PsychNology Journal

ISSN 1720-7525

Vol 4 n.1

PSYCHNOLOGY JOURNAL

The Other Side of Technology

PSYCH**N**OLOGY **J**OURNAL, **PNJ**:
Published online since Summer 2002
Web Site: http://www.psychnology.org
Submissions: articles@psychnology.org

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PsychNology Journal, 2006
Volume 4, Number 1, pp. 5 - 6

Editorial Preface

The first 2006 issue of PsychNology Journal collects contributions from disparate areas of the human relation with technologies, in compliance with the typical multi-disciplinarity of the Journal. Some papers may sound like ethnographic reports from foreign territories to some part of our readership, and will strike with unexpected similarities and insights.

The first contribution, 'Navigating Information Space: Web site design and lessons from the built environment' is authored by a well known scholar in the area of human-computer interaction and information spaces, David Benyon, who has recently joined the Editorial Board of PsychNology Journal. The paper suggests that territories otherwise distant such as digital and physical places have an activity in common, 'navigation.' This commonality can be exploited by designers of information spaces to liberate the possibility of the medium without forgetting the principles learnt by so many years of experience with the human navigation in physical environments. The paper offers a rich discussion on these principles accompanied by examples from actual applications. It ideally goes back to PNJ issues on Space, Place and Technologies (PNJ 3[1-2]), where the idea of virtual spaces having their spatial coordinates defined by human activity was a central one.

The second contribution comes from Francesca Cilento and Carlo Galimberti and is entitled 'Stereotypes and Gender Identity in Italian and Chilean Chat Line Rooms'. Similarly to David Benyon's, this paper also goes back to a previous issue of PsychNology Journal (PNJ 3[3]), where the topic of gender difference in mediated environments was addressed from the perspective of gender gap. Cilento and Galimberti take a slightly different perspective and examine the extent to which gender stereotypes emerge from Italian and Chilean conversations. A peculiarity of this work is the effort of matching the results of quantitative and qualitative analysis, showing that one approach can highlight differences to which the other one may be blind. Another interesting point is the discussion on the use of 'flames' as a socialization device, in which gender seems to play a significant role.

The third contribution is by Francesco Martino and Andrea Spoto, and represents an overview of Social Network Analysis and of the ways in which it can serve the study of mediated interaction. This approach is increasingly used to make sense of the relational patterns experienced in on-line communities where the amount of actors connected to each other is huge and needs to be effectively described and represented in its spatial and temporal unfolding. 'Social Network Analysis: a brief theoretical review and further perspectives in the study of Information Technology' is able to gently touch the mathematical basis

of the method and to take a future-projected historical perspective on it.

The fourth contribution is entitled 'Radiology Informatics and Work Flow Redesign' and is authored by Guido Vaccari and Claudio Saccavini. It addresses the use of images in medical practice, and offers another journey in the way in which technical advances and professional practices pursue each other in a continuous reciprocal chase. The extent of this change is well represented by the space occupied by image handling: if in the past radiologists used to walk along the walls of the department, commenting on the photographs hanging there, today they engage in a virtual navigation similar to the one described by David Benyon, with archives from all over the world being accessed and compared via a networked computer.

The possible connections interlacing the themes in this issue are countless, including a possible social network analysis conducted on the different laboratories exchanging radiographic images through the Internet. The issue is closed by 'The Pasion project: Psychologically augmented social interaction over networks', an invited paper where Cristina Brugnoli, Francesco Morabito, Richard Walker and Fabrizio Davide describe the background, thrust and plan of a EU funded research project on augmenting social presence that involves a large group of European research centres.

Before concluding, we would like to express our infinite gratitude to the anonymous reviewers, prominent scholars who give a fundamental contribution to the papers' publication but do not receive any direct benefit from this; the editorial assistants who have collaborated to this issue, Marta Nicolosi and Giovanni Petrucci and their patient formatting and reformatting of the files; especially, we would like to thank the authors who decided to disseminate their work and thoughts through our Journal.

Sincerely,
The Editors-in-Chief
Luciano Gamberini,
Anna Spagnolli,
Giuseppe Riva

PsychNology Journal, 2006
Volume 4, Number 1, pp. 7 – 24

Navigating Information Space: Web site design and lessons from the built environment

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ABSTRACT

The Web is the archetypal information space but even on a well designed site it can be difficult to find all the information you need. It is impossible to design a site so that all the information needs of all the users of the site are satisfied on a single screen. Accordingly people have to pick up information from a variety of sources; they move through the information space to gather all the information that is required. This is generally called 'navigation'. Navigation is concerned with finding out about, and moving through, an environment. Of course there is a long history of designing for navigation in physical spaces. Architects, urban planners, geographers and others have studied navigation and learnt how to design physical spaces to help people find the place they are looking for, to enjoy exploration for its own sake, or to help find their way through a space to get somewhere else. The question arises as to whether we can leverage any of this knowledge for the design of information spaces such as Web sites. In this paper we review a variety of views on navigation of physical space to see how this knowledge might transfer to the design of information spaces. The example of using Gordon Cullen's serial vision theory to design a Web site map is used to show the transfer of knowledge from the design of urban space to the design of digital space. Guidelines for good Web site design and examples of how social navigation can be used within Web sites are provided.

Key words: *Navigation, information space, urban planning, built environments, environmental psychology, Web site design.*

Paper Received 25/04/2006; received in revised form 9/05/2006; accepted 15/05/2006.

1. Introduction

The Web is the archetypal 'information space'; a combination of content and presentation that allows people to plan, monitor and control their activities (Benyon, 2005). However, even on a well designed site it can be difficult to find all the information you need. It is impossible to design a site so that all the information needs of all the users of the site are satisfied on a single screen. Accordingly people have to

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pick up information from a variety of sources; they move through the information space to gather all the information that is required.

This process is generally called ‘navigation’. Navigation is concerned with finding out about, and moving through, an environment. Of course there is a long history of designing for navigation in physical spaces. Architects, urban planners, geographers and others have studied navigation and learnt how to design physical spaces to help people find the place they are looking for, to enjoy exploration, or to help find their way through a space to get somewhere else. Can we leverage any of this knowledge for the design of information spaces such as Web sites?

Of course there are important differences between physical and information spaces. Moving through a physical space requires a body. It can take advantage of the full range of human senses and proprioception. In information spaces people can easily jump from one part of the space to another; something you cannot do in physical space where the laws of physics constrain movement. But whilst the physics are different, the design principles may transfer more readily (Benyon, Turner & Turner, 2005). In this paper we present some principles of good design, learnt from the design of physical spaces, and applied to the design of Web sites.

We firstly review some views on navigation in physical spaces, drawing upon architects, designers and geographers to highlight the important concepts and key design issues. The following section provides a review of good Web design practice. This in turn is followed by an example of using urban design principles to design a Web site. A short conclusion ends the paper.

2. Navigation

There are many shades of opinion on exactly what activities constitute navigation. In an early review we identified three different but related activities (Benyon & Höök, 1997).

Object identification which is concerned with understanding and classifying the objects in an environment.

Exploration which is concerned with finding out about a local environment and how that environment relates to other environments.

Wayfinding which is concerned with navigating towards a known destination.

Although object identification is somewhat akin to exploration, the purpose is different. Exploration focuses on understanding what exists in an environment and how the things are related. Object identification is concerned with finding categories and clusters of objects spread across environments, with finding interesting configurations of objects and finding out information about the objects. For example when you look at a scene from a distance, say a viewpoint overlooking a city, you can explore the scene by trying to identify the different areas such as the river, the harbour and the city centre. You can also identify the objects – the cathedral, the skyscrapers and so on – and see how they are related physically and conceptually.

Navigation is concerned with both the location of things and with what those things mean for an individual. Landmarks are notoriously personal. How many times have you been told something like 'turn left at the grocer's shop, you can't miss it', only to drive straight past the supposed obvious landmark? Objects in an environment have different meanings for different people.

A lot of work in psychology has been done on how people learn about environments and with the development of 'cognitive maps'; the mental representations which people are assumed to have of their environment (e.g. Tversky, 1993). These representations are rarely wholly complete or static. People do not store road maps in their head. They may be able to construct one when required, but cognitive maps are more patchy and people make use of much information 'in the world' as they move and navigate. Ecological considerations are concerned with the cues that people draw from the immediate environment as they interact with it. People develop knowledge of the space over time and through the experience of interacting with and within a space. There is still much debate about how much knowledge is 'in the head' and how much is 'in the world' (Norman, 1999).

Wayfinding is concerned with how people work out how to reach their destination. For Downs and Stea (1973) and Passini (1984) the process involves four steps; orienting oneself in the environment, choosing the correct route, monitoring this route, and recognising that the destination has been reached. To do this people use a variety of aids such as signposts, maps and guides. They exploit landmarks in order to have something to aim for.

Learning to find ones way in a new space is another aspect of navigation considered by psychologists (Kuipers, 1982; Gärling et al. 1982). First, we learn a linked list of items. Then we get to know some landmarks and can start relating our position with regards to these landmarks. We learn the relative position of landmarks and start

building mental maps (i.e. cognitive maps) of parts of the space in-between these landmarks. These maps are not all complete. Some of the ‘pages’ are detailed others are not, and more importantly, the relations between the pages are not perfect. Some may be distorted with respect to one another.

In the 1960s the psychologist Kevin Lynch identified five key aspects of the environment; nodes, landmarks, paths, districts, edges (Lynch, 1961).

Districts are identifiable parts of an environment which are defined by their edges.

Nodes are smaller points within the environment, those with particular significance may be seen as landmarks.

Paths connect nodes.

These concepts have endured, though not without criticism. The main issue is to what extent are features of the environment objectively identified. Other writers (e.g. Barthes, 1986) have pointed out that the identification of these features is much more subjective. It is also important to consider the significance and meanings that are attached to spaces by people. Different people see things differently at different times. Shoppers see shopping malls in a different way than skateboarders do. A street corner might feel very different in the middle of the day than it does at night. There are different conceptions of landmarks, districts, etc. depending on cultural differences such as race, gender or social group. The ship's captain can see many different landmarks in the ebb and flow of a river than the novice. Navigation in a wilderness is a wholly different activity from navigation in a museum.

In addition to the five features identified by Lynch, it is generally assumed that there are three different types of knowledge that people have of an environment; landmark, route and survey knowledge (Downs and Stea, 1973).

Landmark knowledge is the simplest sort of spatial knowledge in which people just recognise important features of the environment.

Gradually they will fill in the details between landmarks, linking them together to form route knowledge. With route knowledge the person knows how to get form one place to another, but does not know what goes on behind the paths they use.

As they become more familiar with the environment people will develop survey knowledge; the ‘cognitive map’ of the environment. This fills in details about the relationships between landmarks, routes and paths.

In the physical world, relative distances and direction are important. This process is familiar to anyone who has got to know a new city, university campus or even a large shopping mall. Reflecting on how to design to support this process is important.

Christian Norberg-Schultz was an influential architectural thinker of the later twentieth century. He describes what it is like 'to be somewhere'; a place has spatial and affective aspects. As a person navigates within a space they begin to create a schema of the environment based on an interpretation of the environment through a range of perspectives. The attributes of the person's 'existential space' is a combination of abstract topological information (e.g. proximity, distance, succession, closure, continuity) and concrete elements (the physical appearance of the environment e.g. a façade on a building). He argues that these aspects are derived from an individual's need to perceive space in relation to places, directions and paths. As part of the navigation process individuals seek to subjectively centre themselves in a space, attempting to reach a focus. The activity of attempting to find a centre results in the creation of places, which contain actions, activities and social interactions. These places are perceptually distinct and relatively static structures within the space.

These views of place and the importance of place (rather than space) are reflected in the works of Edward Relph (1976) and Ti-fu Tuan (1974). Also writing in the 1970s these authors explore the personal nature of people's interactions in spaces and how the meanings they make, the actions they take and the feelings they have develop spaces into places. Recently Edward Casey has shown how the concept of place has returned to the philosophical foreground (Casey, 1997; Casey 2001).

Edmund Bacon was an influential town planner responsible for the development of Philadelphia. He suggests that any experience we have of space depends on the form (shape, colour, location and other so on), the features that infuse character, space and time (each experience is based on partially those preceding it) and involvement. These all have an impact on navigation. For example if a person feels a feature of the environment is intimidating, lacks character or if the collective experience of the environment is unpleasant, they may be unwilling to continue exploring.

The guidelines and concepts provided in *Responsive Environments* (Bentley, Alcock, Murrain, McGlynn & Smith, 1983) focus how to make an environment responsive to the needs of the people undertaking activities. The book has been reprinted often suggesting that their organisation of design knowledge is long lasting. The guidelines aim to address a range of issues which affect the "choices people can make". These are:

Permeability. How the design of the environment affects where people can and cannot go.

Variety. The range of uses available to people.

Legibility. The ability of people to understand the opportunities afforded by the environment.

Robustness. The degree to which people can use a place for different purposes.

Visual Appropriateness. The detailed appearance of the environment and how this makes people aware of the available options.

Richness. The choice of sensory experiences afforded to the users.

Personalisation. The ability of the individual to customise the environment.

Permeability is critical to navigation. It is concerned with how the environment supports movement of individuals. The availability and use of paths depends both on their physical existence and their visual appearance. Permeability is also dependent on public and private space, the connectivity of routes and the nature of the environment. For example, physically separated spaces force people to take a certain path. A strict hierarchical space forces movement up and down, rather than across the structure.

The guidelines that Bentley *et al.*, come up with, such as to obtain maximum permeability the environment should contain the smallest block size and connect as many of the smaller routes as possible to the main routes are reminiscent of the architectural patterns of Christopher Alexander (Alexander, Ishikawa & Silverstein, 1977). These have become very influential as rich qualitative sources of good design advice. The principles behind patterns as a way of capturing design knowledge have spread into software engineering, human-computer interaction and Web site design (Graham, 2003).

Too much similarity between different areas of an environment can cause confusion. The design should encourage people to recognise and recall an environment, to understand the context and use of the environment and to map the functional to the physical form of the space. Another important design principle from architecture is the idea that to gain a gradual knowledge of the space through use, designers should aim for a ‘responsive environment’. Such as environment would ensure the availability of alternative routes, the legibility of landmarks, paths and districts and the ability to undertake a range of activities.

Of course this is just a sample of the design advice that is available within architecture, urban planning and environmental science. But the issues of encouraging understanding, of realising that people need to attach meanings to spaces (to create

their places) and of designing to support the activities that people want to undertake are crucial.

Good, clear signposting of spaces is also critical in the design of spaces. There are three primary types of sign that designers can use.

Informational signs provide information on objects, people and activities and hence aid object identification and classification.

Directional signs provide route and survey information. They do this often through sign hierarchies with one type of sign providing general, 'global' directions being followed by another that provides local directions.

Warning and reassurance signs provide feedback or information on actual or potential actions within the environment.

Of course any particular sign may serve more than one purpose and an effective signage system will not only help people in getting to their desired destination, it will also make them aware of alternative options. Signage needs to integrate with the environment in which it is situated aesthetically so that it will help both good and poor navigators. Consistency of signage is important, but so is being able to distinguish different types of sign.

Maps can be used to provide navigational information and supplemented with additional detail about the objects in the environment, they become guides. There are many different sorts of map from the very detailed and realistic to the highly abstract and schematic. Maps are social things. They are there to inform and help people explore, understand and find their way through spaces. They should be designed to fit in with the signage system. Like signs there will often be a need for maps at different levels of abstraction. A global map which shows the whole extent of the environment will need to be supplemented by local maps showing the details of what is nearby.

A well designed environment with good signage and well designed navigational aids such as maps will be conducive to good navigation, but even in the best designed environment people will often turn to other people for information on navigation rather than use more formalised information artifacts. When navigating cities people will often ask other people for advice rather than study maps or follow signs; particularly when the signage system breaks down. Information from other people has a huge advantage over information on signs and maps because it is usually personalised and adapted to

suit the individual's needs. Often advice is accompanied by personal stories and experiences.

Even when people are not directly looking for information they use a wide range of cues from the behaviour of other people and the traces of their behaviours, to manage our activities. We might be influenced to pick up a book because it appears well thumbed, we walk into a sunny courtyard because it looks attractive or we might decide to see a film because our friends enjoyed it. We find our way through spaces by talking to or following the trails of others. The whole myriad of uses that people make of other people to help them navigate – whether directly or indirectly - is called *social navigation*.

3. Navigation design for Web sites

In information spaces people face similar problems and undertake similar activities as they do in geographical spaces. They may be engaged in wayfinding – searching for a known piece of information. They may be engaged in exploration of the space to understand its scope and overall content, or they may be involved in object identification; working out exactly what something is. They will move rapidly between these activities and they will pick up new information from the local environment. Indeed often they will rely on designers putting information in an environment to remind them of different functions and options that are available; what Pirolli calls 'information scent' (Pirolli, 2003). Information spaces such as Web sites have different districts, with nodes and paths linking the sections together. Landmarks will help people to recognise where they are in a space and hopefully help them to plan and monitor a route to where they want to go. People will have simple route knowledge of some information spaces and survey knowledge of others.

The essential thing about designing for navigation in Web sites is to keep in mind the different activities that people undertake in a space — object identification, wayfinding and exploration — and the different purposes and meanings that people will bring to the space. The practical aim of navigation design is to encourage people to develop a good understanding of the space in terms of landmark, route and survey knowledge. However, another aim is to create spaces which are enjoyable, engaging and involving. Design is about both form and function and how these can be harmoniously united.

Information architects design information spaces. According to Brinck, Gergle and Wood (2002), the design of navigation mechanisms is the second main pillar of information architecture. They add to the general ideas of navigation by identifying seven types of user navigation from the omniscient user ('they benefit from short, efficient paths') to the rote memorization ('use distinctive landmarks and orientation cues'). Along with Rosenfeld and Morville (2002) they identify three key features of a good navigation design for Web sites; labelling, navigation support and searching mechanisms.

Labels are the information space equivalent of signs in the physical world, providing information, direction and warning, or reassurance.

Navigation support will be provided through lists of links in addition to good labels that will enable people to find distant information from local 'information scent'.

Searching mechanisms should be based on a clear understanding of naming and alternative vocabulary.

Labels are used for internal and external links, headings and sub-headings, titles and related areas. Not all labels are text; iconic labels can be very useful if the context and design is clear. Paying attention to good, consistent, relevant labels is a critical part of information architecture. Information architects must develop a clear and unambiguous preferred vocabulary. All the principles of good signage design apply to Web sites. Signs need to be hierarchically structured to provide both an overview and the local detail. Maps need to be provided including the 'You Are Here' maps. The design language (colour, font, size, style, etc.) needs to be well thought out and consistent.

Of course many of the signs and labels on a Web site are deliberately placed in order to support navigation. It is common to have a navigation bar across the top of a site which points to the main, top level categories. This is often called the global navigation. Within each of these there will be sub-categories. These might be placed down the left hand side of the site or my drop down when the main category is selected. These are known as local navigation. It is a good design principle to have the global, top level navigation bar the same on every page so that people can easily jump back to the home page, to a frequently asked questions page or to one of the other main categories.

Other devices such as indexes and glossaries are helpful in assisting people find exactly what they are searching for. A site map should be made available that can be

called up when needed. The map displays the structure and content headers of the various categories. ‘Breadcrumbs’ (such as used by Hansel and Gretel to find their way back when they were taken into the forest) is a common way of showing people where they are.

Navigation bars – both local and global — are essentially signposts and landmarks, leaving the site visitor to pick their way through the site structure. Site maps and good feedback on where people are in the structure will also help. Another alternative is to provide a clear path through a part of the site. This is particularly important when a number of activities or pages have to be visited in sequence. A site ‘wizard’ can help here that guides people and explains what each activity is for. Often this is simply a succession of pages, such as when buying a ticket or booking a flight.

4. Applying urban design principles to Web site design

There are many good textbooks that provide advice on Web site design, but few provide a systematic approach in the same way that good (physical) architecture might guide the design of a city. One application of urban design principles to Web sites is described in Benyon and Wilmes (2003). Bettina Wilmes used the ‘serial vision’ theory of town planner Gordon Cullen to design a concept Web site that demonstrated a sense of location, place and included a dynamic site map that indicated the distance and direction of the other pages on a site.

Cullen’s theory of serial vision was based on the gradual unfolding nature of vistas as one walked through an environment. Possibly the most famous example is the Taj Mahal in India where every step towards the monument reveals a new view. Taking Downs and Stea’s (1977) concept of wayfinding and Cullen’s view of townscapes as a basis, Wilmes identified five design objectives for Web navigation. Web navigation should aim to provide:

1. A sense of place (uniqueness)
2. Information on size and dimension (scale)
3. Information on closeness and distance (approach)
4. Information on direction and perspective
5. A sense of arrival

The process of wayfinding (Downs & Stea, 1977) is broken down into four steps: orientation, choice of route, monitoring of route, and discovery of the objective. Each of these steps requires a certain design quality of the space. In order to orientate oneself in an environment it is necessary that the space has a series of unique, distinguishable characteristics and features. A *sense of place* is often understood as something that is of significance to people. In a physical environment a sense of place is created by physical and landscape attributes as well as human activities In a Web site the different categories can be designed to include characteristics, which are unique for that specific place, by using textures, colours and styles.

Golledge and Stimson (1997) argue that the concept of place generates strong psychological and emotional links between people and places, which depends on the range of experience that people have with places:

> The sense of place incorporates not only the concepts of location and pattern but feelings of belonging, invasion, mystery, beauty, and fear. As time changes, cultures alter settings, and the sense of place, its symbolism, its meaning, its cultural significance, and even its boundaries, may change. (pp. 393)

It is this sense of place that we wish to engender in Web site design.

If transferring the concept of sense of place or uniqueness to the information space of a Web site, it is essential to aim for a distinguishable look and feel of the site including a clear-cut navigation strategy. Both Nielsen (2000), and Flanders and Willis (1996) promote the use of a well-designed home page as a tool for providing a sense of place and helping users to orientate themselves. This may assist the sense of arrival when coming from another Web site.

The next design objectives all derive from the navigation steps ‘choice and monitor of route’; they are concerned with the actual extent of the space and associated spatial attributes such as closeness/distance, and direction/perspective. Although these spatial attributes are understood to be objective and can be measured by certain standards (e.g. the number of pages or the number of mouse clicks required to get from A to B), a person is likely to have an individual perception of the spatial dimensions of a site.

In order to decide on a sequence of movements from the current location to the desired destination, people need to know the dimensions of the space and which route is the most efficient one. Furthermore, it is critical that they are continuously provided with information on the remaining distance to the goal. This will give them a feeling for

approach throughout the entire movement. This can be seen, for example, in serial tasks such as completing an on-line booking when information such as ‘step 2 of 5’ is provided. When moving through the site, people’s perspectives of the site changes constantly, with individual targets moving into the back- or foreground. People need to be aware of these changes, in order to adjust their path if required.

