Affordances of Elliptical Learning in Arcade Video Games

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ABSTRACT
Many researchers consider that video games have a unique potential for learning. However, Linderoth (2010) criticizes the way researchers link a successful action in the game and learning, without denying this conclusion. Using Gibson's affordances (1979), he argues that, in order to study learning in a video game, one must carefully study the game itself. This article attempts to understand how "great video games" (Kunkel, 2003) may take "a minute to learn and a lifetime to master." As a part of my Ph.D research, I trained for six months to perform a one-credit run on the *Alien Vs. Predator* (Capcom, 1994) arcade game. This expertise will be used to study affordances of learning and non-learning in this video game in order to introduce the concept of "elliptical learning".

Keywords
Video game, elliptical learning, affordance, closure, ellipsis

INTRODUCTION
James Paul Gee argues that good commercial video games incorporate good learning principles, which he describes in his famous book *What video games have to teach us about learning and literacy* (2003). What players learn when they are playing video games is not always good, but "what they are doing when they are playing good video games is often good learning" (*ibid.*, p 199). Gee sees 36 learning principles at work in video games, although they are not exclusive to games. Among these, we may mention the following principles (*ibid.*, p 207-212):

- Active, Critical Learning Principle: The learning environment encourages active, critical and not passive learning.
- Achievement Principle: For all skills levels there are rewards for improving oneself.
- Practice Principle: Learners spend a lot of time on the task.
- Multiple Routes Principle: Learners are allowed to find their own way to make progress relying on their strengths and their own style of learning or problem solving.
- Discovery Principle: Learners are given the opportunity to experiment and make discoveries.

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Marc Prensky considers that learning always occurs when someone plays (2005, p 104):

> Learning takes place every time one plays, in every game, continuously and simultaneously, on several levels. One need not even be paying much conscious attention. But we do have to pay some attention in order to analyze how and what players learn.

The process of learning a commercial video game may be observed as what Daniel Schugurensky calls "informal learning" (2007). Informal learning is not easy to define. Formal learning refers to learning occurring in situations specifically designed to teach by educational institutions. Non-formal learning happens in situations designed to teach by other institutions. Informal learning would thus be "everything else" (*ibid*., p 14).

One problem with informal learning is that it may be unconscious as well as unintentional. Plus, we often lack tools to estimate the efficiency of this type of learning. In school, we may use exams or tests to evaluate students, however it is more difficult to evaluate players of video games. Exams and exam situations are designed to avoid cheating, which may be understood as minimizing the risk of students giving the right answer without having learnt it. Video games do not face the same issue; they want players to keep playing. One methodological obstacle is highlighting the actual learning that occurs in commercial video games. Prensky also pointed out that measuring "true learning […] is no easy task. The real measure of learning is behavior change [and] we can never know this until it happens" (2005, p 103).

According to Gilles Brougère (2005, p 152), the question of informal learning lies in the relationship between the learning affordances of an activity and the player's engagement in this activity. In other words, informal learning relates what is possible to learn from a situation to the player's disposition to actually learn what she or he may learn from this situation. What a player can learn with a game greatly depends on the game's design (Prensky, 2005, p 103):

> Many criticize today's learning games, and there is much to criticize. But if some of these games don't produce learning it is not because they are games, or because the concept of "game-based learning" is faulty. It's because *those particular games are badly-designed*.

A good video game may be designed to help the player learn how to play but the activity itself is not designed by the game developer. Indeed, if "ultimately, game design is play design" (Salen & Zimmerman, 2003, p 299), the game designer only defines it indirectly. You can never know for sure whether or not the game will work (*ibid*., p 67):

> Game design is an act of faith – in your rules, in your players, in your game itself.

This article will leave the question of engagement aside and study video games' affordances of learning. More precisely, the focus will be placed on the particular learning offered by "great video games" (Kunkel, 2003). This study will allow the introduction of the concept of "elliptical learning."

LITERATURE REVIEW

Many researchers share a belief in video game's educational potential. Kurt Squire and Henry Jenkins (2003) pointed it out in *Harnessing the power of games in education*, but even today we are still "a long way from having tapped the full pedagogical potentials of existing game hardware and design practices." Katrin Becker studies the design of successful commercial video games to improve the design of educational digital games (2008). However, as pointed out by Van Eck (*2006*):

> If we continue to preach only that games can be effective, we run the risk of creating the impression that all games are good for all learners and for all learning outcomes, which is categorically not the case.

