DESIGNING FOR STOCHASTIC GAME-BASED COMPOSITION WITH MAX & UNITY

Thomas Studley
School of Creative Industries
The University of Newcastle, Australia

Jon Drummond
School of Creative Industries
The University of Newcastle, Australia

Nathan Scott
School of Creative Industries
The University of Newcastle, Australia

Keith Nesbitt
School of Electrical Engineering and Computing
The University of Newcastle, Australia

ABSTRACT

This paper explores the design of digital, composition-based games that enable players to enact creative musical decisions via symbolic gameplay interactions with a stochastic music generation system. Digital game technologies continue to emerge as a versatile platform for researching generative music systems, with past applications ranging from the design of new instruments and interactive "sound toys" to assistive compositional tools. Underrepresented in this space is an exploration of the interplay between musical decision-making processes and more formal gameplay interactions – or rather, "composition games". The authors investigate this intersection as an avenue for exploring new forms of interactive composition in an accessible and engaging environment. Related media are first reviewed to inform a discussion of the conceptual differences between the proposed composition games and existing musical applications of game engines. The authors then detail the use of Max (*Cycling '74*) and Unity (*Unity Technologies*) in the ongoing development of a set of demonstrative creative works, the examination of which suggests key design elements for future composition games. The research indicates that further investigation at the nexus of generative music systems and formal game design holds the potential to unearth new insights regarding real-time interactive music composition.

1. INTRODUCTION

Digital game technologies have accrued great interest as a platform for exploring diverse computer music applications. A particular fervour has emerged around the use of automatic music generation in conventional game music contexts; that is, music designed to support emotional affect (Ekman 2014), immersion into a game world (van Elferen 2016), the auditory display of gameplay information (Ng and Nesbitt 2013), or narrative discourse in a role akin to film score (Summer 2016). Several researchers have developed generative systems with such aims (Brown 2012; Prechtl 2016; Scirea et al. 2016; Herremans and Chew 2017; Gillespie and Bown 2017), an effort mirrored by industry practitioners in both the developmental *Melodrive* (Elmsley et al. 2017) and Paul Weir's procedural sound design for *No Man's Sky* (2016). Yet despite the domain's high activity, scarce few of these systems are being used to explore the potential of automatic music generation in the design of *music-based* games.

This is not to suggest that digital game technologies have yet to be repurposed for music-centric endeavours. Practitioners have long harnessed game engines for diverse applications ranging from the design of new interfaces for musical expression (Berthaut et al. 2011; Sa 2014) to interactive "sound toys" (Dolphin 2009, 2014) and assistive compositional tools. Further, a proliferation of playful mobile apps have garnered popularity for providing casual access to music creation via simple, symbolic interactions (Kassabian & Jarman 2016). Despite their use of game technology, a pervasive trait of these designs – whether tool, toy, instrument, or app – is their avoidance of classical game elements and "ludic" (Caillois 1958) structures; a detail which historically has complicated their conception as musical "games" (Collins 2009; Blickhan 2016).

At the nexus of these two contexts, then, lies an opportunity to investigate the interplay between musical decision-making processes and more formal gameplay interactions – or rather, the design of "composition games". Familiar game metaphors can be harnessed to offer musically inexperienced users a form of abstract creative interaction with automatic music generation in real-time. Here, the authors investigate this intersection as an avenue for exploring new forms of interactive composition.

This paper examines the interplay between stochastic music generation and game-based interaction in the context of player musical creativity. The authors examine two original works-in-progress, *EvoMusic* and *Chase*, to interrogate the design and limitations of each as they relate to the notion of an accessible "composition game". We detail the use of Max (*Cycling '74*) and Unity (*Unity Technologies*) in the development of the works and discuss future directions. This work contributes to a larger research project exploring the compositional potential of

game environments when paired with varied strategies for music generation, and more broadly the "gamification" (Deterding et al. 2011) of composition in digital settings.

2. COMPOSITION GAMES

A lineage of game-based musical praxis can be traced at least as far back as the Musical Dice Games of the 18th Century. These games, wherein a series of dice rolls were used to organise pre-composed musical fragments, were popular amongst the Western European middle class as an access point to compositional processes for the musically inexperienced (Hedges 1978). Though an important precedent for the game-based democratisation of composition, the dice games' reliance on chance operations as the sole mode of player interaction precludes players from making informed compositional decisions; they are afforded no creative agency beyond their choice to "play" or "not play". This distinction provides a useful starting point for our intention with "game-based composition".