If aware of it, the interplay of changing perspectives or views, can add an interesting aspect to the Web navigation experience. Following Gordon Cullen’s theory on ‘Serial Vision’, the Web space can be split into two elements: the existing view (i.e. the view of the current locations or page) and the emerging view (i.e. the view of locations or pages directly accessible from the current one). By moving through the Web site, the user is exposed to a chain of events experiencing a constant change of view. Ideally, the entering and leaving spaces (i.e. pages) in combination with the shift in views evokes a positive emotional reaction and the Web site is experienced at a much deeper level. This follows Gordon Cullen’s theory on ‘hereness and thereness’ and his claim that the designer needs to be aware of the existence of these two spaces. One could argue that if people know what is ahead of or immediately around them and are able to catch a glimpse of these, they may feel curious and intrigued to find out more and subsequently move to another space.

The final design objective, *sense of arrival*, derives from the final step in the wayfinding process, the discovery of the goal. Once people have arrived at their desired destination they need to be made aware of their arrival. It is not enough to provide a sign ‘you have arrived’ (which is in architecture and landscape architecture considered to be a design failure); it is here again that the sense of place becomes important. The designer should aim to create the ‘space of arrival’ in a way that it becomes obvious that the goal is reached, such as a countryside mansion located at the end of an avenue.

5. Social Navigation of Information Space

As we noted earlier, the design of the physical environment is important, but so are the other people who are in that space. People use a whole variety of socially-based techniques to help navigate environments. The social is something that is typically missing from information spaces.

Social navigation of information space aims to leverage techniques and designs that make people aware of others and of what others have done. *Designing Information Spaces: the social navigation approach* (Höök, Benyon & Munro, 2003) provides many detailed examples and reviews of techniques. Some designs such as on-line communities exist solely for the purpose of enabling people to maintain and build links with other people. Other systems are more concerned with making people aware of what others are doing and others with making aggregate knowledge of others available.

A direct form of social navigation is concerned with putting people in touch with other people (or with artificial agents). When we talk to someone else, the information we get back is often personalised to our needs and the advisor may offer information that changes what we want to do or how we might approach it, making us aware of other possibilities. People can judge to what extent the information given can be trusted depending upon the credibility of the information provider. Even if the information cannot be trusted, it may still be of value as people know where it is from.

In information spaces, using person to person communication is an important part of the information architecture that is often overlooked. Direct social navigation comes in many forms. At its most prosaic it consists of a link such as mail 'webmaster'. At least these impersonal connections suggest that there is a real person at the end of the line. Having individuals identified by name adds another level of personalisation (but creates difficulties if that person is not answering their mail for a few days). From such beginnings rich webs of direct social navigation support can be developed. There may be an instant messaging facility, video conferencing and so on.

Systems supporting direct social navigation can soon turn into fully fledged on-line communities where the whole basis of the information space is to support communication and exchange of information around a particular theme. On-line communities are springing up devoted to all manner of social and recreational questions. They combine e-mail lists, threaded conferences, chat rooms, message boards, diaries ('weblogs' or 'blogs') into a coherent structure to support some domain. Systems such as Geonotes (Persson, 2003) aim to augment the geographical world with virtual 'post-it' notes. Thanks to the advances in positioning technologies an electronic message can be left associated with a particular place. When another person (suitably technologically equipped) arrives at the place the system alerts him or her to the message. As Persson points out such attachments of information spaces to

geographical spaces goes back to the cave paintings and people continue to annotate places with graffiti, post-its and fridge magnets.

If other people are not around to provide help and advice then there are a number of systems that try to filter out uninteresting information and which point people to things that they will find relevant. Just as a newspaper editor filters news into a form that readers of that newspaper like, so content filtering systems aim to tailor information to people. (Conversely the newspaper or TV channel that we choose is selected because we like the way that news is filtered and presented).

In content based filtering the information is scanned for specific articles that match some criteria. Based on a statistical analysis the system rates the relevance of the information to the user. Usually keyword-matching techniques are used to filter the information. The user supplies a preference file to the system with keywords that the system should look for in documents. For example, an agent scans a newsgroup for documents that contain the keywords on regular basis.

Recommender systems make suggestions to people for information based on what other people with similar tastes like or dislike. Personal profiles are matched and the system creates clusters of people with similar tastes. Book recommendations from the Amazon sites are probably the best examples of a mature recommender system. People who subscribe to Amazon can have the system recommend books based on those that they have bought previously and on those that they rank and on those that others have bought. Konstan and Riedl provide a thorough review (Konstan & Riedl, 2003)

Another method of providing social navigation is to provide a tag so that whenever a person comes upon a new piece of information she can see what other people with similar interests as her think of that particular piece of information. Some sort of rating of the information pieces have to be done by the users of the system so the system can create and cluster personal profiles. The more people that rate items, the more accurate the system can group users. Ratings can be done either explicitly and/or implicitly. Implicit ratings are, for example, time spent reading an article. Explicit rating let people score information sources. Filtering needs some sort of input to work with, and explicit ratings of information is not all that simple. How do we judge ratings from someone who has created the information? Explicitly rating information is also an additional burden on people, so sometimes they will not bother. EBay is a great example of reading explicit ratings.

History Enriched Environments, or ‘readware’ is another technique for social navigation. What other people have done in the past can tell us something about how to navigate the information space. If we get lost in the woods and come upon a trail, a good idea is to follow that trail. People that take a certain path through the information space. Another familiar technique is to automatically change the colours on the links in a Web page when a person has visited that page. In some other systems this may be generalised based on usage of links. Perhaps the main example of this was the Footprints project (Wexelblatt, 2003) where ideas of interaction history are associated with an object.

Finally ‘social translucence’ is an approach is based on three core principles; visibility, awareness and accountability. The concept has been developed at IBM by Tom Erickson and Wendy Kellogg amongst others and has been implemented in a number of prototype systems. Erikson and Kellogg (2003) illustrate their concept by telling the tale of a wooden door that opened outwards in their office. If opened too quickly the door would smash into anyone who was walking down the corridor. The design solution to this problem was to put a glass panel in the door. This enabled the three principles of social translucence to be met. Visibility is achieved because people outside were now visible to those inside who were going to open the door. Of course the transparency of the window meant that people inside the office were also visible! Awareness was achieved because people could see what others were doing and could take appropriate action – opening the door carefully, perhaps. Accountability is particularly important. Not only are people aware of others but now they are aware that they are aware of others. If the person inside the office opens the door and smashes into someone in the corridor the person in the corridor knows that the office person knew this. Hence he or she has to be socially accountable for the action.

These principles have resulted in a number of ‘social proxies’; software systems that capture the principles of social translucence. The best known of these is Babble – a social proxy for meetings, chat and e-mail. People are represented by ‘marbles’ and the space of discussion by the large circle in the centre of the systems. The more active people are the nearer the centre they are and the marbles gradually move towards the periphery if they do not participate in the chat for some length of time. Other details of the people can be seen in the panes around the edge of the system.

6. Conclusions

Navigation of Web sites - information spaces - is a key activity that people undertake. We can learn much from studying navigation in geographical spaces and indeed apply design principles from urban planning and architecture. This has already been suggested for virtual environments (Vinson, 1999). The principles of how we find our way in information spaces are the same as those in geographical spaces. The differences are that we have far less sensory cues in information spaces and the physics are different – we can jump to different parts of the space, fly over data landscapes and move through virtual walls. These differences notwithstanding, design principles transfer well from physical to information spaces.

But just as it took architecture time to migrate from the purely functional to the more aesthetic, so we see this in Web sites. Designers are often too focused on the information on the site and not enough on navigation; movement through the site. Web sites get overloaded. There is no pleasurable experience to be had moving through the site. Navigation is wholly cognitive, rather than intuitive. By looking to theories of physical space design that emphasise ease of movement and naturalness of interaction, such as Gordon Cullen, the experience of Web site navigation can be much more pleasurable and rewarding. Social navigation is also important and designers should seek to bring people, and the activities of people, into the dead space of information.

Navigation of information space is concerned with good design through the use of maps, labelling and signage. It is about helping people obtain a survey knowledge of the whole information space and enabling the three key activities of wayfinding, exploration and object identification. Providing assistance for social navigation – using other people and their activities - to help navigate the information space will ensure more effective and more enjoyable Web sites.

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PsychNology Journal, 2006
Volume 4, Number 1, pp. 25 - 52

Stereotypes and Gender Identity in Italian and Chilean Chat Line Rooms

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ABSTRACT

This work is an attempt to analyze how men and women communicate gender identity by using stereotypical traits in a chat line environment, through quantitative and qualitative data. In Study 1 (Coding & Counting Approach, Herring, 2004), 80 same-sex conversations (40 men and 40 women; 40 Italians and 40 Chileans), carried out in public chatrooms were analyzed using some Project H-Codebook categories and the X^2. The categories taken into consideration were: *Firstper*, *Opinion*, *Apology*, *Question*, *Emoticon*, *Emodevice*, *Coalition_1*, *Coalition_2, Fact*, *Action*, *Challenge*, *Flame, Status, Style.* The results showed no significant differences between women and men in the use of these categories, except for *Flame* ($p<0.001$). We used the Conversational Analysis method in Study 2 to examine conversational dynamics which chatters use to co-construct their identity. Qualitative results have emphasized the existence of specific gender related mechanisms, thereby making it possible to understand the construction of online subjectivity through relationships. Our results suggest that there is an opportunity to investigate communicative style through both quantitative and qualitative differences.

Keywords: *Identity, CMC, Gender, Conversational Analysis, Language Style.*

Paper Received 22/11/2005; received in revised form 11/05/2006; accepted 20/05/2006.

1. Introduction

The subject of online identity is one of the largest branches of research in the area of CMC (Computer-Mediated Communication), which over time has discovered the users' communication pathways for presenting their identity. Many researchers, such as Danet (2001) and Mantovani (1995), have described some mechanisms through which traces of the Self may be found; Walther (1996) in particular emphasizes the importance of

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stereotypes as a guide during this process. When looking at other research which has been conducted on gender identity, the basic aspect of the self, it can be noticed that in many cases traditional stereotypes are found in asynchronous online environments (Herring, 1994; 1996; Witmer & Katzman, 1997). All things considered, we believe it is indeed possible to carry out further investigations using quantitative and qualitative data; currently, it appears to us that the need to combine the two methods seems to be spreading, even though there is no real multi-methodological approach. This study is an attempt to respond to the underlying requirements from which this new perspective arises. It is our intention to add to the existing results by way of an investigation to verify how men and women characterize themselves by using stereotypical traits in a synchronic environment (chat line rooms). Methodologically the need to integrate quantitative and qualitative methods cropped up when we were faced with the choice of associating the results obtained with the traditional method (grid analysis) or with Conversational Analysis (C.A.). Nevertheless, we analyzed two samples composed of men and women of different nationalities: Italian and Chilean. This is not a cross-cultural study; in fact the focus of the study was to verify the results obtained from the Italian sample by comparing it with a sample which has similar neo-Latin cultural roots. Both of these cultures are characterized by an Interdependent Self, which is typical of Latin-American cultures and of many southern European cultures, as opposed to the Independent Self (Markus & Kitayama, 1991).

2. The management of identity: online gender as a polymorphic gender

It is possible to observe and describe what was experienced on the Net, by focusing on three principal perspectives: subjects, processes and objects (Galimberti & Riva, 2000). The aim of this study was to focus on the subjects in order to verify the extent to which people use stereotypes to construct their identity online. This stance includes communication and the cognitive and identity aspects through which it is possible to create an effective image of the self (Belloni & Galimberti, in press). To this end, the Net gives many opportunities for play (Baym, 1995) and also for testing a “new self”, being therefore a sort of “Workshop of Identity” (Peace, 2000). A theory has been suggested that our system of stereotypes remains active, even in an online context, so that when we meet someone we use this system to categorize our interlocutor. This Hyperpersonal Model stated that, in many cases, communication is very often better

through the computer than FTF (Face to Face) communication, and it becomes Hyper-personal: “CMC is more socially desirable than the experiences we tend to achieve in parallel FTF interaction” (Walther, 1996).

Desirability depends on four factors. The Sender is aware of what he/she transmits and he/she is able to choose it. The Receiver participates in the construction of the sender’s image by using the categories of stereotypes to put the information he/she has received in order. The Channel facilitates the selective presentation of the self and the Feedback warrants a confirmation.

Various clues regarding social roles are utilised; the nickname (Bechar-Israeli, 1995), the communicative style, the paralinguistic aspects or the way one’s own personal homepage is constructed (Kibby, 1997). Identity is fluid, it is the result of an unwritten choice in a precise context which always tries to develop along a path of continuity; besides “the representation of identities through the technological artifice of cyberspaces is necessarily an act of repetition; the identity exists at no time other than the performance” (Marks, 1996).

Moreover is well known that gender is a category of basic importance in our social life because it is always associated to the body, which disappears on the Net. The body refers to a biological fact, sex; gender includes the expectations of a specific group about men and women (Arcuri & Cadinu, 1998). It is a social construction which is contextualised in space and time and is characterized by a certain level of fluidity which has always been sacrificed in favour of biological bipartition (O’Brien, 1999). Cyberspace has also been seen as the place in which to develop these opportunities (Biocca, 1997; Chua, 1996), but it is still a tool used by a society which knows only “male” and “female” (Hamilton, 2000; Haraway, 1999). Many researchers have described what happens between the two sexes in cyberspace. Vaughn Trìas (1997) has distinguished between two traditions; the “*Democracy*” paradigm states that women and men participate equally in online life, leading to the disappearance of discrimination. On the other hand, the “*Difference*” paradigm has outlined how traditional cultural stereotypes have been transposed to the Net – with all their effects - describing the way in which they represent themselves (Perry & Perry, 1998; Patterson, 1999; We, 1993; Jaffe, Lee, Nuang & Oshagan, 1995).

2.1. Gender Language Style

The majority of these studies focused on the differences inherent to the communicative style of men and women, in order to verify a relationship with the

traditional stereotype (Ferris, 1996; Savicki, 1996; Witmer & Katzman, 1997). Herring (1994,1996) has described two gendered communicative styles reached in two academic lists: the **Assertive Style or Negative Polite Style**, typical of men (heavy assertions, humiliation, frequent answers, sarcasm and auto-promotion) and the **Supportive Style or Polite Style**, typical of women (appreciation, words of thanks, collaboration, doubts, apologies, questions and suggestions).

While this type of research was being carried out, reflection begun as to the meaning of these results. The first possible criticism of this perspective is that research on a stereotypical style is an oversimplification which does not take the features of the different online environments into consideration (Rodino, 1997). Indeed the differences could be more qualitative than quantitative; we learn to be men or women through communication, gender is both its product and influences it at the same time (Mulvaney, 1994). For this reason, if "different communication ethics provide an explanation for the different styles" (Wallman, 1993), previous studies should have been the first step to the study of a traditional communicative ethic which influences the intentions of men and women offline as well as online.

Based on the features of our study, as described above, we needed to identify a good method in order to study it. In other words, we tried to find a way of studying how stereotypes and gender identity work in online interactions, in both the linguistic and interactional choices made. It would have to be a dynamic approach in order to enable us to consider the totality of the communicative elements which are present as well as the characteristics of the vehicle.

3. A new proposal: towards an interactional perspective

As we explained in the introduction, the aim of this research is to offer a new contribution to the series of University researches which are concerned with the manifestation/construction of gender identity in Cyberspace through two studies: a quantitative study and a qualitative study. Both have analyzed chat line same-sex conversation.

We have chosen the Chat Line because of some of its interesting characteristics. It is an environment in which communication is synchronic and its purpose is to chat and to make friends (Bonaiuto, Buffone & Castellana, 2002; Roversi 2001). In it we can find: funny and serious discussions, games (Danet, 2001), stories, arguments and true

representations (Paolillo, 1999; Bechar-Israeli, 1995; Danet, Ruedenberg & Rosenbaum-Tamari, 1998). It is well known that the chat room was created as a place to bring people together freely, even if in some cases little communities arise; people who habitually go to the same chat line or to the same chat room to get to know new people and to meet old friends (Suler, 2000). The methodology used in the previously mentioned research came from the analysis of synchronic environments texts, characterised by long interventions, which can be re-elaborated many times before being finally submitted, and which are finalised for a rhetoric purpose. The chat line environment is closer to female communicative needs but it is also less adequate for classic research (Stewart, Shields, Monolescu & Taylor, 1999). In this same environment it was possible to observe the dynamics of self presentation which refer to the general mechanisms of the chat line, as well as the communicative forms typical of that specific community. Understanding these mechanisms, which can be general or more specific, means understanding the way subjects present and reveal themselves during the interaction (Belloni & Galimberti, in Press). Even the language is specific; the traditional forms of writing and speech typically used on the Net are called Netspeak or Written Speech. In chat lines, more than in other environments, the desire to reproduce the forms of speech conflicts with the slowness of writing (Crystal, 2001; Collot & Bellmore, 1996, December 1993; Werry, 1996). In subsequent paragraphs we will describe the quantitative and qualitative tools used to gather and analyse data, based on the theoretical choices described above.

4. Study 1: Method

The first study used the typical methodology for this type of research (Herring, 1994; Rafaeli & Sudweeks, 1993), which is called the “Coding & Counting Approach” (Herring, 2004): using an observational grid, it was possible to count how many categories, referred to as a stereotypical language style, there were in female and in male conversation. The object of the analysis was a group of 80 conversations lasting about 20 minutes, gathered between January and March 2003. The chats taken into consideration are linked to national radio stations or to portals and preference was given to the welcoming rooms or to the ones dealing with general subjects. The chat rooms we considered were: www.supereva.it; www.rin.it; www.buonconsiglio.com/chat; www.estranet.it; www.chat.tome.it; www.terra.cl; www.sipo.cl; www.angelfire.com;

www.riosysenderos.com/chat. The choice was limited to those chat lines in which a person is allowed to "observe without participating" (lurk) and especially ones which allowed the conversations to be copied. It was all same sex conversation, meaning that the chatters declared that they were of the same sex. The choice of same sex conversations is due to the fact that the gender of our interlocutor influences our communicative style; if I am communicating with a same-sex person my style would be more stereotyped (Carli, 1989). Since we could not verify this information with certainty, we took into consideration the nickname and grammatical clues; the cases in which incongruence was observed in these considerations were excluded.

The analysis grid we mentioned above includes some of the categories of the Codebook of the *Project H's work group* (Project H, 1993), which were validated by achieving average agreement through coders percentages of 90%. Basing ourselves on its validation, we used an instrument from 1993, even though online communication actually evolved after this date. The categories we chose were those which have been described as being typical of women and men's language in previous online (Herring, 1994,1996) and offline studies (Lackoff, 1975; Kirchler, 1992; Glass, 1992; Hall & Braunwald, 1981; Thorne & Henley, 1975). The categories used were: *Firstper* (personal contents), *Opinion*, *Apology*, *Question*, *Emoticon*, *Emodevice* (use of punctuation marks to fade emotive meanings), *Coalition_1* (appreciations referred to other chatters), *Coalition_2* (use of the first person plural), *Fact* (description of a fact), *Action* (encouragement to execute an action), *Challenge*, *Flame* (message which creates tension), *Status* (identification of the personal social status), *Style* (colloquial language). In literature, the first 8 categories were indicated as more female, whereas the rest were more male.

An almost-experimental design was conducted; the independent variables were "gender" and "nationality". Through the comparison made between the Italians and the Chileans, it was possible to check whether any difference really was linked to gender.

The 80 conversations we analyzed were divided into 4 equal subgroups, which was the result of crossing the independent variables (20 for each subgroup): Women Italy, Men Italy, Women Chile, Men Chile. Five codifiers analyzed the texts, two of them being bilingual (Italian and Spanish). Italian conversations were coded by a bilingual codifier and two Italian native speakers; the Chilean conversations were coded by two bilingual codifiers and one Italian native speaker, an expert in Latin-American languages.

The presence/absence of each category was revealed through the analysis grid during the whole conversation. The data thus gathered was submitted to statistical analysis through X^2. The tested Hypothesis was: Women and Men samples differ in the use of all the categories we considered.

4.1. Results

The results of Study1 show that men and women use all the categories we considered, except for one, which had a similar frequency. It doesn't seem possible to observe the same linguistic styles in the chat line which previous research has found**,** for instance**,** in focus groups.

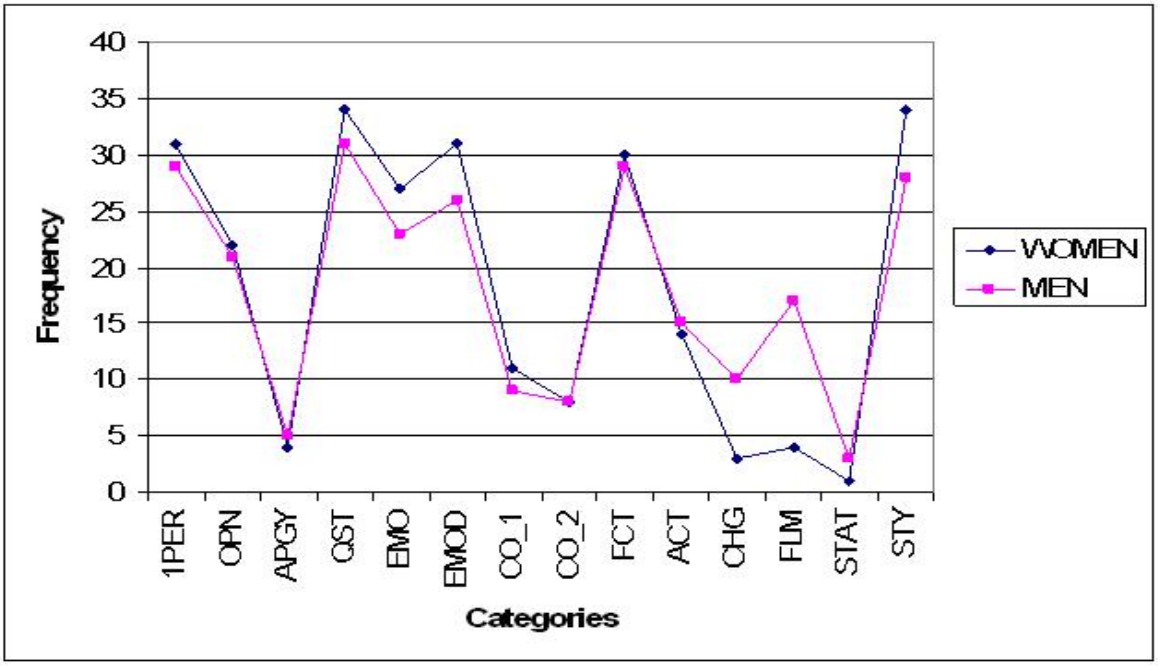

Figure 1: Frequency of the categories we considered in male and female conversations

The categories are divided in three groups depending on their frequency: low frequency (*Apology*: 12,5%; *Challenge*: 15%; *Coalition_2*: 20%; *Status*: 5%); middle frequency (*Opinion*: 53,8%; *Action*: 36,3; *Coalition*: 28,8%; *Flame*: 26,3%) and high frequency (*Firstper*: 75%; *Fact*: 67,5%; *Question*: 81%; *Emoticon*: 62,5%; *Emodevice*: 68,8%; *Style*: 77,5%). The frequencies of all categories are reported in Figure 1 and in Figure 2. The comparison between men and women shows that only 1 of the 14 considered categories turned out to be significant, being a traditional male style trait:

Flame; X^2 (1) = 10.912, p = 0.001. Examining Italian and Chilean groups, there are three significant differences: *Emoticon* (X^2 (1) = 5.33, p = 0.02), *Emodevice* (X^2 (1) = 7.040, p = 0.008), *Flame* (X^2 (1) = 5.230, p = 0.02).

