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Playing in fractal universes: Thinking with scalable patterns in interdisciplinary game studies

Abstract

Games offer a scaled and scalable experience of technologically mediated human action and interaction. The study of games therefore holds the potential to offer a far wider analysis of our technical and social structures than might be first apparent. Yet this scaling of behaviours and frameworks is applicable not only beyond simply an increase in degree, but also across different types of meaning, society, reality, and our understanding of them. Thus, to assess the expansion of games beyond conventional dimensionality, we can identify in games and game studies a fractal metaphor to guide our analysis. Drawing on concepts of iteration, self-similarity, recursion, complexity, and scalability, this article examines key games that embody a fractal dimension to their in-game universe, the player's experience, the game's development, and games as a field of study. The fractal analysis of a game will thereby be revealed as also an analysis of the metagame and its situatedness in broader concerns of technoculture and its academic study. The model offered will be applied to specific games and the existing literature through which game studies is formed as an interdisciplinary fractal conceptual space of its own.

Key words: fractal, game studies, games, No Man's Sky, Everything, EVE Online

Introduction

The playing of a particular game generates iterative and often functionally self-similar experiences for players based on the ludic and narrative constructs that constitute the game itself. Yet these experiences are increasingly interdisciplinary in their

relation to human activity, creating ever more total works of media that engage with simulations and representations of our social and technological realities and fictions. This necessitates an inherent and increasing interdisciplinarity to the study of games that expand the player's interaction from the quantum to the cosmological, from the individual to the collective, and from the fictional to the real. This article offers a new mode of viewing games as both a mode of interaction and a field of study: the fractal mediation of humanity by technology.

Firstly, we will construct a fractal metaphorical framework through close analysis of examples that directly address such mediation of humans at different levels of reality. The highly anticipated, controversial, and often much maligned game *No Man's Sky* creates a procedurally generated reality that expands algorithmically to produce a fractal game on the ontological level. *Everything* takes the fractal experience to an extreme by offering the player the opportunity to interact with the universe by 'being' everything, scaled from cellular to stellar levels. Consideration will also be given to similar games that involve such fractal realities even in their construction, generating a relation with players during the design stage through user-created content and responsive beta testing. *Worlds Adrift* creates an environment filled with floating islands created by users during alpha testing, expanding fractal interaction between players and with the environment according to a functional mediated logic developed further through beta testing. *We Happy Few* takes this beta testing further with extensive player involvement that has initiated major changes in the game's aesthetic and the relation between which ludic and narrative aspects players would prefer to see emphasized. Finally, the long-running *EVE Online* demonstrates fractal human organization with its emergent and expansive economies and politics from the individual to the guild up to the entire player base and game world. Across these examples, a fractal expression of representation, reality, and relationality can be elucidated in the ludic structures and open narratives. Beyond the restrictions of closed objectives that define clear methods of interaction, the ludic mediation and human engagement still results in self-similar or iterative experiences of fractal play.

We will then address the fractal study of games across disciplines – the similarly situatedness of gaming in broader social reality, and the recursive relationship between games and our own world. Focusing on the extensive literature of *EVE Online* and applying these findings to newer games, the discussion will explore the necessary links between different fields in game studies. In the analysis of games, particularly those with MMO, procedural, or social aspects, there is an inherent need to take into account mathematics, computer science, psychology, economics, philosophy, art, literature, media, and many other fields. Yet the mediation of the ludic experience unveils scalable and self-similar features between these fields, already embedded within the construction of game studies as a distinct discipline. Indeed, it is notable that game design itself straddles the arts and sciences, employing programmers, writers and artists (to name a few) to construct a full experience across traditional disciplines. Amidst the myriad future paths of game studies, therefore,

the article will posit the need for fractal modes of thinking about play and narrative in the persistent mediation of humans by their ludic creations, as well as the broader mediation of our society and experience by technology.

Fractal Games

Fractals – a concept with a long history in science, mathematics, and culture, but given voice as a coherent theory by Benoit Mandelbrot in the 1970s – has perhaps most poetically been defined as a way of seeing infinity in the mind’s eye.¹ Indeed, fractals appear to have had almost limitless applications and have contributed to the understanding of chaos and of conceptual and actual spaces beyond the conventional three dimensions of Euclidean geometry. The term fractal has its roots in fragmentation, with the aim of breaking down the infinite complexity of nature into human-readable patterns. Yet for all their mathematical precision, it is important to remember that “there are no true fractals in nature”². Fractals only ever offer an approximation of natural phenomena, an abstraction of patterns far beyond human understanding. The use of fractals should therefore always be combined with an acknowledgment of their position as an artificial framework of thought. Fractal analyses to some degree therefore always create the precise pattern they are analysing. Indeed, as an abstract human construct, the development of fractals was inherently bound to that of computers, another quantized reality that builds worlds through rigid codes not possible in the physical world. Not only did Mandelbrot work as a researcher for IBM at the time he developed fractal geometry, but it was the increasing access to and power of computers that enabled Mandelbrot and others to calculate fractals and construct the abstract shapes they produce. The artificial forms of fractals, while offering a way of abstracting and understanding nature, tend to exist “entirely inside a computer’s memory”³. They thus provide a constructive analogy and conceptual framework for understanding the abstract and computational dimensions of computer games. Not only that – and moving beyond the simple use of fractals as actual graphic constructions in the style of computer-generated landscapes or trees used in many films or games – but the application of fractals to diverse fields of natural and human activities lends itself to an exploration of the social aspects of games and the broader facets of game studies.