The late 20th century then saw the emergence of "game pieces", a tradition which do not prescribe a pre-defined sequence of events but rather a system of rules under which a form of controlled improvisation could freely unfold. In performances of John Zorn's *Cobra* (1984), a conductor organises bouts of performer creativity using a set of symbolic cue cards with corresponding musical rules (Brackett 2008). Xenakis' *Duel* (1958) and *Stratégie* (1962) adopt a more formal game framework, facilitating a numerically scored "combat" between opposing orchestras with "points" and a victor awarded using pre-determined "payoff matrices" (Sluchin and Malt 2011). These works present an interesting platform for professional instrumentalists to express creativity through game-based interaction, yet their format bars the inexperienced from engaging as more than a passive audience. This too informs our intention with the proposed "composition games": that none should require theoretical or instrumental expertise.

An increasing degree of interaction between gameplay and musical creativity has emerged in recent years. This trend extends well beyond the device-bound systems primarily explored in this paper, as exemplified by the interdisciplinary festival *Musify+Gamify*. Installations like *Urban Musical Game* (Cera 2013) and *Bowls* (Bown and Ferguson 2016) explore the sonification of existing physical games, the latter being particularly notable for the player's use of networked audio devices as game props themselves. Other physical works like *The Music Table* (Berry et al. 2006) do not repurpose known games as musical interfaces, but rather encourage playful creative musical exploration through simple game-like interactions (e.g. arranging blocks to generate music). These systems combine the accessibility of dice games with the creative agency of "game pieces", yet distance themselves from the competitive dialogues present in Xenakis' *Duel* (1958) and *Stratégie* (1962).

This trend is similarly reflected in digital music games (i.e. computer-, console-, or device-bound), our core focus here. Few would question the "game" status of popular *performance*-based anthologies like *Guitar Hero* (Harmonix) and *SingStar* (Sony) where players can compete, score points, win or lose, and progress through increasingly levels of difficulty. Yet beyond these titles exists a plethora of mobile apps designed for casual music-making engagements, the perceptions of which are less clear. While all allow for simple compositional interactions in real-time, their diverse intentions include "toys" like *Soundrop* (2010) and *Pulsate* (2012), "tools" like *Seaquence* (2017), academic exercises like *Pop Tones* (Hoeberechts et al. 2014), and even interactive "app-albums" like Björk's *Biophilia* (2011). Rising to meet this complex landscape is the discipline of ludomusicology, which aims to interrogate the relationship between music and digital play. The work in this domain offers an appropriate lens for apprehending the litany of game-like media related to game-based composition.

There have been two notable classifications of "music games" within this recent discourse. Austin's (2016) broad typology suggests four categories of game-based musical interaction: *matching*, *mixing*, *making*, and *metonymy*. Music-*making* games, the relevant category here, are described as "allowing players to actually compose music of their own…if only to a limited degree" (Austin 2016, p. 13). Kassabian and Jarman (2016) present a more discerning framework, suggesting that music games "are those where the majority of gameplay…[is] predicated on the ability to make good sound and/or musical choices" (p. 124). This notion of *musical* choices (i.e. as opposed to game actions with an arbitrary musical outcome) forms a useful frame of reference for separating interactions like those in the dice games from the compositionally "meaningful" game interactions we seek to describe.

Of course, much of the game-like media in this space does allow for meaningful compositional engagement. Gameplay metaphors and strategies for music generation vary substantially between systems. The mobile apps *Soundrop* (2010) and *Pulsate* (2012), for instance, allow the user to generate deterministic music in real-time by manipulating simple physical models. The mini-game "Hanenbow" from Toshio Iwai's *Electroplankton* (2005) is a seminal case of such design, allowing players to manipulate pitch, rhythm, and timbre by launching organisms at a moveable musical plant structure. These designs foremost promote an aesthetic of accessibility as evidenced equally by their diatonic, timbrally "polite" sound worlds and easily decoded compositional controls. Dolphin (2009), while commending this democratisation of interactive composition, notes limitations in the use of "generic tones" as restricting sonic possibilities. Dolphin answers this with his own "sound toys" (Dolphin 2014) – notably *SpiralSet* (2009) and *ResOscope* (2016) – which adopt similar gameplay metaphors but with a "deliberately abstract" sonic character focusing on evolving textures and "spectral development" (Dolphin 2009).

