical,” “The musical output was satisfying,” and “I would like to play it again”).

At a later date, users were invited to participate in two public performances, as seen in Fig. 14.4, which had 15 and 35 viewers respectively. Both performances involved both local and remote players. In each performance, a local player’s screen was shared on a projection screen, allowing the audience to experience both the sonic and visual elements of the performance, including the rotating disc structure, the interface elements of the system, and textual conversations among the players. After the performance, the audience members were invited to participate in an online survey where they were asked questions about the performance. Following these public performances, the players were contacted for an informal discussion about their experiences with using *Monad* as a networked performance tool.

**Fig. 14.4** Images from two *Monad* performances held at venues in Istanbul. In both performances, the screen of a local player was shared with the audience through projection

The results showed that all users felt their performance with the system improved over time. The users reported that the color schemes and nicknames were sufficient to distinguish each performer during the performance, implying that a sense of agency among the players was achieved. All users reported enjoying the musical product, and stated a preference towards playing again.

The amount of competitive behavior between users was surprisingly low. In the study conducted with the first version of *Monad*, where players rewarded each other for their actions, a collaborative attitude was noticeable throughout the performances. Players whose resources were getting low asked for help through the chat system, which prompted other players to reward points to keep them in the game. The client-driven reward mechanism also created interesting musical dynamics. For instance, some players began to rapidly alter the textures on a groove, causing noticeable changes in timbre while at the same time losing a significant amount of resources. Musically, such actions resulted in solo-like gestures where other users displayed a musical inactivity while providing resources to the "soloist" to keep them in the game.

With the client-driven reward mechanism, we observed that as the number of players increased, the coherence between decisions from different players began to degrade. This created sonic results that were characterized by the participants as being cacophonous. This result can be attributed to the fact that the implementation of the client-driven reward mechanism can promote simultaneously rewarded actions that clash with each other. While this was not a concern with 3-player performances, with increasing number of players we observed instances of parallel musical directions emerging between player pairs. Furthermore, users reported that diverting their attention from the visual structure to the stream of actions on the left to cast rewards was at times distracting, especially when more than 4 players were involved.

We compared this model with the server-driven reward mechanism in the second version of *Monad*, where effective collaboration was defined by players imitating each other rather than explicitly approving each other's actions. The musical outcome in this case was less chaotic. Participants indicated that the automated rewarding system worked much less obtrusively, and motivated them to be more attentive to what others were doing in order to "survive." The audio recordings of the performances with the second version of the system evidenced a more coordinated collaboration, since the underlying game mechanic encouraged the players to perform actions that are similar. The resulting change in the musical output from the same group of players indicates that the mechanics had an observable impact on the nature of collaboration, and therefore the aesthetics of the performance.

During the design of the system, a feature considered for both mechanics was a countdown system, where extended stasis on a player's part would result in gradually decreasing resources only alleviated by participation in the performance. However, during the evaluation, we did not notice a need to entice users into active participation. The players largely favored the exploration of the visual structure and its sonic output over the preservation of resources through inactivity. In that sense, we observe that what drives the competition in the game is a motivation to earn points, as opposed to retain them. Players are inherently inclined to perform and have their actions evaluated within the framework of the game mechanic. This conforms to the previously described nature of conflict mechanics in music, such as those observed in musical competitions, that rely heavily on cooperation.

### 14.5.2 Audience Feedback

Brief surveys were carried out with the members of the audience after each performance. In both performances, very little information about the system was disclosed to the audience in advance. Most of the audience members reported having previous experience with electronic music and networked performances, but indicated that they lacked experience with video games. A majority of the viewers expressed having enjoyed the performance, and were interested in experiencing it again.

The audience members were able to view a projection of one of the local performers' screen. While less than half of the survey-takers reported not having noticed the underlying game mechanics throughout the performance, the rest stated that it became noticeable as the performance developed. Interestingly, the latter group rated the coherence between sounds and visuals higher than the former group.

One of the audience members stated that the disembodied (i.e. laptop-based) and process-oriented interactions felt non-musical. Other participants suggested that the local players could have utilized the physical space more expressively. During the informal discussion that followed the performances, one of the local players responded to this criticism by expressing that physical gestures would have implied a hierarchy among the performers by way of overpowering the role of the remote players in creating the audiovisual output.