¹ James Gleick, *Chaos*, (London: Vintage) (1998), p. 98.

² Kenneth Falconer, *Fractal Geometry: Mathematical Foundations and Applications (3rd ed.)*, (Chichester: John Wiley & Sons) (2014), xxix.

³ Benoit Mandelbrot, *A Fractal Geometry of Nature*, (New York: W.H. Freeman and Co) (1983), p. 10.

Yet fractals persist as an elusive concept, with definitions relying more on a series of typical characteristics.⁴ For the present discussion, therefore, a few key concepts will suffice as a starting point to develop a fractal framework for thinking about games. Firstly, fractals are *iterative*, simple to define and often *recursive*. They produce the same patterns at arbitrary locations and use the same functioning – the same code – to create evolving and scaling structures. They are also often *self-similar*, spreading this symmetry and iteration across scales. These characteristics combine to form the “pattern inside of a pattern”⁵ whereby the part matches both other parts and the whole. While this is not necessarily an essential part of all fractals,⁶ it defines simpler linear fractals and appears in some form (for example, quasi- or statistically self-similar) in most practical definitions of the concept. Thus, self-similarity allows us to view patterns between arbitrary facets that may indeed have chaotic or emergent properties, or which obfuscate simple comprehension via high complexity. Another key concept is the notion of *scale*. Fractals allow us to view symmetry not only between parts of equal size, but also across scales. The recursive quality of fractals enables a shift in perspective between large and small levels of difference and irregularity, thus offering a mode of viewing functional rules in even the most chaotic data. In computer games, this shifting in perspective can occur at the technical or social level, between systems, renderings, and servers or between players, economies and conceptual spaces. This scaling goes beyond an increase in conventional dimensionality into partial and even abstract dimensions that cut across individual human perspectives and thereby reveal, at the level of the metagame, a hidden order in chaos and functional consistency between apparently disparate parts of a complex whole. Between these various parts and scales is revealed the *complexity* of fractals, which cannot be expressed through simple geometry. Indeed, the emergence of games as a distinct field of study highlights the additional experiential intricacies compared to traditional art, film, or other media. From complexity stems the notion of a *fractal dimension*, itself open to variable definition but always signalling a dimensionality greater than its topology. At a basic level, this can be expressed in the link between the concrete world presented on the screen and the vast array of code beneath it. Using procedural generation and non-linear structures, across player narratives and experiences it forms the ‘greater than the sum of its parts’ quality that generates the ‘replay value’ of games. Procedural generation, originally developed in ‘roguelike’ games of the late 1970s and early 1980s, is a process of compressing the game world. This was exemplified in the space exploration game *Elite*, which sought to create a huge world using only 22k of memory.⁷ By reducing the internal reality

⁴ Kenneth Falconer, *Fractal Geometry: Mathematical Foundations and Applications (3rd ed.)*, (Chichester: John Wiley & Sons) (2014), xxviii.

⁵ Gleick, p. 103.

⁶ Mandelbrot, p. 166.

⁷ David Braben in Emma Boyes, “Q&A: David Braben--from Elite to today,” *Gamespot*, <https://www.gamespot.com/articles/qanda-david-braben-from-elite-to-today/1100-6162140/> date accessed 27 February 2018.

of the game from a detailed description to a functional algorithm, a much greater space can be unfolded from comparatively minimal code. Finally, fractal dimensionality can be seen in the multiple fields that games straddle and the implied relation to our own world that games can address, stage, and critique, expanding our metaphor to situate games in their broader context. We will now elaborate this conception of games through examples that address gaming reality, gaming experience, and game design.

