Networked Flow in Creative Collaboration: A Mixed Method Study

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Abstract

The recent model of Networked flow (NF) mapped out factors underlying optimal creative collaboration in blended spaces (physical and digital). NF conceives creativity as an evolving network bridging material and symbolic resources of the creative collaboration process at both inter and the intra-group levels. First, this model posits that optimal group creativity is characterized by highest levels of the experiences of flow and social presence. Secondly, these experiences should stem from a peculiar group communicative structure. Therefore, group creativity should be studied through a mixed-method approach focusing on experiential and structural features of group collaboration, on their evolution, and on group artifacts. Here, we measured the evolution of 10 groups' structural dynamics by means of Social Network Analysis (SNA), and we assessed group experience through group flow experience (Flow State Scale) and social presence (NMSPI). Moreover, four independent raters evaluated the creative products through a domain-based approach, that is the Consensual Assessment Technique. Finally, we deepened the analysis of the highest creative group' micro-interaction through the qualitative approach of Interlocutory Logic. Group flow and social presence were positively related. Both experiential dimensions and creative outcomes were predicted by specific SNA indexes. Qualitative approach of Interlocutory Logic and an analysis of most and least creative groups' sociograms, suggested two structural patterns underlying optimal group creativity instances. Specifically, even a few but well-aimed interactions could facilitate the emergence of higher creativity levels, which could emerge silently, with few but effective interactions, or explicitly, with several (mostly) democratic exchanges among members.

Introduction

For many years, research on creativity focused on an individual level of analysis, following up the romantic image of the "lone genius" (e.g., Montuori & Purser, 1995; Eisler, Donnelly, & Montuori, 2016; Sawyer, 2007) and identifying key personal factors sparking unique and useful ideas. However, now, scholars are becoming increasingly aware of the importance of socio-cultural factors in shaping creativity (e.g., Glăveanu, 2010). Creativity viewed as an individual-level phenomenon emphasises

more intrapersonal processes (Walton, 2003) compared to interpersonal ones, such as the role of social, cultural, and physical contexts.

The perspective on creativity as a systemic and context-dependent process is reinforced by the words of Csikszentmihalyi:

We cannot study creativity by isolating individuals and their works from the social and historical milieu in which their actions are carried out. This is because what we call creative is never the result of individual action alone. (1988, pp. 325–326)

Creativity theories based on individual factors and on socio-cultural processes can appear as incompatible, yet a recent model proposed a feasible way to integrate both. The *We-paradigm*, introduced by Glăveanu, includes individual-based theories as part of a complex creativity system (Glăveanu, 2015) and relies on a distributed creativity concept (Hutchins, 2006) as a phenomenon dwelling beyond individuals' minds and consisting of a *network* of people, cultural and material artefacts, as well as their relationships across time.

Along this line of thinking, Gaggioli, Chirico, Mazzoni, Milani, and Riva (2017; Gaggioli, Mazzoni, Milani, & Riva, 2015; Gaggioli, Riva, Milani, & Mazzoni, 2013) have developed a theoretical and methodological framework – (*Networked Flow*) – which posits the concept of creative networks as a means to capture the complexity of collective creativity (Gaggioli, et al., 2013). The core of this model rests on three ideas.

First, the concept of "group creativity" is extended by introducing the notion of *networked creativity*, relying on the *structural* dynamics among individuals, material, and symbolic resources as part of the same creative collaboration process. That is, groups achieving optimal creativity levels also show a *peculiar network structure*, also including communication arte-facts used by group members to collaborate – i.e., online collaboration platforms, groupware tools, social media, etc. (Gaggioli, et al., 2013). The NF model captures the "blended" side of communication prevailing in creative collaboration practices when people combine in-presence communication and mediated communication for achieving a common goal (e.g., Bell, Sawaya, & Cain, 2014; Hinds, Kiesler, & Kiesler, 2002; So & Brush, 2008). The NF model states that it is possible to achieve optimal group creative performances even in mediated communication exchanges, thanks to a peculiar *quality of group experience*. That is, when group members experience the highest levels of social presence (i.e., sense of being cognitively, behaviourally, attentively, and emotionally interconnected with other people in the real and virtual world; Biocca & Harms, 2011) and flow experience (i.e., an optimal psychological state associated to outstanding group performance; Diana, Villani, Muzio, & Riva, 2012; Jackson & Eklund, 2002; Jackson & Marsh, 1996), they enter a *Mutual Zone Of Proximal Development (MZPD*) (Goos, Galbraith, & Renshaw, 2002; John-Steiner, 2000) (i.e., members share the same frame of reference, and co-build a collective intention) at the base of optimal group creativity levels. Following up Vygotsky's model, John-Steiner and Mahn (1996) stated that the participation to group activities would allow sharing collective knowledge and its final internalisation in peoples' consciousness. All group members scaffold each other, and this process allows the network's ideas development. This collective space has been conceived as a "*Mutual Zone Of Proximal Development*" (Armstrong, 2008) where people can negotiate shared meaning and generate and pursue collective intentions (Sawyer, 2007).

Finally, to assess the emergence of the MZPD, the analysis of microlevel qualitative communicative interactions among group members is also required. The main goal of the present study was to investigate creative collaboration through the lens of the NF model, using a mixed-method approach.

More specifically, we zoomed in on the relationship between the aforementioned key components of the model:

1. *Communicative structure* (to identify network markers of optimal creativity);
2. *Quality of experience* (to investigate flow and social presence);
3. *Communicative interaction* (to assess the collective zone of proximal development and dialogical style);
4. *Creativity performance* (to assess the final product of the creative collaboration).

At the methodological level, these tenets can be translated into three main operative requirements. A first requirement is to consider both structural and experiential features of creative collaboration and its outcomes, thus focusing on the quality of group experiences, on the structural features, and on the creative product. The structural dynamics of group collaboration can be detected using Social Network Analysis (SNA) (Scott, 2000). Then, the experience of group involvement can be measured through group flow experience (Csikszentmihalyi, 1990; Diana, et al., 2012; Jackson & Marsh, 1996) and social presence (Biocca & Harms, 2011). Finally, the creative product should also be analysed through a domain-based approach, such as the Consensual Assessment Technique (Amabile, 1982). As a second requirement to examine the evolution of the creative collaboration, we should focus on micro, meso, and macro levels of interaction, that is, on the interaction patterns between group participants over time (micro-level); on the structural changes in internal group dynamics (meso-level); and on the outcomes of micro and meso interactions, i.e., transfer of the creative product (the artefact) over a larger socio-cultural context (i.e., a community: the macro level).

As a third requirement, in order to identify the possible links between the experiential features of NF (social presence, flow) and the inherent dialogical structure of group dynamics, qualitative and quantitative data need to be collected. A key prediction of this model concerns the role of a specific group structure in facilitating (or not) the emergence of an optimal group experience and creative performance.

