Engineering emergence: applied theory for game design
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It seems that perfection is reached not when there is nothing left to add, but when there is nothing left to take away.
Antoine de Saint-Exupéry (1939)

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Rules, Representation and Realism

Within the entertainment game industry, much effort is spent on making games more realistic. Game productions get bigger every year as graphics, physics modeling and artificial intelligence take huge strides to ever more realistic simulations. Although these developments advance our understanding of the medium of games, few developers show an active interest in alternative approaches to games. Certain type of games, such as serious games, suffer from this trend. Compared to other educational media, serious games are already quite expensive to produce. If the players and producers of these games expect a level of realistic sophistication that approaches the level found in triple-A titles these games will fail to keep up.

This chapter presents an alternative perspective on games that breaks away from realism and investigates games as a form of abstract, non-realistic, and rule-based representation. From this perspective, the strength of games does not lie in the accurate modeling of fantasy worlds but in capturing complex systems with relative simple rules, while still retaining the overall dynamic behavior of the original system a game is trying to model. In this chapter I argue that games, as rule-based systems, are excellent vehicles for knowledge, learning and entertainment, irrespective to whether these games have been created for fun or education. Even if they are not created with photo-realistic assets, detailed physics simulations and multi-million dollar budgets.

Games constitute a new form of rule-based representation that is fundamentally different from static representation through non-interactive text, images and sounds. According to Rune Klevjer, simulation is a form of procedural representation; simulation represents rules instead of events (2002). Gonzalo Frasca classifies simulation as an alternative to narrative or representation (2003, 223). Ian Bogost picks up on Frasca’s work when he defines simulation as follows: “A simulation is a representation of a source system via a less complex system that informs the user’s understanding of the source system” (2006, 98).

This link between games, rules and simulation is especially clear in the con-

\[\text{This chapter also appeared in a slightly altered form as a journal article for Simulation & Gaming (Dormans, 2011a).}\]
temporary focus on realism found in many modern games. Over the years games have grown increasingly more realistic. The power of modern computers allows us to render nearly photo-realistic images in real time; the visual and auditory qualities of games quickly approach the quality found in cinema. Games often refer to elements recognizable from real life: real cars, real environments, real weapons. Games that look and feel realistic sell well. In some cases the reality a game refers to is purely fictional. Games set in the Star Wars universe depict many things that are not real, but still the players have a clear idea what a Star Wars game should look, sound and feel like. Much industry research is aimed at making games more realistic. Realism features prominently in the “top ten hurdles facing game designers today” published on the website of the magazine Popular Science. All are concerned with the accurate and realistic simulation of real-life phenomena. Getting water and fire effects right made that list, as did realistic movement, rendering human faces and artificial intelligence designed to capture realistic behavior (Ward et al., 2007).

On the other hand, in certain circles of game critics and scholars, it is in vogue to point out that realism is not what games are about. Steven Poole’s Trigger Happy deconstructs the supposed realism of games. He argues that most players play games because they allow them to do things that cannot be done in reality. A thoroughly realistic race game, for example, would require a player to undergo thorough training before he can even try to complete a single round on a racing circuit. A game that is totally realistic ceases to be a game (Poole, 2000, 77). He concludes: “videogames will become more interesting artistically if they abandon thoughts of recreating something that looks like the ‘real’ world and try instead to invent utterly novel ones that work in amazing but consistent ways” (Poole, 2000, 240).

The sentiment that games are different from realistic and accurate simulations can already be found in the early work of Chris Crawford who states:

“accuracy is the sine qua non of simulations; clarity the sine qua non of games. A simulation bears the same relationship to a game that a technical drawing bears to a painting. A game is not merely a small simulation lacking the degree of detail that a simulation possesses; a game deliberately suppresses detail to accentuate the broader message that the designer wishes to present. Where a simulation is detailed a game is stylised” (1984, 9).

Jesper Juul also points out that: “games are often stylized simulations; developed not just for fidelity to their source domain, but for aesthetic purposes. These are adaptations of elements of the real world. The simulation is oriented toward the perceived interesting aspects of soccer, tennis or being a criminal in a contemporary city” (2005, 172). Games allow us to do things not available to us in real life, and it is rules that grant us this power, as long as the player follows them. However, rules create both limitations and affordances. Without

