Virtual Small Group Dynamics:a Quantitative Experimental Framework

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Abstract-We present a research framework consisting of a standard chat environment and a set of analytical tools, able to detect some relevant characteristics of the group dynamics of interacting people. The analysis is independent of the semantic content of the exchanged messages, and the standardized interface avoids hard-to-detect non-verbal communications, still providing the expression of emotional contents. This study proposes a quantitative approach to the investigation of the cognitive small group dynamics, considering the personal representation of the others, and communication dynamics. We developed a framework for the analysis that merges the complex network theory with concepts from social psychology and sociophysics. The focus of the framework is a quantitative investigation of how people explore and build their cognitive representation of the social space. Moreover two different experimental tasks have been proposed in order to investigate the role of some ecological constraints on the cognitive heuristics used by the subjects. The results show how people behave differently with respect to the task they are facing. In particular the absolute and the relative frequencies of the messages and their qualitative aspects significantly differ between the two conditions, as so as the cognitive strategies used by subjects to assess the affinity with the others.

Keywords-Virtual Dynamics; Small Group; Social Psychology; Complex Systems

I. INTRODUCTION

In the last decade, research has clearly shown how much the individual behaviour is strongly dependent on the social and relational dynamics, also at a neuro-physiological level [1, 2]. This assumption was already present in the field theory approach, as proposed by Kurt Lewin [3], who went further by introducing the key concept of group mind in order to indicate that certain collective systems are characterized by emergent behaviours with specific features, not present at the individual level. Lewin, by looking at the group as a single entity, assumes that individuals are linked to each other and totally interdependent. The emerging collective behaviour is therefore bounded by the structure of the communications and relationships within the group. The psychological literature, starting from the mid-twentieth, offers many examples of the role of the communication network and of its structure, on both the macroscopic (i.e. the group dynamics), and the microscopic level (i.e. the perception of the group dynamics by the individuals) [4, 5, 6, 7, 8, 9]. Furthermore, by analysing the communication structures, it is possible to study the dynamics of social groups using tools originated by the investigations of complex and social networks [10, 11]. Nowadays the ’cyberspace’ constitutes a brand new natural-ecological environment (i.e. experimental setting) to explore and investigate the nature of the social dynamics within humans.

Despite the lack of those elements that characterize the face-to-face communication such as speech and all its features (i.e., tone, pauses), and those related to non-verbal language (i.e., facial expressions, body gestures) [12], in the modern society, social groups are used to exploit internet-based communication devices, as illustrated by the proliferation of social networks [13]. The cyberspace provides a unique opportunity to track individual and collective dynamical behaviours in interactive settings.

In the present study, we introduce a virtual setting to investigate the dynamics of a small group. The initial step of this work was to create a chat interface, which was designed in order to simulate a virtual room where the participants could interact anonymously, under controlled (or nearly controlled) experimental conditions. The small group was treated as a complex dynamical system where the subjects represent the network nodes [25, 26]. In this way, we have the possibility to define some control parameters to be subsequently inserted into a model which takes into account the groups and the individual dynamics; and to investigate, through some order parameters, the emerging properties arising from the group dynamics [10, 23]. We basically focused on the structure of the communication network, by considering three different dimensions: the communicative dimension, visualizing the communication in terms of messages sent or received by the subjects and the relationships among the members of the group as influenced by the content and the number of messages produced; the quality of the interactions among the subjects and in particular the emotional moods that accompany the textual messages [18]; and the ”spatial” dimension of the group interactions, namely the affinity space, in which the subjects build their own social space representation of the group.

In order to study also the effect of the task on the subject’s cognitive strategy, first we designed a control task, labelled as Blank Modality, whose target was to introduce the smallest possible number of constraints and biases. Accordingly, we selected a classic everyday social problem, estimating the affinity with another subject by freely chatting for 45 minutes. The participants could interact using public and private messages, and were asked only to assess their affinity with the others, reporting them on their private radars before the end of the experiments.

The affinity with someone was introduced to the subjects as the perceived degree of similarity in terms of opinions, beliefs and attitudes.

The Topic Modality was designed to introduce a first constraint affecting the same task of the Blank Modality. Subjects were asked to participate in a role game where they belonged to an ethic committee that was charged to reform the law that controls the researches involving animals. The requirements were to discuss about the given topic, developing before the end of the experiment one or more shared ethical positions, and assessing the affinity space accordingly. Hence agents in the Topic modality were confronted to the freedom to be socially seductive (i.e., adopting strategies to appear socially desirable).

