Game Studies

the international journal of computer game research

volume 19 issue 2
October 2019
ISSN:1604-7982

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The Open, the Closed and the Emergent: Theorizing Emergence for Videogame Studies

by Joan Soler-Adillon

Abstract

Emergence has been suggested as one of two basic game structures that distinguish between open and closed gaming paradigms: games of emergence and games of progression. The first category relates to most traditional games and also some videogames. It encompasses games that, starting from a relatively small set of elements and rules, can have a multiplicity of possible outcomes. The second one refers to games in which the player needs to complete a series of predefined tasks in order to advance. This is the case of some traditional games, such as treasure hunt, but also of the majority of existing videogames in which solving puzzles and quests, or overcoming obstacles organized in screens or levels are the basis for progressing in them. This article argues that the use of emergence in games research falls short in capturing the full potential of such an intricate concept. Clarifying the term and its use can help expand this theorization of games, separating what refers to -- or is a result of -- an open space of possibilities and what is indeed emergence in a strict sense. Distinguishing the notions of open and emergent widens the discourse on game design. It will allow game scholars to account for self-organizing phenomena in digital games on one hand, and for the appearance of emergent novelty on the other, both during the design process and in respect to the model player of the game.

Keywords: Emergence, design, gameplay, videogames, openness, self-organization, novelty, game of life, Sim City, artificial life

1. INTRODUCTION

In game studies, the term emergence has been used to describe one of two basic game structures that distinguish between open and closed gaming paradigms. The first category encompasses games that, starting from a relatively small set of elements and rules, can have a multiplicity of possible outcomes. These are the open games, or games of emergence according to this terminology. This is often associated mostly with traditional games, although videogames are not excluded. The second category, games of progression, refers to games in which the player needs to complete a series of predefined tasks in order to advance. This is the case of many traditional and board games, too, such as treasure hunt, but also of the majority of existing videogames in which solving puzzles and quests, or overcoming obstacles organized in screens or levels are the basis for progressing in them.

The emergence-based distinction was first proposed by Jesper Juul (2002; 2005) and was taken on by other game researchers (e.g. Salen and Zimmerman, 2004; Adams and Dormans, 2012), while others have proposed somewhat different readings of the term itself and its influence in categorizing games (e.g. Walsh, 2011; Karhulahti, 2013, 2015). The distinction is based on a general understanding of how the term emergence is used in complexity sciences (see e.g. Cruthfield et al., 1984; Prigonie and Stengers, 1984; Protevi, 2006) and, in particular, in artificial life (e.g. Langton, 1984; 1988; Holland, 1998), where it is a central concept in order to explain organizational processes in which large numbers of agents are involved. It is the 'order out of chaos' idea; or the 'whole being more than the sum of the parts'. Additionally, emergence refers to how these organizational processes can appear as surprising to an observer (i.e. they are new in respect to some frame of reference). It has been argued that, in fact, emergence refers to two separate (but combinable) ideas: self-organization and novelty (Nagel, 1961; Soler-Adillon and Penny, 2014; Soler-Adillon, 2015a, Soler-Adillon, 2015b).

However, as recognized by Juul among others, the uses of the term are often vague or contradictory among themselves, even within the academic literature. In other words, it is a multi-discursive concept, in the same way that Jensen labelled another disputed idea: interactivity (Jensen, 1998). Thus, any discussion based on emergence should clarify what is understood by it in order to clearly frame an argument. To that end, it is worth noting that my proposal is based on an understanding of emergence based on a systemic point of view, and on the above-mentioned distinction between emergence as self-organization and emergence as the appearance of novelty.

From this understanding of the term, the main argument is that the use of emergence in games research falls short in capturing the full potential of the idea. Clarifying the term and its use can help expand this theorization of games; distinguishing what refers to an open space of possibilities and what is indeed emergence in a strict sense. The idea is that separating the open from the emergent can enrich the discourse. This article will delve into this differentiation and exemplify it with two case studies. The first is *Game of Life*, as a representative example of what game researchers have used in order to exemplify emergence. The second is *SimCity* (Electronic Arts, 2014), which would be classified as a game of emergence according to Juul's classification.

2. EMERGENCE

2.1 What is emergence?

As said above, emergence is often explained with the idea of the whole being more than the sum of its parts. Typical examples include the complexity of the ants' nest or the human mind as the result of the millions of neural connections in the brain. Emergence is a key concept in artificial life, and it is from within these discourses that Juul picked up the idea for the theorization of videogames.

In the academic literature, the concept of emergence appears as related to two different and not necessarily related phenomena: self-organization and the appearance of novelty (Soler-Adillon and Penny, 2014; Soler-Adillon, 2015a). The first refers to the observable systemic patterns that result from multiple local interactions among agents within a system. These patterns are self-organized in the sense that no particular agent or group of agents is intending to produce them, and are emergent in the sense that they could not be understood, nor anticipated, through the analysis of the elements and their behaviours in isolation (e.g. Langton, 1988; Holland, 1998; Bedau, 2008). Typical examples of this type of emergence are found in systems that exhibit complex behaviours from a relatively small set of simple rules and behaviours. When in the form of novelty, emergent phenomena appear as new functions or behaviours in a known system. They relate to fundamental novelty and, thus, to creativity (e.g. Steels, 1995; Cariani, 2012). In this case, emergence is often used when referring to learning systems or adaptive devices.

Prominent among those concerned with emergence and its relation to novelty, Peter Cariani has elaborated the theory known as emergence-relative-to-a-model (ERTM) (Cariani 1992; 2009; 2011; 2012). Cariani articulates ERTM as a discourse that aims at identifying emergence as novelty in a given system in a way that can be scientifically communicated. The basic idea is that this emergent novelty can only be accounted for scientifically if, first, the observer of the system defines its states and state-transitions by creating a model of it, and afterwards uses these observations to make predictions on the future states of the system. In this context, emergence occurs whenever unanticipated behaviours, states or functions appear: it is "the appearance of novel entities that in one sense or another could not have been predicted from what came before" (Cariani, 2009). I have discussed both Cariani's theorization on emergence and the historical account on the following section in detail in (Soler-Adillon, 2015a).