To meet all these requirements in a consistent way, a longitudinal, mixed methodology, combining qualitative, quantitative, and topographical analysis of NF process (Galimberti, et al., 2015), has been developed. Here, the term "mixed methodology" refers to the procedure of collecting and analysing heterogeneous types of data within the context of a single study. Then, it was investigated that the emergence of the NF process in ten groups of university students tasked with the ideation of a videoclip over 11 weeks within the context of a university teaching course on "Enterprise Communication" at Università Cattolica del Sacro Cuore. They were not told explicitly to produce "creative" ideas. We assumed that a peculiar group structure was able to promote (or hinder) group optimal experience and group creative performance. We longitudinally analysed the groups' network structure by extracting online communication datasets from social media applications used by the teams to collaborate, and then we integrated.

Method

Sample

This study took place during the winter semester. It involved 111 undergraduate students (30 males and 81 females, mean age = 24.44; SD = 3.75) enrolled in a course on "Enterprise Communication" at the Università Cattolica del Sacro Cuore. The Ethical Committee of Università Cattolica del Sacro Cuore assessed and approved the experimental protocol. Each participant provided written informed consent for study participation in accordance with the Helsinki Declaration. Students participated in

the study on a voluntary basis, and they did not receive rewards or credits. They were aware of each stage of the research process.

Setting and Experimental Design

The course on "Enterprise Communication" at the Catholic University of Milan focuses on topics related to the design, management, and assessment of communication processes within groups and organisations. As part of the final assignment of the course, students worked in groups and created a multimedia project (i.e., including photographic, video, and audio materials) addressing the topic of improvisation in organisational settings. This is an open-ended task, related to a specific domain, in which students were trained during the course. During task execution, students were invited to collaborate both face to face or using two widespread and free social media applications (Facebook and WhatsApp). The course combined both frontal lessons and commentaries from experts in the field of improvisation.

The study consisted of a longitudinal design, in which social network data were collected from online group interaction over 11 weeks of project collaboration. The research protocol also: included (i) an assessment of group quality of experience in the last week of collaboration; (ii) a collection of conversational data; and (iii) the creative product assessment by independent experts in the domain (Figure 4.1).

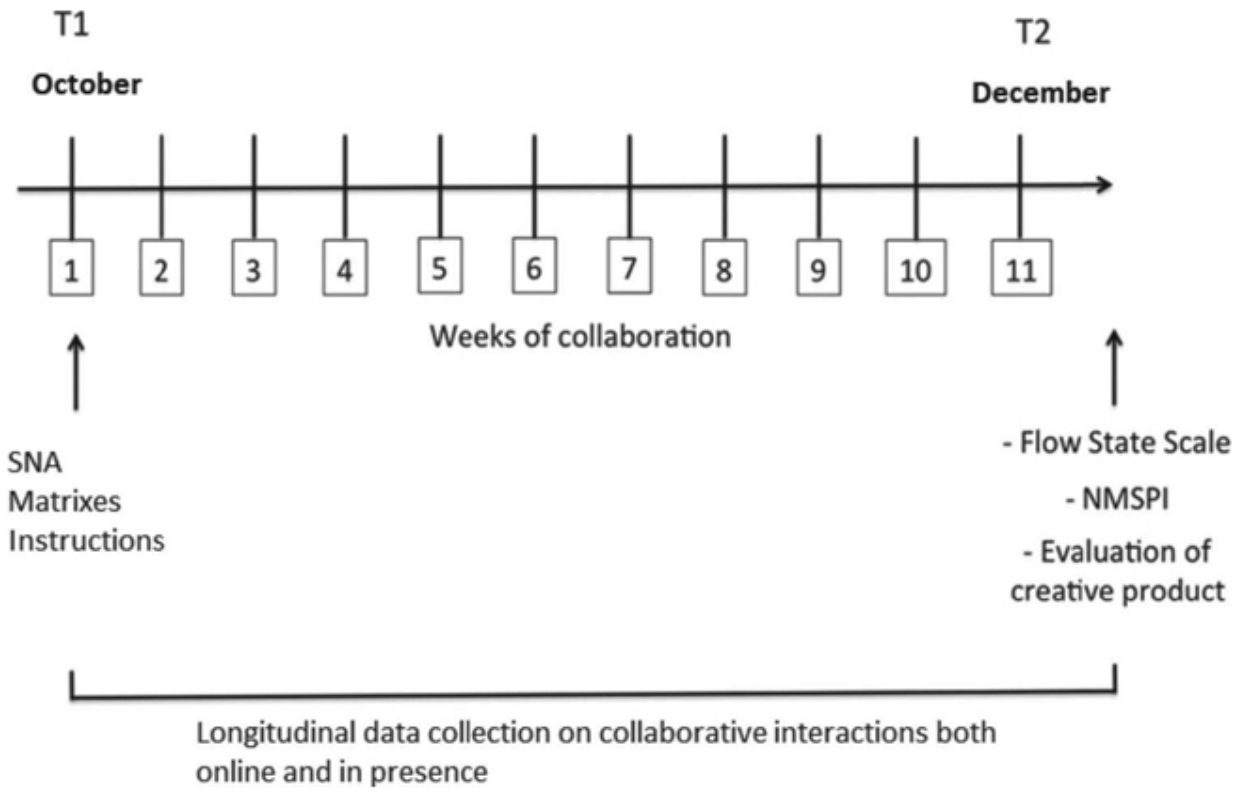

Figure 4.1 Graphical representation of the research flow

Measures

This mixed methodology integrated four measurements: (i) *communicative structure* (to identify network markers of optimal creativity); (ii) *quality of experience* (to investigate flow and social presence); (iii) *communicative interaction* (to assess mutual zone of proximal development and dialogical style); and (iv) *creativity* (to assess the final product of the creative collaboration).

