KTH Royal Institute of Technology
Philosophy of Science , October 29, 2013

A Game of Science

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1 Introduction

Science and games are usually regarded as 2 very distinct activities. Science, with its rigour and plethora of theories is seen as the major motor behind human evolution and the understanding of the world surrounding us. Gaming, on the other hand, is usually seen as a recreational activity with little to no effect on human life but that of providing entertainment.

In this essay, I attempt to show how these 2 areas might not be as different as one would initially think and are, in fact, intrinsically linked. In section 2, I establish a series of parallelisms between the concepts of science and the scientific method and those of games and gaming. Motivated by these parallelisms, in section 3, I consider what the relation between the 2 areas might be: synonymity, specialization, instrumentation?. Finally, in section 4, I describe, appealing to real ongoing projects, how cleverly designed games might contribute to the advancement of specific fields of science.

2 A parallel between science and gaming

To be able to develop this essay and establish the proposed parallel, one first has to attempt to come up with a definition of what a game is. While, at first, this might seem like a simple task, there is some debate regarding the actual criteria that allow us to distinguish games from other activities. On the one hand, we have philosophers like Ludwig Wittgenstein who, in his work *Philosophical Investigations*[1, p. 31-33], defends that there's no complete definition and that none is needed since people use it successfully by relating to what he calls family resemblances:

> Consider for example the proceedings that we call "games". I mean board-games, card-games, ball-games, Olympic games, and so on. What is common to them all? Don't say: "There must be something common, or they would not be called games" but look and see whether there is anything common to all. For if you look at them you will not see something that is common to all, but similarities, relationships, and a whole series of them at that. [...] How should we explain to someone what a game is? I imagine that we should describe games to him, and we might add: "This and similar things are called games". And do we know any more about it ourselves? Is it only other people whom we cannot tell exactly what a game is? But this is not ignorance. We do not know the boundaries because none have been drawn.

On the other hand, philosophers like Thomas Hurka think that Wittgenstein's reasoning goes too far and that a clear definition of what constitutes a game is not only possible but already provided by Bernard Suit in his work[2, p. 2]: *The Grasshopper: Games, Life and Utopia*[3, p. 41]:

> To play a game is to attempt to achieve a specific state of affairs [prelusory goal], using only means permitted by rules [lusory means], where the rules prohibit use of more efficient in favour of less efficient means [constitutive rules], and where the rules are accepted just because they make possible such activity [lusory attitude]. I also offer the following simpler and, so to speak, more portable version of the above: playing a game is the voluntary attempt to overcome unnecessary obstacles.

Although many other attempts at defining the concept of game exist, Suit's is widely regarded as being one of the simplest, most general and overarching ones. Therefore, throughout this essay the use of the concept of game will relate to his definition. The main components of a game are then: the game world, the concepts and environment surrounding the game and governed by the so called constitutive rules; the players, those who play the game under the defined game world; the goal(s), the ultimate objective(s) of the players; and strategies, the sequence of decisions and actions undertaken by the players restricted by the lusory means, with the objective of reaching the goal(s).

Having found an adequate definition for one end of the parallel, a definition is now needed for the other end – science. Curiously, the first part of the parallelism between the 2 concepts is precisely the debate surrounding their definition. Much like what happened with the concept of game, the definition of 'science' is subject of much debate. In fact, this debate constitutes one of the main topics in the area of Philosophy of Science and is still very active, more than a century after being initiated. It is known as the *Demarcation Problem.* Given the high volatility of this debate (as opposed to the one surrounding the definition of game which raises far less criticism), I shall not refer to science according to any individual definition or criteria but will develop the essay by establishing parallelisms with the most popular definitions proposed by such philosophers as Karl Popper, Thomas Kuhn and Imre Lakatos.

What is commonly agreed between most of the philosophers of science is that science describes a field of knowledge where scientists, armed with a set of methodologies and theorems, formulate hypothesis and theories regarding observable phenomena with the objective of being able to explain and justify it. Most of the debate around science vs non-science is focused on the properties of the aforementioned theories and on the details of the methodology used to arrive at such theories that distinguish it from other fields of knowledge. With these basic concepts, one can attempt to establish a link between science and gaming by associating the observable world with the game world and its underlying rules, scientists with players, theories and methods with strategies and the explanation of some phenomena as the game goal. We will see in the subsequent paragraphs how this link behaves when placed under the scrutiny of the different viewpoints of what constitutes science.