In order to use video games properly, we should not only understand how and why they may work as learning tools but also, and perhaps even more importantly, how and why they may fail. Linderoth (2010) suggest that we may be mistaken about their potential as teaching tools. More precisely, he criticizes the way researchers relate a successful action in the game to learning. He uses Gibson's ecological approach and the concept of affordance to study how video games may facilitate the player's progression without requiring actual learning. Thus, he points out that, in order to know whether or not a player has learnt something in order to achieve a goal, one must carefully study both the game and the practice. This approach allows the researcher to understand the difficulty level in order to track whether or not the player has gained knowledge.

Through the concept of affordance, Gibson's ecological approach (1979) leads us to consider the relations between the environment and the subject. There is often some confusion between Gibson's affordance and Norman's affordance (1988). Joanna McGrenere and Wayne Ho (2000) compared affordances as defined by Gibson and Norman:

Gibson's Affordances	Norman's Affordances
Offerings or action possibilities in the environment in relation to the action capabilities of an actor Independent of the actor's experience, knowledge, culture, or ability to perceive Existence is binary – an affordance exists or it does not exist	Perceived properties that may or may not actually exist Suggestions or clues as to how to use the properties Can be dependent on the experience, knowledge, or culture of the actor Can make an action difficult or easy

Table 1: Comparison of affordances as defined by Gibson and Norman.

Norman himself recognized a misunderstanding about the way he used the term "affordance" (2011):

> I introduced the term affordance to design in my book, "The Psychology of Everyday Things" (POET: also published as "The Design of ..."). The concept has caught on, but not always with true understanding. Part of the blame lies with me: I should have used the term "perceived affordance," for in design, we care much more about what the user perceives than what is actually true. What the designer cares about is whether the user perceives that some action is possible (or in the case of perceived non-affordances, not possible).

An affordance is an action possibility offered by the properties of an environment to the capacities of a subject. According to this concept, an action is possible not only because the subject is able to perform it but also because the environment allows it. The environment may make an action easier; in this case, performing it will require fewer capacities. An action may be facilitated by the game itself which would limit compulsory learning. Linderoth (2010, p 6) enumerate several ways to do so:

- Designs for supporting exploratory actions: Highlighting, alternative vision modes and points of interest help players to see and find affordances available in the game environment.
- Designs for supporting performatory actions: Changing the played character, improving her or his capacities or equipment, giving temporary power-ups make performing actions easier.

Using this kind of assistance reduces what a player has to learn in order to succeed in a video game. It is why this learning has to be questioned by a real knowledge of the studied game. Linderoth's argument may be related to Becker's "Magic Bullet" Model (2011). This tool is intended to monitor the way a game manages the player's learning and it classifies learning in four categories (*ibid.*, p 22-24):

- Things we CAN learn: It includes "anything and everything we can learn directly from the game."
- Things we MUST learn: This set is "almost always […] a subset of the first category". It includes "only those items that are *necessary* in order to win or get to the end."
- Collateral Learning: This category includes things that "are not part of the game and that *do not impact on our success in the game.*"
- External Learning: This set includes "learning that *can impact on our success in the game* but that happens entirely outside of the game in places like fan sites and other social venues."

Linderoth does not negate the amount of "Things we CAN learn" from a video game. On the contrary, he suggests that the category of "Things that we MUST learn" in order to finish a video game may be far smaller than what researchers would expect initially.

LEARNING IN GREAT VIDEO GAMES

As Linderoth pointed it, video games may be designed to minimize the risk of players giving up because they failed. A game which is too easy would also be boring; a balance between boredom and anxiety has to be found to reach "optimal experience" (Csíkszentmihályi, 1991).

In my PhD research, I study how learning works in "great video games." Great games should take "one minute to learn and a lifetime to master" (Kunkel, 2003). This particular learning is what makes great games great. If a game is able to maintain this balance between boredom and anxiety, then it remains interesting for a long period of time even though the player improves her or his skill level. Linderoth (2010, p 2) defines learning "in ecological approach [as] becoming attuned to perceiving and being able to utilize specific sets of affordances that belong in specific practices." An affordance of learning would be a possibility of action offered by a game to a player which results in a modification of the player's abilities to perceive or use this game's affordances. These abilities may be physical as well as mental. Learning would be an action improving the player's ability to perform actions. Thus, great games have properties allowing this type of learning.