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2The paintings that are most stylized are modern paintings that strive to capture the essence of that which they depict through non-realistic means. I assume that Crawford is referring to this type of paintings.
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rules, games would have little structure and actions would have little meaning (Juul, 2005, 58). It is for similar reasons that I linked rules to agency in a study on pen-and-paper role-playing games, even though many avid role-players tend to downplay the importance of rules in favor for interactive play-acting. In a pen-and-paper role-playing game the rules form an interface with the fictional world, and it is through rules that players can affect that world; game rules create agency (Dormans, 2006b). When looking at a game it is more important to look at what rules allow, instead of how they limit the player (cf. Wardrip-Fruin et al., 2009). Pressing the jump button in a Super Mario Bros. game has the satisfactory effect of making the on-screen avatar jump way beyond the capabilities of any human being. Game rules amplify our own abilities and allow us to explore strategies or tactics in artificial conflict that would be dangerous, destructive, impractical or impossible in real life.

2.1 The Iconic Fallacy

Ian Bogost’s definition of a simulation as: “a representation of a source system via a less complex system that informs the user’s understanding of the source system” (2006, 98) closely resembles the semiotic triparte model of the sign drafted by Charles S. Peirce. This resemblance provides an opportunity to investigate realism in games from a different, semiotic perspective. This perspective reveals that the current trend towards realism games is preoccupied with only a small subset of possible forms: iconic forms. At the same time, Peirce’s semiotic theory also suggest where to look in order to explore games and rules beyond realism.

In Peirce’s triparte model a sign is connected to an object: that what the sign represents, and an interpretant: the mental concept the sign invokes; which “is neither an interpreter nor a user of signs” (Kim, 1996, 12). This model of the sign is best known for the classification of signs into icons, indexes, and symbols. This classification is based on the nature of the relation between the sign and its object: when a sign resembles its object it is an icon, when the sign has an existential connection to its object it is an index, and when the connection is arbitrary it is a symbol (Kim, 1996, 19-21). Figure 2.1 combines Bogost’s definition of simulation with Peirce’s model of the sign.

If games and simulation are forms of representation, then the same categories of relations between their form (simulation) and that what they represent (source system) apply to games. This perspective dictates that games, like any form of representation, always signify something outside the game. This is true even for games that are created for the purpose of entertainment only. No matter

\[ \text{Figure 2.1: Triparte model of signs and simulation.} \]
how much the “poetic function” (Jakobson, 1960) of an entertainment game calls attention to its representational form, it still is a form of communication that does refer to many meaningful and recognizable elements outside the game. Cultural interpretations of relative simple and abstract entertainment games like **Pac-Man** (Poole, 2000, 178-183) or **Tetris** (Murray, 1997, 143-144) have been made, and even though these interpretations are sometimes quite far fetched, the point is that, like any form of art, no game exists within a social and cultural vacuum. As David Myers points out: “human play as a cognitive and symbolic act that is fundamental to the human representational process” (1999a, 486).

In this semiotic model of games and simulation realism and iconicity are linked. We call a simulation realistic when the simulation (as a system) closely resembles the source system; we call a simulation realistic when it is iconic. From this analogy two other forms of simulation suggest themselves: indexical and symbolic simulation. If games are ultimately not realistic, then indexical and symbolic simulation might be interesting notions to help us understand games better. As we will see in the next two sections, constructions that we could call indexical or symbolic have been used in games to great effect.

Before exploring indexical and symbolic simulations I would like to push the analogy between linguistic signs and simulation one step further to make apparent an interesting discrepancy between the current focus on iconic games and the highly symbolic nature of language. Natural language is by its nature very abstract, not realistic; most words do not resemble what they stand for. And it is the abstract nature of language that contributes to language’s great expressiveness. This notion can be traced back a long time. It was already apparent in the works of seventeenth century philosopher John Locke who observed:

“Men making abstract Ideas, and settling them in their Minds with names annexed to them, do thereby enable themselves to consider Things, and discourse them, as it were in bundles, for the easier and readier improvement, and communication of their Knowledge, which would advance but slowly were their words and thoughts confined only to Particulars” (Locke, 1975, 420).

It is on similar grounds that, roughly a century later, the philosopher Edmund Burke attaches greater aesthetic power to poetry than to the realistic paintings of his age. Poets use words to “obscure” the image they try to get across. Paradoxically, this leads to a mental image that is more vivid and evocative than painting a complete and detailed picture of the same thing (Burke, 1990, 55). These days the development of abstract art has changed all this and has increased the expressive power of the image dramatically, as is exemplified by the names used by art history to identify particular genres: Impressionism, Expressionism, Abstract Expressionism, etcetera.