Karl Popper argues in his work *Conjectures and Refutations*[4, p.33-39] that science is a field of knowledge which differs from other such fields due to the fact that its theories are ultimately falsifiable or refutable. In this sense, one should be able to conceive a test in which, failing to accurately describe that which is observed, a theory would be subject to discredit and discarded. Scientific theories must, therefore, be associated with a certain degree of risk. Popper also argues that fixing a theory with ad-hoc assumptions ultimately hurts its scientific value.

Transposing this to our game domain, the equivalent criteria would be that adopted strategies shall be refutable and risky. A refutability test for a strategy is as simple as testing if, under a certain game configuration permitted under the set of game rules, it is able to direct the player closer to the game goal. If the player employing said strategy cannot achieve the goal by relying on it, then the strategy is refuted. Take, for example, a traditional game of football: 2 teams, each with 11 players, fight for possession of a ball with the objective of being able to put it into the opposing team's goal area. The clearly demarcated football field limits the movements of the players and a complex set of rules conditions their behaviours: offsides, fouls, freekicks, etc. For the purpose of this example, let us consider the teams at a macro level, with each team being a player in a 2-player game. The strategy adopted by each team (player) determines the positioning of its assets (the individual football players) on the field (defence, middle, attack), their behaviour in response to the other team (counter-attack, focus on defence, focus on attack), plays with which the team hopes to exploit the weaknesses of the opponent (flanking, pressuring, air play), etc. These strategies are defined through careful study before the actual match and are of vital importance to the victory of the respective teams. They are risky in the sense that if they fail to accurately predict the behaviour of the opposing team or coordinate the assets of their own team during a football match (a refutability test), they may lead to their defeat and, thus, the refutation of that strategy. During a match, one might attempt to make small fixes to the strategy given what has been observed up until then but the introduction of these ad-hoc fixes is simply a short-term solution that is usually not very fruitful in the long-run and motivates the creation of a significantly different strategy.

Thomas Kuhn offers an alternative interpretation of science in his essays, such as *Logic of Discovery or Psychology of Research*[5] and *Objectivity, Value Judgement and Theory Choice*[6]. To Kuhn, science is composed of a set of paradigms (including theories, hypothesis, methods, etc.) which then allow the solving of puzzles in their specific area of application. However, Kuhn details his definition of science further by identifying 2 distinct types of science: the aforementioned puzzle solving based on a defined paradigm which he labels as *normal science*; and the adoption of new revolutionary paradigms that go against previously established ones – *extraordinary science* or *paradigm shift*. The parallel is immediately evident when it comes to normal science as what are puzzles if not a specific instance of a game? However, to understand paradigm shifts from a game viewpoint, one has to first understand what motivates such revolutions. According to Kuhn, science is intimately related to the context in which it is practised and to the scientists who practice it. During normal science, if a scientist fails to solve a puzzle using the established paradigm, it is the competence of the scientist and not that of the paradigm that is questioned. There is, thus, a bias towards the maintenance of established theories. Only when the number of failures starts increasing does confidence in the paradigm start to lessen and a new one starts being created. When proponents of the new paradigm manage to convince a majority of those of the old one through different mechanisms of subjective persuasion (as both observations and meanings are theory-laden), this revolution takes place.

Appealing to the previous football example, the coach of a team might hold on to a strategy with which it has obtained good results in the past. However, in recent games, said strategy has failed to secure victories for the team. At first, the natural reaction of the coach is to place the blame on individual players whom he perceives as not applying the strategy correctly. After some time, either the coach realizes that it is the strategy itself that is at fault or he is convinced by the elements of his team or the technical staff that a strategy shift is needed. The coach is then, in this example, a good metaphor for the scientific community applying a paradigm to a particular area. A paradigm change has to be made by this community and it is motivated either by its members or by peer communities offering alternative paradigms. In some games, particularly those of a more casual nature, the role of the coach and the player becomes less distinct with every player becoming its own coach or the more experienced players assuming that role over the less experienced ones. An example of one of these games is poker, where it is common to see players holding on to their favourite strategies even after consecutive losses until it becomes clear to them that a change is needed and that the losses aren't just a product of bad luck.

Imre Lakatos offers a third view of what differentiates science from other fields of knowledge in his work *Science and Pseudoscience* [7]. To Lakatos, it is not the properties of the theories and their applications that define science but rather the way in which these theories are constructed – the programmes. To Lakatos, science is characterized by following a progressive programme, one where theories are created and updated to explain and predict novel concepts – to innovate –, while non-science is characterized by degenerative programmes where theories are mainly focused on the past. Scientists gradually flock from degenerative to progressive programs as these start to gather momentum. In a similar sense, a player might choose to adopt new strategies to explore novel ways of reaching the goal in a game or they might simply employ strategies supported by previous experience or memory. The first are, in the end, more likely to adapt to game instances not yet perceived or to find more efficient strategies although they might not have such a strong performance in known game instances. This also addresses a point raised by both Kuhn and Lakatos: that of leniency towards new paradigms/programmes as a requisite for innovation as they might, initially, not be as strong as their established counterparts (Kuhn's Loss).

