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Assessing the Impact of Visual Facilitation on Inter-Organizational Collaboration: An Experimental Study

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Abstract: As suggested by several scholars, inter-organizational collaboration is an important vehicle for innovation, but working across organizational boundaries entails great complexity. In this paper, we argue that visual facilitation may act as a catalyst of inter-organizational teamwork, leading to increased knowledge sharing quality (H1), team performance (H2) and satisfaction (H3). On the other hand, we suggest that the aesthetic beauty of visual representations may exert a manipulatory effect, inducing inter-organizational actors to overestimate the collaboration value potential (H4). We adopt an experimental design (N=145 participants) in order to assess the advantages and disadvantages of visual facilitation in inter-organizational teamwork. In particular, we compare inter-organizational teams working with i) software-based visualization, ii) poster-based visualization, and iii) text-based facilitation (control condition). By comparing results across the two treatment conditions (software and poster), we disentangle the effects of visual facilitation and computer interactivity, therefore making a unique contribution to research on information visualization. The experiment findings show that software-supported teams outperform the control groups in terms of performance (H2), and exhibit greater satisfaction with the inter-organizational meetings (H3). We extend our experimental study by conducting focus groups with 17 experiment participants to gain an in-depth understanding of the users' experience with the different support systems. After discussing relevant implications for both researchers and practitioners, we point out the limitations of our study and suggest directions for future research.

Keywords: Information Visualization, Visual Facilitation, Visual Representations, Inter-Organizational Collaboration, Inter-Organizational Teamwork, Inter-Organizational Innovation, Experimental Research, Focus Groups
Categories: H.4.3, H.5.3, J.4, L.2.3, M.0, M.2, M.8

1 Introduction

More than ever before, organizations continue to look for innovation opportunities beyond their organizational boundaries, therefore becoming involved in a variety of inter-organizational collaboration efforts. A by-product of these arrangements is the formation of inter-organizational teams, set up by the partner organizations in order to make the collaboration operational. As coordination mechanisms between the partner organizations, inter-organizational teams should provide a common medium where

knowledge can be shared, integrated, and re-combined. In this context, team members may encounter considerable challenges, due to differences in the management styles, power bases, and cultures of the represented organizations. Failure to overcome such challenges may lead to frictions among team members, and eventually backfire on the collaborative agreement between the parent organizations [Fong, 03, Pearce, 09, Vlaar, 06].

A burgeoning stream of research [Bresciani, 09a; Ewenstein, 07; Whyte, 08] suggests that *collaborative knowledge visualization* plays a pivotal role in supporting knowledge-intensive teamwork. However, none of these studies has specifically addressed the question of how visual representations can assist teams working across organizational boundaries. In this study, we adopt an experimental approach to assess the advantages and disadvantages of using visual representations to facilitate inter-organizational meetings. We structure our paper as follows: In the theoretical section, we take a closer look at the challenges of inter-organizational teamwork, and we describe how visual facilitation may mitigate such challenges. In the empirical part, we present the findings of our experimental study, while also integrating additional insights from focus groups with experiment participants. In the concluding section, we acknowledge the limitations of our study, and pinpoint avenues for future research on visual facilitation for inter-organizational teamwork.

2 The Challenges of Inter-Organizational Teamwork

For the purposes of this article, we define inter-organizational teams as sets of 3-20 people working together to pursue a joint output, on the background of formal arrangements between two or more organizations. Drawing on [Schopler, 87], we further specify that inter-organizational teamwork requires engagement in regular face-to-face interactions over time. Another distinguishing feature of inter-organizational teams is a *representative membership*, by virtue of which team members act on behalf of their organizations, and not just as linking devices between different organizations. While excluding loose coordination mechanisms, our definition is broad enough to encompass different domains of inter-organizational teamwork such as project management, product development, or policy formulation.

As pointed out by several scholars, inter-organizational collaboration is an important vehicle for innovation processes, but working across organizational boundaries entails great complexity [van Wijk, 08]. By virtue of their structural configuration, inter-organizational teams are faced with the dual challenge of overcoming both *functional and organizational boundaries* to knowledge sharing [Pearce, 09]. Along the functional boundary, team members are confronted with the problems of understanding raised by the multi-disciplinary nature of inter-organizational work. While functional barriers are present also in intra-organizational settings [Carlile, 02], they are deemed to assume heightened relevance in inter-organizational contexts. In fact, inter-organizational teams are more likely to lack a shared language for interpreting, transferring, and integrating knowledge. [van Wijk, 08] showed that knowledge ambiguity, defined as uncertainty about the underlying components, sources, and interrelations of knowledge, is more detrimental at the inter-, rather than intra-organizational level. In turn, this supports the notion that inter-organizational teams are endowed with fewer opportunities to eventually make sense of ambiguous knowledge.