Ferdinand de Saussure identifies the arbitrary character of the linguistic signs as their principal characteristic. Although he does not rule out the possibility of non-arbitrary signs, he argues that in human languages most signs are arbitrarily linked to their meaning. There are usually no characteristics of what we are referring to that are connected to the words we use (de Saussure, 1983, 67-69). In
other words, language consists mostly of symbols; there are only a few linguistic icons and indexes. For Saussure too, it is the human faculty to construct a “system of distinct signs corresponding to distinct ideas” that makes language possible (de Saussure, 1983, 10). Through the human capability to take abstract meanings and handle them in bundles, human expression and understanding is taken beyond the level of particular things and into the realm of general knowledge. In other words, abstract, non-iconic presentations contain more expressive and representational power than realistic or iconic representations.

Ian Bogost’s definition of simulation quoted above is not complete. Bogost emphasizes that subjectivity is inherent to simulation: “A simulation is a representation of a source system via a less complex system that informs the user’s understanding of the source system in a subjective way” (Bogost, 2006, 98). In a simulation a system is represented through another system and the choices made in the construction of the second system reflect the values of its creator: “no simulation can escape some ideological context” (Bogost, 2006, 99). As Bogost insists, this subjectivity can be partly attributed to the fact that with simulation the simulating system is by necessity less complex than its source system. A simulating system always deviates from its source system and the choices made in that deviation reflect the understanding and/or ideology of the person or group that created the simulation. What Bogost exactly means with ‘less complex’ is not made explicit. Here, I interpret ‘less complex’ as ‘consisting of fewer parts’. The number of parts in a simulation is usually lower than the number of their counterparts in the source system. This also means that in most cases those parts are abstractions of more complex subsystems in the source system. For example the parts that make up a simulated weather system bundle many actual air-molecules that make up real weather. This makes the simulation more convenient to handle, or to paraphrase Locke: it enables us to consider the multitude of parts of a simulated system in bundles for easier and readier understanding, and for easier and readier communication and improvement of that understanding.

Thus, there always exists a gap between a simulated system and its simulation, and that gap always renders the simulation subjective to a lesser or greater extent. However, this subjectivity is the price we pay for the convenience and enhanced understanding that subjective simulations allow. In most cases the gain in expressive power outweighs the loss in resemblance to particular instances.

When one considers a simulation as essentially subjective, it is worth noting that any claim to realism becomes an ideological maneuver in itself. For example, the high level of verisimilitude in AMERICA’S ARMY can be read as the rhetoric claim that its apparent realism and correctness in visual representation can be extended into the ideological domain: ‘the game got its physics right, so its ethical claims must be realistic, too’ (Bogost, 2007, 78). On the other hand, in commercial entertainment games realism is often rendered as a special effect. In these games realism and authenticity becomes a spectacle designed to impress and to be appreciated by the audience. Realism, with its high poly-count, plasma effects and particle engines, is foregrounded and hyperreal. Or to use the words with which Geoff King described a very similar phenomenon in blockbuster films:
it is “the hyperrealistic spectacle-of-authenticity rather than authenticity itself” (King, 2000, 136).

### 2.2 Indexical Simulation

To start looking beyond iconic simulation, the notions of indexical and symbolic simulation are obvious points of departure. In this section I will discuss the first notion, in the next section I will discuss the second. The ‘inventory system’ that first occurred in Diablo and that has since featured in many other games can be seen as an example of the first. It inspired Warren Spector, developer of Deus Ex, into saying that: “Diablo got Inventory right. There’s no sense messing with something that works...”.

For quite some years now, many computer games have included an ‘inventory’: the game allows the main character to pick up objects and carry them around. The player can manage these objects in the game’s inventory screen. Most games restrict the number of objects the character can carry in some way. There might be a fixed number of objects the character can pick up, or all the game objects might have a weight value attached to it and the character can only carry objects up to a particular load.

Diablo’s inventory system takes object size as its main restricting factor (see figure 2.2). Each item takes up a number of inventory ‘slots’, the available slots are limited and organized in a grid. An item may take up 1x1, 2x2 or 1x4 slots for example. Depending on the available room in the inventory an object can be picked up or not. The upper half of the screen is dedicated to the objects the main character currently has equipped.

I argue that this is an example of indexical representation in games. The main restricting factors for somebody to carry objects in real life (shape, size and weight) are represented by easily understandable two-dimensional shapes.