A common point in the considerations of all 3 philosophers is that no amount of corroboration can ever ascertain the correctness of a theory. Just because a theory appears to explain all observable facts, one cannot assume that the theory is undoubtedly correct as future observations may end up discrediting it. The same usually happens with game strategies. No matter how sound and full of contingencies they are, we cannot be certain that there isn't a configuration in which that strategy alone may not allow us to reach the goal or, in the worst case, may lead us astray. This is all too common in puzzle games like Sudoku where strategies that seem quite solid and corroborated for a particular type of instances, say easy difficulty, may be insufficient to solve instances of a greater difficulty level where more complex reasoning should be employed.

3 The relation between games and science

Having seen a series of parallelisms between games and science, an issue that naturally ensues is that of the specific relation between the 2 concepts. Is it one of synonymity, that is, do games and science reference the same thing just with different terms? Are games a particular type of science or is science a particular type of game? Or are the concepts completely unrelated and it is just a coincidence that they appear to share so many aspects in their execution?

Considering the hypothesis of synonymity would entail a reasoning where a certain type of game could be seen as an instance of a particular science and vice-versa. Intuitively, this doesn't seem very plausible. How could *Sudoku*, *Rubik's Cube*, *Hide and Seek* among other games with very limited worlds/domains attempt to compete and ultimately match the richness of such sciences as Physics and Biology? At the very least, the 2 first games, could be seen as matching and exercising certain aspects of Logic while the third one reporting to particular cases of the science of Psychology [8].

Does this then mean then that games are simply instruments or special cases of science? Tools used by scientists to exercise their theories and, perhaps, develop new ones? Sudoku might indeed have contributed with puzzle instances for the field of Logic or Mathematical Optimization to test their theories against. However, to be considered as a simple instrument of science, that would mean that the creation of Sudoku would have had as its primary motivation, its application to a particular science field. Yet, the history of Sudoku tells us a very different story. With its roots on number puzzles published in French newspapers at the end of the 19^{th} century, modern Sudoku is believed to have been designed by Howard Garns and published by Dell Magazines in the late 70s under the designation of *Number Place*[9]. This suggests that the main focus of Sudoku was that of providing entertainment in the form of logical challenges, not of advancing or corroborating any particular type scientific knowledge.

Could it then be the case that science is but a particular type of game? Relating to the reduction theory as formulated by Ernest Nagel in *Issues in the Logic of Reductive Explanations* [10], could it be that science can be reduced to gaming? By considering this, we are admittedly moving past Nagel's scope of reduction involving 2 scientific theories, into reduction involving 2 domains: gaming and science. We can workaround this by considering the actual definitions of the 2 domains as *definition theories*. This being the case, to reduce the definition theory of science to the definition theory of gaming would mean that, from a set of premises describing that which characterizes games (such as Suit's definition in page 2), we would be able to logically derive conclusions describing that which characterizes science (such as Popper's demarcation criteria or Kuhn's paradigms). This would correspond to an inhomogeneous (or heterogeneous) reduction as the concepts of *theory*, *methodologies*, *programmes*, among others employed by philosophers to describe science do not appear in the corresponding description of games and such terms as *play* and *rules* are not employed in the most traditional definitions of science. The observant reader might have by now realized that most of the previous section of this essay, by trying to establish precisely the parallels between the 2 concepts, provided an overview of the major bridge laws needed for this correspondence. In addition, the previous section also provides an intuitive account, and, thus, admittedly lacking considerable deductive proof, of the way in which one could map the different descriptions of the scientific method to that of the gaming activity. A full, rigorous deductive proof would be a gigantic undertaking certain to take not only a considerable amount of time and patience, but also more than the few pages at my disposal for this essay. Thus, I'll simply choose to reinforce this mapping by providing yet another example.

