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Evolution for games

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Abstract: *The function-focused model of biological evolution is applied to board games studies. After a brief survey on the recent framework of evolution, a comparison between biological systems and games is performed. "Life" and "death" are defined, together with the application of the concept of "random change" and "competition". When applied to games, the evolutionary model seems to robust enough.*
Keywords: Software; Rules; Mutation; Competition; Complexity

Introduction and reported evolutionary studies of games

The extension of concepts from one field of the science to another one is a powerful source of inspiration. However, these extensions must be always carefully controlled, since free analogies could lead easily to incorrect conclusions. In this respect, the concept of "evolution" has gained an increasing success from the early works in the middle of the 19th century. It has been widely applied to several processes that change over time, even in common life and in current speeches, but not always properly.

Many works focused on the production of game variants in general (Schmittberger, 1992), and Chess variants in particular (Pritchard, 1994), (Duniho, 2005), (Neto, 2005), since Chess is the abstract game that has been most studied during the centuries. However, in these works, the concept of "evolution" was not clearly stated. For example, the term "ludeme" was used by Parlett (1990), that credited it to Borvo and Berloquin (Parlett, private communication). It was modelled on the words "ludus" and "gene" and indicates the characteristic game elements, as a clear analogy with the biological gene. Neto preferred the word "mutator", that describes better the action of his operators (Neto, 2005). Furthermore, some phylogenetic maps were drawn by Eagle (1998) and Voogt (Voogt, 1999), to rationalise

the plethora of Mancala games, but some difficulties were observed. For example, these games evolved from ancestors having sometimes easier rules and sometimes more complex rules (Voogt, 1999).

Two case studies confirmed these difficulties.

(a) Race games

Race game is a typical instance of a development of an idea along the time. In these games, the winner is the player who firstly arrives to a finish line (Parlett 1999). In the oldest type of these games (*Hyena game*, or *Mehen*), pegs were moved according to the toss of some randomisation devices (dice, sticks, and so on). In the *Game of Goose*, or in *Snakes and Ladders*, eventualities could occur in some spaces of the track and alter the outcomes deriving from the simple toss of the dice. In *Ludo* and *Parcheesi*, the race game was enriched by the possibility of capturing opponent's pieces. In *Malefiz*, players had to manage (to overcome or to place) barriers. In recent games, such as *Hare and Tortoise*, *Cartagena*, or *Die Oster Insel*, the progress of the pegs was determined mainly by a strategic management of the players' resources, with marginal element of luck.

The development of these games along the centuries seems to be the limitation of randomness and the involving of the players' skill. However, nowadays *Games of Goose*, *Ludo* and *Ludo*-like games, such as *Rüssellbande*, are still commonly played, together with the other ones, that require a higher skill degree.

(b) Connection games

Hex is a connection game that was proposed independently by Hein in 1942 and by Nash some years later. It is played on a rhombic board made up of hexagons. Two players in turn put one of their pieces on an empty hexagons on the board and attempt to connect two opposite sides of the board. Complex strategies arise from these simple rules, and a general winning strategy is unknown (Browne, 2000).

Hex is the precursor of several different connection games (Browne, 2005). For example, *Bridg-It* was proposed in the early 1950s by Gale, and by Schensted and Titus. The game is topologically equivalent to the Shannon's "*Edge-Switching game*" (Browne, 2005). It was abandoned when a pairing winning strategy was found. On the other hand, an unsolved and successful connection and blocking game is *Twixt*. The *Game of Y* was proposed in the early 1950s, by the same Shannon and by Schensted and Titus.

The game is played on a triangular board tiled with hexagons, with the goal of establishing a chain that connects all three sides of the triangle (Browne, 2005). Several other games with more complex rules or more complex board patterns have been reported. Up to now, *Hex* is the most played connection games, and only *Twixt* and *Y* succeeded sometimes in challenging its success (Browne, 2005). In this case, the attempts of producing a more interesting games by introducing new and more complex features have not yielded a more successful product.

In summary, cases (a) and (b) confirmed that a more controlled definition of the term "evolution" needs to be applied to games.

A brief survey of the original biological model follows, to look for inspiration and a better application of the concept of evolution.

Evolution in living organism

In the past years, Richard Dawkins popularised a successful approach to describe phenomena that are subjected to evolution (Dawkins, 1976) (Dawkins, 1986).

The concept of evolution is applied to "living" organisms. In a simplified model, an entity can be considered living if: (i) it is able to growth as a consequence of exchanges of matter and energy with the environment; and (ii) to reproduce. This model of life is oversimplified, since it is well-known that some "living" organism (mules, or workers ants) are unable to reproduce, but it is satisfactorily complete for the present purpose. In this simplified model, life can be thought as a mix of "hardware" and "software", if terms from the computer sciences are borrowed. The hardware is the physical body. The software is the set of instructions for the correct acting and reproducing of the hardware. In the living organisms, the software is coded into the nucleic acids (DNA or RNA), that are the molecules that supervise the synthesis of the key intermediates of the biochemical process (*e.g.* proteins and enzymes).