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3 Quoted on S. T. Lavavej’s Deus Ex webpage. URL: [http://nuwen.net/dx.html](http://nuwen.net/dx.html) (last visited June 23, 2011). However, it must be said that opinions on this system differ; not everyone is as enthusiastic as Warren Spector (see for example Adams & Rollings, 2007, 516-518). Whether it is a good design decision to burden players with the upkeep of their inventory depends on the type of game and intended gameplay.
shapes and their relative size can be said to be existentially connected to the size and weight of their simulated counterparts. Therefore the simulation qualifies as an indexical construction as it is parallel to indexical signs in which the relation between the sign and its object is also based on an existential connection (rather than resemblance or arbitrary convention).

The number of games that have copied this system in one form or another is a testimony to the quality of this construction. The internal rules and constraints are immediately apparent (not in the least because they are tailored towards visual representation on a screen). The management problems the system gives rise to are very much like those problems in real life. The system even allows players to make an inefficient mess of their inventory, teaching them something about the need to organize themselves.

What the Diablo inventory system does very effectively is to take many related and similar functioning game rules and replace them all by a single mechanism that is well suited to the medium of the video game. Obviously some accuracy of simulation is lost (an item cannot be large and light at the same time), but the overall behavior is retained (the players are limited in what they can carry). The cleverness of the Diablo inventory is that it collapses all the nuances of managing an inventory into a problem of size, which is easily represented by a computer screen, instead of weight which was the more common choice before, but which translate to the visual medium of the computer less well.

Another example of indexical simulation is the way most games handle ‘health’. Health of characters and units is often represented by a simple metric, be it a percentage or a number of ‘hit points’. Obviously in real life the physical health of a person or the structural condition of a vehicle is a complex matter to which many different aspects contribute. By using a generic health for a single character games bundle all these aspects into one convenient mechanism. Both players and computers can easily work and understand the numerical metric to represent the bundle.

2.3 Symbolic Simulation

Symbolic simulation goes one step further in breaking away from modeling a system with rules that closely resemble the mechanisms of the source system. The use of dice in many board games tends to be symbolic. For example, the roll of a few dice can stand for a complete battle in a game of Risk. In this case, the relation between rolling dice and fighting is arbitrary, and one simple action well-known from other games is used to simulate a multitude of actions for which most players would lack expertise. Dice can replace these battles because, for the purpose of the game, as the player should have little influence over the outcome of these battles. Risk is about global strategy, not about tactical maneuvers on the field of battle. A player cannot control the result of dice (not without cheating anyway) just as a supreme army commander cannot win every battle personally. Yet, the player needs some sort of influence and the rules tie in with the dice rolling: committing more armies to a battle allows to player to roll more dice and improve chances for success. Something similar
Dice are wonderful devices to create a nondeterministic effect without the need of detailed rules. From a suitable high level of abstraction, a complex and nondeterministic system, such as fighting, has a similar effects as rolling a few dice. Especially when the player is not supposed to have much influence over this system, dice mechanics can be used to replace the more complex system. The characteristic randomness of different dice mechanics can be used to match many superficial, nondeterministic patterns created by more complex systems. Pen-and-paper role-playing games have come up with many clever and interesting ways of using dice, allowing more or less influence by the player. In fact, dice mechanics related to a set of characteristics representing skills and attributes forms the core of most pen-and-paper role-playing systems. Often the same mechanism is used to represent a wide variety of actions.

Other examples, such as jumping on top of enemies in order to dispose them in the classic video game SUPER MARIO BROS. fall somewhere in between symbolic and indexical forms of simulation (see figure 2.4). Although the precise implementation differs from enemy to enemy, and certainly does not work against all enemies, it is a frequent feature throughout the game and the series it belongs to. It is unlikely that I am the first to point out that this method is a little odd, to say the least. However, it has become a convention within platform games that is instantly recognizable to gamers, and ties in with that genre’s defining action of jumping from platform to platform.

The connection between jumping on top of something and defeating something in real life is not completely arbitrary, but its use in platform games has become so conventional it parallels the definition of a symbolic sign in language. In the real world, there are creatures that can be squashed by jumping on top of
them. However, there is no creature that I know of that is lethal when bumped into, but not when stepped upon, which makes this exact mechanism somewhat arbitrary.\textsuperscript{4} What is more, this method of fighting in \textit{Super Mario Bros.} is motivated more by the use of the genre’s most prominent action of jumping, than it is motivated by any claim to realism. The link between the simulation and what is simulated is both arbitrary and conventional. Especially in the multitude of platform games that followed the example set by \textit{Super Mario Bros.}