Given the rate at which technology is evolving, it is not that inconceivable to believe that at some point in the future, video games will be able to realistically simulate (or at the very least emulate) our observable world, that is, provide an accurate kind of virtual reality. In fact, current generation video games already bear quite a striking resemblance to our world, depicting, with a certain degree of accuracy, gravitational and contact forces, fluid dynamics, climates and social interactions. Imagine now a game played in this simulated world where you control your own avatar and can order it to perform any type of conceivable action that does not violate the game rules. Furthermore, assume that a manual for the game has not been written yet and, as such, the existing rules are not known a priori but have to be gradually discovered (therefore, rules provide the lusory means but a constitutive rule states that such rules are not previously known, thus prohibiting the more efficient play in which rules wouldn't have to be discovered). Your ultimate goal in this game is to guide the actions of this avatar according to your whims until the day it dies. Such a game would, according to today's video game ontology, be characterized as a type of Open-Ended Free-Roam Role-Playing-Game, not unlike the wildly known game of Second Life. It is very much conceivable that, in such a game, a group of people might find pleasure in trying to understand and compile the rules governing the game world (in fact, even in simpler games, we can find such groups of people creating what is known as game wikis, e.g: the community-created OGame Wikia [11]). These people might also find out that they end up producing a better compilation of rules (and thus, achieving a better goal) if they agree on a set of principles and methodologies to which the compilation of the rules must conform. Such principles and methodologies might very well reflect criteria discussed in the previous section regarding the most popular definitions of science.

In the previous paragraph, I have just described a very specific game conforming to all the concepts in the definition by Bernard Suit. Along with this game, I've identified a very likely game goal among the infinitely varied set of possible goals: identifying the rules of the game. I've also conjectured (with some support based on people's behaviour in current games), that a group of people might find it entertaining and satisfying to play the game with such a goal in mind and to collaborate with one another so as to achieve a better version of that goal and to do so at a faster rate. These people are, thus, attempting to understand and explain the rules governing this game through the use of a set of agreed principles and methodologies which may very well share the same criteria that today characterizes the scientific method. By realizing that the game just described constitutes what may be called as life and that the people identified are those that are attempting to find the rules governing all phenomena in life through the use of a method conforming with scientific criteria, we have just witnessed science being practised by players of this game who we can then call scientists. One might argue that such a gaming scenario does not reflect the rigour and seriousness that are often entailed by science. However, gaming is not necessarily a synonym of casual entertainment. The field of professional gaming is evidence of a whole new way of playing where rigour, efficiency and accuracy are valued more than entertainment value. In fact, even in casual gaming, it is often the case that players end up focusing on the finding of the best possible strategy at the expense of great frustration in the process. This is particularly evident in certain video games offering the choice of extreme difficulty levels where everything in the game world appears to conspire against the player, forcing he or she to be slow, methodical and rigorous in its progress, much like what happens in science.

The last 2 paragraphs motivated a reduction of far greater scope than the one I initially set forward to address. In a sense, I have motivated a reduction, not only from science to a game, but of the whole concept of life to a game. This raises significant philosophical questions as is usual in such matters that attempt to explain or question life and reality (e.g How to know if we are living inside such a virtual reality or if there is a definite reality?). Indeed, this very game could have been the one which humans were forced to play and believed to be reality in the blockbuster *The Matrix*. However, the focus of this essay is not on such questions but on those related to science. Science, constituting a proper subset of life (with other subsets being things such as Art, Literature, etc.) was also described as being a subset of the activities that could be accomplished in the game (after all, the goal that motivates the compilation of rules is but one of the infitely many goals that players may choose to follow in the game). Therefore, gaming allows for a subset of activities which includes those pertaining to science and is then more general and inclusive.

4 Contributing to science through gameplay

We have seen, in the previous section, how one might perceive science as being a specific type of game. While this is compatible with Suit's definition of games, one can argue that when someone usually reasons about games (at least in our current age), it's those of a less complex nature that are often invoked: puzzles, sports, board games, video games, etc. In this section, we investigate whether these simpler games could be used for the advancement of science and, if so, in what ways.

For a game to be useful to science, that would mean that the game is used, to some extent, to enable progress in science. The concept of games using a set of simpler games to allow progress in them is not unheard of. In fact, these simpler games are often called *minigames*. In football, for example, a match could be considered as the actual game and the minigame of penalty kicks introduced to enable progress in the event of faulty impediment of a goal or in the event of a tie in a selection match (where one of the teams has to win over the other, no draws allowed). Minigames often make use of the structures built by the main game but changing the rules slightly so as to, usually, simplify the gameplay: penalty kicks in football pit a single fixed player (instead of 11 moving ones) against a single fixed goalkeeper (instead of the 11 players of the opposing team) while maintaining the set of rules that determines what constitutes a goal. Thus, should these simple games be used by science, they can be seen as minigames of science and not conflict with the reduction made in the previous section.