2.2 A (very) brief history of the concept

2.2.1 Emergence in Philosophy

The term 'emergence' was coined in 1875 by George Henry Lewes, in the context of a discussion on different types of causation inaugurated by John Stuart Mill three decades earlier. At the heart of it was the idea that reductionism is inadequate when analysing how certain components -- mainly chemical in these early examples -- result in higher order elements. In some cases, applying a simple aggregation is sufficient; these are the resultants, in Lewes' terms. But in others, there is something that Mill identifies as breach in the principle of composition of causes, and simple aggregation does not explain the results (e.g. there's 'something more' in water than simply putting together hydrogen and oxygen). These are what Lewes labelled as emergent effects.

The discussion on emergence, however, didn't find a fertile ground until the early twentieth century, when the British Emergentists used it to define reality as being organized in different levels of complexity, in which superior levels are not reducible to inferior ones (McLaughlin, 2008). That is, they are not explainable as resultants of the levels below but, rather, they are emergent in the sense that Mill and Lewes formulated the idea. British Emergentism flourished before the turn of the twentieth century and vanished with the event of quantum mechanics. In parallel, vitalism, through ideas such as Bergson's 'Élan Vital,' would hold that there is something essentially different between living and non-living systems: fundamental forces or impulses that drive the appearance and the evolution of beings (Bergson, 1911). Although the vitalists did not use the term emergence, they understood these forces to be emergent in the sense that they were not reducible to the lower levels of reality sustaining them (i.e., matter). The interest in vitalism also diminished as scientific advances were made.

It wasn't until a few decades later when the new context of cybernetics and, later, of complexity sciences allowed the concept of emergence to regain importance in the philosophical debate, mostly, in discourses related to the philosophy of science, artificial life and to the physicalist debate on reductionism. Within this line of thought, it is prominent the work of Jaegwon Kim, which builds a strong philosophical critique on some of the notions around emergence (Kim, 1999, 2006). These contemporary discussions, Kim's included, are in general articulated around a series of central concepts, such as supervenience and downward causation. The former is the idea that any emergent phenomena have to depend on a causal base. That is, while not reducible to it, they are not something that just randomly appears. Therefore, whenever these basal conditions are given again, there are chances for the emergent phenomena to reoccur. In contrast, downward causation is a relation of influence of the emergent phenomena to its causal base. It is precisely what differentiates it from an epiphenomenon that randomly appears in a system. To be truly relevant as such, what is emergently generated must exert some kind of influence on the same elements that, with their individual behaviours, generated it. Resolving the potential circularity problem of combining supervenience and downward causation is one of the key issues in some of the philosophical discussions around emergence (see e.g. Bedau, 1997; 2008; Protevi, 2006; Campbell and Bickhard, 2011).

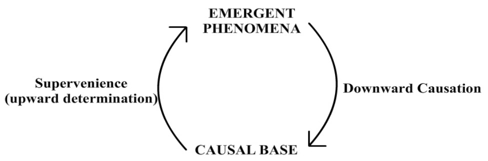

Figure 1: Supervenience and Downward causation affect, respectively, the emergent phenomena and the causal base (source: Soler-Adillon, 2015a).

These philosophical approaches are, for the most part, ontological. That is, they are concerned with determining whether or not emergent phenomena actually exist, i.e. if they are part of reality or if they are just an epistemological construct at best. In fact, the debate on downward causation and supervenience is usually rooted around the theoretical efforts on defending or refuting emergent phenomena as truly existent.

2.2.2 Cybernetics, Complexity Sciences and Artificial Life

In 1972, Phil Anderson published the influential paper 'More is Different' in Nature, in which he questioned reductionism for being unable to completely explain complexity at different levels of reality (Anderson, 1972). The title of the article refers to the classic idea of emergence, which states that there are cases in which a whole is not explainable as a mere aggregation of its parts. But even written by a soon-to-be Nobel Laureate, emergence, had not been, was not, and would not be considered an important scientific topic for some time.

Despite the aforementioned use of the concept by Mill and Lewes in the mid/late ninetieth century, the idea of emergence remained still a marginal concept for a long period. In the Newtonian science paradigm, emergence was unknown and unknowable, since reductionism was an indisputable method. But even when the once revolutionary 'modern' science was reshaped by the Twentieth Century revolutions of relativity and quantum mechanics, emergence remained an outsider to scientific discourse. It was not until the second half of the twentieth century that the work of some rather unorthodox scientists prepared the context for emergence to appear in its contemporary form. By the end of the century, it was a central concern in the complexity sciences (artificial life, dynamical systems theory, neural networks, etc.).

These first thinkers and experimenters to reintroduce, if not emergence per se, a context for it to be relevant, were the 1950s British cyberneticians (Pickering, 2008; 2010). Some of these artists and experimenters were the predecessors of artificial life, a discipline in which, as said above, emergent properties acquired a fundamental role. Particularly, Ashby's Homeostat, Walter's tortoise robots and Gordon Pask's devices and artworks were both pre-configurations of emergence as self-organization and as generation of novelty (Soler-Adillon and Penny, 2014). Three decades later, Anderson would be one of the founders of the New Mexico's Santa Fe Institute, an innovative interdisciplinary centre for what they decided to call complexity sciences, in which disciplines such as artificial life would appear (Waldrop, 1992). It was in that context of chaos theory and the complexity sciences -- including artificial life -- in the 1980s and 1990s that emergence and emergent properties gained a central status as a scientific matter.

In this context, the idea was not put into question and scrutinized as it was in philosophy but. Most researchers on complexity, chaos theory or dynamical systems would assume that emergent phenomena exist, and therefore move the focus from ontology to epistemology. They were not concerned with whether or not emergence exists, but on how -- as existent -- it affects the dynamics of the complex systems they were aiming to explain (see e.g.

Kauffman, 1993; Kelso, 1995; Solé and Goldwin, 2001; Crutchfield, 2008).