In addition to facing semantic barriers to knowledge sharing, inter-organizational teams are confronted with pragmatic concerns related to the protection of proprietary knowledge against unintended leakages to the collaborating partners. In fact, team members may inadvertently trade away market insights that otherwise may have been an exclusive advantage of their parent company. In turn, fear of helping a competitor may induce opportunistic behaviours in knowledge sharing, and undermine the trust base of the inter-organizational team [Fong, 03]. This challenge is not present in intra-organizational contexts, where the common affiliation enables team members to share knowledge without appropriation concerns. [Husted, 10] note that inter-organizational actors experience a "dual allegiance", as they are faced with the ambivalence of being loyal to both the team and their parent organization.

Besides facing substantial difficulties in sharing knowledge, inter-organizational actors are confronted with the challenge of coordinating teamwork in the absence of hierarchical lines of authority [du Chatenier, 09]. As suggested by [Mintzberg 96:64], inter-organizational actors "are not formally subject to the authority of each other, and are likely to treat attempt at dominance with mistrust and suspicion". In the lack of a chain of control and command, team members are not in the position to issue orders, or in duty-bound to act accordingly. This is not the case in the intra-organizational context, where team members understand the bureaucratic imperatives of the organization, and are formally subject to hierarchical lines of authority.

While hierarchical power is suspended across the organizational boundaries, inter-organizational collaboration is generally fraught with power struggles at multiple levels [Gray, 85]. At the macro level, power asymmetries can stem from a number of factors, such as an uneven distribution of resources, or the existence of organizational dependencies as in the case of buyer-supplier relationships. At the micro level, power conflict may arise between team members who attempt to take control of resource allocation, or to dominate decision-making processes [Pearce, 09]. As pointed out by [Ackermann, 05], power struggles may severely undermine team performance, and present the potential derail the inter-organizational collaboration. On the contrary, in intra-organizational contexts even open turf wars can be ultimately solved by making appeal to managerial authority.

The power conflict may be even more prominent in the earliest stages of inter-organizational collaboration, when the team task is surrounded with ambiguity [Huiskonen, 02]. In the transition to a collaborative relationship, team members do not know each other well and may look with suspicion at the agenda, values and beliefs of the partner organization. This may lead participants to develop different interpretations of the same phenomena, and increases the likelihood of misunderstandings and conflicts [Vlaar, 06]. In the next section, we suggest that collaborative knowledge visualization may work as a catalyst of inter-organizational teamwork, by facilitating knowledge sharing, and leading to greater team performance and satisfaction.

3 Visual Facilitation as a Catalyst of Inter-Organizational Teamwork

The current research on collaborative knowledge visualization consistently indicates that visual representations facilitate knowledge sharing in the context of co-located

teamwork. According to [Ewenstein, 07], visual representations are both communication devices whereby meaning is conveyed, and tangible artefacts whose manipulation affords the generation of novel insights. By virtue of their interactive property, visual representations can work as *boundary objects*, thus facilitating the creation of shared meaning across different practices. The interaction with visual objects enables individuals to make sense of their knowledge differences, and provides an infrastructure for translating knowledge across boundaries [Carlile, 02]. As boundary objects, visual representations should be particularly helpful in inter-organizational contexts, where the collaborating parties face multiple barriers to knowledge sharing. Along the semantic boundary, visualization may provide participants with a shared syntax for representing their knowledge, and learning about their reciprocal interdependences. Along the pragmatic boundary, visualization can contribute to address the appropriation concerns of the collaborating partners, by making explicit the border line between pooled and proprietary knowledge.

Beyond the domain of knowledge visualization, the role of visual representations for collaborative teamwork has been explored also in the fields of education and computer-supported collaborative learning (CSCL). Developed in the domain of CSCL, the notion of *representational guidance* [Suthers, 03] suggests that visual representations play a crucial role in the sense-making of groups. In effect, the notations on a visual representation may constrain what is expressed, and make certain aspects more salient [Suthers, 01]. Therefore, visual representations support collaborative teamwork by providing an overarching structure which organizes information, coordinates the group dialogue [Hundhausen, 05], and highlights relevant aspects [Suthers, 01]. In a consistent way, [Stewart, 01] have found that the use of visual representations enhances group performance in cognitive tasks. While conceived in different application domains, the above notions apply also to the context of organizational teamwork [Bresciani, 10], with possible extensions to the inter-organizational setting. The strategy literature has also shown the importance of visual representations for addressing several processes in strategy making [Eppler, 09]. Scholars in this field view conceptual representations as "process catalysts that can improve analysis, decision making and communication of strategies" [Bresciani, 10].