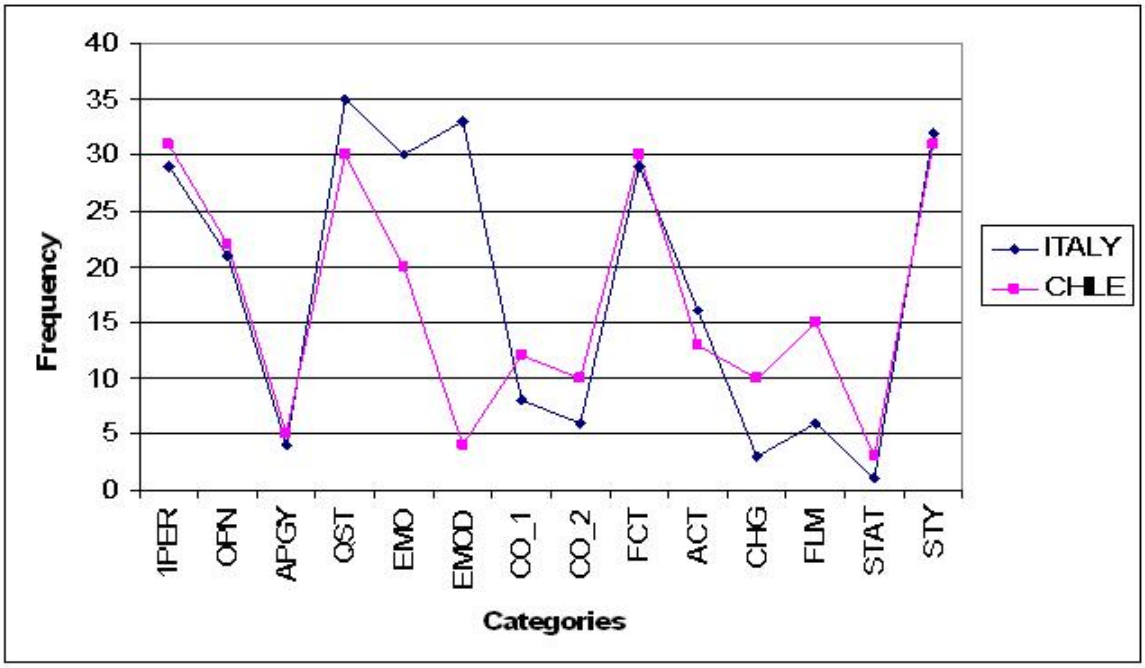

Figure. 2: Frequency of the categories we considered in Italian and Chilean conversations

4.2. Discussion

Study 1 states that only *Flame* really differs in male and female conversations, indeed it is also relevant in the Italy-Chile comparison. However, these results do not allow us to say that there is a gendered language style which is valid for chat rooms. There are more "first encounters", in which an individual presents him/herself, and basic information (gender, age, residency etc..) is negotiated, in the chat lines rather than in an online forum. This creates the expectation that considerable use will be made of all those strategies which can counterbalance the absence of body, in order to be easily recognized as a man or a woman. The decision to count only the presence/absence of a category in the whole conversation without considering how many times the category was present within a session, was intended to reveal strong differences. Probably with a "weaker" method it would be possible to achieve results that are more similar to those in previous studies.

While observing how these categories have been used by chatters during conversations, it emerges that each one is a sort of label which gathers similar

behaviour with different intentions. Women and men use the same communicative tools in various strategic ways. For example, *Emodevice* category implies the use of capital letters, repetitions, and an incorrect use of punctuation to fade emotive meanings. Even if they are the same *Emodevice* elements, in female conversations they allow interlocutors to: place an emphasis on the phrase, call the chatter's attention, and reproduce intonation or expressions such as doubt and surprise. Also men frequently used the same elements in order to increase their own visibility in the group and to emphasize single words or parts of a phrase. Also *Flame* is used in many ways in analyzed conversations, and not always with hostile intent. It is possible to distinguish the flaming sessions by: Purpose (vulgar attacks to insult somebody on a personal level, jokes and coalition aimed at excluding one or more chatters), Targeted Person (a member of a minority) and Development (rapid development, quite contained, hidden origin from a false gentle behaviour).

These observations do not lessen the importance of the quantitative results. The near absence of flame in the female subgroup is an important indication of the communicative habits of women in chat rooms, but on the other hand, the presence of this mechanism in male conversations doesn't mean that there is a hostile mood. In this case those differences will also emerge within the same group, as shown for *Flame*.

In conclusion, compared with the results found in the literature, very few differences were found whilst comparing the two groups of men and women without taking into consideration the different nationalities. It may be possible that the method of counting is too selective and that it doesn't allow us to detect more differences. On the other hand, these differences are not linked to nationality. A more in-depth analysis about the way of using such categories shows how behaviours which are categorized as similar, are used with different intentions, thereby allowing us a new perspective with which to compare women and men. However this type of information needs to be integrated with the analysis of the intentions and the dynamic mechanisms of the conversations which can lead to different situations which are heterogeneous This first study demonstrates the need for a method which is able to recognize the dynamic interweaving of the intentions and the active construction of conversations, and this is what has encouraged us to use C.A.

5. Study 2: Method

This kind of approach has been useful on many occasions, but it does not consider the “more subtle nuances of interaction that can meaningfully describe a community” (Thomsen, Straubhaar & Bolyard, 1998). So, 10 of the 80 codified sessions of conversation have been submitted for Conversational Analysis. The criteria for selection were based on the results in the first phase of the research, the sessions we considered are the ones in which there are the highest numbers of considered categories involved. The two most interesting conversations are presented in this article, one for each gender. The names of the users were not modified due to the use of nicknames which protect the anonymity of the chatter. The discursive ethnomethodological perspective, which focuses attention in group dynamics, was followed. (Hamman,1996). According to this paradigm, participants express themselves in the interactions, from which the community’s shared meanings arise. During these exchanges the users negotiate the modality of their own presentation which will be held valid by those who form part of such an environment and who recognise each other in this way, due to this behaviour (Zucchermaglio, 2002). Instead of depending on the precision of numbers, the reliability of this method depends on: “prolonged engagement and persistent observation, depth of analysis and sampling, learning rhetorical codes over time, dealing with dissimilar people, using informators” (Thomsen, Straubhaar & Bolyard, 1998).

The method which has allowed us to re-enact interactions and to observe the meanings negotiation is Conversational Analysis. C.A. focuses its interest on the combination of representations which emerge from the flow of the interventions which are also at the basis of numerous social dynamics (Galimberti, 1992). “The semantic representations which are reconstructed through deciphering are utilised only as a source of hypothesis and of clues for the second process of communication, the inferential process” (Trognon, 1992). The ambiguity which is dealt with and reviewed in due course during the conversation through a correction subsystem, is at the basis of a communicative result which is necessarily localised.

In this research we will focus on two fundamental mechanisms of conversation: successful performance (or accomplishment) and satisfaction of linguistic acts. A linguistic act is successfully performed if an interlocutor first of all understands the content of the proposition. Whereas a linguistic act is satisfied if there is a correspondence between what the interlocutor has said and the real world. For

example, if someone gives an explicit command ("I order you to do…"), the act is successfully performed if interlocutor recognizes it as a command. On the other hand, the act is satisfied if the interlocutor then obeys (Giglione & Trognon, 1993). As a theorem of interlocutionary logic says, a linguistic act cannot be satisfied if it is not successfully performed: "this theorem means that the conversational value of an illocution is established through the accomplishment of the illocution which follows it. Thus, accomplishment (in the sense of conversational analysis) is always the fulfilment (in the sense of general semantic) of the preceding illocution" (Trognon & Brassac, 1992).

"Yet (…) the conversational interpretation of the previous theorem makes a rule of it by default in such a way that the conversational interpretation (by default) of an illocution does not suppose a pair of two illocutions (initial illocution and the conversational accomplishment that follows it) but at least three. When "everything is going well" this sequence of three illocutions allows the speakers to "face" the problem of mutual knowledge, i.e., to continue the exchange (…). This type of three-way exchange is thus indicative of the creation of a pooling between the two interlocutors" (Trognon & Brassac, 1992; Trognon, Grusenmeyer, 1993).

These two properties of conversation will allow us to clarify the dynamics of the construction of social texture typical of any analysed sequence of which the observed local network of interaction is a consequent manifestation (Trognon & Brassac, 1992; Galimberti, 1992).

The work of co-construction makes the two interlocutors co-utterers, both responsible for what is happening. This highlights how it is not possible to consider their identity, which is constantly being revealed, as optional (Galimberti, 1994). In the course of this stream, C.A. will study two different approaches, two ways of intending to present oneself as a man or as a woman.

The qualitative analysis was conducted by two judges. First, the utterances were recognized (in a chat they can be divided into several separate sentences), after which the mechanism of success and satisfaction were detected. It was possible to model a Psycho-social Hypothesis on this "structure", which explains the relational dynamics and the negotiated meanings.

5.1. Analysis of the First Sequence

The first session to be analysed contains a conversation between female users. They seem to be well acquainted, and refer to preceding interactions in order to observe how they use the communicative instruments which are available to them, so that they can preserve their relationships and demonstrate their reciprocal sympathy.

Greetings	*Plant*	MD1	madlaine says, "speriamo di rianimarla"
		A1	azzurra says, "ma attenta alle correnti"
		MD2	madlaine says, "essì ok"
		MD3	madlaine says, "grassie"
		L1	larossasposata. says, "mettile l'acqua"
		L2	larossasposata. says, "da sotto il vaso"
		A2	azzurra says, "e possibilmente senza calcaree"
		L3	larossasposata. prega x l'azzalea di mad1
		MD4	madlaine says, "eeheheheh rossss"
		M1	_martina_77 . o O (non lo vede +)
		L4	larossasposata. says, "ehehehehehe"
		MD5	madlaine says, "che ti sei persa martì?"
		M2	_martina_77 . o O (sisi itoo)
		MD6	madlaine says, "o meglio..chi..."
		M3	_martina_77 says, "me so persa uno madddddd"
		M4	_martina_77 says, "ehehehehehe"
		MD7	madlaine says, "accc sempre a intortà questa"
		MD8	madlaine says, "eheheheheh"
		M5	_martina_77 says, "ehehehehehe"
		M6	_martina_77 è viziosa
		MD9	madlaine ha visto uno steward sull'aereo martedì
		MD10	madlaine TROPPO BONOOOOOOOOOOO
		L5	larossasposata. says, "mmmmmmmmmmm"
		M7	_martina_77 says, "azz"
		L6	larossasposata. says, "e ce lo dici kosì mad1?"
		MD11	madlaine says, "uddio non volevo piu' scendere"
	Stewart	S1	steana69 says, "buon giornooooooooooooooo"
		L7	larossasposata. says, "e ce credo"
		M8	_martina_77 says, "giornooooo stèèèèèè"
		MD12	madlaine says, "non potete capire cosa fosse"
		L8	larossasposata. aiutatemi sto maleeeee
		S2	steana69 says, "ciao nam"
		MD13	madlaine says, "steeeeeeeeeeeeeeeeeeeeeeeeee"
		A3	azzurra says, "heheheeheheh"
		L9	larossasposata. soffro il mal d'ariaaaaaa
		S3	steana69 says, "madddddddddddddddddddddddd"
		S4	steana69 says, "madò azzurra"
		A4	azzurra says, "steana ciaooo"
		S5	steana69 says, "sempre in chat"
		S6	steana69 says, "a tutte le ore!"
		MD14	madlaine era alto moro abbronzato con 2 spalle così...
		A5	azzurra says, "eccolallàààà"
		A6	azzurra says, "io è???"
		S7	steana69 says, "ti fa maleeeeeeeeeeeeeeeeeeeeee"
		L10	larossasposata. Azzzzzz
		MD15	madlaine says, "capello liscio okkio verde"
		M9	_martina_77 says, "ammazza mad che aereo era?"
		S8	steana69 says, "sis"

Table 1: Full Text of the First Sequence. Female Conversation

There are five subjects in this exchange, and all of them are very active in the discussion of each topic. It is possible to detect four threads of conversation, even if the contributions are collocated in a way which doesn't always follow a linear and temporal development. The chatters showed they were at ease when following the course of the conversation.

The first subject to be tackled, of which only the final part is shown, refers to plant care (*Plants*). The conversation starts with a series of comments and advice with regard to the care of MD's plant, which is not really an answer to an explicit request (perhaps contained in one of the preceding interventions). Two interlocutors respond to her with some advice (A1-A2 and L1-l2 answer MD1) taken into account by MD (MD2-MD3-MD4). The combination of advice + thanks is an expression of a good atmosphere and they are followed by words of thanks which express appreciation towards that specific person.

M enters the conversation through auto-selection and this marks the passage to the second argument (*Stewart*). M1 is immediately welcomed by MD and only two chatters participate at the beginning of the new exchange, but after a few interventions L joins in, always through auto-selection. The conversation progresses through a series of funny comments which seem successful and satisfied, judging by some expressions, mostly laughs (M3-MD7/MD8; MD10-L5; MD11-M7). At this point S enters the room, and a series of greetings (third argument: *Greetings*) are added to the previous discussion. The chatters demonstrate that they are able to deal with the situation efficiently. They don't give up talking about *Stewart* and the conversation progresses efficiently anyway with a series of questions and expressions that are successful and satisfied: MD12-L8-L9-MD14-L10-MD15-M9-L11_MD16-L12-MD17-L13-Md18-L14. Neither do they ignore the entrance of a friend, quickly answering her greetings (Md13-S3; S4-A4; S9-M10).

When the greetings conclude, S demands attention in order to introduce the fourth argument of the session (*Film*). The interesting thing to note is that despite the speed with which the interventions can follow each other in a public chat, for S only one directive is enough to obtain an immediate answer. (S10-A8-M11…). The group redirects its attention very easily to any new topic introduced by another member of the group. As observed before, the chatters easily accept the proposal answering the suggestion with explicit appreciations of this idea. (A9-MD19-M14-...).

The session is an excellent example of the “choral” harmony created by female users; this mood is constructed through recurrent mechanisms. First of all, aggressive tones are avoided; the language is never vulgar and the allusions are accompanied by expressive linguistic acts which are useful for easing the meaning and for specifying the intentions of the chatter who is speaking (MD7, MD8). Emoticons and Emodevice elements are utilised both to shape the tone of an intervention and as an intervention in itself. Even in chats, such elements have sufficient strength to create a successful and satisfied intervention and to constitute an additional communicative element which enriches the conversation and favours its development.

No incomprehension or any form of misunderstanding are present thanks to constant attention being paid to all the interventions. All the proposals coming from the users are answered immediately: in fact, there is no single case in which a new subject is not replied to (M1-MD5; S1-M8, S10-A8). It’s true that not all interventions are successful and satisfied, but this happens during the deepening phase; refusal of a subject never occurs. At least, also if attention for the others is a constant element in this group, the “advice-appreciation” mechanism which features at the beginning of the conversation, although less frequent, is just as important. The exchange of positive replies reinforces the users and creates a reassuring climate in which any of the chatters can feel free to introduce any subject.

5.2. Analysis of the Second Sequence

The second session can be considered to be a typical example of a conversation between males, in which a challenge develops into a light flame.

The interlocutors are three male chatters; one of them tries to attract the attention of the women present in the room, but he only manages to get the ironic replies of two men who were present. The conversation is constructed in three moments: the *challenge*, the *flame* and the *coalition* and the *revealing of the game*.

The session is opened by the creation of the challenge; S in 4 interventions tries to attract the girls who are present in the room, but the only one to answer him and to make his interventions successful in a very ironic manner is A (A1). S doesn’t accept that initially, but even the subsequent appeal is accepted only by A2. At this point S answers by describing his interpretation of the intentions of A as a challenge (S6-S7); A doesn’t answer directly, but his subsequent behaviour seems to validate this hypothesis. From this moment all the interventions, which feature irony and quite heavy

offence, seem to be successful and satisfied by the two interlocutors (A and S) and by SK, a third chatter who joins them. Sk enters the conversation with a negative comment which is replied to by A with laughs of appreciation: a silent coalition between the two forms. This situation is made explicit once again in S9- S10 and it is not contested by anyone. Then a flame occurs in the form of a provocation and a response until A5. A6 marks a turning point. Perhaps because A perceives that the chat is becoming too heated up, he reveals the true nature of the conversations, by specifying the playful mood.

challenge	S1	<SEMENTAL>AHORAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
	S2	<SEMENTAL>YAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
	S3	<SEMENTAL> ALGUNA INTERESADA
	S4	<SEMENTAL> SOY ARDIENTE
	A1	<andyu2> k tu culo es ardente
	S5	<SEMENTAL> CONOZCO TODAS LAS POSICIONES
	A2	<andyu2> como te dan ???
	S6	<SEMENTAL> CHE PASA COMPADRITO
	S7	<SEMENTAL> QUIERE GUEVEAR
flame	Sk1	<skatala> POR QUE NO TE CORRI UNA PAJA MEJOR SEMENTAL O ES QUE NUNCA LE HAY PUESTO GENIO
	S8	<SEMENTAL> OTRO GUEON MAS
	A3	<andyu2> jajajajaja guena compare
	S9	<SEMENTAL> 2 CONTRA 1
	S10	<SEMENTAL> ME LOS COMO
	Sk2	<skatala> HUEN PERO NO PAJERO COMO VO MAS VALE
	A4	<andyu2> Como t keri engrpir una mina por el chat tai guen del hoyo
	S11	<SEMENTAL> MMMMMMMMMMM
	S12	<SEMENTAL> SON GAYS
	A5	<andyu2> soy entero apavao
game	A6	<andyu2> aki es puro hueveo no mas loko
	Sk3	<skatala> NO SOY NORMAL PERO EL QUE TIENE PROBLEMA SOY VO PASANDOTE ROLLOS POR PIXEL

Table 2: Full Text of the Second Session. Male Conversation

Assuming a conversational stance, we can say that the sequence engenders a particular but effective form of collaboration. The scheme illustrates how only the interventions which interpret the situation (S7 - S9) are not replied to, whereas those pertaining to the flame are answered throughout the conversation. Chatters respond to each other's intervention as in the first female session.

5.3. Discussion

Some interesting conclusions can be drawn from the qualitative analysis. The quantitative results are confirmed on the one hand; their availability opens up new interpretative lines on the other: this can be assumed to demonstrate differences in the underlying motivations to behaviour not discriminated by quantitative analysis.

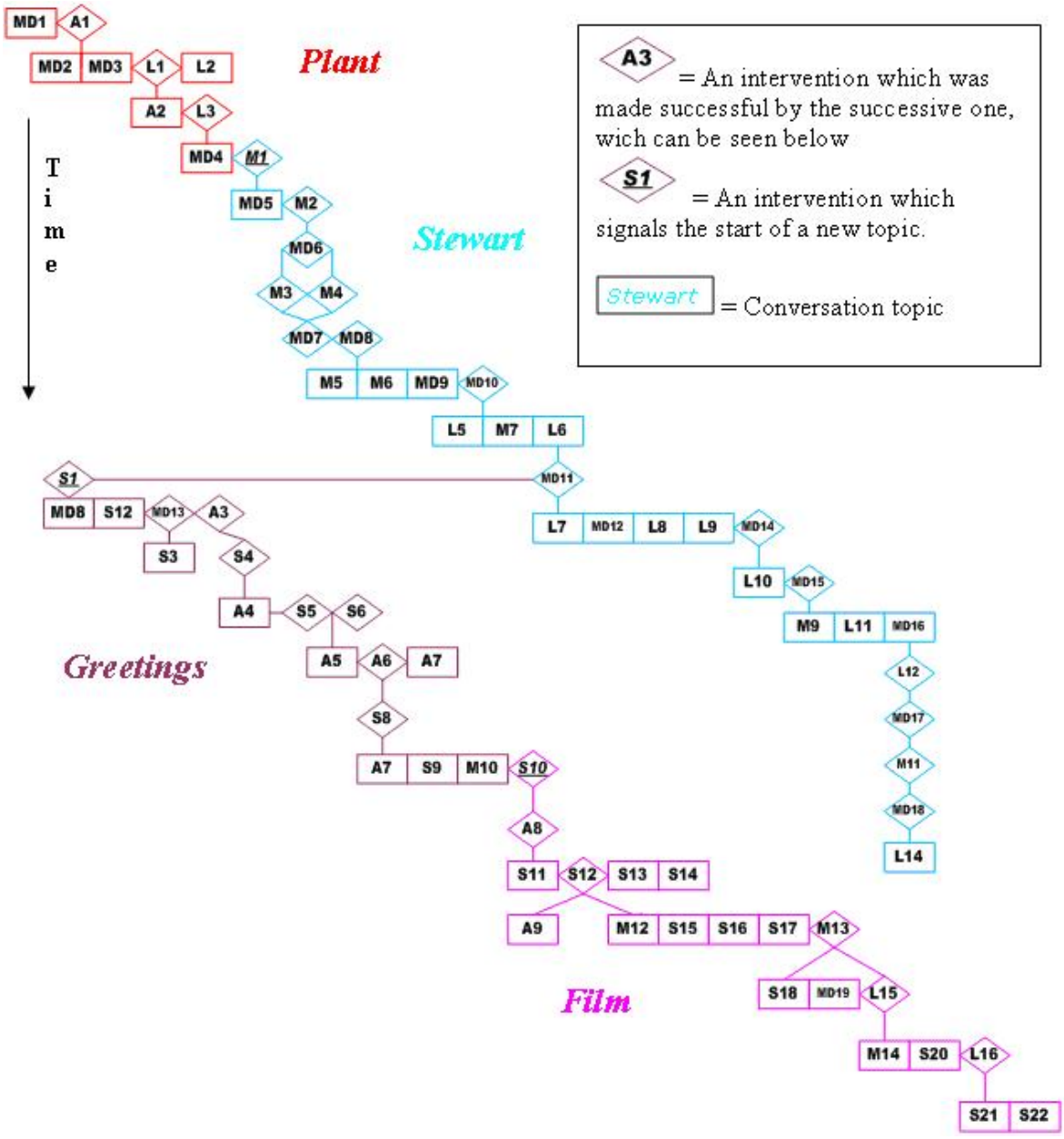

Figure. 3a: Scheme of the first conversation (Female users) which emphasizes the topics and the “satisfaction” and “successful performance” relationship between utterances

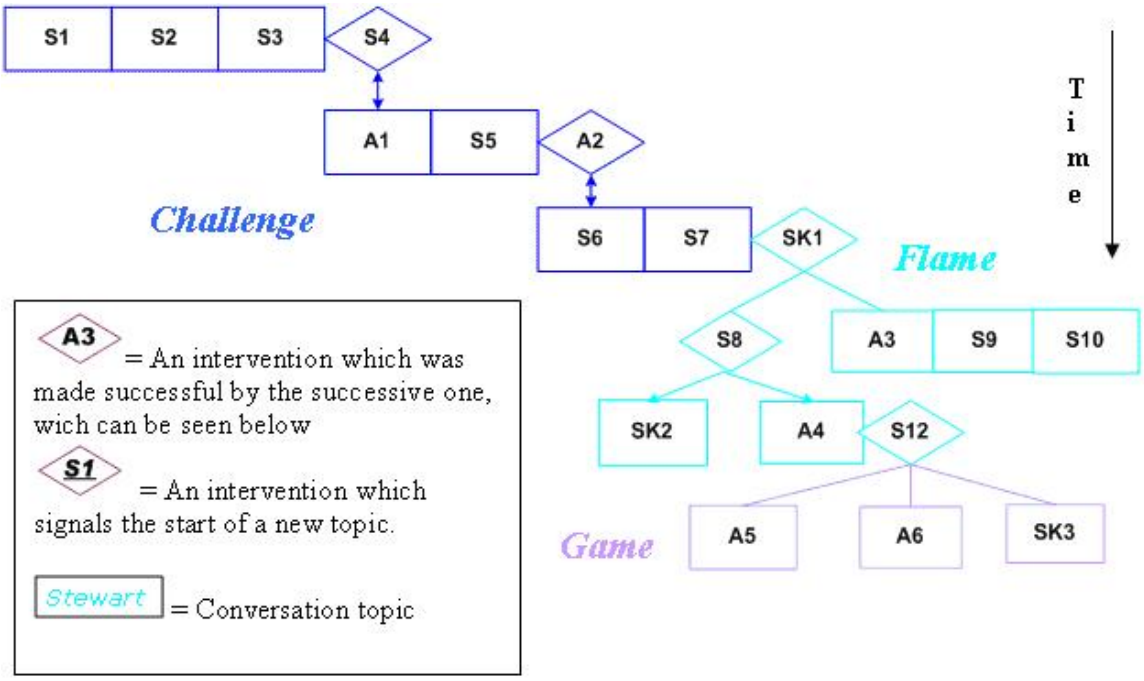

Figure. 3b: Scheme of the second conversation (Male users) which emphasizes the topics and the "satisfaction" and "successful performance" relationship between utterances

Through the observation of the mechanisms of success and the satisfaction of linguistic acts in particular, the conversation analysis enabled us to shed light on the **mechanisms of collaboration** used on the meta-communicative plane present in both the sessions (The categories Coalition_1 e Coalition_2 were not coded for either of them) even though they had different finalities which can be referred to gender stereotypes. Women in fact demonstrate a propensity to create an atmosphere which does not enable the development of tension, facilitating the development of more and more strength ties in the group. This result is obtained with the use of two mechanisms: a constant attention to the interventions of the people present in the room and the exchange of help and words of thanks. The conversation proceeds with questions and expressive interventions that show interest and which allow them to elaborate on the theme which has been introduced. The chatter speaking always claims the attention of others active online, to the extent that the subject is discussed thoroughly and never just truncated. Even when a chatter who is well known enters the room, the greetings don't prevent any of the other users continuing to talk about the previous argument.