Specifically within artificial life, the centrality of the idea sparked some significant efforts to explain and exemplify the idea (Wolfram, 1983, 1984, 2002; Langton, 1984; 1988; Roland et al, 1999; Holland, 1995; 1998; Assad and Packard, 2008). For some authors, such as Langton or Wolfram, emergence is, like for many complexity scientists, essentially understood as self-organization, while others like Holland point out too that this concept can be, and is very often, linked to generation of novelty. It was within this context that Peter Cariani developed his theory of emergence-relative-to-a-model in part as a critique of more ambiguous formulations within the field. His ERTM moves the focus away from self-organization schemes in favour of emergence as a generator of novelty, and offers a framework for scientific discussion on emergence that aims at circumventing this lack of concretion.

3. EMERGENCE AND GAMES

3.1 Open and closed game structures

A common assumption is that one of the characteristics of games is, regarding their underlying structure, the degree of to which they are linear (i.e. they present a unique path to their resolution), are non-linear or are open (multiple paths or no such thing at all). In the more sophisticated analysis of games, this does not apply only to the overall game experience, but to many of the particular aspects that constitute it.

In their open-ended [1] game typology, Elverdam and Aarseth (2007) elaborate a detailed classification of games according to eight metacategories (e.g. virtual space, external time or game state), each of them containing one to three of the total defined dimensions (e.g. virtual perspective, interval control, teleology, goals). In it, 'open' and 'closed' are neither metacategories nor dimensions, but are rather embedded in one way or the other in almost all of them. An obvious example is environmental dynamics, a dimension of virtual space that describes whether or not the player can change anything in the game space. If alterations are allowed, the game will weight towards openness, and the contrary will happen if no changes whatsoever are allowed. Similarly, games with a finite teleology (i.e. they end at a given time) will tend towards closeness, while games with an infinite teleology (i.e. that they could go on forever) will tend, theoretically at least, to generate more open scenarios. One of the dimensions, player bond, is directly defined as either static or dynamic

When the focus shifts to narrative, or to ludo-narratives, the distinction between static and dynamic plays a more central role. Dynamics, determinability, and random vs. controlled access are some of the variables involved in textual interpretation (Aarseth, 1997), and openness (as opposite to linear and multicursal) is a key characteristic of how story-based games are perceived (Aarseth, 2012).). Within this context, openness can lead to emergent phenomena, both in the form of self-organization or in the form of a novel effect that the designer did not predict. For example, the *Deadline* sequence discussed in (Aarseth, 1997: 123-124) illustrates that "the possibility of unintentional sign behavior makes cybernetic media creatively emergent" [2].

Coming from a different conceptual basis, Jesper Juul presented his characterization of games of progression and games of emergence in an influential paper published in 2002, and expanded the argument in his 2005 book *Half-Real*. At the basis of this idea, he notes, is Harvey Smith's use of the term emergence and emergent gameplay (Smith, 2001) to talk about gameplay situations that were unexpected to the game designers.

Juul's distinction is used to characterize two different ways of presenting the player of a game with a challenge. The first is that of a game that develops from a relatively simple set of rules. These games are replayable, and lead to a considerable variety of possible outcomes. Card games, board games or strategy games fall into this category. These games, which are in fact almost all traditional games, are mainly based on the game structure that Juul labels 'emergence'. On the other hand, some newer computer-based games are based on the structure of 'progression'; one within which the player has to perform a series of predefined actions in order to advance.

One of the differences between these two types to games is that, while the first foster competition and strategy, those of the second type lead to step-by-step guides that help the user advance: "as a rule of thumb, the simplest way to tell games of emergence from games of progression is to find guides for them on the net. Progression games have walkthroughs: lists of actions to perform to complete the game. Emergence games have strategy guides: rules of thumb, general tricks" (Juul, 2002). According to the author, most pre-electronic games are games of emergence, while videogames combine both structures or favour progression.

Within this context, Juul proposes to use emergence to explain how the variation of a game is "a non-obvious consequence of the rules of the game" (Juul, 2002). Whatever is emergent (these game situations and the strategies that players develop in order to win) is "neither anticipated by the game designer, nor is easily derivable from the rules of the game." At the heart of it is the idea that games, even when made out of simple rules, generate systems that are complex, and as complex systems they produce unanticipated results that can be identified as emergent. The parts -- the rules and mechanics of the game and the actions of the players -- generate a complex whole (the gameplay), which is emergent in respect to these parts. As expressed by some of the game scholars that picked up on this argumentation: "the rules of Pong [(Atari, 1972)] are relatively simple, but if you imagine all of the ways that a game can play out, from a quick-win match where one player dominates, to an extended, dramatic finish, it is clear that the system of Pong demonstrates emergence" (Salen and Zimmerman, 2004).

According to this, the paradigm of progression games is adventure games. The range of examples goes from the text-based adventures from the 1980s like *Zork* (Infocom, 1980) or the graphic adventures games like *Maniac Mansion* (Lucasfilm, 1987) to contemporary videogames like the *Grand Theft Auto* game series. The advances in such games happen through finding objects, discovering doors, solving puzzles, etc. Each of these actions, or a group of them, is always a pre-requisite to move forward in the game. Thus, the gameplay is in this sense closed: a series of predefined actions must be made, always in the same way and in the same order. As Juul notes, replaying these games is not usually appealing for a player, because, once the progression mechanisms of each stage are discovered, the game offers nothing new to the player.

In contrast, what Juul refers to as emergence games are games that offer an open structure, in the sense that the gameplay can develop in very different ways, and different strategies can be created in order to try to succeed in the game. Open and closed structures for characterizing games are very well defined within these parameters. Most games, however, are not located on the extremes of this categorization, but rather at some point in between (Juul, 2005: 82).

3.2 Categorizing Emergence

In his monograph *Half-Real* (2005), Juul expands his categorization of emergence, a term that, as he admits, he uses only in order to understand game rules, while not aiming at dealing in full with a concept that is commonly used rather loosely and even contradictorily within the literature. Juul presents here four types of emergence, which can arguably be reduced to the two concepts of emergence of (Soler-Adillon, 2015a): self-organization and novelty. 'Emergence as patterns' is clearly identifiable with the former, while 'emergence as novelty or surprise' is identifiable with the latter. 'Emergence as variation' and 'emergence as irreducibility', as it is argued below, are not in fact types, but characteristics of emergence.

