Assessing the educational potential of video games through empirical research on their impact on cognitive and affective dimensions

1. Research plan summary

In the last decades, the interest for video games has grown among children and general population, but also in academic research. A large body of educational research has investigated the potential of information technology as tools for learning, and particularly of games specifically designed for educational purposes (edutainment). Recently, a growing interest has appeared for the potential of mainstream games for education (in or out of the classroom). The basic claim of this line of research is that videogames may have beneficial educational impacts (Prensky, 2005), but few empirical findings reinforce this assumption.

On the other hand, the psychology research has investigated the effect of video games in two directions: A first body of research aims at measuring the effect of playing video-games on cognitive abilities (perception, visual attention) and on development and personality (particularly aggressive behavior). A second body of research has appeared recently within the theoretical framework of the multimedia learning community, in which content-based video games are considered as a particularly interactive multimedia instructional material. In both cases, the video game is used as a particular task or material but its specificities are not taken into consideration. The effects of playing video games on cognitive and perceptual abilities, emotional responses and knowledge acquisition have appeared in the literature, but they remain very disparate and inconsistent. Moreover, despite the formal differences, the psychology research has never compared the effects of different types of games on the developed assessments. We claim the research on video games is in need of a conceptual and methodological framework in which results could be compared, interpreted and generalized.

On the basis of both the education and psychology literature on video games, the objective of this project is to propose a methodology to experimentally assess two hypotheses: **First, playing video-games on a regular basis affects cognitive, perceptual and metacognitive abilities as well as emotional responses. Second, games can be categorized as a function of the specific abilities and dimensions they affect.**

The research plan is constituted of two phases. In the first phase, a meta-analysis of the literature will provide a set of dimensions that were found to be affected by playing video-games. The sensibility of these dimensions will be assessed within our population in an experimental study comparing video game players and non video game players. In the second phase, a categorization of video games as a function of the dimensions they are expected to affect will be elaborated and experimentally tested. Participants (secondary school students) will be asked to play one game on a regular basis for one month in order to investigate whether each category of game differentially affects specific cognitive and affective dimensions.

2. Research plan

2.1. State of the art

2.1.1. Understanding the effects of playing video games

Despite video games is a relatively recent research topic, its success among academics follows the general public interest. Since 30 years, social and computer science researchers have included games in their general problematic. The result is an extremely lively community but also a lack of common references and very heteroclite studies. The last published volumes and reviews show a strong academic interest from human and cognitive sciences (Raessens & Goldstein, 2005; Wolf & Perron, 2003). Most psychology studies focus on assessing the effects of video games on the user or using video game like tasks to manipulate desired factors. However, despite the first attempts to look back and regroup the multiple publications, the literature remains very disparate. Perspectives, methodologies and even definitions of games vary. Moreover games used in the studies can be very different but are still referred simply as “video games” or sometimes “action video games”. The term “computer game” is also very common and used to differentiate games played on a television, through a console from games played on personal computer. Today, very few studies make a difference between the two, and in this work we will always refer to them as “video games”.

2.1.2. Evolution of the media

A problem with video game research, as often with information technologies, is the quick evolution of the media over the years. Video game research is only a few decades old but meanwhile its object has changed a lot. As Kirriemuir & McFarlane (2004) reminded, it is hard to compare an early text-based adventure game with tomorrow’s high-definition first-person shooter. Some constitutive rules of games and their ability to catch our attention completely, called “immersion” (MacMahan, 2003), can remain comparable over the ages. But the games that people play today have diversified and evolved in a number of directions. The move from penny arcade video games to networked personal consoles and home computers modified our relation to virtual play. Advances in game design and ergonomics also made game designers adapt their products. The market evolved from a limited and specialised phenomenon to mass market strategies. The way people play has changed, and is still changing. Therefore, if past research determined the potential effects and use of video games we still need to understand what in a game can have an influence, and what can be done to use a game in a given way. If games can change the players this change could be targeted on serious purposes, like educational ones.

2.1.3. Video games to learn

Games at large, without computers, have always been strongly connected to learning and education. Today, the literature about traditional games for education rarefies in favour of its digital child. The potential of video games for education meets agreement of number of scholars. Several works on its theoretical existence have been achieved (Egenfeldt-Nielsen, 2005; Frété, 2002; Prensky, 2001).