Communication Structure

NF considers both processual and structural features of collaboration and its outcomes (e.g., the creative product). Therefore, the Social Network Analysis (SNA) technique was used to analyse communication exchanges as an index of group structure. This analysis has been already successfully implemented to study creativity and friendship (McKay, Grygiel, & Karwowski, 2017). SNA is a quantitative method to analyse real (Zohar & Tenne-Gazit, 2008) and virtual interactions (De Laat, Lally, Lipponen, & Simons, 2007; Palonen & Hakkarainen, 2013). Any kind of interaction among group members can be examined (e.g., money, friendship, information) and represented into two formats: numerical and graphical. The resulting group structure can be visualised as graphs (i.e., *sociograms*), representing the members as nodes of the graphs and the exchanges among them as lines in the graphs. Alternatively, group structural characteristics can be encapsulated into numerical indexes, which can be individual indices (i.e., based on relations and exchanges characterising each actor of the networks) or group indices (i.e., based on relations and exchanges characterising the network as a whole). To study the NF, different structural SNA indices have been proposed, such as *Density*, *Group Centralisation*, and *Cliques Participation index* (CPI) (Table 4.1) (for a full description of these indexes, see Gaggioli, et al., 2015). Furthermore, it is possible to carry out SNA either focusing on the group structure at a precise moment in time or adopting a longitudinal approach, thus taking multiple "snapshots" of the network structure over time. In this study, a longitudinal structural data analysis concerning group exchanges across 11 weeks was carried out. SNA data were collected every week, but we split the collaboration process in three phases according to the instructions provided to participants during the course. First, groups were created. Central weeks dealt with group collaboration. Last weeks concerned the final stages of collaboration after the delivery of the group product. Here, given the crucial role of central weeks of collaboration for the emergence of a specific group structural pattern (Galimberti, et al., 2016), we focused on the time window ranging from the 4th week to the 9th week, the middle stages of the collaboration process.

Table 4.1 Metrics for social network analysis

Factors	*Measures*
Density	Represents the intensity of communication/ collaboration within the group: the relationships expressed with respect to the maximum of possible relationships (percentage that describes how much in a group everyone has interacted or looked at all the other group members).
InDegree Centralisation	Represents the inequality in the intensity of incoming interaction; the more this value increases the more there are individuals who have received a greater intensity of communications/collaborations (i.e., the more a person receives relations or exchanges, the more he/she is relevant for the analysed dynamics).
OutDegree Centralisation	Represents the inequality in the intensity of outgoing interactions; the more this index increases the more there are students who have sent/started a greater intensity of communications/collaborations (i.e., the more a person activates relations or exchanges the more he/she is influent).
CPI (Cliques Participation Index)	Considers not only the number of cliques (i.e., subgroups) but relates it to the total number of members for each group. Identifies the average involvement of each subject in the existing subgroups

Finally, dichotomous relations (the relation is present/not present) were calculated to perform correlation analyses and comparisons, and to analyse the structural features of each group.[1]

Quality of Experience

We investigated group quality of experience in reference to the constructs of flow and social presence, as indicated by the NF model (Gaggioli, et al., 2013, 2015).[2]

Flow was assessed using the Italian version of the Flow State Scale (Diana, et al., 2012) initially developed by Jackson and colleagues (Jackson & Marsh, 1996; Jackson & Eklund, 2004), a widely

used 36-item self-reported questionnaire on a 5-point Likert scale. Each item taps one of the nine dimensions of flow (Csikszentmihalyi, 1990; Jackson & Csikszentmihalyi, 1999). This scale showed an acceptable internal consistency (global mean Cron-bach's alpha = 0.83) (Jackson & Marsh, 1996). A total flow score for each dimension (ranging from 4 to 20) was obtained by summing the scores of the single subscales. The range of scores for individual flow is from 36 (lowest flow) to 180 (highest flow). Global group flow score is computed by summing the average flow score for each of the individual team members.

Social presence was assessed using the *Networked Minds Social Presence Inventory* (NMSPI), a 34-item scale developed by Biocca and Harms (Biocca & Harms, 2003, 2011; Harms & Biocca, 2004) and adapted into Italian (Gaggioli, et al., 2017), also for non-mediated settings. Here, we focused on the first- and second-order constructs of social presence (Figure 4.2).

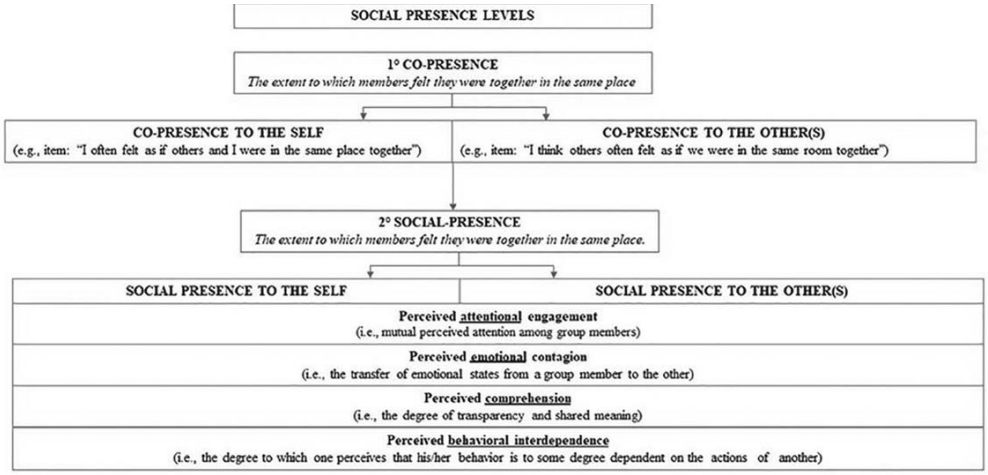

Figure 4.2 Social presence concept and Networked Minds Social Presence Inventory schema

The internal consistency of the scale is high (mean Cronbach's alpha = 0.83). Here, we computed a global level of social presence by summing the co-presence and second-order social presence dimensions scores for each team.

Communicative Interactions

We investigated communicative interactions in relation to the concept of *Mutual Zone Of Proximal Development* (MZPD) and dialogical style. The focus was on dialogical processes in conversations (i.e., dialogical patterns between participants during their group's activity; Galimberti, et al., 2016) analysed by means of Interlocutory Logic (Trognon & Batt, 2010). The qualitative analysis of macro-sequences of idea-generating processes is aimed at identifying potential dialogical markers of NF, such as:

- the ratio between conflicts produced and conflicts resolved;
- the number of group members that take part in the conversation;
- indicators of role fluidity: organisational/institutional roles, enunciative roles;
- team management processes (problem solving, decision making, etc.) supported by internal or external (material and/or human) resources;
- type of problems and the created ethnomethods used to solve them;
- number of subroutines that the group can/cannot solve;
- prevalence of dialogical continuity over monological coherence;
- the ratio between successful and satisfied speech acts and the total number of speech acts.

Creative Performance

Four expert judges in the domain of Enterprise Communication independently evaluated each group's creativity using the *Consensual Assessment Technique* (CAT) developed by Amabile (1982). This procedure involves participants with instructions for creating (in this case) group artefacts and asking experts to independently evaluate the creativity levels of those products (Amabile, 1982). Following this procedure, we asked four raters to judge the creativity levels of group artefacts on a 7-point scale, using their expertise on creativity in this domain.