Indeed, attention is always paid to the advice-intervention, and sincere appreciation is given for the interest the other has shown. (*Plant*) or the whole group (*Film*). Vice versa for men it's not so important to create a good atmosphere in a group, but on the other hand they are interested in spending their time playing pleasantly even if the interaction is with strangers, preferring in any case activities linked to competition. Obviously the mechanisms used to deal with the conversation change. In fact, the definition of the antagonists through the differentiation process and the use of the flame in a joking manner, both prevail in the male sample. The intention is to pass the time by challenging oneself in an apparent contrast. Everything appears clearly when A decides to reveal the playful context in which the discussion is taking place because he has the impression that someone is interpreting it in an incorrect way. The chatter critiques the wrong interpretation of the situation, not the colloquial style or the offences. Considering these premises, it is obvious that we will not find this type of conversations referred to as "us" which is united since the frame activated is "challenge". Once again the making of a collaborative context is revealed by the analysis of conversation mechanisms.

It can therefore be observed that despite appearances, a glance at the communicative and social intentions of the participants has allowed us to find intentions examined in the dynamics in line with the dominating gender stereotypes, even though they are masked by behaviours which are apparently contrasting. These behaviours did not permit recognition of the creation of the group climate in female subgroups, with the use of the quantitative method, and they also hid the male propensity to competition behind a real argument. Observing carefully the two conversational schemes in Fig. 3a and Fig. 3b, it's possible to recognise the two "gender" conversational strategies emerging from the analysis of the linguistic acts. A dialogical continuity, used as a sort of social "glue", prevails in the conversation between women (Fig. 3a), whilst the one between males (Fig. 3b) is characterised by a typical monological coherence. The conversation analysis has thus allowed us to recreate the collaborative dynamics which for many authors are the basis of those fixed categories which are utilised (and which we also utilised) for a quantitative analysis.

6. Conclusions

By summarizing our analysis, we can now recognize the two main purposes of this paper:

1. To call into question some of the results present in literature through the study of online gender which is the basis of a context which was never previously considered, that is synchronic environments. Since most of the works in literature are carried out by means of a quantitative approach, we were obliged to use this approach.
2. To start exploring both quantitative and qualitative methods to produce and analyze interactive data on online gender-related phenomenon.

The choice of using both approaches is based on the need to consider two sides of the gender identity and stereotypes construction:

- as products of online interactions within chat lines
- as processes; through C.A. it was possible to observe how they emerge from the stream of analyzed conversations.

For us, a great advantage arises out of this choice: the possibility of analyzing these mechanisms as generators of social phenomena (in both the “weak” and the “strong” sense) as we will illustrate afterwards, as shown in Fig. 4.

With regard to the results, the quantitative analysis described in the first part does not confirm the presence of a stereotypical style outlined by previous studies. Only one category resulted in being significant (*Flame*), excluding those categories which are considered to be fundamental in the definition of gender stereotypes, such as *Emoticon*, *Coalition* and *Question*. These findings made us reflect on how it would be possible to fit these results into the series of researches on Gender Language Style which have confirmed gender specificity on several fronts: style (Herring,1996, 1999; Ferris, 1996), usage of emoticon (Witmer & Katzman, 1997) and group incidence (Savicki,1996).

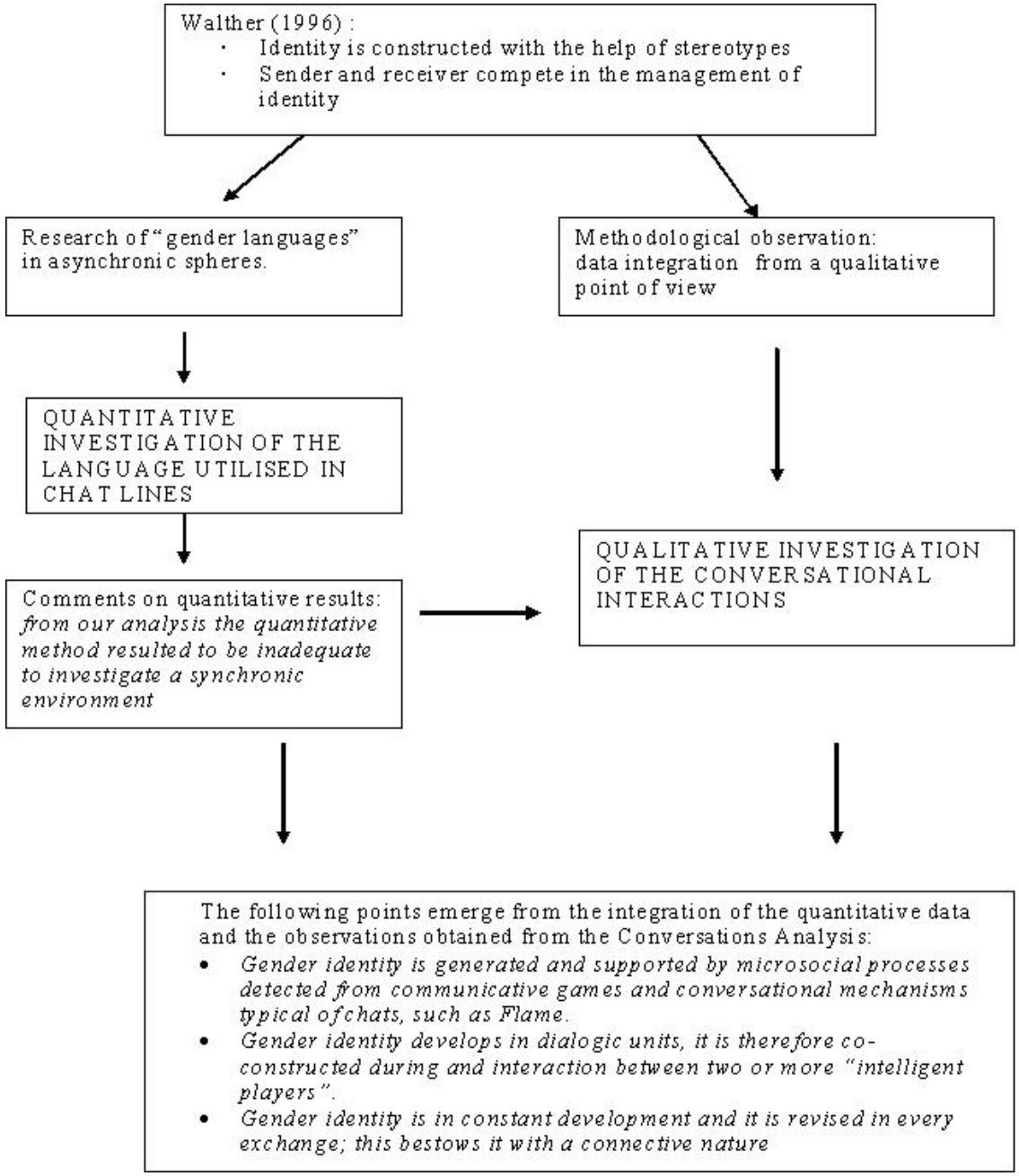

Fig.4: Structure of the article

The reply to this question came while we were working on the second point, dealing with methodological issues which we proposed from the start. Besides being a way of going more in depth when analyzing the results previously obtained, the openness towards qualitative research methods seems to be the most adequate choice of studying the phenomena in a synchronic environment (the chat line) which would otherwise remain hidden to our observation. This statement is in line with the attempts

of anyone looking for a method which can find the user's strategies in the communication of the self in CMC. They adapted communication to the presence of a computer as a medium, and also to the characteristics of each environment present on the Internet in which it is possible to meet other netizens. Typing speed, the recreational atmosphere and the impulse to get to know people, are the characteristics which are most evident in chat lines and create material which can be investigated dynamically, as it evolves.

The comment on the utilisation of categories in conversations is the first step in defining their meaning in a more precise way, for example outlining how behaviours inserted in the same category arise from different intentions. Conversational Analysis offers a more complete vision of the interactive dynamics which occur in the sessions we considered, highlighting the intentions beneath the coded behaviours, and allowing them to be 're-qualified'. So, it was possible to grasp the dynamism of the communicative behaviours in their environment and the development of a gender identity constructed step by step by the group. The whole interaction appears more "female" or more "male", depending on whether it was focused on finding the harmony and the collaborative support, or was more based on clashes and transgression. Even though at a "micro" level the quantitative analysis did not reveal significant differences, thanks to an adequate research instrument, such as the analysis of conversations, it was possible to find the same stereotypes which according to Walther (1996) guide the subjects during online interaction.

Another important consideration emerges from the analysis of the sessions of conversation. It was shown how the male subjects could use the flame to socialize. This analysis is carried out on content and structure, ,creating meaning and structures interaction. This double function is further confirmation of the rate of socialisation present in CMC, because it demonstrates that these mechanisms become independent from the objectives for which they are usually enacted. It becomes a real tool at the service of the creation and maintenance of social relations. These conversational mechanisms should not be considered to be social phenomena in a "weak" sense, as indicators of the phenomenological level of a sense of society elaborated elsewhere. They became indicators of microsocial processes in a "strong" sense; processes which generate evaluation, attitudes and behaviours "sensitive" to stereotypical representations and objectives of subjects (all elements which are "filled" by the *gender identity* and the "games" by means of which the subjects have the possibility to interact). These processes are linked to social rules and norms (which are also

characterised in cultural terms and are therefore “sensitive” to gender identity) and obviously, to the characteristics of the environment. Smart players enact these types of mechanisms in order to create a dialogical and connective gender identity. We have tried to demonstrate these phenomena by addressing central methodological issues. A research on stereotypes and gender identity can be conducted by investigating extracted monological chunks of communication, in order to move to dialogical units in which gender identity is created. This work indicates that gender identity should be considered as a construct which has an interactive and relational nature and not as an attribute which exists *a priori* from the personality of the subject: “social identity refers to the sense of the self constructed in time through participation in social life and identification with others” (Hewitt,1996).

This opinion is in tune with the theories which support a “social” development of gender stereotypes, arising from what a group considers to be “male” or “female”. On this front there are different theorists who are interested in the mechanisms which favour the genesis of stereotypes. Hoffman and Hurst (1990) who researched the rationalisation of unequal group distributions, or the theorists of Social Learning according to whom the group rewards the behaviours which conform to dominant models. Therefore it is up the group, during reciprocal interactions, to elaborate the content of the category “gender” and to push its own members to reproduce it or to make it their own. The creation of gender identity in a social exchange confers a **connectivist** nature to it, besides a **dialogical** one. This term doesn’t only indicate that with time the communication strategies elaborated in the community become a common heritage of its members, which can be summarised in rules available in the FAQ (Frequently Asked Questions). The connectivist identity, similarly to the connectivist intelligence described by De Kerckhove (1991), is the result of an exchange produced in the “here and now”, always available to ulterior modifications in subsequent exchanges. It does not arise from general knowledge but from the agreement of a group of interlocutors which becomes the basis and a starting point for a new re-elaboration. The connectivist identity condenses in itself the synchronic exchange between the users which doesn’t stop because it is continuously enacted.

Taking all this into consideration, many different points emerge. On one hand there is the need to deepen the qualitative observations in order to describe more precisely the process of the creation of the social function of some conversational mechanisms. On the other hand, considering the ecological nature of the data which has permitted us to observe the natural phenomena, it seems appropriate to extend the research in the

laboratory, to effectively control the way in which the two variables of age (as suggested by the work of Huffaker, Calvert & Lee, 2005) and sex are working. In this study the proposal for adopting a pluralism of research methods has revealed a remarkable potential for an improvement in the understanding of gender differences which doesn't stop at a linguistic level to outline a more articulate Gender Communicative Style by taking into account a more complex and socially articulated level: the conversational level.

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PsychNology Journal, 2006
Volume 4, Number 1, pp. 53 – 86

Social Network Analysis: A brief theoretical review and further perspectives in the study of Information Technology

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ABSTRACT

Social Network Analysis is a widely used approach in psychology, as in social science, economics and other fields. The peculiarity of this perspective is that it focuses not on individuals or other social units, but on the relationship between them. In this paper, our aim is to give a general review of this perspective, giving a description of resources and principal topics covered by Social Network Analysis. In the first section, we will concentrate on methodological and formal perspectives of analysis. In the last section, we will introduce some recent studies about Social Network and its relationship with Information Technologies, in particular on the Internet. Lastly, we will show how this approach can be useful to study some aspects of the web.

Keywords: *Social Network Analysis, Social Web, blogosphere, social network indexes, social quantitative indexes, hyperlinking networks, roles algebra, Computer Mediated Communication.*

Paper Received 15/04/2006; received in revised form 28/05/2006; accepted 31/05/2006

1. Introduction

Every kind of social aggregation can be represented in terms of units composing this aggregation and relations between these units. This kind of representation of a social structure is called “Social Network”. In a social network, every unit, usually called “social actor” (a person, a group, an organization, a nation, a blog and so on), is represented as a node. A relation is represented as a linkage or a flow between these units. The set of possible relations is potentially infinite; the term relation can have many different meaning: acquaintance, kinship, evaluation of another person, the need

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of a commercial exchange, physical connections, the presence in a web-page of a link to another page and so on.

Therefore, the objects under observation are not individuals and their attributes, but the relationships between individuals and their structure. The advantage of such a representation is that it permits the analysis of social processes as a product of the relationships among social entities.

In Social Network Analysis we can study two different kinds of variables: *structural* and *composition.* Variables of the first type are the most important in this field because they represent the different kinds of ties between social actors (friendship, trust and so on). The composition variables can be seen as actors' attributes. To make a deeper attribute analysis we suggest the use of more sophisticated formal theories, like Formal Concept Analysis (Wille, 1982).

2. Main characteristics

2.1. Social Network Analysis history

According to Scott (1991), there are three main research lines about Social Network Analysis, lead respectively by:

- Sociometric Analysts, who mainly used and developed graph theory;
- Harvard researchers, who in a first moment studied models of interpersonal relationship and cliques formation, and after 1970 developed algebraic models of SNA;
- The anthropologist part of the school of Manchester, who studied relational structures characterizing tribal society community.

There is a general agreement about the origins of the Social Network Analysis: the first studies were realized by Jacob Moreno (1889-1974) on "sociometric" (1934) and by Fritz Heider (1896-1988) on the triad equilibrium analysis (1946). In recent times, some authors have criticized this idea, marking how the concept of Social Network was developed before the famous Moreno study (Freeman, 1992).

These ideas were first developed by Frank Harary (1921-2005) and Dorwin Cartwright (-1988) which, using methods from the newborn graph theory (König, 1936), found a powerful formal tool for social structures analysis (Cartwright & Harary, 1956; Harary, Norman & Cartwright, 1965). According mainly to Heider theories, Harary and

coll. studied an extension to a more complex case of structural balancing (i.e. an application of the notion of equilibrium to groups with more than three elements). The base theory was to decompose a graph (a group) in different subgraphs (subgroups), in order to analyze relationships and balancing between and within groups: every balanced graph can be divided in subgroups with positive internal relations and negative external relations.

Around the Thirties and Forties, some Harvard researchers dedicated their attention mainly to the search for decomposition and exploration methods of blocks or structures composing a graph, and their informal relations. In particular, the two leaders of the movement were W. Lloyd Warner (1898-1970) and Eltan Mayo (1880-1949), who started several researches about Chicago's central plant "Hawthorne", employed working conditions and about New England's communities. The originality of their studies consisted of the large usage of sociograms (Mayo, 1945), and the introduction of the concept of "clique" as "intimal not-parental group" (Warner, Lunt, 1941). We must say that this notion of clique is different from the sociometric meaning typical of graph theory, which we will discuss in section 3.2: Warner described a clique as some kind of "social set" (Scott, 1991).

Moreno's sociometry and Warner and Mayo's theories were unified by a Harvard professor, George Homans (1910-1989), who thought sociometry to be a good and valid foundation for social analysis (Homans, 1951).

A new and fundamental development in SNA was due to researchers from Manchester University Department of Social Anthropology. Manchester researchers pointed their attention at the effective configuration of relationships deriving from power and conflict between individuals, instead of set up norms and institutions of a society (Scott, 1993). John Barnes (1918-), who first introduced the term "Social network" (Barnes, 1954), gave life to a remarkable formal development of the analysis of social structures. Developing Barnes and colleagues' ideas, Siegfried Nadel (1903-1956) began his fundamental works, underlying the importance of a structural analysis rather than a contents analysis (Nadel, 1957). The main topic of his works, unfortunately interrupted by his premature death, was the notion of "role", considered as the foundation of social life, and defined by the interrelation of independent networks. Nadel also suggested the utility of algebraic tools for role analysis; although he had no opportunities to develop such a proposal, we must say that this kind of approach is central and of great influence in current studies (Pattison, 1993).

Nadel's ideas were pursued by Clyde Mitchell (1918-1995), which introduced the difference between total network and ego-centred or local network (see section 2).

Mitchell's analysis is important because of the reflection about some social indexes (as density, see section 3.2) and their meaning in the description of a network too.

In the following years, new important theoretical and formal acquisitions were developed in Harvard: in the setting of a continual development of algebraic models, the idea of "block model" was introduced (see section 4).

As suggested by Nadel (1957), the concept of role began to take a central part in Social Network Analysis: many ideas were developed by Harrison C. White and his colleagues.

White's group focused on the analysis of mathematical-formal aspects of Social Network, giving new directions to graph theory and introducing some new important characteristics coming from semigroup algebra (see section 4), with the aim to formalize different structural relations inside a group (White, 1963).

As we said, they introduced the concept of block model, which was intended as corresponding to the role of a group of components of a social network (Lorrain & White, 1971; White, Boorman & Breiger, 1976). The central idea of White is that the search of structures in a network should not be based on a-priori defined and well-known categories, but on the real relations among the network nodes and on how these relations structures it, with the aim to describe the concrete and emergent role structures.

In this context, a study by Mark Granovetter on the importance of weak ties is really interesting (Granovetter, 1973). His idea was shown to be useful in many researches, as in his analysis of looking for a job mechanisms (Granovetter, 1974).

From the Harvard group, a former student of White's, Barry Wellman (1978), created an international group aimed to get SNA researchers together. This group was called INSNA (an acronym for International Network Society of Social Network Analysts); its web page is available at the following URL: http://www.insna.org/INSNA/insna_inf.html.

Among the different kinds of analysis, an original theory, known as "small world phenomenon" and proposed by Stanley Milgram (1933-1984), revealed to be rich of cues. His approach concerns the empirical effort to determine how many steps (or ties) are necessary, in a well-defined population, so that two different individuals can meet each other. For instance, given a source individual that we call *a*, the number of individuals tied by a relation of acquaintance so that a chain that links *a* to a different target individual *b* is calculated. Notwithstanding the large number of methodological

criticisms posed to the original experimental paradigm, the problem turned out to be of remarkable general interest, and the “Small world phenomenon” has became a large studied issue; in particular, many studies have been carried out in order to explore which factors determine the shortest path search in a network between two individuals, and how a defined system could be defined a “small world” or not. An empirical approach of this phenomenon has been studied in relation to the construction of virtual network on the web, giving birth to system like Friendster, or to explore the functioning of Instant Messaging software (Adamic & Eydar, 2005).

We want to end this section pointing out Social Network Analysis interdisciplinary endeavour: it was born from the joint activity of social psychologists, anthropologists, sociologists, mathematicians, physicians and economists, and can be used with profit for research in behavioral, social, economical or political discipline. In the following sections we will show how mathematics (in particular, algebraic methods and graph theory) has also a strong tie with SNA. We want to point out that this tie is not monodirectional: empirical applications of graph theory had been proven to be a benefit for the graph theory itself, because this application gave the possibility to give life to some new ideas and to develop some aspects of this branch of the mathematic (Harary was a mathematician, and his innovative ideas were often used to get the graph theory richer).

A critique seldom posed to Social Network Analysis concerns the possible triviality of the results: Boissevain (1979) pointed out how SNA is mainly focused on technical issues, rather than empirical research about social topics. On the contrary, Barnes and Harary (1983) answer to this critique arguing how graph theory is a powerful and not still used at its full capability perspective. Researchers have made too little a use of this theory and its full potentiality:

> *Graph theory uses two primitive, undefined terms, point and line; these two terms are mentioned in a small number of axioms, unproved statements assumed to be true. […] Its theorem consists of statements each of which can be derived logically either directly from the axiom system or indirectly by making use of theorems already proved. […] (A theorem) can be used with reference to any appropriate mathematical model of the real world that has been constructed with material from its axiom system. It than reveals real world implications of the model that might otherwise have not been noticed or utilized by the designer of the model. (p.239)*

With this statement, the two authors try to underline how this potentiality is not limited to the use of a precise terminology, but the use of mathematical theories in this field can give new ideas, can *“enable to move ahead faster”*, while these methods are

generally neglected. In Barnes and Harary's article, some examples are shown, and some ideas from near topics are described.

