

# PsychNology Journal

*where do you feel you are today?*  
**PRESENCE**

Edited by

**David Benyon & Anna Spagnoli**

In cooperation with PEACH Summer School 2007

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# PSYCHOLOGY JOURNAL

## The Other Side of Technology

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## Editorial Preface

In July 2007 sixty people from thirteen countries met on the stunning island of Santorini, Greece to participate in the first Peach Summer School. Peach ([www.peachbit.org](http://www.peachbit.org)) is the coordination action for presence research established under the European Union's Framework 6 programme for research and development. The aim of Peach is to develop a greater understanding of presence research and to widen participation in the area. Four large integrated research projects on presence were also funded under framework 6. Peach aims to coordinate their actions and maximise the impact of their research.

The Summer School consisted of keynote talks, workshops and demonstration activities presented by experts in the field of presence many of who were members of the integrated research projects. Topics covered included some philosophical views of what presence is, artificial companions and social presence, mixed reality in urban environments, ethnography and the understanding of presence, virtual reality systems and fundamental aspects of physiology. Participants provided a poster for their work.

Following the Summer School, participants were invited to submit an extended abstract for possible inclusion in this special issue of PsychNology Journal, starting a process of expansion and revision that led to the four articles published in this issue. The first one, authored by Daniela Villani and Giuseppe Riva, is entitled '*Presence and Relaxation: A Preliminary Controlled Study*' and assesses the effectiveness of a VE designed to help stress management, in addition to investigating the relationship between such effectiveness and self-reported sense of presence. Four groups of users exposed to a relaxing narrative through different media are compared; the results add to an increasing corpus

of works on cybertherapy and presence, and raise the issue of the relative importance of content and medium. In the second article '*Practices to Display Social Presence: A Study in a Shared Mediated Environment*', Fabiola Scarpetta describes a qualitative, contextualized approach to the study of presence practices in a special kind mediated environment, a dyadic chat in a multi-user collaborative game. Thanks to the conceptual tools of conversational analysis, some phenomena are identified as particularly eloquent of the presence resources available in the mediated environment under observation. The next couple of papers are exploratory, yet insightful attempts to investigate novel phenomena such as community connectedness and presence in atom visualizations. Luis A. Castro and Victor M. Gonzales in their '*Being Part of the Life of One's Hometown: Strategies to Support Community Connectedness*' frame presence as an experience relating not just the migrant to important Others, but to his/her whole home community. The mediated Social presence in this case is not an actor's but that of a whole aggregate of actors. Finally, Assimina M. Kontogeorgiou, Joan Bellou and Tassos A. Mikropoulos, in their graphically enticing '*Being inside the Quantum Atom*', bring the readers into the fascinating field of educational virtual environments. In a first evaluation of the Quantum Mechanics visualization system they have built, the authors discuss the participants' statements on their sense of presence, and sketch some possible implications for learning.

In his introductory speech at the Summer School, Giulio Ruffini the Peach coordinator argued that presence stood at the intersection of human cognition, machine cognition and human-machine interaction. We see presence as being grounded also

in the social and in the phenomenology of existence. Others emphasise presence as a central component of survival; presence allows people to distinguish the real from the imagined which gives those people an evolutionary advantage. For many researchers presence is inherently bound up with immersive virtual reality systems, but for others it includes all media and technologies concerned with creating complex experiences. Presence is when the technology disappears from a mediated experience. Presence extends human abilities into far away places, or into different times. This special issue provides concrete examples of what is happening now and a few glimpses into that future.

The issue of *PsychNology Journal* also includes a paper among the group of works presented at CHIItaly 07 and

selected for the high scores obtained from the conference reviewers. A first group of them was collected in a special issue at the end of 2007; the remaining ones are published during 2008. In '*Task and Stimulation Paradigm Effects in a P300 Brain Computer Interface Exploitable in a Virtual Environment: A Pilot Study*'. Piccione, Konstantinos Priftis, Paolo Tonin, Denis Vidale, Roberto Furlan, Marianna Cavinato, Antonio Merico and Lamberto Piron report their pilot study in the groundbreaking area of brain computer interfaces. They examine a setting where the elicitation stimulus is presented in a virtual environment and suggest, on the basis of their findings, that the structure of the elicitation paradigm, the modalities of stimulus presentation, and the complexity of stimulus recognition and semantic processing affect the BCI system.

*David Benyon*  
*Anna Spagnolli*

Guest Editors

# Presence and Relaxation: A Preliminary Controlled Study

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## ABSTRACT

Technologies such as Virtual Reality (VR) that induce presence in a virtual, but still external, perceived world, have great power to evoke emotional experiences that can lead to psychotherapeutically valuable changes in the individual. This reflects the power of presence – seen as the feeling of being located in a perceived, external world – in developing and affecting psychological wellbeing.

Until today Virtual reality Environments (VEs) have been incorporated into a variety of clinical and everyday settings to improve mental health. Nevertheless many areas in the health field can be still explored by using this innovative technology. One example is represented by stress management area, one of the leading mental health problems of western societies linked to several pathologies.

Following this trend our proposal is to investigate with a non clinical sample the efficacy of a relaxing narrative through a virtual experience. In a controlled study we compared three different media: Immersive VR, DVD and Audio speaker, by using the same therapeutic narrative and protocol. A control group without treatment was also included in the study.

The sample included 60 university students, randomly divided in four experimental conditions.

Non parametric test and correlation were used to analyse self-reports and physiological parameters. Within groups analysis - in both VR and DVD conditions - showed a significant improvement of the emotional state and significative physiological changes. Furthermore, regression analysis showed that a relationship exists between the sense of presence and the outcome achieved by the mediated experience. However, the absence of significant differences from the analysis between groups suggests that the principal determinant of presence might be the content proposed within the mediated experience.

Further reflections about sense of presence in relaxing virtual environments will be discussed.

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## **1. Introduction**

Looking at the technologies used until now to induce relaxation, we observed that some tools already exist. CDs of calming music have shown positive effects on stress reduction and relaxation and combined with relaxation techniques these CDs strengthened the positive effect of calm and sedative music. To increase effectiveness, commercial relaxation DVDs have also integrated visual stimuli to support the process of relaxation by creating an isolated context.

Virtual Reality (VR) represents a further advance. It provides such a convincing interface that users believe they are actually present in a three dimensional world and they navigate and interact with it in real time while their actions and reactions are experienced in the present moment (Wiederhold & Wiederhold, 2005). In fact, the key feature of VR which differentiates it from other media, is the sense of presence (Riva, Davide, & Ijsselstein, 2003; Ijsselstein, 2003).

Our proposal is to take advantage of the potentiality of this technological tool, by enhancing the quality of the experience through the elicitation of the sense of presence. Thanks to the sense of presence experienced through this tool, it could be possible to enhance the quality of the relaxing experience.

Considering the strong potentiality of VR in clinical psychology, we can recognize two different approaches. On one side, VR has been traditionally used to deliver graded exposure, as an adjunct to cognitive-behavioral therapy (CBT) (Moore, Wiederhold, Wiederhold, & Riva, 2002; Riva, 2005) to treat pathologies such as phobias, post-traumatic stress disorder (PTSD), and other disorders related to anxious stimuli management (Riva, Wiederhold, & Molinari, 1998; Pull, 2005). The principal disadvantage of this approach is that it is content specific: a new virtual environment has to be developed for each particular context. So it is hardly applicable to some conditions, like stress and general negative emotionality, not strongly related to a specific scenario.

On the other side, other researchers have used VR to enhance well being by using a different approach. We propose that this approach could offer a series of advantages in relaxation too. A virtual environment including positive visual and auditory stimulation could be used to produce an optimal experience. Within the environment, it could be important to include contextual sensorial cues (Morie, 2002) to enhance the realism and the sense of presence experienced by the participants. For example Plante and colleagues have recently observed (Plante et al., 2003; Plante, Cage, Clements, &

Stover, 2006) that individuals who interact in an enriched environment with a variety of positive visual and auditory stimulation report greater improvement in self-efficacy and mood (McAuley, Talbot, & Martinez, 1999; Turner, Rejeski, & Brawley, 1997). This suggests that it is possible to use VR to manipulate experience-related self-efficacy and mood.

A further advance in this direction has already been tested by Freeman and colleagues (Freeman, 2003; Freeman, Lessiter, Keogh, Bond, & Chapman, 2004; Freeman, Lessiter, Pugh, & Keogh, 2005) too, that consider VR as useful to support relaxation. In this case, an important role was also played by an audio narrative that supported each phase of the experience, both guiding participants in the navigation and helping them to perform the cognitive and relaxation exercises.

As we already stated, the principal feature of VR, that distinguishes it from other media, is the sense of presence.

To define presence is not an easy task and it is possible to recognize two different perspectives. The rationalist point of view considers a VR system as a collection of specific machines with the necessity of inclusion of the concept of presence. The researchers agreeing with this approach describe the sense of presence as a function of our experience of a given medium (*Media Presence*). The main result of this approach is the definition of presence as the *perceptual illusion of non mediation* produced by means of the disappearance of the medium from the conscious attention of the subject. Within this approach, Slater and colleagues (1994) listed the technological and participant factors that contribute to presence by presenting three aspects: the sense of being in the environment; the tendency of users to respond to events in the VE rather than in the real world; the memory of the experience, after the VE session, of such as having visited a place, rather than just having seen images generated by a computer. However, the technological definitions of VR do not deny the existence of the psychological component offered by the VR systems, it is simply not included in the definition. At the other extreme there is the psychological or ecological perspective (*Inner Presence*). Within this perspective, the feeling of presence is seen as a common experience among different types of human experiences independent of any technology.

Aiming to take in consideration both perspectives, we can state that the experience of presence is a complex, multidimensional perception, formed through an interplay of raw (multi) sensory data and various cognitive processes (Ijsselsteijn & Riva, 2003). Ijsselsteijn, de Ridder, Freeman, and Avons (2000) suggest a vision that aims to

overcome the debate related to the determinants of sense of presence and they suggest a wide categorization of variables that can determine a user's presence. These authors propose two general categories: media characteristics and user characteristics. Media characteristics category can be subdivided into aspects of "media form" and "media content". "Media form" refers to physical, objective properties of a display medium, covering the means by which an image is represented (for example photo-realistic video or animated computer graphics). "Media content" includes the theme, narrative or story represented by the medium.

Is presence related to the efficacy of the experience?

Until now the relationship between the sense of presence and treatment outcomes has been explored but it didn't result in a final conclusion. In fact, in the anxiety treatment, that generally involves specific VEs and a graded exposure therapy, presence presumably contributes to the amount of anxiety felt during an exposure to a feared virtual stimulus. Recently, results found by Price and Anderson (2007) considered presence as a factor that contributes to the experience of anxiety in the virtual environment. These authors considered also a relation between presence and phobic elements, but they did not support a relation between presence and treatment outcome. The authors suggest that feeling present during exposure may be necessary but not sufficient to achieve benefit from VR exposure.

The goal of the study of Freeman and colleagues (2004) was different. It was focused on relaxation and in particular it aimed to test the effect of a relaxing narrative through the comparison between a narrative only condition (eyes-closed) and a narrative plus the visual and background audio stimuli of the Relaxation VE. Results showed that the presentation of the narrative within the audio visual VE resulted in significantly greater increases in relaxation in relation with the presentation of the narrative alone. Furthermore, presence ratings were higher for the VR condition than for the Audio one. To sum up, the authors suggest good potentiality for the use of VEs as devices to improve relaxation. Unfortunately, probably due to the low statistical power derived from the small sample size, the relationship found between presence and relaxation was not consistent.

In summary, results from empirical works on the relation between presence and treatment efficacy have been inconclusive.

The specific goal of the present study was to investigate with a non clinical sample the efficacy of a relaxing narrative through a virtual experience. After analyzing the literature in this field we decided to use different techniques to induce relaxation,

involving Autogenic training (Schultz & Luthe, 1969), Progressive Muscular Relaxation - PMR - (Jacobson, 1938), and breathing techniques.

We were interested in verifying the efficacy of the relaxing therapeutic narrative (“media content”), by manipulating the “media form” variables, according to Freeman and colleagues categorization (Freeman, 2003; Ijsselstein et al., 2000). For this reason we compared three different media: Immersive VR, DVD and AUDIO tape. We also included in the study a control group without treatment.

In particular, this study was conducted to test to the following hypotheses:

*Hypothesis 1:* There is a significant emotional modification within groups. In particular we expected an increase of relaxation and a decrease of anxiety;

*Hypothesis 2:* There is a significant difference between the conditions in terms of efficacy. In particular, we expected an increase of relaxation and positive emotions higher in VR condition than in the other groups;

*Hypothesis 3:* A relationship exists between the sense of presence and increase of relaxation and positive emotions. This relationship is also related to the medium used.

## **2. Method**

### **2.1 Participants and Design**

We recruited sixty participants (30 female and 30 male students), aged 21 to 28 years ( $M=24.52$ ,  $SD=1.75$ ) for the study from the Catholic University of Milan. We randomly allocated groups of 15 participants to each of the four experimental conditions by a true random number service (Haahr, 1998). They voluntarily participated to the experiment after having subscribed the informed consent.

In order to study the efficacy of different technologies on relaxation, we carried out a mixed design. We developed a relaxing narrative (“media content”) that involved different relaxation techniques and we manipulated the “media form” variable, comparing three different media: Immersive VR, DVD and AUDIO tape. In particular the design involved 3 experimental conditions and repeated measurements (pre and post-treatment).

All participants in the VR, DVD and AUDIO conditions listened to the same narrative and followed the same exercises, based on Progressive Muscular Relaxation - PMR - (Jacobson, 1938), Autogenic Training (Schultz & Luthe, 1969), and deep breathing techniques.

Let's see more in depth each condition:

- VR: An immersive virtual reality environment, the Relaxation Island (experienced with a head mounted display, head tracking and joystick). Participants moved through different relaxation experiences, exploring the environment and watching waves lapping gently on a shore, or sitting near a waterfall and watching leaves float down a stream into the surrounding ocean. Each experience was supported by a relaxing narrative.
- DVD: A commercial DVD (experienced on the Computer screen with relaxing tropical videos). Participants moved through different relaxation scenes, watching water at beach levels. Each experience was supported by the same relaxing narrative.
- AUDIO: An audio-tape was used with the same relaxing narrative. In this condition participants were required to use their imagination skills to visualize the tropical scenario.

Furthermore we compared these conditions with a control group (composed by 15 participants too) without treatment.

Participants sat in a swivel armchair in front of a computer and were tested once per session. At the beginning of the sessions, they provided their informed consent and received a set of instructions about the experiment. The experiment consisted of 2 sessions carried out on two different days within the same week.

Participants in the control condition did not receive the treatments, but they were only assessed on two days within the same week.

## 2.2 Measures

To test the dependent variables - the emotional response (with special focus on relaxation) and the sense of presence - we considered that emotions are complex phenomena that comprise multiple components ranging from the purely subjective to the purely physiological. No single method of emotion assessment can possibly capture the richness of emotional phenomena, and a complete evaluation of emotion phenomena can only be gained through multiple-method investigations.

Therefore, we decided to use an Integrated Multimodal Assessment - combining self-reports and objectives measures. In particular for the emotional evaluation we used:

- The *State Trait Anxiety Inventory* (STAI) (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) to assess state anxiety levels. Respondents indicate how much each statement reflects how they feel on a 0-3 scale. It has two versions, asking

participants “how they feel right now” (state version) and “how they generally feel” (trait version).

- The *Positive and Negative Affect Schedule* (PANAS) (Watson, Clark, & Tellegen, 1988) to measure the positive and negative affects through 10 positive and 10 negative moods/emotion adjectives. The PANAS allows to indicate the time frame when considering the experience of the affect items (i.e., ranging from “current states” to “general feelings”). We decided to examine the “current state” of the participants.
- The *Visual Analogue Scale* (VAS) (Gross & Levenson, 1995) to describe different emotions using 8 adjectives. Participants are required to indicate how they feel at a specific moment in time with reference to each of the eight visual analogue scales measuring: happiness, sadness, anger, surprise, disgust, anxiety, quietness, and wrath.
- The *Coping Orientation to Problems Experienced Questionnaire* (COPE) *Questionnaire* (Sica, Novara, Dorz, & Sanavio, 1997) assessed the different strategies commonly activated in daily problem solving, focusing on three categories: problem, emotive expression and maladaptive mechanisms.

From a physiological point of view, we considered stress to be generally accompanied by generalized activation of the nervous central system, autonomous nervous system, and neuromuscular system. This implies an increase in muscular tension, heart rate, blood pressure, palmar sweating, peripheral vasoconstriction, and rate and irregularity of respiration. For this reason we selected:

- Different physiological parameters (Respiration Rate, Respiration amplitude, Heart Rate, Heart Amplitude, Skin Conductance, Electromyography) to test the activation of the subjects in correspondence with emotional arousal at the begin and at the end of the experience.

To measure the level of subjective presence we used the ITC–Sense of Presence Inventory (ITC-SOPI) (Lessiter, Freeman, Keogh, & Davidoff, 2001) that refers to after and during the mediated experience. It considers four dimensions: Physical space (a sense of physical placement in the mediated environment, and interaction with, and control over, parts of the mediated environment); Engagement (a tendency to feel psychologically involved and to enjoy the content); Ecological Validity (a tendency to perceive the mediated environment as lifelike and real) and Negative effects (adverse physiological reactions).

### 2.3 Tools

The virtual environment used, termed the Relaxation Island, was conceived and had previously been used by Freeman and colleagues (Freeman, Lessiter, Keogh, Bond, & Chapman, 2004) within the EMMA - “Engaging Media for Mental Health” - European funded project. Exploration in the immersive VR condition involved 4 different zones related to different relaxation exercises: beach zone 1, beach zone 2, the clouds and waterfall. The zones were presented in versions both by day and by night. One example is showed in Figure 1. The DVD used was a commercial relaxation system, with the visual content similar to that of the VR condition - 4 beaches of tropical islands - supported by the same narrative. An example is showed in Figure 2.

The audio tape included only the same narrative. For this reason this condition required imagination skills by the participants.



**Figure 1.** The waterfall zone of Relaxation Island by day.



**Figure 2.** The Island DVD by day.

The computerized and Virtual Reality materials consisted of:

- a portable computer (Fujitsu Siemens AMILO Processor, Pentium 4);
- a wireless joystick (only in the VR condition): Logitech Wingman Cordless Rumblepad Gamepad;

- a Head-Mounted Display (only in the VR condition): a Sony Glastron PLM S-700 with a head-tracker: Intersense Intertrax2;
- an Audio-tape with headphones.

For the physiological measurements, in this study we also used the BioGraph Infinity Procomp.

### 3. Results

The data were not normally distributed in almost all multimodal aspects evaluated. For this reason and to avoid analyses with a low statistical power we conducted non-parametric analyses.

- First, before treatment we compared the participants in the four experimental conditions (VR, DVD, AUDIO, Control) we didn't find significant differences between groups.
- Then, we analyzed the degree of change on the dependent variables achieved with the treatment separately for each group (within groups effects).
- As a third analysis set, we focused on testing whether the degree of change was different among the four groups (between groups effects).
- A final analysis tested whether a relationship existed between the sense of presence and the efficacy of the treatment through correlation and regression analyses.

We analyzed data from the following four "moments/time points" in the treatment:

- T1: before Session 1 (pre-treatment)
- T2: after Session 1
- T3: before Session 2
- T4: after Session 2 (post-treatment)

#### 3.1 Within Groups Effects

To compare different moments of the treatment for each condition we used both the Friedman and Wilcoxon tests (paired samples), as showed in Table 1.

We found a significant reduction of anxiety measured through the STAI questionnaire in the first session both in:

- VR ( $Z=1,905$ ,  $p<.05$ ), DVD ( $Z= 2,852$ ,  $p<.01$ ), and AUDIO ( $Z=3,244$ ,  $p<.00$ ) conditions.