The most ambitious target that moved the development of the present framework was to study the cognitive heuristics used by humans during small group interactions, to explore and to build their representations of the social psychological field [3]. Moreover, assuming the Small Group Dynamics as prototypical events of the human social environment, we can presume the existence of some shared and adapted cognitive strategies, developed within the community to face with those tasks [19, 22]. Consequently we should expect to reveal a certain agreement among the adapted strategies (i.e. cognitive heuristics) shown by the subjects, and a certain degree of variation of such strategies between the different experimental conditions, may be greater than that shown by subjects within the two conditions separately.

The cognitive heuristics have been frequently defined as computational algorithms which operate on the available data (i.e. knowledge and perception) producing an adaptive answer/behaviour [[20, 21]. Following such definition we used a linear regression modelling approach to relate the communicative observables (i.e. the behaviour of the subjects) with the affinity spaces (i.e. the subjects' representation of the group). In other words we modelled the average cognitive recipe used by subjects to estimate the affinity with the others, as a mathematical linear function of some predictors coming from the experimental observables.

A. The Experimental Environment

The issue of the social dynamics in virtual environments has become one of the most attracting fields in various scientific disciplines, due to the increased possibilities of digital connections among human beings, which also offers the possibility of new environments and communication contexts. The new technologies also provide a high level of accuracy in the detection of the variables of interest and the possibility of gathering a large amount of data, allowing extremely refined experimental investigations. In this regard, we developed a java interface environment based on a classical model of chat lines. The experimental task proposed to the subjects is that of interacting freely in this virtual environment. Once a subject has logged, it is assigned a random simplified avatar representing him/her within a single session, in order to standardize the initial information available to participants. This setting shows the classical features of a chartroom, with two different parts: a private and a public space. The participants can choose which one to use for communications, either with all logged people or with only one. There is also the possibility to accompany the textual messages with some information about the mood of the sender. There are three different choices: neutral, negative and positive mood. An original innovation is the presence of two "radars", that are used as a representation of the social and physical space. In the private radar, labelled "place others", subjects can modify others' positions, depending on the perceived agreement with them. Everyone has his/her own private personal radar.

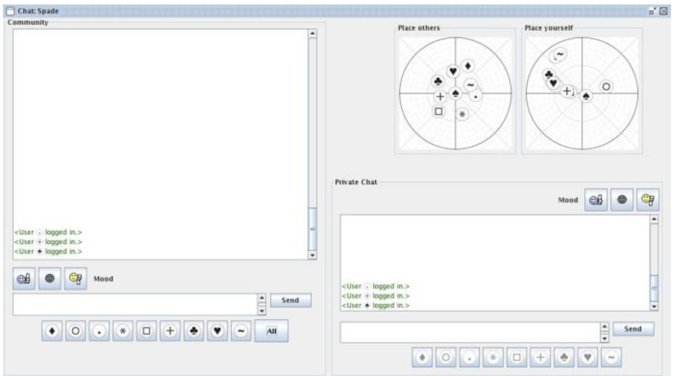


Fig. 1 The experimental interface. On the left the community side, on the right the private side, each with its own space for entering messages and choosing the mood that accompanies the message. On the top-right there are two "radars", a spatial two-dimensional environment, labeled "place others" and "place yourself", manipulable by the subjects

The other radar is the public one ("place yourself"). A change in its configuration will be instantaneously visible to all participants, and in this sub-environment one can only move his/her own avatar symbol. This is reflected by a change in the visibility (transparency) of the messages appearing in the public chat. Namely, the farther is the receiver avatar from the sender's one, the lighter is the message. This allows a more realistic simulation of a real environment, simulating the different loudness of a spoken message due to the 'physical distance among the participants.

B. Methods

The population selected for the experiment is composed of 100 subjects. The subjects were asked to fill a questionnaire, in order to anonymously collect socio demographic data like gender, age, educational qualification, years of schooling, and current profession. These data have been connected to the avatar assigned by the software. Each of the ten experimental sessions consists for a total of 51 males and 49 females. The average for each experiment has been around 5 females and 5 males, unknown to each other, with mean age equal to 23.8 years, SD 2.83. The average age of education is equal to 16.3 school years, SD 1.52.