Building on the reviewed literature, we hypothesize that visual facilitation improves the quality of knowledge sharing (H1), and leads to greater team performance in inter-organizational meetings (H2). We also assume that visually supported teams will experience greater satisfaction with the meeting process and outcome, compared to textual-supported teams (H3). However, the literature on collaborative knowledge visualization suggests that visual representations are not without disadvantages, although providing a means of group sense-making. In a recent review of literature, [Bresciani, 09b] indicate that the beauty of visual representations may exert a "cajoling effect", inducing the recipients to develop overly positive attitudes towards the represented objects. In the transition stage to a strategic alliance, the persuasive effects of images may be particularly detrimental, leading team members to overrate the collaboration value. By engaging in the visual depiction of collaboration opportunities, team members may be cajoled by the image of a productive relationship, and develop excessive confidence in the alliance for which they have developed collaboration ideas. Drawing on this literature stream, we therefore suggest that visual repre-

sentations may exert a manipulating effect on the alliance making attitudes of inter-organizational actors (H4).

In addition to assessing the impact of visual facilitation, we are interested in understanding whether and how the use of different supports for visual facilitation (i.e., software and printed support) bears an influence on inter-organizational teamwork. Researchers in the field of information system (IS) study the impact of group support systems (GSS) on organizational teamwork, with particular attention to assessing idea generation, problem solving, and decision making. Building on Adaptive Structuration Theory (AST), [DeSanctis, 94] suggest that GSS provide a structure which enables, and at the same time constrains group interaction. In particular, the technology features of GSS – defined as the rules, resources, and capabilities offered by the system – give shape to the group collaborative processes. While IS research has neglected visual support as a distinct typology of GSS, we can derive relevant insights as to the difference between computer- and poster-supported visualization. In particular, software support provides greater restrictiveness, interactivity, and revisability in structuring group collaborative processes. Restrictiveness is defined as the "degree to which a [structure] restricts its users' appropriation processes to a particular subset of all possible processes" [Silver, 88:52]. Compared to printed support, software support provides less latitude or alternatives for its use, therefore structuring the group discussion with greater effectiveness. In addition, software support presents the advantage of providing response to the users' inputs (interactivity), therefore facilitating the revision of the contents being visualized (revisability).

In summary, the IS literature suggests that software support provides a richer experience in comparison to printed support, but this assumption has not yet been tested empirically. We tentatively hypothesize that the positive (H1-H3) and negative (H4) effects of visual facilitation will present greater intensity when the visual representation is created by means of software, rather than printed support. By comparing the different supports in an experimental design, we should be able to assess the added value of software-based visualization, and to appreciate the combined effect of software interactivity and visual facilitation. In [Fig. 1], we present our research model, and we subsequently report our four hypotheses on the advantages and disadvantages of visual facilitation on inter-organizational teamwork.

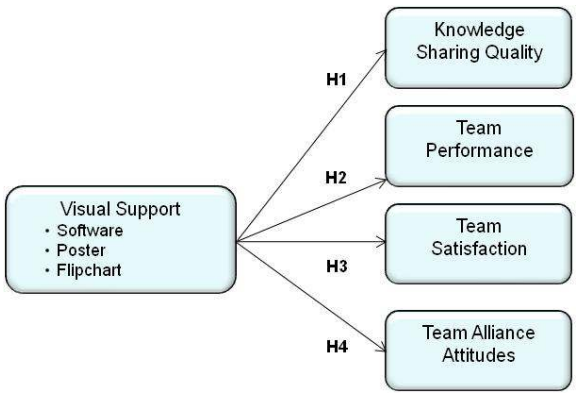

Figure 1: Research Model

Hypothesis 1. Visual facilitation positively influences the quality of knowledge sharing in inter-organizational teams. This effect presents greater intensity when the visualization is created by means of mapping software, rather than on a poster-based support (annotated with post-it notes).