2.1.3.1. Games for educational purposes

Educational video games started to be developed relatively early in the video game history. The obvious fascination of games and the power of computers to handle rules, interactions and feedbacks led to a growing interest. Very quickly, educational researchers and game developers started to investigate the potential of video games for education. The approach was to develop games that could teach contents or specific skills. In the eighties, the genres started to diversify (Willis, Hovey, & Hovey, 1987). Educational adventure games began to spread (*Snooper Troops*® in 1982, for problem solving or *Where in the world is Carmen Sandiego*® in 1985 for geography). At the same time, the later called *edutainment* titles came out. Based on behaviourist approaches, these games alternate educational challenges and reward or punishment reinforcements. The player is assumed to learn by doing exercises over and over again. With the video game market growing through the eighties, the edutainment genre also grew quickly. Egenfeldt-Nielsen (2005) argues that this growth was driven by business and market interests rather than by educators and real public need. Therefore, this genre became dominant in the educational video game world and pushed other types out of the market. In the nineties, educational games progressively loss their appeal. In particular, edutainment titles are now mostly targeted at young and pre-school children.

2.1.3.2. From edutainment to the potential of mainstream games for education

Educational researchers are more than ever very positive upon the educational potential of video games (Egenfeldt-Nielsen, 2005; Prensky, 2001). In a sense, the decay of edutainment titles left room for researchers to speak out about edutainment and the need for thoughtful and innovative educational games. Nevertheless, the academic interest evolved and adopts today a different approach. Instead of developing specific games for specific learning purposes, they investigate the potential of mainstream games for education (Kirriemuir & McFarlane, 2004). They show more and more that games developed solely for entertainment purposes are not short of educational potentials. Gee (2003), mainly by analysing mainstream video games, picked out 36 principles of learning which, he argues, are build into good video games. These principles, such as multiple routes to progress or the distribution of knowledge among artefacts, could inspire education and reinforce contemporary learning theories. But they also illustrate quite strongly the complexity of what any video game can bring to the player. Gentile & Gentile (2005) demonstrate how several well recognised learning techniques are present in violent video games.

Over the last decade, the educational boards gradually realised the importance of computer literacy and informational technologies for contemporary education. A number of studies have been commissioned, and video games have not be left apart. McFarlane, Sparrowhawk, & Heald (2002) leaded a large study in twelve primary and secondary schools of the United Kingdom. The goal was to collect data on the presence and use of video games in education. Teachers, parents and pupils were involved in the study and several types of games were used in classrooms. Their main conclusions go strongly in favour of a potential for mainstream video games in education, and furthermore in classroom environments. But not all genres of games are concerned, and their role should be to support learning outcomes. They address some issues like the need of accuracy in content: consistency with reality, correct simulations of phenomenon and accuracy of historical facts. Efficient information from the game developers should also be available for the teacher. Knowing more exactly what is involved in the game; which contents are presented and how it can affect the player would help the teachers

integrating video games in the classroom. As noticed by Larose, Bédard, Grenon, & Palm (2005), games not produced as didactical software and calibrated for school purposes will hardly be adopted by teacher who will not see their potential usefulness. The Canadian research fund is currently funding large surveys and investigations to bring these games to the teachers by understanding precisely their effects and potentials and transfer them for classroom use.

McFarlane et al. (2002) distinguish three potential uses of video games in a classroom environment:

1. Developing skills and abilities: from specific skills like deductive reasoning or memorization, to more contextual ones like co-operation and communication skills, the authors draw up a list of potential developments through games, with integration in a classroom setting. These are **cognitive abilities and skills.**
2. A stimulus for learning: the game sessions can be used as a starting point for other activities such as creative writing or charts analysis. These are **affective and motivational aspects.**
3. Content related learning: possible but can be very peripheral. Moreover, content in the game can be presented in a very different way as it is in the classroom. Simulations remain the games with the greatest potential to directly teach content, but the accuracy of their driving models has to be irreproachable. These are **knowledge and content learning.**