Procedure

At the beginning of the course, ten self-selected student groups (size 8–11 members) were tasked with the creation of a multimedia product (time constraint: 11 weeks) on the theme of "improvisation" in organisational settings. The instructions were as follows:

Please, get inspiration from experts, who talked during our lessons, or from other elements presented during our lessons and related to the topic of "improvisation", to create a multimedia product (min 3 minutes – max 5 minutes length) in which the topic of "improvisation" is represented.

They were allowed to collaborate through (a) face-to-face meeting sessions in the classroom – video-recorded by students themselves and used to carry out qualitative analyses of dialogical interactions (2-hour session once a week), and (b) virtually – using two social media platforms (Face-book and WhatsApp as they chose – both or one), analysed by means SNA. Teams created either a WhatsApp group or a Facebook group to exchange information supporting their collaborative process. To collect data related to online interactions, a critical issue was how to safeguard students' privacy, following the recommendation of the Ethical Committee. To address this issue, we asked and taught students themselves to collect data related to their online conversations and create the adjacency matrixes, i.e., a square matrix used to represent relational data as a starting point for SNA.[3]

Data Analyses

Results

A global creativity score for each group was computed, given the high level of consistency among raters (Cronbach's alpha = .729). Considering the aim of this study and the longitudinal nature of SNA data, all analyses were carried out at group level (ten groups). First, the focus was on the relationship between SNA indexes, quality of experience, and group creativity scores. Then, the SNA analysis was deepened by considering the structure of communication exchanges in three groups, which showed the highest (Group A, Group B) and lowest (Group C) creativity scores. The choice of these groups was determined by the interactive dynamics showed by their members that were interesting and suitable for the following qualitative analysis. Finally, the analysis concerned verbal exchanges at quantitative levels – by means of SNA – and qualitative levels – through Interlocutory Logic analyses of conversation. Two normality tests (i.e., Kolmogorov-Smirnov and Shapiro-Wilk) showed that variables were normally distributed. Then, Pearson correlation coefficients indicated positive correlations between global and subdimensions of flow and social presence, as reported in Table 4.2. Results showed that Global Flow and Global Social Presence were positively and highly correlated. Moreover, $rwg_{(j)}$ indexes for Flow and Social Presence factors were computed in order to justify the aggregation of scores, as reported in Table 4.3. To test the relationship between structural dynamics (SNA), creativity, flow, and social presence, we carried out a Generalized Linear Model which can accept a violation of sphericity and collinearity (Agresti & Kateri, 2011; Mackinnon & Puterman, 1989). Therefore, three models were tested, including all SNA indexes (i.e., Density, Indegree Central-isation, OutDegree Centralisation, CVIndegree Centralisation, CVOutdegree Centralisation, CPI) for predicting creativity, group flow, and social presence levels. By calculating

these SNA indexes, based on exiting literature (such as Freeman, 1978; Mazzoni, 2014), dichotomous data become continuous, as they represent interconnected dynamics of the entire network. In Table 4.4, all the tested models are reported. Group creativity was significantly and positively predicted by OutDegree Centralisation and InDegree Centralisation, although in an opposite direction. Flow was negatively predicted by Density, but positively by CPI. Finally, Density predicted Group Global Social Presence negatively. The analysis was deepened by focusing on three groups, which were selected because they showed the highest (Group A, Group B) and lowest creativity scores (Group C). Given the crucial role of central weeks of collaboration for the emergence of a specific group structural pattern (Galimberti, et al., 2016), only the time window ranging from the 4th to the 9th week was considered.

Table 4.2 Pearson's correlations between global and sub-dimensions of Flow and Social Presence

	Perception of the Self					*Perception of the Other*					
	Co-presence	*Attentional Engagement*	*Emotional Contagion*	*Comprehension*	*Behavioural Interdependence*	*Co-presence*	*Attentional Engagement*	*Emotional Contagion*	*Comprehension*	*Behavioural Interdependence*	*Global Social Presence*
Challenges Skills Balance	.58	.65*	.41	.74*	.81**	.59	.53	.49	.68*	.59	.67*
Action Awareness Merge	.91**	.66*	.49	.88**	.87**	.86**	.80**	.56	.82**	.62	.84**
Clear Goals	.73*	.44	.46	.77**	.83**	.68*	.59*	.56	.71*	.57	.73*
Unambiguous Feedback	.55	.32	.36	.67*	.81**	.53*	.58*	.53	.64*	.60	.64*
Concentration	.84**	.59	.65*	.86**	.93**	.75*	.70*	.75*	.83**	.71*	.87**
Paradox of Control	.69*	.41	.28	.73*	.78**	.65*	.70*	.46	.73*	.55	.67*
Loss of Self	.86**	.67*	.38	.78**	.75*	.82**	.83**	.51	.81**	.53	.77**
Time Transformation	.86**	.75*	.66*	.79**	.78**	.79**	.60	.61	.62	.48	.79**
Autotelic Experience	.57	.38	.68*	.69*	.75*	.53	.32	.63	.54	.55	.67*
Group Flow	.81**	.56	.54	.85**	.91**	.76*	.69*	.63	.79**	.65*	.82**

Note: N = ten teams.

*p < .05, two-tailed; **p < .01

Table 4.3 $rwG_{(j)}$ indexes for all Flow and Social Presence scores

Group	*Chall Skills Balance*	*Action Awareness Merge*	*Clear Goals*	*Unambiguous Feedback*	*Concentration*	*Paradox of Control*	*Loss of Self*	*Time Transformation*	*Autotelic Experience*	*Group Flow*	*Co-presence*	*Global Social Presence*
1	0.95	0.88	0.90	0.99	1.00	0.84	0.99	0.93	0.86	0.94	0.98	0.97
2	1.00	0.90	0.83	0.96	0.86	0.85	0.89	0.87	0.84	0.96	0.96	0.97
3	0.93	0.83	0.89	0.90	0.87	0.87	0.88	0.83	0.89	0.94	0.95	0.95
4	0.88	0.88	0.75	0.82	0.89	0.87	0.93	0.76	0.85	0.94	0.96	0.97
5	0.89	0.90	0.93	0.89	0.93	0.92	0.87	0.94	0.93	0.96	0.99	0.99
6	0.75	0.91	0.70	0.79	0.78	0.77	0.90	0.83	0.71	0.89	0.98	0.96
7	0.84	0.90	0.91	0.92	0.93	0.94	0.96	0.90	0.80	0.97	0.97	0.96
8	0.94	0.95	0.90	0.92	0.90	0.94	0.88	0.93	0.81	0.97	0.97	0.98
9	0.86	0.92	0.88	0.89	0.96	0.95	0.93	0.94	0.89	0.96	0.99	0.99
10	0.81	0.87	0.83	0.88	0.88	0.96	0.81	0.76	0.76	0.94	0.97	0.95

Note: We computed $rwG_{(j)}$ (>= .70) to calculate interrater agreement. All $rwG_{(j)}$ coefficients are reported in the table. We found all the groups had a $rwG_{(j)}$ value of .7 or higher for all of the scales.