The experimental setting has been set up in a computer lab. At each subject was given a personal computer running the client chat; a server machine that managed message passing and data collection. Each subject was isolated from the other, in order to preserve the subjects' anonymity and to permit the interaction only trough the chat.

Each experimental session had a total duration of 60 minutes with the following temporal subdivision: 5 minutes dedicated to the collection of socio-demographic data, 10 minutes of standardized training in which the basic usage of the chat and the experimental task was communicated to the subjects, and 45 minutes of free virtual interaction via chat. The subjects were explicitly trained in the use of the radars, and were asked as part of the task to use them to represent the social space (private radar) and to announce their agreement to others (public radar).

Finally, the sample has been randomly spilt in two, respecting the balance for the gender, and each sub-sample has been asked a different task. The two experimental procedures have been designed to study the effect of the complexity of the task on the cognitive processes involved in the virtual small group dynamics. The experimental task proposed to the subjects demanded them to interact freely, i.e., without any argument specified, only through the chat. This means that the subjects are completely free to adopt personal communication strategies to explore the social environment in which they are inserted.

The second experimental procedure has been labelled as Topic Modality. The experimental task proposed to the subjects demanded them to discuss about animal experimentation. The subjects have been asked to support and negotiate its position during the entire discussion. This topic was chosen in order to polarize the opinions of the subjects in virtual interaction and to force the communication strategies of the subjects around a specific topic.

C. Data Analysis

Data produced by chat interactions and by radar manipulations are collected in a log file, recorded on the server side. In this way it is possible to examine the list of all events occurring within each experimental session. The group was treated as a dynamical system with the subjects representing network nodes. We considered 11 dimensions, as illustrate in Table 1. Of these, 9 are related to the real communication dynamics, one is related to the public radar, and one to the private radar.

TABLE I OBSERVABLE DIMENSIONS

Dimensions	Description
G_M	Messages globally sent, both in the public and private side
C_M	Messages sent in the community chat area
C_{POS}	Messages sent with positive mood in the public side
C_{NUL}	Messages sent with neutral mood in the public side
C_{NEG}	Messages sent with the negative mood in the public side
P_M	Messages sent in the private side
P_{POS}	Messages sent with positive mood in private side
P_{NUL}	Messages sent with neutral mood in private side
P_{NEG}	Messages sent with negative moods in private side
PUB_{RADAR}	(x,y) are the coordinates of the subject within the public radar r.
PRI_{RADAR}	(x,y) are the coordinates of the subject within the private radar

These experimental observables are considered as potential order parameters of the system (i.e., dependent variables). We do not investigate here the communication contents and their characteristics, like length, syntactic or semantic structure of the messages, that will be the subject of a future study. The time-series data were analyzed by means of a Perl script. We obtain a series of three-dimensional matrices W_t representing the cumulative number of events produced by subject *i* and directed to subject *j* at time *t*,

$$W^t_{ij} = \sum_{t=0}^{t} M^t_{ij}, \tag{1}$$

where M^t_{ij} = 1(0) denotes the presence (absence) of a message from *i* to *j* at time *t*.

We normalized these data as stochastic matrices P^t_{ij},

$$P^t_{ij} = \frac{W^t_{ij}}{\sum_j W^t_{ij}}, \tag{2}$$

where the element P^t_{ij} represents the probability that at some time t a communication occurred from *i* to *j*, and clearly $\sum_j P_{ij} = 1$.

The public and private radar data were recorded as three-dimensional matrices where each element D^t_{ij} represents the Euclidean distance between the coordinates of the *i* avatar and those of the *j* one at time *t*. Finally, we reconstructed the closeness among the subjects, here intended as the complementary of the distances, collected in the matrices *V*. For the private radar, the item V^t_{ij} represents the closeness among *i* and *j* in the radar handled by the subject *i*, while the item V^t_{ji} refers to the private radar of subject *j*.

The time activity a^t_i is defined asy

$$a^t_i = \sum_{j=1, i \neq j}^{N} \frac{W^t_{ij}}{t}. \tag{3}$$

This parameter was collected from the public and the private communications, and from radar manipulation.