It is appropriate here to consider other work in generative music tangentially related to gameplay, or that otherwise harbours potential to be applied to composition

games if not for their intentions. *Magenta*[1] projects like *NSynth* have interesting implications for timbre-based music games, while *Latent Cycles*[2] (built with *Magenta.js*) resembles the playful music-making interactions enabled by apps like *Seaquence* (2017). *The Predators* from Thor Magnusson's "ixiQuarks" collection (Magnusson 2007) is an artificial life instrument predicated on predator-prey interaction; components like environmental obstacles, death, and reproduction were excluded for simplicity, yet their inclusion in Aneesh Vartakavi's *geneSynth*[3] project demonstrates a marked similarity to classical game elements. Closely related are musical experiments with Conway's Game of Life (Ogawa and Kuhara 2009), which include an accessible adaption for gaming platforms in the free *glitchDS* (Nintendo DS). Further, the growing interest in using evolutionary methods to generate emotionally affective game music (Scirea et al. 2016) could well be applied to the design of *music-based* games. Even recent developments in the use of *Musebots*[4] has seen a shift from their original function as strictly autonomous ensembles towards human intervention and live collaboration (Brown et al. 2018), potentially paving the way for their future use in creative game-based settings.

Unique amongst these designs is *Pop Tones* (Hoeberechts et al. 2014), an academic exercise designed to test the researchers' "Algorithmic Music Evolution Engine" (AMEE) in a music game context. *Pop Tones* adopts the more formal game framework of a "match-3 style game" with quantifiable win/loss conditions. By matching colour-coded balls, players can broadly influence the emotional character of music being generated by a hybrid of stochastic and grammar driven strategies in real-time. Novice users are granted access to generative music making through game interaction, yet the ability of players to *fail* (i.e. by missing too many balls) presents a rare departure from the systems discussed thus far. Though several researchers (Dolphin 2014; Blickhan 2016; Kassabian and Jarman 2016) have examined the game-like qualities inherent to interactions with *Electroplankton* (2005), Björk's *Biophilia* (2011), and even Brain Eno's ambient apps *Bloom* (2008) and *Scape* (2012), the lack of traditional conflict, scoring, and quantifiable outcomes (Salen and Zimmerman 2003) has long complicated their conception as "games".

It is this arduous discourse of game ontology that must last be addressed in building any conception of a "composition game". To avoid a protracted discussion of game definitions, we adopt the perspective that games are not a formally definable category (Wittgenstein 1953; Aarseth and Calleja 2015) and that any element-based definition should only be framed as context-sensitive tools for specific research purposes (Arjoranta 2014). In the expanded modern discourse, games are understood not just as formal *objects* but as *activities* (Ferreira and Falcão 2009) and *processes* (Aarseth and Calleja 2015) that are both socially negotiable (Deterding et al. 2011) and contingent upon the player's "mental model" of the system (Grip 2017). The authors' prior work offers a more detailed examination of the ontology of creative-based music games (Studley et al. 2018). It is sufficient here to summarise that conflict and quantifiable outcomes (e.g. winning and losing) are perceived as "formal" game elements. Given this frame of reference, it becomes apparent that an exploration of the interplay between more formal game interactions and musical decision-making processes is presently underrepresented in the wider practice of interactive composition.

To summarise this paper's intention, "composition games" are considered to be interactive systems that enable players to explore creative musical decisions in real-time via symbolic gameplay interactions with a music generating system. There are three characteristics critical to this conception beyond the use of game-based interaction itself: 1) the player is afforded the agency to make meaningful *compositional* decisions, 2) the decisions are enacted through compositional controls that are *accessible* to novice users, and 3) this occurs in *real-time*. The limitations of this design philosophy are examined during a discussion of the author's original work (Section 4).