There is, however, an affinity between the skills needed to defeat enemies in \textit{Super Mario Bros.} and in real life. In the game, it requires timing and accuracy, which are among the skills involved in real fighting. The point is, the simple representation in the game allows us to do more than to hone and train those skills. The simple metaphor of jumping on top of enemies is easy to grasp by the player, but the game then goes on by inviting the player to experiment and develop strategies. In most platform games each level ends with a ‘boss’ enemy which is typically designed to test the effectiveness of players’ strategy. It is the ultimate test for the players to demonstrate they understand and have mastered the simulation, and are able to combine different moves.\textsuperscript{5}

What the jumping on enemies mechanism accomplishes is a very clever way of adding combat rules to a jumping game; it introduces no new actions for the player. It manages to do this by replacing actions it tries to represent by other, arbitrary rules already implemented in the game. This reduces the number of actions players need to learn, allowing players to quickly move on to a deeper, more tactical or strategical interaction with the game instead of fussing around with its interface. As is argued below, symbolic simulation effectively reduces the system to a simpler construction with more or less equivalent dynamic behavior.

\section*{2.4 Less Is More}

Indexical and symbolic simulation tend to create simpler game systems than iconic simulation. The reduction in rules these forms of simulation allow is in general benevolent. Simpler games are easier to learn, yet they still can be quite difficult to master. Games are not the only medium for which the expression ‘less is more’ rings true. In almost any form of representational art, saying more with less means is appreciated, especially by critics and connoisseurs. Christopher Alexander, drawing inspiration from poetry for his pattern language for architecture and design puts it like this:

\begin{quote}
“This language, like English, can be a medium for prose, or a medium for poetry. The difference between prose and poetry is not that different languages are used, but that the same language is used differently.”
\end{quote}

\textsuperscript{4}Even if such creatures do exist, they are certainly are not tortoises.

\textsuperscript{5}These lessons carry over to situations beyond the game. The mentality of the players that have learned these lessons is excellently described by John Beck and Mitchell Wade: they know that solutions will eventually present themselves, and they have mastered a trial and error approach to many problems in life (2004, 11-14).
In an ordinary English sentence, each word has one meaning, and the sentence too, has one simple meaning. In a poem, the meaning is far more dense. Each word carries several meanings; and the sentence as a whole carries an enormous density of interlocking meanings, which together illuminate the whole.” (Alexander et al., 1977, xli)

And:

“It is essential then, once you have learned to use the language, that you pay attention to the possibility of compressing the many patterns which you put together, in the smallest possible space. You may think of this process of compressing patterns, as a way to make the cheapest possible building which has the necessary patterns in it. It is, also, the only way of using a pattern language to make buildings which are poems.” (Alexander et al., 1977, xlv)

For poetic language, or rather for any form of representation art, this quality is very important and does not stem from the use of abstract signs only. The combination and structure of these signs, or to use the linguistic term, syntactical relations between these signs also play an important role. In this light, Noam Chomsky observed that language allows speakers to make infinite use of finite means: the number of words we have may be limited (and is vastly outnumbered by particular things in reality), the number of combinations we can make with them is infinite (Chomsky, 1972, 17). This characteristic of language is often called discrete infinity.

It is impossible to exactly quantify how many rules a game should have; it is impossible to quantify how much less is how much more. Each individual design has its own balance. A particular number of rules could be too few for one game and too many for another. The balance a game should seek to strike is between the number of gameplay options the rules create on the one hand and the cognitive burden it requires to understand or operate those rules on the other. Antoine de Saint-Exupéry’s famous quote “it seems that perfection is reached not when there is nothing left to add, but when there is nothing left to take away” (1939) applies extremely very well to games.

In general, games are very good at creating endless possibilities with only a few rules. It is estimated that there are more possible game states in games like Chess and Go than there are atoms on earth (see Shannon, 1950). It is the rules of the game that determine the number possible states, but it is not necessarily true that more rules will lead to more possible states. In addition, when a game can create a large number of possible states without using many rules, the game will be more accessible.

Possible game states and trajectories through a games state space are emergent properties of the game rule system. The elusive notion of gameplay is related to these properties. Games that allow many interesting trajectories arguably have more gameplay than games that generate fewer trajectories or less interesting ones. However, determining the type and quality of the gameplay is hard, if not impossible, by simply looking at the rules. Comparing the rules
of Tic-Tac-Toe and Connect Four serves as a good illustration of these difficulties. The rules for Tic-Tac-Toe are:

1. The game is played on a three by three grid.
2. The players take turns to occupy a square.
3. A square can only be occupied once.
4. The first player to occupy three squares in a row (orthogonally or diagonally) wins.