Table 4.4 Generalised Linear Model: SNA indexes as predictors, Group Flow, Global Social Presence, and Group Creativity as measures

Predictors	*Dependent Measures*			
	Statistics	*Creativity*	*Group Flow*	*Global Social Presence*
Density	B	−4.455	−62.518	−159.562
	Wald χ^2	3.236	19.812	7.894
	Sign.	p = .072	p < .005	p = .005
InDegree Centralisation	B	62.151	−79.872	−721.133
	Wald χ^2	4.177	.164	.818
	Sign.	p = .041	p = .685	p = .366
CVInDegree Centralisation	B	.236	−.511	−5.510
	Wald χ^2	.445	.369	2.629
	Sign.	p = .118	p = 543	p = .105
OutDegree Centralisation	B	−62.494	90.761	785.197
	Wald χ^2	4.178	.212	.972
	Sign.	p = .04	p = .645	p = .324
CVOutDegree Centralisation	B	.193	.237	4.923
	Wald χ^2	1.720	.085	2.25.4
	Sign:	p = .190	p = .770	p = .133
CPI	B	.476	7.020	11.487
	Wald χ^2	.959	6.668	1.092
	Sign.	p = .327	p = .010	p = .296

Analysis of Group Structural Dynamics

Because of the richness of SNA data available, we decided to focus the analysis on a subset of groups with well-defined profiles in terms of creativity outcomes, flow, and social presence. The selection criteria are detailed as follows. All groups were ranked based on creativity. Then, groups with the highest creativity scores (i.e., Group A and Group B) and the group that reported the lowest creativity score (i.e., Group C) were identified. Since the aim was to map out relevant structural dynamics involved in creative collaboration, communication exchanges among members were used to build a model of group interactions. However, Group A (highly creative) reported very few online interactions across the 11 weeks of collaboration. Therefore, in line with NF model requirements, we chose to balance this out in two ways. First, we included in the analysis another high-performing group whose exchanges were richer (Group B). Second, we deepened the analysis of Group A by focusing on the micro-level of interaction among members, using the Interlocutory Logic technique (Trognon & Batt, 2010). The analysis of dialogues allowed us to examine more closely the group dynamics and to provide a richer context for the interpretation of the relatively small number of online communication exchanges reported by this group.

In Table 4.5 Group A featured the highest global Creativity scores (i.e., 28) and Group Flow (326), as well as a high Global Social Presence (1038). In terms of SNA, Group A showed low Density and low InDegree Centralisation (Figure 4.2). The sequence of images in the line above showed the amount of interactions between the group across four weeks and during the ending phase (Figure 4.3). This group accrued all interactions between the 8th and the 9th week of collaboration. Images above showed sociograms of interactions during the ending phase (Figure 4.3). The left-bottom image showed the trend of Density, InDegreeCentralisation, OutDegreeCentralisation (we considered only dichotomous values indicating only the presence/absence of an interaction between members), and CPI during the same phase. The right-bottom image represented the same trend for InDegree and OutDegree Centralisation.

Table 4.5 Group Creativity, Group Flow, and Global Social Presence of the selected groups

Groups	*Creativity*	*Flow*	*Social Presence*
A	28	326	1038
B	23	251	851
C	11	225	824

Note: Three out often groups are presented. Scores were computed as sums.

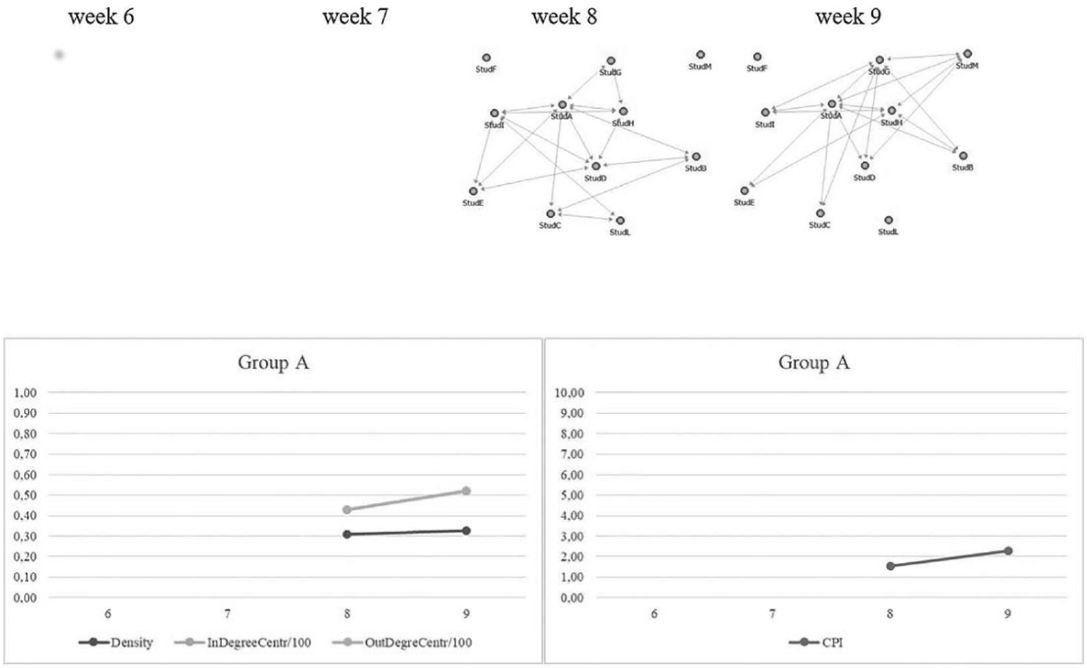

Figure 4.3 Group A SNA indexes across central weeks of collaboration

In Table 4.5 Group B showed a high Creativity score (23), as well as high levels of Group Flow (251) and Global Social Presence (851). SNA data indicated that Group B featured both high Density and high InDegreeCentralisation (Figure 4.4).