2.2. Types of studies

According to Pattison (1993), the range of use of the idea of social network is very comprehensive, but there is a general agreement about the presence of two main classes of conceptions about the role of social networks. The main idea in the first class of studies is based on the link between properties and behaviors of an individual and the environment in which he is located. In a first kind of research, SNA has been used as a tool to explain individual behavior (Wellman, 1988; Granovetter, 1985; Anderson & Jay, 1985). In a second kind of studies of this kind, it has been proposed to use the structure of the relationship of the member of a group in order to understand the social (collective) behavior of a group (Laumann & Pappi, 1976).

The second class of conceptions is based on the idea that an understanding of network structure allows the understanding of social processes occurring on that network: "social networks define paths for the flow of social traffic" (Pattison, 1993, p.4). In a first kind of studies, the nature of social networks has been studied as a function of social variables (occupation, gender, urbanizations and so on) (Blau, 1977; Coates, 1987). A similar idea is the study of the relationship between large populations parameters (for example, those connected to job finding), and some network characteristics (Granovetter, 1974), in order to explain macro-behaviors as the result of aggregations of micro-interactions among individuals (Skog, 1986).

2.3. Resources

The growing significance of Social Network Analysis research, since 1970, is well attested by the great number of papers and books connected to it. One of the main resources is the "Social Networks" journal, published by Elsevier Science, and edited by Linton Freeman and Ron Breiger, two of the most important researchers on this topic. The journal deals with theoretical, methodological and substantive themes, and is characterized by a multidisciplinary approach. Another journal dedicated to SNA is "REDES". It can be consulted online at URL: http://revista-redes.rediris.es, as "The Journal of Social Structure", available online at http://www.cmu.edu/joss. Also available online is "Connections", the official journal of INSNA.

INSNA also provided to create a mailing list for discussion on issues related to SNA; free subscription and information about it are available at the following url: http://www.insna.org/INSNA/socnet.html.

Many other journals often deal with Social Network Analysis: methodological problems are often approached in “Journal of Mathematical Psychology” (Pattison & Bartlett, 1982; Pattison & Wasserman, 1995; Pattison, et al., 2000, etc.), “Journal of Mathematical Sociology” (Cartwright & Harary, 1977; Doreian, 1987, etc.) and many others. A great interest is generated by the “small world” problem, as one can see by the great number of papers approaching broad themes as those published in “Nature” (e.g., Watts & Strogatz, 1998) and “Scientific American” (e.g., Watts et al., 2002).

Some manuals have been made to introduce SNA: “Social Network Analysis. Handbook”, written by John Scott (1991), offers a simple and empirical introduction to this topic. Methodological and analytical issues, with a particular attention to graph theory, role algebra and statistical tools are described in Wasserman and Faust’s manual, “Social Network Analysis: Methods and application”, written in 1994, and his complement “Models and Methods in Social Network Analysis”, written in 2005 by Carrington, Scott and Wasserman. An introduction to algebraic methods of analysis is provided by “Algebraic Models for Social Networks”, by P. Pattison (1993). Another interesting book, by S. Bornholdt and H. G. Schuster, is “Handbook of Graphs and Networks: From the Genome to the Internet” (2003); it shows the large potentialities of the approach we are talking about. A large number of brief introductions to SNA books are available online at http://www.insna.org/INSNA/books_inf.html.

2.4. Sampling and boundary specification: types of network

A network necessarily consists of a finite set of actors; this is due to two reasons: on one hand, this could be due to some restriction on the object under observation (for example, the interest of a researcher is the survey of the social structure of a small village or a classroom). On the other hand, this is mainly due to analytical requirements: so the problem is how to sample a group representative of the population, and how to set the constraints of this sample.

One proposal is to define unit set boundaries using the frequency of interaction, or intensity of ties among actors (Wasserman & Faust, 1994). According to Laumann et al. (1983; 1989), two different approaches can be used to specify boundaries in social network studies: the first one is called *realist approach*, the second one *nominalist*

approach. In the realist approach, subjects have some kind of shared knowledge of the network as a social entity. In the nominalist approach, boundaries are defined by research aim, so actors can be separated by attributes of potential members of the network, relational properties between potential members, and activities in which actors are involved into.

Sometimes, when boundaries can not be defined at the very beginning, researchers use sampling techniques like *snowball sampling* (Goodman, 1961; Erickson, 1978) or *random nets* (Fararo & Skorovetz, 1984). A general review of Social Network sampling can be found in Frank (1988).

Frank (1979) categorizes snowball sampling like a "chain method", designed to trace ties from a source to an end: an actor, or a little number of actors, is chosen among the set of potential actors. After this first step, every chosen actor reports on the actors to whom he has a link according to the relation under examination. The first actor is called *ego*, while actors chosen from him constitute the "first-order zone" of the network. Actors of the first order zone are now taken for reporting on the actor to whom every one of them as a tie, and so on. For every k step, k = 1, 2, 3..., we have a new order zone, called "*k-th order zone*".

The main problem with sampling is that any procedures can alter or loose relations inside the considered group.

In literature, a distinction is often made between "Complete networks" and "ego-centered networks". An *ego-centered network* (or *local network*) consists of a network built on the basis of a focal person, *ego*, like in snowball sampling. So, the entire network is referred to this focal person, and every relation is reported by the *ego*. The situation can be more complicated, if we consider every new link as an *ego* (this is the case of snowball sampling), or if we start from more than one *ego* to build a sample of a population. A *complete network* is built upon every node (or a sample of nodes) from a population, but any relation is considered for every node composing the network. The last distinction is fundamental in algebraic modelling, because it leads to different algebraic models (see section 4).

3. Methods of Social Network Analysis

Sections 3, 4 and 5 will provide a brief description of mathematical perspective from which Social Networks has been studied. We will first introduce the concept of set-

theoretic relation, which is the basis of Social Network Relations. Later, we will describe the main ideas coming from graph theory and algebraic semigroup theory, to give a short description of methodological issues about Social Network Analysis. In section 5 we will describe some of the most recent developments in SNA: statistical models issues and Dynamic Network Analysis.

3.1.0. The concept of relation

The formal analysis of a social network can be dealt with different tools, every one of them with its own peculiarity, with its different operation. Also, every one of them can give different outcomes, and have different purposes.

There are two different, but not independent, perspectives from which Social Network Analysis has been observed in its short but rich history: on one hand there is the graph theory, on the other hand there is Algebraic Theory of Semi-Groups. Before starting to give a short description of these two kinds of approach, we will pinpoint their common base: the fundamental concept they share is the notion of relation, as it is considered from a set-theoretical point of view.

Definition 1: let's consider two sets, labeled X and Y; a *relation* between X and Y is every set of ordered couples where the first element belongs to X, and the second element belongs to Y.

3.1.1. Network description

For the sake of simplicity, we will now consider only the simplest form of network, a binary network (so, every relation involves only couples of units), on the set of units X.

There are three kinds of representation of a Social Network: the first description is the simple list of all the elements taken from the set of actors, and the list of the pairs of elements which are linked by a social relationship of some kind (see table 1).

$$A = \{(x_1, x_2), (x_2, x_1), (x_4, x_2), (x_3, x_1), (x_3, x_4), (x_4, x_3)\}$$
$$B = \{(x_1, x_2), (x_2, x_1), (x_3, x_4), (x_4, x_3)\}$$

Table 1: Two relations A and B on the same set $X = \{x_1, x_2, x_3, x_4\}$.

The second description comes from the Graph Theory: every actor is represented by a point, called *vertex* or *node* of the graph; the links defined by pairs of individuals, represented by lines between two linked points, are called *edges* of the graph (see fig. 1).

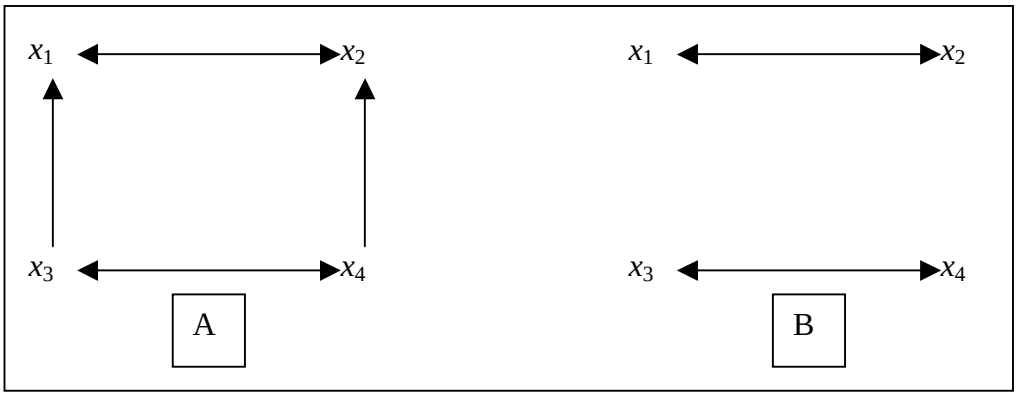

Figure 1: The corresponding graph for the relations *A* and *B* (see table 1) on the set $X = \{x_1, x_2, x_3, x_4\}$.

The third description has the form a matrix (see table 2).

	x_1	x_2	x_3	x_4
x_1	0	1	0	0
x_2	1	0	0	0
x_3	1	0	0	1
x_4	0	1	1	0

	x_1	x_2	x_3	x_4
x_1	0	1	0	0
x_2	1	0	0	0
x_3	0	0	0	1
x_4	0	0	1	0

Table 2: Corresponding Boolean matrix for *A* and *B* (see table 1) relations on the set $X = \{x_1, x_2, x_3, x_4\}$.

There are other kinds of networks: for example, there can be more than one relation, so we consider a set of different relations $\mathbf{R} = \{R_1, ..., R_t\}$. Another kind of network is

called “valued networks”, when a relation R_v can assume possible values different from 0 and 1). The most general binary case is that of a multiple valued network.

Definition 2: Let X represent a set of n social units, and let $v_k(i, j)$ the value of the R_k relation from unit i to unit j in X. R_k can be considered as:

23 a valued, directed graph where nodes are the elements of X and edges are the edges of type k, with value $v_k(i, j)$, directed from node i to node j;

24 a valued relation, assigning the value $v_k(i, j)$ to the ordered pair (i, j);

25 an $n \times n$ matrix, where entry (i, j) assumes the value $v_k(i, j)$.

The collection $\mathbf{R} = \{R_1,..., R_p\}$ is termed a (*multiple*) *valued network*.

Is it also possible to use relation with arity more than 2 (for example, ternary relations); this approach is not very common in Social Network Analysis: “[binary relational representations] include the vast majority of the models that have been proposed and applied in the social network literature to date” (Pattison, 1993, p. 12).

3.2. Graph Theory

Graph Theory has been used in several different scientific fields like anthropology (Hage, 1973; Zachary, 1977; Mitchell, 1980), social psychology (Heider, 1946; 1958; Leavitt, 1951; Freeman, 1977; 1979; Freeman, Reoder & Mulholland, 1980), communication (Herring et al., 2005), on-line business (Dellarocas, 2003), geography (Pitts 1965; 1979), and many others. In Social Network Analysis, Graph Theory assumes a crucial role because it has been used first of all to denote the structural properties of a network. Graph Theory works as a theoretical frame in which we can formally analyze different characteristics and properties of a network. Graph Theory is essentially a mathematical theory. For this reason it provides to Social Network Analysis a tool to quantify and measure some properties of the network. The ability to prove theorems about graphs and network structure is just a consequence of working in such a formal context. There are a lot of advantages in the use of Graph Theory in Social Network Analysis but, as it happens for many formal theories introduced in a psychological frame, often researchers prefer not to refer their studies to this formal background, so they “make too little use of the theory of graphs” (Barnes & Harary, 1983, p.235). Graph Theory, and more generally a graph, is one of the best and clearest way to represent and detect the structure defined by the way a relation (or some relations) connects different individuals of a social group. The evident advantage

of the graph representation is that it provides an immediate interface through which it's possible to find, and also easily to understand, the way individuals in the network are connected.

In the following pages we'll introduce first some basic concepts of Graph Theory trying to evidence how these concepts are easily exportable to a social context. In the second part of this paragraph we'll briefly speak about some indexes we can calculate on a network using Graph Theory concepts.

3.2.1. Graphs and Di-graphs

As we have seen, the aim of Social Network Analysis is to detect and to understand the structure identified by a set of relations defined on a set of individuals. Graph Theory is an important tool for this aim. First of all we have to consider an important question: what kind of relation are we interested in to study?

We have said above that we'll investigate binary relations, so we look at only a couple of individuals a time. We have also specified that the relation is not reflexive (we don't have the relation between x and itself: $x \neg Rx$). But it doesn't suffice: we need to know if we are analysing a *directed* or an *undirected* relation. If the relation we analyse is undirected (relations like "to be married to…" or "to be neighbour of…" are undirected relations) we'll use a graph to represent it; otherwise (relations like "to be parent of…" or "to be subordinate to" are directed relations) we'll represent the relation using a di-graph (directed graph).

In any graph we have g nodes and L lines. We can easily find the parallelism between this formal notation and a social network: the "actors" of the network become the "nodes" of the graph, and the "ties" between actors in the network become "lines" between nodes in the graph. As we just mentioned, a graph can be used to represent an undirected relation: we can express this assumption by saying that there mustn't be any difference between a line $l_k = (n_i, n_j)$ and a line $l_h = (n_j, n_i)$ between two nodes n_i and n_j. From this sentence it derives that any undirected relation is also a symmetric relation: if n_i is married to n_j, n_j is married to n_i too.

Let us now consider the case in which we have to study a directed relation, i.e. the case in which the tie between two actors is oriented from one to the other. This condition implies that the two ties $l_k = (n_i, n_j)$ and $l_h = (n_j, n_i)$ are different. In order to represent such a relation we need to use a directed graph (*di-graph*). We define a di-graph as a set of *nodes* (the actors of the network) and a set of *direct lines* (the ties of

the social network) between nodes. Every couple of nodes connected by a direct line is an ordered couple: formally $l_k = <n_i, n_j>$ means that the arc l_k is directed from the node n_i to the node n_j, and the order of this relation is not invertible (so the formula $l_k = <n_i, n_j>$ differs from the formula $l_h = <n_j, n_i>$) . The first node is called the *"sender"* while the second node is called the *"receiver".*

Now we introduce the important notion of *subgraph,* which is fundamental for several operations and indexes which we can obtain in a social network. A graph G_s is a subgraph of a graph G if the nodes of G_s are a subset of the nodes of G and the lines of G_s represent a subset of the lines of G.

There are some basic units of any graph that are also subgraphs: the dyad and the triad. A dyad consists of a pair of nodes and the lines (arcs) between them: in a graph we can have adjacent or not- adjacent pairs of nodes, that is to say 0 lines or 1 line; in a di-graph the situation is more composite because between any two nodes we can have 0 (*null*), 1 (*asymmetric*) or 2 (*mutual*) direct lines. Similarly a triad is composed by three nodes and the lines between them: in a graph we can have from 0 to 3 lines; in a di-graph we can have from 0 to 6 lines. Triads have been largely studied in a theoretical and practical way (e.g. Granovetter, 1973). Dyads and triads are a part of a special kind of subgraphs called *node-generated* that we are going to analyse in the next pages, together with the *line-generated* subgraph and the *cliques.*

Another useful concept is *clique*, the maximal complete subgraph composed by at least three nodes. What does maximal and complete subgraph mean? A clique is complete because each node in it is adjacent to any other node in the clique. A clique is maximal because there are no nodes not included in the clique which are also adjacent to all the nodes in the clique (Luce & Perry, 1949; Harary, Norman & Cartwright, 1965). The concept of clique introduces the larger concept of *cohesive subgroup.* A clique is the example of the most restrictive cohesive subgroup (Festinger, 1949) using graph theory. In the subsequent years several different kinds of cohesive subgroups for graphs but also for di-graphs have been investigated. Considering graphs, some of them are: *complete mutuality based subgraphs* (like cliques), *reachability and diameter based subgroups* (like *n-cliques,* see Luce, 1950; Alba, 1973; or *n-clans* and *n-clubs,* see Mokken, 1979), *nodal degree based subgroups* (like *k-plexes*, see Seidman & Foster, 1978a; or like *k-cores*, see Seidman, 1983b). Considering di-graphs some of them are *reciprocated ties based cliques* (see again Festinger, 1949; Luce & Perry, 1949) and *n-cliques for directional relations* (Peay, 1975a; 1975b; 1980).

We have presented some of the main properties of graphs relating them to Social Networks.

3.2.2. Main quantitative indexes

We will now introduce the main quantitative indexes which we can find in a network using Graph Theory.

Since the beginning of Social Network Analysis, Graph Theory has been a very important tool both to represent social structure and to calculate some indexes, which are useful to understand several aspects of the social context under analysis. In this section we present the main indexes usually associated with graphs and di-graphs.

The first and simplest index is *nodal-degree*. We define the degree of a node in a graph as the number of lines incident with that node. We can calculate the mean nodal degree of a graph with the following formula $\overline{d} = 2L / g$: we have to consider twice the total number of lines in the graph (L) because each line has to be considered both for the first and the second node. Dividing this product by the number g of nodes in the graph, we obtain exactly the mean number of lines incident with each node. Also in this case, di-graphs present a more complicated situation. There are two kinds of degree for each node: the in-degree, the number of direct lines adjacent *to* a node, and the out-degree, the number of direct lines adjacent *from* a node. It's a simple task to demonstrate that the mean in-degree and out-degree values are equivalent: $\overline{d}_i = \overline{d}_o = L / g$. Nodal degree gives information of how many ties each social actor has; also, we can see for every actor if the relation is direct from each one of them to the other members or the other way round (from this difference we can calculate different centrality indexes: *centrality* and *prestige*). In a social context, the degree indexes can indicate for example the number of friendship ties among a class: if there is a high mean degree we can suppose that in such a class there are many friends; for each subject we can say if his/her friendship is either reciprocated or not (in-degree, out-degree). It might be clear that the meaning of "degree" is different in different contexts of research. Degree in general seen as an index for centrality: in this sense, it can tell us about an actor's prominence in the network (Knoke & Burt, 1983) or his/her prestige (Bonacich, 1987). Furthermore, the mean degree value can be read as a first index of connectivity in our network.

Closely tied to the concept of nodal degree is the second index we're going to present: *density*. When we look at a graph, we observe a set of nodes and a number of

lines between them. The density index indicates the proportion of lines really present in the graph over the total number of possible lines (par. 3.2.1). In a graph the formula for computing the density index is $\Delta = L/[g(g-1)/2]$, where *L* is the number of lines effectively present in the graph and the denominator is the maximum possible number of lines in the graph. In the density formula for di-graphs only the denominator value differs (see par. 3.2.1): $\Delta_d = L/g(g-1)$. The density index takes on a value between 0 (there are no lines/arcs in the graph/di-graph) and 1 (there is the maximum possible number of lines/arcs). Density indicates in an immediate way how our network is cohesive as a whole. It's a simple but fundamental index from which we can start to analyse the structure present in a network (in section 6, we will show some uses of this index, with the aim to describe the structure of the blogosphere, e.g. Adamic & Glance, 2005). The higher is the density index in a graph, the more the actors of our social context are connected each other. We can imagine, for example, our graph as a social support network of a group of old people. The more the graph is dense, the more the social support network connects different individuals to each other member of the group. So, density has been shown to be a good index for group's homogeneity and cohesiveness (Friedkin, 1984).

There is another important "descriptive" index which is easy to calculate, but gives us important information about the closeness of the nodes in the graph: the *diameter.* Defining *geodesic distance* (Harary, 1969) between two nodes the shortest path between them, we define diameter of a graph as the maximum geodesic between any pair of nodes. The diameter value of a connected graph (a graph where any node is reachable by any other node) is defined. When a graph is not connected the diameter value is not defined. The same is in the case of di-graphs. So the diameter index has an important limitation. Many programs used to analyze networks (UCINET, Pajek) calculate two connectivity values based on the number and on the length of geodesics present in a network. The mean geodesic value is calculated using only reachable pairs of nodes. The advantage of these indexes is that they are calculated on connected and not-connected graphs and di-graphs. It's easy to understand that the longer the diameter is, the more a graph is dispersive: if we think our graph to represent a collaborative working group (CWG) in which there a long diameter and/or a high mean geodesic value, we can suppose that communications between different subjects in the CWG may be difficult or at least slow. We will soon explain this discussing Cluster Coefficient.

Heider's (1946) gave the first definition of balance, as this notion involves ties among individual's attitude, opinions or people; he considered direct signed ties.

Harary (1953) introduces the notion of structural balance: let's consider two generic social actors, n_i and n_j, for $1 \leq i \neq j \leq g$; a group is *structurally balanced* when, if n_i and n_j like each other, then they both like and dislike the same other people, or if n_i and n_j dislike each other, then they disagree in every evaluation of all other people.

In a un-equilibrated graph, we could look for some equilibrated subgraphs (that represents, under SNA perspective, equilibrated social actor's sub-networks in a wider social network). The operation that led us to derive the balanced components is called *clusterability*,and every balanced subgraph is called a *cluster* (Davis, 1967).

Holland and Leinhardt (1970) suggested an extension of clusterability to unsigned direct relations: transitivity is the central framework behind their work. They focused on the analysis of triples, and relations (symmetrical, asymmetrical or anti-symmetrical) among any two of them.

A different, and maybe more pertinent to our discussion, use of the term "cluster" is provided by Watts and Strogatts (1998). "*Clustering coefficient*", as in their definition, gives a good measure if a given network can be considered as a "small world" or not.

Let's consider a generic node n_i, with a number $t(n_i)$ of others nodes connected to it (every one of these nodes is called *neighbourhood* of the node n_i), in a connected graph. There can exist at most $t(n_i)(t(n_i)-1)$ edges between these nodes ($t(n_i)(t(n_i)-1)/2$ if the graph is not directed). Let C_v denote the fraction of the edges that actually exist in the neighbourhood of a generic node and the allowable edges. The *clustering coefficient C* is defined as the average of every single node in the graph C_v. These two authors show that a highly clustered network has the characteristics of a small world network. For our purpose, this index can be truly determinant: many researches on the structure of the web, like those we will show in section 6, try to discover if the web (or simply, the blogosphere for a specific argument) can be considered a small world. With these indexes, we can draw some interesting conclusions.

The aim of this paragraph was to present how Graph Theory has been used in Social Network Analysis. To do this, we have presented the fundamental indexes necessary for a first analysis, which are also the ones from which all the researches (both formal and empirical) about the relations between these two theories, started.

4. Algebraic models

Another class of models for analysing social networks comes from an algebraic perspective, in particular from algebra of semigroups and order theory. The rationales for this approach are two: the first one is the opportunity of using profitable models "that will enable the analysis of network data in a number of different forms". A second theme is the possibility to develop "data models attuned to variety of theoretical claims about the nature of the role of social networks in the development of social and psychological relations" (Pattison, 1993, XIX).