These great games are not necessarily Massively Multiplayer Online Role Playing Games, in which there are far too many possible things to do. Great games may be arcade games you can finish within one hour. These games have to fit the definition of great games because of the context in which they are meant to be played. Originally players had to pay every game they played. In order to earn as much money as possible, an arcade game has to be easy to understand so that the player may quickly have fun but also hard to master so that the player keeps playing (and paying).

Shoot'em-up games are a very good example of arcade game. Once the player has understood how to move and fire, she or he can play them, but the games remain difficult. "MON" is a Japanese supergamer on shoot'em-up games. More precisely, he plays *danmaku* games. The Japanese word *danmaku* literally means "bullet curtain" ("bullet hell" in English) and it refers to a shoot'em-up game in which the screen is practically covered with enemy bullets. MON estimates that in order to finish one of the most difficult mode of *DoDonPachi Daioujou* (Cave, 2003), called "Death Label" mode, a complete beginner would have to play 4 hours a day… for ten years (Kemp, 2011, p 166).

However, as difficult as it may be, finishing an arcade game does not necessarily mean having mastered it. The danmaku called *Ikaruga* (Treasure, 2001) was first an arcade game; on the Gamecube version (*Ikaruga*, Treasure, 2003), the player is given a new credit for every hour of play. Every credit increases her or his chances to finish the game, after seven hours of play the "infinite credits" mode is unlocked. As every level is timed, it is not necessary to achieve something to get to the level after. If the player does not defeat the boss before the time is up, he just goes away and the next level begins. No matter how bad you are, you just have play long enough in order to finish the game, but there is a quantum leap between finishing it and having a decent high score. The score is reset to zero every time a credit is used, so it is necessary to finish the game with one credit before even thinking about getting a high score. Michael Molinari (2009) reviewed 83,279 high scores of Xbox Live *Ikaruga* players:

> Knowing how brutally the learning curve treats players, the top score of 34.4 million points is quickly cut in thirds to 10.3 million by the 500th player. […] At 10,000 players, the score is at 1.3 million. From there, it has a steady decline in scores until around the 83,000th player, who has 11,100 points. […]

> And speaking of low scores, I understand that the game is a tough cookie to play, let alone master, but many of these scores are just horrible. […] If you *just hold the fire button down and stare at the screen*, you get a game over with 40,000 points, a score that over 4,000 people failed to acquire.

Ikaruga is known for its difficulty. Molinari considers that "everyone dies very early upon first playthrough, [and] the next 50 to 500." There are really bad players and really good players, but bad players are far more numerous. However even top players were once beginners and had to learn how to reach this level; this learning did not work for everybody.

Tetris (Bullet-Proof Software, 1989) is typically a game that is easy to learn and hard to master. But at very high speed, the original game is impossible to play because it was not created to be played very fast. The *Tetris: The Grand Master* (Arika, 1998) series gathers versions of the original *Tetris* that are specifically designed to be played at a very high speed. At the maximum speed, a tetramino takes one frame to go from the top to the bottom of the screen. In *Tetris: The Grand Master 2* (Arika, 2000), obtaining the highest rank, "Grand Master," requires one to get the "Master" rank, which is already hard to get, and then to survive one minute at the highest speed without seeing the tetraminos. According to "Amnesia," a French supergamer on this game, this minute of invisible play represents a real gap and requires an additional year of training after getting the "Master" rank (Pilot, 2009). The mechanisms of the game have been changed in order to increase the learning possibilities of the original game concept.

"DamDam," (Pilot, 2008) a French supergamer on musical games, talks about "infinite superplay" on *Pop'n Music* (Konami, 1998). *Pop'n Music* is a rhythm game which may be compared to *Guitar Hero* (Harmonix, 2005). Instead of five buttons aligned on the handle of a guitar, there are nine big buttons in two rows on a one-meter board. Sometimes, the player has to press five buttons at the same time. The game presents an almost unreachable challenge, because even the best player in the world has not reached the highest score on the most difficult songs. In DamDam's opinion, *Guitar Hero* is too easily beaten because it is possible "to finish the most difficult song with the maximum score within six months," which is far too short (Falcoz, 2011).