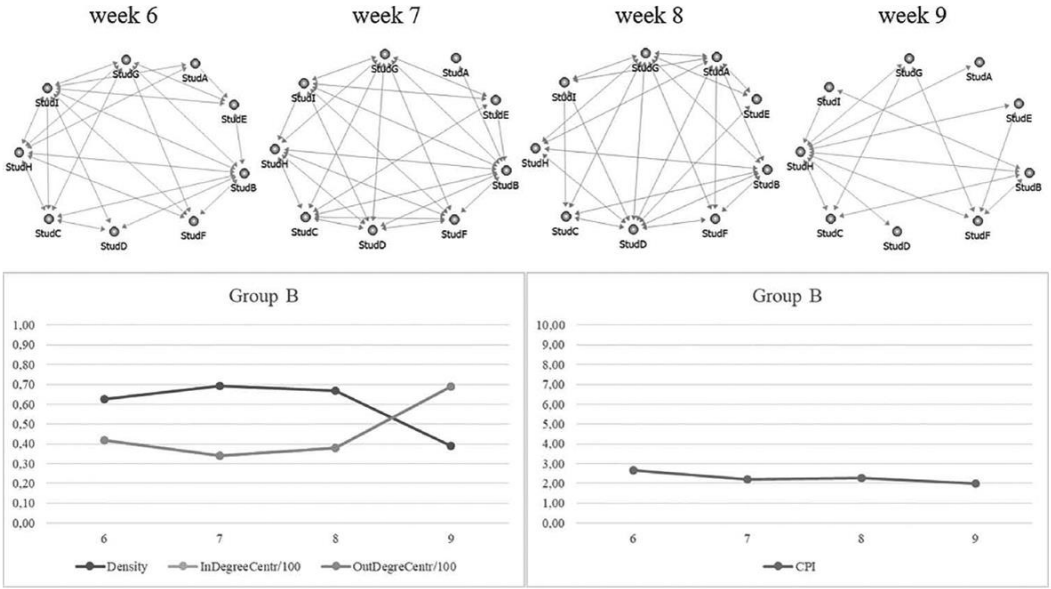

Figure 4.4 Group B SNA indexes across central weeks of collaboration

In Table 4.5 Group C, whose global Creativity score (i.e., 11), Group Flow score (225), and Global Social Presence score (824) were the lowest, showed lower Density but higher InDegree Centralisation indexes compared to the previous group (Figure 4.5).

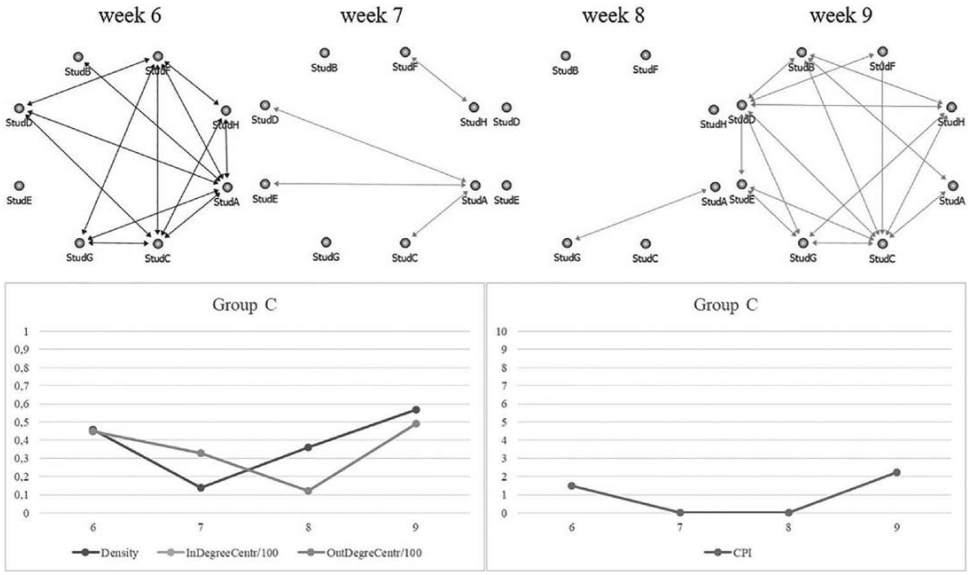

Figure 4.5 Group C SNA indexes across central weeks of collaboration

The analysis of interactions of Group A was deepened following the guidelines of the Interlocutory Logic method. This group was chosen since it was the most informative group, according to the NF model, because it scored highest on creativity. Two recordings of conversations from the first and central weeks of Group A's meetings were considered to find out prototypical macro-sequences of problem-solving or creative (idea-generating) processes. Three sequences from the first meeting and one from the halfway meeting were selected. These sequences were transcribed adopting the most commonly used conventions for transcribing vocal conduct in talk-in-interaction (Sacks, Schegloff, & Jefferson, 1974; see supplementary materials) and revised by two researchers until a high level of consent (agreement rate = 90%) was reached. Crucially, the analysis of the first off-line meeting reported group collaborative dynamics occurring in the "silent" phase of online group collaboration, that is, when no SNA data was collected. The analysis of these sequences identified specific patterns of communicative interactions that may help explain the high creativity scores obtained by Group A, as well as a high level of flow and social presence that were reported by its members.

Results of the analysis highlighted that Group A used the same pattern of "accumulation" of ideas across meetings and that two types of actors mainly managed this process. The first type of actor attended the first meeting and was the functional leader of the team. The second type of actor was absent but was "presentified" through the other participants' discourse. His "fictional" presence was used by the group to regulate decision-making processes. This second type of regulator could be either an absent team member or a person external to the group (in the following example, the regulating figure is the professor of their class). Two excerpts from the sequences are used here to support these analyses.

In this first meeting, group members accumulated and discarded ideas randomly and rapidly, with no specific time management and no clear goal. Members showed a low monological coherence across different topics, but looked for dialogical continuity, necessary to solve the assigned task. This strategy was crucial to mantain group dialogue, and to start shaping the quality of *group experience*.

Excerpt 1

1	G	= and we see ehm: different artists how they react, thus the: [= poet what he writes, the painter what
2		He paints and: [the dancer what he dances:[= and:: that all I think
3	H	[Otherwise you cannot hear
4	E	= th[e painter!
5	H	[Otherwise you cannot hear
6	E	[=Eh!
7		Correct
8	H	*[This is so nice!*
9	G	*[*= And:: then-
10	A	[Then (0.3) or we decide on a common theme, not music, a theme
11	G	A theme:
12	H	[But, that is:
13	-	[=
14	B	[Yeah one says to improv on something, instead a theme is focused
15	G	Then, what she is says is ok, but if you do that it's not real group work. I
16		Think that it depends, that i[s= – depends on how you sell it (0.4), meaning-
17	B	= [that is- (0.3) correct that in my opinion if-
18	C	*Then* in the end there is something made by the group, because everyone is influenced by the same thing
19		So if we rely on the fact that in the end the result is a – group thing (h) it is on point
20	G	In my opinion yes
21	A	Maybe we have to choose ehm: a theme – an idea