## 14.6 Conclusion

Networked musical collaborations offer unique challenges and opportunities. Research into designing networked music systems is motivated not only by technical limitations rooted in network latency, but also by the practical and conceptual implications of remote performance. For instance, the inability to share the same physical space, and the lack of non-musical communications between performers can adversely affect a more traditionally conceived musical performance. Online video games that successfully facilitate absorbing experiences and creative play among remote agents can serve as a model when designing networked music systems. Novel music HCI applications—ones in which video game mechanics function as musical rule systems that facilitate collaboration—can therefore be favored over more traditional approaches to performance in the context of networked music.

In this text, we investigated the parallels between games and music in order to highlight game-like elements that can be incorporated into the design of networked music HCI applications. We then introduced one such application, *Monad*, that allows remote participants of a networked performance to cooperatively manipulate an audiovisual structure within the limiting context set by an internal economy mechanic. In our preliminary user study conducted with *Monad*, we observed that imposing game mechanics upon a networked performance directly affected the nature of the musical collaboration. Specifically, we found that a game mechanic that emphasizes imitation over approval increases the amount of active collaboration between performers. Additionally, we observed that facilitating non-musical elements, such as in-game conversations between performers and a visible economy of the game, contributes to the audience's appreciation of the performance.

Under both mechanics, players were primarily focused on cooperation rather than competition, with the imitation mechanic promoting a more attentive collaboration. This result motivates us to further explore the element of attentiveness between remote players, and to investigate how the imitation mechanic could be adjusted to improve its extent. Furthermore, we are also interested in exploring how more competitive behavior could be motivated in a networked music performance. For instance, a mechanic based on a player's removal of resources from another player, or a system-driven imitation mechanic that re-allocates resources between players, could force players to be both attentive and competitive at the same time. Based on our preliminary study, we would expect such changes in the rule system to have a noticeable impact on the musical result of a performance.

We believe that exploiting the similarities between video games and music by applying game mechanics to musical collaboration presents new and interesting possibilities. Moreover, we believe that new characterizations of meaningful musical collaborations within music HCI systems can be used to aid the design of new game mechanics and new forms of gameplay.

## References


Abt C (1987) Serious games. University Press of America

Adams E (2013) Fundamentals of game design. Pearson Education

Alexandraki C, Akoumianakis D (2010) Exploring new perspectives in network music performance: the diamouses framework. Comput Music J 34(2):66–83

Berthaut F, Dahl L (2016) BOEUF: a unified framework for modeling and designing digital orchestras. In: Kronland-Martinet R, Aramaki M, Ystad S (eds) Music, mind, and embodiment. CMMR 2015. Lecture notes in computer science, vol 9617. Springer, Cham

Berthaut F, Marshall M, Subramanian S et al (2013) Rouages: revealing the mechanisms of digital musical instruments to the audience. In: Proceedings of the 2013 conference on new interfaces for musical expression, pp 164–169

Blacking J (1969) The value of music in human experience. Yearb. Int. Folk Music Counc. 1:33–71

Blaine T, Fels S (2003) Contexts of collaborative musical experiences. In: Proceedings of the 2003 conference on new interfaces for musical expression, pp 129–134

Bryan-Kinns N (2004) Daisyphone: the design and impact of a novel environment for remote group music improvisation. In: Proceedings of the 5th conference on designing interactive systems: processes, practices, methods, and techniques, pp 135–144

Burk PL (2000) Jammin' on the web a new client/server architecture for multiuser musical performance. In: Proceedings of the international computer music conference 2000

Çakmak C, Çamcı A, Forbes AG (2016) Networked virtual environments as collaborative music spaces. In: Proceedings of the 2016 conference on new interfaces for musical expression, pp 106–111

Çamcı A, Lee K, Roberts CJ et al (2017) INVISO: a cross-platform user interface for creating virtual sonic environments. In: Proceedings of 2017 symposium on user interface software technology (UIST)

Çamcı A (2016) Imagining through sound: an experimental analysis of narrativity in electronic music. Organ. Sound 21(3):179–191