2.1.3.3. Different types of games

From an educational point of view, the choice of the game is very important since it is a learning material. Any game will not necessary be appropriate for the teacher's objective. To choose the good one, it is necessary to classify games in a number of categories. Besides, this has been the first move of number of studies. Kirriemuir & McFarlane (2004) underlines the absence of a standard categorisation and chose, like Orwant (2000), the Herz (1997) system, in eight categories (action, adventure, fighting, puzzle, role-playing, simulations, sports and strategy games). Other works on the educational potential of video games are also categorising video games (Egenfeldt-Nielsen, 2005; Frété, 2002; McFarlane et al., 2002; Prensky, 2001, 2005). The classifications employed vary widely in the number of categories and in their ability to differentiate games. Nevertheless, an underlying idea is common to all the works: All video games are not equal, particularly in an educational setting. If an efficient classification of video games is awaited for years and do not enter in the scope of this research, a classification of games for educational use is one of our objectives. Larose et al. (2005) suggest an analysis of a wide distribution of games in order to make it possible for teacher to efficiently use them as tools in the classroom. Kirriemuir & McFarlane (2004) also recognise the actual importance to better understand the potential and diversity of these new tools. They also ask for an involvement of the game development industry to better fit in the multiple constrains of educational context. Teachers and educational researchers need to differentiate games on the basis of their potentials for learning, and the classification we aim to develop will respond to this need.

2.1.4. Psychology research on video games

Studying the effects of video games, lead to ask what dimensions of the game experience can affect the cognitive abilities. Gentile (2005; Gentile & Stone, in press) defined four independent dimensions: amount, content, form and mechanics. The *amount* refers to the time spent playing video games and the habits of play. This leads to considerations about video game addiction. *Content*, refers to effects of the messages carried by the video games as a media. Studies about games having an effect on behaviours, skills and attitudes typically enter in this dimension. Effects can be studied as negative, like violence and aggressiveness change, or positive like health promotion (Lieberman, 2001). *Form* refers to a kind of knowledge of the media. For example, the constant need to scan the screen in action games could improve some visual attention skills. Realism issues are also contained in this dimension. *Mechanics* refers to mechanical input-output devices used. Immersion in the game would be different depending on the interface, the results in effects or learning could follow. Nevertheless, finer definitions can always be found. Inside of what Gentile (2005; Gentile & Stone, in press) call *content*, one could differentiate the effects on several supplementary dimensions, already enumerated from educational research needs:

- **Cognitive abilities and skills**: work of researchers in perception and attention (Green & Bavelier, 2003; Greenfield, deWinstanley, Kilpatrick, & Kaye, 1994; Kearney, 2005)
- **Affective and motivational aspects**: Like the current works on aggressiveness and hostility (Anderson & Bushman, 2001; Durkin & Barber, 2002) or motivational issues (Mortensen, 2003; Yee, 2005).
- **Knowledge and content learning**: addressed by educational psychology studies (Mayer, Dow, & Mayer, 2003; Moreno & Mayer, 2005; Sims & Mayer, 2002).

These three categories are to be taken as examples, since multidimensional approaches of video games study are only to appearing now. Nevertheless it is about time to see the first attempts to regroup the number of psychology studies involving video games published the last decades.

2.1.4.1. Cognitive abilities and skills

In five experiments, Green & Bavelier (2003) assessed regular action video game players with several tasks such as the flanker compatibility, enumeration performance, attention over space and attention over time. Regular action video game players always performed better at these tests than non video game players. The increase of performance seems induced by the activity of playing an action video game, since in another experiment, a control group played *tetris*® and the experimental group played *medal of honor*® for ten days (one hour a day). Afterwards, the experimental group performed better at several of the same tasks than the control group. Nevertheless, in other studies, *tetris*® was used as the experimental setting, and changes were observed. In two experiments, Okagaki & Frensch (1994) asked students to play *tetris*® for half an hour a day during twelve days. Their improvement at six spatial performance assessments, four of which were taken from French, Ekstrom, & Price (1963), were measured. The results indicated improvement of mental rotation time and spatial visualization for *tetris*® players. Important gender differences, favouring males, were also obtained on complex mental rotation tasks. More recently, Sims & Mayer (2002) demonstrated the specificity of spatial expertise obtained by playing video games like tetris. In their setting, experienced *tetris*® players outperformed non-players at mental

rotation tasks, but not at a series of other spatial ability tests. In a second experiment, female students played twelve one hour sessions of *tetris*® and showed the same gain than control group on the spatial ability tests. They concluded that if a spatial expertise can be gained by playing *tetris*®, it is likely very domain specific and could concern only specific representations, (here *tetris*® shapes).