Having established that, in our current treatment of science, the concept of minigames does not conflict with previous assumptions, one can move on to finding evidence of their use. Fortunately, this is not a hard task. In recent years, a great number of projects have surfaced in which a game is created to help in the discovering of patterns and connections in data and, thus, contribute to the formulation of new theories. Some examples of these games are *PHYLO* [12] and *EteRNA* [13] in the field of Biology or *Science at Home* [14] in the field of Quantum Computing. These games are created to help solve particularly challenging subproblems in their fields of application by encoding known theoretical and experimental laws in the game world, lusory means and constitutive rules. They also usually use some kind of scoring mechanism (an utility function of sorts) to establish the lusory goal of the game: maximize the score. Thus, they are able to abstract away all (or most of) the complex field-specific knowledge and quality requirements into a game that can easily be played by anyone without needing extensive study of the underlying concepts.

To understand the importance of such games, one has to consider how science usually comes up with explanations for various phenomena. Two of the most popular models for scientific explanation were introduced by Carl G. Hempel in his essay *Two Basic Types of Scientific Explanation* [15]: the *Deductive-Nomological Explanation* (D-N model) and the *Inductive-Statistical Explanation* (I-S model). In the D-N model, the event to be explained (the explanandum) is logically deduced from a set of explanatory facts (the explanans), composed of both particular facts and general laws which have to be true. In the I-S model, Hempel allows for the use of probabilistic laws to explain events in a similar fashion to that of the D-N model. However, in this case, the explanandum is not logically deduced from the explanans but follows from it with high inductive probability. In both models, the actual derivation of explanandums requires a large set of explanans and intermediate derivations. Knowing which explanans to use is something that is learnt with experience and study. Even so, some explanans are usually omitted and implicitly assumed as they are considered obvious or trivial. These things make it difficult for a person not familiarized with the field to contribute to its advancement. But even for an expert in the field, taking into account the amount of data processed nowadays, this can be a daunting task. With the appearance and evolution of computers, the evaluation and derivation of such explanations received a much needed computational aid. However, no computer today can hope to match the pattern recognition capabilities of a human being nor the irrational choices that often lead to exploration of new areas and phenomena.

Therefore, the abstraction of these models, particular facts and general laws into a game has the consequence of allowing non-experts to participate in the derivation of explanations and theories for the associated field of science and to do so in a simplified, less daunting manner. In fact, the lusory and entertainment factor associated with these games even serves as a motivation for continuing interaction and contribution. The advantages of this are two-fold: the speed at which new data can be processed and analysed significantly increases as we can now have more people working on these derivations and people can be several times more efficient than even the most advanced computers at finding patterns and dealing with new situations; the introduction of new people to the advancement of the field brings with them new ideas and approaches as everyone has its own unique take on how to approach and solve a difficult problem. This last point is closely related to Helen Longino's social objectivity of science. In her essay *Values and Objectivity* [16], Longino argues that:

> "…the greater the number of different points of view included in a given community, the more likely it is that its scientific practice will be objective, that is, that it will result in descriptions and explanations of natural processes that are more reliable in the sense of less characterized by idiosyncratic subjective preferences of community members than would otherwise be the case."

Therefore, the use of games in the practice of science is particularly useful, because it opens specific fields of science to the scrutiny, interest and contributions of not only scientists in other fields but also to non-scientists, thus contributing to a greater variety of points of view and a greater reliability of the combined outcome.

5 Conclusion

In this essay, we have seen how concepts usually associated with science have striking similarities with those usually associated with games: scientific theories may be construed as game strategies; the "real" world (or parts thereof) may be modelled as game worlds and underlying rules; the explanation and understanding of observable phenomena may be seen as a game goal; etc. These similarities appear to hold under the consideration of the viewpoints of different philosophers regarding that which differentiates science from non-science: refutability and risk by Popper, puzzle solving and paradigm shifts by Kuhn and the progressive and regressive programmes of Lakatos.

We have also seen, supported by observed behaviour and by previously established parallelisms, how science may be seen as a special case of gaming, that is, how the practice of science may be, in fact, reduced to gaming.

Finally, we have also considered how simpler, more traditional types of games can be used to help the advancement of science. How these games are able to abstract the underlying theories and methods, ultimately opening the practice of science to a greater audience and providing a greater diversity of viewpoints. This variety promotes robustness and objectivity in the resulting theories.

Having seen all of this, it is my hope that the initial gap between these 2 concepts has now been successfully bridged and that the importance of games to science has been clearly highlighted.

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