The same outcome was found in the second session, both in VR ( $Z= 2,923$ ,  $p<.00$ ), DVD ( $Z= 2,946$ ,  $p<.00$ ) and AUDIO ( $Z= 1,889$ ,  $p<.05$ ) conditions.

Furthermore we found significant increases in relaxation measured by the VAS questionnaire both in VR ( $Z= 2,288$ ,  $p<.05$ ) and DVD conditions ( $Z= 1,904$ ,  $p<.05$ ) in the first session and in the second session (VR:  $Z= 2,648$ ,  $p<.005$ ; DVD:  $Z= 2,138$ ,  $p<.05$ ). Reduction in sadness was found only in VR condition ( $Z= 2,232$ ,  $p<.05$ ) measured by the VAS questionnaire in the second session. No significant changes were found in Control condition.

Session	Dependent Variables	Condition	Mean	SD
1	Anxiety State (STAI)	VR	M1= 37.19 M2= 31.81	SD1= 8.84 SD2= 7.62
		DVD	M1= 34.63 M2= 29.19	SD1= 7.96 SD2= 4.42
		AUDIO	M1= 39.31 M2= 30.88	SD1= 10.43 SD2= 6.26
2	Anxiety State (STAI)	VR	M1= 37.94 M2= 32.69	SD1= 9.46 SD2= 5.84
		DVD	M1= 33.50 M2= 29.38	SD1= 6.80 SD2= 4.54
		AUDIO	M1= 37.50 M2= 34.69	SD1= 8.63 SD2= 9.06
1	Relaxation (VAS)	VR	M1= 4.13 M2= 5.06	SD1= 1.50 SD2= 1.29
		DVD	M1= 4.81 M2= 5.44	SD1= 1.17 SD2= 1.03
2	Relaxation (VAS)	VR	M1= 4.44 M2= 5.31	SD1= 1.36 SD2= 1.20
		DVD	M1= 4.31 M2= 4.81	SD1= .79 SD2= 1.11

**Table 1.** Within groups effects.

Since the time between the two sessions involved in each condition was 3-4 days, some participants started the second session with different mood and relaxation levels

in comparison to the ones achieved at the end of the first session. For this reason we considered both the whole treatment but also the outcomes obtained in each session.

Related to trait aspects, we found only significant changes in coping skills in DVD condition, in particular in Avoiding Strategies ( $Z=2,264$ ,  $p<.05$ ) and Positive Attitude ( $Z=2,741$ ,  $p<.05$ ). A probable explanation is that the length of the experiment, one week, was not a sufficient amount of time to achieve considerable trait changes.

Some interesting results were found with respect to the physiological parameters assessed. For this reason we decided to investigate only the differences within each session and not within the whole treatment.

- In VR group we found a significant reduction of Respiration rate mean both in the first ( $Z=1,939$ ,  $p<.05$ ) and in the second session ( $Z=2,329$ ,  $p<.05$ ).
- In DVD group we found a significant reduction of Heart rate mean both in the first ( $Z=2,947$ ,  $p<.005$ ) and in the second session ( $Z=2,275$ ,  $p<.05$ ) and a significant increasing of Skin conductance both in the first ( $Z=2,844$ ,  $p<.005$ ) and in the second session ( $Z=2,430$ ,  $p<.01$ ).
- In Audio group we found a significant reduction of Heart rate mean both in the first ( $Z=2,741$ ,  $p<.005$ ) and in the second session ( $Z=2,120$ ,  $p<.05$ ). A significant increase of Skin conductance was found only in the first ( $Z=2,669$ ,  $p<.005$ ) session.

### **3.2 Between Groups Effects**

We investigated whether the degrees of change in anxiety and emotional states were different among the four groups (VR, DVD, AUDIO and Control) through the Kruskal-Wallis (4 independent samples) test. No significant differences were found either in the questionnaires or in the physiological parameters. The interpretation of these results will be presented in the conclusion paragraph.

### **3.3 Relationship between Sense of Presence and Treatment Outcome**

To reach this aim, first we used several rho-Spearman non-parametric correlation tests. In general, the data showed a significant correlation between changes in anxiety and emotional state and some factors of presence, considering separately the first and the second session. These results indicate that the sense of presence experienced by the participants is correlated to the effectiveness of the treatment, considering both the whole group of participants and the four conditions separately.

At this point we were interested to better understand whether the sense of presence experienced by the participants was higher in VR condition. For this reason we

conducted the chi square test. Unexpectedly, DVD was the medium that showed higher sense of “ecological” presence, both in the first ( $\text{Chi}^2=5,184$ ,  $p<.05$ ) and in the second session ( $\text{Chi}^2= 7,534$ ,  $p<.01$ ).

Furthermore we were interested to investigate whether a causal relationship existed between presence factors and emotional changes. To reach this aim we carried out the linear regression analyses (Table 2).

Session	Dependent Variables	Model	Variables	t	p
1	Anxiety State (STAI)	R square=.437 F=6.796 p=.000	Ecological Validity	t= -2.415	p<.05
			Negative effect	t= 3.540	p<.005
1	Relaxation (VAS)	R square=.345 F=4.082 p<.01	Ecological Validity	t= 3.129	p<.005
2	Anxiety State (STAI)	R square=.354 F=4.791 p<.005	Physical space	t= 2.422	p<.05
			Engagement	t= -2.471	p<.005
			Negative effect	t= 2.278	p<.05
2	Anxiety State (VAS)	R square=.303 F=3.696 p<.05	Physical space	t= 2.327	p<.05
			Ecological Validity	t= -2,259	p<.05
			Negative effect	t= 2.432	p<.05

**Table 2.** Relationship between sense of presence and treatment outcome.

In particular, as showed in Table 2, from linear regression analysis we found that in the first session:

- the Anxiety state (measured by STAI) change is determined by presence, in particular by the “ecological validity” and “negative effect” scale;
- the Relaxation change (measured by VAS) is determined by presence, in particular significantly by the “ecological validity”.

In the second session:

- the Anxiety state (measured by STAI) change is determined by presence, in particular by the “sense of physical space”, “engagement” scale and the “negative effect” scale;

- the Anxiety state (measured by VAS) change is determined by presence, in particular by the “sense of physical space”, “ecological validity” scale and the “negative effect” scale.

#### **4. Conclusion**

The goal of this study was to investigate the efficacy of a relaxing narrative (“media content”) experienced through a virtual experience with a non clinical sample. For this reason we manipulated the “media form” variables and we compared three different media: Immersive VR, DVD and AUDIO tape. We also included in the study a control group without treatment.

Results show a significant reduction of anxiety and a significant improvement of positive emotional states - in particular, relaxation - measured through self-report questionnaires in all conditions. Physiological parameters showed some good changes related to respiration rate, heart rate, and skin conductance parameters, but less than expected.

The appraisal theory of Scherer (Scherer, 2001; Sander, Grandjean, & Scherer, 2005) could help us to interpret these results. In Scherer’s Component Process model, it is assumed that there are direct connections between stimulus evaluation check (SEC) units and response modalities in the neuro-endocrine system, autonomic nervous system, and somatic nervous system, independently from action tendencies. Two dimensions in particular involved in this model, “goal conduciveness” and “intrinsic pleasantness”, could have modified the expected physiological results. On one side, the goal of achieving a relaxation state might not be strictly pertinent to the participant’s interests because we did not select stressed people for this study. According with Van Reekum and colleagues (Van Reekum et al., 2004) non-pertinent goals can be related to an increase in heart rate and muscle tension. On the other side, the pleasantness of the virtual relaxation experience might predict a reduction of heart rate and skin conductance. We also have to consider that the novelty effect related to using these technologies could have caused physiological activation conflicting with relaxation.

Furthermore, we expected an increase of relaxation and positive emotions higher in VR condition than in the other ones. On the contrary we didn’t find significant differences between groups. This result could be also due to the intrinsic pleasantness

and goal conduciveness of the experience. All people, in fact, could have found positive the mediated experience: they listened to the same narrative and did the same relaxation exercises.

This result seems strictly related to the one found about sense of presence. First, between subjects analyses showed that DVD is higher in “ecological validity” than VR. The explanation is clear: ecological validity is the tendency to perceive the mediated environment as lifelike and real and DVD showed images coming from reality.

Nevertheless, correlations exist between the sense of presence and the increase of relaxation and positive emotions, both considering the whole group and the separated conditions. People felt generally involved in the mediated experiences proposed.

According to a study by Baños and colleagues (Baños et al., 2004), presence is not a direct function of immersion and interaction. In agreement with Ijsselstein (2003), to induce an emotionally mediated experience, it is important to focus on the content and the emotions that are being communicated. Moreover, presence might not be only influenced by the environment’s graphic realism, immersion, and other technological features, but even more by other characteristics of the experience, including the emotional ones, provided by technology.

Results suggest us that it is possible that the predominant effect was played by the relaxing content of the experience, using different techniques in a quiet multi-sensorial scenario, while the technologies used didn’t show different effects.

As third we were interested to investigate whether a relationship exists between presence and treatment outcomes. In this study, our proposal was to take advantage of the potential of this technological tool, by enhancing the quality of the experience through the elicitation of the sense of presence. We hypothesized that, thanks to sense of presence experienced through this tool, it could be possible to enhance the quality of the relaxing experience.

We found several significant correlations between Presence and the emotional change of the participants. Furthermore, as showed by the regression analysis, participants felt engaged in the mediated experience and at the end we found an increase of relaxation and a reduction of anxiety.

How can we interpret this relationship? According to our hypotheses, results confirm the role of the sense of presence as a mediating variable between the mediated experiences and the induced emotions, but some limitations didn’t allow us to consider VR the better tool to achieve relaxation outcomes.

It is not possible to clarify which aspects of the “media form” manipulated (the interaction, the immersion or the visual cues) have had a stronger impact on the sense of presence. In fact, DVD showed real images and was higher in “ecological validity”. Probably, in DVD a key function was played by the visual cues proposed that attracted the user’s attention, while in VR the sense of presence could be enhanced by the interaction and the immersion. The consequence was that participants of both groups generally felt involved in the mediated experiences proposed.

Furthermore, as also showed by the analysis between subjects, we think that in this study the principal determinant of presence is the content proposed within the mediated experience. As we stated at the beginning, we didn’t manipulated the “media content” variable: all people lived an equal positive experience based on the same relaxing exercises. For this reason we found that there were no differences related to the outcomes between groups and that the sense of presence, enhanced by the content, was related to the outcome achieved in DVD and in VR groups.

When considering presence it is also important to consider its opposite, “absence” (Waterworth & Waterworth, 2001), the feeling of being absorbed in an internally generated world of thought and imagination. According to the bio-cultural model of presence (Riva, Waterworth, & Waterworth, 2004), the overall presence level depends on how well integrated the cognitive system is to focus on the environment around the individual. In this study we could consider that virtual relaxation may have reduced the attention to the environment, producing a high degree of absence, in which participants were focused on some cognitive activity related to their Self and not related to directly perceiving the environment.

Despite these limitations, the goal of this study was to test the efficacy of VR as a tool to support the relaxation process. We believe that the use of immersive VR in this non-traditional way could represent a further approach to promote relaxation. What is important is to work on the specific content and the emotions that are being communicated. The novelty of combining different methodologies, quantitative and qualitative, for integrated multimodal assessment is also an important aspect to take in consideration. It is convenient to use more advanced technology, such as VR, whether or not it is possible to use all the potentialities and affordances that such strategies could offer to therapy.

This is a preliminary study in this field. Limitations due to the rather small sample size lead us to view the obtained results with caution. Nevertheless, important clinical applications suggested by these results include the possibility that people might learn

relaxation strategies within controllable mediated experiences. Certainly significant efforts are still required to move VR into routine clinical use in relaxation strategies. Controlled clinical trials are needed in order to compare the efficacy of the proposed VR approach with competing methods. Furthermore it will be interesting to integrate relaxation in a more complete emotional management protocol supported by different strategies.

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# Practices to Display Social Presence: A Study in a Shared Mediated Environment

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## ABSTRACT

The current study belongs to a series of studies promoted by the EU funded project "PACION", which focuses on augmenting social presence. The underlying assumptions to this series is that participants' interventions in the shared environment represent a way to exhibit their being socially present in that environment. Therefore, the practices organizing these interventions define "when", "why" and "how" social presence become relevant in the group. In the study presented here, participants navigate in a shared, non immersive virtual world, and can contact each other dyadically via instant messaging. Their task as a team consists of finding as many treasures as possible in the virtual world. Chat logs and video recordings of the activity on the screen are collected, and subsequently analyzed with the approach of Conversation Analysis. The results show the way in which social presence is addressed in the chat openings, the occasions in which the intervention of the interlocutor on the chat is made relevant and the format of this intervention. These results are connected to the nature of the activity and of the mediated environment.

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Keywords: *Social Presence, Conversation Analysis, Mediated Interaction, Video Game, Collaboration.*

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## 1. Introduction

Social presence can be defined as "the phenomenal sense of being there with another, or quite essentially, the sense of another through a medium" (Biocca, Harms, & Burgoon, 2003, p.456). This concept has socio-psychological roots, and it was originally meant to describe inner feelings due to the others spatially present or to the

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thought of another person being in the position of the observer (Short, Williams, & Christie, 1976). The notion of “being socially present” or “socially absent” has gained particular attention with the advent of telecommunications. How much do we feel the weather man of the television broadcasts present? Do we feel our mother present with us when she sends an SMS to our mobile phone? In an attempt to provide a definition of social presence, scholars have first of all tried to respond to the basic question: what does it mean to be socially present? According to the existing approaches to social presence, there are mainly three ways to be present with the others: physically, psychologically and behaviorally.

Regarding the possibility to be physically present with the other in the environment, a dycothomic approach to social presence has linked it to the other being physically present or absent in the same environment (Huguet, Galvaig, Monteil, & Dumas, 1999): in this case social presence is seen as a dichotomy, the other is or is not present. This definition has been expanded by Goffman, with the introduction of co-presence (1959). Differently from the previous approach, it considers social presence as having different degrees, according to the possibilities of the medium to convey both sensory awareness and mutual awareness. Co-presence, which “renders persons uniquely accessible, available, and subject to one another” (Goffman, 1959, p.22), has been linked to both the sensory awareness of the embodied other, for instance the possibility to see or hear the others, and mutual awareness, the awareness of the existence of the other accompanied by the other’s reactions to the self. Using questionnaires to detect this dimension, some examples of items investigating co-presence have been: “To what extent did you have a sense of being in the same room as your partner?” (Schroeder, Steed, Axelsson, Heldal, Abelin, & Wideström, 2001) or “I was often aware of others in the environment” (Biocca, Harms, & Gregg, 2001).

If being physically present is traditionally considered a fundamental dimension conveying social presence, different definitions have focused more on the role played by the psychological engagement with the other (Rice, 1993; Nowak & Biocca, 1999 in Biocca, Harms, & Burgoon, 2003; Biocca, 1997). In fact, being present with others also means that we feel a certain psychological involvement with them. According to the existing definitions of psychological involvement, the sense of access to intelligence, salience of interpersonal relationships, intimacy and immediacy and mutual understanding all relate to this dimension. Being psychologically present to the other means to relate actions performed by others to states of the intelligence animating the body, feeling involved in the relationship, feeling intimate and similar to the others in

terms of emotions or attitudes (“homophily”). “When I was happy, the other was happy” “The opinion of the other was clear to me” (Biocca, Harms, & Gregg, 2001), “My partner did not understand my needs” (Kumar & Benbasat, 2002) are just some expressions used in questionnaires to address psychological involvement in the social presence experience.

Finally, some other definitions have been formulated considering that we are socially present when we display behavioural engagement. “My behaviour was in direct response to the other’s behaviour” (Biocca, Harms, & Gregg, 2001) is one of the assertions which can summarize what we mean by this dimension. The feeling that there is a synchronized and coordinated interaction among the parts, regulated by gaze, nonverbal mirroring, turn-taking and so forth has been seen as fostering social presence (Garau, 2006).

This brief review of social presence definitions, based on the Biocca, Harms, and Burgoon paper “Toward a more robust theory of social presence: review and suggested criteria” (2003), clarifies in which positions the “agents” involved in social presence stand. The individual being is the main focus of attention, because social presence is considered as an intimate state, the mediated environment and the mediated other act as factors affecting the individual feelings of being socially present. In particular, social presence would depend on the capability of the medium to filter to a greater or lesser extent cues coming from the others (such as gaze, body position, speech, etc.).

Social presence, however, also opens new issues more related to how this phenomenon is displayed (more than “felt”) and made evident in the environment. The question would not be “what social presence is” but “how social presence is” or, to put it differently, “how I act to be socially present with and to the other”. In order to provide a response to these questions, we need to shift the focus of attention to the relationship between the individual and the environment (including the social environment) as it is in this respect that actions performed by individuals are developed (Spagnolli, Varotto, & Mantovani, 2003; Reno’, 2005). Such an action-based approach to social presence considers the environment as “a set of resources organized and transformed by the involvement in human action at any certain moment” (Spagnolli & Gamberini, 2005, p.8). The term “resources” in this approach refers to the material (physical) and symbolic (cognitive-cultural) resources hosted by the environment. In the first case, they refer to the physical resources present in the environment. In the second case they refer to the symbolic world which comes with the individual and the affordances of

the medium, such as expectations and possibilities to interact with the environment (Spagnolli & Gamberini, 2005). According to this definition, resources and actions are interdependent, because resources are exploited by the individual to perform actions and actions are performed thanks to the available resources. The way resources are exploited and actions performed, however, is not a random process, but it depends on the practices defined as socially legitimate and appropriate as well as relevant to the on-going activity.

The action-based approach to interactions builds on a tradition of multidisciplinary research, coming from anthropology (Goodwin, 2003), sociology (Schegloff, 2007), and cultural psychology (Mantovani, 1999). Theories such as Situated Actions (Suchman, 2007) and Distributed Cognition (Holland, Hutchins, & Kirsh, 2000) have been based on this approach, being their units of analysis participants' actions within their natural environment, more than investigation of mental processes which could lead to perform them. These two theories depict interactions as negotiated moment by moment, according to the possibilities of actions perceived by the participants in the environment at their final aims, dictated by the kind of activity at hand. With the advent of technology, its wide use in workplace settings has enabled people to verify the practices regulating interactions between workers and their surrounding settings, generally to design more efficient technologies or reconstructing the environment to increase performance (Hindmarsh & Heath, 2002; Gamberini, Spagnolli, Bua, Cottone, & Martinelli, 2004).

Such an approach can be fruitfully adopted in the study of social presence, whenever the focus of attention is on actions performed by participants to make their presence in the environment relevant to the others. In fact, it allows the researcher to investigate the unfolding interactions between the individual and the environment, linking them to the possibilities of actions offered by the latter as well as to the task to be accomplished. Adopting this framework, the question to be addressed will be "how do participants make their presence relevant to the others and why?"

This study is aimed at exploring the development and re-configuration of social presence by observing practices through which people manifest their presence in a specific environment, namely an online game, and to relate them with the specific resources of the medium. As practices constitute the focus of interest of this research, an action-based approach to the study of social presence will be adopted, conducting a systematic analysis of verbal actions performed in chats by participants to signal their "being present with the others in the mediated environment". As a last step, an

interpretation about how these practices can be related to the specific resources of the medium used to interact and the task to be accomplished will be provided.

This paper is organized as follows. In section 2 will be illustrated how participants, according to the existing literature, can make their presence verbally relevant in a mediated environment. The first situation will be openings, while the second one will comprise verbal actions further developing the on-going interactions. In section 3 method and analytic approach will be introduced and will lead to the results section. Results will be divided according to the two categories mentioned before, stressing on openings, on one side, and relevant actions used to foster interactions on the other side. Finally, conclusions will offer a summary and some comments on future research.