Lorrain and White (1971) emphasize the primary importance of the concept of role in a group: role of an individual in a social system "has often been described as consisting of sets of relations of various types linking this person as ego to sets of others" (p.350). So, the *role* of an individual is identified by the incoming and outcoming ties this individual has with other members of the group. Tools proposed to identify and describe a role, different roles in a social network, and a way to compare social structure considering different role structures, come from semigroup algebra, as proposed by White.

The starting point is the notion of *Structural Equivalence*:

Definition 3: Let R = {R_1, ..., R_p} be the set of relations in a network **W**. Two individuals *x* and *y* are said to be Structurally Equivalent if, for all nodes $k = 1, \ldots, t$ ($k \neq x,y$), xRk iff yRk, and kRx iff kRy.

That is, two nodes are structurally equivalents if and only if they share the same set of ingoing and outgoing ties with a defined individual. If two actors are structurally equivalent, they are said to hold the same position in the network (White et al., 1976). Individuals sharing the same position can jointly form a partition of a group: this kind of partition is said to be a "blockmodel", and it is representative of the social position that each block member holds. A blockmodel may be viewed as a new Social network, in the sense that it can be represented as a set of multiple binary relations defined among blocks.

Some criteria for determining a fit to a blockmodel of a set of data with a weaker condition than structural equivalence has been proposed. One, called *lean-fit*, is a weaker condition of the *fat-fit*, in the sense that at least one individual in a block has a relation to every individual in the second (Breiger et al., 1975). Another, called α–

blockmodel fit, is a condition where only a limited number of relations (the number of total relation multiplied by α, called *criterion*) is considered (Arabie et al., 1978).

One of the most remarkable consequences of the use of a blockmodel is that roles (and role structures) are not a-priori defined, but are seen as emergent and elastic structures to describe a social group: a role is completely defined by the set of relations composing it; furthermore, an individual could be unaware of his role.

We will now describe, with the aid of an example, how to build an algebra for a social network. This description is given for two main reasons: one is to illustrate how it is possible to compare different networks, and to have some further information about network structure. The other is that we want to describe, at a very simple level, how an algebraic analysis is made, in order to give an introduction to this complex topic.

We will limit our example to a complete network (we mean complete in the sense described in section 2.4); although building an algebra for an ego-centred network is similar to the construction of a complete network, there are still some differences and difficulties, which are not in our interest to explore in this paper. For further details, a complete description of a local role algebra construction, that is the algebra made from an ego-centred network, is provided in Pattison (1993).

The basic notion of algebraic modelling is *composition* (among binary relations): according to Lorrain and White (1971), composition represents “the basic logic of interlock in the system of relationship”((Lorrain & White, 1971, in Pattison, 1993, p. 40). Pattison writes that “compound relations are claimed to define the paths where social processes flow”. Lorrain (1972) says that “any concatenation of social relationship is itself a social relationship, whether perceived or not” (Lorrain, 1972, in Pattison, 1993, p. 41). By composing two (or more) primitive relations, we may produce a collection of compounds relations.

Let’s consider the two relations already discussed in section 3.2. If we compose a relation A with a relation B, say AB, we will have a new kind of relation (see table. 3) (the operation of composition is not commutative, i.e. AB is not necessarily the same as BA).

$AB = \{(x_1, x_1), (x_2, x_1), (x_3, x_2), (x_3, x_3), (x_4, x_1), (x_4, x_4)\}$

	x_1	x_2	x_3	x_4
x_1	1	0	0	0
x_2	0	1	0	0
x_3	0	1	1	0
x_4	1	0	0	1

Table 3: The list of the couples composing relation *AB*, and the corresponding Boolean matrix.

There are an infinite number of possible compound relations (for instance, AB, BA, AAB, BBA, AAABBAAA and so on). So, a way to compare relations is needed.

We can consider if a relation is included in another relation (i.e. if a relation is a subset of another relation). We can see, in our example, that every couple in *B* is also in *A*, but not the other way round. So, *B* is a subset of *A*; we write $B \leq A$. As stated from the anti-symmetric property of inclusion, if A and B are binary relations on a set X, we define $A = B$ if and only If $A \leq B$ and $B \leq A$. If two or more relations (primitives or compound) are equal, they are redundant so one can be expressed by the other (Boorman & White,1976).

All distinct relations can be found by an iterative process (the algorithm is described in Pattison, 1993, p. 49).

Using the relation ≤, it's possible to build an order among primitive and compound relations, with the following three properties: reflexive, transitive and anti-symmetric ($A \leq B$ and $B \leq A$ imply $B = A$, for every *A*, *B* in *X*). In mathematics, this order is called "partial order".

A	B	AA	AB	BA
0 1 0 0	0 1 0 0	1 0 0 0	1 0 0 0	1 0 0 0
1 0 0 0	1 0 0 0	0 1 0 0	0 1 0 0	0 1 0 0
1 0 0 1	0 0 0 1	0 1 1 0	0 1 1 0	0 1 1 0
0 1 1 0	0 0 1 0	1 0 0 1	1 0 0 1	1 0 0 1

BB	BBA	BBB	BBAA	BBBB
1 0 0 0	1 0 0 0	0 1 0 0	1 0 0 0	1 0 0 0
0 1 0 0	0 1 0 0	1 0 0 0	0 1 0 0	0 1 0 0
0 0 1 0	0 1 1 0	0 0 0 1	0 1 1 0	0 1 1 0
0 0 0 1	1 0 0 1	0 0 1 0	1 0 0 1	1 0 0 1

Table 4: Some of the compound relations of *A* and *B*. As one can see, A = BBA ≤ B = BBB, BB ≤ AA = AB = BA = BBAA = BBBB. So, to describe the possible relations on the network is sufficient to use relation A, B, AA, and BB (every other relation is congruent with one of these). The partial order is A ≤ B, BB ≤ AA, A and BB, A and AA, B and AA, B and BB are not comparable.

We will now describe the main concept, the *partially ordered semigroup*. A semigroup is an algebraic structure defined by a domain *X* and a characteristic binary operation *O* among members of *X*, so that *O* is internal in *X* and is associative.

If we consider every relation (primitive and compound) in the network as an element, and the composition operation as the characteristic operation of the structure, a semigroup is obtained. Now we can create a representation of the network as a "partially ordered semigroup" (see table 5). Why is it so useful to build a semigroup? Because it gives an abstract representation of a network, which is possible to compare with other abstract representations (i.e. another semigroup), in order to find differences and similarities between different networks. Let's consider the two partially ordered semigroups of networks $\boldsymbol{N_1}$ and $\boldsymbol{N_2}$, respectively $S(\boldsymbol{N_1})$ and $S(\boldsymbol{N_2})$. If there exist some mappings so that every element of $S(\boldsymbol{N_1})$ can be transformed into an element $S(\boldsymbol{N_2})$, the entire structure of $S(\boldsymbol{N_1})$ can be replaced by the structure of $S(\boldsymbol{N_2})$. The two structures are said to be structurally equivalent, and that they share the same skeleton. A network and its blockmodel share the same skeleton.

	Composition				Partial order			
Element	A	B	AA	BB	A	B	AA	BB
A	AA	AB	A	A	1	1	0	0
B	AA	BB	A	B	1	0	0	0
AA	A	A	AA	AA	0	1	0	0
BB	A	AB	AA	AA	1	1	0	0

Table 5: This table shows the semigroup obtained from the network in table 1, and the partial order on it. The composition section must be read in this way: if we compose the element in the row with the correspondent element in the column, result is the relation in the correspondent cell. The partial order section must be read in this way: if there is the relation ≤ from the element in the row to the correspondent element in the column, value is 1, otherwise is 0.

It's possible to operate more complex comparisons among semigroups, but it's not our aim to describe that. For every detail, a global description of methods of analysis of semigroups is provided by Pattison, 1993, Pattison & Bartlett, 1982, Pattison & Wasserman, 1995, Pattison et al., 2000.

5. Dynamic Network Analysis (DNA) and statistical issues

In this section two fundamental aspects of SNA will be exposed: the first represents a new development of the complexity of the theory (DNA), while the second is a topic always present in SNA, that in the last years has become one of the most interesting fields of research in SNA (statistical issues).

One of the most recent developments in SNA considers network as an ever-changing and dynamic structure: this approach is called Dynamic Network Analysis (DNA).

While SNA concentrates mainly on small, bounded networks, on a limited and sometimes small number of relations, observed only at one point in time, DNA tries to

study multi-modal, multi-plex[1] dynamic networks with varying level of uncertainty. The aim of this second kind of studies is to understand how a network can evolve, change and stabilize (and eventually, which kind of intervention could be done in order to modify a network in a chosen direction).

Some of the main peculiarities of DNA are the use of a meta-matrix of relation, the treatment of ties as probabilistic and the combination of social network with cognitive sciences and multi-agent systems (Carley, 2003).

A meta-matrix (Carley, 2002) is a multi-colour and multiplex representation of nodes and the connections among them. Considering a group of people, not only relations among them are considered, but also relations in the field of the global information inside the network, people's needs, linkages among every organization they are in and so on. The fundamental idea is that a change in one network can cause a change in the others, because every relation implies a relation in another one.

Probabilistic ties are considered because in this kind of network not all the information about the structure is well-known; probability of a relation can be affected by factors such as the observer's certainty in a tie or the likelihood that a given tie is manifest at a moment in time.

Multi-agent system means that social actors are treated as active adaptive agents capable of taking action that can alter the network structure. Social and cognitive processes that can influence ties are considered.

As stated in Wasserman and Faust, in 1993, "the statistical approach has been in use since the beginnings of social network analysis. However, it was not widely used until the research of Holland and Leinhardt (1970, 1971)" (Wasseman & Faust, 1994, p. 506).

The fundamental concept is that of *random graph*: a random graph is a graph in which properties such as the number of graph vertices, graph edges, and connections between them are determined in some random way. Some distribution models have been proposed, from the simple Conditional Uniform Distribution (Katz & Powell, 1957) to exponential family of Probability Distributions (Holland & Leinhardt, 1981). Wasserman & Iacobucci (1988) propose a generalization of the last distributions, based on log-linear models; in the same paper, two statistical models are proposed: an associative one, that allows the study of changes of a network over time, and a predictive one, that permits to predict the state of a network in a time point if the previous states are known.

[1] Multi-plex ties are those in which several types of relationships come together.

A dependence graph considers the statistical dependencies among the elements of random variables based on the relational ties in a network: it is a graph in which nodes are the set of all possible ties, and edges, specifying the pairs of ties, are conditionally independent (Wasserman & Robins, 2005)

Some random graph models for multiple relations networks are described by Koelhy and Pattison, 2005:

Statistical analysis has been used in order to build algebraic models (Pattison & Wasserman, 1995), to know the tendency over reciprocation of choice, or mutuality (Katz & Powell, 1955), to study network evolution over time (Snijders, 2005), to compare sociometric relations recorded in distinct sociomatrices (Wasserman, 1987), and so on. Statistical approach now represents one of the most productive and ongoing fields in SNA.

6. Social Networks and ICT (Information and Communication Technology).

It's quite simple to understand SNA potentialities in the study of social aspects of the web. Maybe the first study on Computer Mediated Communication (CMC) was made by Freeman (1986): he used a dataset consisting of measurements of computer mail interaction, in order to study how this computer network modified acquaintenships and friendship. Park (2003) distinguishes among various types of networks: a social network is defined as a set of people connected by a set of relationships, where relationships are any kind of social relation; a communication network is composed by interconnected individuals linked by patterned flows of information. This classification proceeds presenting three other kinds of networks that are more related to the content of this section: computer mediated network, a kind of communication network where all the relations are mediated by computer; internet network is a computer mediated network which uses internet as channel of information flow; hyperlink network is an internet network that uses hyperlinks as channel of information flow. As we can see, among any kind of network there is a relation of inclusion (a kind of network is included in another one, where SNA is the most general case).

In the last years, researches in this field have looked with increasing interest to the blogosphere phenomenon using the hyperlink networks. Herring et al. (2005) have investigated the structure subtended by a sample of 5517 blogs about religion. They have looked at some SNA indexes taken from Graph Theory like in-degree, out-

degree, reciprocity and so on. Their findings were that some blogs are overrepresented and central in the network, although other blogs are more densely interconnected. Majority of blogs link sparsely or not at all to other blogs in the sample, suggesting that the blogosphere is partially interconnected and sporadically conversational. Adamic & Glance (2005) analyzed a list of 40 political blogs (conservative or liberal) for a 2 month period and a sample of 1000 political blogs for a day in the period of USA presidential election in 2004. They tried to investigate the relations between the two groups of blogs and to discover the structure subtended by the two groups and possible differences between them. They used some measures of SNA like in-degree and out-degree and they found that liberals and conservatives link primarily within their separate communities, with far fewer cross-links exchanged with the other party. Conservative bloggers more likely link to other blogs: primarily other conservative blogs, but also some liberal ones. The conservative blogosphere is more densely linked. Starting from these results, Ackland (2005) proposes an interesting distinction between 2 types of blogs: *authorities* are highly-referenced pages on a particular topic, while *hubs* are pages that point to the authorities (and thus confer authority). There is a mutually reinforcing relationship between authorities and hubs: a good hub points to many good authorities, and a good authority is pointed to by many good hubs.

On one hand we can see how SNA is a very suitable tool to analyze the structure (if there is any) of the blogosphere; on the other hand the analysis of blogosphere, thanks to its peculiarities, provides many interesting cues for the theory evolution. Such a kind of topological analysis of linkage structure underneath websites, the characteristics of this structure and the comparison between different sets of web entities are only possible using the tools provided by SNA.

Sometimes when SNA is used to study social structures in the web and the investigated relation is only hyperlinking, we refer to it as Hyperlink Network Analysis (HNA). HNA has been used in several different fields of research, like e-commerce (Park et al., 2001; Palmer et al., 2000; Krebs, 2000) or international communication (Barnett et al., 2001; Hargittai, E., 1999).

An interesting example is provided by Adamic and Adar (2003): they considered home pages and mailing lists of MIT and Stanford University students to investigate the presence of any factors which indicate social connections between individuals. Classical SNA indexes like in and out-degree are here employed in addiction to some peculiar indexes like *clustering coefficient* (ratio between couples of individuals linking each other and the total possible couples, where a high value of this index indicates the

presence of a small world) and *cohesiveness of subgroups associated with a data item*, obtained by the ratio between total and within-group density.

From a larger perspective, if we consider internet network (as defined in the beginning of this section), Paolillo (1999) analyzed the modifications of common language in a virtual speech community trying to identify a correlation between roles in the network and the language modifications used. In other words, the aim of this paper is to demonstrate that the more a node (a group of subjects in the community in this case) is central and have strength ties with the others, the more some language modifications, typical in a IRC, are concentrated around this group.

Some studies have explored the behaviour of users inside networks, and not only the structure: Adamic and Adar (2005) has tried to investigate how people are able to select among hundred of acquaintances the correct person to form the link in the chain. Two different kinds of network have been examined: one is that of email mutual contacts inside an Information Technology group, and one is built upon some buddy list of Stanford students. As one could expect, it's easier to reach a person in a network when the network is hierarchically organized and well defined and its structure is well known to each member of the network.

Licoppe and Smoreda (2005), starting from some previous data, advanced some reflections on the relation between social networks and Technology (in the larger sense of this term). These reflections were inserted in a broader analysis context of how technologies can influence communication finalities and modalities. It seems very interesting over all the finding that the most recent media (like SMS or Instant Messaging Softwares) are often centred on the *phatic* function of communication (as intended by Jakobson, 1960). The discursive content of the communication gestures results less important than the message itself, and how, instead of the play between absence and co-presence (as in traditional phone mediated communications), we would have a play between lack of attention and absorption, between safety and interactional vulnerability. "*The risk is that ties with friends will become institutionalised in the form of expectations and mutual obligations to be constantly available electronically"* (Licoppe & Smoreda, 2005).

In the last years CMC has become a fundamental tool for several different fields of research and knowledge. SNA is a useful tool to understand how subjects interact with one another through CMC. The application field of CMC is really huge but there are some areas in which it seems to be particularly advanced: Cho, Stefanone and Gay (2002) try to clarify how SNA can be very useful in order to analyse the development of

a Computer Supported Collaborative Learning (CSCL) group; in a similar framework, the research of Palonen and Hakkarainen (2000) aimed to investigate, using SNA, patterns of elementary school students' peer interaction in a CSCL environment, which in this case was a computer supported classroom; a very interesting work has been made by Martinez et al.(2003), using CSCL, the authors propose a mixed approach combining traditional data sources with computer logs and integrating quantitative statistics, qualitative data analysis and SNA to provide an overall interpretative approach to the explanation of classroom social interactions.

In section 5, we briefly introduced the concept of Dynamic Network Analysis. DNA has shown to have a wide range of applications in Information Technology related fields: for example, it has been usedin the analysis of factors affecting team successes and failures in videogames (Carley et al., 2005).

A very common problem in studying Social Networks on the web is that of data retrieval. As Park (2003) pointed out, there are two ways to measure hyperlinks as relations: observation and computer-assisted measurement. We find that direct observation has been the most employed measurement technique for gathering this kind of data (Herring, 2005). The problems associated with this method are in the possibility of coding errors and the high labor cost (the researcher has to surf among a huge number of sites). On the other side, the computer assisted tools up to now developed are "*idiosyncratic answering only the research question being investigated*" (Park, 2003).

7. Conclusions

As we have just pointed out at the end of section 2.1, SNA has been seldom criticized for concentrating more on methodological issue than on the empirical one (Barnes & Harary, 1983). In this paper, we have tried to show how the formal aspects of this topic are complex and advanced, basing on strong and consolidated mathematical theories, such as graph theory and semi-groups algebra, and what the potentialities and the benefits of this approach are. Many methodological problems, if concerning the possibility to study social aspects of the web, are still to be solved, mainly in sampling. For example, in Herring (2005), a snowball procedure has been used: in a wide and complex relation network, constituted by a huge number of nodes (as in blogosphere, a growing, complex and with not well defined boundaries domain), sometimes this

procedure could hide the real structure beneath the network, because it considers only a limited number of links and composes a map that not necessarily corresponds to the real one.

Also, the real meaning of a hyperlink as a communication relation, and what the meaning of social network indexes when applied to web is, have to be investigated.

Notwithstanding these problems, Social Network Analysis could be a powerful and useful tool for examining the social aspects on the web. As we have shown in section 6, in the last years we have seen a growing number of studies on this topic. Many aspects should be still examined: for example, SNA indexes would be suitable for examining online gaming communities and their behaviour. Such a community would be easier to examine, because of a simpler sampling procedure, and the possibility to study relations also different form hyperlinking. Another field with many potentialities is that of Instant Messaging Software: previous research, as that shown in section 4, describes this network as a spare and chaotic network. Some constraints could be applied to the modalities of Instant Messaging, to give a more defined structure (for example, to help with the search of an individual as described in Adamic & Adar, 2005).

Potentially, these new ways of communication could offer the possibility to measure relations in a dynamic way, with the possibility given from SNA to offer some description of how networks work and evolve. If a group communicates by computer-mediated instruments, the analysis of role structures (as described in section 3.3) could permit the study of complex structures, that define the group and have not been yet studied (for example, how computer mediated communication can change the role structure of a group). To our knowledge, there are no studies using Social Network Analysis perspective to explore Internet or Computer Mediated Communication with the aim to study the social structure of a group as described in section four. This is maybe due to the fact that this kind of tools are significant only in the case of a multi-relational network, while we know, for example, that a hyperlink network is constructed only on the basis of one relation. We think, for example, that role algebra could be a powerful tool to explore the difference and the structures of networks where actors use different communication instruments to relate to each other. A relation would be constructed on the basis of the used instrument.

As outlined in the famous paper by Barnes and Harary (1983), possibilities also arise from a mutual exchange between SNA and ICT: new fields of applications imply the possibility for SNA to improve the empirical applications of the theoretical findings (for

example, the sampling problem described in these conclusions), with the aim to study different and more common (in the literature) kinds of networks.

8. Acknowledgments

The authors wish to thank the anonymous reviewers for their insightful comments, Luca Mammi and Giovanni Petrucci for their linguistic support, the HTLab people for their availability, and prof. Luigi Burigana for his valuable advices and comments. Every mistake has exclusively to be attributed to the two authors.

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PsychNology Journal, 2006
Volume 4, Number 1, pp. 87 - 101

Radiology Informatics and Work Flow Redesign

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ABSTRACT

The transformation from film-based to filmless operations has become more and more challenging as medical imaging studies expand in size and complexity. To adapt to these changes radiologists must actively develop new workflow strategies to deal with increasing work demand. This article addresses the evolutionary changes underway in the radiology interpretation process, reviews shifts that have occurred in the past years and presents our departments experience with an open source radiological information system based on IHE (Integrating Healthcare Enterprise) directives. These undergoing changes include a number of development in soft-copy interpretation, electronic decision support and learning tools such as MIRC (Medical Imaging Resource Center).

Keywords: *radiology informatics, radiological workflow, human computer interaction, PACS, RIS, MIRC.*

Paper received 03/02/2006; received in revised form 20/03/2006; accepted 30/03/2006.

1. Introduction

Technology expansion is evident throughout all medical fields, but no area is more affected than radiology, the only medical specialty that is 100% technology driven. Informatics creates a unique opportunity for radiology growth and a whole new breed of research tools. At the same time, however, new imaging and computer technologies present a whole new set of scientific, clinical and educational challenges for radiologists. As new technologies are introduced into the practice of radiology, so are expectations heightened concerning the time taken for information delivery, the accuracy of radiologic diagnosis and the overall standard of patient care.

The evolving technologies within medical images take on a variety of forms from diagnostic imaging modalities (i.e. the machines acquiring images from the patient's

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body) to information systems and picture archiving and communications systems (PACS) namely server-class computers connected to a data network and devoted to storage and retrieve operations. Radiologists, clinicians, technologists and information technology (IT) personnel are always introduced to new medical imaging and computer applications that exceed their predecessor in speed, complexity and sophistication. This creates a series of economic, educational, integration and implementation challenges. The long-term success of these professionals will be linked mostly to their ability to incorporate the changing technologies into their workplace. This article, written from the perspective of a clinical radiologist, discusses how these evolutionary pressures are changing the way radiology is being practiced and taught. We begin by analysing past and current trends, moving on to attempt to predict how future technology enhancements will change the data gathering workflow and the inherent interpretation process.

2. Filmless Radiology

The availability of digital radiographic images is no longer limited to CT, MR (Magnetic Resonance) and nuclear medicine (specialties that were born digital) and has opened a new and concrete path for informatics within the medical imaging department.