Clearly, this type of learning does not work for every player. Progression in these cases is not about learning how to perform a new task, rather it is about learning how to perform the same task better despite the fact that the game remains exactly the same. So, a great game offers, to the same player and at the same time, several different affordances to complete the same task. These affordances require more or fewer skills and more or less knowledge. The more difficult an affordance is, the more performing it rewards the player. Great games have properties that offer a fast and yet long learning. The purpose of this article is to study the properties of a video game and the capacities of the player affording this kind of learning. To do so, we will carefully study one particular mechanism in one specific arcade video game. Thus, we will highlight how a mechanism may be quick to learn and yet, take a long time to master.

METHOD

As a part of my research, I trained on the *Alien Vs. Predator* arcade game and became a supergamer by performing a one-credit run. This was featured on the 45th episode of a

TV show called *Superplay Ultimate* on the Nolife channel in France (Pilot, 2011). *Superplay Ultimate* features the performance of an expert player, or superplayer in French, on one video game. The performance is commented on by the player and the presenter. I did not use the default settings for my run, but rather increased the number of extends (i.e. lives you can win by earning points) and increased the difficulty from 4 to 8.

Before I started this training, I had been playing this game for years and had already finished it dozens of times. I thought I knew this game but I was wrong. I trained for six months; it took me 200 hours, which included 150 hours of actual play. I kept a thorough report of each training session which included the following information:

- The length of each run and the settings
- Where and why I lost each life
- What I learnt during the session about the game (new strategies, new mechanisms…)
- My physical and mental shape (which had an influence on the way I played)

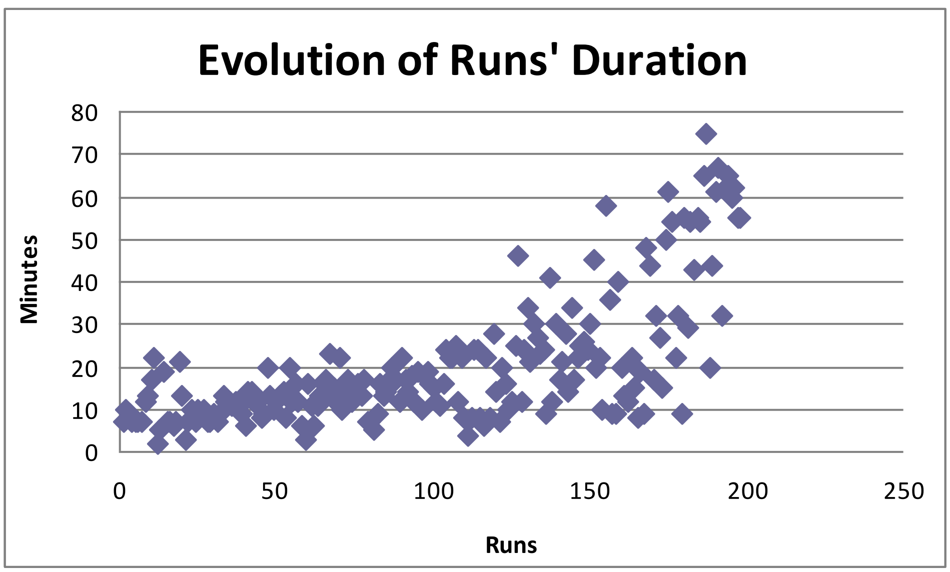

Table 1: Evolution of runs' duration throughout training.

A run's length is directly related to the level I reached. Finishing the game took me at least 65 minutes. This table only includes sessions where I actually tried to finish the game as opposed to sessions where I was just training. I also set aside runs where I stopped playing before losing because it was obvious I was not in a good physical and or mental shape to play properly. Even in these conditions, some runs ended very early even at the end of my training. Becoming able to succeed does not prevent a supergamer from failing. Furthermore, I performed a one-credit run only three times out of almost two hundreds. At my best, my success rate hardly exceeded fifty percent.

However the most interesting part is that of the strategies I used to pass each section of the game. From the very beginning, I regularly passed the first ten-minute section of the game, yet my strategy for these first ten minutes has deeply changed throughout my training. The strategy reports allowed me to follow my evolution through several layers of understanding. At the beginning of my training, I found some strategies to beat the early portions of the games. These strategies appeared desperately risky and inefficient with more experience; in order to progress, I had to find and use more efficient affordances. But theses affordances only reduced the probability to lose during the first sections of the game, I was never sure to beat them.