## **2. Social Presence in Verbal Communication**

To study the verbal practices adopted in the construction of social presence, Conversation Analysis has been applied (Schegloff, 2007). Derived from a sociological approach to communication, this method defines conversations as an interactional achievement continuously negotiated through verbal actions pragmatically linked one to the other. Based on Austin's "How to do Things with Words" (1962), this approach does not focus on the pure meaning of words, but relates them to the interactive function they perform when uttered. Consequently, Conversation Analysis allows to see verbal exchanges as a series of actions sequentially positioned.

Considering conversation as an ordered sequence of actions has provided the possibility to point out practices ruling when, how and why social presence was displayed verbally during the game. In what follows, two phenomena, which will be the focus of attention of the whole study, will be presented. First of all, a brief review of literature on openings will be provided, at the aim of explaining why they can be considered a valid practice to display social presence and how they differ according to the media used to interact. Secondly, the environmental resources to be exploited to manifest social presence will be introduced to provide a theoretical framework into which social presence can be positioned and studied.

### **2.1 Openings**

Openings are the very first verbal actions performed at the beginning of encounters. According to Schegloff (1968), who has for a quite long time investigated the practices

of openings, these are seen as serving mainly three functions. Considering that conversations are developed by two or more persons, the use of openings would first of all establish mutual attention. In face-to-face encounters as well as mediated ones, openings direct the attention of the participants to the activity which will take place after the beginning of the encounter. As asserted by Schegloff, they can be seen as a pre-sequence of actions which introduces the reasons for the encounter and its successive possible development. For instance, when meeting our friend at the supermarket, we use openings with the aim of making his/her attention shift from the freezer to ourselves. By so doing we are not only taking priority over what is in the surrounding area, but we are also verifying our partner's availability to interact with us. To explain the concept of availability, let's think for instance of telephone conversations. According to Schegloff (1972), the first action a speaker performs to initiate a conversation at the telephone, is to summon the called. The summon is constituted of the ring of the phone and the answer of the other person detects by itself the presence of the other on that specific medium. The action of answering creates a boundary between the relationships with the world the answerer was involved in (e.g. cooking, sleeping, washing the car) and a new one, which involves attention to the caller. The called person is completing a pre-sequence, as prefatory of another activity which will follow, for instance a friendly chat. Thereby, completing the summon-answer sequence, the called person signals her/his availability to talk. Was it not the case, no one would answer. However, it is not sufficient to obtain the other's availability in the openings, because after the response the partner could decide to stop the conversation, impeding its development. For this reason, availability needs to be constantly negotiated during the whole interaction, in order to develop it further on.

Finally, openings signal that the speaker wants to interact with the partner (even if only for a brief exchange, or more demanding conversations).

Openings, therefore, can be seen as the first practice in terms of the time we engage in to make ourselves relevant to the other, displaying our social presence as well as trying to detect the others' availability to be "present with us" in the interaction.

Greetings and summons are the most used forms of openings in face-to-face encounters (Schegloff, 2002). However, studies on different media used to interact have emphasized that their use is deeply affected by the medium and the activity the speakers are engaged in (Arminen, 2005; Weilenmann, 2003).

For instance, with the introduction of mobile phones, the structure of openings has changed compared to that of landline phones. The possibility of detecting the ID caller

and the certain knowledge about the identity of answerer-addressee, are different from landline phones and seem to have limited the presence of acknowledgments after greetings (Hutchby & Burnett, 2005). In this case, the first exhibition of social presence by the ring of the phone does not need any further recognition process, as the caller identity is already known. For this reason the first action performed by the answerer is greetings, signaling that he/she already knows who the caller is. At the same time, mobile phones have modified the availability issue. The phone is constantly at hand and is personal, so that the caller is not intruding in a public space such as a house where more inhabitants live, but an individual space. The possibility to see who is calling, the phone ringing wherever the addressee is and the private owning of the cell phone, all offer a “sense of perpetual contact” between the potential users (Katz & Aakhus, 2002).

Openings have evolved differently in SMSs (Spagnolli & Gamberini, 2006). In their study practices developed by participants to display their “being present with the other” have been addressed. Considering that these kinds of messages have a cost, information is usually managed to fit a unique message (differently from messages exchanged in chats); furthermore, it is possible to detect the sender’s identity from the cell number displayed at the message arrival. Consequently, practices developed by participants to perform openings and then to continue the interaction take into consideration all these aspects (e.g. multiple action turns or going directly to the reason of the interaction). As regards openings, it is interesting to notice that greetings are usually not responded to, as if it was evident that mutual presence was already established. For the same reason stated above, thence, availability on the mobile phone does not need to be established, as it is already made evident by the characteristics of the medium itself.

These studies support the idea that individuals manage the beginning of their encounters differently according to the established availability to the interaction allowed by the media used. Furthermore, a criterion for the development of a practice on another is the relevance of certain actions or, more precisely, what is made relevant by the situation in order to achieve a fruitful interaction. The decreased presence of identification in mobile phone openings, for instance, can be a practice developed by participants who rely on the knowledge about who is calling provided by the mobile phone itself and, therefore, consider identification less relevant. Again, the practice to open up SMS with actions going directly to the core business of the interaction is

motivated by the relevancy of these actions because the cell already provides us information about other important personal cues, for instance the caller.

Considering that openings, as stated before, are the first verbal display of social presence, it should consequently be affected by the availability on the medium already or still to be established and the relevance social presence acquires in the specific situation.

## **2.2 Environmental Resources for Social Presence**

A second insight on social presence could be provided by verbal actions performed exploiting the environmental resources.

Being socially present means first of all being present in the environment. Such an environment is constituted by material, symbolic and behavioural resources (Spagnolli & Gamberini, 2005). Goodwin (2000), studying interactions developed between girls playing hopscotch, emphasized that social actions were developed exploiting physical resources (body positions), material resources (the hopscotch grid), other's actions resources (talk or gaze), cultural resources (knowledge about the norms ruling the game). All these resources present in the environment, served for the girls to interactively carry out courses of action in concert with each other. The development of interactions considering what is present in the place where they unfold, exploiting what is considered as relevant to foster them can offer an insight on social presence. In fact, responding to the question "how is your way to interact with the other affected by the environment?" means to focus on practices developed by participants to carry on relationships in accordance with the characteristics of the material and social environment they are placed in.

Part of the resources which can be exploited to manifest social presence are verbal actions performed by the other inhabitants of the environment. Considering that a verbal interaction has already been opened, how do participants exhibit their being tuned and present to collaborate in the conversation process? How do individuals exploit others' actions to exhibit that they are present and collaborative in the environment?

Conversation analysis, considering conversations as a micro context where verbal actions unfold to construct and sustain interactions, provides some important cues to investigate these aspects. Conversation is seen as an ordered process, where actions are pragmatically linked one to the other. This link is determined by the relevance acquired by a certain action to a previous one. For instance, a question is likely to be

followed by an answer. When fruitfully interacting, though, contributions need to be a) relevant, for instance providing the appropriate answer after a question; b) provided at a relevant time, when the contribution is needed and c) in an appropriate format, for instance verbally or non verbally.

These principles seem to discriminate between a series of randomly performed actions and, on the contrary, actions aimed at constructively feeding social interactions. Called by Schegloff (1991) "intersubjectivity", these actions build "in some coherent fashion with respect to what went on before" (p.157). They should manifest our being in the same environment with the others, working to make the interaction develop. To achieve this goal, participants need to share understanding of what has happened before and foresee adequate actions to develop the next moves.

One aspect fostering intersubjectivity, coherently linking actions among them, is the sequentiality of contributions building interactions. As already said, sequentiality can be seen as a way to manifest social presence, to say "I am here, coherently collaborating with you and further developing our relationship".

Herring (1999), analysing data collected in chat conversations, asserts that participants develop new practices based on the characteristics of the medium, to keep sequentially coherent their contributions.

The existing literature supports the idea that sequentiality is supported in mediated communication by topicality and the turn-taking system. McCarthy, Wright and Monk (1992) have emphasised the importance of continuity in the topic addressed to maintain contributions as sequentially related. Analysing chat communication they found that the use of co-references, terms of address and acknowledgments were used as valuable strategies to keep interactions sequentially linked. Considering that in chat communication many messages can intervene between a first message addressing a topic and a second one addressing the same topic, multiple threads of messages can be developed at the same time. Even if these threads can be seen as disruptive to coordination, because participants could get confused about which contribution the new one is referred to, ambiguity seems to be solved using addressing or quoting the related message (Reed, 2001). On the other hand, to preserve topicality a strategy developed in chats is that of breaking messages in chunks; sending an evidently incomplete message to the partner would signal that the intervention is not yet finished and, consequently, would prevent the addressee from introducing new topics (Baron, 2004).

Another resource considered in the literature to support the development of action sequences in mediated communication is the turn-taking system. Garcia and Jacobs (1999) analysed how participants in chat communication could detect the appropriate moment to intervene, avoiding interrupting the partner. The grammatical completion of the received message allowed the receivers to place their intervention in the conversation. Having the possibility to manipulate the environment, Reed (2001) demonstrated that an updated knowledge about the others' actions in the chat environment highly helped coordination among the partners.

In the light of these results, it seems that participants adopt locally situated strategies to manifest their being socially present and engaged in and with the environment. The accusation moved to mediated communication to hurdle social presence, because of its incapability to convey rich social cues, therefore, rapidly decays (Herring, 1999).

In the present research, interactions under analysis to investigate the exhibition of social presence will be those developed in written dyadic chats. At first, the focus of investigation will be the analysis of the very first verbal encounter between the participants. The analysis of the openings will permit to analyse the moment, the way and the reason fostering the exhibition of social presence in the chat, trying to understand how these aspects can be affected by the characteristics of the media and the task assigned.

Secondly, "intersubjectivity" will be investigated. If social presence is manifested during the on-going interactions performing actions relevant to the their development, the focus of attention will be on the existence of messages pragmatically linked. Then, the research will investigate if some actions performed by the conversational partner are considered as relevant resources to be exploited to manifest social presence and, finally, if action formats chosen to display social presence were in some way related to what could result to be particularly relevant to the prosecution of the task.

### **3. Method**

#### **3.1 Experimental Setting**

##### *The Study*

This study belongs to a wider series of studies promoted by the European Funded Project "PASION". The data presented here have been collected within the "Crossfire1" study of this project, whose results have been published in Gamberini, Martino,

Scarpetta, Spoto and Spagnolli (2006). The current paper will consider the same data from another perspective.

### *Participants and Setting*

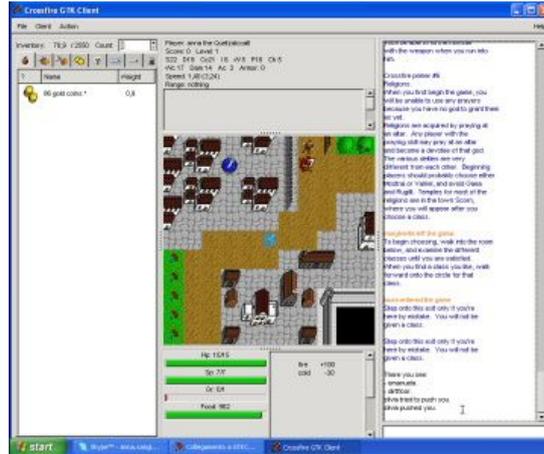
In the present study 24 students (aged 24.88 on average, standard deviation 2.96) of the University of Padua played a collaborative online game called Crossfire. Sometimes they knew each other because they belonged to the same class, sometimes they were strangers. However, their identity was hidden by their nicknames which had been assigned by the researchers. Participants were asked to sign a consent informing them that everything happening on the computer screen was going to be recorded and then analyzed. The pc stations were located in a room at the at the Psychology main building in Padua and each participant sat at an individual station. Due to the size of the room, none of them could see the others' screen and, furthermore, they were prevented from talking during the task (see Figure 1).



**Figure 1.** The experimental setting.

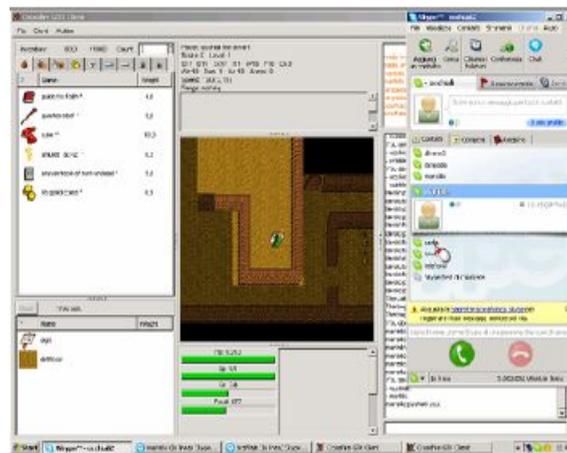
### *The Virtual Environment and the Task*

The virtual environment in which participants were asked to play was constituted by a game, called Crossfire supported by a chat system (Skype®). From the pc screen participants had access to the game environment, representing a virtual world; the interface displayed the portion of the world immediately surrounding the participants' avatar, including the avatars of other participants navigating in that region (see Figure 2).



**Figure 2.** A screenshot of the game environment. The blue dragon is the participant's avatar while the brown dragon and the man on the right upper part of the street are other participants' avatars.

The instant messages (IM) window was also displayed and could be adjusted in the screen as desired (see Figure 3).



**Figure 3.** A screenshot of the participants' desktop during the game. In the central part, an image of the virtual environment, on the right the chat.

This game was chosen because of its free availability on the Internet and then modified to adapt the navigable environment to time constraints (participants were required to play for forty minutes). Considering that the study's aim was to observe which actions individuals performed to make their social presence verbally evident to the others, some issues led to the choice of this specific game. First of all, participants needed to construct interactions. Crossfire satisfied this requirement, because it allowed a free number of people to collaborate in the game. Furthermore, the Crossfire game was full of clues indicating the positions of the treasures (goblets) or other, more

specific clues, thereby fostering verbal interactions. Finally, the collaborative nature of the task itself (to find as many treasures as possible in the environment) further enhanced motivations to communicate. In order to verbally communicate, participants could use a dyadic Skype chat opened on the pc screen from the beginning of the game. Notice that using both the Crossfire game and the Skype chat provided the player with the possibility to be present at the same time through different modalities. In fact, the teammates' reachability was signalled by the entrance of the avatar in the user's region of navigation and by the colour of the symbol near the contact nickname in the chat (see Figure 4). However, only in the verbal modality supported by the chat were teammates always reachable during the game. The possibility to rely on both nonverbal and verbal modalities of communication (through the avatar and through the chat), allowed the researcher to investigate practices adopted to manifest social presence considering the possibility to be already socially present in other modalities.



**Figure 4.** The Skype® chat. All names are listed and a green sign displayed on their left.

Participants operated in groups of eight, with the common assignment of finding as many treasures (which were goblets) as possible in the virtual game. They played two forty-minute sessions of the game. In the environment they could also find clues about the location of the treasures. Verbal communication was useful to notify when some treasures were found, and when new hints on the treasures' whereabouts were discovered. Considering that communication did not take place in a common chat with

all 8 participants, but in dyads, each participant could start up to 7 conversations with as many teammates.

### *Data*

The study aimed at understanding which actions individuals performed to display their social presence during the collaboration task in the Crossfire environment. Considering that in the Crossfire game participants could also rely on modalities different from the verbal one and social presence was established from the beginning of the task, the focus of investigation were contextual situations or needs pushing participants to exhibit their social presence verbally. Consequently, the analysed data were all the chat logs and videos of the duration of the entire game session. Chat logs were collected in .txt format and the videos captured with specific software called Zdssoft®, generating .exe files. The chat logs reported in textual format the time in which the message had appeared in the chat window, the nickname of the speaker and the message. The video files showed everything that took place on the screen during the game. Navigation of the avatar in the game environment and composition of messages in the chat were both visible in the videos.

### **3.2 Analytic Approach**

The aim of the research was to investigate verbal practices adopted by participants to exhibit social presence in the specific mediated environment. As practices are constituted by actions, adopting a Conversational Analysis approach to the study of actions we considered as units of analysis the turn, the action format and the action position.

- Turn: the start and end of a single contribution from one participant to the communication process; in this kind of mediated communication, each turn is constituted by a message entered in the chat.
- Actions: what actions do people perform by speaking (e.g. offering, questioning, answering, aligning).
- Action Positions: actions are sequentially connected to each other. This connection is evident in the topic, grammar and format of the message. The sequential position an action holds with respect to other actions is not the one it has in the chat log, but the one it has with respect to other messages pragmatically connected to it. The time gap between the actual moment of production of the message and its delivery could be filled in by other partner's contributions. Consequently, the produced message could refer to messages other than the last one appeared in the chat window. A basic

sequence, called Adjacency pair (Ap), is composed by two subsequent actions produced by different speakers, in such a way that the former makes relevant another action immediately after it. The first action is called 'First Pair Part' (FPP), the second 'Second Pair Part' (SPP); as already mentioned, in mediated conversation the first occasion to produce the second pair part is often not immediately adjacent to the First Pair Part as it is in face-to-face. Finally, in some cases a third turn is produced after a SPP, which does not make another action relevant next. It is called SCT (Sequence Closing Third).

In Extract 1 these units of analysis will be summarised, applying them to a brief exchange between participants.

Arancia and Mandarino were the nicknames of two participants to the Crossfire games. No one had visually access to the portion of virtual environment where the other's avatar was navigating and, thereby, they did not know what the other was doing and if the other had collected some important information about the treasures. Indeed, participants were not obliged to communicate and they could also decide to keep hidden the retrieval of a treasure and never contact anyone. They had never been verbally in contact until the moment reported in Extract 1.

Extract 1

[10.33.15] Arancia says: ciao, hai visto qualche cartello?

*hi have you seen any sign?*

[10.33.49] Mandarino says: si il calice si trova nelle case verso ovest... mi sembra

*yes the goblet is in the houses toward West... I think*

[10.34.26] Arancia says: ok grazie

*ok thanks*

Extract 1 is opened by Arancia greeting and questioning Mandarino about the possible retrieval of a clue (FPP), followed by a second turn performed by Mandarino, who announced that he had indeed found a clue, thereby providing an answer to the question (SPP). The sequence is ended up by Arancia, who thanked for the information (SCT). To sum up, this example counts 3 turns (3 messages), a complete action sequence of the type question-answer-closing performed through the adjacency pair followed by a sequence closing third.

In some cases the basic adjacency pair is expanded by further adjacency pairs, pragmatically linked to the basic one, which can introduce the main pair (pre-

expansion), or can follow it (post-expansion). The conclusion of the main adjacency pair can also be postponed by an inserted sequence (which starts after the basic FPP and finishes before the basic SPP, see Extract 6).

In Extract 2, which will be reported as an example of expanded sequence, Tavolo and Sedia were exchanging some information about food position. Food was a particularly important topic in Crossfire, because participants who ran out of it were automatically repositioned at the very beginning of the game. To avoid the consequent loss of time, all participants needed to pick up food found in the environment. Thereby, many verbal exchanges were based on food position.