Hypothesis 2: Visual facilitation leads to greater inter-organizational team productivity (2a) and precision (2b). This effect presents greater intensity when the visualization is created by means of software, rather than on a poster-based support.

Hypothesis 3: Visual-supported teams report greater satisfaction with the inter-organizational meeting. This effect presents greater intensity when the visualization is created by means of software, rather than on a poster-based support.

Hypothesis 4: Visual facilitation induces inter-organizational teams to overrate the value potential of their collaboration. This effect presents greater intensity when the visualization is created by means of software, rather than on a poster-based support.

4 Method: Simulating Inter-Organizational Teamwork through Realistic Experiments

4.1 Experimental Design and Participants

In order to test our research hypotheses, we have developed a *between subjects* experimental design, with participants being randomly assigned to three different modalities of the independent variable. The independent variable is visual support, and the corresponding experimental conditions are i) *software-based visual support*, ii) *poster-based visual support*, and iii) *text-based support* (flipchart). As dependent variables, we have measured (perceived) knowledge sharing quality, team performance, team satisfaction and attitudes towards alliance making [see 4.3 for greater details]. The 145 participants were advanced (part-time) students enrolled either in an Executive Master (N=109) or a Master of Arts (N=36) in Business Administration. Data was collected in the course of six experiment runs, carried out between June 2009 and October 2010 at the Universities of Geneva and St. Gallen (Switzerland). In total, we had 12 software, 12 poster, and 12 control groups – a balanced distribution allowing for comparable results across the experimental conditions.

The participants were given a hidden-profile, role playing case study containing detailed information as regards their organization, but only limited information about their potential partner. The case game [Comi, 09] is set in the construction industry, and provides asymmetric information about two building companies – Beacon and Dioguardi – considering the constitution of a strategic alliance. Beacon is a service-oriented company based in Boston, Massachusetts, whereas Dioguardi is a technical-oriented company headquartered in Bari, Italy. The readability of the case game was tested in the context of three experiment pre-tests (March-May 2009), where the participants were asked to point out unclear wordings in both the case versions. Since the 145 participants lacked first-hand experience in the construction industry, no team had an unfair advantage in solving the case game.

After reading the case study, participants were paired up into inter-organizational teams of 3 - 6 participants (4 is the modal team size), and played the role of executive managers representing the two sides of the prospective alliance. The experimental design – with random assignment of participants to the three experimental conditions, and the set-up of inter-organizational teams – is illustrated in [Fig. 2].

