VIRTUAL AND REALITY: THE NUMERICAL BOUNDARIES. ANALYSE OF TWO INTERACTIVE AND TOTAL IMMERSIVE DEVICES WITH HEADSET (360° VISION).

The aim of this article is to reflect on the notion of a boundary as a tool to establish correspondences between the artificial situations that only really exist in the doings of an individual and the manner in which one represents the real world through tangible situations, be they symbolic or tangible. Our study analyzes two 3D interactive and total immersive devices and the boundaries between reality and virtual in an organization. For this, we study the numerical boundaries by analysing two interactive; total immersive in synthesizes images devices with a 360° view of the environment.

Keywords: numerical boundaries, total immersive and interactive devices in synthesizes images

Introduction

Today's numerical environment implies more than a simple adaptation to technologies. It is an amplification of the senses through which man comprehends the environment around him, both verifying and expressing his perceptions. The constant availability of personal information and its distribution from one continent to another is changing our social and/or moral principles. It is standardizing the manner that societies function through the normalization of exchanges from one culture to another, the perception and transmission of values. On the other hand, it is exacerbating ideologies and convictions.

From now on, the question will be to know if technologies are contributing to the real development of man and if they are helping him and peoples to understand and embrace their future – a future that can no longer dissociate itself from the numeric environment and puts into question the boundary between real and virtual. However, is a boundary between these two environments still necessary? Are there still checkpoints that link both types of perceptions and create a new one? Will controlling this boundary provide a future that is a logical, continuous and foreseeable extension of the past? In other words, will what we know in the real enable us to reasonably and logically extrapolate what we will do in the virtual?

The aim of this article, without claiming to have the answers to these questions, is to reflect on the notion of a boundary as a tool to establish correspondences between the artificial situations that only really exist in the doings of an individual and the manner in which one represents the real world through tangible situations, be they symbolic or tangible. It is a tool that makes it possible to exploit the differences between "what I know" and "what I want to discover", a tool that sometimes expresses itself in intelligible terms and is perceived by our senses, sometimes in sensitive terms and is perceived as being more or less real through our thoughts. The boundary is therefore first an idea that produces in our minds the order and composition of a space. It reveals the principles and values that go beyond the nature of relationships and objects in each space by giving them a sense.

We studied two interactive (functional and intentional interactivity) and immersive (technical and psychological immersion) devices with a personal 3D viewer (360° vision and environmentally ego-centered) and their effects on the explicit long-term memories of the subjects (4 groups of 30 students for a total of 120 subjects) (Lombardo, 2007 and 2012).

We have tested memory, communication and feeling of presence in our virtual environment with a canonic test of presence (Witmer and Singer, 1998). In our first experiment (Lombardo, 2007), the results showed that there was no improvement in mnemonic performances compared with other types of media (PowerPoint classes without taking notes, with the taking of notes and a lecture class with no other medium). Our second experiment (2012) used a total-immersion device with the ability for the subjects to share their emotions and sensations through a network, results in progress). This article is a reflection on numeric boundaries, values and principles through these two experiments.

Hybridization and boundary

From its etymological origin[1], the term "hybridization" evokes a fecundation that does not follow natural laws. It is the act of cross-breeding two different species or genera in order to provoke the creation of hybrids which present, to a more or less marked degree, the specific characteristics of both parents.

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1 From the Latin hybrida: "mixed blood"

Its application to numeric technologies supposes that the characteristics of the two environments can be found within the potentials of the boundary. Such hybridization of one environment with another can lead to "functional hybridization" in the etymological sense of the term when in both environments, one systematically intertwines objects, practices, values that refer to the two great founding ideologies of society. Functional hybridization requires a crossing of the applications, products and services offered by each of these environments. It can take several forms between two extremes: complementarity and substitution. For example, if one observes a friendly relationship, complementarity means that the friendship bonds in the real increase in proportions that are quite similar to those in the environment of numeric social networks. On the other hand, substitution corresponds to cases where a relationship replaces another. Thus, when one returns from a trip, numeric photos tend to replace analog photos.