Not surprisingly, there are other authors who have attempted to clarify the concept of emergence through the discussion of different types of it (see e.g. Bedau, 1997, 2008; Protevi, 2006; Baljko & Tenhaaf, 2006; Assad and Packard, 2008; Cariani 2012). Amongst them, Fromm presents an interesting and comprehensive classification based on the different levels of complexity that can be involved in such processes (Fromm, 2005). In it, he presents four types of emergence, the first three of which have two subtypes. Starting with the simplest form of a purposeful system (which arguably is in fact not really a case of emergence), the classification builds up mostly around the notion of feedback -- appearing in simpler forms in type II to multiply in type III and, finally, reaching the most extreme case, strong emergence [3].

Fromm	Juul	Soler-Adillon
Type Ia: Simple Intentional Emergence	Closed systems	Systems (not emergence)
Type Ib: Simple Unintentional Emergence	Emergence as patterns / irreducibility / variation	Emergence as self-organization
Type IIa: Weak Emergence (stable)	Emergence as patterns / irreducibility / variation	Some cases are of self-organization, but many are not, in fact, cases of emergence.
Type IIa: Weak Emergence (instable)	Emergence as patterns / irreducibility / variation	Some cases are of self-organization, but mostly are not, in fact, cases of emergence.
Type IIIa: Multiple emergence (stripes, spots, bubbling)	Emergence as patterns / irreducibility / variation	Emergence as self-organization
Type IIIb: Multiple emergence (tunneling, adaptive emergence)	Emergence as novelty and surprise / ireeducibility / variation	Emergence as generation of novelty
Type IV: Strong emergence	Emergence as novelty and surprise / ireeducibility / variation	Emergence as generation of novelty + Emergence as self-organization

Table 1: Fromm's classification, with the closest correspondence in Juuls' and Soler-Adillon's.

Table 1 shows a correlation between Fromm's types of emergence, Juuls classification, and my own distinction. As it can be observed by the repetition, both Juuls and especially my categorization are significantly more restrictive than Fromm's. One could argue that the emergence as self-organization and emergence as generation of novelty dichotomy could be further subdivided to accommodate for a more nuanced discussion of cases, but this does not in fact invalidate but rather reinforce the idea that emergence is, on a fundamental level, always based on either or both these ideas.

However, the main conflict between Fromm's classification and the one this article is based on goes beyond the classification. In his account of Emergence, Fromm allows for an element that is fundamentally contradictory with the systemic view of self-organization. Type II b is the unstable version of Weak Emergence. In a nutshell, this means that emergent processes occur due to either negative feedback from the macro level affecting at the micro level (the agents causing the process). However, Fromm includes here the idea of intention as part of the loop. That is, that the agents are willingly and consciously participating in the creation of the emergent phenomenon. In contrast, self-organization is built on the idea that the agents react exclusively to local interactions, unknowingly generating and, in fact, not necessarily able to perceive, the macro level phenomenon.

His example of Wikipedia is illustrative of this. Every contributor of Wikipedia does indeed work on a small (micro level) part of the project. However, they are not only aware of, but also willing to influence, the macro level project that is the encyclopaedia itself. It is a crowd-based effort, and the wikipedians are in some sense self-organized. But they are not so in the sense of the self-organization-based systems that produce emergent effects, which are by definition not intended by the individual entities (here, the wikipedians) that constitute the micro level. It is in this sense that Kelso states that the 'self' in self-organization is a rather misleading term: "The system organizes itself, but there is no 'self', no agent inside [or outside] the system doing the organizing" (Kelso, 1995).

3.3 Meaningful Play, Puzzles and Games

Back to games and to Juul's characterization, Salen and Zimmerman draw upon it in order to present the concept of 'meaningful play' in their influential book *Rules of Play* (2004). The basic idea here is that the meaning of an action of a game's player resides in the relationship between this action and the outcome it produces in the game. It is based on a systemic understanding of games, where rules and player's actions constitute the basic building blocks of a system that is set in motion as the game is played. Basic premises here are that this system is capable of generating some degree of complexity, and that there are perceivable relationships between player actions and game outcome.

According to the authors, meaningful play is emergent, and "emergence arises trough the interaction of the formal game system and the decisions made by players" (Salen and Zimmerman, 2004: 164). Therefore, it is not designed per se. Instead, the designers of games engage in a sort of second order activity, in which they aim at creating a rich space of possibilities, the elements of a language that will create the experience of the game. "The goal of successful game design is meaningful play, but play is something that emerges from the functioning of the rules. As a game designer, you can never directly design play. You can only design the rules that give rise to it. Game designers create experience, but only indirectly." (Salen and Zimmerman, 2004: 168).

A different and, arguably, more sophisticated take on the issue is Karhulahti's use the notion of dynamic and static game environments. Here the idea is that closed game structures are, in fact, not games but puzzles. In this context, the linearity translates into the notion of the static system, where a determinate configuration outcome results in a determinate system state. The regularities of the game make it predictable once the ludic artefact is known (Karhulahti, 2013; 2015). Essentially, the closed game structure of Juul's categorization becomes under this theorization a mere puzzle, however sophisticated.

In contrast, the dynamic relates to the unpredictable and indeterminate. The challenges afforded by the different types of dynamics that Karhulahti defines offer different types of game experiences. From direct dynamics where, despite the system state being determinate, the player does not know the consequences of her configuration, to totally dynamic structures where both outcome and system state are indeterminate, thus being this the most 'open' of the possible structures. This use of the term dynamics -- which as noted by the author is borrowed from physics through its initial, yet somewhat underdeveloped, use by Chris Crawford (1984) -- nicely connects this account to dynamical systems theory, which closely relates to emergence, to the point where it is the domain where emergence as self-organization is rooted (Soler-Adillon, 2015a).