Using different video games (*marble madness*® for the experimental group and *conjecture*® for control), Subrahmanyam & Greenfield (1994) reported some improvements in the dynamic spatial reasoning abilities of eleven years old children. The genre was an issue as boys benefited more from the video game than girls. But initial visual ability turned out to determine the influence of the playing sessions: participants highly skilled in spatial reasoning showed no gain with the action game or the control game. But low skilled participants who played the action game for three sessions of forty-five minutes significantly improved at the post test. The list of studies assessing different cognitive aspects of participants is still long. The methodologies are rather comparable, they either compare regular video game player to non video game players on several tests, or they establish a pre test-post test paradigm and ask participants to play in between. Depending on studies, control groups do not play and sometimes play a game considered to have no influence. Green & Bavelier (2003) asked their control group to play *tetris*® while Sims & Mayer (2002) found effects of playing *tetris*®, both assessed perceptual abilities.

If the methodologies themselves are solid, the applications differ. The games and populations are rarely the same from a study to another and the duration of playing sessions are also variable. Moreover, the conclusions are not always in favour of an improvement of the capacity for video game players. Genre and initial abilities could be an issue but also certainly the type of video game involved in the experiment. We listed here researches about perceptive abilities, however other abilities have to be integrated. Meta-cognitive abilities, for example, could play a role (Veenman, in press), as problem-solving tasks have been investigated (Dempsey, Rasmussen, & Lucassen, 1996). Integrating psychological research in this topic would lead to a fundamental question in this project: what are the characteristics a game needs to be a factor in the change of cognitive and perceptual abilities? The reverse question is: what can a given game potentially change in the player's cognitive and perceptual abilities?

2.1.4.2. Attitudes, aggressiveness and motivation

Studies investigating affect (and even behavioural) change such as the influence of video games on aggressiveness and hostility have been numerous. Recently the American psychological association issued a *resolution on violence in video games and interactive media* (Williams & Skoric, 2005), recognizing multiple negative influence of these media on players, especially younger ones. This can be a very important issue since in 2001, 64% of E-rated[1] video games involved intentional violence (Thompson & Hanninger, 2001). The social learning theory would predict a promotion of aggressive tendencies through violent video games (Bandura, 1986). But on the other hand, the catharsis theory would predict a channelling of latent aggression in the player

[1] Rated by the American entertainment software rating board (http://www.esrb.org) as suitable for everyone (six years and older).

(Feshbach & Singer, 1971), and therefore video games would have a positive effect on this dimension. Griffiths (1999) reviews twenty-four studies using different methodologies to examine the relationship between video games and aggression (self-reported aggressiveness, experimental or observational studies). Only studies using observation of very young children's free play concluded to a potential increase of aggressive behaviours. The author also underlines the many different types of video games and the difficulty to define "violence" and "aggressiveness", especially with the evolution of technical capabilities over the years. Another larger meta-analysis across 54 studies, suggests that playing violent video games increases aggressive behaviour and several hostility factors in children and young adults, male or females (Anderson & Bushman, 2001). Anderson & Dill (2000) moderate the results since initial hostility trait may influence the effect of playing violent video games, but also found negative effect on academic performance of game play in general (not only violent video games). Gentile, Lynch, Linder, & Walsh (2004) also showed that adolescents more exposed to video game violence were more hostile, got into more arguments and fights and performed more poorly in school. Goldstein (2005) critically reviews the literature about video games and aggression. He asks why and how people play violent video games as no one is forced to, except in a laboratory. The effects of video games on emotional aspects are clearer day by day. The studies presented here refer mostly to aggressiveness and hostility changes, but motivational aspects and investment are also to take into account. Like motivation of play (Yee, 2005), video game addiction (Griffiths & Hunt, 1998), the flow of optimal experience (Csikszentmihalyi, 1992) or emotional appraisal (Van Reekum et al., in press). What makes someone play and keep playing and how it influences motivations and investment for other activities, is a strong question asked today. How the motivation induced by mainstream video games can be used for educational purposes, is one of the questions we ask in this project.