Extract 2

[16.40.08] tavolo says: se sei a città del sud, ad ovest trovi isolotto con castello  
stracolmo di pappe buone  
*if you are in the Southern city, at West you find an oxbow  
overstuffed with good food*

[16.50.17] sedia says: no, sembra non ci sia nulla qui!  
*no, It seems there is nothing here!*

[16.50.37] tavolo says: neanche una merendinaaaa?  
*not even a snack?*

[16.51.22] sedia says: nou!!!!!!ci sono un sacco di prosciutti nell' edificio prima!!!!!!  
*no!!!!! There are a lot of hams in the building before!!!!!!*

[16.51.45] tavolo says: grasssie!  
*thanks!*

Tavolo (FPP) opened the chat by the announcement that, in case Sedia needed it, there was a lot of food in an oxbow in the Southern city. Tavolo was, therefore, providing useful information to Sedia who decided to go feeding its avatar in the suggested place. Ten minutes after the provision of Tavolo's information, Sedia (SPP) complained that the place indicated by Tavolo was empty. By so doing, Sedia did not open any new sequence, but provided a disalignment (introduced by "no") to the "fake" information. Tavolo (FPP) did not let the topic decay and continued asking if the place was really empty or if there was little to eat. Even if the basic sequence had been closed by Sedia disalignment to Tavolo's announcement, the latter, who had been indirectly accused of the fake provision of important information, reacted post-expanding the basic sequence, though producing a new FPP under the format of a

question. Sedia (SPP) responded repeating what he had already said and adding new information about food position. Acting as SPP he provided a conclusion to this second adjacency pair which then definitively ended by the SCT performed by Tavolo.

The whole expanded sequence, composed by more adjacency pairs pragmatically linked, will be referred to as “thread”.

All the chat logs and the videos were completely analyzed, for a total of 116 chats, 966 messages and 32 hours of video-recording. To analyze the sequential structure of communication, attention was paid to the videos, where it was possible to see the time at which the participant started to write a message in the composition window of the chat. As underlined by Garcia and Jacobs (1999), in chat communication actions that seem to constitute adjacency pairs, because of their format and sequentiality can also be “phantom adjacency pair”, as meant to refer to other previous actions and, thence, born to belong to other adjacency pairs. To solve this problem, videos were the most reliable source of information as they allowed us to understand the real sequential organization of the messages. In the following paragraphs some recurrent practices emerging in the communication mode will be described, connecting them with their implications for social presence.

In the first part of the results the focus of attention will be the very first verbal actions performed by participants to manifest their social presence in the chat environment. The analysis of these openings will allow us to understand when, why, and how social presence was displayed, linking this phenomena to the characteristics of the media and the task.

Then, the author will illustrate how social presence is displayed during ongoing verbal interactions. Considering that one possibility to make ourselves present to the other when verbally interacting is to keep feeding talk, attention will be paid to the development of thread of messages signalling the development of verbal interactions. Then the analysis will investigate if action formats performed by the conversational partners affected in any way the likeability to receive manifestation of social presence by the other participants, investigating if a discrimination between actions with a high or low-relevance for social presence was retraceable in the participants’ behaviours and, finally, if the practice through which social presence was manifested depended on the relevancy of actions formats to be performed, always considering the task and the environment.

## 4. Results

### 4.1 Openings: The First Verbal Exhibition of Social Presence

In the verbal exchange the first display of social presence was performed in the openings of the chat. However, previously to the first verbal exchange, in the Crossfire environment the interlocutor's social presence was established in different ways from the beginning of the game. Her/his identity was displayed by the nickname, always visible in the chat windows. A green oval displayed on the left of the nickname in the contact list signalled the interlocutor's availability on the medium (see Figure 4). Finally, all participants were present in the environment from the beginning of the game through their avatar, who had all entered the shared virtual environment at the same time. All these characteristics can explain why the most used practice to start encounters in face-to-face communication, namely greetings, was present only in 7.70% of chat initiations, as reported in Table 1.

Chat Starting Actions	Occurrence	Percentage
announcement	50	43.10%
question	50	43.10%
greeting	9	7.70%
order	6	5.17%
request	1	0.86%
Total	116	100%

**Table 1.** Occurrence of chat starting actions and percentage.

If greetings were rarely produced to open verbal exchanges, in our data participants showed an equal preference to start speech exchanges with announcements and questions (43.10%). Extract 3 presents an example of chat opening performed using a question.

In this specific situation, as already mentioned, Ananas knew that Fragola was available in the chat by the green oval sign near the latter's name. Furthermore, the latter's avatar had entered the environment at the beginning of the game making legitimate to think that Fragola was participating in the game. When the chat was opened, Ananas had been navigating without finding anything relevant for the game development (treasures, clues, food), while Fragola had entered a building, together with another player (Melone), from which she had not yet managed to exit. It is to be

remembered that participants were never forced to communicate verbally in case they found a treasure or a clue and, therefore, they often solicited this kind of information.

Extract 3

[12.47.30] Ananas says: trovato niente?

*found anything?*

[12.47.54] Fragola says: no.. sia io che Melone siamo bloccati in una casa da cui non possiamo uscire

*no.. Melone and I are both stuck in a house from which we cannot exit*

[12.48.09] Ananas says: ahah

*Ahah*

Extract 3 is the starting sequence of the chat between Ananas and Fragola. At time 12.47.30, about 10 minutes after the beginning of the game, Ananas (FPP) performed the first verbal attempt to contact Fragola, asking about her progress in the game. The first action through which Ananas decided to exhibit her social presence to the teammate, avoiding any greeting, acknowledgment or introduction, hence, was a question whose response could have updated Ananas' information about the retrieval of a treasure or some other clues, consequently helping her in the advancement of the task.

In the following extract, the chat is opened by an announcement performed by Mandarancio. Similarly to questions, announcements played the role of making information flow among players, alerting the participants about the retrieval of some goblet, the finding of food or clues. In Extract 4 Mandarancio had just found a treasure and, with the chat, communicated it to Nocciola.

Extract 4

[16.38.11] mandarancio says: trovato calice

*goblet found*

[16.38.24] nocciola says: well done!!

*well done!!*

In Extract 4 Mandarancio (FPP) contacted Nocciola to provide her with a relevant information about the retrieval of a goblet. As in the previous example Mandarancio did

not choose to summon or greet the partner, opening the chat directly with the reason for the verbal contact, namely to inform the partner about the fact that a treasure had been found.

Both extracts represent the most common ways found in our data to open the first verbal encounter with teammates.

The wide use of questions and announcements to start up conversations to the detriment of greetings suggests that participants strongly relied on what they had previously acquired from different non-verbal interaction modalities. In particular, their nickname on the contact list, their red sign near their nicknames and their avatar navigating in the environment constantly fed their awareness that they were socially present, available and engaged in the game from the very beginning of the session.

Consequently, the social presence on the medium did not seem to be something discontinuous with respect to the social scenario before the start of the message exchange, something that needed to be addressed again. It seemed something already established, on whose bases the conversation could enter directly into its core.

#### **4.2 Exploiting Environmental Resources to Support Social Presence**

As already anticipated in the introduction, social presence can be displayed during the ongoing conversations by means of contributions which are relevant and coherent to the actions performed by the partner. In other words, being socially present means not only sharing the same space, but also performing actions which acknowledge what was previously done, with the aim of enhancing interactions. For this reason, attention was paid to how conversations were supported and developed in the Crossfire game, in terms of sequentiality on which action sequences were unfolded, responses provided to the partner's verbal actions and action formats.

##### *Sequentiality*

To verify how participants displayed their social presence coherently with the actions previously performed by their partners, thence demonstrating that they were engaged in the task and in the environment, the existence and development of action sequences turned to be the main focus of attention.

Following Spagnolli and Gamberini (2006), the number of messages in the chat left isolated was considered. These cases did not receive any response or acknowledgments by the addressee.

In the chat conversations developed during the Crossfire game, only 10.43% of messages (101 out of 968 messages) did not receive any acknowledgement by the partner, as in Extract 5.

Extract 5 reports an encounter that took place after a long lasting navigation in the environment (about 20 minutes), when Lontra contacted Scoiattolo to ask for the retrieval of clues. In the game, clues were disseminated all over the virtual environment and, being numerically superior to the number of hidden treasures, it was easier to reach a treasure following a clue than by chance. Thereby, clues resulted to be the topic of many conversations, as they could help players to localize treasures and go directly to fetch them.

Extract 5

[16.43.02] lontra says: indizi?  
*clues?*

Lontra (FPP) asked to Scoiattolo (potential SPP) in a very synthetic way about the retrieval of some clues on the location of the goblet. In this case, however, no response was provided by Scoiattolo and the basic Adjacency Pair remained uncompleted.

As cases such as the previous one constituted a minority, in terms of social presence this means that whenever required, the addressee tended to manifest her/his social presence by responding to the request demonstrating that he/she was paying attention to the other and was there actively reacting.

Thread Length	Number of threads	Percentage
1	101	26.90%
2	127	33.90%
3	48	12.80%
4	42	11.20%
5	25	6.60%
6	12	3.20%
7	9	2.40%
8	5	1.30%
9	6	1.60%
Total	375	100%

**Table 2.** Occurrence of Threads of messages of different lengths.

To further support and expand this result Table 2 reports the variety of thread length found in the chats. The total number of threads found in the analysed data was 375. The threads found varied from 1 to 9 messages. Some examples are reported below.

The following thread has been developed near to the end of the game. Scaffale and Occhiali had previously verbally interacted to coordinate their moves. Interestingly, towards the end of the game sessions, participants tended to plan their moves communicating about their position in the environment and verifying, considering that they started to run out of time, how many treasures were still hidden in the environment. In this specific situation, Occhiali had previously signalled that he was in the Northern city and Scaffale had responded warning him not to attempt entering the Southern city. In what follows Scaffale, who knew that Occhiali was exploring the North, contacted him.

Extract 6

[16.37.51] scaffale says: trovato qlc?

*anything found?*

[16.38.20] occhiali says: no ero arrivato dove si trovava un calice ma qualcuno era arrivato prima di me

*no I arrived where the goblet was but someone else had arrived there before me*

[16.38.34] scaffale says: oh cacchio

*oh gosh*

[16.38.49] occhiali says: io l'ho trovato al porto non andare

*I found it at the harbour, don't go there*

[16.39.32] scaffale says: hai trovato un calice?

*did you find a goblet?*

[16.39.41] occhiali says: -si

*-yes*

[16.40.24] scaffale says: nella citta del nord?

*in the Northern city?*

This thread is opened by Scaffale (FPP) questioning about a possible retrieval. Occhiali (SPP) provided a negative response, underlying that he had arrived too late where there had been a goblet. The main basic sequence is concluded by Scaffale commenting on this unlucky event (SCT). Then Occhiali (FPP) reopened the sequence

by providing information which was anyway related to the question already responded to. Even though the first response had implicitly assumed that Scaffale was referring to the specific city where Occhiali was as the potential place for a clue or a treasure, they had never before communicated the retrieval of anything to each other. Consequently, Occhiali reopened the sequence announcing that he had indeed found something (action pragmatically related to Scaffale's question) in the harbour and suggested her to avoid losing time going there. This announcement is expanding the basic sequence. Scaffale, at this point, posed a question (what CA calls a repair) to make sure that she had exactly understood what Occhiali said. This action was not a response to Occhiali announcement, as it postponed a possible response which could be provided only after Occhiali's clarification. Scaffale was, in this case, performing the role of the FPP of an inserted sequence which was completed by Occhiali's answer. Again, the response to Occhiali's FPP did not arrive because Scaffale asked for a second clarification about the place where he had found the goblet. By so doing, she was offering an extension of the inserted sequence which did not receive a closure. This thread is an example of complexity which can be reached when the participants exploit as resources the others' verbal actions, enhancing interactions.

Thread complexity varies according to the sequences composing them. The existence of sequences of messages related one to the other demonstrated that participants tended to carry on the verbal activity started by someone else, manifesting that they too were actively engaged in the task. These threads support the possibility of maintaining sequentiality in mediated communication (Herring, 1999). When an exchange was opened it was very likely that the addressee responded by providing a coherent conclusion to it, avoiding leaving the first pair part unconsidered and troubling the development of the task itself.

In terms of social presence, it meant that, when verbally addressed participants did not drop the possibility to reply. Once received a message, they did not ignore it remaining inactive in the verbal modality.

### *Returning Relevant Actions*

In order to better understand which kinds of actions were considered particularly relevant and, consequently, particular useful resources present in the environment to be exploited to manifest social presence, attention has been paid to which kinds of actions were more likely to be responded by the addressee. In fact, the typology of actions performed by the FPP stimulating a high level of response, which means to

which the participants were more likely to manifest their social presence, could offer some insights about the relevancy of these actions performed in the Crossfire game.

In the analysed chats we found six different kinds of actions performed in the First position (FPP), as reported in Table 3.

Action	Occurrence	Percentage
announcement	244	46.47%
question	205	39.04%
repair init	35	6.6%
greeting	18	3.42%
Order	15	2.85%
complaint	8	1.52%
TOTAL	525	100%

**Table 3.** Occurrence of actions and percentage.

The preference for questions and announcements is easily due to the nature of the task and the possibilities of actions to be exploited in the environment. The game required to find the position of the treasures in the virtual world, but the access to each other's achievements in the graphic world was very limited. Therefore each player had to keep the teammates updated on the treasures or on the clues discovered using announcements, or to obtain this updates with questions.

The next step was to verify, among all these actions, which were those more likely to receive a response, stimulating the partner's exhibition of social presence.

Generally, only the 28.5% of actions did not receive a response, while the 71.5% did (Table 4).

Action	Unreplied	Occurrence
complaint	5 (62.5%)	8 (100%)
greeting	11(61%)	18 (100%)
announcement	86 (35.2%)	244 (100%)
order	5 (33.3%)	15 (100%)
repair	8(22.8%)	35 (100%)
question	35 (17%)	205 (100%)
TOTAL	150 (28.5%)	525 (100%)

**Table 4.** Amount of unreplied actions by type, and total occurrence of that type of actions.

According to Table 4, announcements and questions, the most frequently performed actions, had been highly reciprocated. Although players constantly received them, they did not give up contributing to the exchange. Their being often responded seemed to underline that these actions were considered so relevant that the partner could not afford to make their reception pass unobserved.

Considering actions less frequently performed, complaints and greetings seemed to be those less likely to be produced, as shown in Extract 7 and Extract 8.

In the sequences preceding Extract 7, Viola had communicated to Blu that a treasure could be found in a house with a red-brick roof. Blu found the house and entered it, but she could not find any sign of the treasure. After having searched the whole house few times, she complained to Viola.

#### Extract 7

[13.17.04] blu says: questo calice è troppo imboscato

*this goblet is too deeply hidden*

By complaining Blu (FPP) was making evident that she was criticizing the fact that the treasure was, in her opinion, too well-hidden and probably quite impossible to find. The complaint, however, was a comment with little relevance for the task itself, as a possible response could not have in any way helped the development of the game, but only provide a support, by co-complaining for instance, to Blu.

Similarly, in Extract 8 Giallo greetings used to open up the chat were ignored by the addressee.

Extract 8

[16.48.49] giallo says: ciao anne

*hi anne*

[16.48.54] nero says: poco più avanti c'è un indizio

*a little bit further on there is a clue*

Giallo (FPP) opened the verbal encounter by greeting the teammate. Nero responded using an announcement about the location of a clue, without greeting back (SPP). This response provided some information which could have been very useful for the retrieval of a treasure and, thereby, highly relevant for the task.

Greetings, as already introduced in the first part of the result section, were rarely performed by the participants. The high rate of ignored greetings (61%) offered a support to those findings, suggesting that social presence also relied on different modalities of interactions and, thence, the relevance of greetings seemed to be diminished here.

To conclude, outcomes on actions more likely to receive an acknowledgment by the addressee pointed out that social presence was more likely to be manifested in the chat by returning actions which were crucial to development of the task.

#### *Returning Relevant Actions in a Relevant Format*

The last outcome of this study involves action formats of responses provided to relevant actions. In particular, considering that social presence was displayed providing a response to what could be considered the most relevant actions, namely questions and announcements, it was interesting to see if this response could be affected by the “relevancy” issue. In other words the question was “do participants exhibit their social presence in responding to relevant actions using actions which are by themselves relevant?” If that was the case, it could have meant that players decided to support the interaction not only by providing a formal response to relevant actions, but providing a response which could advance further the task. In particular, the data emphasized the existence of new formats of SPP provided to announcements. While the traditional pair is composed by announcement in the first place (FPP) and alignment/disalignment in the second place (SPP), the considered chats showed that these actions were frequently reciprocated by other announcements.

In the following extract Ananas and Arancia had been wondering around for about thirty minutes. While Ananas had already found a treasure, Arancia had continued

looking around communicating very often to gather clues and information, but she had not found any goblet yet.

Extract 9

[16.34.22] ananas says: ho trovato un calice!!! Edificio bianco città del nord

*I have found a goblet!!! White building in the Northern city*

[16.34.49] arancia says: anch io tempio a cupola zona templi nord

*Me too domed temple temple area North*

[16.34.55] ananas says: bene

*Good*

Extract 9 is opened by Ananas (FPP) who informed Arancia (SPP) about the location and the retrieval of a goblet. Very often, indeed, participants communicated not only that they had found a treasure, but also where they had found it preventing others from looking in the same places. Arancia (SPP) responded performing the same kind of action, another announcement. Even if standard actions coupling announcements are alignment or disalignment, in the analysed data 20.8% (33 out of 158) of responses to announcements were constituted by actions in the same format.

To identify which announcements were meant to be responses (viceversa they could be FPPs, opening new sequences) a series of “strategies” used to connect two subsequent announcements emerged. In Extract 3 this was recognizable in the starting terms ‘me too’, together with geographical coordinates mirroring the one provided by the first announcement. Some other examples were: “I found the same sign”, or “I have already been there, but I did not find anything”. It has to be noticed that these reciprocating announcements were never treated by the first speaker as disregarding their original announcement for the absence of an explicit align/disalignment. Consequently, it seemed that the speaker accepted as legitimate closure of the pair a response in the format of an announcement.

Considering all the adjacency pairs composed by two announcements, one in the first position and one in the second, results showed that they usually addressed the same topic, namely goblets, clues and participants’ positions.

In Extract 10, Tavolo and Telefono had just found a clue in the environment and communicated it to the partner. Sometimes clues were about the location of a treasure, while some other times participants could find clues about the location of other clues.

Extract 10

[13.22.13] tavolo says: c'è un indizio su un calice in un tempio a nord-ovest

*there is a clue on a goblet in a temple North-east*

[13.24.36] telefono says: nella taverna al centro della città c'è un altro indizio

*in the tavern in the centre of the city there is another clue*

The announcements performed by Tavolo (FPP) and Telefono (SPP) are about two locations of clues.

This practice underlines that, by providing an announcement in response to another announcement, participants did not open new sequences, ignoring what the conversational partner had previously done, but they were performing a cooperative action considering the current activity. By using an announcement in the second position, the speaker increased the amount of information exchanged and, therefore, actively enhanced the game.

In terms of social presence this further supports the idea that the strategies adopted by the players to make their social presence visible to the others are deeply affected by what is relevant to the activity at hand.

## 5. Conclusions

The present study investigated when, how and why social presence was manifested during an online game. The first interest was to verify how the possibility to rely on different communication modalities could affect the very first exhibition of social presence. The possibility to be already present in the environment in modalities different from the verbal one, the participants' availability was signalled by a green sign in the chat list, their avatar being present in the shared environment (even if not constantly displayed), could be hints to understand why social presence was verbally displayed without using greetings or summons. On the contrary, players opened verbal exchanges going directly to the motives of the interaction, which were mainly asking for information or providing it. Verbal interaction was seen as a continuum with the previously established framework in which social presence had been displayed.

The second aim was to see how social presence could be exhibited during the interactions, underlying which were the legitimate practices to do it. In the Crossfire game, information flow was fundamental to speed up the retrieval of treasures in the

environment. Considering that participants did not have access to the teammates' actions, because the visual space display on the computer screen only covered their avatars' surroundings, verbal interactions were the only way to spread information in the team. Thereby, in the game a legitimate practice to display social presence was by performing actions which were relevant to the task itself, in particular announcements and questions. These actions were so important for the development of the task that they were usually followed by a response from the addressee and not let ignored. On the contrary, greetings and complaints, which did not particularly enhance information flow, were rarely considered by the partner. To sum up, social presence was more likely to be manifested in the chat by returning actions which were crucial to development of the task.