***No Man's Sky*: a fractal gaming reality**

Hello Games' *No Man's Sky* is a vast procedurally generated universe of unprecedented size, containing 2^{64} (18,446,744,073,709,551,616) planets. While this 64-bit algorithmically-created galaxy falls far short of the unknown limits of our own physical universe, the scale in relation to human perception achieves the same relative infinitude. Even at the impossible rate of one planet per second, it would take over five billion years to explore every single planet in the game - longer than the lifespan of our own sun.⁸ Fractals, as a way of converting limitless complexity into scales perceivable by humans, offer a convenient method of understanding the construction of this game reality. Much like the mathematical functions of fractals, *No Man's Sky* creates its reality according to strict deterministic calculations that can nevertheless generate a far larger universe than any single human could ever hope to experience. Yet it is not only the construction of *No Man's Sky* at the planetary scale that takes on a fractal quality, the analogy scales too. Rather than loading a new environment when a player hopes to explore a given planet, the game's procedural generation scales down to render landscapes, mineral deposits, environmental factors such as weather, and a rich population of fauna and flora. Yet this functionally limitless expanse returns to haunt us in its endless iteration. The looping nature of the gameplay extends beyond an identical algorithmic mediation of one player and another. The algorithmic construction of similar planets initially offers wonderment and variety, but after visits to multiple planets the appearance of the same kinds of worlds exposes the underlying iteration and an evolving self-similarity through time. This limit of the aesthetics of the game reality applies also to the gameplay. The open exploration, the often repetitive (particularly in the initial release before the streamlining aspects of later updates) nature of gathering resources needed for survival and travel, and the scaling of achievements (in terms of both in-game economic attainment and the convention of ludic 'achievement' rewards) can end with the player seeing through the complexity and reaching a level of predictability to the game over longer timescales through fractal understanding.

⁸ Chris Higgins, "No Man's Sky would take 5 billion years to explore," *Wired*, <http://www.wired.co.uk/article/no-mans-sky-planets> date accessed 1 September 2017.

Thus, the kaleidoscopic non-novelty highlights the creative limitations of self-similarity and the ontological limitations of the *No Man's Sky* reality, as after a certain number of iterated experiences everything looks the same (much like many fractal images), creating a scalar shift in perception whereby the detail becomes flattened. Here we can attempt to behold the entirety of the complexity at work, and the processes of mediation reveal themselves within the literal frame of the screen and the conceptual framing of the universe held within the computer and within the game.

However, the narratological aspects of *No Man's Sky* further this relation to iteration and scalability in constructing a reflexive ontology that loops into itself. What sparse storyline there is to find across the vast emptiness of space reveals a universe that embraces its algorithmic functionality and challenges its relation to the player. The main 'goal' – although this is entirely optional and only one path of achievement a player can explore – of *No Man's Sky* is to follow the instructions of a being called Atlas to reach the centre of the galaxy. Along this path the play encounters two recurring NPCs, Nada and Polo, who describe themselves as errors within the simulation. They are counterposed to the Sentinels, a variety of robotic entities that enforce the rule-based system of the Universe's will by attacking players who rapidly interfere with the landscape by mining for resources or killing fauna. The player is part of a universe-wide experiment to break free of these rules and discover the source of the Sentinel's power,⁹ and it is the ultimate quest of the player to become an anomalous entity by achieving self-awareness of the rules and systems of the universe. The ending of the game, the big reveal at the centre of the galaxy, takes on a tragic tone that embraces the full despair of mediation and control by technology. The universe is revealed to be a simulation, nothing more than an absolute deterministic causal structure – a game – and while the character (the 'traveller') becomes self-aware, the player is returned as a new traveller on a new starting planet at the edge of the galaxy to begin the cycle anew. As the player learns more and more information, gaining greater and greater detail as they move closer to the centre of the reality, they end up being thrust outwards to the broadest scale. The player's perspective, and their causal relations with the game, go beyond even a fractal towards a strange loop, "a paradoxical level-crossing feedback loop".¹⁰ Even in a supposed critique of the medium itself, the recursive element exposes the iterative repetition of game playing and the rigid and ultimately deterministic causality of apparent complexity and chaos in both fractals and gaming structures. Perhaps this is why Mandelbrot himself focused on consequences over causes,¹¹ working backwards from human-readable problems to create gradually more detail from the

⁹ See from 10:00 - Wanderbot, "Let's Play No Man's Sky Update 1.3: Atlas Rises - PC Gameplay Part 1 - All Sorts Of New Stuff!" *Youtube*, <https://www.youtube.com/watch?v=bITsv0TXJ7k> date accessed 1 September 2017.

¹⁰ Douglas Hofstadter, *I Am a Strange Loop*, (New York: Basic Books) (2007), p. 102.

¹¹ Mandelbrot, p. 423.

chaos of recursive complexity. Cast into a universe and expected to find not only our own meaning but to discover for ourselves the limits of the simulation, the monstrous character of fractals unfold in *No Man's Sky* as a ludic and narrative experience beyond rational scientific or philosophical explanation.

***Everything*: a fractal gaming experience**

A game that embodies fractals in the experience of the player is *Everything* by David O'Reilly. Described as “a magical playpen of being, rather than doing”,¹² and – with an eleven-minute trailer that made it the first video game to qualify for an Oscar – *Everything* displays the fractal experience of being-in-the-world. Players interact with the universe through being anything and ‘everything’. Starting as a mammal, players can shift from item to item and ascend/descend scales to play as approximately three thousand different objects. These items fall into a variety of categories and include natural objects such as animals as well as man-made objects as well as more abstract entities. Examples include a shoe [attire], cigarette butt [trash], warped ruins [space junk], scale manipulator [tool], recursive house [home], convex stellated polyhedron [3d], and Planck length [1d]. This selection in particular highlights a focus on scale and a relation to fractal perspectives and experience. The objects themselves and the perspectives the player encounters create a fractal reality whereby we are offered the self-similar experience of simply ‘being’ across all scales of matter. Like *No Man's Sky*, this universe is procedurally generated, but it is also connected and persistent, remembering the state of a previous scale when you next return. However, the map at each scale is not particularly large, enacting spatial loops where necessary that are visible upon zooming out but not ascending to the next scale. But a fractal universe does not need to be large (and even if it is, as with *No Man's Sky*, there is fundamentally no difference between ‘more’ space and ‘more of the same’ space). The expansive environment here comes from the fractal dimension, moving beyond three dimensions to folded spaces of experience and new perspectives of scale.