2.1.4.3. Knowledge and content learning

Psychological research on comprehension and learning from multimedia contents is an active research domain (Rouet, Lowe, & Schnotz, to appear). Recently multimedia research has begun to focus on more interactive devices, though the attempts to investigate the effects of the video game media are scarce. Moreno & Mayer (2005) asked college students to play an interactive multimedia game designed to teach botanic. Different learning conditions were proposed and the study underlined the importance of guidance for retention and transfer of learned knowledge. Positive aspects of interactivity were found but on specific conditions. The game used was a quiz-like multimedia simulation and could more be compared to an edutainment product than a mainstream video game.

In order to study the learning potential of games, Rieber, Tzeng, & Tribble (2004) used a computer-based interactive simulation to teach Newton laws to adults. Delivery features like the modality of feedbacks (animated graphics or numeric displays) or the presence of brief multimedia explanation were experimentally investigated. Results are in favour of graphical feedbacks and explanations to improve comprehension and retention of the material. Rieber & Matzko (2001) present several simulations as activities to learn physics. They discuss the importance of "serious play" as a design goal for active and meaningful engagement by the students. They show that without multimedia explanations, the content from the game is not remembered. If these studies are very valuable and add to the understanding of the field, they are not really using games. They start from the multimedia learning field, and often add interactivity as a new dimension. Video games developed for educational purpose or mainstream games are not simply interactive multimedia explanations.

2.1.5. Conclusion

In summary, a large body of research aimed at assessing the effects of games on several effects, competences and abilities. But this review is not exhaustive and needs to be completed: numerous studies inspect general problem-solving abilities (Dempsey et al., 1996; Egenfeldt-Nielsen, 2005), feeling of presence and immersion (Lombard & Ditton, 2000; Witmer & Singer, 1998), or appraisal and emotion manipulation (Van Reekum et al., in press). Often studies start from their field, with their techniques and paradigms. Most of them used video games (or game-based tasks), as new paradigms for their research area. This can explain the lack of common views and definitions on games from the cognitive sciences. The specific field improves, but the comprehension of video games at large remains clustered and highly dependent on the specific game or task used in the experiment. Washburn (2003) reviews twenty years of psychological research on video games. He identifies three major problems: first, the lack of control, for the experimenter, over all the variables that can affect performance. Second, these paradigms can increase the complexity by addition of new variables (like attention scanning demands for example). This can complicate the analysis of the variable of interest. Therefore the significance of laboratory work as opposed to real world situations is questioned. Third, as games are designed for entertainment purposes, it can be hard to make them recognise as a valid task on several research areas.

A multidimensional approach is strongly needed today in the video game research community. One clear advantage, formulated by Gentile & Stone (in press) is to move beyond the public and scientific dichotomous view on video games, seen as *good* or *bad*, depending on the study. Multiple dimensions are of course to take into account. And if current research worked a lot on different aspects of games, we need now to gather the finding in order to get an informed point of view. We are asking what a given game can do and change in a player's mind. This is a different approach since most of literature until now asked to what extent a given change is influenced by playing video games. Stating that different types of games have different potential on learning is trivial and educational researches went straight to identifying the potential of each category. But cognitive and psychological research never really compared different types of video games on several dimensions. And this is precisely the point this project is aiming at.

We argue that video games can have multiple influences on players and that these influences can be used as educational potentials. The aim of this research is to create an empirically-based classification of games depending on their potential effects for educational purposes. In order to reach this objective, we designed two research phases. The first one will focus on identifying and verifying the pertinent dimensions of video games effects, which are potentially interesting for educational purposes. The second phase will focus on defining a classification of games based on potential educational uses; and to empirically verify the different effects on video game players.

2.2. Related research of the applicants

Learning with computer supported multimedia materials is the major area of investigation of the applicant of this project. Topics of interest include spatial integration of text and picture information (Bétrancourt & Bisseret, 1998), sequential display of graphics (Bétrancourt, Bisseret, & Faure, 2001) and computer animation (Bétrancourt, 2005; Bétrancourt & Tversky, 2000; Tversky et al., 2000). Computer animation has been particularly investigated by the main applicant and Cyril Rebetez (candoc applicant in this project) in the last two years thanks to a SNSF grant currently in progress (project CLEAP #11-68102.02, October 2003 – March 2006) in collaboration with Pierre Dillenbourg (main applicant, Craft-EPFL) and Mirweis Sangin (Craft-EPFL). In a series of experiments, we investigated the conditions under which continuous animation can be beneficial to learning over studying series of static graphic. Two factors were explored: the learning setting (collaborative or individual) and the interface delivery features (control over the pace of animation and presence of memory aids). One of the main results is a beneficial effect of animation for learners studying in pairs but not individually (Rebetez, Bétrancout, Sangin, & Dillenbourg, 2005; Rebetez, Sangin, Bétrancourt, & Dillenbourg, 2004). This finding reinforces the claim that computer animation causes an illusion of immediate understanding and is often processed at a surface level (what Lowe (2004) called an underwhelming effect). In order to foster the cognitive processing of instructional materials, one possibility is to increase the level of interactivity with the device. Consequently, the multimedia research has started to investigate interactive form of multimedia presentation, and particularly instructional material embedded into games (Mayer et al., 2003; Moreno & Mayer, 2005; Rieber et al., 2004).