3. CREATIVE WORKS

This section details the design of two original works-in-progress, *EvoMusic* and *Chase*, as a preliminary investigation of the compositional interplay between game interaction and stochastic music generation. The authors first outline the roles of Max (*Cycling '74*) and Unity (*Unity Technologies*) in building the music and game systems that comprise the works. We then describe each work as an interactive system in greater detail, addressing the game rules, interface, musical constraints and assumptions of each. Section 4 reflects on the works, discussing their limitations and the insights revealed.

3.1. System Design

EvoMusic and *Chase* each consist of a game system and music system operating in direct communication with one another. The game system is the central brain of the works, serving as the point of player interaction and information display. It handles the game logic and importantly directs the music system to respond to player actions as control inputs. The authors have built the game systems using Unity (*Unity Technologies*), a versatile 3D game engine popular with indie developers. As an object-oriented engine, Unity makes available a comprehensive set of physics and gameworld data (e.g. object position, rotation, velocity, etc.) which can easily be mapped to sonic parameters.

The music system is responsible for the generation and playback of musical content, but more conceptually for reflecting the player's compositional decisions. We have built the music systems within Max (*Cycling '74*), a visual programming environment with diverse multi-media

[1] https://magenta.tensorflow.org

[2] https://codepen.io/teropa/details/rdoPbG

[3] https://cycling74.com/projects/genesynth

[4] http://musicalmetacreation.org/musebots/

applications. Basic stochastic strategies (e.g. first order markov chains) are applied within designed parameters to generate MIDI data, which is then passed to free, non-licensed VST plug-ins for playback. Max manages an internal metronome in *EvoMusic* and *Chase*; that is, it organises timing and quantisation independently of the game system. Unity is occasionally asked to respond to Max's externally timed sonic events to aid information display, meaning that communication between systems is to a small extent bidirectional. Still, Max is hierarchically subservient to Unity within the larger system design.

Interoperability between Max and Unity is achieved through Open Sound Control (OSC), a networking protocol useful for communicating between interactive systems. Crucially, the authors utilise a C# script from Thomas Frederick's *UnityOSC* project[1] to allow Unity to send float or string values to Max over a local network (using the **udpreceive** object). Several others have successfully adopted a Max-Unity design, the most relevant here being Dolphin's (2009) early sound toy *SpiralSet* (2009). It should be noted, however, that the current developmental builds of *EvoMusic* and *Chase* require that two applications run simultaneously – the Max and Unity systems – to constitute the intended "work" in its entirety. This is due to the lack of a compiler for converting Max patches to native C# code, which would enable Unity to run both the music and game systems from a single packaged application.

3.2. EvoMusic

EvoMusic is inspired by the principles of mitosis and evolution. It enables players to explore compositional decisions by curating the growth of an evolving population of musical "cells". Each cell is assigned a discrete sonic event (e.g. a pitch, a percussion hit, a sound effect) which are collectively organised by Max into an open and evolving musical piece. The role of the player is to cast a personal judgement on the favourability of each musical event and destroy any cells misaligned with their compositional goals. Cells grow over time before eventually dividing into two child cells; one inherits the sonic event of the parent and the other is assigned a new event via a stochastic process. This not only provides novice users with a continually renewing stock of musical events to interact with, but preserves any sonic features favoured by the player to allow a shaping of compositional identity over the course of a playthrough.

There are six cell types in *EvoMusic*. A cell's type defines its behaviour and determines which "class" of sonic event can be assigned upon creation (see Table 1). Cell division normally creates two children of the same type, but there is also a 50% chance that a "mutation" will occur resulting in one child of a different type (whichever did not inherent the parent's sonic event). Further, the "malignant" cell type has the unique behaviour of destroying any cells it collides with in the game environment. While the standard cells promote a largely creative interaction, the malignant cells introduce a more formal game dynamic; that is, the player can lose their musical "progress" if they fail to destroy malignant cells.

Cell Type	Colour	Sonic Event
Pitch	Yellow	Short, pitched notes
Harmony	Magenta	Long, pitched notes
Bass	Red	Low-register notes
Percussion	Green	Percussive layers (e.g. snare)
SFX	Cyan	Miscellaneous SFX
Malignant	Black	Dissonant synthesiser

Table 1. Description of the six cell types in *EvoMusic*.