This emergence as self-organization is particularly relevant to Walsh's discussion on 'emergent narrative', which describes emergence as a feature of complex systems that "refers to phenomena or behaviour produced by a system but not apparent from an inspection of the elements of the system and the laws governing it" (Walsh, 2011). This is a common approach to the term, which, as the author notes, requires to differentiate among two different levels organization: one for the underlying system; and one (above) for the emergent phenomenon to be identified. This higher level would be, so to speak, the narratable part of the system. According to this account, emergent narrative occurs when there is an interaction between the agents at the basis of the system (or agents and system) that are affecting the sense-making process at the higher level (the emergent phenomena). Importantly, they do so while responding to this sense-making process itself. However, as discussed above, it is problematic to associate self-organization to processes in which the agents generating the phenomenon are aware of it. Additionally, this notion of emergent narrative seems to be conflating with the experience of playing games, which doesn't necessarily relate to whether these can or would be narrated.

4. DISCUSSION: EMERGENCE IN GAMES

4.1 Case Studies: *Game of Life* and *SimCity: Buildit*

4.1.1 *Game of Life*

Game of Life (GoL) is the most popular instance of cellular automata. A cellular automaton is an abstract model of an informational system. In it, a series of neighbouring cells, usually in a one or two-dimensional grid, interact with each other through a set of simple local rules. Each cell determines its behaviour (often a change in its binary on/off state) through analysing the neighbouring cells according to a predefining set of conditions. At each iteration of the system, cells decide whether to change state or stay still according to this exclusively local information.

Cellular automata are paradigmatic examples of how very simple rules can generate complex structures. They were first proposed by computer pioneer and mathematician John Von Neumann, who in the in the 1940s set up to create a self-replicating machine, with the intention of understanding the logic of the process. Decades later, researchers such as Christopher Langton and Steven Wolfram contributed greatly to the understanding and significance of such mathematical constructions (Von Neumann, 1966; Langton, 1984; 1986; Wolfram, 1984; 2002).

GoL was devised by John Conway, and first presented in 1970 (Gardner, 1970), but it became much more popular years later once computer simulations could be easily implemented. It consists of a two-dimensional grid (which can be of any size) with binary cells that can be either on (alive) or off (dead). At each iteration of this cellular automata system, the cells on the rectangular grid change from the on/alive state to the off/dead state depending on these very simple rules:

- If a cell is alive, will remain alive if it has two or three neighbours, but it will die otherwise.
- If a cell is dead it will come to life if it has exactly three alive neighbours. Otherwise it remains dead.

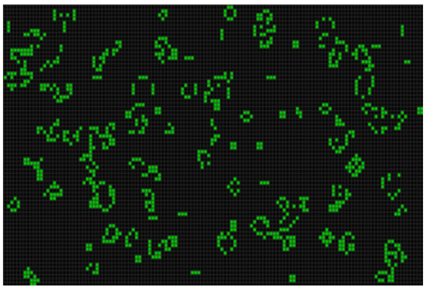

Figure 2: *Game of Life*

Throughout years of research and simulation, GoL has fascinated not only mathematicians, but also, and very especially, the field of artificial life. Cellular automata are indeed canonical examples of emergence within the Artificial Life discourses (Penny, 2010) and GoL is by far the most widely discussed. The artificial life researchers saw in GoL a perfect example of the phenomenon, since its very simple rules were able to create some very considerably complex behaviours in the system. Some of these were structures that appeared and disappeared, but some others sustained themselves or created others, such as the case of those known as gliders and glider guns. The potential of the system is proved in that even a Turing Machine has been devised using GoL (Rendell, 2011).

4.1.2 *SimCity Buildit*

SimCity Buildit (SCB) is a mobile installment the *SimCity* series. A 3D environment since the *SimCity* (Electronic Arts, 2013) release, this game series consists of creating cities while playing the role of an all-powerful mayor that can decide what to build, where and when, provided the budget and necessary materials are available. In the case of SCB, the player places and upgrades buildings, and as the game advances and features get unblocked he or she has to provide for services such as power or waste management. Factories and shops create goods, and those combine into other goods that are used for upgrading houses. Simoleons (the basic type of money within the game) are used to buy service buildings and is generated as the inhabitants in the city pay taxes or when the user sells his or her goods in a market were all the players can connect in order to trade.

All these processes within the game take time. Factories take from 1 minute up to 7 hours in creating the basic goods and shops create secondary or tertiary goods after some waiting time too. Thus, cueing these processes is key in a game that requires the player to connect often and 'farm' for what has been produced. Simoleons can be collected at intervals too. Depending on the population, so much of them are generated within 24 hours. SCB is a freemium game. That is, it is free to download and play, but users can make purchases within the game in order to speed these processes up. This is done with SimCash, a second type of money that is found in the game. Players can earn small and limited amounts of it in the free version or buy them through in-app purchases.

This game is a clear example of what Juul labelled a game of emergence because, like all other *SimCity* games, it presents an open structure to the player. The challenge is to make the city grow, but there is more than one way to make this happen. Following some rules and processes, players pursue a goal that is also open in the sense that there is no winning in the game. SCB is potentially infinite, since even if players had all the available building area covered with the best possible buildings, they could still keep playing to increase their earnings and population.

Figure 3: *SimCity Buildit*

In addition, to illustrate the previous point that almost no games are purely on one end of the spectrum defined by Juul, there are some progression elements in this game, too. As more buildings are built and more game cash is earned, levels increase, which in turn unlocks a series of new types of buildings, new elements to be produced, or new events to happen through their construction (e.g. the port and airport or Dr. Vu's tower for disaster challenges).

4.2 Games and emergence as self-organization

The theorization of emergence in games has GoL as a prototypical example, something which is shared with other computationally based approaches to the term (e.g. artificial life). It is in fact through the artificial life discourse that GoL entered the discussion on emergence and game design. Juul, Walsh, Salen and Zimmerman or Adams and Dormans all use GoL as a prominent example of what is meant by emergence. It is indeed a perfect example of how something complex (the patterns observed in it) can arise from something very simple and well-defined (the rules of the simulation). From this point of view, it is a good illustration of what emergence is. But it is also a good example of the subtleties of the idea and of the limits of what emergence is and what it is not.