Nicolas Szilas (academic applicant in this project) is starting at Tecfa in March 2006 (MER). His current research project explores the frontier between game and narrative. While most commercial games contain narrative elements, the way these elements are integrated into the gameplay is trivial. The story serves as global setting in which interactivity occurs, but the user's actions do not significantly influence the story itself. Narrative is a fundamental way knowledge is structured and the possibility to interact with a narrative opens new perspectives in the communication between Human and Computer. The project consists in finding and implementing experimental games allowing the player to modify the storyline through his/her actions. Algorithms based on the simulation of narrative laws are used, in order to provide the player with a large range of actions while monitoring the narrative nature of the experience. Applications of the project include interactive entertainment and educational technologies.

Cyril Rebetez (candoc applicant in this project) also wrote his master thesis for the DESS STAF on the FNS CLEAP project (Rebetez, 2004). He is actually writing his master thesis for the DEA in cognitive and experimental psychology, of Geneva, in which he further investigates the effects of individual differences, such as visuo-spatial skills, when processing multimedia content extending finding reported in papers previously mentioned (Rebetez et al., 2005; Rebetez et al., 2004)

2.3. Detailed research plan

Our research is aimed at understanding the potential uses of mainstream games for education and learning from an empirical perspective. We will focus on three dimensions of effects capable to be used with educational purposes: cognitive abilities and skills, affective and motivational aspects, knowledge and content learning.

In order to confirm the positive effects of video games on these dimensions, we designed a research project in two phases.

- **Phase one:** what are the cognitive and affective dimensions that are affected by video-games?
    - **1a:** definition of the dimensions affected by playing video games on the basis of a review of the psychology literature and a meta-analysis of the relevant studies.
    - **1b:** empirical verification of the sensibility of these dimensions on regular video game players as opposed to non-players
- **Phase two:** which kind of games are bringing the desired effects.
    - **2a:** create a classification of video games on the basis of their potential effects for educational purposes on the basis of a review of the literature and meta-analysis of the relevant studies.
    - **2b:** empirical verification of the presence of the awaited effects after playing a game from a specific category.

2.3.1. Phase 1: Dimensions of video game effects for educational purposes

Duration : 1 year

This phase will consist two parts: the first will mainly consist in literature review, gathering of tests and interviews construction. A meta-analysis will allow us to clearly identify the aspects on which video games can have an effect, in an educational setting and purpose. The second part will focus on verifying the presence of the effects on regular video game players and non players.

Part 1a: Definition of the dimensions from the literature and empirical studies

This work will consist in literature review, mainly psychology research, on the effects of video games. The effects pertinent for educational use of video games will be selected and be part of a meta-analysis with the objective of defining dimensions of effects. This work involves both theoretical readings and empirical results from the literature. At the actual state of the project, three principal dimensions of potential effects have been defined:

1. **Cognitive abilities and skills:** the effects of games on specific cognitive skills will enter in this category. The subcategories defined from theoretical works, could be the ones defined by Calvert (2005). She compares cognitive effects on perception, visual attention or representation and memory. This means perceptual tests such as elements from the French et al. (1963) battery (perceptual speed, card rotation test, cube comparison, form board test, paper folding test), computerized tests as the ones used by Green & Bavelier (2003) (flanker compatibility test, enumeration performance, attention useful

field of view and attentional blink) and other more classical tests such as rotation of two and three-dimensional shapes Shepard & Metzler (1971), or the corsi blocks (Milner, 1971). But other abilities have still to be investigated like meta-cognitive skills (Veenman, in press) for problem solving tasks.