Initially, however, the player can simply move around (and even that is somewhat stilted as the movement animation for mammals is a rather ignominious and awkward four-frame roll). As one early-encountered NPC (a mammoth) remarks, “you can't control Everything//not yet anyway”.¹³ Indeed, the game often plays with the double meaning of its own title and the objects it contains, applying the different levels of parts and the whole within its very construction. The ability to move around as objects (no matter how improbable their independent locomotion might be in our

¹² Colin Campbell, “Everything review”, *Polygon*, <https://www.polygon.com/2017/3/21/14991494/everything-review-ps4-PC> date accessed 1 September 2017.

¹³ See from 9:16 - JackSepticEye, “BLOW YOUR MIND | Everything #1”, *Youtube*, <https://www.youtube.com/watch?v=GeJvh212pEQ> date accessed 1 September 2017.

universe) is gradually augmented through talking to (or ‘thinking as’) other objects. Increased abilities include being able to join with other entities of the same kind or category, moving around as a collective being and even dancing together in order to create new objects. The player also obtains the ability to ‘ascend’ and ‘descend’, moving up and down in scale. Manipulation of the environment here stems directly from expanded notions of being in greater dimensions beyond human perception, a philosophical and even spiritual sentiment reinforced by the inclusion of recordings of a lecture by Zen philosopher Alan Watts concerning nature, patterns across scale, and being. This grows in *Everything* with the player’s expanding experience. For example, once you have ‘become’ a particular item, you can become it again at any time via the encyclopaedia, but it will then be scaled to the current perspective, offering a self-similar and scale invariant quality to even objects usually experienced at a single given scale. Further, if one is to keep ascending or descending far enough, the game universe loops round between galaxy clusters and atoms via a ‘feedback sphere’ at the one-dimensional Planck scale. This embodies Hofstadter’s ‘strange loop’ in terms of space-time, a sentiment echoed in Max Tegmark’s loop between cosmology and quantum mechanics via a multiverse of mathematical structures.¹⁴ It also embodies recursion in terms of human consciousness as a feedback loop that intensifies over time.¹⁵ In *Everything* these two feedback loops are one and the same, for our consciousness of the game expands fractally alongside our experience of being at different scales, or even simply perceiving/thinking as the game autoplays if left to its own devices.

The fractal strange loop of causality and the gaming medium that we saw in the ending of *No Man’s Sky* returns once more to haunt us at the ending of *Everything*. As another game with sandbox-like and experiential open play, the term ‘end’ must be used loosely, but open reaching a certain level (having achieved ‘being’ a certain number of objects) the player may descend into the ‘Golden Gate’. Here an abstract space of random objects awaits in a collision of different scales. Among these, surrounded by pieces of skeletons, is a computer which duplicates the player’s screen on its own monitor. After a lengthy but vague monologue lamenting the frustration of *Everything* in this place, the player is instructed to ‘empty your mind’ in order to escape this world. The player is finally allowed to ascend the Gate, triggering an ending cut scene of a glowing particle flying through different scales before returning the player once more to a starting position (with new abilities such as instantly bonding with objects or a documentary mode). There is no escape from a fractal game, as with all games. The fundamental mediation of a game system is to keep playing, returning always once more to a reality of rules which deterministically controls not only itself but our own actions. Whether we play as an abstract concept or a piece of shit, we experience the same mediated play in a simulated universe, beholden to the whims of the game developers.

¹⁴ Max Tegmark, *Our Mathematical Universe*, (London: Penguin) (2015), p. 358.

¹⁵ Hofstadter, pp. 19-23.