As I had to stop using non-optimal affordances, improving myself on this arcade game implied unlearning as much as learning. My guess is that it would require around six more months of training to finish the game with one life and at least six additional months to get close to the world record. I will explain here how I learnt and unlearnt the way shooting works in *Alien Vs. Predator* and how the game properties afford to players the specific learning of great games.

RESULTS

Alien Vs. Predator is a 2D arcade beat'em-up game created by Capcom in 1994 on CP System II. In this game, up to three players may choose between four characters—two predators and two cyborgs. They have to stop an alien invasion in the city of San Drad. The game uses an 8-direction stick for moves, one button to jump, one button to hit and one button to fire your gun. It is possible to combine one button and one direction or move on the stick in order to do special moves. Pressing two buttons at the same time launches a powerful attack which makes one's character lose some hit points.

There are mainly two ways to kill your enemies: you may hit them or shoot them. We will focus on the shooting mechanism. Linn Kurosawa is the character with whom I chose to perform the one-credit run. She is less resilient and harder to master than the other characters, but she is my favorite character and has the most interesting gun mechanism in terms of learning. There are several levels of understanding of how Linn's pistol works. Here are the four levels I went through.

The first level of understanding is explicitly described in the game instructions, "Button A: Fire". Some details are given about the gun gauge:

- When Gun Gauge is green, the gun can be fired.
- When Gun Gauge is red, the gun can't be used. Watch out!

This information is true for every character. Once you have played the game, you implicitly reach the second level of understanding: when you fire, the gauge empties; when you do not, it fills up. When the gauge is red, you cannot fire, which means that you are more exposed to your enemies. You also realize that the four guns do not have the same effect. Human guns fire bursts of bullets while predator guns fire one single shot that explodes on impact. The explosion may knock back several enemies at the same time. At the second level, predator guns seem to be more efficient.

The third level of understanding highlights a strong difference between Linn's gun and the others' guns. There are two things that are not said about her gun:

- When Gun Gauge is red, it is impossible to move.
- Linn's Gun Gauge can only be refilled after being completely emptied.

With the other characters, when the gauge is empty, you may still fight, and if you fire only once, the gauge will fill up automatically. Linn may only reload her gun when it is out of ammunition, and when she does, she cannot move at all, making her even more vulnerable. When I started my training, I was at this third level. I thought Linn's gun was less efficient than the others. It could not touch several enemies with the same bullet, it did not automatically reload, and it prevented Linn from moving when she had to reload it. I changed my mind when I reached the fourth level of understanding.

This fourth level is hidden but can be found. Indeed, Linn's gun has more ammunition and does more damage than the other characters' guns. With one single gauge, Linn's pistol may kill a few enemies, when the other guns cannot even kill one. The other's guns are just emergency weapons to be used as backup while Linn's gun is a real fighting weapon. There is also a possibility to move (and fight) while reloading. To do so, the player has to jump, shoot the last bullet in the air, land and try to shoot once. It is then possible to move freely. It is tricky or even difficult to do, since you not only have to be able to do it, you have to integrate this chain into the way you fight.

Without this tip, Linn's gun is powerful enough to take care of at least four enemies at the same time. Shooting knocks the targets back, giving a skilled player enough time to reload the gun. Moving while reloading only becomes useful against more enemies than that. But once you master it, Linn's gun is truly the most powerful weapon of the game. As far as I am concerned, I would tend to think that it is possible to finish the game just with this gun, while it is impossible to do so with the other guns.

AFFORDANCES ON LEARNING

What I have described may appear as a self-experiment that only highlights a personal and not generalizable experience. This is where the differences between Gibson's and Norman's affordances really become helpful. Gee (2003) and Becker (2008) use their own experience of gameplay in their research, but they focus on the learning occurring between the beginning and the end of a video game. Conversely, in an arcade video game, most of learning happens after the player finishes the game for the first time. Similarly, David Sudnow (2000) described his pursuit of the perfect game on *Breakout* (Atari Inc., 1978). According to the author, computers, and computer games, are the union of three older tools: television, typewriter and piano (*ibid.*, p 23):

> Of all things exterior to the body, in its every detail [piano] most enables our digital capacities to sequence delicate actions. […] At this genetically predestined instrument we thoroughly encircle ourselves within the finest capabilities of the organ.