In terms of emergence as self-organization, GoL is an example of such phenomena if we understand it as a heavily abstracted model of a complex process. There are two levels to take into account: the micro level is that of the individual cells and the relations among them (the rules); the macro level is that of the observed patterns. What is observed in the macro level is generated through the exclusively local interactions of the elements at the micro level. There is no entity at that micro level in charge of them or even trying to influence them. And this is how this differs from the example of a game; there is no entity trying to direct what is happening at the macro level (the 'no one doing the organizing' cited above).

In games, players can be understood to be at the level of the observer in GoL, and this is how it is presented in games research. There is a micro level that is formed by the game rules and mechanics that interact among them, but the player is one level above that with a vision of the whole system and of its current outcome. This is precisely what gives the player the ability to make decisions that shall influence the future states of the game. Meaningful play is exactly this: the intentional influence of the game state in order to produce a future state that affects the outcome of the game in favour of the player. There is here, thus, an intralevel interaction that is contradictory to self-organization: in meaningful play there is someone (the player) intentionally influencing the elements at the micro level.

One of the issues, here, is that despite the name of the simulation, GoL is not a game (note that this is acknowledged, of course, by all game scholars). There is no actual player in it: the observer of the patterns has no means of affecting how these are generated, and thus this intralevel interaction does not take place. In a game, the simple parts do not solely interact with each other, like in GoL, but also with the players' actions, goals and intentions.

In the case of SCB, there is at least one strategy that can be understood as generating a self-organizing pattern. I'll label it the '10 donut pattern', for it is with the selling of donuts that it first appears to a player. It develops as follows: one of the ways to earn SimCash is to trade items in the so-called 'Trade Depot'. In it, players can put produced goods for sale for other players to buy. This is done in theory either to earn Simoleons to buy other things, or to buy goods that one can't produce fast enough. But there is also a mechanic that awards players for having traded so many Simoleons, and the price is some amount of SimCash. Thus, trading can become a means for earning SimCash. And this is arguably what happens when lots of users pile up in tens (as ten is the maximum number of items to sell on a single slot) the most expensive items they can sell. It's very unlikely that a player would actually need 10 donuts in a particular moment in the game. Therefore, we can assume that this is a strategy to buy and sell them and thus to rapidly increase the amount of Simoleons spent and earned in trading. By doing so, players will achieve the SimCash prices for the amount traded much faster than if they simply trade the items in the need to advance in each particular moment in the game. This creates a trading pattern at the game level from the one-to-one interactions and local interests of the players. It is a case of self-organization because the strategy is deployed player by player, interacting only through the sale on the Trade Depot. No player is directing the 10 donut pattern and, as far as my extensive online search for of SCB game strategies goes, it is not even documented as such.

It is of key importance here that self-organization emergence is only such when the micro level interactions are not driven by the intent, or will, to affect the macro level. The local interactions at GoL, as the local interactions of e.g. cars generating a traffic pattern, are not trying to affect the emergent phenomena. There is an effect in both directions which, as mentioned above, has been extensively discussed in philosophical accounts of emergence under the terms of supervenience and downward causation; a discussion the details of which fall beyond the scope of this paper. What is important here is that if one type emergence can be characterized as being based on self-organization, then the pattern occurs independently of the intentions driving the interactions of the causal base (the micro level). The 10 donut pattern exemplifies this. The players are driven exclusively by local interest (their own game play), and can't in fact be aware of whether or not this is creating a larger phenomenon at the game system level.

This is a relevant point in regard to Walsh's emergent narrative (Walsh, 2011). In his account, he explicitly mentions the goals of the player (or participant, in non-game contexts) in creating the narrative experience (arguably, in fact the game experience), which would in some cases be emergent. This emergent narrative, which he differentiates from the emergent behaviour of a simulation (e.g. GoL), is "a semiotic activity, a sense making process" that represents a discrete temporal sequence, while a simulation represents the globality of a system. Along these lines, he distinguishes between behavioural interactivity (related to units of action) and semiotic interactivity (units of meaning). The latter is, quite obviously, the one that is relevant in respect to emergent narrative. In his non-digital example of dramatic improvisation, the participants interact among themselves to create what he labels as emergent narrative. But these participants are fully aware of the overall meaning and their participation in the system is being influenced by the will to affect is, as it should be in such dramatic exercise. Similarly, the player creating a non-conventional narrative in the Sims is fully aware of this narrative (the macro level) while interacting with the game system at the micro level.

Like with the example of meaningful play, this intentional influence on the overall pattern is inconsistent with the idea at the heart of self-organization (see Kelso above). The improvisation actor or the Sims player is, indeed, doing the organizing; i.e. trying to actively influence the resulting narrative. The option, here, is to either characterize this as a different type of emergence than that which finds its roots in self-organization, or to label this as something different altogether. My proposal is to do the latter, as it is the case for the example of dynamics discussed in the following subsection.

4.3 Open spaces, open possibility

4.3.1 Irreducibility

As said above, emergence as self-organization fits nicely with the 'emergence as patterns' of Juul, while ERTM is a good framework for his 'emergence as novelty or surprise'. Whilst his 'emergence as variation' is addressed in the following section, a note here is due to his 'emergence as irreducibility'. This is an idea that relates to what philosopher Mark Bedau, when discussing emergence in relation to artificial life -- and with GoL as the main driving example --, has articulated as the need for simulation in order to account for an emergent phenomenon (Bedau, 2008). The idea is that something is emergent if we cannot anticipate it. In systemic terms, this means that we need to put the system in motion (for real or in a simulation) in order to see what happens. Bedau exemplifies it in some particularities of Game of Life, while Juul does so in the need for game designers to play their game iteratively in the process of design.

Similarly to the notion of emergence as novelty, however, the problem with this is: where do we draw the line between the possibility of anticipating some system outcome and the need to simulate or play the game? Some cases are clear, but in some others an experienced player can anticipate much more than a novice, so again the discussion falls into the realm of subjectivity. In (Soler-Adillon, 2015a) I presented the example of the 'modified beehive', a GoL structure that takes exactly 16 steps (iterations) to resolve to a still figure, as a counterexample of Bedau's example of the R pentomino, which takes 1103 steps to come to a halt. While it is clear that 1103 steps are too much to anticipate, it is not so clear that an astute GoL expert might not anticipate the 16 necessary steps for the modified beehive (which is a simple structure formed by seven active cells). Following this, it can be argued here that irreducibility is a necessary but not sufficient condition of emergence. Thus, while some notion of irreducibility is necessary to understand emergence, the notion of 'emergence as irreducibility' is redundant from this point of view.