Finally, practices adopted by the players to manifest their social presence in the Crossfire game seemed to be also affected by what was considered relevant in the task. In particular, the traditional format of alignment or disalignment following an announcement had been sometimes replaced by other announcements which could enhance the development of the game.

To conclude, Crossfire results highlight that the emerging practices used to display social presence in this specific environment are connected to both the nature of the activity and of the mediated environment where they take place.

The results of this study suggest new ideas in the study of social presence in mediated environments. Adopting an action based approach to the phenomenon, it would be really interesting, for instance, to consider what is the most legitimate modality to display social presence whenever different options are available to the participants. Furthermore, how different tasks establish different relevance of actions performed to exhibit that we are actively collaborating to its development? Once determined which practices are considered legitimate, what are the reactions to transgressions to the legitimate practices of social presence display? It will be worth investigating these issues in the future.

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# Being Part of the Life of One's Hometown: Strategies to Support Community Connectedness

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## ABSTRACT

Information and Communication Technologies can be instrumental for those who have moved away permanently from their places of origin. This paper presents a condensed analysis of interviews conducted with twenty six (26) Mexican migrants and family members living in Mexico. The interviews addressed several topics ranging from family communication to communication with the community in general. In this paper, we identify and discuss the strategies followed by those living away to keep the sense of community connectedness high. Among those strategies, we found that they keep connected with the community life through several sources following certain communication patterns which are used to as a way to reencounter with their people periodically. These findings serve to highlight the relevance of the role played by ICTs on supporting community connectedness for migrants and the opportunities for defining and developing new technologies.

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Keywords: *Community Connectedness, Presence, Migration.*

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## 1. Introduction

Information and Communication Technologies (ICTs) have always been a key mechanism to coordinate and make people feel closer to others. With the advent of new technologies, people have been able to overcome more easily the limitations imposed by space and time. However, this situation gains more significance particularly in contexts where people stay permanently far away from their hometowns and, most of the times, from the people they love.

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As people move away from their home communities, staying in touch and frequently returning to their hometowns can become of paramount importance. Due to the need of being in touch with those left behind or the belief of an eventual return to their homeland, many migrants look for the ways to keep strong connections to their home communities, i.e. to be connected to the daily life in their home communities, which we will refer hereinafter as *community connectedness*. One of the obvious ways for keeping strong connections is returning home frequently (Suro & Escobar, 2006). However, very often, many migrants fail to do so due to many factors such as their migratory status, work commitments, or financial limitations, so that all links they currently have with the home community are necessarily *mediated* through social networks either face-to-face or by using some form of technology (e.g. the phone).

An understanding of the role played by ICTs on supporting migrants' sense of community connectedness is clearly relevant all over the world but it is even more for those countries facing major migratory flows. Our investigation focuses on the migratory flow from Mexico to the USA as it has been identified as one of the most dynamic worldwide in terms of movements of people and economic integration (Roberts, Frank, & Lozano-Ascencio, 1999) and, therefore, an ideal scenario to understand the implications of technology for community connectedness. In general, migration is a phenomenon of major dimensions and is likely to reshape societies forever (Castles & Miller, 2003). In Mexico, as in many other countries, emigration is often experienced by regions with fewer opportunities of development such as jobs and education (Rinderle, 2005). Economically, the receiving regions benefit from such migratory flows as immigrants are seen as key to the community's long-term social and economic health (Grey & Woodrick, 2005). On the other hand, the expelling regions receive every year billions of dollars in remittances, usually for family consumption and community projects (Burgees, 2005). During the last two years, 2006 and 2007, the Bank of Mexico reported Mexico received more than US\$ 46 billion in remittances (BANXICO, 2008). Socially, the migration from Mexico to the USA is a phenomenon of major dimensions. According to the National Council of Population in Mexico (CONAPO), there are about 10 million people born in Mexico in the US and the figure can be twice as large considering people of Mexican descent (CONAPO, 2005). Within this particular context, it has been suggested that Mexican migrants contribute generally to reduce inequality and better-off households in their home country (Ratha & Shaw, 2006).

Nowadays, many Mexican migrants, absent for years from their home communities, as well as those that emigrated recently, are increasingly using ICTs to get in touch with their roots, their home communities and their families. New communication technologies have provided migrants a better opportunity to be part of the daily life of their home communities since now their spectrum of alternatives to get in touch with them has been broadened. A palpable example of this is the hundreds of community web sites in the Internet that have been established with the aim of connecting those living away (Gonzalez & Castro, 2008). However, a most typical scenario is one where the links with the day-to-day homeland occurrences that the migrant has are still mediated through family and friends (typically by phone calls). This can undermine the richness of the information received as it depends on the ability, availability and willingness of the interlocutor. This paper presents empirical, preliminary results aimed to identify the strategies followed by migrants to keep the sense of community connectedness high. We also discuss the role that non-conventional presence-affording technology (e.g., environmental microphones) could potentially play on the sense of community connectedness.

This paper is organized as follows. In section two we discuss previous studies and identify some of the main reasons why migrants would be interested in maintaining certain levels of interest in their homelands. Next, section three describes the characteristics of our study and the participants. Section four presents the results of the study, describing the current strategies used by our participants for keeping community connectedness. Finally, we discuss our findings, and conclusions and future work are presented.

## **2. Presence in Absence: Toward Connecting Migrants to their Hometowns**

Previous studies have confirmed the potential of internet-based tools such as e-mail and web sites as a way to keep in touch with the family, close friends and to obtain a certain notion of what goes on in the home country (Bernal, 2005; Castro & Gonzalez, 2007; Hiller & Franz, 2004; Miller & Slater, 2000). As such, ICTs have been a valuable mechanism to make people feel 'closer' to others and, in the case of migrants, reconnect with the life in their home communities.

## **2.1 The Need to Be Connected to the Life of the Home Community**

### *Place Attachment and Belonging*

Previous research suggests that this need of returning is caused by psychosocial bonding to that particular place which can be ascribed to landscapes, childhood experiences, and, symbolic and cultural ties (Chawla, 1992; Hummon, 1992; Low, 1992; Riley, 1992). Other studies show that humans have a natural need to belong and are usually reluctant to be unattached (Baumeister & Leary, 1995). This can be the situation of many immigrants when they do not get fully integrated into the new society thus resulting on their longing for home. In general, some of these theories are still to be consolidated and more research is needed to fully understand it (Stedman, 2002).

### *Distress after Relocation*

It has been found that humans tend to experience distress after a move (Fisher, 1989). The need of returning or getting in touch with the community in the very early stages of migration might be due to the need to alleviate the distress experienced by many factors, including the drastic loss of social capital, which is one of the most important aspects in community life (Putnam, 2000). Social capital is a collective value of all social networks, i.e. a public good, and comprises several aspects such as trust, reciprocity, information flow and social norms (Coleman, 1988). After moving out from small (geographical) communities, migrants' stock of social capital is likely to change drastically as they face an entirely new context.

In the same way, other studies concerning diasporic communities suggest that longing for homeland is a typical behavior of members of a Diaspora and that these communities are very prone to be disturbed by the effects of homesickness. Homesickness is a reaction to leaving one's home and occurs typically after a move (Fisher, 1989; van Tilburg, 1997). Fisher (1989) reported that this phenomenon could potentially hamper the adaptation of migrants to their new society, and yet, not so much research has been conducted in this area (van Tilburg, 1997). Although, some studies have identified some causes and effects of homesickness (Fisher, 1989; van Tilburg, 1997), research has scarcely addressed the problem of coping with homesickness.

### *Living a Lifetime Away from Home*

As discussed previously, there are several reasons why migrants need to return. Urry (2002) discussed the need of physical co-presence and travelling in many situations

which might provide also some initial clues (Urry, 2002). In particular, we are interested in understanding the role played by technology in keeping migrants in touch with the daily life in their places of origin. This situation seems to be even more relevant when migrants are deprived of an eventual return to their homeland meaning that the only alternative they have to remotely experience the community life is necessarily *mediated* either through their social networks (who people know) or technology. Along with these works, several studies have placed particular emphasis on studying the role played by ICTs to support the life of diasporic communities (Bernal, 2005; Hiller & Franz, 2004; Miller & Slater, 2000). Every study in their own way concluded that the role played by Internet was fundamental for these kinds of communities to know the details, to get to know their roots, to rediscover their past, to strengthen family communication and, finally, to keep some sort of connection to their home communities. For the particular case of Mexicans immigrating to the USA, a study conducted by Pew Hispanic, after the 2006 presidential election, concluded that they have strong connections to their home country either by watching news about Mexico (in Spanish) or by calling frequently (Suro & Escobar, 2006). There is no doubt that the communication support provided by technology is of paramount importance for many migrants since sometimes it is the only alternative they have due to their migratory status.

Along with these works, in a previous study, Gonzalez and Castro (2008) found hundreds of community web sites in Mexico aimed to maintain those living in the US aware of the events going on in the home communities (Gonzalez & Castro, 2008). These web sites include similar services such as synchronous and asynchronous text-based communication tools (e.g., guestbooks, chats, forums), photo sharing systems, and others. They argue that those services are used to alleviate certain needs of the community such as the need to be part of the community, social and civic participation, and the need of being aware of everything that goes on in those communities. Other studies on community networks reported that, depending on the individual, Internet can enhance community participation by “mediating the link between the disposition to be civically active and the actual activity of making the activity easier” (Carroll et al., 2005, p.179) which, in the particular case of migrants, is much more relevant due to distance and extended period of absence from their hometowns.

## **2.2 Community Connectedness, Awareness and Presence**

As it can be seen, the context presented in this work is somehow different from those presented typically in the area of presence since this work is not about exploring how

we can make migrants feel like being home which, although interesting, is not the aim of our research. Our research aims to shed some light on the nature of community connectedness, identifying some of the main elements influencing the fluctuations of community connectedness and, finally, understanding the role played by ITCs on these. The problem presented in this work is a particular phenomenon that involves mainly two parties: those living away and those still living in the home community. There is empirical evidence that suggest that both parties are interested in maintaining certain degree of intimacy and immediacy. However, on top of these feelings, empirical evidence suggests that migrants also need to know about the local events and random occurrences in their home communities which, in this work, we refer to community connectedness. Formally, community connectedness has been described as “the inclusion of the community in self” (Mashek, Cannaday, & Tangney, 2007, p.259) meaning that migrants and community are part of each other. They know what is going on with the community and the community is aware of the life of those living away.

Awareness is a concept largely used in Computer Supported Cooperative Work (CSCW), which has been defined as “an understanding of the activities of others, which provides a context for your own activity” (Dourish & Bellotti, 1992, p.107). Even though the concept of awareness has been mainly used in terms of supporting work-related activities, it can be applied also to other contexts such as Computer-Mediated Communication (CMC). Indeed, it has been found that by increasing awareness on human or machine partners the interactions could be improved (Picard, 1999). For instance, computers that can recognize interest, disliking or confusion could certainly be used to improve human interactions with them. This improvement could also be experienced in human relationships by the conveyance of emotional information between lovers or family members. Indeed, distant lovers could be very favored by the conveyance of emotional information since that issue may be fundamental for the relationship to prevail. Recent research on personal awareness systems have focused on designing systems for the home setting as well as creating affection connections between lovers (Chung, Lee, & Selker, 2006; Dey & de Guzman, 2006; Fujita & Nishimoto, 2004; Keller, van der Hoog, & Stappers, 2004; Mynatt, Rowan, Craighill, & Jacobs, 2001). These systems have been mainly designed for families, friends, and lovers to keep them feel *connected* to each other. Indeed, as suggested by Licoppe (2004), several frequent, continuous communicative gestures can yield to what he calls ‘connected presence’ (Licoppe, 2004). Connected presence refers to a continuous stream of contact between two persons throughout the day afforded by the

uninterrupted use of different technologies such as SMS, electronic mail, Instant Messaging (IM). This concept *per se* is very important as it extends interpersonal (intermittent) interactions to an uninterrupted state of connection. However, this stream of research has been focusing on the sense of connection between people rather than connecting people to communities as a whole. In the particular case of study presented in this work, migrants' need to be connected with the family seems to be woven together with the need to be connected with the community. In addition, following this latter perspective, little or none research has been conducted to investigate the effects of technology on community connectedness since, in this particular case, is the main liaison between those living away and the homeland. Moreover, many of these works consider the feeling of connectedness as a finite state resulting from an interpersonal exchange. In this work, we conceive community connectedness as a continuous, variable state experienced by migrants toward their community of origin.

### **3. Understanding the Needs of Migrant Workers**

In January, 2007, we conducted a study aimed to understand how migrants keep up to date about family and community events. In particular, the study aimed to understand the role of technology in connecting migrants to their families and their home communities. The initial study consisted of ethnographic-based interviews with people experiencing the phenomenon (Figure 1).

The topics (see Appendix 1) covered by the interviews are: the general understanding of the migration experience, the feelings produced by immigrating, patterns of communication, contact with the home community and future perspectives. Interviews lasted in average about 53 minutes. The data collected was then analyzed using a comparative approach aiming at identifying patterns among the responses and producing an integrated set of findings as suggested by the Grounded Theory approach (Charmaz, 2006; Strauss & Corbin, 1998).



**Figure 1.** Migrants, participating in our study, gathering before going to work (left) and a migrant worker with all his children in the USA (right).

This study involved migrants living in Southern California as well as some members of their family and/or acquaintances living in the municipality of Juchipila in the central state of Zacatecas, Mexico. All interviewees (Table 1) were originally from the same municipality. Twenty six interviews were conducted from which thirteen were carried out in California and the rest in Mexico. Finally, the interviews were verbatim transcribed for their posterior analysis.

Country of Residence	20 – 40 years old		41 – 60 years old		60 and older	
	M	F	M	F	M	F
United States	6 (3) [1]	–	6 (3) [1]	–	1 [1]	–
Mexico	1	2	2	5 (2)	3 (1)	–

**Table 1.** Demographic data of interviewees and transcripts: (1<sup>st</sup> round), [2<sup>nd</sup> round].

The analysis was aimed to obtain the meaning of the phrases or comments made by the interviewees. The relevant ideas were assigned a code to be used throughout the analysis since different people can refer to the same codes previously identified. Nine interviews (see Table 1) were first transcribed, analyzed, and codified in three stages from which the first draft of code emerged. As the analysis continued, some categories emerged as the main ones as well as some of the properties and dimensions of the categories (see Appendix 2). After concluding this stage, associations were created between categories and properties. From the rest of the interviews, three more were fully transcribed and analyzed. Finally, we carefully listened to the rest of the interviews to fill any gap left by the initial analysis.

#### 4. Physically Absents: Strategies to Be Part of their Hometowns' Life

To overcome remoteness many migrants use different strategies. It is important to see that many migrants indeed remain socially and economically 'present' in their home communities despite the distance. There are several means they use to do so. Among those, the remittances are mechanisms used by migrants to be there present in absence and the effects they have on their home communities have been subject of study several times (Ratha & Shaw, 2006). Indeed, remittances have been considered as one of the most effective strategies for development since the money go straight to those who need it the most (Garcia-Zamora, 2005). In the same way, Hometown Associations (HTA), formed by migrants of the same community of origin (Figure 2), are recurrently doing fundraising activities to support community projects and charity in their home communities (Burgees, 2005).



**Figure 2.** Two migrants, participants of our study showing pictures of the community projects they have participated in.

These are some of the facts that reflect the migrants' desire of being there in some way. We move now to the analysis of how migrants use technology to be aware of everything that goes on in the home community i.e., how to be there without actually being there.

##### 4.1 Keeping Connected with the Community Life

Many Mexican communities are dispersed throughout several locations in Mexico and the USA forming small satellite communities of migrants from the same place of origin that are permanently in touch with the homeland (Roberts et al., 1999). In our study, the informants commented keeping strong communication bidirectional flows within and between the communities through informants in the hometown. On the one hand, the

*inbound* information flows are toward the home community and are characterized by the inclusion of information about the activities and occurrences in the satellite communities. Likewise, it also includes the social life within those communities as well as particular events from isolated migrants. On the other hand, *outbound* communication flows are originated in the home community and are aimed to keep migrants well informed about the occurrences in the home community. The main difference is that *outbound* communication conveys information about the daily occurrences as well as fortuities in the home community whereas *inbound* let people in the community know how they are doing in their new communities. Inbound and outbound communication involves the inclusion of different channels.

#### *Through Close Informants*

The migrants participating in our study mentioned that they usually have one main informant in their home communities, or even in their own family in the US who are usually relatives (e.g., mother) or very close friends who, depending on the situation, can be reached by telephone or internet based services. One of our participants, a young university student living in the US for 11 years commented *"My dad calls them and he just tells me something if anything [extraordinary] happens there and that's the way I get to know things... and I think that's reciprocal, what happens here it's told [there], because many people there knew I had been in the navy"* (male, 27). This scenario is mirrored in the home communities where our informant's father has one main contact (one of his siblings) to obtain information about the community and family. Highlighting the importance of being aware of the events in the community, a migrant, 42, commented *"Well, important dates, say, in December that sometimes I cannot go, I'm always with the curiosity 'what will be happening? if someone got married, how it would have been?' in December, January, May... those are the times when there are a lot of family birthday parties... that I wish I could be there and you have to wait till they are finished to know how they went, the news the next day... things like that"*. These types of comments were typical among migrants. They have their local informants to keep them well aware of the events in the community.

#### *Through Local Social Networks*

When Mexicans migrate, they tend to form small groups of migrants from the same place of origin since they share common values and traditions (Roberts et al., 1999). This situation was highlighted by our informants who said they organize, coordinate

and perform fundraising activities to contribute to the wellbeing of the community as well as to help each other. One active member of the community currently living in Los Angeles commented *“we get to know everything very fast, we are used to that, if an accident occurs [in our hometown], we collect money quickly, quickly, we communicate with each other and well, with the pain when someone dies... Always, when it happens something like that, we are always informed ‘that someone died because he crashed his car’ or ‘that someone spilled and got disabled’. We are always helping each other and because it’s such a small village. One can be informed about everything and you feel something about everyone or everything there, even though this person is not a relative, because you have always lived in conviviality with everyone”* (male, 42). Most migrants rely on these local social networks as a support network as one of them living for over 20 years in the USA commented *“Around 6 months ago, a man died there [his hometown], and his daughter was here... they organized a barbecue as a fundraising activity to help to the burial costs and I told them ‘what you collect, I will make it double’”*. Similarly, many of them are used to augment their communicative repertoire as another professional migrant worker commented *“When something just happens, there’s always someone calling here and the one who receives the call distribute them [news] ‘look, you know what happened? That someone fought with this other –and how was it? Well, like this’ the gossips are easily spread”*. Hence, every migrant is seen by the rest as a potential source of news about the hometown.

#### *Through the Community Web Site*

While community web sites might afford certain levels of social presence by including synchronous communication tools (e.g., chat), the importance of these sites rely in that they allow migrants to have a place where people from the community can virtually gather, create and exchange information about the community (Bernal, 2005). They can directly obtain ‘raw’ information that can help them to spread all the news about local events such as weddings and the local festivities. For instance one migrant, male, 45, commented *“like now [January], the fair should be there [on the web site], I haven’t seen it... and people have been asking me ‘hey, do you know something?’ because they used to send me pamphlets [to the store] before, about the bullfights, cockfights, and they haven’t sent anything... and somebody told me ‘it’s on the internet, you can download it from there’, but before they used to bring me [those things]”*. Others usually find the web site as informative as one commented *“it’s good that these pages exist, to be informative and very far from being gossiping... they’re to be in touch”*. Similarly,

some others use the web site as an escape from their realities in the US, as one young migrant worker, 21, commented *“Well, you feel like you transport yourself, let’s say, you can imagine that you are there”*. Thus, migrants usually use the community web site to feel part of the life in their place of origin by obtaining a taste of those goings-on not easily conveyed through their social networks.