We tried to put into evidence the topological and metric characteristics of the interaction network by introducing quantities like the centrality degree and the betweenness centrality degree, used in the theory of network analysis. The centrality degree c^t_{ij} is defined as

$$c^t_i = Tr(P^t)^2_i. \tag{4}$$

It represents the weighted numbers of arcs per node, i.e.,, the normalized total number of contacts received at some time $\tau < t$ by node i. The centrality degree of a node is the parameter most easily studied because it discriminates the characteristics of a complex network [15]. The betweenness, the closeness and the degree of a node are a standard measures of the centrality of the node, originally introduced to quantify the importance of an individual in a social network [16,17]. Considering the peculiarities of little group dynamics phenomena we here adopt a wide definition of centrality, considering the probability of an interaction as a direct measure of "social distance between two individuals. As a consequence centrality would be defined on a continuous domain in [0, 1].

The betweenness centrality degree is

$$b^t_i = \sum_{j,k \in N, j \neq k} \frac{S^t_{jk}(i)}{S^t_{jk}}, \tag{5}$$

where $S^t_{jk}(i)$ denotes the sum of the minimum weighted paths joining nodes *j* and *k* and passing trough node *i* at time *t*, and $S^t_{jk} = \sum_i S^t_{jk}(i)$. The node with the higher degree of betweenness is the one that manages the flow of information within the network. Therefore it provides information about its structural importance for the communications among the members of the group [14]. The two experimental conditions should allow the exploration of the differences between the appropriate (i.e., optimal and stable) strategies required.

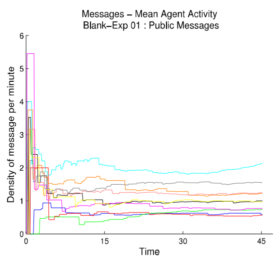
As a first step we studied the main differences among all the experimental observables taken into account, computing the student t statistic considering the two series of five experiments as independent sample

As a final step we study the cognitive heuristics used by the subjects to face with the social problem solving process elicited by the task [24], we investigate some regression models that relate the private radar betweenness b_i (e.g., personal representation of the social space) with the other dimensions.

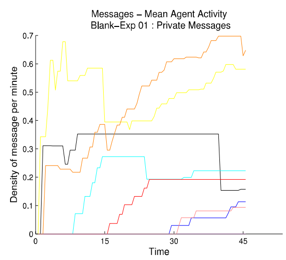
Finally the two best regression models, respectively for the Blank and the Topic modalities, are compared in order to assess both, the sensitivity of the framework and possibly the effects of the cognitive required task (i.e., social problem solving) on group communication topology.

II. PROOF

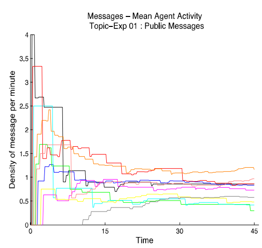
A first and rational class of observables related to human group dynamics is the "activity", Eq. (3). In order to analyse this dimension we consider the total amount of actions for each subjects during the 45 minutes of the experiment. As an example, the activity plot of the first of the ten experiments is shown in figure 2.



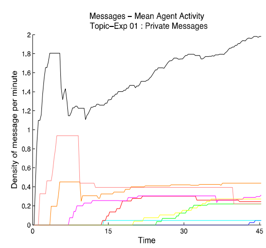
(a) Blank modality public activity



(b) Blank modality private activity



(c) Topic modality public activity



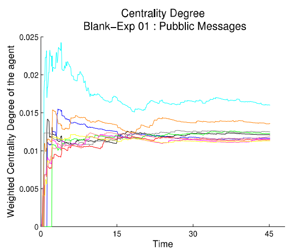
(d) Topic modality private activity

Fig. 2 (a,b) Public vs Private activity in Blank modality (average number of messages exchanged into the public or private area by a subject). (c,d) Public vs Private activity in Topic modality

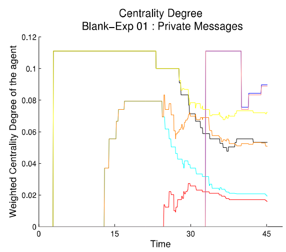
Figure 2-a and 2-c show the average activity of the subjects in the global message dimension for respectively the Blank and the Topic modality. After an initial phase, common to every experimental session, where subjects explore the chat environment and present themselves to each other, the system reaches very quickly for both Blank and Topic modality (in less then 15 minutes), a stationary state where all subjects exchange a comparable number of messages. A remarkable feature is the strong similarity of this observable in all the experiments.