Fractal game development and its problems

If fractals can be used to analyse the in-game ontologies and the experiences of the players, they can be applied also to the existence of the game throughout its development. *No Man's Sky* received much positive attention prior to its release, so much so that the developers received death threats after announcing a delay to the release date. And when the final release of the game failed to meet certain advertised promises, the backlash was again significant. These issues span creative, cultural, and legal concerns in the feedback loop of perception and expectation. The spiral of hype that led to death threats, as part of the often vitriolic cultural sphere of gaming,¹⁶ was echoed in the spiral of disappointment that led to a (cleared) advertising standards investigation. This latter issue, whereby key features such as multiplayer, ship design and others were missing from the initial release, sparked a fractality to the development of the game itself. While DLC add-ons to games is becoming increasingly common, and updates or patches are standard practice, the free updates to *No Man's Sky* instigated major changes to the way the game plays. The development of the game after its release thus constructed a temporal fractal zoom, adding greater and greater detail to the game with each iteration. Each upgrade made visual improvements, refined the interface, and provided more content in various categories. The first (1.1 Foundation) update added the freighters and base building that were originally missing; the second (1.2 Path Finder) added exocraft, online base sharing, multiple ship ownership and ship specialization; and the third (1.3 Atlas Rises) added missions, increased story mode, portal travel and (crude) multiplayer. This last development was a major change, and one that was high on the list of missing features. While communication between players outside the game made it possible relatively easily, the original idea with *No Man's Sky* was that it would essentially be single-player in a multi-player universe, for the odds of randomly encountering another player were astronomically low. Yet this feature was only added later, transforming the game fractally by adding greater levels of interaction and expanding the experience not only in level but also in kind, creating new dimensions of play. As an indie developer trying to create an AAA title, Hello Games had given themselves an unenviable task. Yet the later additions have not simply added what was originally promised. Rather, they have evolved in an emergent manner in light of the game being released in the world. The interaction between players and developers creates new perspectives and functions that otherwise may not have been thought up.

In the wake of the release disaster of *No Man's Sky*, other games appear to be learning from their mistakes. While open beta and early release testing is now commonplace via platforms such as Steam, *Worlds Adrift* by Bossa Studios involved players before

¹⁶ Such as gamergate, an example of mass abuse by collections of gamers against (in this case female) games developers.

even the alpha release in order to create a user-generated world. Functionally quite similar to *No Man's Sky*, *Worlds Adrift* is an open environment for exploration and resource gathering. However, it has several key differences. The game is highly multiplayer, indeed for many activities collaborative play is nearly essential, and it is highly creative, being based on players/groups designing and building their own ships with which to travel between floating islands in a limitless sky. Thus, while the expansive universe of areas is much reduced, there are greater dimensions of interaction. Not only that, but the islands themselves are procedurally generated content as well as user-created content, embedding players in the pre-alpha stage via a separate, free, *Worlds Adrift Island Creator* game. Thus, throughout and before the extensive closed and open beta phases, players were able to work with Bossa Studios to collaboratively create a game that itself opens up opportunities for free interaction between players, building on core functionality before adding visual detail in a fractal development of form and content. Beyond the initial release, Bossa set up mechanisms to continually include players in the game's ongoing development. *The Sky Crier*, a weekly news summary of stories from players, highlights the importance of player experience in the history of the game, while further developments to the *Island Creator* have been aimed at turning players into game designers by producing new levels and new experiences for other players.

The desire to integrate this degree of player involvement is also echoed in Compulsion's *We Happy Few*, which, in strong contrast to Hello Games' closed development and the misinformation of *No Man's Sky*, focuses on transparency and inclusion.¹⁷ As another small studio thrust into creating a higher profile game than they had intended, Compulsion sought to make regular public announcements about the process. This helped guide their relationship with players through an extended, delayed, and not unproblematic development. But it was not only communication that aided them, for they made several key changes to the game in response to early player comments. As the developers describe, "What the public and the press were telling us they loved about our game wasn't anything like the procedural, story-light, rogue-like survival game we were creating at all".¹⁸ As a result, they switched their focus to develop in greater detail the story, the world, and the mechanics in response to what players wanted. The move to Kickstarter also emphasized a literal investment by players, drawing them into the game world not only through the experiential suspension of disbelief for this psychedelic drug-fuelled horror game, but also as co-creators and co-owners, bringing all perspectives into the discussion across different scales and types of engagement. This extended to further types of gameplay based on five drug-specific modes, as well as a suspension of the gaming framework with the addition of a non-violent 'Birdwatcher' mode in which players

¹⁷ Jessica Conditt, "How 'We Happy Few' plans to avoid the pitfalls of 'No Man's Sky'", *Engadget*, <https://www.engadget.com/2017/08/17/we-happy-few-fans-feedback-release-date-gearbox-compulsion-interview/> date accessed 1 September 2017.

¹⁸ Quoted in Conditt.

could simply explore the environment and, much like *Everything*, enjoy ‘being’ in the game. After the shift in expectation towards an ‘AAA’ level game by partnering with Gearbox Software, however, the communication and inclusion broke down somewhat. The sudden doubling in price and further delays angered many fans, although the level of engagement already established did allow for some mitigation of these problems. Bonus content was promised to early backers, and the financial support from the larger studio enabled a fourfold scaling of Compulsion’s team. This reminds us that the business side of gaming cannot be forgotten, for while the reactive nature of the development that increased in size to handle the increased expectation does itself embody a certain fractal quality, the problem of shifting scales highlights the competing forces at work in game development. In *We Happy Few*, we can at least see the creative intent towards creating a fractal experience that extends between layers of in-game perspective, modes of gameplay, and involvement in the design process.