The author describes a tool whose "every detail" calls for the acquisition of the "finest capabilities of [our hands]" in order to use it properly. In other words, the possibilities of action require specific properties of the object as well as specific capacities of the subject. Thus, Sudnow deals with affordances. As we have seen, Gibson's affordances are Boolean; they exist or do not exist. If anybody is able to do something in a video game, it means that the video game and the player respectively have the properties and the capacities affording this action. If the affordance was considered impossible, it may imply a misperception of the object's properties and then open the field of possible affordances.

It is also true for my own experience with *Alien Vs. Predator*; however it is still not generalizable. But this article deals with possibilities rather than actualities.

On the one hand, the game itself is the result of an affordance offered by the properties of digital technologies and the capacities of game developers; it means that digital technologies may be used to create such mechanisms. Since there are many great games, there are also many developers able to create them. In addition to that, a player just cannot disobey a program's code, no more than there is "a choice about obeying gravity" (Lessig, 2006, p 110). Consequently, a video game's properties will be the same for every player and any property found in a video game could be found, or at least reproduced, in another one.

On the other hand, every player does not have the same capacities. As a game designer, game design teacher and video game researcher I have more practice and knowledge than many players. Maybe the way I learnt is not afforded to average players. However, it is possible to reverse this problem by considering affordances of "non-learning" instead of affordances of learning. If someone as experienced as me could have spent years playing this game and not understanding it, the same affordance should be available for most of players.

ELLIPTICAL MECHANISM + ELLIPTICAL CLOSURE

The non-learning afforded by Linn's gun to the player emerges from both the properties of the gun and the capacities of the player. In order not to learn something about this gun, there must be something that can be learnt and subsequently ignored about it. I consider the two main points to be hidden features and a weakness that can be counterbalanced. On the one hand, hidden features refer to the fact that one press of a button may have many consequences at the same time. When you press the button A, there are two possible outcomes: you may fire bullets and empty the gun gauge or you may prevent your character from moving while she is reloading. These outcomes depend on the state of the game at the moment you press the button. It is possible to ignore some of these relations and consequently not understand what is happening.

On the other hand, Linn's gun has a strong weakness that can be compensated. This feature allows the gun to present two faces to the player. Without mastery, it seems weaker than the other guns, but with enough skill, it becomes the most powerful. This gun may perfectly have been the best weapon for both beginners and expert players. A gun which could instantly kill every enemy on the screen with infinite ammunitions would be the best weapon for beginners as well as experts. But Linn's pistol is not good for beginners; this change of perception rewards the attention given to the game by the player. It also makes learning worthwhile because there is a real gap between the average affordances offered by the gun to a beginner and the ones available when you truly master it.

In video games, many weapons offer various affordances depending on the player's skills. In *Halo and Philosophy* (Hock-koon, 2011), I highlighted the phenomenon through a study of *Halo: Combat Evolved* (Bungie Software, 2001). The different weapons of the game are more or less efficient according to the player's skills and the difficulty level. Beginners' weapons are easy to use but finally become ineffective as the player reaches harder levels. Experts' weapons are rather useless as long as they are not mastered, but once they are, beginners' weapons cannot compare with them. But even a good player may keep using beginners' weapons if she or he does not know what experts' weapons are capable of. Indeed, Gibson's affordances are independent from the subject's knowledge or ability to perceive them.

When I started my training, I was at the third level of understanding. I reached the fourth level by watching a one credit-run performed by the supergamer "Naru2005" (2008). I had to watch a few levels before realizing that the player was able to move while reloading. It made me realize how bad I was and that I was wrong about Linn's gun's properties. Then, I had to play myself in order to figure out how the player did this. This technique is not well-known even on the internet, and without Naru2005, I may perfectly have never heard of it. It opens a whole new set of very efficient affordances. Finishing the game with one credit without these affordances would have been far more difficult.