The corresponding behaviour of the activity in the private chat is quite different, as shown in Figure 2-b and 2-d. In this case the individual attitude in exchanging private messages varies significantly, and the pattern appear as different for all the experiment. From a psychological perspective this two ways of communications have to be considered as theoretically quite different, since the nature of the communication strategies implied in dyadic or group dynamics.

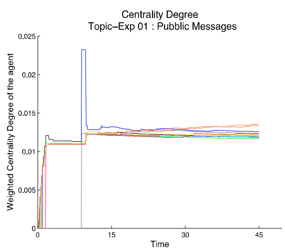
Another important class of observables are represented by the centrality degrees. These variables give qualitative and quantitative informations about the a group structure, and the communications dynamics among the individuals. As shown in Figure 3-a and 3-c, the public centrality quickly tends to a stationary state for both the experimental conditions (i.e., Blank and Topic Modality).



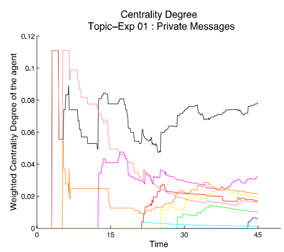
(a) Blank modality public centrality



(b) Blank modality private centrality



(c) Topic modality public centrality



(d) Topic modality private centrality

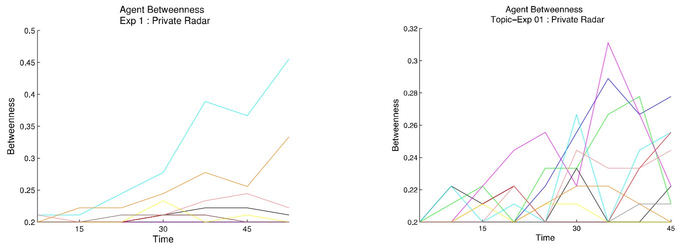
Fig. 3 (a, c) Public centrality degree (weighed centrality degree for all the subjects), and (b, d) Private centrality degree, respectively for Blank Modality (a, b) and Topic Modality (c, d)

At the same time the centrality degree seems able to characterize efficiently the private messages spaces, as shown in figures 3-b and 3-d.

Taking into account the average public centrality degree for all the sessions of the research, we found that always it tends toward a steady state around the value of 0.11, which indicates that we are in the presence of a fully connected network, where each person establish contacts with all the other members of the network. Each node therefore has equal probability of being connected with any other node. This average value holds also for the private centrality degree, despite its irregular character.

The last communication observable we have taken into account is the betweenness centrality degree for all the eleven experimental dimensions. As examples in Figure 4 the temporal series are reported of this function for both the Blank and the Topic modality. In general, this measure has shown an average increasing behaviour over time, always assuming at the end of each session a particular structured hierarchy. This variables appears to be important. since it is able to capture the importance degree of a node has in the topological communication structure of the network.

The average trend of this function along the five experiments composing each experimental session appears as quite different. In the Blank Modality, in Figure 4-a, the hierarchy among subjects seems arise during the first fifteen minutes of interaction, mainteining it for the rest of the session. On the contrary, in the Topic modality, the dynamics of the betweeness degree appears as more complex. In particular for the private radar space, which indicates the representation of the others, it appears to be less stable than in the Blank Modality, and evolving during all the entire duration of the experiment (Figure 4-b).

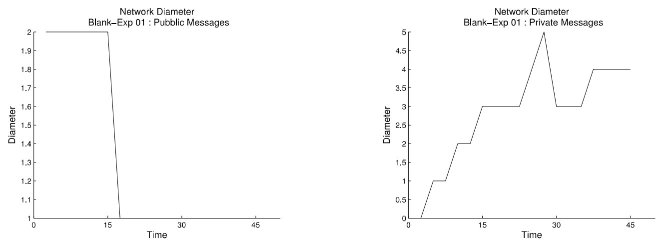


(a) Private radar betweenness Blank modality

(b) Private radar betweenness Topic modality

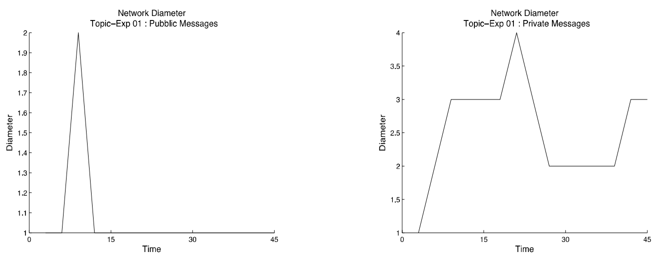
Fig. 4 Temporal trend of the betweenness centrality degree in the private radar. (a) Blank Modality, (b) Topic Modality