The boundary also performs a "structural hybridization" when it elaborates, inside each of these environments, a social process that includes reciprocal interaction between the human players for the real and the human and non-human players for the virtual. This structural hybridization contributes in return to the structuring of the specific characteristics of each player.

The word boundary did not wait for the numeric environment to be polysemic. One can easily attribute several meanings. A river is a natural boundary. A wall is a tangible boundary. The boundary between two countries often follows an historical logic: the Brandenburg Gate was the symbol of the intangible and symbolic boundary between the East and the West as much as the Green Line that splits Jerusalem in two. Adolescence is the physiological boundary which separates a child from an adult… A boundary is therefore both a geographic and a topologic concept which delimits a country, but it is also psychological concept or a symbolic organization which moves dream closer to reality and can therefore be concrete or intangible. Be that as it may, the boundary goes beyond the notion of a "limit to" or an "opening on". It is represented according to values, intentions and representations.

In numeric environments, the boundary between tangible and intangible has been crossed since the emergence of symbiotic man (de Rosnay, 1995). Since then, virtual environments have attempted to favor the implication of the body in virtual experience and sought to make a connection between daily tangible situations and daily sensations (Potier, 2009 or Tisseron, Missonnier and Stora, 2012). From now on, it would be well-founded to know which symbolic or tangible forms can have a boundary or boundaries produced or questioned by a numeric environment. Beyond these boundaries are the stakes for mankind, for each person, for the relationships between people which must be put into question.

It is therefore the points of view of the person who goes back and forth through the boundary of numeric immersion that interest us. Knowing that one's round trips crystallize in the values that each person finds in everyday life and that every new boundary fits into those already marked by previous representations of spaces put together by the actions and perceptions of our predecessors. The greater the number of round trips, the more the boundary is soluble and the more it provides space for an immersion which can lead to immigration toward a virtual environment for geeks or towards the real environment for digital natives. Whatever the migratory direction, immersion today goes beyond the framework of technologies. For us, it is a reflexive and abstract concept which serves to guarantee the pragmatic character of the interaction between people and the objects in immersion (Besnard, Metge and Agostinelli, 2012). First, reflexive, because immersion serves to understand the

conditions of the action "before doing it" and in particular, it orients the action through the comprehension that it allows "what there is to do". Then, abstract, because it does not only refer to functional aspects but also to psychological aspects (emotion, intentionality…). The mixing of the reflexive and the abstract leads us to representations that people have of what they are or of what the numeric environment made of them through their avatars. When one knows the importance of self-representation in social or individual human development, one can also ask if there is a risk that self-virtualization will replace self-representation. Indeed, if self-representation is founded on the articulation of cognitive identity structures and subjective identity forms (Guichard, 2004), we can ask ourselves the following: on which articulation can self-virtualization be found? How can cognitive identity structures such as categories, diagrams, scripts, mental models, social representations, which enable a person to organize his/her vision of the environment and therefore build relationships with others, be implemented in an immersive environment? If subjective identity forms define a vision of others or oneself according to a determined identity framework (Guichard, 2004), how can these identity forms go from one side of the boundary to the other?

The option that we have retained for this article places hybridization between the real and the virtual through the concepts of interaction and immersion. Interaction can be functional or machinic. However, it can also be intentional on the human side. In the same manner, immersion can be technical but also psychological with the sensation of being present in a virtual environment. It can also be sensorial with mixed emotions in an immersion network.