These three different channels are used to obtain a ‘taste’ of the community life supplement each other. Nonetheless, it is still unclear to what extent each of these channels contributes to the sense of connection to the life of the community.

#### **4.2 Keeping Certain Communication Patterns**

The analysis revealed that migrants follow some preconditioned behaviors ruled by the need to be part of the life of their families and communities. We identified three main types of simultaneous cycles influencing the communication practices as well as visiting patterns of migrants.

Firstly, the *annual festivity cycle* is formed by the most relevant events for migrants throughout the calendar year (e.g., Independence Day). This cycle influences their practices mainly in terms of communication, traveling and emotions. For instance, one of the traditional annual fairs in Juchipila is held in January. Many migrants said they prefer to visit during those days rather than during the Christmas holidays. One of our interviewees, living for 8 years in the US, even said *“Last year, 2006, I couldn’t go in January, so I went until May that is also when we have another fiesta in my hometown”*, which obviously confers some significance to community events. Likewise, migrants said they usually call home before, during and after the annual fair to get the details of the event as commented by one of our informants *“When I’m going in May [community fair], in April I start calling ‘what is it going to be? When does it start the fiesta? Are there pitahayas<sup>1</sup> already?’ and that’s when I [call] more...and in December, before going there, the same, to know how’s the panorama”* (male, 42).

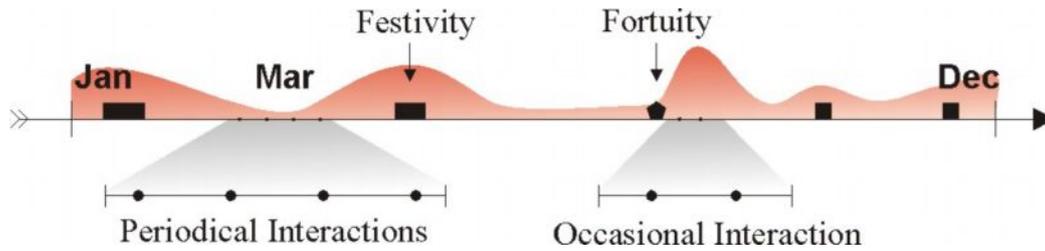
Interestingly, dates for similar celebrations in Mexico and the USA are likely to vary such as the Mother’s Day. As such, that difference could also have peculiar effects on the communication patterns, traveling and even celebrations. One active member of the community living in the US for over 20 years commented *“I love to go during the Fiesta de la Cruz [May], but also because it’s so familiar, not only because of the event, but because you see people. Since most people are students, they set the dates so*

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<sup>1</sup> It is the fruit of several cactus species, are also known as dragon fruit. Native to Mexico and Central and South America (source: <http://en.wikipedia.org/wiki/Pitaya>)

*well that we can take the Memorial Day long weekend [US]. Then I go from Thursdays and I can take Monday off, since it is the last Monday of May. Then we don't set it [the date of the fiesta] because of the [religious] tradition, that it's supposed to be on May, 3rd, [instead] we do it like this so people can go, I mean, it was changed almost a month so people can go and enjoy a little bit"* (male, 38). Likewise, another interviewee said *"I remember that happened on the 10th of May [Mother's Day], and I called with the card and the [phone] lines were saturated. I dialed the number but it said 'We are sorry, but we can't communicate', the lines were all busy, and I finally could go through around midnight, because the lines were a little less busy. That day I worked and during the day I couldn't [call], because I was working, it was until I got home, but I couldn't till midnight"* (male, 21). It is clear then that family communication is shaped in some way by social norms which usually coincide with the important events during the calendar year (e.g., traditional celebrations).

Secondly, overlapped, the *communication cycle* is formed by periodical interactions spaced out uniformly over time (e.g., weekly) and it is used mainly to stay in touch and exchange information about any incident occurred since the last interaction. These sorts of periodical interactions are likely to become part of the life of the migrant forever. Moreover, these interactions are periods reserved exclusively for communication with the family as one of the interviewees commented *"that time is reserved... my program is... I mean my routine is: on Saturdays, as soon as I wake up I pick up the phone and I call her [mom]... That time is set aside, it's not that interferes with other things"* (male, 39). Interestingly, these exchanges become part of the routine as another migrant worker commented *"every Thursday... every Thursday, I mean... I'm a gardener, and when I finish the third house on Thursdays, automatically, now, bum!... sometimes I chat for 5 minutes, sometimes 1 minute, when there is something to talk about I usually last [more]... or when it's my birthday, they call me on weekdays, or things like that, but every Thursday is ritual"* (male, 38). Migrants develop a certain sense of communicative ritual where these periodical exchanges seem to serve both parties primarily to reassure the commitment on each other, and secondarily, to exchange everyday experiences from each place. Indeed, some research has found that the content of communication is sometimes secondary when interacting with someone you care about (Rettie, 2003).



**Figure 3.** Hypothetical example of an annual cycle showing the fluctuations of community connectedness.

Finally, the *occasional interactions cycle*, less uniform, is formed by other extraordinary incidents. For instance, migrants usually return (or call) when something exceptional goes on in the home community and needs urgent attention (e.g., a relative's death). Figure 3 illustrates both of the aforementioned cycles and the fluctuations of the emotional load. Several other events such a visit to the family might also alter considerably these fluctuations.

#### 4.3 Periodical Encounters to Be Together

Undoubtedly, ICTs play a major role on the communication practices of migrants to get close to home. Any technology comes with different communicative affordances, as discussed by the Media Richness Theory (Daft & Lengel, 1986), but also with an associated usage cost. It can be argued that that cost inhibits, in some way, the action of communicating. Migrant workers, as many people, are also restricted by the cost of communicating, which together with emotions shapes their communication practices. We found that the main medium used by our participants was the telephone, which provides an opportunity to spend some time together and to be used as a resemblance of a get-together as has been pointed by previous studies (Licoppe & Smoreda, 2006). For the people we interviewed, these periodical synchronous encounters (i.e., phone calls) afford certain degree of social presence as one of our informants commented when asked about the means he used to communicate "*with the telephone, in one second, you are there*" (male, 59). This quote, as simple as it may seem, provides strong evidence of the practical uses of the telephone. Another interviewee, a mother who has her children and husband in the US, commented "*the telephone you actually hear them, you know they are ok at that moment and the letters at times when you get them only God knows how... what had happened during that time... and telephone, you hear them clearly how they are doing at that moment, and the voice, listening to them is like... and now that I know where they live I feel more... before, I felt like they*

*were in a lost place even when I talked to them I didn't even know where... and now that I go and I see them I feel... they tell me 'I'm here, I'm there, now I'm at this place', and it's more like a consolation for me to know where they work, where they go out to... all that makes me feel more calm".* These periodical encounters through the telephone are used just to be some time together (Licoppe & Smoreda, 2006).

To some extent, these encounters are defined by the service used to communicate. In the case of migrants interviewed, for convenience, many of them use prepaid phone cards. This kind of service affords having long conversations which is seen, as mentioned, as a window of opportunity to be together. One young migrant worker, 21, commented with regards of the phone calls *"One doesn't really mind the money but because one is barely beginning the conversation at ease... and that's the problem I have more than anything, we are talking, talking and then I tell my mom 'hold on, the call is going to be interrupted because the card is running out of credit' and it's like we have a limit, an amount... we are talking and that's it when we are talking about something interesting, the card is finished... you have to dial again or just tell her 'I'll call you tomorrow or one of these days'"*. Communication exchanges are often seen as finite windows of opportunity (i.e., sessions) to reencounter with the family at a regular basis, for some extended time, but still restricted in terms of time.

## **5. Discussion of the Study**

The analysis presented before is evidence of how, migrants have been managing to keep some sense of closeness to the life in their hometowns. They use certain people, in their families or members of the community, who keep them informed about the occurrences in their home communities. In the same way, some of them have been using a community web site as a source of information not easily obtained by any other mean.

In addition, migrants' need of returning and communicating is mainly influenced by recurrent cycles ruled mostly by the calendar year, fixed periodical interactions and occasional interactions derived from unexpected or sporadic events. Moreover, regarding the periodical interactions, many of our informants prefer to follow a rigid habit of getting in touch to stay informed about the events in their home communities and their families. These uniform patterns of communication usually become part of their routine and from this work it is complicated to compare the levels of significance

between migrants' need to be connected and the need to be connected with the community, although both of them seem to be important

This work presented empirical, preliminary results aimed to identify the current strategies followed by migrants to keep the sense of community connectedness high. We also discussed the role that presence technology could potentially play on the sense of community connectedness since it can potentially augment the quality (and kind) of the information migrants receive.

The main challenge faced by this work is the convergence of several areas of research (e.g., Psychology, Sociology, Computer-mediated Communication) and several theories within those areas that could help to fully understand the phenomenon (e.g., homesickness, connectedness, intimacy, media richness theory, social identity, social capital, community attachment). Undoubtedly, there are several areas of improvement to be taken into consideration for future similar studies. A proper study of conversation analysis between migrants and their local informants is necessary. Currently, we are analyzing the usage of a community web site (i.e., a web site used exclusively to connect those living away with those in their places of origin), which will provide a characterization of the actual communication exchanges between the dispersed members of the community. In general, this work has several implications for the design of appropriate communication instruments that afford the conveyance of information (and perhaps feelings) within the members of community networks that surpass space and time.

Our future work consists of longitudinal studies that involve the inclusion of 24/7 community cameras onto the web site as well as a set of periodical activities that participants will be asked to which will enable us to investigate the temporal patterns of communication and variations over time.

## **6. Closing Remarks**

There is no doubt that there is still a long way to go in the area of connectedness and hence in community connectedness. Technologically, connectedness as a concept is very appealing to investigate. However, the relationship with the psychological background supporting this area is still a bit unclear and more work is needed to make more robust the research in the area. In addition, measuring the concept of connectedness is inherently complex. Even though there have been some efforts

toward the design of effective measurement instruments there is still some work to do (Mashek et al., 2007; van Baren, Ijsselsteijn, Markopoulos, Romero, & de Ruyter, 2004).

In practice, community connectedness is a concept that could potentially relate to the concept of presence. A focal point in future research would be to see if presence-affording technologies can influence community connectedness. Using technologies that can offer presence as an affordance could potentially increase the sense of being part of the life of the community beyond the interaction timeframe. Alternative mediums such as 24/7 cameras or environmental one-way audio channels can provide 'raw' context straight to migrants' senses which may facilitate the sensation of being there and might even have a particular effect on community connectedness. However, just as connectedness, and similar areas, presence also faces challenges to measure the level of presence on individuals in VE (Ijsselsteijn, de Ridder, Freeman, & Avons, 2000). Finally, we argue that a migrant with a greater community connectedness might potentially feel more engaged in the community life and hence feel more willing to participate socially, civically and financially. Indeed, Carroll et al. reported that, depending on individuals, internet can enhance social and civic participation (Carroll et al., 2005). Our future work in this area will aim at revealing a better understanding of the effects of using certain technologies and information on the way migrant workers engage with and take an active role in the life of their homeland.

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## 8. Appendix 1

### General Excerpt of the Interview Guide

General Category	Topics Addressed
General understanding of the phenomenon	<ul style="list-style-type: none"> <li>– Experiences as immigrant</li> <li>– Reasons to migrate</li> <li>– Frequency of visits to Mexico</li> <li>– Remittances</li> </ul>
Feelings	<ul style="list-style-type: none"> <li>– Distance and time</li> <li>– Community of origin</li> </ul>
Patterns of communication	<ul style="list-style-type: none"> <li>– Frequency of contacts</li> <li>– Means of communication used</li> <li>– Cost</li> <li>– Barriers that hamper the frequency of contacts</li> <li>– Quality of contacts</li> <li>– Transference of information</li> <li>– Usage of the community web site</li> <li>– Perception of the reduction of the distance factor</li> </ul>
Information/objects exchange	<ul style="list-style-type: none"> <li>– Types of information exchange</li> <li>– Frequency of exchange</li> <li>– Particular events that alter the communication ritual</li> <li>– Perception of information relevant for the family</li> <li>– Information not currently obtained but desired</li> </ul>
Contact with the community	<ul style="list-style-type: none"> <li>– Means of communication used</li> <li>– Social, economic and politic participation</li> <li>– Cost</li> </ul>
Perspectives	<ul style="list-style-type: none"> <li>– Future plans for your family</li> <li>– Additional comments</li> </ul>

## 9. Appendix 2

### Main Categories Emerged from the Analysis

Category	Sub-categories
Being away from home	<ul style="list-style-type: none"><li>- Experiences</li><li>- Family abroad</li><li>- Future perspectives</li><li>- Feelings toward the absents</li><li>- Getting connected to home</li><li>- Reasons to migrate</li><li>- Feelings related to being away</li></ul>
Returning home	<ul style="list-style-type: none"><li>- Activities at home</li><li>- The idealization of home</li><li>- Reasons to go home</li><li>- Reencountering with home</li></ul>
Staying in touch	<ul style="list-style-type: none"><li>- ICTs</li><li>- Awareness</li><li>- Informants (social networks)</li><li>- Content of communication</li><li>- Communication ritual</li><li>- Remittances</li></ul>

# Being inside the Quantum Atom

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## ABSTRACT

This article explores the possibility of using dynamic Educational Virtual Environments (EVEs) for helping students with limited background in physics and mathematics to deeply understand Quantum Mechanics principles and create the correct mental images of atomic models. Taking under consideration the results of our pilot study we have created “The Quantum Atom”, an educational environment with which 38 students interacted during well-designed learning tasks based on the social constructivist approach. The sense of presence seems to play an important role in our positive learning outcomes. Further research must be done in this domain focusing on the main features of Virtual Reality as many researchers argue that they support knowledge construction.

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Keywords: *Quantum Mechanics, Atomic Model, Educational Virtual Environments, Presence, Learning Outcomes*

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## 1. Introduction

Virtual reality (VR) is expected to bring dramatic changes in the educational process and learning environments as it provides first-person, non-symbolic experiences that are specifically designed to help students learn material (Winn, 1993). Learning in VR has been proposed since 1990, when Bricken specified “natural semantics” and “cognitive presence” as the main features of virtual environments (1990) and constructivism as the theoretical model supporting Educational Virtual Environments (EVEs) (Mikropoulos, 2006).

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Presence, in relation to synthetic environments, has been defined by many authors. Although there are some differences among these definitions researchers agree with the description of presence as “the sense of being there”. One of the most important subjects in presence research is the factors, attributes, results and consequences of presence. These are useful and applicable in practical situations and designate the influence of “being there” in VR applications (Mikropoulos, 2006). Researchers have developed a number of both objective and subjective methods in order to study and investigate the sense of presence in numerous VR applications (Slater, Usoh, & Steed, 1994; Witmer & Singer 1998; Schubert, Friedman, & Regenbrecht, 1999; Kim & Biocca, 1997; Lessiter, Freeman, Keogh, & Davidoff, 2001; Lombard & Ditton 2000; Mikropoulos, Tzimas, & Dimou, 2004).

Although the evaluation studies for the educational benefits of using Educational Virtual Environments (EVEs) are insufficient, it has been reported that VR is a new challenging technology that increases student interests, understanding, and creative learning (Winn, 1995; McLellan, 1996; Olson, 1998; Barab, Hay, Barnett, & Squire, 1998; Shin, 2002; Kealy, Chitra, & Subramaniam, 2006). Moreover, presence seems to play an important role in EVEs although there is no much research in the educational domain concerning its learning effects (Mikropoulos, 2006). In general, the minority of research reports on specific VR features and the sense of presence that EVEs exploit. Thus, the essential features that designate VR as a promising and powerful educational tool, such as free navigation, first-person point of view, natural semantics, size, transduction, reification, autonomy and presence, are not yet very clear (Mikropoulos, 2006; Mikropoulos & Bellou, 2006).

Physics and Chemistry deal with three dimensional (3D) objects and phenomena. Since students learn more efficiently if the instructional methods and tools match their learning style and support the creation of mental images and models, then the ability to visualize and manipulate shapes is very helpful in their learning. In fact, much of what physics and chemistry students know takes the form of images. However, little attention has been given to the pedagogical effectiveness of visual stimuli in those disciplines. Computer-based environments contribute to the visualization of physical and chemical processes allowing for better conceptual understanding (Trindade, Fiolhais, & Almeida, 2002).

In particular, the structure of matter is a fundamental topic in science education from the primary school up to the university level. Students from the advanced high school classes up to the last university years have difficulties in grasping the main notions and

principles for describing an atom according to Quantum Mechanics (QM) as they demand an important level of abstraction, a reconceptualization in intellectual activity and strong competences in physics and mathematics. Many researchers have already shown that students in all levels have difficulties in understanding the concepts associated with the nature of matter and especially with atomic models (Harrison & Treagust, 2000; Olsen, 2003; Taber, 2003; Dimopoulos & Kalkanis, 2005). To overcome these obstacles researchers propose the use of Information and Communication Technologies (ICT) that help students to qualitatively approach the QM principles and the microscopic models resulting from them (Dori & Barak, 2001; Trindade, Fiolhais, & Almeida, 2002; Trindade, Kirner, & Fiolhais, 2004; Dimopoulos & Kalkanis, 2005). Trindade and his colleagues have shown that 3D virtual environments may help students with high spatial aptitude to acquire better conceptual understandings (2002). Features such as interactivity, navigation and 3D perception seem to contribute to scientific concepts such as molecular orbitals and densities, molecular geometry, and the phases and phase transitions of water itself in the “virtual water” learning environment.

The aim of this article is to argue that presence is a unique sense experienced in EVEs that contributes to positive learning outcomes. We use some questions to investigate the sense of presence, following the statement of Slater (1999) saying that presence can be estimated by “the extent to which participants, after the VE experience, remember it as having visited a place rather than just having seeing images generated by a computer”.

Unfortunately, most of the software packages that are available concerning the 3D representations of the Quantum Atomic Model (QAM) do not help students to understand the main physical concepts for describing it when they have been used as educational tools. According to our pilot study there are no positive learning outcomes (Kontogeorgiou, Bellou, & Mikropoulos, 2007). This might be because of the piecemeal description of the orbitals and electron clouds given in these visualizations. In addition, our students have not reported a sense of presence during their interaction with the software packages proposed by Winter (2002) and Blaich (2005).

Taking these results into consideration, we are interested in designing EVEs in order to help students assimilate Quantum Mechanics in a qualitative way. These EVEs integrate meaningful learning activities and enable users to become participants in abstract and notional 3D spaces.

The objectives of our study were:

- to create 3D dynamic visualizations of the atom by taking advantage of EVEs main features, so as to give a total and integrated picture of the atomic model avoiding misconceptions coming from the Bohr atomic model. In the Bohr model the neutrons and protons occupy a central region, the nucleus, and the electrons orbit the nucleus much like planets orbiting the Sun;
- to investigate if students are able to connect the dynamic visualizations with the basic principles of Quantum Theory;
- to explore students' mental models for the atom after interacting with the dynamic visualizations in an EVE with well designed learning tasks.