Dawkins' description focused on the software of the living entities, discarding the complexity due to a different hardware. Hence, the focus is moved from the form to the function. In this framework, evolution is described by the occurrence of two sequential processes, mutation and competition.

Mutation

The mutation is a random change in the genetic instructions that could be caused by many different agents (errors in the transcription of the genetic material, radiation, chemical agents, and so on). Usually these mutations cause an immediate and fatal damage to the living entity. On the other hand, even if it occurs seldom, the modified software is able to survive and later to reproduce, thus yielding a son that will inherit its modified genetic material.

Competition

The old (not mutated) species and the new (mutated) one, and their respective descendants, compete in the environment for the available resources. Competition should not be thought as a bloody fight. Evolutionary competition represents merely the ability of one entity to reproduce itself more efficiently than the other ones, thus overcoming them numerically. In this framework, mutation could not be "rational", according to a naive judgement. For example, it is hard to find a rationale in the enormous tail of a peacock, a tail that exposes that specie to its predators. However, that tail is indeed the final result of the evolution, probably because it is a sexual call and it ensures many descendants to its owner.

This two steps model (mutation and competition) is difficult to accept, because the competition of biological systems occurred over many millennia, a time interval that is far beyond the common experience. Only the scientific evaluation and interpretation can disentangle the puzzles of the evidences.

If this model is accepted, the problem of arising of complex organisms as the final product of the evolution is approached from a different point of view. In fact, only complex systems reached a steady state because only systems with a high number of interacting components are able to prevent or to correct the misprints in the reproduction of its software. The need for an accuracy in the reproduction of complex, and thus slowly-mutating species, is not a contradiction with the request of mutations because, rigorously speaking, a species that underwent a mutation is different from its parent, since it owns a different software.

First extension of the evolution

The reported model answers to a large number of biological questions and it was successfully extended also to other software based systems. For example,

a virus is a borderline entity between the "living" cells and the "inanimate" macromolecules, since it carries only short ribbons of nucleic acids, surrounded by a protective jacket (the "capsid") (Villarreal, 2004). It has no exchange of matter and energy, as other living entities do. It lives as a parasite into the cells of other organisms, its only ability being the extraction of the molecules for its reproduction from its host, according to its software (Villarreal, 2004). Therefore, a virus is an almost pure software system, and fits well into Dawkins' description. Evolution of common viruses (for example the flu virus) is commonly and thoroughly investigated.

Further extensions of the evolution

The way of acting of a virus has inspired a further striking application. The pirate programs capable of reproducing, damaging and spreading from a computer to another one are called "computer viruses". Even for these programs, indeed pieces of pure software, the concepts of evolution has been appropriately applied (Kephart *et al.* 1997).

Another metaphor was introduced by the same Dawkins (Dawkins, 1976), as a middle way between a serious hypothesis and an intellectual provocation. He observed how the ideas, the scientific theories, but also the fashion and the urban legends, act as parasites of the brains and reproduce by leaping from a brain to another one. Dawkins suggested to call these ideas, that are indeed pure software, as "mental viruses", or "memes", because they reproduce as parasites of a certain host brain. Differently from a virus or a computer virus, a meme has no clear instruction about its reproduction, but this event occurs because there are some hidden acting mechanisms that are able to stimulate the host system (*i.e.* the "infected" brain) "to spread the contagion". A meme is a piece of pure software that is able only to replicate, as computer viruses usually do. As an extension of the virus metaphor, also memes dynamic has been investigated from an evolutionary point of view, even if some conclusions were questioned. In particular, meme metaphor was found to be excellent to describe existing phenomena, less useful when predictions need to be made.

In conclusion, the focus on the software of some odd systems (living entities, viruses, computer viruses) has yielded useful evolutionary studies.

Games and evolution

Could evolution for games be investigated as occurred in the previously cited systems? What are life and death for games? What are the hardware and the software of a game? What is the reproduction of a game? The answers to these questions define the modes and terms of application of the concept of biological evolution to games.

The object

It is easy to agree about the fact that a game is a mixture of hardware and software (see for example, Kramer, 2000). The board, the pegs, the dice and the other gaming equipment constitute the hardware. The set of the rules, that supervises both the correct acting and the establishment of the end, is the software. If so, the software focused framework of the evolutionary investigations prompt us to focus only on the rules of the games.