Coalescence and dichotomy between real and virtual environments: beyond the boundaries

The virtual environment appears to be a "bridging notion" (Sfez, 1999) which for certain authors is either opposite the real (Deleuze, 1985) or opposite the actual (Quéau, 1993, Weissberg, 1992, 2005). These two dichotomic or symbolic sides of a same concept have engendered either a critical or even paranoid approach (Proulx, 2000) which tends to denounce the virtual either as an artificial reality or as a utopic approach (Proulx, 2000) with the virtual making an updating of a world of possibilities feasible. Bergson (1939) went beyond this dichotomy between the actual and the virtual through a concept linked to time from pure memory: the pure memory of a virtual state changing to an actual state, but by actualizing, keeps its virtual character which is attached to the past. Pure memory is therefore a virtual image of our past whereas the present is an actual image that has yet to be actualized. Gilles Deleuze (1985) took up the theses of Bergson (1939) to adapt them to a theory of cinematographic image which he exposed in *Image-Time* and *Image-Movement:* in the same way there is a correlation between the actual image and the virtual image in time through memory according to Bergson, for Deleuze, there is coalescence between actual image and virtual image in cinema. Actual image and virtual image therefore do not stop changing places through a "crystal" image and a "mutual" image to the point where they sometimes become imperceptible. Pierre Lévy has another way of establishing links between the actual and the virtual: for him, these two notions are "two manners to be together" (Lévy, 1995), and two sides that are perfectly reversible. Through its virtualization, actualization triggers a new virtualization, producing a passage from the interior to the exterior and from the exterior to the interior by what Lévy calls a "Moebius effect". This "virtualization" effect appears to affect all domains: Lévy refers to virtualization of the body, virtualization of the memory through writing, virtualization of text and reading through hypertext, virtualization of the computer through cyberspace, virtualization of the economy (virtualization of the market and

labor), virtualization of technology, language and art. Finally, Weissberg refers to hybridization between the real and the actual: here we are witnessing the creation of a "compact real-virtual", a sort of mix or hybridization between the two notions that create another form: "Virtual and real are two sides of the same question. The virtual does not replace the real; it helps to give it a meaning." (Weissberg, 1992, p.3).

As for our perceptions, the systems of virtual reality enabled Lévy to experience a dynamic integration of the diverse perceptive modalities and through them "we can almost relive the complete sensorial experience of someone else" (Lévy, 1995, p.26). This is the Moebius effect that Pierre Lévy referred to, a movement of deterritorialization and passage from the interior to the exterior, like turning a glove inside out, which leads to virtualization in several domains (private/public, proper/common, subjective/objective, author/reader…) (Lévy, 1995, p.22). This reversal from the interior towards the exterior and the exterior towards the interior is particularly in operation vis-à-vis the body of the spectator: "Each new device adds a type of skin, a body that is invisible for the actual body. The inside goes outside while at the same time staying inside because the skin is also the limit between oneself and the exterior."(Lévy, 1995, p.28).

Functional and intentional interactivity

The concept of interactivity is not new in literature review (Huhtamo), (2000). (Barchechat and Pouts-Lajus (1990) differentiated functional interactivity from intentional interactivity. Geneviève Jacquinot (2000) and Daniel Peraya (1999) resumed this distinction. In order to avoid confusions between the notions of interaction and interactivity which also designate the interactivity process as an intersubjective relationship between individuals, Geneviève Jacquinot (2000) distinguished several types of interactivity: 1) Functional, machinic and transitive interactivity which enables the user to interact with the program. 2) Mental, intentional and intransitive interactivity which enables the user to mentally react, hence, the difficulty to establish communication between the two systems. Functional interactivity is "the process of man/machine communication which directs the communication protocol between the user and the machine" (Peraya, 1999, p.156), whereas intentional interactivity is "that which directs the communication protocol between the user and the absent author, but is present through the software" (Peraya, 1999, p.156). For Weissberg (2005), the notion of interactivity is linked to that of action and observation and questions the classic notions of the spectator, the player and the representation. The interactive situation combines the action and contemplation and invents the notion of "spect-actor" which supposes there is corporal user implication. The "acting projective imaginary body" is the virtual body acting in a virtual environment and the "perceptive body" is the user's real body. Therefore, for Weissberg, interactivity does not refer to instrumental communication, but to both auto communication and metacommunication.