2. **Affective and motivational aspects:** Hostility and aggressiveness is a strong subject on the actual literature but as we focus on potential educational other emotional dimensions can not be left apart. For example, extrinsic and intrinsic motivation for the game and the effects on more scholarly but related subject. Presence and immersion in the game also have a strong importance, like addiction issues.
3. **Knowledge and content learning:** Retention and transfer of content will be less studied in this first phase, because it depends strongly on the game played. This will be mainly studied on the second phase.

Part 1b : Verification of effects of video games play on the dimensions

This part aims to confirm the presence of higher abilities and skills on video game players (gamers) as opposed to non video game players (non-gamers). Moreover, genre will be included as a factor because it is referred as influent in several studies. In order to verify these claims, an experimental setting has been defined.

Method

Participants and design: Participants will be 60 adolescent in secondary school (Swiss post obligatory school). They will be assigned to one on the four experimental conditions (2x2 between subjects design). The first factor, gaming habits will oppose gamers to non-gamers. Participants will be selected in the first category if they declare at least four days a week and one hour a day for the last six months. And in the second one if they declare a rather nonexistent game experience in the last six months. Participants in between will not be kept in for the experiment. The second factor will be the genre of participants, half males and half females. All participants will be paid for their participation to the experiment.

Materials and apparatus: The tests will be regrouped depending on the dimensions identified in part 1a. At this point the battery still needs to be exactly defined, but it will consist of several tests, questionnaires and interview grids. Again, the dimensions will not cover every possible cognitive aspect but only the ones possibly involved in educational use of video games.

Procedure: Appointments will be taken with participants and tests and interviews will be held during sessions of maximum 45 minutes, in order not to exhaust participants.

Data analysis: Data will be gathered from the several tests and interview grids. Variance analysis will be used to verify our hypothesis. If a large number of tests have been selected in part 1a, we will use factorial analysis within our dimensions in order to extract the most significant ones. A compromise must be found between the precision of the cognitive assessment and the dimensions really relevant for educational purposes, in order to keep the number of tests relatively low.

Hypothesis: As most of the tests are taken from the video game studies literature, we expect to find comparable results. We will not list the entire hypothesis for all tests here since; first, they are not all selected yet and; second, we wait for similar results from the literature for every one of them. The most important claim here is that gamers should have different scores than non-gamers.

- Gamers will have different scores than non-gamers at the different tests from the dimensions selected in part 1a. Scores will be higher or lower for gamers, depending on the test, according to the literature.
- An effect of genre is awaited for several tests, according to the literature, particularly for visuo-spatial tasks in which males are usually found to perform better.
- An interaction between gaming habits and genre is to be awaited when the genre has an influence, as often genre hides up another factor (like spatial reasoning in Subrahmanyam & Greenfield, 1994).

2.3.2. Phase 2: Classification of video games in an educational perspective

Duration: 1 year

This second phase will identify different types of games as a function of their potential effect in an educational perspective. It will consist in two parts. The first one will focus on educational literature on video games to obtain a categorisation of games which can be useful for educational purposes. The second part will use the tests defined in phase one to compare the effects of a number of games from the categories identified here.

Part 2a: Definition of a categorisation of video games in an educational perspective

Categorisations of types of games are numerous and we are not aimed here to build another global classification. In order to present video games to teachers, we need to differentiate video games on dimensions appropriate to the use that will be made of them. The taxonomy has to reflect formal elements (theme, content, gameplay, …), but also potential cognitive and emotional effects of the game on the player. Current categories for educational use of video games are based on Prensky (2001) which includes almost twenty categories. This is clearly too much for practical use. Our categorisation of video games will be defined for the potential educational use and psychological effects.

A meta-analysis of the literature will underline to what purpose specific games have been used in education. A description of the games will then be used to identify what elements in the games are associated with an educational activity. Games sharing these elements should be potential materials for the same objectives.

Once the categories have been identified, specific games will be selected. Potential knowledge and contents learnable from these games have to be defined and a retention and transfer questionnaire will be developed. This will be used in part 2b in order to assess contents from these games.

Part 2b: Validation of the categorisation of video games for education

Categorisation of video game for educational purposes will be based on the potential effects of the video game on the learner. In order to validate the classification of part 2a, we developed an experimental setting.