The collective network dynamics is reported in Figure 5 using the network diameter as order parameter . In particular the public spaces appear characterized by a simple trend towards a full connected condition for both the experimental modalities, while the private spaces always show a continuous process of clustering



(a) Public Network Diameter Blank modality

(d) Private Network Diameter Blank modality



(c) Public Network Diameter Topic modality

(d) Private Network Diameter Topic modality

Fig. 5 Public and Private temporal dynamics of the network diameters. The public diameter (a, c) show a quite trivial behaviour in both the experimental conditions. On the other hand the diameter of the network determined by the private messages appear as more informative, for both the Blank and the Topic Modality (b, d)

After the exploration of the graphical behaviour of the experimental observables we used some inferential statistics in order to profile the peculiar subjects strategies among the two experimental conditions. The activity related variables shows many large differences on the subjects' communicative behaviour. In particular, the communication rates are significantly larger for the Blank modality public and private dimensions (e.g. Activity C_M (45′); t 2.697, $p.$ < .01; Activity P_M (30'); t 3.471, $p.$ < .01), as so as for the communications with "positive" and "negative" mood on the public and private (e.g. Activity C_{POS} (45'); t 4.611, $p.$ < .01; Activity C_{NEG} (30'); t 2.139, $p.$ < .05; Activity P_{POS} (45'); t 4.395, $p.$ < .01.

On the other hand, the neutral messages (i.e., the messages which have a neutral mood/smile) in the public space show the opposite behaviour, and within the topic modality the messages with a neutral mood prevail (e.g. Activity C_{NEU} (45'); t -2.401, $p.$ < .05; Activity C_{NEU} (15'); t -3.085, $p.$ < .01). Finally we dedicated an apposite activity measure of the subject's private radar management, that was just the number of displacement the subjects done during the experiments. Such measure can be interpreted as a direct measure of the complexity or of the length/effort of the subject's process of problem solving. Interestingly also this observable distinguishes significantly the two experimental modalities. In details the subjects belonging to the Topic modality spent a larger period, making more adjustments/displacements on their private radars, than the Blank modality's Subjects (e.g. Activity PRI_{RADAR} (45'); t -2.826, $p.$ < .01). The observables related to the Nodes' Centrality Degree on both the communicative and the radar variables, delineate a similar scenario highlighting some interesting additional aspects. In our framework the centrality degree on the communicative network, indicates the weight of a subject on the entire communicative dynamics, while the same measure for the Private Radar Space represents the degree of closeness that characterizes the subjects' average representation of the community. As happened for the activity related variables, the average Centrality Degree for all the communicative dimension is larger for the Blank modality (e.g. Centrality Degree C_{POS} (45'); t 3.616, $p.$ < .01; Centrality Degree C_{NEG} (30'); t 4.468, $p.$ < .01; Centrality Degree P_M (45'); t 2.356, $p.$ < .05; Centrality Degree P_{POS} (45'); t 4.223, $p.$ < .01; Centrality Degree P_{NEG} (45'); t 2.064, $p.$ < .05), with the only exception of the public neutral messages space where coherently with the activity measures the average degree of the Topic's subjects is greater than the others (e.g. Centrality Degree C_{NEG} (45'); t -4.030, $p.$ < .01). The analysis of the Centrality Degree distributions on the privates' radar spaces has supported the previous results, the average closeness (i.e., the normalized average distance of a subject from the others considering all the subjects' private representations on their private radars) appear as larger for the Blank modality than for the Topic modality (e.g. Centrality Degree PRI_{RADAR} (45'); t 3.375, $p.$ < .01). This result suggests that the cohesion, or the degree of connection among the sub communities, is smaller in the task with more cognitive constraints. The subsequent analysis of the betweenness centrality has confirmed and replicated accurately the previous results, and has indicated the betweenness as an more stable and clean indicators of the centrality degree for the Private Radars' space (e.g. etweenness $P\ RI_{\ RADAR}$ (30'); t -2.512, $p.$ < .05). As a consequence of a minor average centrality degree, the nodes belonging to the topic experiments are characterized by a greater average betweenness, that is the destruction of a single link could operate an abrupt change of the network topology. Finally, in order to estimate the cognitive heuristics used within the two experimental conditions (i.e., Blank and Topic) we produced the two best regression models, that is the two significant models characterized by the maximum explained variance (r.^{2}) and the minimum standard error.