Although the natural selection metaphor in *EvoMusic* resembles a genetic strategy (e.g. with player taste as the "fitness function"), the underlying music system is a simple stochastic design. When informed by Unity that a new cell has been created, Max uses the **urn** object to randomly assign an unused sonic event from a player-defined scale. This scale is selected by the player in a pre-game menu (see Figure 1) where they may also configure the starting tempo, starting metre, speed of cell growth, and cell types used. The new event is added to a pool of currently "active" events (specific to each cell type) where it remains until the cell is destroyed in Unity. Max then treats this pool of events as the restraints for stochastic music generation. As a further dimension, population growth is tied to an increasing chance that new sonic events will *not* conform to this pre-selected scale. This reinforces the formal game dynamic by providing a compositional equivalent of difficulty progression. The musical effect, however, is that a playthrough begins like the constrained diatonic sound world of *Electroplankton* (2005) before evolving and expanding as the population grows – should the player allow it, of course.

Figure 2. Settings in the pre-game menu for *EvoMusic*.

Interaction with the game interface itself (see Figure 2) closely resembles that of *Electroplankton* (2005), *Soundrop* (2010), and other mobile designs. Players "point-and-click" upon a two dimensional plane to affect clearly identifiable sonic results (e.g. remove *this* sound). Players are also free to pause the game session or add cells manually by clicking the icons the right (see Figure 2). With regards to information display, Max instructs Unity

[1] http://thomasfredericks.github.io/UnityOSC/

to "flash" a cell whenever its respective musical event is played. This is integral to a functional play experience as it allows players to identify the relationship between the abstract game object and the sonic outcome, a relationship upon which the "composition game" is predicated.

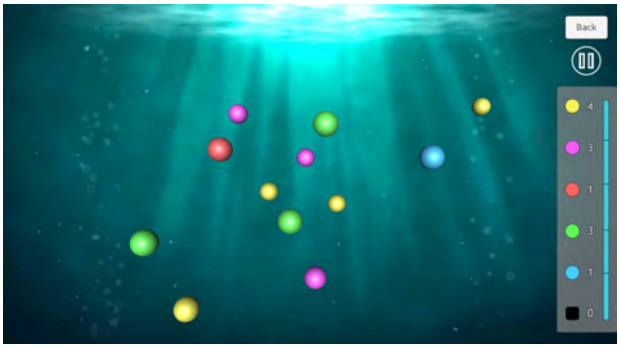

Figure 2. The game interface for *EvoMusic* during play.

3.3. Chase

Chase is a substantial departure from *EvoMusic* in both its game framework and compositional control. The player is perpetually pursued by a red humanoid agent over a 3D gameworld divided into four connected environments. The proximity of this "red man" to the player is scaled by Max and used to increase the tempo and velocity of stochastically generated music. The harmonic treatment of this music is determined by the red man's current environment (see Table 2). Using this, players take advantage of the various objects and architecture populating the gameworld to manipulate the red man's location and influence the music. The player takes damage if the red man gets too close, eventually leading to their death (and loss of the game). New musical layers are accumulated as the player loses "health", though are removed if the player restores health by collecting the heart-shaped tokens distributed throughout the gameworld. The result is a risk-reward dynamic where the music grows more interesting as the danger of losing increases. This relationship between game and sonic outcomes is quickly decoded, allowing players to exploit it alongside their own game "literacy" (Zagal 2010) to exact compositional control.

Environment	Harmonic Treatment
Forest	Major
Desert	Phrygian-Dominant
Snow	Lydian-Dominant
City	Harmonic Minor

Table 2. Harmonic treatment of environments in *Chase*.

Where *EvoMusic* provides highly granular control (e.g. note-level decisions), players in *Chase* explore composition through broad musical gestures. Game interactions affect overarching characteristics such as tempo, textural density, harmonic treatment, and overall velocity. The music generation again relies on basic stochastic methods; chords, for instance, are selected using first order markov chains designed for the current harmony (see Table 2). Each playthrough begins with a base musical layer comprised of a melody and chordal accompaniment on an instrument chosen by the player. This base layer forms a game and musical foundation that persists regardless of player health. Rhythmic treatment throughout is uncomplex and strictly quantised. As such, and with the exception that players can pre-select a timbre, the sound world of *Chase* is again quite constrained so as to appear "disarming" (Wang 2016) to the compositionally inexperienced.