Students avoided starting an argumentative discussion to convince the other party to accept or retract his/her standpoint (van Eemeren & Grootendorst, 1992), which is clearly illustrated in line 15, when the student G advances an argument in support of his standpoint: *but if you do that it's not real group work*. Even though the argument advanced by the student was introduced by the linguistic marker "but", which typically indicates the beginning of a disagreement between the participant to a discussion (Schiffrin, 1987), it did not trigger any conflict among the students. Rather, all the students promptly showed their agreement with student G's argumentation. In this case, the absence of impulsive responses and rude behaviours during the argumentative discussions among group members may have played a crucial role in favouring group-creativity (Chiu, 2008; Chiu & Khoo, 2003; Hawlina, Gillespie, & Zittoun, 2017). Recently, several studies have demonstrated the link between the presence of argumentation among group members and the group-creativity levels. For instance, previous studies found that when group members value one another's diverse contributions they create more ideas and justifications (Larson, 2007; Paulus & Brown, 2003; Stasson & Bradshaw, 1995; Swann, Kwan, Polzer, & Milton, 2003). In the same line, De Dreu and West (2001) found that a disagreement among the members of the group might help them consider more aspects of a problem from more perspectives and, accordingly, increase the level of creativity of the group (in this regard, see also Nemeth & Chiles, 1988; and Nemeth & Rogers, 1996). In a similar vein, Gajda and her colleagues (Gajda, Beghetto, & Karwowski, 2017), using a micro-level interactional analysis to visually illustrate patterns of interactions between teachers and students, found more extended and exploratory interactions in classrooms where there was a positive association between students' measured creativity and academic achievement.

Excerpt 2

1	E	*But I think that he ((the professor)) wants us to use music because in my opinionbecause he* – (.) but we – he is
o		Introducing music to us, it's jazz and he linked jazz to organisations, to enterprises, to business
3		etcetera, etcetera – thus perhaps he – thus he brings in music bands for us, otherwise he could have brought in
4		even a painter – [and the painter would have done improv
5	G	[But maybe (0.4) ehm::: a way to demonstrate improv could be
6		I put – a musician and – a painter in the same room and see how they relate to each other = – and I just
7		Ask them "paint according to what you hear or play according to what you see:"

In the second excerpt, the group members accumulated ideas and proposals, analysed each possibility, and solved problems. Then, they moved to another point of the discussion. At that moment, the group

had a specific goal in mind that needed to be reached. Hence, dialogical continuity was no longer a need to be fulfilled. On the contrary, the emergence of small oppositions in the dialogue in Excerpt 2 marked argumentative interactions among the members of the group. Accumulation of topics and ideas advanced as arguments in support of opinions was strictly linked to a sequence of problems and to the attempt to find their solutions. In this case, confrontation – the externalisation of disagreement on a certain standpoint – emerged as a necessary condition for an argumentative discussion to occur. Therefore, recalling how group members dialectically solved differences of opinion was useful to highlight dialogical choices, forms, and dynamics adopted by students.

In conclusion, the results of the qualitative analysis of two excerpts evidenced how Group A members exercised and managed both the *dialogic continuity* and the *monological coherence*, which is at the basis of the ability to manage both the group dynamics and the organisational dimension of the communication process within the group.

Discussion

A key finding concerns the relation between SNA indexes, creativity outcomes, and flow. All SNA indexes resulted as significant predictors of group creativity outcomes, flow, and social presence. These results are in line with a key hypothesis of the NF model on the role of group social network structure as a proxy of creative collaboration. However, as suggested by NF, SNA remains a quantitative method providing rich data that needs to be complemented by an integrative approach (Gaggioli, et al., 2013; Wasserman, 1994) focusing on group performance, optimal experience, and dialogical dynamics.

On group performance, group centralisation indexes (i.e., InDegree Centralisation and OutDegree Centralisation) predicted teams' creative performance, even though in an opposite way. Specifically, the InDegree Centralisation index was positively related to creativity, while the OutDegree Centralisation index showed a negative link with group creative performance. OutDegree Centralisation and InDegree Centralisation indexes are measures of different kinds of groups' leadership dynamics. High levels of OutDegree Centralisation indicate a group structure with all interactions stemming from a specific member(s) – leader(s) – as a group "manager". InDegree Centralisation indicates the extent to which group exchanges are directed towards a specific member(s), intended as a reference point or as an inspirational source.

Consistently, several studies evidenced that network structural dynamics were crucial to achieve a shared goal (Brass, 1984; Burton & Carroll, 2001; Friedkin, 1993; Ibarra & Andrews, 1993; Molm, 1994; Sparrowe, Liden, Wayne, & Kraimer, 2001). Studies on small collaborative web groups showed that High Density and Low Centralisation were associated with better performances (Aviv, Erlich, Ravid, & Geva, 2003; Mazzoni & Gaffuri, 2009; Mazzoni, Gaffuri, & Selleri, 2013). Also, Cliques Participation Index (CPI), defined as the average individual involvement in the substructure (clique), can be conceived as an indicator of small groups' originality and creativity levels, when members are involved in a shared-goal task (Mazzoni, 2014). Here, we found only a significant relationship between group creativity outcomes and centralisation indexes, as a potential consequence of the small number of team members (Mazzoni, 2014). More, the density index was also not a significant predictor of creativity score. This may suggest finer processes underlying group creativity, thus requiring a more detailed approach of analysis. The NF model prescribes to deepen the analysis of the group creativity process by focusing on a micro-level of analysis, i.e., analysing single group exchanges.

As such, we chose to zoom in to three paradigmatic groups (which we called "Group A", "Group B", and "Group C") identified as the highly creative (vs. lowly creative) teams. First, we differentiated

these groups on the base of the interactive dynamics represented by the sociograms. Then, we integrated the structural data from Group A with the dialogical ones achieved though Interlocutory Logic analysis. Group A – the most creative group – accrued interactions during last weeks, but several members interacted and participated. It showed low density and a low centralisation. Despite the lack of online interactions during the first two weeks, members might have been able to bring forth necessary exchanges to generate a creative artefact. Qualitative dialogical analysis showed that Group A proceeded randomly in the initial phases, but it ended with a high level of monological coherence. Once a collaborative frame has been established in the early stages of group work, members might have been able to focus on a common goal: the assigned task. Probably, they just need to interact to share ideas relevant to pursue the goal and be able to promote combination and "confrontation" of different points of view. Maybe, their overall approach led to low centrality and low density, as detected in the final stages of group collaboration. Similarly, Group B (the second most creative group) displayed low density, low CPI, and low centralisation. It also showed, in the final stages, a strong leader to whom information were oriented.

On the opposite side, Group C (the least creative group) displayed a higher centralisation of interactions oriented to specific members across the whole period (higher density and CPI). This pattern might have invalidated group creative performance.