The rules for Connect Four are (with the differences emphasized):

1. The game is played on a seven by six grid.
2. The players take turns to occupy a square.
3. A square can only be occupied once.
4. Only the bottom most unoccupied square in a given column can be occupied.
5. The first player to occupy four squares in a row (orthogonally or diagonally) wins.

While the differences in rules for these two games are only a few, the differences in gameplay are immense. Far larger than the difference in cognitive effort needed to understand the rules. In the commercially available version of Connect Four, the most complicated rule (number 4) is enforced by gravity: a player’s token will automatically fall to the lowest available space in the upright playing area (see figure 2.5). This relieves players from manually enforcing this rule and allows them to focus on the rules effects instead. Despite the small difference in the complexity of the rules, Tic-Tac-Toe is suited only for small children, whereas Connect Four can also be enjoyed by adults. The latter
game allows many different strategies and it takes a considerable longer time to master the game. When two experienced players play the game, it will be an exciting match, instead of a certain draw as is the case with Tic-Tac-Toe. It is hard to explain these differences just by looking at the differences in the rules.

These days, emergence of complex behavior from relatively simple elements is an important aspect of many fields of research in the domains of mathematics, physics and social sciences. In the research of games, too, emergence is becoming an increasingly important notion. From the computational side, emergence is an important technique used in anything from development of artificial intelligence to the realistic rendering of water and fire. For Penelope Sweetser the disadvantageous loss of creative control in a system that is set up for emergence is outweighed by the more consistent and intuitive player interactions such systems allow (Sweetser, 2006, 14). Likewise, game designer Harvey Smith argues that attempting to design a totally controlled game environment that allows rich interaction is no longer economically viable, as the sheer amount of detail cannot be efficiently produced manually (Smith, 2001).

One major advantage of games that feature emergent gameplay is that a rule-system allows, and often even invites, players to experiment with the game, instead of merely repeating the moves a game designer intended. Ultimately emergent games allow the transformation of the game rules itself (Myers, 1999b). This has severe consequences when building an educational game, but also when the game designer has a particular story or message in mind. For Jan Klabbers it is the responsibility of the game designer to shape the whole of the game system in such a way that behavior that conforms the design specifications emerges from its components. At the same time, the system should leave enough freedom for players to act according to their own strategies, goals and incentives, in order to elevate the position of the player into that of a reflexive actor. This is “one of the major bottle necks in the design” (Klabbers, 2006, 102).

However, in some ways, computer games seem to be moving against the trend of emergence. Jesper Juul differentiates “games of progression” from “games of emergence” as a historical newer category associated with computer games. The rise of computer games, and adventure games in particular, has made games of progression possible, as without a computer the amount of data and the number of special case rules facilitating the progression through a multitude of game spaces would have become unwieldy (Juul, 2005, 5).

Chris Crawford’s notions of data intensity and process intensity (Crawford, 2003a, 89-92) can be pitted against Juul’s observation that games of progression are a younger form and the implication that progression is the result of a natural evolution of the medium. Crawford argues that computers are both suited to handle large amounts of data and crunch vast quantities of numbers, but it is the latter ability that sets computers apart from most other media. Handling data is something that all media are good at. The computer often allows faster access to remote locations within the data, an ability put to good use within hypertext (Lister et al., 2003, 23-30). However, it is the ability to create new content on the fly where the computer really shines. Like no other medium before, the computer has the capacity to surprise players and designers alike (see also Smith, 2001).
For Chris Crawford, games should capitalize on this ability of the computer, games should be process-intensive, rather than data-intensive. In other words, games should be games of emergence rather than games of progression.

2.5 Designing Emergence

Designing emergence is a notoriously hard, somewhat paradoxical, task. Emergent properties of a system only surface when a system is put into motion. Even when a system behaves in a certain way during all test, there is no guarantee it will do so all the time. In this light the realistic fallacy seems to be a fairly conservative strategy to avoid the difficulties of designing truly emergent games: that have relative simple systems and display interesting, complex behavior. Simply adding more, and more detailed rules is only a poor substitute for creating complex gameplay through a lean and elegant rule system.

Emergence can be the result of relatively simple rules, therefore games do not need to rely on complex rule systems in order to create interesting gameplay. On the contrary, using simple means to generate complex gameplay has many advantages. The design becomes easier to manage for the designer, and the game becomes easier to learn for the player. In the examples of non-iconic simulation above (DIABLO’s inventory, the use of hit points, dice in KRIEGSPIEL and jumping in SUPER MARIO BROS.), the use of indexical and symbolic simulation resulted in a simpler rule system than an iconic simulation would have. This is not a characteristic of the examples discussed above, rather it is the advantage of using non-iconic rules in games. Compared to a completely detailed, realistic system that tries to simulate through accurate detail, indexical and symbolic simulation aims to capture the essence of the source system with fewer means. When done correctly, the result is a leaner, more elegant system that minimizes on parts and maximizes on expressiveness.