The fractal model at the level of the metagame is thus achieved by enabling players to engage at multiple scales, creating their own local perspective through the emergent differences between iterations. Far from being a rigid abstract reduction, the conceptual ‘geometry’ of such games could only be mapped in multidimensional relations between the designers, the manifold facets of the game, and its many players. The feedback loop of a fractal game extends spatially, temporally, and conceptually back into itself as an evolving experience for all involved.

Fractal Game Studies

We have explored how fractals might be used to view games, but what of game studies as a discipline? Fractals can be considered one of three major revolutions in twentieth century science¹⁹ and, perhaps even more so than the other two (relativity and quantum mechanics), have far-reaching interdisciplinary applications not only within the sciences but across social science and the arts. Mandelbrot’s initial work on fractals, coalescing a collection of vaguely similar approaches in mathematics spread sporadically across several centuries, was driven by a combination of geography (the problem of measuring an infinite coastline at high enough resolution) and economics (the need to balance sudden dramatic fluctuations with periods of stability). But his own work and the work of others quickly spread the fractal concept across a wide range of disciplines, and today there is a rich yet often unconnected literature that applies fractals to diverse fields. Indeed, perhaps the fractal as a field of study is itself fractal in its iterative self-similarity and possible application at various scales and in various locations. However, it must be remembered that fractals only ever offer an approximate representation of reality, an abstraction and

¹⁹ Gleick, p. 6.

reduction of complexity into human frameworks of thinking. The broader application of fractals therefore takes on an inherently aesthetic quality within scientific thought, a mathematical *description* of a topic rather than a rigid methodological framework. Examples abound of this fractal interpretation of our universe and society: in physics, fractals have been used to understand the two other key developments of modern science (quantum physics²⁰ and relativity²¹) as well as cosmology²²; in economics they have been applied not only by Mandelbrot but also to financial crises²³; in organization theory they are useful for assessing interdependence and multi-dimensional folding in networks²⁴, as well as management²⁵ and organization design²⁶; in biology, furthering Mandelbrot's focus on analysing nature, they are relevant in, for example, the organization of cell nuclei²⁷; in psychiatry to movement and depression²⁸; and in applied computing it can assist in understanding IT needs for complex organizations.²⁹ Fractals can be useful to understand any natural, human and artificial systems at scale, and the field itself therefore takes on its own implicit metafractal quality in its interdisciplinary application.

In a more explicitly and intentionally interdisciplinary manner, games as a field of study also acts as a fractal description of human culture and its mediated constructions of reality. There is a microcosmic quality to many games, particularly those that display MMO, exploration, or social characteristics. Indeed, the field of serious and educational games demonstrates the usefulness of games as a scaled-down staging of wider society or reality, especially when speculating on complex behaviours in exceptional environments or circumstances. From individual experiences to inter-human relations and up to the overarching societal structures,

²⁰ Arkadiusz Jadczyk, *Quantum Fractals from Heisenberg's Uncertainty to Barnsley's Fractality*, (Singapore: World Scientific) (2014).

²¹ Laurent Nottale, *Scale Relativity and Fractal Space-time: A New Approach to Unifying Relativity and Quantum Mechanics*, (London: Imperial College Press) (2011).

²² Jonathan Dickau, "Fractal cosmology" *Chaos, Solitons and Fractals* 41 (2009), pp. 2103-2105.

²³ Jay Sorkin, Shera Buyer, "Using fractal geometry in a financial crisis" *Futures* 31:10 (2002), p. 48.

²⁴ Kathryn Pavlovich, "A Fractal Approach to Sustainable Networks" *E:CO* 11:3 (2009), pp. 49-60.

²⁵ Ikujiro Nonaka, Mitsuru Kodama, Ayano Hirose, Florian Kohlbacher, "Dynamic fractal organizations for promoting knowledge-based transformation – A new paradigm for organizational theory" *European Management Journal* 32 (2014), pp. 137-146.

²⁶ S.M. Saad, A. M. Lassila, "Layout design in fractal organizations" *International Journal of Production Research* 42:17 (2004), pp. 3529-3550.

²⁷ Aurélien Bancaud, Christophe Lavelle, Sébastien Huet, and Jan Ellenberg, "A fractal model for nuclear organization: current evidence and biological implications" *Nucleic Acids Research* 40:18 (2012), pp. 8783-8792.

²⁸ Selma Aybek, Anisoara Ionescu, Alexandre Berney, Oury Chocron, Kamiar Aminian, Francois Joseph Godfried Vingerhoets, "Fractal temporal organisation of motricity is altered in major depression" *Psychiatry Research* 200 (2012), pp. 288-293.