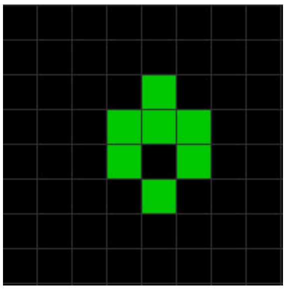

Figure 4: The modified beehive in its initial state

4.3.2 Variation and openness

Finally, Juul presents the category of 'emergence as variation', which relates to the notion of openness, and to the title of his seminal 2002 paper. The basic idea is that games of emergence are open in the sense that they afford multiple outcomes (i.e. every gameplay is different), and they do so because the gameplay is emergent in respect to the simplicity of the rules. In contrast, games of progression, where players perform a series of predefined tasks to achieve a goal, always produce exactly the same result.

The problem here is that, if this is true for games, it is true for almost any activity that is not strictly predefined. A conversation, someone's life path, or a football match can result in a multiplicity of outcomes depending on an enormous number of elements that interact. Arguably, if we label this emergence then anything open-ended in this sense is emergent, and in fact we are conflating the terms emergent and open, instead of using them to account for different phenomena. Like with irreducibility, anything emergent needs a large degree of openness, but not everything that results from openness is emergent.

A good term to address this discussion is the idea of 'probability space'. This term is proposed by Adams and Dormans (2012: 26) precisely in the argumentation in favour of Juul's notion of emergence in games, but in fact it can be used in contraposition to it. It is a notion that refers to how open the possibilities are in a given system state to achieve different configurations in the future. Probability spaces are wide when many different states can be reached from the current state, and deep when many different states can be reached after a series of changes. Applied to Juul's categorization, this means that "the shape of the probability space generated by typical mechanics of emergence and mechanics of progression is quite different. Games of emergence have a probability space that is large and wide, because the game presents players with many options, and the game's direction is often subject to factors outside the player's direct control (such as die-rolling). In contrast, the probability space of games of progression tends to be small but deep." (Adams and Dormans, 2012: 38).

The aforementioned distinction between games and puzzles, and the underlying use of dynamic systems theory, comes in handy to further elaborate on this. The dynamics-based indetermination that Karhulahti proposes as the basis to understand the challenges of games is an excellent framework to understand the openness that is being discussed here (Karhulahti, 2013; 2015). While the puzzle is essentially closed from this point of view, the game is open, indeterminate (in various degrees) and thus unpredictable and dynamic. In other words, different possibilities are open at the same time (there is a wide probability space in regard to possible outcomes of a game state), which is precisely what makes these challenges engaging. However, this openness doesn't necessarily lead to the appearance of emergent phenomena. It is again a necessary, but not sufficient condition. And while there is an argument to be made that Karhulahti's dynamics present a very solid account of the idea of openness discussed here, keeping emergence as a separate concept, and thus maintaining the triad of the closed, open (or dynamic) and emergent, is a more fruitful approach.

4.4 Emergent novelty

The second type of emergence is that which relates to novelty, and here GoL is again illustrative to the debate. Salen and Zimmerman explain how GoL's extremely simple rules produce "strikingly unexpected patterns" (Salen and Zimmerman, 2004: 162). The problem here is: unexpected to whom, or in respect to what exactly? A particular pattern of GoL can indeed be unexpected to the eye of the inexperienced observer, but once it has been seen it ceases to be surprising. The same argument is valid for a new pattern discovered by an expert.

As said above, emergence-relative-to-a-model is an attempt to articulate a discourse on emergence and novelty that does not rely on the subjective realm, such as the notions of surprise, unexpectedness or awe do. And ERTM fits in fact very well with the systemic view of game design deployed by Juul, Salen and Zimmerman or Adams and Dormans. It is about describing system states and transitions and anticipating future system states in regard to these. Within that framework, a newly discovered structure or pattern in GoL is emergent because it is new in respect to the model; i.e. it couldn't have been anticipated by the predicted system states and system transitions. However, once incorporated into the model, it ceases to be emergent, as it is no longer new.

Similarly, the above-mentioned *SimCity Buildit* 10 donut pattern can be understood under this framework. As a local strategy (generate large amounts of trading in order to get SimCash awards faster), it will only be developed by a player with some degree of familiarity with the game. Besides the fact that some unlocks in the game are a prerequisite of it (i.e. trading and the manufacturing of donuts), the SimCash bonuses are unlikely to be a goal that an early player pursues. It is at the moment where the strategy is discovered and implemented that it is emergent, only to be then incorporated into the player's model of the game. In terms of novelty in respect to the game designers, it depends on whether or not the designers of SCB did or did not anticipate such patterns of behaviours from their players. If they did not, then it is a case of ERTM.

4.4.1 Relative to the model player

The main problem of using the ERTM framework in the gaming context is that, when referring to human players and not to abstract percept-action systems like the original formulation does, we run into the issue of subjectivity and intent. First, what is new to a player is not something that can be easily accounted for, much less scientifically communicated in the terms established by ERTM. Furthermore, this becomes even more complicated when we think about it from the designer's point of view. By definition, emergence cannot be designed. Only the conditions for its appearance can be. Thus, when designing for emergent systems, one sets up the system that allows for a big enough space of possibility and hopes that emergence will occur. This is why it found such a fertile ground in the computer simulations that drove artificial life.

From this perspective, there is a figure that has been used by games researchers that can be a valid construct to understand how the design of games can relate to emergence: the model player. The idea, taken from Eco's model reader (Eco, 1981), was introduced by Gonzalo Frasca (Frasca, 2001), and was further developed to discuss the figure of the ideal player that a designer of a game anticipates to be playing (see e.g. Lee, 2003; Ferri, 2007, Pérez-Latorre, 2010, 2013; Genvo, 2014; Pérez-Latorre, Oliva & Besalú, 2016).