In essence, indexical simulation bundles a number of related and more or less isomorphic rules into one game mechanism. Symbolic simulation goes one step further, it connects rules in the game where they would not be connected directly in the source system. As in the use of symbols in language, there are symbols that work better than others. The symbols that work best seem to connect two unrelated rules that still have some affinity between them. In the case of SUPER MARIO BROS. there is a natural affinity between the physical skill and timing involved in both jumping and fighting (also see Lakoff, 1987, 448).

The development of the serious board game GET H2O, in which I took part, is very good example of the application of non-iconic reduction. In this game, produced as part of an educational program for adolescents in East-Africa, the players struggle to survive in the poor residential areas of an African metropolis (see figure 2.6). The vital resources are scarce, players need to balance carefully between personal gain and community efforts. The players only have indirect influence over bad events that might happen, but sometimes players can benefit from these events, sowing the seeds for conflict. The game simulates life in an African metropolis, and is designed to give the players a top-down view of their own lives. It is designed to function as a vehicle for exploration, discussion and
Instead of trying to simulate the East-African urban life in detail, the game reduces the number of resources and rules to a relative simple set. The game uses three main resources: money, houses and clean water. The latter two determine how many actions a player can take each turn while the money is used to build more houses. These resources are under constant threat. Money and water might get stolen, houses might be burned down. In reality, an African family has many more needs, but these three resources are enough to simulate an economy of scarcity that behaves not unlike the real economy in urban African areas. The indexical nature of this simulation makes it possible to create a relatively simple system that is still recognizable for people who grow up in those areas. In fact, the game became more recognizable because it lacked detail: fewer details creates more room for personal interpretation and less chance that the game does not match the individual experience. What is more, this economy creates the particular balance between short term personal gain and long term community interests that causes social instability. Creating this instability was the prime design goal for the game. The game is supposed to train people in dealing which such a situation in the first place. Simply put, more resources and a more complex economy were not needed to replicate the volatile social system of an East-African urban sprawl.

The game also uses symbolic simulation. After every player has taken a turn, all players discard one playing card without revealing it. These cards are normally used for player actions. The discarded cards are then shuffled and revealed. Every card has a symbol representing bad things that might happen, from corruption and pollution to arson and drought. If the same symbol is played
twice the effects are aggravated: one drought symbol does nothing, but two drought symbols indicate that a drought strikes, often with devastating effects. Obviously playing cards have nothing to do with the occurrence of real droughts. The cards are a way of simulating bad events that are mostly beyond the control of the people living in an African metropolis. One that also conveniently ties in with other mechanics of the game: all players will also get a secret role which allows them to benefit from bad events such as corruption, scapegoating and arson.

When used correctly, indexical and symbolic reduction reduces the number of elements in a system without affecting its structural complexity and emergent properties too much. In the Get H2O example many similar resources that are needed on a daily basis are replaced by just one: water. The feedback structure that entails having access to these resources is pretty much unchanged. The number of feedback loops, for example, is not affected. In fact, the game emphasizes these structural features, by taking away unnecessary detail. By reducing the number of elements in a game system the cognitive burden of the player in keeping track of all these elements is also reduced, allowing the player to focus more on these features and the strategic interaction that they allow, or in the case of Get H2O, on the social implications they have.

There are more advantages. A system that uses indexical and symbolic simulation can concentrate the experience, allowing a complete session of play to run much quicker than what the play represents in real time. The player is confronted with the results of his actions fast and efficiently. It allows players to ‘handle the rules in bundles for the easier and readier improvement of their understanding of the system’. On the one hand this allows players to go through the process more often and on the other hand it will contribute to the pleasurable experience of agency and power that drives many commercial entertainment games. In the Get H2O game this was certainly one of the design goals. The game can be played in roughly forty-five minutes, allowing players to experiment with different strategies efficiently while reducing the costs of failure.

For the designer of games there are advantages, too. A game system that is reduced to its essence becomes better manageable and easier to balance. Without many parts, the designer can focus on those elements and structures that contribute directly to the game’s emergent behavior and more easily tweak that behavior into the desired shape. Games would do well to strive for non-iconic, discrete infinity rather than detailed realism. Not only is this economically more feasible, it is also more interesting artistically and it allows for more effective communication.