In *Understanding Comics*, McCloud (1993, p 63) uses the concept of "closure"; he understands it as the "phenomenon of observing the parts but perceiving the whole." Closure is what allows a reader to fill the gap between two panels in a comic or a viewer to transform the separated frames of a movie into a continuous movement. Closure also allows people to understand what is represented in a picture or to read words. It refers to the action of completing something as well as the feeling that something has been completed, or understood. So the capacity to perform closure is essential to any affordance of understanding. For example, if you can read these three sentences, you are making several closures, two of which are wrong:

- "This is closure"
- "Tihs is clo sure"
- "Tihs is colsure"

Closure may be applied to the type of learning I described but it does not bear a notion of missing something. On the contrary, the word "ellipsis," which consists of the omission of some elements, does bear the notion of omission. This omission is made by the author to allow closure from the reader. But while completing what she or he sees, a reader may also omit some elements while thinking that she or he has correctly understood everything. It is what I did on each level before the fourth level of understanding. I built a comprehension using the elements I had and thought I did understand the affordances offered by Linn's gun. Further learning proved to me that I effectively made several ellipses and then was wrong about these affordances. The phenomenon of understanding something while omitting some elements may be called "elliptical closure".

To perform an elliptical closure, one has to give a meaning to something and think she or he has understood this phenomenon while having neglected a part of it. Raphael Koster (2004, p 12-33) considers the pattern of a situation as what we understand of it. As for him, people are "amazing pattern-matching machines" that "tend to see patterns where there aren't any." He states that our brains have the following properties:

- The brain is good at cutting out the irrelevant
- The brain notices a lot more than we think it does
- The brain is actively hiding the real world from us

These properties have an influence on the way our brain applies a pattern. We may see a pattern where there is none and we may not see elements that do not fit in the pattern we see. The properties of our brain result in our capacities to perform closure and ellipsis at the same time. Let us take the example of elliptical closure concerning the way Linn's gun works. Please consider the following figure:

Figure 1: Linn Kurosawa and four possible targets.

Readers may know a lot about her gun's mechanism now. But do they know what would happen if she shot in this position? If one has not played the game, or at least seen it, chances are one would not know the four targets would be touched. When Linn fires a burst of bullets, first she aims at the ground just in front of her, and then she raises her gun to touch more distant targets. This detail was omitted on purpose; if readers did not ask themselves how she actually fires, then an elliptical closure made them think they understood how shooting works with this character.

The gun's mechanism has properties allowing elliptical closure. Such a mechanism could be called an "elliptical mechanism". It would have several levels of understanding leading to different perceptions of the affordances it offers. Each level would rely on a closure which would make the player believe she or he has understood the mechanism and an ellipsis which would make her or him ignore some parts of it. Thus, an elliptical mechanism could be understood roughly or deeply. Due to the capacity to perform elliptical closure, a rough understanding would not prevent the player from thinking that she or he has correctly understood the mechanism. Elliptical learning, resulting from elliptical closure, would be afforded by elliptical mechanisms and the player's capacity to realize an elliptical closure.

ELLIPTICAL LEARNING

The study of a specific mechanism in a specific great video game led us to the concept of elliptical learning. We have seen the four levels of understanding one single mechanism may have. It may be learned quickly, but it does not require a lifetime or even years to be mastered. However, there is more than one mechanism in a video game; shooting is only one of the possible actions. The mechanisms managing movement or fighting may also be elliptical and each enemy may have an elliptical behavior. Thus they could all provide an elliptical learning. The interaction between all of them may make the game even more complex. At the same time, a rough understanding would remain fast to acquire. All these causes may explain how one can think that a game can take a minute to learn and a lifetime to master. Such a game would make the player believe she or he has learnt it quickly while still overlooking a majority of it and therefore still having much to learn.

This changes the way we should look at great games. They do not take one minute to learn and a lifetime to master; it takes one minute for the player to believe she or he has learnt the game while it takes years to actually master everything that can be mastered. Thinking that you have mastered a game while you have not is an obstacle to learning. If a player does not think there is more to learn, she or he is not likely to look for it. Unless something shows the player how bad she or he is, further learning may not happen, especially if she or he is already able to finish the game.

To better understand elliptical learning, the next step would be to study further both great video games and expert players. Other great games could provide some other types of elliptical mechanisms. Comparing great video games to great non-digital games would highlight the very specific properties of the digital medium affording game designers to create this type of mechanism. On the players' side, it would be interesting to study how expert players are able to break their own elliptical closure in order to truly understand a game and whether or not the video game itself may have an influence on it. These properties and these capacities could lead to the discovery of unknown affordances of digital technologies. However, whatever is found will have to be related to engagement and then validated through empirical experimentations.

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