According to Pérez-Latorre, the model player is in fact a designed player, and it is actually a conceptual crossover of Eco's interpretative semiotics' model reader and the rational player of games research. It is strongly related to the idea of gameplay, as it represents the person that would engage in the game. The model player is the abstraction of the actual player (the empirical player) for whom the game is being designed, and it allows designers to have expectations about how it will engage with the game, anticipate what will be challenging, etc. This means that, to understand videogames, we must "think of the player not as an empirical player but as a 'model player', which implicitly means that we must regard the game experience not as the general experience of playing but as 'designed play experience' (i.e. gameplay)"[4] (Pérez-Latorre, 2010).

Thus, the model player becomes here a conceptual construct of the recipient of the experience. The designer of the game is not actually dealing with the empirical player necessarily but with this abstraction of it. And, arguably, it is from this point of view that emergent novelty can be conceptualized, and the conditions for it to occur designed and anticipated in the game design context.

Of course, the actual practices of game design do break this abstraction: the iterative design process, which involves trying out the game again and again deals with the empirical players directly, and is thus a confrontation with the subjectivities and particular circumstances of the player. It does offer an approximation, since the players would ideally be chosen within a target audience, but it is far from being a construct.

In any case, it is for the model player for whom the game creator can specifically design novelty, and expect that it will appear as emergent. Taking yet another leap into abstraction, we can use Don Norman's mental model of interface design (Norman, 1988). The idea is that, when facing an interface, the user will form a mental image of it (in a nutshell, what it can do and how it does it). If this mental model matches that of the designer of the interface, then the designer has been successful in communicating what the system can do and how. If not, the user will be surprised by the system, but not in a positive way in this case.

We can, here, conceptualize the game or, rather, the expected gameplay, as an equivalent to Norman's mental model. The game designer can expect the model player to form a mental image of what the game can do and how he or she has to go about the game in order to achieve the desired goals. There has to be a successful relation between this mental image and what the designer has anticipated, just like in Norman's interface design guidelines. However, if emergence is a desired outcome, there can be unanticipated mechanics, responses, etc. that will surprise the model player.

Through this construct, the fact that each and every one of the empirical players is or isn't surprised, while obviously important when playing, becomes irrelevant from the design point of view. The designer is here, in fact, engaging in a second order design effort through which he or she is relating to the expectations of the model player, which are indeed part of the design effort, as acknowledged by Pérez-Latorre.

CONCLUSIONS

As noted by Juul and other game researchers, some game structures afford wide probability spaces, and are thus of unpredictable outcome. Replaying such games is appealing to players precisely because of that. No *Pong* gameplay is perceived to be exactly the same as a previous one, while repeating to play *Maniac Mansion* can feel indeed like a déjà-vu.

However, the argument here is that it is useful to use the term 'open' and the notion of wide and deep probability spaces in order to characterize these type of structures in games, while leaving the term 'emergence' to account for something else. The aim of this proposal is to enrich the terminology in game design by adding at third element to the dichotomy of the open/closed or emergent/progressive. Doing this can help us account for (1) self-organizing phenomena in digital games where a number of agents (human or artificial) interact with each other at one level without interferences, and these interactions produce patterns at a superior level that can be observed and (2) for novelty within games in two ways. First, concerning the account for novelty during the game design process. The idea is not new: iterative design, which is universally recognized to be the basic game design strategy, is just that. It essentially works under an equivalent paradigm to that of emergence-relative-to-a-model (ERTM): a known systemic structure is tested, and as some new features are discovered, they are incorporated into the model of the system so they cease to be new (or the system is fine tuned to avoid them if undesirable). Second, once the game is released, new strategies, mechanics, etc. might appear that, if unpredicted by the game designers, would fit into the ERTM paradigm if we understand that the 'model' is that of the designer (Smith's emergent gameplay). They can also be new to the players, but only for so long, until they are incorporated into the general knowledge of how the game works. Along with this, the introduction of the model player into the discourse allows for designers to anticipate emergent novelty for the (model) players, and thus to introduce this idea in the process of design.

Therefore, separating the notions of open and emergent widens the discourse on game design, while conflating them precludes a useful theory of emergence to be developed in the parameters of game studies. As said above, the proposed approach is presented with the understanding that it is more fruitful to separate the closed, the open and the emergent in the study of games.

Endnotes

[1] The fact that the typology itself is presented as open-ended is very interesting from the point of view of ERTM, as it helps capture the essence of Cariani's idea and how it understands emergence -- that is, emergence as novelty. If we accept that Elverdam and Aarseth's typology is complete enough, we can consider it to be the model through which we analyze games in general. Then, if something new, unexpected, is observed in a game -- i.e. something that is not covered by any of the model's metacategories and dimensions -- then this something is emergent relative to the model. Consequently, we modify the model in order to incorporate the observed novelty, that from that moment on ceases to be new.

[2] Interestingly, earlier in the book the author points out that there is a fundamental question of "whether a system capable of producing emergent behavior based on an initial state and a se to of generative rules should be considered as semiotic system at all" (Aarseth, 1997: 30). This connects to the discussion below on intentionality in self-organization emergence in games, which questions the phenomenon

as such when a player is knowingly affecting the system states in order to achieve the desired output (i.e. future states).

[3] Strong emergence is a problematic concept in the philosophic discourses on emergence. Mark Bedau has in fact argued that it should be situated outside of the scientific domain: "strong emergence starts where scientific explanation ends" (Bedau, 2008). In contrast, Assad and Packard (2008), similarly to Fromm, situate it at the end of a scale that starts with weak emergence. Fromm advocates for it and argues that it is useful to account for no less than the origin of culture and of life itself.

[4] Original citation in Spanish: "La consideración del jugador no como jugador empírico sino como 'jugador modelo'; lo cual lleva implícita la consideración de la experiencia de juego no como experiencia de juego en general ('*play*') sino como 'experiencia de juego diseñada' ('*gameplay*')."

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