## **2. Method**

### **2.1 The Virtual Environment**

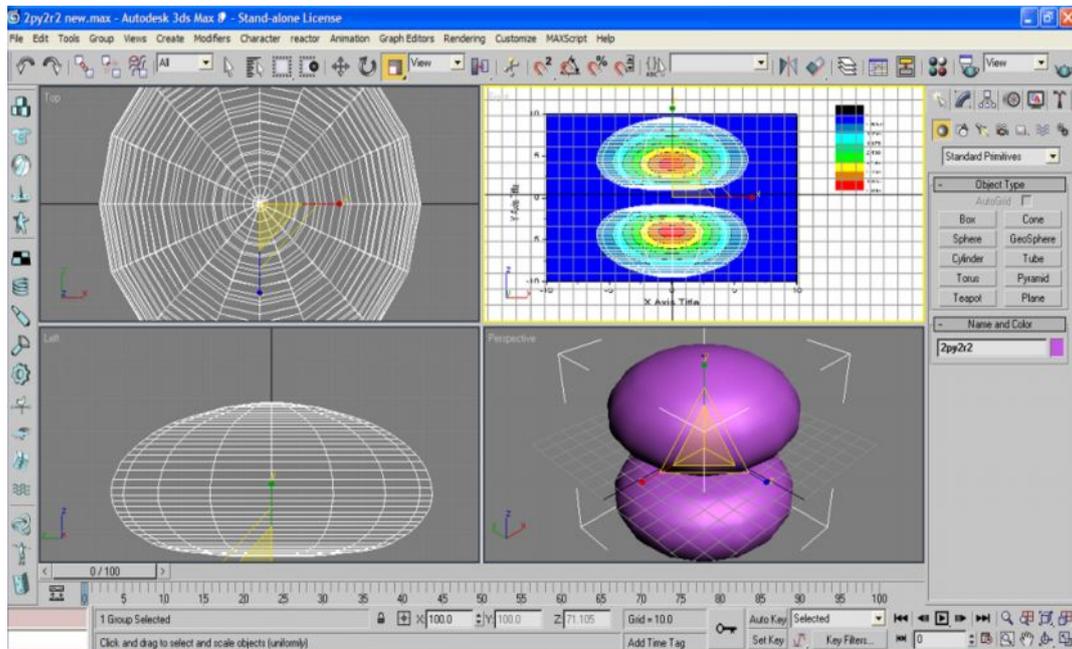
An Educational Virtual Environment (EVE) or Virtual Learning Environment (VLE) can be defined as a virtual environment that has one or more educational objectives, pedagogic metaphors, provides users with experiences they would otherwise not be able to experience in the physical world and redounds upon specific learning outcomes (Mikropoulos, 2006).

In this perspective we have created the dynamic EVE "The Quantum Atom", using the Virtools software package. The hydrogen atom was visualized at the ground, the first and second excited states according to QM, based on scientific calculations (Figures 1 - 5). The EVE consisted of six parts. The atom was developed and presented at a desktop VR system supporting immersion and following the theoretical approach of social constructivism according to which meaningful learning occurs when individuals are engaged in social activities. This pedagogical model is the most dominant in educational technology, and VR characteristics such as 3D spatial representations, autonomy, sensory modality, first-person point of view, freedom in navigation and interaction arise from this approach (Mikropoulos, 2006). The social activities in our EVE occur in the scheme student-EVE-researcher. "The Quantum Atom" gives the possibility of a first-person point of view using stereoscopic glasses and involves students in well designed learning tasks. More specifically, our visualizations have the following characteristics:

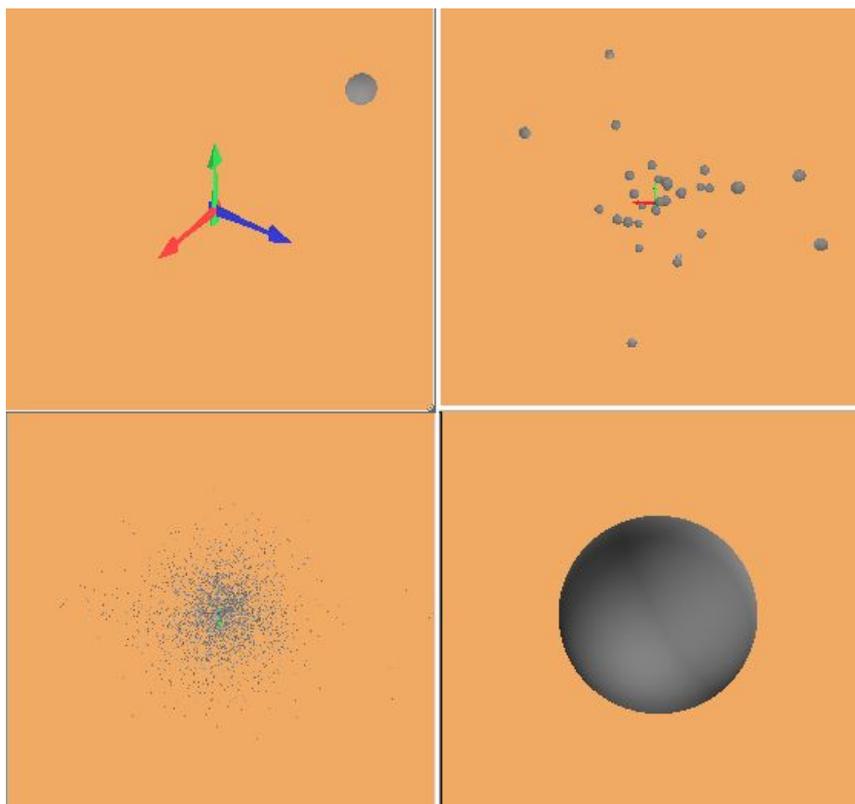
- giving a sense of the 3D space and of the spatial distribution of electron clouds;
- giving students the possibility to freely navigate outside and inside the atom;

- giving students the possibility to interact and change energy states;
- giving students the possibility to comprehend the electron's properties.

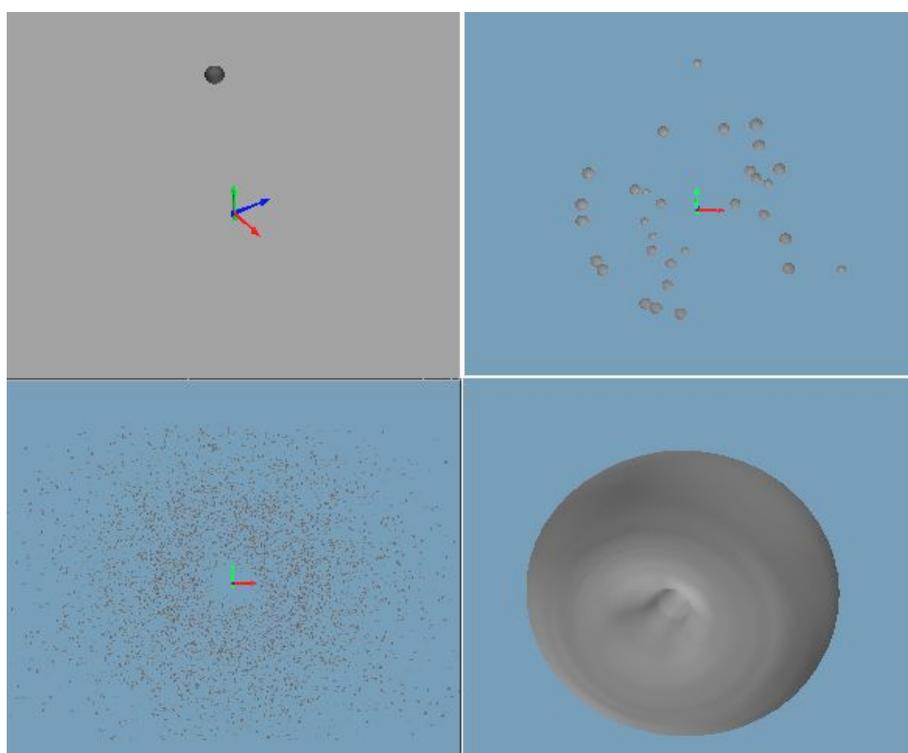
Our pilot study's outcomes (Kontogeorgiou, Bellou, & Mikropoulos, 2007) led us to design "The Quantum Atom" so that the electron cloud is created step by step in every energy state. As a result, the student realizes that the electron cloud consists of different positions within which it is probable to locate the electron. Moreover, a surface in space on which the probability of the electron to be located is the same (isodensity surface plot) is supposed to represent the atom shape according to QM. This surface in space comprises a space where the probability for the electron to be localized is about 90%. So the isodensity surface plots (Figure 6) replace the image of the atom according to the classical theory (Bohr's atomic model) that students keep in their mind even at the end of their university studies (Johnston, Crawford, & Fletcher, 1998).



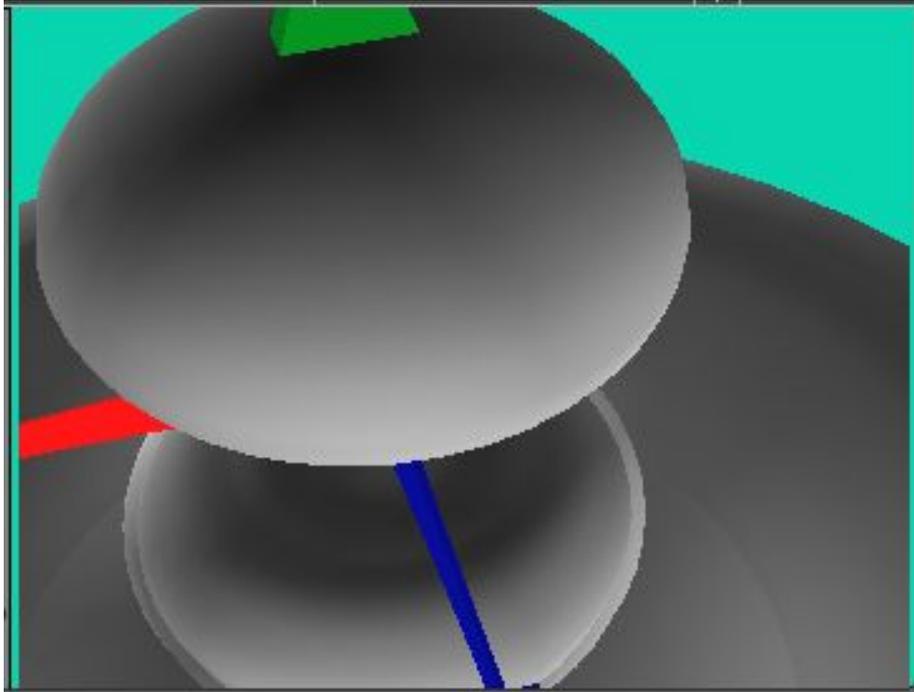
**Figure 1.** 3D visualization of the hydrogen atom at the first excited state resulted from linear polarized electromagnetic radiation.



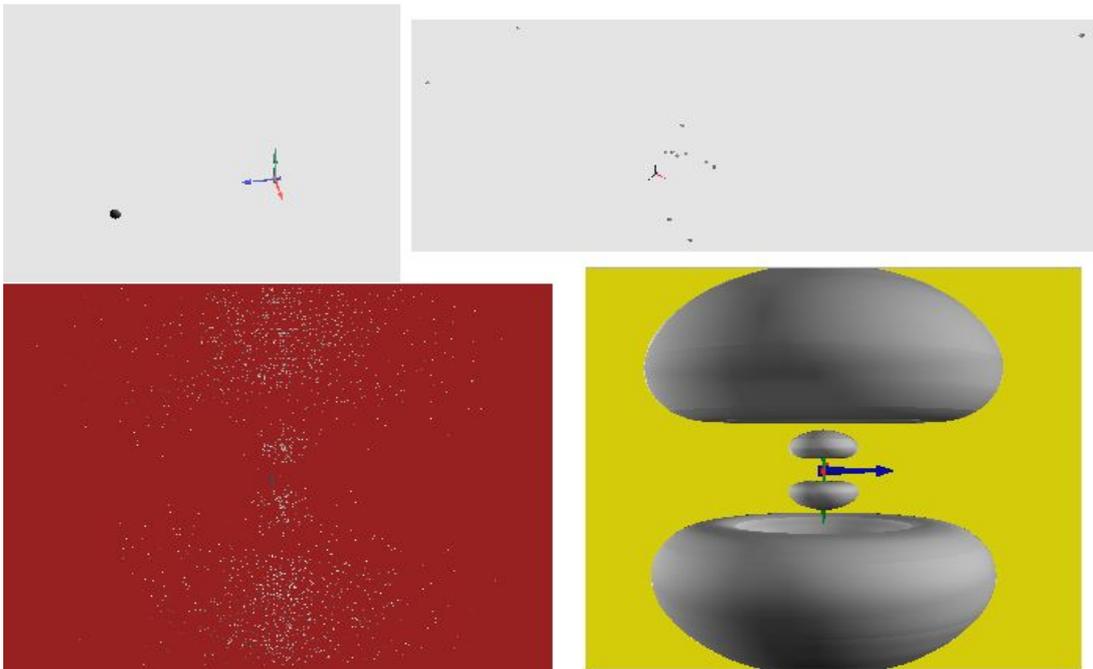
**Figure 2.** Ground state of the hydrogen atom.



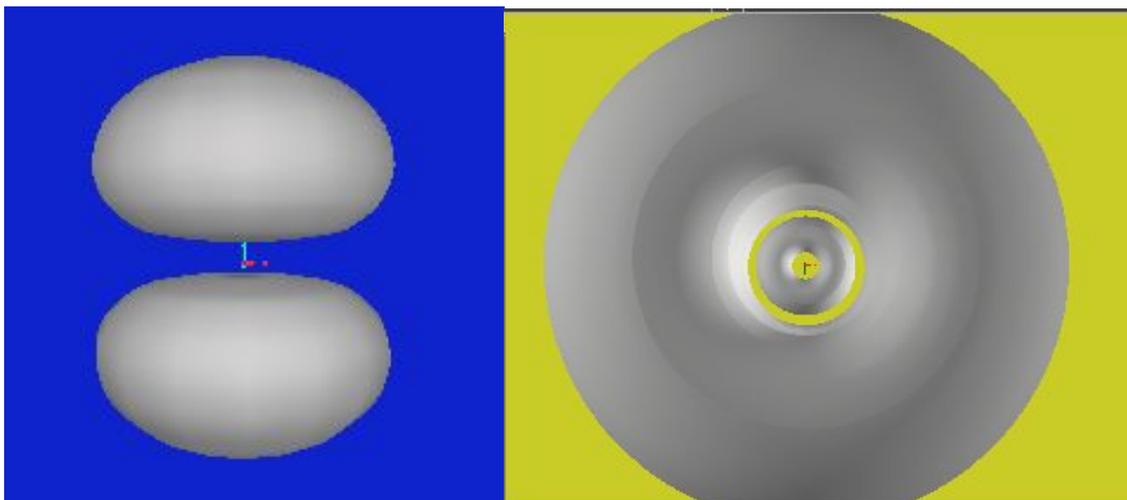
**Figure 3.** First excited state of the hydrogen atom resulted from circularly polarized electromagnetic radiation.



**Figure 4.** Second excited state of the hydrogen atom resulted from linearly polarized electromagnetic radiation; a viewpoint close to nucleus.



**Figure 5.** Second excited state of the hydrogen atom resulted from linearly polarized electromagnetic radiation.



**Figure 6.** Isodensity surface plots. Left: The hydrogen atom at the first excited state. Right: The hydrogen atom at the second excited state.

## 2.2 Sample and Procedure

An empirical study was conducted with thirty-eight (38) first year students of the Department of Primary Education, University of Ioannina. The learning tasks were related to the students' mental images for the hydrogen atomic model at its ground, first and second excited states in accordance with QM principles.

Firstly, the students answered a questionnaire about the QAM of hydrogen, the electron attributes and atom shape. After that, each of them interacted with "The Quantum Atom" EVE during a semi – structured interview, whose questions depended on their mental images as revealed from the answers to the first questionnaire. After the interaction, a second questionnaire was administered. Two months later a similar questionnaire was administered in order to investigate the retention of knowledge (see appendix).

In order to investigate the role of presence in the educational activities the students interacted with the EVE during the first three parts without wearing stereoscopic glasses. Afterwards, they used the glasses with the three last parts of the EVE and described their experience. In an abstract 3D virtual space like the Quantum Atom, we expect that stereoscopic view will be a discrete factor concerning the sense of presence. The questions concerning the sense of presence were included in the second and third questionnaires. They were the following:

1. Do you realize any differences in the depiction and position of objects when you wear the glasses and when you do not wear them?
2. Do you feel that the atom became the reality for you, and you almost forgot about the real world?

3. Do you think that you were inside the atom or you have seen images generated by the computer?

### **3. Results**

#### **3.1 Cognitive Content: The Quantum Atomic Model**

The learning outcomes of our study were positive as most of the students assimilated the main principles and notions of QM. Therefore, after the interaction with “The Quantum Atom” students sketched the hydrogen atom in different energy states according to the QAM, using the isodensity surface images. Thirty two students (84.2%) formed a mental image compatible with Quantum Mechanics having abandoned the planetary atomic model after the interaction with the EVE. Two months later 31 students (81.6%) had kept this image for the atom shape. We base the creation of student’s mental images to their sketches, since sketches are considered to be tools for knowledge representation (Friedman & diSesa, 1999; Jonassen, 2000).

Furthermore, 32 students (84.2%) explicitly expressed their point of view on the electron’s behavior, stating that “it is impossible to determine the electron’s position every moment with accuracy, so it is impossible to draw its trajectory. This is not due to the effect of our method to perform a measurement, but it is a main attribute of QM Theory”. Concerning the electron cloud, all the students affirmed that it consists of “thousands of probable positions, where the electron of the hydrogen atom could be located. The probability of the electron localization depends on the density of the electron cloud”. Two months later thirty students (78.9%) did not change these concepts that had constructed embedded into the EVE.

#### **3.2 The Sense of Presence**

Our study revealed that 32 students answering the two first questions reported very enthusiastically a sense of presence during their interaction with the EVE as a result of the use of stereoscopic glasses. In that case they had a very strong sense of presence during their free navigation inside the hydrogen atom. Some of their expressions were: “I see different possible positions for the electron like in the real world”, “I think that I can touch the electron in different possible positions”, “the electron is real”.

Five students stated that they found no big differences with and without the stereoscopic glasses, although they reported a sense of presence inside the atom.

Finally, one student did not observe any difference. It is noteworthy that the answer of one of the students who found no big differences in the sense of presence shows the restriction coming from the existence of the surrounding real world: "OK there is a difference; however, it is not so intense because the screen limits my optical field. Moreover, I can see other objects around, in the real world. This is something that influences the way we see the depiction of objects in the computer. You can distinguish this characteristic if you have interacted with virtual environments under other conditions". Only this student had experienced a virtual environment before our study.

Concerning the third question, almost all the students (35) stated that they remembered the EVE as a place they had visited. Their experience was like they have been inside the atom. Interacting with our EVE nobody described it as images generated by the computer. Some of their statements were: "I am into the space", "I am close to the nucleus of the atom", "I can see inside the atom", "I am inside the atom".

Two months later 31 students expressed a very strong sense of presence in the third questionnaire too, still remembering the EVE as a place they have visited, while 29 of them insisted that wearing the stereoscopic glasses the atom was much more "live", "real" or "impressive". They felt to be "present" in the microcosm.

In general, the students had a high sense of presence interacting with our EVE and this helped them perform their learning tasks successfully and work in a constructive learning environment. This is in line with Winn's and his colleagues' findings on student – built virtual environments. They have reported that students' enjoyment, ability to work in VE, success and their sense of presence were all interrelated (Winn et al., 1999).

The visualizations of the atomic model of hydrogen via the proposed EVE helped them to acquire stable mental images which remained two months later. Their initial mental representations replaced from other compatible to Quantum Theory. We suppose that presence has positively contributed in overcoming the students' difficulties about QAM.