Immersion and the presence sensation in a virtual environment

The presence sensation in a virtual environment is sometimes mixed with that of immersion, but it is the psychological side, whereas the notion of immersion refers more to the technological side. The notion of "presence… is the psychological sensation of *being* in an environment whose technological base is the immersion" (Slater and al., 2001). Moreover, the immersive solution system does not necessarily include the presence sensation for the user (Slater and Usoh, 1993, Slater and al., 2001). Indeed, the presence sensation is not characteristic of Virtual Reality and could also be associated with other media such as cinema, literature, or theater. The presence sensation can therefore appear in a non-immersive environment. In an experimental study, Shubber (1998) demonstrated the existence of a

presence sensation during the playing of video games, considered as non-immersive virtual environments. The interactive aspect, user action on the environment and the action of images on their perceptions appear to be sufficient to provoke a presence sensation in the user and "the perceived image coupled with the action (is) sufficiently strong to make the player react and experience a presence sensation". The presence sensation therefore seems to be independent of the degree of immersion in the environment. In order to perceive the sensation of being present in an environment of virtual reality rather than in other media, Barfield and Hendrix (1995) distinguished "virtual" presence from presence in the physical environment: "virtual presence is generally conceived as being a subjective and hypothetical state of consciousness and implication in a non-present environment" (Barfield and Hendrix, 1995). The term telepresence is sometimes designated by some researchers as being synonymous with the presence sensation: "telepresence is defined as the experience of presence in a virtual environment…" (Steuer (1992). For Steuer, the term presence refers to the natural perceptions of an environment whereas telepresence refers to the mediatized perception of an environment. "This environment can be a non-existent animated virtual environment that is synthesized by a computer (for example, an animated world created in a video game)" (Steuer, 1992). According to Seipel, (2003) a virtual environment is considered in total immersion when the totality of the user's senses is called upon on the one hand, while on the other hand there is total immersion of each sense (even if this total immersion is seldom attained in practice), the environment is considered like non immersive when one uses a «desktop» display (Psotka and al., 1993). These are generally computer screens. According to Slater and Usoh (2001), in an **immersive** environment, the users have an:

- egocentric   view of the virtual world, that is, a view from the inside of the environment or of the phenomenon, as opposed to an

- exocentric view from the outside of the environment, where the user does not directly take part in the virtual world. For systems of these types, immersive technologies are used: data gloves, CAVE or HMD headsets, etc. Technologies of this kind allow visual immersion of the user in a virtual environment. In virtual environments, the user's interactions are said to be subordinated to four tasks, according to Fuchs et al. (2001), as regards functional interaction. The user's four tasks are: observe the virtual world, navigate in the virtual world, act upon the virtual world, and communicate. We can therefore describe the structure of our experiment as **an immersive, interactive structure, giving the sensation of presence**.

Boundaries therefore become more and more blurred between the real and the virtual through immersion and interaction which virtual and immersive technical devices enable. In this article, we will examine the ethical problems that such hybridization poses between real and virtual in the numerical world. We will begin by making an inventory of the different definitions of ethics in order to identify our meaning of this notion and attempt to define the ethical position of immersive technical devices.

Methodology

We created (Lombardo, 2007) five homogeneous groups of students (18 students per group in the second year of initial training, DUT (Diplôme Universitaire Technologique) of TC (Techniques de Commercialisation, IUT: Institut Universitaire Technologique.) at the IUT of Université du Sud, in the setting of our courses in the Psycho-sociology of Organizations), ninety students were tested. The content of this course was the same in the five groups:

1. An oral, media-based course: the course was dictated but the students did not take notes.
2. A media-based course in PowerPoint alone but without note taking. The images and the diagrams were the same as those that were used in the course in synthetic images.
3. A media-based course in PowerPoint, with note taking. The images and the diagrams were the same as those that were used in the course in synthetic images.
4. A media-based course in virtual imagery and synthetic images (3D, vision headset, total immersion).
5. A control group course, the pre-test and the post-test only.