To address the justification of filmless radiology we must understand the existing factors contributing to the adoption of PACS and digital radiography. In 1998, according to the American College of Radiology's Professional Bureau there were 1.3 job listings per job seeker (Sunshine, 2002). By 2000, this ratio of job listings to job seekers increased to 3.8, reflecting the existing crisis in the radiology workforce. Bhargavan et al. recently, in 2002, postulated that if the demand for imaging services continues to increase at its current rate and radiologists productivity is not fully achieved, then the radiologists shortage could increase by another 250%. The authors of this study stated that PACS-related productivity enhancements could decrease the demand for radiologists by 20% over the next 10 years. The hypothesis that PACS can improve radiologist productivity has also been reported in a number of other studies (Reiner, 1999). Such an increase in productivity is believed to be multi-factorial, including the automation of a manual task (e.g. image display), electronic access to patient clinical data through the integration of PACS and HIS/RIS (Hospital Information

System/Radiology Information System), prefetching of historical comparison studies, use of electronic window/level[1] visualization presets, decreased interruptions and reduced work fatigue. At the same time, studies demonstrated striking productivity gains for technologists (the professionals who acquire images at the modality) associated with film-based operation (Reiner, 2002).

In addition to the improvement of radiologist workflow, PACS has added theoretical benefit of improving interpretation accuracy. In a recent study (Reiner, 2002) a soft-copy[2] interpretation of CT exams was linked to a significant improvement in interpretation accuracy when compared with an equivalent hard-copy CT interpretation using films. This improvement is believed in a large part to be the result of more free usage of multiple window/level settings when using a computer workstation. This observation was supported also in another study (Pomerantz, 2000) which found that the repeated view through additional window/level settings using a computer workstation resulted in improved characterization of abnormalities in 67% of cases and additional findings of clinical significance in 18% of CT exams.

Although the combined effects of improving productivity and interpretation accuracy should justify the transition to filmless operations, there are also additional reasons: filmless operation with PACS has been shown to contribute to reduced report turnaround time, improved clinician access to medical images and decreased exam backlog (Flagle, 2000).

2.1. Evolutionary changes in the Image-Interpretation Process

Once adopted, PACS and digital radiology needs to be adequately used to achieve their full potential. In particular, one must realize the extent to which imaging technology for medical usage has been transformed in its short life-span. CT, for instance, has undergone a transformation from single-slice, to helical single channel, to helical multi-channel[3]. In 10 years, typical abdominal/pelvic CT exams have gone from

[1] The original concept of window and level evolved from CT imaging and has historically expressed the range of displayed data as the absolute value of the difference between the highest and lowest numerical pixel values (eg. Hounsfield Units) to be displayed (the window width) and the numerical midpoint of that range (the level). Window/level settings acquire clinical relevance allowing better visualization of free air or soft tissue.

[2] Soft-copy, opposite to hard-copy film-based imaging, means displayed on computer screen.

[3] Conventional single-slice CT involves an x-ray source that rotates around the patient. The housing was designed so the x-ray source rotated over the patient to obtain a single transverse image and then unwound to prepare for another rotation and scan. The advent of slip-ring technology in the 90s enabled the x-ray source to rotate without having to unwind. In addition, more powerful computers allowed a process known as helical-CT which consists of continuous activation of the x-ray source and continuous movement of the tabletop through the gantry, resulting in multiple transverse slices and volumetric data acquisition.

80 images to 1,000 images, thereby eliminating film as a practical form of image display: a 1,000-image exam printed on 12-on-1 image format, for a single window/level setting, would require 84 individual sheets of film. The need to film images with lung, liver, soft-tissue and/or osseous window/level settings may increase the estimated number of sheets of film by a factor of two to five. Conventional film display devices are equally obsolete for image interpretation. An eight-panel viewbox would require 11 separate hangings to accommodate the 84 sheets of film with a single window/level setting and this does not take into account the need to hang comparison studies. This way of displaying images will result in loss of radiologist spatial memory, highly inefficient workflow and the potential to overlook subtle pathological details when comparing serial examinations.

Radiologist workflow has undergone significant changes during the first decade of PACS with several display and interpretation strategies employed (Table 1). Initially, when hard-copy film images where replaced with soft-copy images (stage two), image display and data navigation remained relatively static. Then radiologists and PACS vendors decided to reproduce the “look and feel” of film images on the computer workstation, which typically contained four monitor with images displayed in tile[4] format. This was a logical extension when one considers the fact that these early PACS users were entirely trained in a film-based imaging environment and therefore could only reproduce what they were familiar with. As radiologists became more experienced with soft-copy interpretation, a number of workflow enhancements occurred, giving way into the next stage, dynamic soft-copy display (stage three). Radiologists could now become active players in the image interpretation process, with active use of a variety of workstation tools, including window/level adjustment, magnification, zoom and pan, and linear ROI (Region of Interest) measurements. In addition, workflow was enhanced by the ability to quickly and efficiently display comparison studies using automated and user-defined hanging protocols reviewing historical reports. It was with reference to this stage that Reiner et al. (2002) and Pomerantz et al. (2000) demonstrated improved radiologist productivity and interpretation accuracy. Even though this strategy was an improvement over conventional film display interpretation, it lacked many of the current advances in workstation functionality.

[4] The tile format implies the arrangement of two or more images on a computer screen so that they do not overlap.

The fourth stage in the interpretation paradigm shifted from tile mode display to stacked[5] or cine[6] display. This allowed radiologists to navigate rapidly through cross-sectional imaging data sets by sequentially displaying consecutive images in the form of a cine loop. This strategy offered several advantages over the tile mode because reading a large data sets require considerable eye and head movement, which is significantly reduced with stack imaging (Beard, 1994). Stack viewing also takes better advantage of the human visual system's ability to detect motion or subtle change. Because stack viewing allows viewers to maintain their gaze on a specific spatial location as images change, the three dimensional relationship of various structures is better realized, than in the tile mode, where the gaze shifts between images (Mathie, 1997). This difference is best illustrated by the process of detecting pulmonary nodules on a chest CT. The ability to sequentially maintain a fixed gaze allows the reader to better appreciate the course of the pulmonary vessels and to differentiate a vessel against a pulmonary nodule.

The next stage in interpretation process is an advanced iteration of the stacked mode, which allows the synchronization of two or more individual stacks (stage five). This can take the form of linking two historical comparison studies or two or more individual sequences within a single examination.

1. Hard-copy film
2. Static soft-copy
3. Dynamic soft-copy (tile mode)
4. Stack Cine Mode
5. Synchronized Stack Cine Mode
6. Multi-planar Volumetric Navigation
7. 4-D Volumetric Navigation and Computerized Decision Support

Table 1. Stages in the evolution of medical image interpretation**.**

An example of synchronized stacking would be a magnetic resonance imaging exam that has separate T1 and T2 weighted sequences[7] in various planes. Synchronizing the axial T1 pre-contrast and axial T2 post-contrast allows the viewer to correlate comparable anatomic images (in the same plane) for the different technique being

[5] The skaced display shows a set of images of a CT/RM study (slices) sorted in craniocaudal or any other axial order.
[6] The cine display allows the user to review a stack in motion.
[7] The relaxation process in magnetic resonance is controlled by the biological parameters T1 and T2. These parameters are tissue dependent, introducing the possibility to separate different tissue types in the human body.

employed. By adding the comparison study, extremely subtle differences can be detected that may otherwise be missed.

The sixth and seventh stages in the CT interpretation paradigm consist of computer processing tools that rapidly reconstruct large volumetric data sets into 2-dimensional and 3-dimensional reconstructions. Use of this technology could potentially obviate the need to review each axial image, enhancing radiologist productivity and workflow. Four-dimensional (eg. 3D in time shifts environment) reconstructions along with complex image segmentation, texture and tone processing and incorporation of computer-aided detection tools (eg. software tools that can highlight mammary or pulmonary nodules in mass screening tests) now allow radiologists to review selected portions of the entire data set and rapidly sort the specific organ systems or anatomy of interest. The volumetric data from a multi-slice CT exam, for example, can be reviewed in parallel as a CT angiographic study (for detection of pulmonary embolus), CT bronchoscopy (for detection of endobronchial pathology) and high-resolution CT (for the detection of interstitial lung disease). At the same time, multi-modality overlays can be applied to enhance diagnostic accuracy. In the example of a multi-slice chest CT with a newly diagnosed pulmonary nodule, functional positron emission tomography (PET) data can be combined with the CT data set to produce physiologic information as to the likelihood of malignancy (PET fusion imaging). With this technology, areas of pathology can be easily reviewed on the computer workstation with graphic presentation displaying the likelihood of malignancy.

3. Overcoming the problems in the Human-Computer Interface.

The diagnostic interpretation of medical images is a complex task consisting of two distinct processes: perception and reasoning. Image perception, from a radiologist perspective, is the process of recognizing unique patterns in the image, whereas reasoning evaluate the relationship between perceived patterns and potential diagnosis (Tourassi, 1999). These processes depend on a radiologist's overall medical knowledge, memory, intuition and diligence. It is interesting to note that the majority of radiology malpractice lawsuits are brought as a result of errors in perception or judgment (Berlin, 1998). This observation surely outlines the significance of the human factor. A possible good synergy can derive from combining the flexibility of the radiologist with the analytical, repetitive capabilities of a computer program. Computers

offer the potential to assist radiologists by deconstructing the complex process of image perception and diagnostic reasoning into a series of well-defined tasks (Tourassi, 1999). In addition, computers can assist radiologist by reducing the “human weakness” of bias, fatigue and inconsistency. Radiologists should use this computer-derived capability not as an independent image reader, but as an adjunct help to their own analysis. By exploiting the inherent advantages of computers (processing power, memory capacity and consistency), radiologists can improve their own diagnostic.

PACS should be an enabling technology improving the time efficiency of all the radiology activities including images and reports generation and management, consultation with referring clinicians and patient, direct patient care, teaching/education, research and technology assessment. Strategies for management change and quality improvement should begin by considering how humans interact with computers. Human-computer interaction in the radiology practice is affected by factors belonging to four distinct areas: psychology, sociology, input device characteristics and hardware visualization capabilities (Carrino, 2005). The entire chain of events from image acquisition through display to communication of a report should be re-engineered considering a whole new set of concepts from different disciplines such as Systems Engineering, Human Factors Engineering, Reliability Engineering and Operation Research.

One of the goals of radiology management should be to encompass the development of a robust practice environment that emphasizes workflow enhancements with seamless integration of decision support and task automation tools.

Despite the benefits of digital imaging and archiving, there are several key challenges that healthcare organizations should consider when planning, selecting, and implementing the information technology (IT) infrastructure to support digital imaging.

The paradigm shift that accompanies operating in an electronic environment requires alterations of the human resources infrastructure and work habits that are not trivial. The new patterns of work will impact all occupations within the radiology department. Additional operational issues that may also need re-structuring include technical support, maintenance, and an emergency course for system downtime (eg. a failover plan). A well-informed implementation plan can facilitate a seamless transition to the electronic environment and relies on the PACS building team.

4. Overcoming the problems in the institutional infrastructure: the development of standards

There have been many systems with proprietary technical implementations in use for many years. Yet there has been little enthusiasm from both the PACS vendors and the radiology community to implement any given or even well-known system. The explanation lies in the absence of a standard, such as it was in PACS before DICOM[8]. RSNA MIRC (Medical Imaging Resource Center) implementation ended the time of uncertainty and established a distributed peer-to-peer Digital Teaching File (DTF) system. However it is still mostly up to the user to develop and implement a way of capturing significant images on a specific PACS system.

One of the most time-efficient methods of data gathering in today's health care environment is surfing the Internet. With its abundant and wide array of resources readily available to any physician with a computer and an Internet service provider, the Net is an oasis of information. While searching for text-based medical information is quick and easy, yet the search for indexed medical images is not. Medical images files are most often found in clinical repositories and local teaching files that are not accessible to most Internet users. The lack of a meta-index of on-line medical image resource that organize information across these numerous resources, makes the process of reviewing and downloading medical images on an orderly fashion time-consuming and laborious for the end user. A number of technical challenges limit the ability to create such a comprehensive image index. The large size of imaging datasets (up to some Gbytes per exam) creates challenges for storage and retrieval, and the concerns with image transmission (eg. regulations about patient privacy and information security) place a series of restrictions on electronic exchange of medical images and data. Even if these technical and medico-legal challenges were satisfactorily addressed, the dilemma of how index images without any available standardization protocols would remain. This combination of factors has prohibited radiologists from incorporating these data elements (eg. key image note[9]) into the daily

[8] The Digital Imaging and Communications in Medicine (DICOM) is an industry standard for distributing and viewing any kind of medical image regardless of the origin.

[9] The key image note technology allows a user to mark one or more images in a study as significant by attaching to them a note managed together with the study. Radiologists may attach key image notes to images for a variety of purposes: referring physician access, teaching files selection, consultation with other departments, and image quality issues, etc.

decision-making process and, in turn, has restricted the contents of the radiology report. On the contrary, if such information were to be available in an easy-to-use, indexed format, radiologists could refer to the images and related data for image interpretation, clinical research and physician education.

In 1999, the Radiological Society of North America (RSNA) proposed the creation of a Medical Imaging Resource Center (MIRC) to establish a community of Web-based libraries of imaging information, including medical image teaching files and research data. The primary goal of this initiative included the development of an information model and technical framework for a multimodality medical image library, development of basic authoring and viewing tools, creation of a standardized repository of medical images and development and incorporation of a radiology standardized lexicon.

This concept evolved from a single, centralized library to a community of distributed libraries, each locally managed but cooperating in such way that any user can search the entire community with a single query. MIRC files are extensible markup language (XML) documents that include descriptive text information and references to images and other medical data. Although commercial PACS vendors are not involved in this early phase of development, it is expected that they will develop tools to integrate the vast growing resources of MIRC into their own commercial PACS and RIS (Radiology Information System). RSNA also anticipates that not only MIRC will become a part of the Integrating Healthcare Enterprise (IHE)[10] initiative, but also predicts the introduction of a “MIRC teaching file integration profile” which would define the transaction required to directly link a PACS workstation to MIRC.

In addition to developing a comprehensive database and indexing system, the success of the MIRC project is also dependent upon the development of a radiology lexicon that establishes standardized terms of pathology and descriptive terminology in the classification, query and retrieval of images and related data. It is interesting to see the potential synergy of this endeavour with ongoing efforts within Speech Recognition (SR) and structured reporting. As radiologists begin to introduce standards and uniformity to the reporting process, this will provide a new ability to cross reference medical images and data according to pathology. This will further the development of the MIRC community and provide all radiologist with a tool to quickly and efficiently search indexed databases with a single keystroke or a voice-activated command.

[10] IHE is an ongoing effort to encourage the health care imaging and information technology industries and developers to implement standards-based methods of information sharing.

Discussions and implementation efforts are currently underway to create standard electronic presentation formats for educational and on-line journals that are consistent with the MIRC information model. In the future MIRC will be part of an integrated clinical and educational health care information system playing a vital role in clinical decision support, education and research. Additional information and an updated version of MIRC can be found on the RSNA Web Site http://mirc.rsna.org.

4.1. MARiS and MIRC

MARiS is a software developed according to the IHE Technical Framework. The goal of MARiS is to realize a suite of IHE actors to better understand the IHE workflow in Radiology and Nuclear Medicine domain. Our MIRC is built around an open source radiological system based on IHE we are using in our department, called O3 project. We developed it completely integrated using the IHE profiles. The system was developed with GPLed tools and is based on open source technologies such as PHP/Apache environment and java/JBoss application server. We installed the MIRC server software to realize a database of teaching file to use it during the reporting on the workstation. In a three month experience we introduced a new model of radiological reporting: not only a comparison between two different examinations of the same patient, but also the comparison between same pathology of different patients. This teaching system proved an higher efficiency in resident training, especially in CT and MR examination. During these three months we submitted about 100 cases, mainly of musculo-skeletal radiology, using the MIRC web application. The next step will be the development of a new MIRC server based on new IHE Profile called Teaching File, along with a full integration between the MARiS and DPACS (DPACS is our in-house developed open source PACS, more infos available at http://www.o3consortium.org). In this forthcoming seamless and integrated environment a radiologist will be able to create a shared teaching file or research data directly during his/her reporting work through the selection of key images and the relatives clinical facts (eg. radiological findings) from the RIS/HIS. Figure 1 shows four displays of our reporting workstation. Top left screen shows the MARiS and MIRC interface (both are web-based). MARiS is built around different IHE component/actors. The screenshot below shows the order filler, the information system that manage the radiological orders workflow and allows access to worklists (pending studies) and previous reports for comparison. The MIRC

interface places submissions and permits query/retrieve of images and related data based upon a standardized query lexicon.

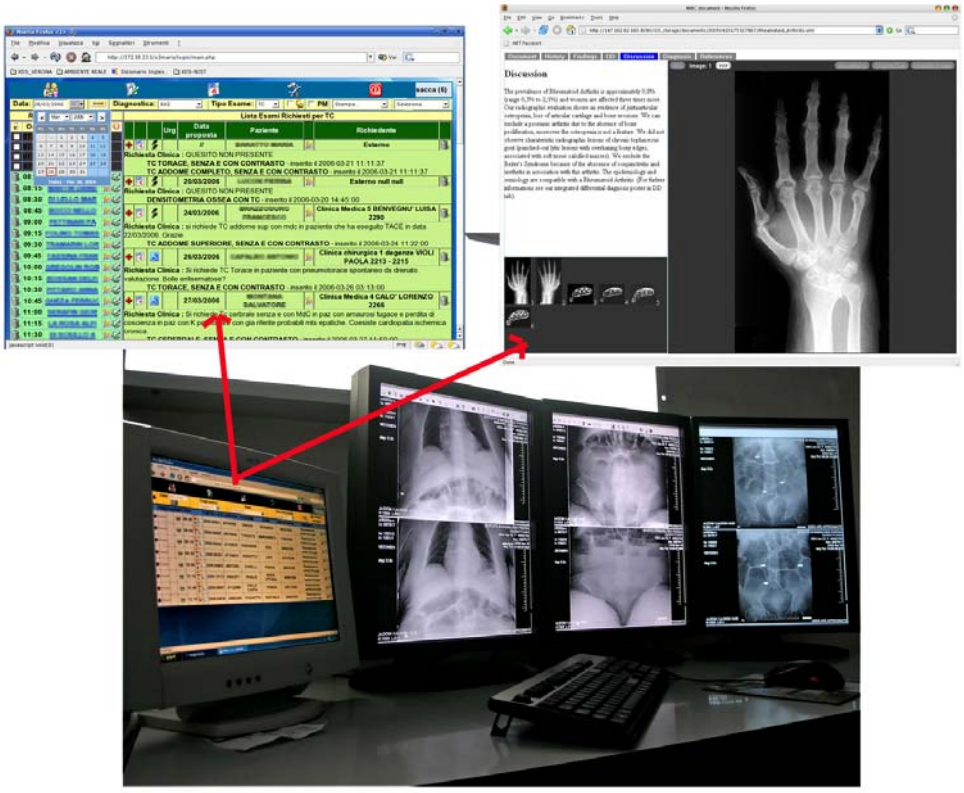

Figure 1 Our MIRC reporting workstation.

5. The Future of Radiology Reporting

Report turnaround time has great value in the radiologist's practice. It is one of the most critical factors in assessing clinicians' satisfaction with imaging services (Seltzer, 1997). Despite an understanding of the importance of report timeliness, most radiologists in hospital-based practices have little control over the process of radiology reporting. This problem is magnified when practicing in the traditional paper and film-based medical imaging department.

If a new technology is to be embraced, it must be able to prove that it positively enhances clinical outcomes and radiologists performance. Improved radiologist performance is a somewhat nebulous concept and can mean different things, depending on the perspective and the way in which performance is evaluated. For the

referring clinician, radiologist performance can be improved by increasing diagnostic accuracy, improving communication of pertinent findings, or improving the content/structure of the report. Regarding radiology itself, performance is often judged in productivity measures, and improvements can take the form of an increased number of interpreted exams and improved workflow. Another subjective factor that indirectly changes performance and is often overlooked by radiologists is the subjective nature of fatigue and stress which can have adverse effects on performance. These can include reduced productivity and heightened exposure to medico-legal issues. These different perspectives must be considered when investigating the impact of a new technology on performance. Given that the radiologists population is heterogeneous, a comprehensive analysis should be considered before arriving at any sweeping decisions.

The following paragraphs briefly review tools and concepts necessary for creating the radiology report of the future.

5.1. Structured Reporting

Interest is growing in redefining the composition and structure of the radiology report. This effort is largely driven by the parallel transitions from film and paper to filmless and paperless operations. With the increasing adoption of PACS-HIS/RIS integration, digital tools are now available to redefine the way radiologists create their reports.

Structured reporting is a point-and-click reporting software that uses templates and macros, enriched with SR and standardized lexicon. Because the text of the report is captured as structured information, an underlying clinical database is created that can be used in a number of ways, previously not so easily achievable. Examples include billing/coding, quality assurance and peer reviewing, clinical follow-up, practice management (identifying clinical trends) and research (database mining).

5.2. Computer-Aided Diagnosis

The concept of using Computer-Aided Diagnosis (CAD) software tools for improving diagnostic accuracy of radiographic and mammographic images was a result of numerous studies that showed significant error rates in the screening of lung and breast cancers (Harvey, 1993). Later studies demonstrated that the use of radiologist “double reading” produced increased sensitivity when compared with single radiologist

interpretation (Hendriks, 1998). If computers could be trained to serve as the source of the “second read”, radiologist productivity and diagnostic sensitivity could be improved.

The initial application of CAD was performed at the University of Chicago more than 25 years ago, using digitized film mammography images (Ishida, 1982). These early attempts at CAD were found to be impractical due to the limitations in computational capabilities. As computer processing speed increased (in accordance with Moore’s law), CAD applications in a clinical setting became more feasible and now a number of forces are converging and will assist the integration of CAD into the radiology workplace. Factors contributing to CAD adoption in image interpretation are listed in Table 2.

- Increasing computer processing speeds and memory
- Decreasing cost of computer hardware
- Increasing size and complexity of imaging datasets
- Increasing adoption of PACS operation
- Increasing emphasis on productivity and diagnostic accuracy
- Routinely incorporation of CAD into digital mammography.

Table 2. Factors contributing to CAD adoption.

From a technical perspective, CAD utilized a range of techniques for quantifying specific visual features on the radiographic image and for providing metrics for the measurement of geometric, topologic, and other characteristics by which medical images are evaluated.

The novel paradigm created by CAD and PACS technologies is the creation of a new approach to image interpretation. Radiologists are no longer restricted to the “single best” image presentation state and image quality. Instead, radiologists will become limited by the psychophysical and ergonomic boundaries in human perceptual process. In fact with the added volume and size of imaging datasets, strategies will need to be developed to deal with a kind of “information overload”. Multislice CT exams can now contain thousands of individual images and thereby place stress on the interpreting radiologists. At the same time, as the volume of screening studies (especially mammography and chest radiography) continues to increase, it is important to have strategies and tools that can handle this demand without sacrificing diagnostic accuracy. The radiologist is ultimately responsible for image review and interpretation, but CAD offers an efficient means to maintain productivity without sacrificing accuracy.