The game control itself relies on the substantial literacy most players have developed for first-person movement within 3D gameworlds. Players move with the arrow keys (or WASD keys), jump with the Spacebar, and "sprint" by holding Shift (which consumes stamina). The design also harnesses traditional game iconography (e.g. health bar, hearts to regain health) to quickly communicate game functionality (see Figure 3). While the generated music primarily serves as the object of composition, it also contributes to the game's information display. Max adjusts panning based on the red man's position, which in union with the proximity-velocity mapping creates the impression that the red man is the source of the music. Players can use this to help locate their pursuer, creating a bi-directional dialogue between the gameplay objective (i.e. avoiding death) and their compositional goals. In the current developmental build, the player is also provided with a numerical representation of the red man's distance and a "rear-view mirror" (see Figure 3). This heightened awareness of the red man's location allows for informed manipulation of the agent's behaviour and thus a more precise compositional control.

Figure 3. The game interface for *Chase* during play.

4. DISCUSSION

Before discussing the limitations of the original works and strategies used, it is pertinent to first detail the research intentions of each. *EvoMusic* and *Chase* are presented as truly interactive systems; that is, they seek to maintain a balanced dialogue between human and computer decision making processes where each asserts a persistent and non-trivial influence over the musical outcome. Beyond this foundation, however, the two

works explore distinctly contrasting game metaphors and compositional controls so that their juxtaposition might begin to chart potential design dimensions for stochastic, game-based composition.

4.1. Insights

EvoMusic enables highly granular command over musical content (e.g. remove a specific note) and presents a casual game framework devoid of "loss" and conventional danger. While risk and conflict are still apparent in the malignant cells' destruction of player music, the player overcomes the obstacle for an explicitly musical purpose and cannot be defeated by the game system (i.e. there is no "game over"). In contrast, *Chase* affords only broad musical influence (e.g. make louder, faster, happy/sad, etc.) and explores the more formal elements of quantifiable loss and danger alongside musical decision-making. Notably, a player in *Chase* might momentarily abandon their compositional objective to prioritise avoiding in-game death; a non-musical decision that nonetheless affects a musical outcome. These juxtaposed designs illuminate two significant dimensions to be considered when designing for game-based composition: 1) the granularity of compositional control, and 2) the interplay of game-based versus music-based decisions.

There are of course many further dimensions to consider. For one, the game interfaces can be compared on their degree of abstraction from known visualisations of music. Though arbitrary and symbolic, *EvoMusic*'s colour-coded orbs are notably less removed from standard notation or a DAW workspace than *Chase's* abstract 3D environment and provide a more explicit visual indication of the generated music's textural composition. Play theory can also be harnessed to evaluate the player's compositional interactions on a continuum from *paidia* to *ludus*[1] (Caillois 1958; Moseley 2016), or further still on a spectrum from "instrument" to "composition" (Herber 2008). Beyond these dimensions, there are also several further game metaphors for which the compositional potential could be explored. *EvoMusic* adopts the familiar 2D "touch-and-play" of casual mobile designs while *Chase* invokes the less examined first-person pursuit through a 3D gameworld. And yet, game-based composition could equally apply to real-time strategy (RTS) games, puzzle games, narrative games, or any other format. Clearly these lines of inquiry are the purview of further investigations.

Perhaps the novel insight unearthed by *EvoMusic* and *Chase* is the unique meld of collaborative and competitive compositional dialogues made available at the nexus of musical decision-making and formal gameplay interaction. The stochastic music systems serve as an assistive compositional force to the inexperienced player, and yet challenge-based game elements present new opportunities for exercising competitive musical strategy in a creative setting. *EvoMusic* invokes a form of musical difficulty progression in its gradual evolution beyond the player's chosen scale, but also offers a more conventional game obstacle in the disruptive malignant cells. *Chase*'s hostile agent combines the two, presenting game-specific danger and loss conditions whilst also tying musical outcomes to a persistent risk-reward mechanic. In both designs, the player and computer each exert a compositional will that variably collides or complies with the other, and so the human-computer dialogue in each moment of interaction exists in a transitory state between collaboration and competition over a shared musical outcome. This harkens back to the musical "combat" facilitated by Xenakis' *Duel* (1958) and *Stratégie* (1962), though imbued now with all the democratising potential of the digital games platform at a time when generative composition tools are more available than ever before (Bray and Bown 2015). In this union lies an avenue for exploring new forms of competitive-based, real-time interactive composition in an accessible and engaging environment.