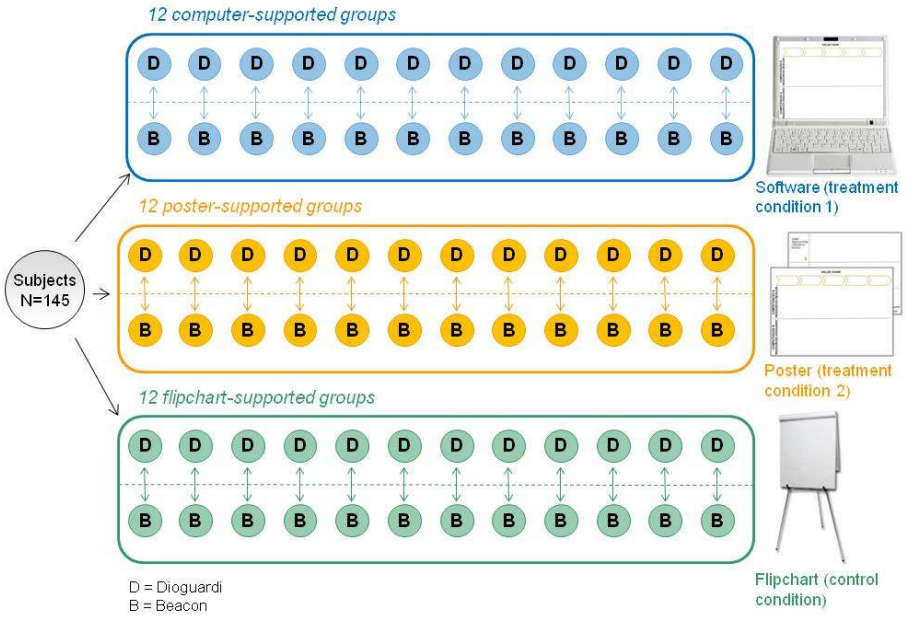

Figure 2: Experimental Design

The team tasks consisted of sharing knowledge in order to identify complementary competences (task 1) and to envision opportunities for collaborative innovation (task 2). Following the task instructions, team members designated a facilitator of the team meeting, elected from the company hosting the meeting (i.e., Dioguardi). The facilitator documented the team discussion with the support materials received from the case game organizers, namely i) software-based templates, ii) poster-based templates, or iii) flipcharts depending on the condition of assignment. While the control groups used a blank flipchart, the experimental groups received the same visual templates, the only difference being the type of medium support (i.e., software or poster). The software-supported groups worked with digital templates loaded on the let's focus visualization software (en.lets-focus.com), while the poster-supported groups used post-its on printed templates [Fig.3]. The visual templates used in the experiment were the competence complementarity chain adapted from [Pietroforte, 96] and the innovation opportunity map adapted from [Muller, 02]. The first template is intended to support the identification of complementarity areas, while the second one is suited to assist the exploration of joint innovation via the systemic recombination of the partners' competences [see 4.2 for greater detail].

Figure 3: Treatment Conditions: Software and Poster Groups

At the end of the team meeting, participants received a questionnaire where they had to express their attitudes towards the prospective alliance, and to evaluate the inter-organizational knowledge sharing process (self-reported measures). Finally, the experimenters analyzed the outcome of the team meeting against the case study solution, and accordingly evaluated team performance (objective measures). To reduce the risk of experimenter's bias [Jung, 71], and to ensure consistency in the team solutions, all the participants received written instructions of the experimental tasks. The instructions explicitly indicated the evaluation criteria used to assess team performance, namely the quantity and quality of the items reported in the team solution. Besides, the meeting facilitators in the treatment conditions received written instructions about how to use the software and the poster templates. The experiment lasted for about 1 hour and a half (30 minutes for case study reading, 20 minutes for each team task, and 10 minutes for filling out the questionnaire). The groups worked in separate environments in order to avoid contaminations between groups and across experimental conditions.

At conclusion of the experiment, the participants convened to a plenary session where they presented their team solutions, after being debriefed about the experimental design. By holding a debriefing session, we ensured that the participants had a learning experience in the case game, and – at the same time – we gained further insights through the team presentations. At the end of the last experiment run, we conducted two parallel focus groups with 17 participants, in order to proceed with a systematic collection of qualitative data. The focus groups provided us with the occasion to gather in-depth insights about the participants' experience with the group support systems, and to clarify unexpected findings arising from the quantitative data analysis. The results of the experimental study – together with the qualitative findings from the focus groups – will be discussed in [Section 5]. In the next sections, we present the visual templates used in the intervention groups, and we subsequently introduce the instruments used to measure the outcome variables of our research model.

4.2 Visual Templates

The rigorous selection of visual templates is of primary importance in order to ensure the internal validity of the research design, as well as the reliability of the experimental results [Bresciani, 09a]. We have identified the competence complementarity chain [Pietroforte, 96] and the innovation opportunity map [Muller, 02] by carrying out a literature review on graphic representations of inter-organizational competences. As a consecutive step, we have performed three experiment pre-tests (March-May 2009) to assess the suitability of the selected templates to support inter-organizational knowledge sharing. Based on the feedback received from the experiment participants, we have slightly adjusted the templates layout in order to correct minor usability problems. The visual templates used in the final experiment are displayed in [Fig. 4-5]: The left side shows the empty templates distributed to the experimental groups, while the right side displays the filled templates used to evaluate team performance. We have elaborated the completed versions in collaboration with a consultant who had been personally involved in the strategic alliance described in the case game.

Both the visual templates are intended to represent the *collective knowledge* of the partner organizations, which is reflected in the *organizational competences* mapped onto the template canvas. The competence complementarity chain [Fig. 4] is a two-layers template where team members can display their organizations' competences along the industry value chain. By matching *core competences*, inter-organizational actors should be able to visually inspect *complementarity areas*, and to better assess the value creation potential of the strategic alliance. As visible in the completed template, team members should fill in the industry value chain (5 items) and identify 20 organizational competences, of which 3 are core competences (to be represented with arrows).