#### **4. Conclusions**

The present study investigates the effect of students' interaction with an Educational Virtual Environment (EVE) on learning outcomes in Science Education, as well as their sense of presence inside the EVE. According to Sanchez and colleagues "scientific

visualization in virtual environments is the art of making the unseen visible: torsion forces inside a body, heat conduction, flows, plasmas, earthquake mechanisms, botanical structures or complex molecular models” (Sanchez, Barreiro, & Maojo, 2000). Towards this perspective we have designed an EVE which gives students the possibility to freely navigate inside and outside the atomic model of hydrogen in order to experience the microcosm while they would not be able to practice that in the real world. Students immerse in a virtual environment and get the feeling that they are actually inside the atom, they are transferred to an environment of pure information that they can ‘see’ and even manipulate.

It seems that the EVEs’ features and the sense of presence are pedagogically exploited during a well structured learning procedure and improve students’ understanding in order to create mental images consistent with scientific knowledge. The results of our study reveal that the students grasp the main notions for describing the QAM. So they are in coherence with other researchers’ conclusions reporting that VR features and the sense of presence play an important role in the learning outcomes (Salzman, Dede, Loftin, & Chen, 1999; Dede, Salzman, Loftin, & Ash, 2000; Bakas & Mikropoulos, 2003).

It seems that the content of the VE together with specific learning tasks is an important factor affecting presence and task performance. Further research is needed regarding the contribution of personal presence and students involvement in learning outcomes concerning the microcosm, for which explanations are given only by scientific theories and two dimensional models, as humans cannot enter this world. We are working towards this direction.

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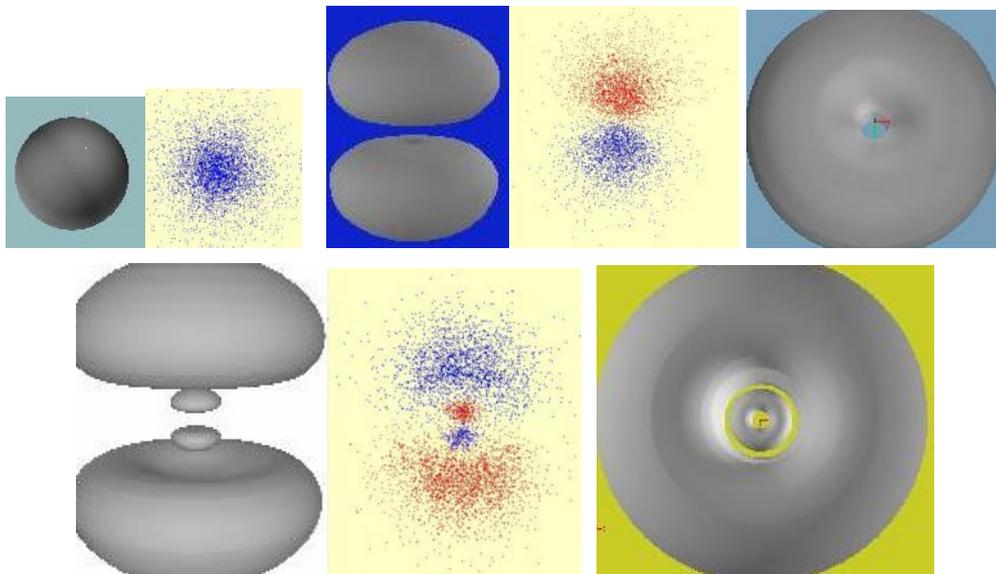
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## 6. Appendix

### The Questionnaire

1. Draw the hydrogen atom. Explain the atomic theory you followed.
2. Using an experimental device, we determine the position of an electron. Show two positions where the electron can be found. Justify your answer.
3. Is it possible to determine the electron's orbit?
  - a. If yes, draw the orbit for the hydrogen atom.
  - b. If no, justify your answer
4. a. What do the following images represent? What kind of information do we get from these?



- b. Describe how you conceive the notion of the orbital.
  - c. Describe how you conceive the notion of the charge cloud.
5. Do any of these images represent an atom? Where is the nucleus?
6. According to the uncertainty principle it is not possible to determine the position and velocity of a particle with accuracy. Why does it happen? Is there any relation between this principle and the images you have seen?
7. Do you realize any differences in the depiction and position of objects when you wear the glasses and when you do not wear them?
8. Do you feel that the atom became the reality for you, and you almost forgot about the real world?

9. Do you think that you were inside the atom or you have seen images generated by the computer?

# Task and Stimulation Paradigm Effects in a P300 Brain Computer Interface Exploitable in a Virtual Environment: A Pilot Study

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## ABSTRACT

The aim of the present study is to compare different visual elicitation paradigms exploitable in a Virtual Environment in order to establish whether the BCI is affected by the structure of the elicitation paradigm, the modalities of stimulus presentation, and the complexity of stimulus recognition and semantic processing.

We have developed a device which can control the motion of a cursor on a computer graphical interface, using ERPs (Piccione et al., 2006). Subsequently, we tested different visual elicitation paradigms which evoked P300 waves to control the movement of an object in a virtual environment. Visual stimuli, consisting of four arrows (forward, right, back, left), were randomly presented in peripheral positions of a virtual environment. Users were instructed to recognize only the stimulus related to the preferred object movement direction (target). The sum of the absolute differences between target and non-target traces (ra index) was compared in the different elicitation paradigms. Results showed a significant reduction of ra index with the use of more semantically complex paradigms. Therefore, the P300 BCI system seems to be affected by the structure of the elicitation paradigm, the modalities of stimulus presentation, and the complexity of stimulus recognition and semantic processing.

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Keywords: *BCI, ERP, P300, Visual Paradigms, Virtual Environment.*

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## 1. Introduction

Brain Computer Interface (BCI) systems have been developed for people with severe disabilities in order to improve their quality of life (Lulè, Gramm, Kurt, Kassubek, Diekman, & Birbaumer, in press; Murase, Duque, Mazzocchio, & Cohen, 2004; Allison

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& Pineda, 2003; Donchin, Spencer, & Wijesinghe, 2000; Farwell & Donchin, 1988). Recently, BCI systems have been also used in other research areas, such as in the field of virtual environment (Bayliss, 2003; Leeb, Scherer, Lee, Bischof, & Pfurtscheller, 2004). Different strategies are used for the control of a BCI. A P300-based BCI (P300 BCI) system has the advantage to not need any specific or time consuming training, given that the P300 is an endogenous response to specific events (Farwell & Donchin, 1988). However, a P300 BCI system needs the elicitation of well distinct target and non-target signals, in order to achieve both a discrete classification accuracy and a communication speed (McFarland, D.J, Sarnacki, W.A., & Wolpaw, J.R., 2003). Furthermore, in the P300 paradigm, focused processing of the targets requires access to limited spatial and sustained attention resources and this could be a limiting factor (Nobre, 2001). To tackle this problem in a virtual environment, both the elicitation paradigm and stimuli presentation should be considered.

This pilot study compares different visual elicitation paradigms exploitable in a Virtual Environment in order to establish whether the BCI is affected by the structure of the elicitation paradigm, the modalities of stimulus presentation, and the complexity of stimulus recognition and semantic processing.

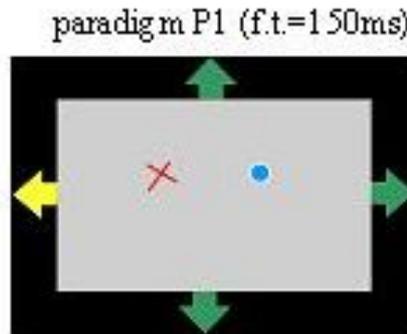
## **2. Methods**

### **2.1 P300 BCI**

The P300 BCI (Piccione et al., 2006) used the P300 wave to control the movement of a cursor (i.e., a blue point on a computer's screen) in order to reach a goal (i.e., a red cross; see Figure 1). There were four possible directions for the movement of the cursor, each one indicated by four flashed arrows (i.e., forward, right, left, and back), that were randomly presented in peripheral positions on the monitor. Users were instructed to pay attention only to the flashed arrow which indicated the required direction of the cursor's movement. Each flashed arrow occurred with a probability of 0.25 and it was considered as a target only when it indicated the required direction of the cursor's movement towards the goal point (i.e., the red cross). Otherwise, the flashed arrow was considered a non-target. Each target stimulus elicited the P300. Every time that the P300 was detected during the trial, the cursor should have moved on the graphical interface according to the direction of the flashed arrow. On the

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contrary, if the P300 was not detected, then the cursor should have remained still. The classifier previously described by Piccione et al. (2006) assessed the presence of the P300 wave, in a single sweep after each stimulus, by performing on-line data processing procedure consisting of an Independent Component Analysis (ICA) decomposition, followed by feature extraction and neural network classification. If the P300 was detected (network output node value 0), the ball moved on the graphical interface according to the last submitted arrow. In all other cases the ball remained still.



**Figure 1.** P300 Brain Computer Interface Paradigm (P1)  
(Piccione et al., 2006).

## 2.2 P300 BCI in Virtual Environment

The Virtual Environment was developed using MS Visual Studio.NET and the DirectX library by Khymeia S.R.L., Padova, Italy. It consisted of a 3D-view projection display with a resolution of 800x600 pixel placed three meters from the subject. The virtual environment represented a room in which the "virtual user" sat on a wheelchair (i.e. Figure 2). Along the room walls there were four doors, on the four directions of the virtual environment, indicated by flashed arrows (i.e., forward, right, left and back). The arrows flashed randomly. The four doors gave access to other different rooms representing the user needs. They were marked with a food icon indicating hungry/thirsty being; a picture of a toilet to indicate washing or physiological needs; a red cross on white, for health related needs; a "return" sign to indicate that some rest is needed. When the user decision was detected, the target door opened and the virtual wheelchair crossed it, entering in the related room.

In successive developments, each new room will represent four further doors, each of them with an arrow lighting up in sequence, one to come back to the previous room, the others to get more specific choices.

In Virtual Environment users are asked to control the movement of the virtual wheelchair from a starting point to a goal-point, through a virtual path. Forward, right,

left, and back arrows were randomly flashed in peripheral positions of the virtual environment. Each arrow indicated one of four possible directions concerning the movement of the virtual wheelchair. Users had to pay attention to the arrow indicating the correct direction (i.e. target arrow; probability of occurrence: 0.25), but ignore the arrows indicating the wrong directions (i.e. distracting arrows; probability of occurrence: 0.75). We hypothesized that every target arrow should elicit a P300 wave.

Each trial comprised the flashing of an arrow for 70-150ms, followed by data processing necessary for P300 recognition and, finally, the generation of the feedback concerning the movement of the virtual wheelchair. The interval between the presentation of two arrows (inter-trial interval: ITI) was fixed to 2.5s in order to achieve optimal off-line data processing. A session was defined as the sequence of trials sufficient to permit the reaching of the goal-point.

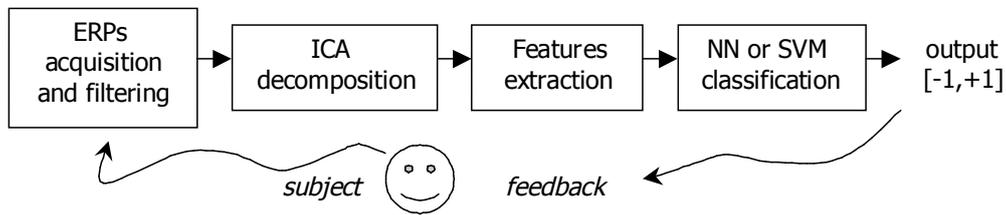


**Figure 2.** Virtual environment.

### **2.3 P300 Acquisition and Analysis**

Cup silver-chloride electrodes were placed according to the international 10-20 system at Fz, Cz, Pz and Oz. All the electrodes were referenced to bilateral (joined) earlobes. Ground was placed in Fpz. The Electrooculogram (EOG) was recorded from a pair of electrodes below and laterally to the right eye. The EOG registration was useful to differentiate eye movement or blinking from P300 component. The four Electroencephalogram (EEG) channels and the single EOG channel were amplified by SynAmps (NeuroSoft Inc.), band-pass filtered between 0.15 Hz and 30 Hz, and digitised (with a 16-bit resolution) at a 200 Hz sample rate. The five channels recorded single epochs of 1500ms length and 300 sampled point per channel were available. The data were processed on-line through a three-step-sequence that included: ICA

decomposition, features extraction and neural network classification (Piccione et al., 2006) (Figure 3).



**Figure 3.** Real time classification of P300.

## 2.4 Subjects and Experimental Setup

The experiment was performed with the approval of the local ethical committee and the written informed consent of the volunteers.

3 healthy subjects voluntarily participated to the study (1 female and 2 males, mean age of 34 years, range 26-40 years). Participants did not present cognitive deficits and had P300 wave parameters within the normative values (American Electrodiagnostic Medicine Guidelines, 1999). One of them wore corrective lens for a low myopia.

P300 BCI paradigm (P1) was compared with graphical variants (S1, S2, S3) in which the position/shape and flash time of the arrows changed (see Figure 4).



**Figure 4.** BCI Graphical variants: S1 (field, arrows, targets, flash time 70ms); S2 (field, targets, arrows, flash time 70ms); S3 (field, targets, arrows, flash time 150ms).

System performance (i.e., accuracy in %) and system transfer bit rate expressed in bit/min of the analyzer were computed for the P300 BCI as in the previous work (Piccione et al., 2006). The total error was computed as follows:

$$etot = 1 - \frac{c_1 + c_2}{n_1 + n_2}$$

where:

–  $n_1$  = numbers of non-target stimulus per session;

- $n_2$  = numbers of target stimulus per session;
- $c_1$  = numbers of correctly classified non-target data epochs per session;
- $c_2$  = numbers of correctly classified target data epochs per session.

The performance in % was calculated as follows:

$$\text{perf} = (1 - \text{etot}) * 100$$

and the communication speed expressed in bit/min (Transfer Bit Rate, tbr) was computed as follows:

$$\text{tbr} = \frac{n_2}{n_1 + n_2} \frac{c_2}{n_2} \frac{60}{\text{ITI}} \log_2(n_{\text{stim}})$$

where:

- ITI = the Inter-Trial Interval was 2.5 s;
- $n_{\text{stim}}$  = numbers of different stimuli used in the interface (4 arrows or directions).

For each paradigm (P1, S1, S2, S3) and subject, 8 sessions were compared; considering a subject and a paradigm, we evaluated the 8 sessions raw traces average of the channel PZ, then the 'ra' index as follow: the sum of absolute differences between *target* and *non-target* average traces (respectively  $\text{avg}_2^{PZ}(k)$  and  $\text{avg}_1^{PZ}(k)$ ,  $k \in [60,160]$ ) in the interval 200-700ms (1). The core of the P300 and non-P300 patterns classifier was the radial basis kernel function (K).

$$\text{ra} = \sum_k \left| \text{avg}_2^{PZ}(k) - \text{avg}_1^{PZ}(k) \right|, k \in [60,160] \quad (1)$$

An analysis of variance (ANOVA) was applied to compare performance data, P300 latencies and ra index of each subject for the different paradigms (P1, S1, S2, S3). A p-value less than 0.05 was considered statistically significant.

### 3. Pilot Study Results

Grand-averaged P300 components of the three subjects for the different paradigms are illustrated in Figure 5. No significant impact had the mean latency and amplitude of the P300 components recorded on Pz of paradigms P1 compared to S1, S2 and S3 (P1: P300 latency 447ms, N200–P300 amplitude 401.1mV; S1: P300 latency 386ms, N200–P300 amplitude 84mV; S2: P300 latency 392ms, N200–P300 amplitude 68.9mV; S3: P300 latency 394ms, N200–P300 amplitude 84mV).

P300 BCI average performance of the three healthy subjects was 71.5% (std 7.1), as shown in Table 1. Sessions successfully completed were defined as the sessions where subjects could achieve the target.

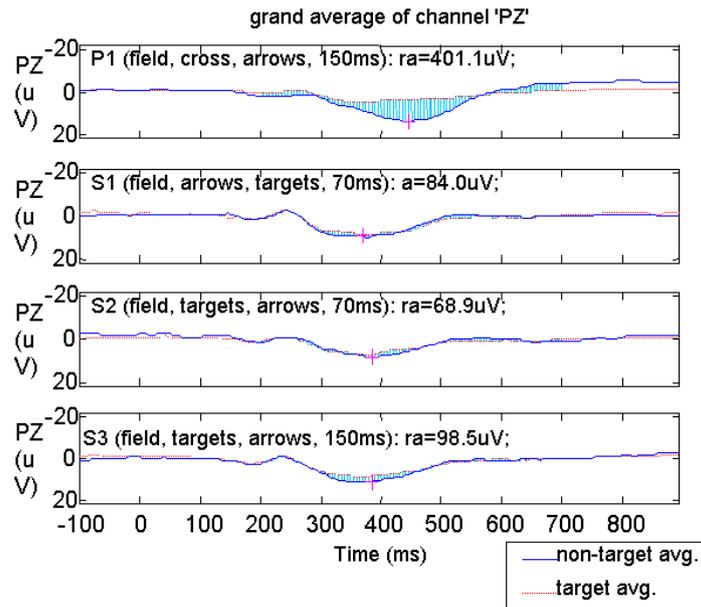
Parameters	Measure unit	3 healthy Subjects	
		Mean	STD
Performance	%	71.5	7.14
Transfer bit rate	Bit/min	6.62	1.2
Percentage of sessions successfully completed	%	62.52	10.84
Number of trials before first successful session	-	169	129

**Table 1.** System performance and communication speed (transfer bit rate in bit/min) of the three subjects.

The statistical analysis of variance (ANOVA) shown that the *ra* index appeared to decrease significantly with the use of more semantically complex paradigms. Pilot results of the comparison of the different paradigms are reported in Table 2 and illustrated in Figure 5. Finally, there was no session-by-session improvement in performance or transfer-bit rate.

	P1	S1	S2	S3
subject	ra (uV)	ra (uV)	ra (uV)	ra (uV)
1	711	195	241	286
2	471	215	128	159
3	188	151	210	82
mean	457	187*	193 *	176**
Std	262	33	58	103

**Table 2.** P1, S1, S2 and S3 paradigms comparison (ra). \*  $p < 0.05$ ; \*\*  $p < 0.01$ .



**Figure 5.** Grand average of raw traces recorded in channel Pz for different paradigms (P1, S1, S2, S3).

#### 4. Discussion

As reported in the literature, the oddball data indicate the ability to attend to the target item, the decision was made to test a system that more nearly approximates a standard oddball sequence, but using three different four-choice paradigms. It was important to utilize more than two stimuli in the sequence because the amplitude of the P300 is affected by the probability of a target stimulus presentation (Allison & Pineda, 2003; Duncan-Johnson & Donchin, 1977). The use of 4 stimuli provides a target probability of 0.25. Furthermore, the P300 wave parameters (latency, amplitude) and its morphology strongly depend on the structure of the elicitation paradigm, the modality of stimulus presentation and the stimulus semantic meaning (Wolpaw, Birbaumer, McFarland, Pfurtscheller, & Vaughan, 2002; Birbaumer, 2006). Our study evaluated the recorded ERPs behavior related to different paradigms in order to check the single-sweep P300 wave recognition capability in virtual environment. The results indicate that although small fluctuations in the classifier accuracy were observed between the differing visual protocols, the relative changes were not statistically significant. However, relevant distinctions among the paradigm P1 and the paradigms S1, S2, and S3 in terms of difference between the P300 amplitudes of target and non-target traces do exist. The different visual elicitation paradigms use the same type and

number of stimuli (four arrows) but have differentiations about the global task and the position/shape and flash time of the stimuli. Comparing the different paradigms through the raw averaged traces, we observed that the discrimination between target and non-target signals can deeply change, making the P300 wave recognition task more complex.

## 5. Conclusion

In this paper, we have analyzed the ERPs response of different paradigms that can be used in a Virtual Environment. Many factors influence the cognitive potential elicitation, modifying the differences between the target and non-target response. Comparing the paradigms, the ERPs behavior changes probably reflect the increment of the task difficulty.

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