Life and death

"A game is *living* if it is played. Otherwise, it is *dead*" is a statement that can be agreed easily. The phenomenon of hybernation, as it occurs for some viruses, is nice to be added to the discussion. *Reversi* is a good instance. The game was played at the end of the 19th century and then it was forgotten for decades. Martin Gardner cited it as an interesting board game (Gardner, 1966). Only some years later, a Japanese corporation re-proposed it (with minor revisions) under the name *Othello*. Since then, this game has been one of the most popular until nowadays. The point is that hardly a 19th century game fits and survives into the current tastes. At the same time, hardly a virus, that was frozen and that returns to life, is able to survive into a mutated environment.

The causes of the "death" of a game are manifold. For example, a game is abandoned if it is clearly unbalanced toward a player (Schmittberger, 1992), or if many draws are observed (Schmittberger, 1992), as occurs for *Tic-tac-toe* on a 3x3 board. Games are abandoned also if they are solved, as occurred for *Bridg-it* or *Nim*.

Reproduction

The "reproduction" of a game can be borrowed from the meme metaphor, in which a game reproduces itself if it is able to "infect" the brain of the players and to induce them to play it and to "spread the contagion". As for

the meme metaphor, this statement describes clearly the phenomenon, but gives little help to foresee if a game will be successful.

At this stage, the main points of the evolutionary, software focused framework are checked by comparing the previous points, that were stated for the biological evolution, with the same points applied to games.

(1) A modification in the software (the rules) originates a new game

It is well-known that every modification of the rules originates a new game, that in general was indicated as a "variant" of the parent one. It must be underlined that even small mutations can have deep consequences. A striking example is the difference between the board game *Risk* and its Italian version *Risiko* (Cardellicchio and Albertarelli, 2003). In this last game, the defending player can oppose three dice to the three dice of the attacking player. It seems only a tiny advantage for the defender, but a completely different game arises from this mutation, unbalanced in favour of the defender. Therefore, the attacking player must plan accurately its moves to avoid ruinous consequences.

Another example is *Shogi*. *Shogi* is sometimes described as a mere Japanese Chess, since the purpose of the game and the movements of some of the pieces resemble those of the western Chess. However, the introduction of the rule of the dropping of the captured pieces changes deeply the strategic plans of *Shogi*.

(2) A mutation is random and could also be a not rational one

Chess is a good confirmation to this point. In the eighteenth century, two great chess-players published their works on Chess, the French Philidor and the Italian Ponziani. Rigorously speaking, they did not play the same game (Chicco and Porreca, 1971). Ponziani firmly refused the French *en-passant* capture. On the other hand, in the Italian Chess, a pawn could be promoted only to replace a piece that had been previously captured. Furthermore, "free-castling", *i.e.* the free swapping of the king and the rook to any two squares chosen by the player, was also allowed in Italy. From a "rational" point of view, it is difficult to find a rationale for an *en-passant* capture and for a player that owes two Queens, or three Bishops. However, the Philidor Chess became the established Chess (Orto-Chess, as it was sometimes called (Pritchard, 1994)) even if Ortochess is "an arbitrary object, far from being

perfect", as reminded by various scholars (Pritchard, 1994), (Schmittberger, 1992).

A criticism to point (2) is that it is difficult to accept that the creative and deliberate action of an author of games should be considered a random event. However, this criticism is only a man-centred perspective. In fact, from an evolutionary point of view, the only relevant aspect is that a novelty arises, regardless of how it was brought. A random events is the accident that sometimes occurred, as an oral unfaithful repetition, that is the main driving force in the production of family variants (Albertarelli, 2000). On the other hand, a professional author has a clear advantage over a random event, since he is well-acquainted with the past and the present trends of the game world and it is more likely that he (and not a random event) can produce a successful games.

The introduction of new game ideas has been investigated and classified (Salen and Zinnemann, 2004), (Neto, 2005), (Schmittberger, 1992). A first instance is the mimicry (with simplification) of events from real life, such as a ceremony, a battle, a race, or a bargaining. Chess was clearly inspired by an old battle.

Another driving force for the production of new variants is the deliberate mixing of ideas from one game to another one (Salen and Zinnemann, 2004), (Neto, 2005). *Chessgi* (or *Mad Mate*, or *Crazyhouse Chess*, or *Dropping Chess*) is the instance of extending the dropping of the captured pieces, that is a characteristic of *Shogi*, to Chess.

Another powerful driving force for the production of new games is the request for a more challenging one. For example, *Tic-tac-toe* on a $3x3$ board is a draw, but enlarging the board and changing the purpose of the game toward other targets (not only the 3-in-line one) can yield interesting games for skilful players (Gardner, 1983). Another instance that was discussed along these lines (Parlett, 1990) is the progressive enrichment of more complex features that moves Whist toward the more challenging Bridge.