As dependent variable of the regression models we choose the final betweenness (i.e., the betweenness after 45') of the subjects on the Private Radar Space of its community/group.

TABLE 2 PREDICTORS COEFFICIENTS OF BLANK MODALITY'S BEST MODEL

Predictor	Stand. Coefficient	*t*	Sig
Activity in Community Messages (15')	$\beta_1 = .599$	2.783	p. < .01
Centrality in Community positive Messages (45')	$\beta_2 = .277$	2.830	p. < .01
Betweenness in Community positive Messages (45')	$\beta_3 = .274$	7.063	p. < .01

The best regression model for the Blank Modality is defined by three communicative dimensions (2), respectively: the activity in public positive messages in the first third of the experiment ((C_M) 15′ *Act*), the final centrality degree in the positive public messages space ((C_{POS}) 45′ *Cen*) and the final betweenness degree in public messages space with positive mood ((C_{POS}) 45′ *Betw*).

The final regression model for the Blank modality can be consequently written as:

$$b(i) = b_1(C_M)15'Act(i) + b_2(C_{POS})45'Cen(i) + b_3(C_{POS})45'Betw(i) + e(i),$$

where b_i is the betweenness of the subject *i* on the Private Radar Space at the end of the experiment, ((C_M) 15′ *Act* is the activity in the public messages space in the first third of the experiment, (C_{POS}) 45′ *Cent* is the centrality degree in public positive messages and (C_{POS}) 45′ Betw is the betweenness degree in the public messages space with positive mood.

TABLE 3SUMMARY OF THE BLANK MODEL

r.	Adj. r.^{2}	*Std. Er.*	SS_{model}	SS_{res}	*F*
.823	.656	.03	,081	.039	32.163*
SS: Sum of squares *: p.<.01*					

As reported in table 3 the Blank model explains the 65% of the variance of data. Moreover the model suggests a possible strategy used by individuals to structure their "perceived social space", apparently strongly related with the communicative role assumed by others during the public interaction.

TABLE 4 PREDICTORS COEFFICIENTS OF TOPIC MODALITY'S BEST MODEL

Predictor	Stand. Coefficient	*t*	Sig
Activity in private radar (30')	$\beta_1 = .517$	4.410	p. < .01
Betweenness in Community negative Messages (15')	$\beta_2 = .271$	2.310	p. < .05

The best regression model for the Topic Modality delineate a reality completely different. It is defined by only two dimensions, one communicative and one related with the use of the private radar during the experiment (4), respectively: the activity in the management of the private radar during the first 30'of the experiment ((PRI_{RADAR})30' *Act*) and the betweenness in the negative first 15' public massage space ((C_{NEG})15' *Betw*).

The final regression model for the Topic modality can be consequently written as:

$$b(i) = b_1(PRI_{RADAR})30'Act(i) + b_2(C_{NEG})15'Betw(i) + e(i),$$

where b_i is the betweenness of the subject *i* on the Private Radar Space at the end of the experiment, (PRI_{RADAR})30' *Act* is the number of displacements done by the subject *i* after 30' of experiment and (C_{NEG})15' Betw is the betweenness degree in the public messages space with negative mood. As reported in table 5 the Topic model explains only the 33% of the variance of data. This result puts in evidence that the variability of the subjects' strategies within the Topic sessions is greater than within Blank sessions, and that they are less captured by the chosen observables with respect to the Blank case.

TABLE 5 SUMMARY OF THE TOPIC MODEL

r.	Adj. r.^{2}	*Std. Er.*	SS_{model}	SS_{res}	*F*
.589	.330	.04	,033	.060	13.057*
SS: Sum of squares *: p.<.01*					

Of course the model suggests that the strategy used by individuals is mainly related to other external aspects of the communications (e.g. the semantic contents). Nevertheless it seems that the more a subject manages its private radar the higher is his betweenness at the end of the experiments. Among the communicative variables the only dimension which explain a significant portion of the dependent variable's variance is the betweenness in the Public negative messages space during the first and apparently crucial minutes of experiment ((C_{NEG})15' *Betw*).