We compared the five courses on:
- - The cognitive and memorial aspects (long-term explicit memory)
- - Identifying the different types of communications

We ventured two hypotheses:

H1: A course in virtual images allows a better memorization compared with other types of media-based presentations (auditory, PowerPoint without notes, PowerPoint with notes);

H2: the type of media-based presentation acts on the communication of course content and the students experienced the four types of media-based presentation differently.

For our first hypothesis our initial hypothesis was calling upon an increasing number of sensory modes which have made simultaneously possible the increasing performance of the long-term explicit memory of the information delivered by the didactic content (Paivio, double coding theory, 1986, and 1991; Paivio and Caspo 1969). As far as our experiment is concerned, we have tested long term / explicit memory. In fact, that is the form of memory at work when memorizing a course, even if learning brings several forms of memory into play. The result of our study showed that students did not have better memory performances in 3D virtual image course with HMD. It is the reason why we thought that these results could be explained by students' resistance to change.

Our approach combined:
1. A quantitative analysis based on hypothetical-deductive reasoning (first hypothesis) in order to analyse if an immersive 3D structure in the framework of our courses on the Psycho-sociology of Organizations would have effects on memorization and to test the sensation of presence in the course presented by means of virtual images
2. A qualitative analysis (second hypothesis) a) in order to understand how the students experienced the different communications situations across the four types of media-based presentation ; and b) to study the different types of reluctance face to change and the ambivalence of this concept.

For our first hypothesis, the differences in results obtained by the courses were calculated by variance analysis (Anova). We used a test T. of Student to test the sensation of presence in the virtual environment. The results of the Anova and the test T. of Student are exposed in this article.

For our second hypothesis, we did 18 interviews of 18 students who lived the course in virtual images with HMD. First, we expose our case study.

CASE STUDY: an immersive and interactive structure, giving the sensation of presence

We can describe the structure of our experiment as 1) an immersive, 2) interactive structure, 3) giving the sensation of presence.

A total immersive structure

Many authors have likened this term to a technical notion, which might act on the user's senses. Cadoz (1994) asserts that immersion is "a technology, an interface technique between man and machine and does not involve the psychological state of the subject". The physical immersion of a subject in a virtual environment is performed by sensory information (sight, hearing, etc.) alone.

For Pimentel and Texeiria (1993), immersion is "the state of a participant when one or more of his senses ... is isolated from the exterior world and he no longer registers any information that does not come from the computer".

Our structure was a total immersive structure because the students had a 360 degrees vision and an egocentric view of the virtual world.

An Interactive Structure

In virtual environments, the user's interactions are said to be subordinated to four tasks, according to Fuchs et al. (2001), as regards functional interaction. The user's four tasks are to:

1) Observe the virtual world
2) Navigate in the virtual world
3) Act upon the virtual world
4) Communicate

Observing the virtual world is a stage that allows us to prepare ourselves for other actions and that is necessary for understanding the virtual world.
Navigating, acting and communicating presume an action on the user's part. The structure of our experiment can thus be considered as interactive in the sense that it allows the user to perform these four actions.

A Structure Giving the Sensation of Presence in a Virtual Environment

The feeling of being present in a virtual environment is sometimes combined with that of immersion, but it forms the psychological aspect, while the notion of immersion refers more to the technological aspect. The notion of "presence" in a **virtual** world is "the psychological feeling of being there in the environment, of which immersion is the technological basis" (Slater and Usoh, 2001).

For our experiment, the students were equipped with:

A HMD (Head Mounted Display, that is, a Sony Glasstron LDI-D100B ruggedized vision headset (LCD screen, Resolution 800x600, non-stereoscopic, visual field 26° Horizontal, 19.6° vertical, headphones with stereophonic sound - see Figure 1).
A Tracker (movement detector) Intersense intertrax² (3 degrees of freedom, angular resolution: 0.02°, latency time 4 Ms: internal refresh rate of 256Hz), mouse buttons as navigation tools.
Software used: Unreal 2004, 3D Studio max, Actor X, PowerPoint.

The students were in total immersion, in an interactive structure giving the sensation of presence.