²⁹ Rajiv Ramnath, David Landsbergen, "IT-enabled sense-and-respond strategies in complex public organizations" *Communications of the ACM* 48:5 (2005), p. 58-64.

games offer a sandbox arena for experimentation (for designers and players) and analysis (for scholars). However, we must remember that games are never an accurate or neutral microcosm for concrete experiments. Rather, they are a hyperreal, mediated representation. It is this quality that expresses the fractal nature of the field, amplifying characteristics of reality with their dimensional reduction to the scale, logic, and experience of a game. A game can thus act as a more extreme expression of diverse problems in diverse fields, iterating broader concerns in specific implementations and intensified at a smaller scale. Some aspects will always be lost (otherwise the game would simply *be* reality), but this in turn generates the non-integer dimensionality of games as a *fractal simulation of reality*. The chimerical nature of games as a discipline is applicable in inspiring an engaged and experiential response to many issues, from the grand questions of reality down to the specific problems of individuals in an unequal world. The complexity of these issues drawn into the sandbox experiment of the game universe and mediated framework reveals an increased dimensionality of the impact of games in their necessary analysis through the lens of other fields. These various perspectives combine to generate a much broader view that expands into the spaces between disciplines and between the game and reality. We will now turn our fractal metaphor to the context of games within their field of study, taking the exemplary case of *EVE Online*.

***EVE Online*: a fractal metaverse of game studies**

EVE Online is a ‘sandbox’ reality, not quite a game and not quite a virtual world but displaying characteristics of both. This space exploration and conquest environment combines the vast open universe and free economy of virtual worlds with the player-versus-player space combat one might expect from a game. There are a number of key aspects of its design, however, that differentiate it from other such games or worlds and emphasize its fractal quality as an object of game studies. Firstly, *EVE Online* goes beyond the iterative environments of many MMORPGs (such as *World of Warcraft*) in that, rather than placing players on different servers to deal with population overload and different rulesets, *EVE* takes place in a single universe on a single server with scalable architecture and adaptive workload management. While there is also a free to play version with much reduced player violence, this is more like a demo than a separate game environment. The main *EVE* platform is therefore not only a marvel of scalable technological achievement but in making the entire universe open to players, what is usually a series of parts becomes a whole system and the simulated reality becomes itself a closer iteration of our own physical environment. The similarity with the material world is emphasized through *EVE*’s second distinctive feature, the lack of constraints. Other than active cheating, almost anything is permitted in *EVE*, including mass player on player violence, scamming and other such nefarious activities. Like a Wild West in space, *EVE* reflects

humanity's best and worst relations, bringing together conflict and collaboration as large-scale guilds are formed for mutual protection and economic or political attainment. As one player review comments, "imagine if every chat troll had guns, and were in the same room as you. That's EVE in a nutshell".³⁰ The characteristic behaviours of humans playing games is amplified in a social feedback loop that allows us to zoom in on radical social interactions at a much faster pace and greater scale than is often the case (in either a game or the real world), and the actual financial value of assets that might be lost or stolen only further emphasizes the social intensity of *EVE*.

The universe of *EVE* takes on a further fractal character through its persistence – a temporal scaling of experience that has, running since 2003, outlasted many other continuous game worlds. This historicity, to an even greater extent than what *Worlds Adrift* is attempting to achieve, forms a feedback loop of the game's internal truth, reality, and identity, between the players, the technology and the designers. Aside from any fictional narrative, the history of *EVE Online* is now that of its players, its guilds, its own pivotal moments, all of which express the shift from narrative to ludic history that Neal Stephenson later detailed as the battle not between arbitrary good and evil of writers but between player-chosen colour palettes in his novel *Reamde*.³¹ *EVE* now includes player activities in its own lore, embedding the human interactions within the game structure in a fractal narrative with a higher degree of 'reality'. This history and player experience scales even beyond the singular game itself, with a tie-in first-person shooter game *Dust 514* expanding the universe onto the planet's surface. More than a game set in the same fictional universe, *Dust* offered a fractal experience in the same game universe, connected in real time with the events of *EVE*, to the extent that players on the surface in *Dust* could signal for orbital bombardment from their guild's battleships in *EVE*, and the players in *EVE* could benefit from resources won in *Dust*. The universe of *EVE Online* is thus constantly expanding in a fractal level of detail in space and time, with new experiences contributing to the constant increase in the game's multidimensional size and impact. This impact extends also into the real world, with *Project Discovery* turning minigames with in-world rewards to the cause of actual space discovery, using players' enthusiasm for astronomy to sort through telescope data to find new exoplanets. The fractal metagame thus expands outwards from itself, iterating through our own reality in social and epistemic detail.

In academia, the scale of the game's impact is such that there is even an *EVE Online* reader,³² establishing the singular game/platform as a worthy field of study on its own. And, much like fractals themselves, *EVE Online* has acted as a lightning rod

³⁰ Styxies, [Steam comment - 5 May 2017], *Steam*
http://store.steampowered.com/app/8500/EVE_Online/ accessed 24 May 2017.

³¹ Neal Stephenson, *Reamde* (London: Atlantic Books) (2012).