Furthermore, during the centuries, a drift toward pure abstract games was also observed, since dedicated players are interested mainly on strategy and tactics, forgetting the theme features, if unnecessary. This simplification is a main driving force in the production of new variants and it was defined as "elegance", that is the combination of minimum rules with maximum strategy (Braunlich, 1994). Along these lines, Schmitterger (1992) observed that "a game may have complicated rules, but it should never have rules that are unnecessarily complicated".

Along these lines, it seems that *Hex* or *Go* were born in their ideal form, always elegantly challenging for their players, without any need for modifications.

(3) Most mutations are unproductive

Several games are known and every year new entries are introduced, both variations of old games and completely new releases. Family variants and professional authors yield a very large number of new games, but only a very small part of these new entries survives along the years.

(4) The mutations operate slowly until a steady state is reached

Chess is still a good example. Several small mutations were introduced during the centuries, one after the other. Actually, this game has reached its "steady state" and mutations are almost impossible, because millions of dedicated players, who spent hard efforts to play Chess at higher levels, oppose firmly to the introduction of new rules, even to eventual improvements, since these variations destroy their knowledge, and the hard work performed.

Along this lines, an intriguing anecdote was reported by Robert Abbott about his *Ultima*, a chess variant played with many not conventional pieces (Abbott, 1963). Since its introduction, some flaws were found. Abbott accepted some suggestions and proposed some modifications to overcome these flaws. The small community of *Ultima* players firmly refused them (Abbott, 2001), even if they were informed that these variations were classified as "improvements".

Conclusion

Games, as other software systems subjected to evolution, have rules that were originated by a random event. As created, the game ideas compete for their existence by stimulating the brain of the player to spread the knowledge and the practice of that idea. The evolution toward both easier or more complex rules can be both accepted, the first one being caused by the loss of the theme feature that originated the game, the second by a quest for more challenging situations. Games can reach a steady state, and hardly undergo mutations, if they remains challenging for the players and no request for further complication is needed (as in the case of Hex).

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Games references

The Board Game Geek web site (`http://www.boardgamegeek.com`) is a valuable and encyclopedic collection of resources about games in general, and the games cited herein.

Board Games Studies was first published in 1998, an initiative inspired by the colloquia on board games held at Leiden University, the Netherlands, in 1995 and 1997. Five institutions affiliated themselves with the journal: the Institut für Spielforschung und Spielpädagogik in Salzburg, the International Institute for Asian Studies in Leiden, the Russian Chess Museum in Moscow, the British Museum in London, and the Department of Computer Science at the University of Maastricht. The journal, which was published by CNWS Publications in Leiden on a yearly basis, was partially funded through the assistance of patrons and boasted a modern layout, trilingual summaries and color plates. The broad ambition of this journal required a continuous commitment from the editors, who reviewed contributions in German, French and English, provided translations of summaries for each article and, in several cases, collaborated extensively with authors to develop manuscripts that were to the academic standards of the publication. The journal had a trial run of three years, after which the format, content and review process was evaluated. The authors of the articles integrated wide-ranging literature necessary for a comprehensive understanding of particular games. Contributions from different disciplines — including psychology, computer science, philology, classical archaeology and history — allowed for a better historical and systematic understanding of board games to emerge. Starting in 2000, a section with a translation of primary sources was added. Book reviews and research notes further complemented the multi-facetted contents. Its first ambition, to serve as a platform for the publication of board games research, was met quickly, while gradually the journal gained prominence among researchers by publishing seminal historical overviews. The colloquia continued from 1995 onwards, moving from a biennial to a yearly schedule. The host institution was expanded beyond Leiden to universities and museums throughout Europe as well as Jerusalem, Philadelphia and, in 2013, the Azores. The colloquia continue to gather an enthusiastic group of scholars, players and collectors. Despite the institutional affiliations and a group of patrons, the production of the journal became financially and logistically problematic with CNWS no longer able to serve as a publisher. Reluctantly, the paper version of the journal was discontinued after volume 7 was published in 2004. The possibility of an online version of the journal had been explored with the online publication of the first issues, a decision that greatly assisted the dissemination of knowledge accumulated in those early volumes. The next step, an online journal that operates again as a platform for recent board games research, was not far away but required the skills and enthusiasm of previous and new editors to materialize. In these last fifteen years, the study of board games has gained momentum and this journal will not only showcase new results but, most of all, will encourage and publicize the work of the dedicated researchers in this field.

Alex de Voogt

To the authors

Board Game Studies is an academic journal for historical and systematic research on board games. Its object is to provide a forum for board games research from all academic disciplines in order to further our understanding of the development and distribution of board games within an interdisciplinary academic context. Articles are accepted in English, French, and German and will be refereed by at least two editors under the final responsibility of the Editorial Board. Please send your contributions in any editable format (Word, LaTeX, rtf, ...) with a matching PDF file. Please send all the illustrations in separate files.

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