6. Conclusions

The transition from film-based to filmless imaging is now a foregone conclusion. The practice of diagnostic radiology should not only convert to filmless and digital work flow, but radiologists must also become active participants in this conversion. Future applications of imaging technologies will be driven in large part by research in the area of medical imaging informatics. It is therefore imperative that the radiologist collaborate with computer scientists and other new technology professionals. During the past few years, the importance of an understanding of work flow devoted to RIS and PACS environment has resulted in substantial improvements in the development of intelligent software and integration with other information systems. This will undoubtedly continue. Universal adoption of communication protocols such as the IHE initiative and standards such as DICOM and HL7 (Health Level Seven) will continue the trend toward the elimination of paper and this will result in further reductions in the number of steps in the flow of information to and from the imaging department and in the frustration associated with routine tasks. This new understanding of the radiological work operations and evolutionary potential of new technology will serve benefit quality and timeliness of care of our patients.

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PsychNology Journal, 2006
Volume 4, Number 1, pp. 103 - 116

The PASION Project: Psychologically Augmented Social Interaction Over Networks

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ABSTRACT

Ever more frequently, social and particularly group interactions, involve mediated communication. Yet we know very little about the factors determining the effectiveness of the interaction. How do participants in mediated communication substitute the implicit, and non verbal signals which play such an important role in traditional, face to face communication? What are the equivalent signals in a mediated environment? The mechanisms involved in traditional communication are well-known. By contrast, very little is known about the forms of mediated communication. For instance, we do not know the role of implicit and non-verbal communication when the communication takes place in a mediated environment. PASION's working hypothesis is that in mediated environments these messages will take completely new forms and that these forms are due to group interactions in technology-mediated environments. As current communication technologies are ineffective in conveying the social, non-verbal and contextual information required for effective communication, PASION will deliver an innovative shared virtual environment where a pioneering mediated social communication will take place.

Keywords: *social presence, mediated social interaction, shared virtual environments, non-verbal and contextual information.*

Paper Received 14/04/2006; accepted 20/05/2006.

1. Introduction

The PASION Integrated Project has been funded on under the Presence II Initiative in the Future Emerging Technologies within the 6th Framework Programme (more information available on http://cordis.europa.eu/ist/fet/pr.htm). The project, which will

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last 4 years, defines an ambitious research program and has the potential to significantly advance the state-of-the-art in basic research, technology development and applications. As the project has just started the paper will focus on the description of the vision, research program, and the main goals that PASION will have to achieve during his time.

2. The PASION project

PASION's working hypothesis is that in mediated environments social communication takes completely new forms and that these forms are due to group interactions in technology-mediated environments. The goal of PASION is to enhance the effectiveness of mediated and media-assisted communication in a group setting – with the ultimate goal of improving the performance of the group. To achieve its goal, the PASION Consortium strongly believes that the real-time capture, interpretation and representation of group metacognitive social psychological, contextual and affective processes can yield key information to inform and enrich traditional interaction, and to create new, emergent levels of social interaction. Technology development in PASION will focus on flexible, scalable, user-friendly and nomadic mixed reality tools, which will provide access to these previously inaccessible levels of social information.

In the four years of the project, PASION will investigate the basic scientific and technological issues which need to be resolved to achieve this goal. Basic research will investigate the socio-psychological foundations of mediated social interaction. Wizard-of-Oz prototypes will be used to elicit user input on basic concepts. Ergonomic studies will investigate critical issues of usability and user acceptability. Using this input, the project will design and develop new techniques to capture information relevant to social communication, and new ways of representing this information to users within the SVE.

As current communication technologies are ineffective in conveying the social, non-verbal and contextual information required for effective communication, PASION will deliver an innovative shared virtual environment where a pioneering mediated social communication will take place. Two trials (one for each specific application collaborative work, and social gaming) will investigate the effectiveness the concepts and technologies incorporated in the environment. During trials PASION will be used by "large community of mobile users" providing strategic support to the activity of the group (adapted to the needs of specific applications in collaborative work and social

gaming) by implementing “specific feedback strategies” based on the interpretation of the state and dynamics of social communication within the group. Finally a special effort will be dedicated to the investigation of the complicated ethical issues raised by this work, and to plans for business development.

3. Project objectives

3.1. Social communication through technology

Traditional communication media such as letters and the telephone created and preserved social bonds and interpersonal relations across borders and oceans. By contrast, today’s electronic communication media –TV, computers and the Internet– seem to have reduced the motivation for and the quality of social interaction. Olson and Olson (2000) provided us with a satisfactory review of literature on this topic see. One of the reasons is that electronic media transmit too little: they are ineffective in conveying the subtle social and contextual information which plays such an important part in non-mediated communication. But another reason is that they transmit too much, they monopolize on users attention distracting them not only from the task-oriented purposes of social interaction but even from its socio-emotional implications.

Ever more frequently, social and particularly group interactions, involve mediated communication. Yet we know very little about the factors determining the effectiveness of the interaction. How do participants in mediated communication substitute the implicit, and non verbal signals which play such an important role in traditional, face to face communication? What are the equivalent signals in a mediated environment? The mechanisms involved in traditional communication are well-known. By contrast, very little is known about the forms of mediated communication. For instance, we do not know the role of implicit and non-verbal communication when the communication takes place in a mediated environment. We have a broad range of strategies to improve cooperation and performance in traditional groups (e.g. through training to improve group skills, games to increase motivation or to simulate a concrete activity). All of which raises a fundamental question: how can we change –and use– technology to facilitate technology-mediated group communication and to increase the effectiveness and performance of the group. It is this question which motivates the PASION project.

3.2. Strategic goals

The basic research, technology and applications development planned by PASION focus on improving the efficiency and effectiveness of goal-oriented groups engaged in social (many to many) communication, in mediated environments, with a particular emphasis on large groups in which communications are maintained on a long term basis (e.g. professional communities) creating a social network.

To achieve this goal PASION will conduct basic research on patterns of mediated communication (on multiple time scales) within large, persistent social groups. This research will study the relationships between emotional and implicit communication in mediated communication, different patterns of group interaction and the performance of the group.

The group will work and interact within a Shared Virtual Environment (SVE) supporting the activities of users (e.g. collaborative work, gaming) and the many to many communications required by these activities. Within this environment, PASION will substitute the channels of non-verbal and implicit communication available in non-mediated communication with new forms of communications, appropriate to mediated environments.

PASION will provide means to monitor the behavior of group members and group dynamics on multiple time scales (short term inter-individual interactions, overall patterns of interaction during a meeting or a gaming session, long term trends in group "connectedness"). The system will construct synthetic indexes showing and comparing dynamics and indicators relevant to different time scales. Using this data, PASION will look at different strategies for providing feedback (including emotional cues), which improves the quality of group interaction.

At an early stage PASION will use basic augmented and mixed reality technology to provide partners in long-distance communications with a range of different channels (e.g. simple visual signals in peripheral vision, 3-D audio, eye tracking, social network analysis tools) to monitor the social mediated communication within the group. On the basis of this initial studies the medium-term (4 year) goal of project will be to investigate the basic scientific and technological questions to be resolved before this goal can be achieved. What cues do they use? How do they use information about the social context in which communication is taking place? What is the role of group dynamics? In technological terms: how can we substitute for social information and the non-verbal channels of communication humans use in their social interactions? How can we

capture, interpret and process user behavior in a group context? How can we capture the user's context (is she in a meeting, writing, resting, driving, waiting for a call) and the more general group context? How can we represent this information to distant communications partners? How can we do this in ways which are non-intrusive? In terms of applications, what can we do with new "social communication technologies" that we cannot do with current systems? And how do we know if we are succeeding? To find answers to these questions, PASION proposes an integrated program of research bringing together basic research, technology integration, user-centered applications design, trials and evaluation.

3.3. Scientific goals

Traditional computer-mediated social interaction lacks the subtle social cues that we use to guide and structure our real world encounters. In a digital world we are socially blind and our attempts to communicate become awkward and labor-intensive. PASION's key scientific goal is to discover how mediated communication affects long and shorter term dynamics of group behavior in a social network and to investigate dependencies between these effects and the broader context of the communication (e.g. conflict and conflict resolution, competitive or collaborative communications). To this end, the project will investigate the nature, semantics and forms of mediated communication during competitive and collaborative group interactions (e.g. during collaborative work, in a game), explore means of making social and other contextual data explicit, and investigate how this can affect the overall performance of the group.

3.4. Technology

Creating a new generation of communications environment and tools will require new developments in the automated detection, analysis and representation of group and individual behavior. To understand the characteristics and forms of socially mediated communication PASION will develop a Shared Virtual Environment in which it is possible to monitor mediated social interactions among members of a group. A specific project objective is to identify strategies (in the form of services, tools and cues) capable of empowering the individual members of the group and the group as a whole.

This work will involve new techniques of data fusion, transforming low level behavioral data into higher level representations. And it will require architectural and integration

work to allow groups of (ultimately mobile) users to share and access this data. The Shared Virtual Environment will support the activities of users (e.g. collaborative work, gaming) and the many to many communications required by these activities.

Initial research will use classical techniques of analysis to capture and analyze the behavior of the group and its components and to provide users with appropriate social and emotional cues. Experimental work will analyze long and shorter-term patterns of group interaction applying techniques from social network analysis. At an early phase of the project off-the-shelf technologies will be used to capture individual behavior and to provide contextual information and emotional cues to users: e.g. non-obtrusive sensor technology for the detection of emotional arousal and attention; high resolution, high accuracy eye tracking for avatar control and attention feedback in e-learning applications, low-cost sensor technologies for increase emotional involvement and social presence in net-communications; PC-based Automatic recognition of attention profiles and emotional user states as input for adaptive systems (agent systems and ambient intelligence); non-intrusive methods for displaying information to users; The use of mobile technologies in mobile contexts will be also probed. The use of group-centered emotion regulation and group processes as therapy for relieving work stress and increasing well-being will also be studied. Based on this research a design space will be formalized based on which concepts are generated.

The long term (10 year) goals of this work include tools to understand the group communication and behavior in mediated environments and to offer “specific feedback strategies”. Goals to be achieved within the life-time of the project include: identification and (where needed), development of new ways of processing sensor and other data to reliably detect and measure group behavior (patterns of interaction among users on different time scales, patterns of interaction between users and virtual objects in the shared environment, identification and development of elegant, effective and meaningful means of representing sensed data for transmission and sharing with others; integrating these developments in a Shared Virtual Environment.

4. PASION research strategy

PASION research activity is structured into 3 main areas: mediated social communication basic research, technical development of the PASION system, PASION application design.

4.1. Social presence as mediated social interaction: PASION basic research

The first research activity area is dedicated to basic research in the field of mediated social interaction. In particular the PASION team will work to identify the salience of socio-emotional communication cues, contextual and situational information in mediated and media-assisted communication and to test the effects of making such information explicitly available to communicating parties, both at the individual and group level. The main objective is to develop a coherent theoretical framework regarding the fundamental role of implicit communication and contextual information in social interaction and to create laboratory tools for basic research into the effects of implicit communication and contextual cues. This will demand basic research into patterns of mediated and non-mediated communication within social groups, focusing on socio-emotional communication cues, place and contextual information on various group scales and on multiple time scales and how to translate these into meaningful synthesized and integrated indicators to enhance and enrich situated group awareness and social interaction.

On the basis of first understanding of the contextual cues effects (sensing, interpreting) the project will identify specific requirements for creating situated social awareness in mediated environments: to determine the spatio-temporal characteristics of successful social interaction environments at micro, meso, and macro level, i.e., in private, semi-private, and public spaces; and to explore basic technological requirements for the detection, transmission and display of social and situational cues and traces of group behavior integrated over time and place, in the form of synthesized and integrated indicators that influence social interaction in virtual encounters. The research activity will be performed trough the following tasks:

- First PASION will survey current indexes of social activity during communication and to investigate how these might improve the effectiveness and efficiency of future communication tools; this study will provide relevant and systematic knowledge of the role of implicit communication cues for social interaction and collaboration, building a comprehensive grammar of transient non-verbal and implicit social communication and contextual cues. The indexes will consider (at least) three related themes: Communication style and strategies (the way in which communicants' contributions coordinate or collide, in terms of turn allocation, overlaps, breakdowns, gaps). Social Positioning (the way in which users' interdependent positions, are

balanced on dimensions such as reciprocation, politeness and mode of participation – centrality-peripherality, initiators versus follower), and Social Microsuasion (indexes directly used by participants as a form of social evaluation and as a tool to affect group communication dynamics).

- Second on the basis of the empirical research conducted PASION will provide basic knowledge on the effects of embodiment and non-verbal communication in HCI (Human Computer Interaction) and CMC (Computer Mediated Communication), small and large scale settings and will identify the role of social activity, transient social communication and contextual cues in shaping mediated social interaction, and determining relevant emotional cues to facilitate interpersonal communication in mixed reality interactions;
- Third PASION will develop protocols for extracting socially meaningful spatio-temporal patterns from clusters of data from individual sensors, identifying emotional cues relevant to the facilitation of group awareness in virtual encounters; alongside indexes which can be used to monitor and enrich social communication will be identified, through intuitive and easy to understand appropriately visualized temporal aggregates of transient socio-spatial behavior patterns and contextual cues, thus improving emotional and group awareness, will be identified.
- The overall findings will lead to formulate requirements for intelligent mixed reality systems (portable awareness tools) for social facilitation, emotional communication, interpersonal conflict resolution, and persuasion and for flexible platforms and authoring tools for the creation of socially intelligent embodied conversational agents. More in general the study will help to develop a rationale for a new generation of shared environments enriched with socially meaningful contextual information, based on collaboration and exchange between clusters of location-based and devices.

4.2. Architecture design for Social presence: PASION technical framework

The PASION technical team will deploy an extensible platform that will be representative of the PASION project. This platform will make it possible to verify the research outcomes of the basis research (descried above in 3.2), implement the PASION applications (social gaming and collaborative work), and test the PASION vision with real life users. The concrete outcome developed by the PASION technical team will be a prototype Shared Virtual Environment (SVE) suitable for deployment on

mobile devices. The prototype will include physical and logical sensors integrating data analysis software components for the extraction of social indicators, and supporting the two mobile applications planned (social gaming and collaborative work).

The PASION technical framework foresee an advanced, mediated environment supporting experimental investigation of the dynamics and behavior of large groups based on the design of ad hoc technologies which uses social network analysis in a closed-loop system to improve the efficiency and effectiveness of goal oriented groups.

The work to be performed includes the definition of an architecture supporting a many-to-many communication environment. This architecture will be designed to provide users with a broad range of information concerning the dynamics of the group and the behavior and state of individual users, thereby enhancing their social interactions as well as their interactions with the physical and virtual world. Applications built over the architecture will allow users to view this information as well as accessing, and modifying interactive and multimedia content. The platform will be designed on the basis of a data management layer (see below) supporting distributed access, by users and applications, to the information generated from sensor data and social analysis tools. From a higher point of view the PASION system platform will be built onto 3 main layers:

1. ***Sensing layer***: the role of this layer is to receive and process raw data from physical and logical sensors, transforming it into manageable information. The sensing layer will integrate the sensors and prototypes produced at the early stages of the project (from the basic research team), creating a unified logical layer. Each source of information (sensor) will be viewed as a publisher entity, with the ability to track some physical and logic events and to publish the information in a format that is manageable by the data management and application layers.
2. ***Data management layer:*** this layer will have the double task of managing information requested and generated by other components of the PASION platform, and merging the behavioral and state information provided by other modules in the architecture, in a model (or in models) of group and individual behavior. The existence of a data management layer decouples data generation from the way the data is used.
3. ***The application layer***: The application layer is the environment where the two applications will run. The application layer will provide a common interface towards the end-user allowing the user to initiate an application and augmenting the content of the application with social and behavioral information generated by other modules

Based on the platform, the main goals of this activity are to:

- Constitute a new technological paradigm for many to many communication based on social network analysis
- Deploy and test applications with large groups users in an experimental set-up
- Evaluate the improvement the efficiency and effectiveness of goal oriented groups by the usage of the platform

On top of this the platform will have to be an overall system able to track and index human-interface events generated during mediated communication and to publish them in a manageable format. Indexes –suggested by the PASION researchers studying specific aspects of social communication in mediated environments– will be formalized and translated into treatable variables fitted to the architecture of PASION platform.

The work will start with the design, development and testing of a prototype system able to recognize and track basic data (like distances, time, frequency of events) and to transform them into synthetic indexes (e.g. intensity of group activity). Further steps will focus on improving the quality of data collected and of the data be provided by the users during their interactions with applications. Special tools will allow users to rate an event, express an opinion and so on. Indexes or the result of their manipulation, will be visualized as graphics, indicators, warning signals etc. thereby providing users with "social feedback". Most components of the systems will be customizable by administrators (e.g. requests, rating system scale). Some indexes will be contextualized to the characteristics of the specific environments and characteristic objects in the environment. A relevant aspect of this activity will be the effort on data analysis and fusion techniques to be developed for the extraction of meaningful measurements from data streams associated with social interaction indicators and nonverbal behavior (gestures, facial displays, gaze, body movements and postures). Required representations will be provided for the processed data on several layers from sensorial layer, movement and expressions patterns to semantic content and finally the goals of the interacting participants High-level multi-modal interpretation and classification of these pattern will be subsequently performed. Behavioral and physiological measurements will be provided in an integrated time-series data protocol that will serve as a basis for psychological analysis to identify the relevant signals provided by the outcomes of studies performed in the field of social communication and social presence (see 3.1).

4.3. PASION customized application design

The system developed by PASION will be tested in two applications: social gaming and collaborative work. User communities will be able to use the normal functions provided in this kind of application (e.g. collaborative tools, multiplayer games) which will be integrated in the SVE. The services offered by the SVE will allow users to conduct their normal activities with strategic support from PASION. PASION will be able to monitor and provide support for group activities (work, gaming) through "specific feedback strategies" based on the interpretation of the state of mediated social communication within the group.

Collaborative work

Modern knowledge work involves formal and non-formal communities of practice. One example of a formal team would be an R&D project team including members from different companies, with different cultural backgrounds; non-formal teams can form spontaneously as when an informal social network of experts shares knowledge in their area of expertise. Teams are characterized by their knowledge creating and sharing activities rather than organizational boundaries.

Effective social communication within the team is a pre-requisite for effective brain-storming, problem-solving etc.. Studies have shown that non-verbal and implicit signals (e.g. smiles and frowns, signs of approval and disapproval) play an important role in facilitating group performance. This is especially important when: i) participants' tasks are time critical and driven by deadlines, ii) the result or success of the work relies on the creativity of autonomous, but interrelated people, iii) there is a culture of co-operation and sharing of knowledge amongst people and iv) people are mobile and distributed (Fagrell, Forsberg, & Sanneblad, 2000). The lack of effective technology for conveying these signals is one of the key factors limiting the use of remote communications in business.

Davis (2002) describes possible beneficial effects of distributed computing. These include: i) enhanced capabilities for communication, coordination, collaboration and knowledge exchange, ii) removal of time and space constraints for doing knowledge work, iii) access to critical decision makers at any time and iv) increased ability to receive and process rich streams of signals about the organization and its environment.

PASION's primary goal in this area is to understand the factors that influence team performance during typical knowledge tasks (e.g. learning, knowledge transfer, brain-storming, product design) within a mediated environment. The second goal is to create

SVE that will facilitate these tasks, creating improved team awareness and contributing to the performance of organizations using the tools. In the final stage of the work, the team will use qualitative and quantitative techniques (group behavior in mediated environment tracking, ethnographic techniques, laboratory studies, etc.) to measure the effectiveness of the technology produced. Tools usually used by workers will be integrated in the PASION system and technologies and to0ls within the SVE will provide an additional channel for social group awareness trough the support of "specific feedback strategies". A key goal is to support collaborative work with **mobile devices.** The development of the final mobile interface will allow the effective communication of the social signals as required by the tool design.

Social Gaming

One of the most important activities in which humans communicate socially is play. Not surprisingly software companies and games manufacturers have a strong interest in the business potential of multiplayer online gaming. After many years in which the only communication channel in games was through text and avatars, several online services now incorporate voice communication as a standard component (Available on http://www.xbox.com/en-us/live/default.htm). Communication nonetheless remains relatively poor and there is little evidence that current commercial games produce the complex social dynamics that characterize physical play.

The long term goal of PASION is to pave the way towards mobile games where the emotional state of a user can be communicated and manipulated as part of the game or experience. Social computer games will embed some of the variety and rich social interaction we see in the playground, but will attempt to capitalize on the affordances of mixed reality as a medium for bringing players together. The design and the evaluation of these games will be based on a sound theory of social presence that will cover the social effects and antecedents of social presence and co-presence. A second key goal is to support multi-player social gaming on **mobile devices** – an important market for the future which major manufacturers are only just beginning to explore.

PASION's primary goal in this area is to understand the factors that influence gaming performance during typical tasks (e.g. competition, simulation, etc.) mediated environment. The second goal is to create SVE that will facilitate these tasks, creating improved multiplayer-awareness and contributing to the performance of to be realized in the game. In the final stage of the work the PASION team will use both qualitative and quantitative techniques (group behavior in mediated environment tracking,

ethnographic techniques, laboratory studies, etc.) to measure the effectiveness of the technology produced. Tools usually used by gamers will be integrated in the PASION system and technologies and tools within the SVE will provide an additional channel for enhancing social group awareness via “specific feedback strategies”. A key goal is to allow gaming on **mobile devices.** The development of the final mobile interface will allow the effective communication of the social signals as required by the tool design.

In parallel with this work, the project will develop common platform requirements that will emerge from the experiences of the project. Elements of common utility will be factored out of the game, and interface components and delivered as self-contained elements to the shared virtual environment. An instruction manual will be created with the purpose of supporting the re-use of the interface elements and social signaling measures in the context of the broader project. The development and testing of the game will proceed in parallel with additional technology work designed to facilitate the development of mixed reality games incorporating ever stronger elements of social communication. A key goal is to facilitate the design and implementation of “plastic” user interfaces, suitable for use in different sized rooms with different numbers of players.

5. PASION Living trials

Achieving PASION’s long-term goals will require many years of development. It is essential that this development should take account of research into the way social interactions can be affected by the introduction of technology. A key goal of the project is to practically assess the social ergonomic implications of the technologies it is proposing. PASION will therefore to develop scenarios, concepts, prototypes and applications from a very early stage in the project, to test these with users, and to use the results as a source of new research questions and new directions in technology work. The aim of the PASION trials will be to:

- Provide a real-life test of PASION services and the SVE and test the scientific and technical choices underlying the project
- Test the specific scientific hypotheses proposed by WPG2 (based on early measures using environments comparable to those developed in PASION but with much more primitive technologies) using an advanced environment
- Tune the “free parameters” in PASION’s complex, closed loop architecture

Experimental studies will investigate the cognitive processes involved in the use of different PASION tools, including the recognition of their affordances in the processing of perceptual (specially visual) stimuli (Ware, 2004), the trade-off between performance and skill-, rule-, knowledge-based errors (Reason, 1990). In testing the PASION systems the project will study the way in which relationships with other people (present or represented) are represented in different scenarios (Rosson, Carroll, 2001) persuasive cues (Fogg, 2003) interaction patterns and norms; turn allocation; sequence organization and repairs (Have, 1999); establishment of common ground (Clark, Brennan, 1991). The planned investigations will use a use a broad range of methods likely to include: ethno-methodologically informed analysis of use contexts; cognitive task analysis; quasi-experimentation, compensatory strategies and attention distribution strategies during multiple tasks. In the second half of the project it is planned to organize trials which involve large numbers of mobile users.

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