Method

Participants and design: participants will be 180 adolescents in post obligatory school; all reporting no or very few video game play during the last six months. The exact number of participants may vary depending on the number of categories identified in part 2a. They will be assigned to one on the several experimental conditions (2x? between subjects factorial design). The first factor will be the genre of participants, half males and half females. The second factor will consider the category game participants will be asked to play on a regular basis.

The exact number of categories is not defined at the moment since it will be defined in part 2a, but we expect it to be five at the most. All groups will be playing a given game from a specific category, except the last group who will not play any game and will serve as a control. All participants will be paid for their participation to the experiment.

Materials and apparatus: The games used will be selected on the basis of their appurtenance to a category defined in part 1a. Moreover, actual mainstream games will be chosen, not specifically designed for learning purposes. The assessment will consist in the tests and questionnaires developed and tested in phase one.

Procedure: Participants will firstly be assessed with the tests developed in phase 1 plus the knowledge and content acquisition questionnaires from part 2a. Depending on the number of tests and questionnaires in the assessment phase, a Latin square design may be used. They then will be affected to one of the experimental conditions; depending on personal characteristics for the genre, and at random for the game to play. Participants will then receive the game to play (or nothing at all for the control group), and will be asked to play the game regularly (at least 7 hours a week). Effective game play will be monitored and participants will be asked to avoid playing other video games. After one month of play, participants will be assessed again using the same battery of tests. If several testing sessions are necessary, participants will be asked to continue to play at the same rate. The order of the tests in the sessions will always be randomized. Participants will be asked to stop playing the given game. A third session of test, following the same procedure will be planned three months after.

Data analysis: A multiple analysis of variance with repeated measures will be used to process quantitative results from the tests. Effective time played will be used for covariance.

Hypothesis (can evolve depending on the categorisation of games issued in part 2a):

- Because change in abilities and attitudes comes from the game and not from initial personal differences, participants playing a game will have different results to the second assessment, whereas control group (not playing any game) will not.
- The effect of playing on each dimension will depend on the type of game played. More explicit hypotheses will be expressed when the classification of games is ready.
- No effect of genre is awaited between the different games, but an effect of genre on the dimension tested can be observed. So, if a game has an effect on one of these tests, an interaction with the genre may be observed.
- Effects are expected to be robust and will still be present at the third assessment, three months after the end of the game sessions.

2.4. Detailed schedule

Phase 1: Dimensions of video game effects for educational purposes			**Phase 2: Classification of video games in an educational perspective**		
may 06-sept 06	sept 06- march 07	march - may 07	may 07-aug 07	aug 07- feb 08	feb 08-may 08
4 months	6 months	2 months	3 months	6 months	3 months
Part 1a and preliminary experiments of part 1b	**Part 1b** : design, running and analysis	Redaction and publications	**Part 2a** and preliminary experiments of part 2b	**Part 2b**: design, running and analysis	Redaction and publications

2.5. Importance of work

The meta-analysis of the empirical literature effects on video games, with an educational point of view (part 1a) will be the first one looking at psychological studies on video games with this particular questioning. Defining pertinent dimensions of video games effects for educational purpose is still lacking. A growing literature asks for multidimensional approaches and a more global approach in this field.

The part 1b implies an empirical testing of the identified dimensions on video game players and non video game players. By replicating several results from the literature, with a common methodology and procedure, we expect to confirm them. This alone is presently missing in the literature. Moreover, the defined theoretical dimension will be validated and could be used in further studies. Such empirical verification will also support the current interest for the multiple dimensions of effects of video games use.

In part 2a we will review the educational literature and produce a classification of games for educational purposes. Again, no meta-analysis has been issued to differentiate games based on their theoretical educational potential. This approach is both innovative and awaited since its aim is operational. We do not aim a universal classification of video games; we seek a classification suitable for teachers and educational scientists. A classification of video games, not based on formal differences, but on effects and potential uses for educational settings.

In part 2b, we plan an empirical verification of the differential effects of games issued from different categories, thus verifying the pertinence of our classification. Further educational research will then be able to assess the relevance of the game classification in real classroom studies. Moreover, the experimental methodology is designed to verify that the effects on the dimensions are due to game play and not to artefacts (like initial player's abilities). This result will reinforce the findings showing a change on several dimensions after video game play. Providing efficient categories to differentiate and understand video games will also help answer the educational practitioners' (and general population's) expectations to better apprehend their effects.

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