³² Marcus Carter, Kelly Bergstrom, Darryl Woodford (eds), *Internet Spaceships Are Serious Business: An EVE Online Reader*, (Minneapolis: University of Minnesota Press) (2016).

for various disciplines as a scaled study of many aspects of human behaviour, society, and technological mediation. This includes (again, offering only a representative sample) applications in: law, for an assessment of property³³ and normative behaviours;³⁴ history, as collective memory;³⁵ politics, for the study of online propaganda³⁶ and political economy;³⁷ social sciences more broadly for issues in identity,³⁸ gender³⁹ and ethnography;⁴⁰ business, for studying the links between supply chains and skills development;⁴¹ technology and networking, for issues of workload and player behaviour,⁴² scaling,⁴³ and *EVE Online*'s unique novel approach to server architecture to overcome these challenges;⁴⁴ and mathematics, in relation to science fiction and reality.⁴⁵ Of particular note is the importance of scaling in both the technology and the socio-political structures. Scalability is a challenge in system design whether it be of the order of CPUs or legal frameworks, echoing human society in general in the complexities across scales of material and social dilemmas. The fractal nature of games reiterates the fractal character that appears in all technology, its design and mediation of human life. The importance of technology studies as an interdisciplinary confrontation with our mediated society reflects the necessity of game studies as a fractal field of its own – a scale model of the relation

³³ Bobby Glushko, "Tales of the (Virtual) City: Governing Property Disputes in Virtual Worlds" *Berkeley technology law journal* 22:1 (2007), pp. 507-532.

³⁴ Nicolas Suzor, Darryl Woodford, "Evaluating Consent and Legitimacy amongst Shifting Community Norms: an EVE Online Case Study" *Journal of Virtual Worlds Research* 6:3 (2013), 16p.

³⁵ Nicholas Webber, "EVE Online's War Correspondents: player journalism as history", in *Fans and Videogames: Histories, Fandom, Archives*, ed. Melanie Swalwell, Angela Ndalians and Helen Stuckey (New York: Taylor and Francis) (2017), pp. 93-110.

³⁶ Marcus Carter, "Emitexts and Paratexts: Propaganda in EVE Online" *Games and Culture* 10:4 (2015), 311-342.

³⁷ Nicholas Taylor, Kelly Bergstrom, Jennifer Jenson and Suzanne de Castell, "Alienated Playbour: Relations of Production in EVE Online" *Games and Culture* 10:4 (2015), pp. 365-388.

³⁸ Marcus Carter, Martin Gibbs, Michael Arnold, "Avatars, Characters, Players and Users: Multiple Identities at/in Play" *OZCHI'12* (2012), pp. 68-71.

³⁹ Kelly Bergstrom, "Virtual inequality: a woman's place in cyberspace" *FDG'12* (2012), pp. 267-269.

⁴⁰ Oskar Milik, "Virtual Warlords: An Ethnomethodological View of Group Identity and Leadership in EVE Online" *Games and Culture* (2015), p. 1-22.

⁴¹ Michael Hugos. *Essentials of Supply Chain Management*, (Hoboken: John Wiley & Sons) (2011), p. 219.

⁴² Wu-chang Feng, "A Long-term Study of a Popular MMORPG" *ACM SIGCOMM NetGames '07* (2007), pp. 19-24.

⁴³ David Brandt, "Scaling EVE Online, under the hood of the network layer" *NetGames '05* (2005). Daniel Horn, Ewen Cheslack-Postava, Tahir Azim, Michael J. Freedman, Philip Levis, "Scaling Virtual Worlds with a Physical Metaphor" *Pervasive Computing* Jul-Sept (2009), pp. 50-54.

⁴⁴ Halldor Fannar Guðjónsson, "The server technology of EVE Online: How to cope with 300,000 players on one server" *Proc. Austin GDC* (2008).

⁴⁵ Darren Jorgensen, "The Numerical Verisimilitude of Science Fiction and EVE-Online" *Extrapolation* 51:1 (2010), pp. 134-147.

between humanity and technology that can provide valuable insights into the fundamental processes of mediation that increasingly define our digitized world.

Conclusion

We have demonstrated the application of fractals as a metaphor for the construction and analysis of games as objects, as a medium and as a field of study. The scalability of gaming experiences offers not only an application of the fractal model but also a model with which to view the interdisciplinary relations inherent to technologically mediated human society. Through the analysis of feedback loops, self-similarity across iterative player experiences in different parts of the same game, and the scaling of experiences to the game world as a whole and the metagame of development and expansion, we have viewed *No Man's Sky*, *Everything*, *Worlds Adrift*, and *We Happy Few* as models of fractal games, and *EVE Online* as a model of fractal game studies. A fractal mode of approaching games allows us to view multiple aspects of ludic and narrative experience alongside external facets of the game in its context. Thus, the fractal metaphor becomes a metafractal analysis whereby the model is itself fractal in nature, self-similar across the various scales and objects of its intellectual gaze, and iterative across disciplines. Games and game studies stand currently at a multidimensional crossroads, having transcended the ludo-narrative dissonance of the field itself, while integrating and spreading across multiple traditional disciplines. It will be essential to find new ways of understanding the intersecting topics and interactions across the ever-expanding dimensions of gaming as a medium.

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