4.2. Limitations

At this point in development, we have constrained our composition game experiments to a simple stochastic model. This allows us to quickly prototype the intended interactions due to the ease with which stochastic, MIDI-based systems can be integrated with real-time environments. *EvoMusic* in particular is predicated on 1:1 relationships between game objects (cells) and sonic events, for which stochastic models are highly accommodating. The limitation, however, is that alternative music generation strategies tend to outperform in the musicality of the system's output. The use of genetic algorithms in *MetaCompose* (Scirea et al. 2016), though less compatible with note-level player interaction, produces more intelligent melodic material as supported by user evaluation. Learning-based paradigms also produce promising results musically, but often aim to generate complete and structurally sound pieces for subsequent playback (García and Serrano 2019); an approach ill-suited to real-time environments for interactive composition. There is also great potential to explore game-based composition in environments like *The Predators* (Magnusson 2007) and other artificial life models (e.g. Cellular Automata, Boids). Our constraint to stochastic systems at this stage allows us to model the interplay between composition and gameplay before exploring the concept more broadly with alternative music generation strategies in future works.

There are also significant limitations in the design philosophy adopted here. Our adherence to an aesthetic of accessibility restricts sonic possibilities and has resulted in a rather constrained sound world within the original works. While *EvoMusic* and *Chase* offer less standard modes (e.g. whole tone, octatonic) and *EvoMusic* sessions can evolve beyond diatonic harmony, their MIDI-based systems offer only "polite" timbres and

[1] *Paidia* represents free, exploratory, unrestricted playfulness. *Ludus* represents competitive, disciplinary, rule-bound engagements.

limited expressive capabilities at present. The player may dictate the instruments used in each layer, but no abstract textural or timbral manipulations are possible as compared to Dolphin's (2014) sound toys. The stochastic systems used also preclude stylistic diversity without a substantial redesign of the parameters, further constraining the scope of each work. Again, the current prototypes are works-in-progress aimed foremost at a preliminary investigation of the interplay between musically creative and gameplay decisions. Accessible design and a constrained, familiar sound world lowers barriers to entry and allows us to interrogate this concept more broadly in any future process of user review.

5. CONCLUSION & FUTURE WORK

In this paper, we consider the context, dimensions, and limitations of designing for stochastic, game-based music composition. Related media are reviewed to arrive at a preliminary conception of "composition games" (Section 2). We detail the use of Max (*Cycling '74*) and Unity (*Unity Technologies*) in the creation of two works-in-progress, *EvoMusic* and *Chase*, and discuss the potential of each as an interactive system for enabling real-time composition through accessible game interactions. The assumptions and limitations of this overarching design philosophy are also interrogated (Section 4.2).

This work is an early exploration of the interplay between musical creativity and formal gameplay. We have constrained our current experiments to simple stochastic models to prototype the intended interactions for broader application in future designs. The presented works highlight several design dimensions for composition games (Section 4.1). In particular, they reveal a hybridised collaborative-competitive human-computer dialogue as one novel contribution of formal game design to the domain of interactive composition.

Future work will investigate this relationship in alternative pairings between music generation strategies (e.g. Boids, Cellular Automata) and digital game environments (e.g. RTS, puzzle-based, multiplayer). We also intend to conduct a series of heuristic evaluations to gain further insight into player perceptions of engagement, usability, and creative agency within such designs. For instance, do players feel that they are creating music or simply "activating" music through arbitrary game interactions? Are there clear and decipherable links between visual and sonic information, or between game and musical outcomes? How do these perceptions differ between the contrasting game environments of *EvoMusic* and *Chase*, or between stochastic and other generative strategies? These lines of inquiry will unearth a more complete understanding of "composition games" as an avenue for exploring new forms of real-time interactive composition.

6. ACKNOWLEDGEMENTS

This work is supported through an Australian Government Research Training Program Scholarship.

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