According to findings on small groups and creativity (Aviv, et al., 2003; Mazzoni, 2014), a *democratic* sharing of information and a good but *thriftly* (i.e., the management of interaction was made only when necessary and not as a default control mechanism) managing of interactions could enhance creative performance. Therefore, despite Group C activating more interactions than Group A (i.e., it showed higher Density), its dynamics resulted as not well structured, and this might have lowered the final performance. To date, we adopted a vertical approach of analysis, from creative performance at the networked level (all groups) to the intra-group level (single groups). This investigation might seem exhaustive, but the NF model suggests also a horizontal plane of analysis. NF posited the need to investigate also the quality of group members' experiences.

As concerns group optimal experience, we found that Density and CPI predicted flow experience at the team level. Density, i.e., a measure of participation, was negatively related to group flow, while CPI (i.e., an indicator of members' involvement in different discussions) showed a positive relation with group flow. Therefore, less but diversified exchanges among group members could lead to an increased experience of group flow. Density was the only significant but negative SNA predictor of social presence. Groups with less exchanges reported a higher sense of co-presence, or a sense of mutual connectedness. At first sight, this result may seem rather unexpected, as one would anticipate that social presence is higher when members interact *more*. Despite previous research that has shown that dense groups are more socially cohesive, share different points of view, and show higher levels of satisfaction and stability (Saqr, Fors, Tedre, & Nouri, 2018), our quantitative findings were consistent with our analysis of dialogues. Only a few interactions were activated by highly creative groups, maybe because they did not need more relational effort to pursue the shared goal, since they have already achieved the right harmony among members. Once harmony was achieved, members, maybe, did not need to interact more; they were already "tuned" with each other.

Conclusions

Twenty-first-century survival skills should include also the ability to manage even complex interactions in a mediated context in a creative way (Kumpulainen, Mikkola, & Jaatinen, 2014). Technology and creativity have become a pervasive issue from the work (Turel & Zhang, 2010), to the artistic (e.g., Biasutti, 2015), to the pedagogical domain (e.g., Kumpulainen, et al., 2014). This work evidenced how creativity occurs even in blended environments when people interact physically

and online. Starting from an idea of *networked creativity*, this study applied the NF model to unveil the experiential and structural dynamics of group creative process in blended environments. Here, we relied on two online social networks to introduce a "mediated" interaction component of analysis, that is, Facebook and WhatsApp. To our best knowledge, this study is a pioneer in the field of these two social networks and creativity. Crucially, since the NF model posited that both online and in presence interactions are useful for group creativity to emerge, an analysis integrating the physical exchanges among members with Facebook and WhatsApp-based interactions was adopted to achieve a more integrated and exhaustive group creative process view.

Practically, the core aspects of this research can be summed up as follows. First, we could assume that creative collaboration performance and group flow do not have a simple linear relationship, even though both experiences resulted related to specific group structural dynamics. Micro-communicative exchanges among members are crucial, and can be either frequent or not frequent, but need to be used to fuel group experience. Our results may suggest a three-stage process. It starts with group members building a common frame to settle a shared collaborative ground with a maximum level of group flow and social presence. This gives rise to a mutual zone of proximal development in which individuals just need to find the best ways to sustain the highest levels of group flow and social presence through specific interactions. This hypothesis is supported also by qualitative analysis of the dialogues among members in the early stages of group collaboration of Group A. Initially, members spend more time sharing ideas to enter a MZPD. At a second stage, they need less coordination effort. This would lead to artefact creation in the third phase. We may assume an initial phase of "closeness" promoting engagement in the creative process. Then, the network could have displayed more lax links among members, bringing forth an "open" network structure with a density no longer related to final creative outcomes (Porter, Keith, & Woo, 2018).

To complete the picture, our results may suggest that a formula for group creativity does not exist; instead, there could be potentially different pathways. Specifically, we found, at least, two possible interactive dynamics at the base of NF experience. NF might be either manifested in many interactions (i.e., "explicit" NF) or in fewer ones (i.e., a sort of "silent NF"). An effective metaphor to explain this process can be drawn from quantum physics regarding the wave-particle dualism. This posits that light can be shaped as a wave or particle, but it is always light. This could be the case of NF in creative collaboration teams. Optimal group experience of excellent creative teams might take two different forms: an explicit one (e.g., Group B: high Density and Centralisation indexes) or an implicit one (e.g., Group A: low Density and Centralisation indexes). The explicit form could be easily detected through SNA indexes, since it would result into a larger number of frequent interactions among members. The implicit form would be more difficult to measure by means of structural indexes since it would require a smaller number of interactions among team members. This depends on the group members' "maintenance" strategy to sustain NF.

A future step to test this hypothesis could be implementing measures of implicit communication such as eye contact exchanges, as it has been successfully done in previous studies but in different domains (e.g., Gaggioli, et al., 2017), overcoming the influence of social norms, and accessing a more authentic and sincere level of group dynamics. Finally, the aim of this study was explorative, and it focused only on ten groups with small size; therefore, it would be useful to replicate and extend the findings of this study with a wider sample. Moreover, in order to advance the implementation of the NF model in ecological and complex contexts, a future step could be to integrate our current longitudinal network analysis approach with a more sophisticated modelling technique such as SIENA (Simulation Investigation for Empirical Network Analysis) (Snijders, 2014).

Appendix

Transcription Conventions

- – cut off of the prior word or sound
- **( )** description of situation / speaker's actions
- **word** forms of stressing (pitch and/or volume)
- **(0.1)** elapsed time in tenths of seconds
- **=** lack of interval between the end of a prior and start of a next piece of talk
- **(h)** explosive aspiration
- °**( )** low in volume
- : prolonging of sounds
- // // segments overlapped by the talk of another

Notes

1. In SNA, relations can be considered as dichotomous (the relation is present/not present) or reported as a range of values that indicate the strength, intensity, or frequency of a relationship. In this research, we calculated dichotomous relations to perform correlation analyses and comparisons, and to analyse structural features of groups. Specifically, dichotomous relations were entered in matrixes from which we calculated specific SNA numerical indexes.

2. The Networked Model posited that the sense of mutual connection among members (social presence) and a sense of group flow are experiential drivers for the emergence of mutual zone of proximal development.

3. The adjacency matrix is a square matrix used to represent relational data, in which the rows and columns represent different nodes or vertices of interactions inside their own group, with the technical supervision of an experimenter, who had no direct access to the contents of the conversations. We devoted two hours-lessons on basic principles of Social Network Analysis (SNA) in the course (second lesson). Specifically, students received instructions on data extractions from their own conversations online on Face-book and/or WhatsApp. Then, as part of their course program, they were taught to create the adjacency matrixes from their own interaction data. The digital instruction materials on how to build SNA adjacency matrixes, which were provided to students, are available upon request.

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