Figure 1 Head Mounted Display

The People Involved in the Project

Doctor Eric Malbos, physician and neuro-psychologist, who has elaborated a system conceived within a virtual environment in order to treat patients suffering from phobias by successive habituations. He created the storyboard of the course in virtual imagery, the animations and the course in virtual imagery.
A professor of Psycho-Sociology of organization who prepared a doctorate thesis (Lombardo, 2007) was the project leader.

A media engineering student from the University of Toulon and the South (Wallid), a specialist in synthetic images, has created, in the framework of a proficiency grant, the 3D images for the course in virtual imagery.

Figure 2 an example of the virtual environment seen by students

A way of verifying hypothesis H1 was to construct a quasi-experimental system that allowed us to vary the different dimensions of the Independent Variable (IV) and to create teaching structures each one of them corresponded to a mode of the IV that we wanted to test, that is the structure of the media-based presentation.

The IV has several modes: course 1 auditory, course 2 PowerPoint without note taking, course 3 PowerPoint with note taking, course 4 by means of virtual images in immersive 3D.
The differences in results obtained by the courses were calculated by variance analysis (Anova), and by a test T. of the Student.

Results

Anova results H1

- Group 3 (PowerPoint with note taking) is the one that had the clearest significant improvement in performance.

- By decreasing order of performance, group 2 came next (PowerPoint without note taking), then group 4 (virtual images), then group 1 (auditory) and last came group 5 (the control group).

Results of the test of presence H1

The results show that the students had a feeling of presence within the virtual environment of the course in immersive 3D.

Results of the qualitative treatment H2

The recurrent themes in the 4 groups (auditory, PowerPoint with note taking, without note taking, and by virtual images) were the following:

Theme 1: emotional

1) Positive emotional dimension: original universe/ environment; innovation/social network; funny.
2) Negative emotional dimension: unreal; "small lab rats".

Theme 2: physical

1) Positive physical dimension : sensation of presence in virtual environment
2) Negative physical dimension : discomfort/sick ; headache

Theme 3: cognitive

Positive cognitive dimension: simulation as a help in learning; simulation as a help in understanding the reality; experiment as a source of motivation
Negative cognitive dimension: no human aspect: learning boundaries

Theme 4: intentional

Positive intentional dimension: emulation to take the course in virtual image
Negative intentional dimension: technical aspects of virtual device

Conclusion

The aim of this paper was to study the numerical boundaries between reality and virtual by analysing two interactive, total immersive devices with a 360° view of the environment.

The numerical boundaries were identified in 4 points:

1) The results show that the students had a feeling of presence within the virtual environment of the course in immersive 3D. This feeling of presence is physical:

Ex: The course in virtual image has emerged as "a universe" (student 5V), a world", "virtual world" (Student 2V), "and thus we entered directly into a virtual world.

The physical immersion was felt by many students in the course virtual images, "I said through the headset and looking directly at the video, we felt really "in", like almost in the character. There was someone who was driving, which met after the questions, we were in the character, the main character, and it is true that I was fully integrated in this virtual world, I had returned"(Student 3V)"The sensation of moving the head, that was interesting" (Student 1V).

2) The interactivity of the device appears to be a factor of interference between reality and virtual ex: There is uncertainty between the virtual body and the real body (one action in the real world: action in the real world (e.g., turning the head to the right with the Headset) resulted in an action in the virtual world (e.g., move to the right).

3) The immersion was also factor interference between reality and the virtual ex: Students confused over the real and the virtual course in their memory.

4) Students spoke of the virtual course outside of the organization of the University, and the interference between the virtual reality has created a true emulation, a kind of fantasy and enthusiasm and motivation :

The course in virtual images caused an excitement and a kind of fantasy so that the students saw it as an imaginary being, a science fiction world, and «Because it was different. Because we were not in a lecture hall, 90, listening to someone speak. It's different. And I remember with one of my colleagues, we said we will have a helmet, we

will believe in "Back to the Future" in fact it was not like this story helmet, we had a good laugh about it" (Student 1PSN).

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