III. CONCLUSION

This study proposes a quantitative approach to the investigation of the existing relationship between the individual dimensions, considering the personal cognition of the interactions with the others, and the group dimension, trough its dynamical evolution.

We have present a research framework consisting of a standard chat environment with some enhancements, such as the social and spatial representation of subjects by mean of "virtual" two-dimentsional playgrounds (radars). The chat was ergonomic and user friendly: all subjects performed the experimental task without problems, as demonstrated by the analysis of activity in time, where we do not observe any drop in interest and participation. The message rate was constant for the duration of a session, after an initial phase of thermalization of the group. We can assume that the proposed interface is very efficient for the subjects with a high confidence with new technologies and the type of assignment task. We have developed a set of analytical tools, with the goal of detecting some relevant characteristics of the group dynamics. The analysis is independent of the semantic content of the exchanged messages, and the standardized interface avoids hard-to-detect non-verbal communications, still providing the expression of emotional contents. The subsequent analysis, mixing social network theory and concepts from social and opinion dynamics, allows us to investigate quantitatively how people creates their social space in virtual interactions, exploring the role of topology and the structure of the group evolution. Finally, we indicate a regression model to explain how the virtual social space is represented by the individuals in group interaction.

It is possible to consider the communication topology, which characterizes a given communicative dimension, as a state variable characterizing the role of different final configurations with respect to the affinity dynamics. In other words, we have started investigating the process by which the representative mental scheme of the community arises. Consequently we designed a neutral task for the detection of quantities. Even in this case, the task appeared to be adequate in terms of cognitive ergonomics.

The observables taken in account represent some potential order parameters to describe the virtual human community. A linear regression method has been used in order to investigate the 'cognitive' strategies adopted by the individuals to "create" their social perception of others both within the Blank and the Topic modality. The dependent variable in the regression model was the betweenness degree in the private radar at the end of the experiment (i.e., the final condition). This observable has been particularly effective to describe the social spaces, suggesting how the individuals detect non-trivial information in order to structure the appropriate cognitive representation of their social space. In particular, the subjects integrate the following dimensions: the average rate of activity in the public messages space during the first third of interaction, the centrality degree in the the public messages space for the whole experiment, and the betweenness degree in the positive messages space. As shown by the model's parameters, the greater effect seems to be played by the third factor, while the others have the same weight. The Blank model explains a large amount of the total experimental variance, suggesting that the individuals tend to adopt a quite common strategy which is well captured by the considered experimental observables.

At the contrary the Topic model is less effective than the Blank to explain the experimental variance ($r^2 = .33\%$) and the strategy is less intelligible from the regression model. Interestingly the model shows a dependency from the management of the private radar, which is an information not directly available by the subjects. The only communicative variables which appears in the model is the betweenness in the public negative message space, and particularly in the degree of the subject after the first 15 minutes of experiment. This result suggests that some relevant aspects are missing in the model, but also that the strategies used by subjects to face with the Topic task are both more variegated and complex than those shown within the Blank task, that is the cognitive heuristics adopted by the subjects are different.

The experimental data appear to be consistent with the classical psychological theories and description of little group dynamics. More precisely the differences between the public and private space with respect to many of the observables previously describe, confirm well known axioms in psychology: that is, individuals use different strategies with respect to the environmental condition (i.e., when they participate to a group interaction or when they are engaged into a dyadic conversation). Furthermore the knowledge of both microscopic and macroscopic dynamics are required in order to explore and understand the human group dynamics.

In conclusion, we present a framework to study the small group dynamics trough a virtual setting. After a preliminary definition of some features of interest both at the individual and collective level, we have demonstrated how it is possible to design real experiments to relate different cognitive aspects of this processes. Among the others, an interestingly topic is how the 'perceived social distances' should be both revealed (measured) and represented. Our preliminary results suggest that besides the artefact experimental conditions, and the generality of the task, a sort of optimal strategy seems to emerge, intended as the strategy which maximizes the social success. Obviously, the present vision of the investigated social dynamics is too limited to abstract so general insights. Further experiments are required to explore different aspects and processes. Nevertheless, the present data represent a baseline for the interpretation of futures experiments.

ACKNOWLEDGMENT

This research has received funding from the European Union 7th Framework Programme, RECOGNITION, grant No. 257756.

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