Coleman DV (1976) Biographical, personality, and situational determinants of leisure time expenditure: with specific attention to competitive activities (athletics) and to more cooperative activities (music). PhD thesis, Cornell University

Costikyan G (1994) I have no words and I must design. Interact Fantasy# 2 J Role-Play Story-Mak. Syst

Crawford C (1984) The art of computer game design. McGraw-Hill

Friberg A (1991) Generative rules for music performance: a formal description of a rule system. Comput. Music J. 15(2):56–71

Game, n1 (2017) In: OED Online. Oxford University Press. Accessed September 20, 2017

Gurevich M (2006) Jamspace: designing a collaborative networked music space for novices. In: Proceedings of the 2006 conference on new interfaces for musical expression, pp 118–123

Hamilton R, Platz C (2016) Gesture-based collaborative virtual reality performance in carillon. In: Proceedings of the 2016 international computer music conference, pp 337–340

Hattwick I, Wanderley MM (2012) A dimension space for evaluating collaborative musical performance systems. In: Proceedings of the 2012 conference on new interfaces for musical expression, pp 21–23

Huizinga J (1955) Homo Ludens: a study of the play-element in culture. Beacon paperbacks 15: Sociology, Beacon Press

Jarvinen A (2008) Games without frontiers: theories and methods for game studies and design. PhD thesis, University of Tampere

Jordà S (2005) Multi-user instruments: models, examples and promises. In: Proceedings of the 2005 conference on new interfaces for musical expression, pp 23–26 (2005)

Jordà S, Geiger G, Alonso M et al (2007) The reactable: exploring the synergy between live music performance and tabletop tangible interfaces. In: Proceedings of the 1st international conference on tangible and embedded interaction, pp 139–146

Juul J (2011) Half-real: video games between real rules and fictional worlds. MIT Press

Lerdahl F, Jackendoff R (1985) A generative theory of tonal music. MIT press

Malloch J, Birnbaum D, Sinyor E et al (2006) Towards a new conceptual framework for digital musical instruments. In: Proceedings of the 9th international conference on digital audio effects, p 49–52

McKinney C, McKinney C (2012) Oscthulhu: applying video game state-based synchronization to network computer music. In: Proceedings of the international computer music conference 2012

Mechanics, n1 (2017) In: OED Online. Oxford University Press. Accessed September 5, 2017

Miller GA (1956) The magical number seven, plus or minus two: some limits on our capacity for processing information. Psychol Rev 101(2):343–352

Miller K (2009) Schizophonic performance: guitar hero, rock band, and virtual virtuosity. J Soc Am Music 3(4):395–429

Moore S, Place TA (2001) Kromozone: a platform for networked multimedia performance. In: Proceeding of music without walls? Music without instruments?

Murray J (1997) Hamlet on the Holodeck: the future of narrative in cyberspace. Free Press

Parlett DS (1999) The Oxford history of board games. Oxford University Press

Raffensperger PA (2013) Measuring and influencing sequential joint agent behaviours. PhD thesis, University of Canterbury

Renaud A, Carôt A, Rebelo P (2007) Networked music performance: state of the art. In: Proceedings of the 30th audio engineering society conference

Rohrer TP (2002) The debate on competition in music in the twentieth century. Update: Appl Res Music Educ 21(1):38–47

Rohrhuber D, de Campo A (2004) Waiting and uncertainty in computer music networks. In: Proceedings of the international computer music conference 2004

Rouse W, Boff K (2005) Organizational simulation: from modeling and simulation to games and entertainment. Wiley, Nova Iorque

Rowe MW (1992) The definition of game. Philosophy 67(262):467–479

Rudi J (2005) Computer music video: a composer's perspective. Comput Music J 29(4):36–44

Salen K, Zimmerman E (2003) Rules of play: fundamentals of game design. MIT Press, Cambridge

Sicart M (2008) Defining game mechanics. Game Stud 8(2):1–14

Smirnov A (2013) Sound in Z: experiments in sound and electronic music in early 20th Century Russia. Koenig Books, London

Suits B (2005) The grasshopper: games, life and utopia. Broadview Press

Weinberg G (2005) Interconnected musical networks: toward a theoretical framework. Comput Music J 29(2):23–39