The Legend of Zelda series is a great example of gameplay design in which only a handful of game objects and associated rules are combined in many interesting challenges. The value of each of these objects and their rules does not stem from its power to represent some sort of realistic aspect of adventuring through a dungeon, but form a potential combination with other objects and rules. The exploration challenges, which the series is famous for, are almost always the result of combinations of simple, reusable gameplay mechanics that are often quite indexical or symbolic. For example, in the The Legend of
ZELDA: Twilight Princess the player can find the ‘gale boomerang’ in the ‘Forest Temple’ level, which creates a gust of air strong enough to activate wind-operated switches and carry small items to the player. This boomerang can be used to carry ‘bomblings’, little creatures that explode a few seconds after the player grabs him by hand or with the gale boomerang. Effective use of this combination is required to defeat the final boss in that level. The same boomerang is used in The Legend of Zelda games for the Nintendo DS, but in this case the player can use the stylus to draw the path of the boomerang quite freely, directing it around obstacles unrealistically. Players appreciate this sort of structures as they have the advantage of being inheritably coherent. And as has been pointed out before, coherence is a strong contributing factor to gameplay (Poole, 2000, 64-66). One can even argue that the appreciation of such structures is in its essence an aesthetic appreciation (Huizinga, 1997, 25). It is the appreciation of the craftsmanship of the game designer in building systems with interesting structural qualities from which interesting behavior emerges. It forces to pay attention to the way the game was constructed and how it is structured (cf. Ryan, 2001, 176).

The meaning that emerges from these games is not necessarily less detailed or less valuable than games that aim for detailed and realistic simulation. On the contrary, as the challenges of exploration in The Legend of Zelda are more abstract, the skills and knowledge the game addresses are more generic; the message of a game that is less iconic is much better applicable outside the particular settings of the game. This is especially useful when one wants to express something through a game that has value beyond the game and its immediate premise.

2.6 Conclusions

Games and simulations share a representational form: representation of source system through a system of rules. Even games that are played as a pure form of entertainment simulate something. Rule-based representation can take many different forms. Traditional simulation has accurate modeling as its main goal, whereas most games are designed to entertain. Games that aim to educate can be said to fall somewhere in between: they seek a certain level of accuracy, but generally enjoy more design freedom than simulations do. However, many games still conform to the norm of simulations; they aim to represent a source system by creating rules that resemble the rules of the source as closely and accurately as possible. This type of rule-based representation is called iconic simulation, in analogy to general semiotics.

Also in analogy with semiotics, the notions of indexical and symbolic simulation were explored as possible avenues to differentiate games from simulations. As pointed out above, the goal of a game is not the same as the goal of a simulation. Indexical simulation, where the rules of the game have some sort of causal relation with the rules of the source, and symbolic simulation, where the rules of the game are linked to the source by convention, allow for much simpler game systems. Although these systems consist of fewer rules and parts, their behavior
or meaning need not be less complex. The power of non-iconic simulation, such as games, lies not in its power to accurately model a source system or in the creation of a vast, realistic game world, rather in its efficient use of expressive game mechanics. I do not wish to claim that the potential of iconic representation has been fully explored. However, to me it is clear that much more progress can be made by developing indexical and symbolic building blocks for simulation, and, more importantly, investigate the effectiveness of particular configurations of such building blocks. Emergent behavior is more likely to originate from the interrelations of game parts than simply the parts themselves. It is the craft of the game designer to create complex systems from appropriate and simple elements. There is little art in creating complex simulation with equally complex (or worse, more complex) means. Yet this seems to be what many developers aim for.

Indexical and symbolic simulation as discussed in this chapter are suggestions to go beyond iconic simulation. They are theoretical notions that help reduce a game system to its bare minimum without affecting the structure from which the gameplay emerges too much. This allows the designer to focus on balancing the emergent behavior and provides the player with a better opportunity to explore the ludic significance, or generic knowledge, codified by the game.

Yet, to design games with emergent gameplay is by no means an easy task, even when the rules are kept simple. Emergent behavior is by definition unpredictable. A game designer’s best bet is to create many prototypes and keep testing them. But even with frequent tests, game designers have to rely on their experience and intuition to create their games. This practice can be improved by creating better tools for the job, especially design tools that acknowledge the emergent aspects of games and focus on those structural qualities that drive them. In this light, Chapter 3 will discuss previous efforts and existing design tools while Chapter 4 will present the Machinations framework as a new, alternative scheme to deal with game mechanics and structures of emergence in games.