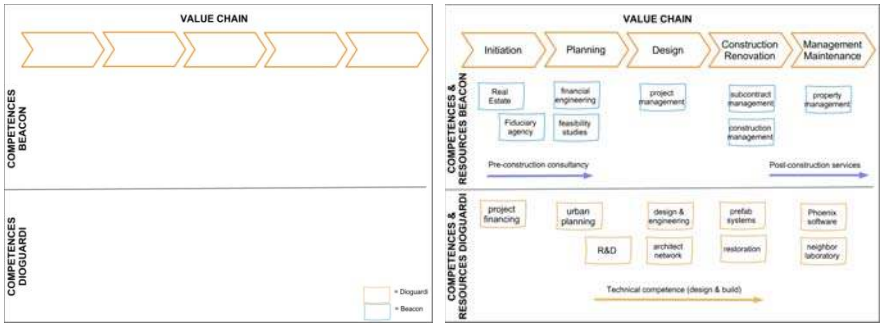

Figure 4: The Competence Complementarity Chain (for Task 1)

The innovation opportunity map [Fig. 5] is a three-layers template, displaying i) *organizational competences*, ii) *market needs and developments*, and iii) *joint innovation opportunities*. With the support of this template, team members can systematically recombine organizational competences to address market trends, and to envision corresponding opportunities for collaborative innovation. As shown in the filled template, team members should be able to generate about 7 innovation opportunities, intended to address 3 major market needs and developments.

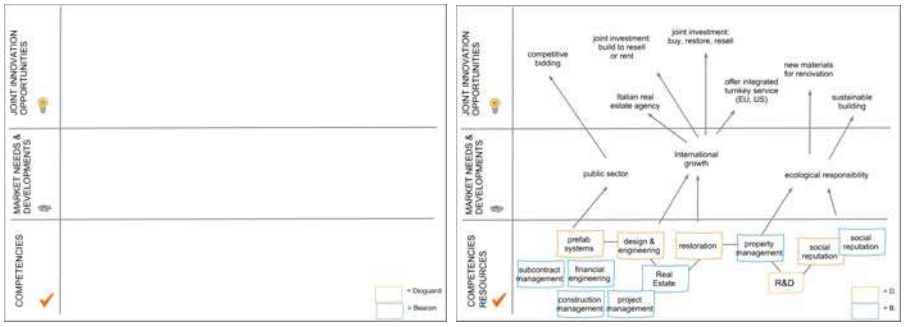

Figure 5: The Innovation Opportunity Map (for Task 2)

In summary, the first template supports the identification of organizational competences (task 1), whereas the second template facilitates the development of innovation opportunities (task 2). As mentioned above, the experimental groups are given the same visual templates, the only difference being the medium used to document team work (computer vs. poster support). The teams in the control condition do not receive any visual support, but are given the same labels reported in the empty templates as cognitive categories to structure their work. In this way, the control groups are in a fair position compared to the experimental groups, and the observed differences should be attributable to the intervention variable only. Due to space constraints, we cannot illustrate the experiment tasks with pictures of the teams' work results. However, relevant examples of team solutions produced across the three experimental conditions can be viewed online at the address: http://www.knowledge-communication.org/visuals.html.

4.3 Measures

Before reporting the results of our experiments in this section, we briefly describe the operational definitions that we have used for measuring the dependent variables of our study. We have introduced self-reported measures for assessing individual perceptions of the team process, together with observed measures for evaluating team performance on the two experimental tasks. The self-reported values were collected by asking the experimental participants to fill out a questionnaire with items measured on a 7-point Likert scale. The objective values, on the other hand, were generated by the experimenters assessing the performance of each team against the official solution of the case game tasks [Comi, 09].

4.3.1 Self-reported Measures

Team knowledge sharing quality. The quality of knowledge sharing in the inter-organizational team was measured with the interpersonal knowledge, skills and abilities scale (KSA) by [Kichul, 00], combined with two facets of the behavioural observation scale (BOS) by [Taggar, 01]. The interpersonal KSA is comprised of three sub-dimensions, i.e. conflict resolution, collaborative problem solving and communication (9 items), while the BOS facets are focus on task-at-hand and synthesis of team ideas

(4 items). In our view, the selected instruments are suitable to measure knowledge-sharing quality, as they tap into the ongoing interaction among team members, with a focus on performing behaviours that precede effective teamwork.

Meeting satisfaction. The satisfaction construct was measured with a validated instrument [Briggs, 06], specifically tailored to the context of groups working with facilitation support. The selected instrument builds on a multidimensional concept of satisfaction and comprises two sub-scales, namely *satisfaction* with the meeting *process* (SP) and *outcome* (SO), each measured with 4 items.

Attitudes towards alliance making. For this construct, we have developed a single item whereby we asked respondents to estimate the value creation potential of the strategic alliance on a 7-point Likert scale. In addition, we have introduced a dichotomous variable (yes/no) to capture the individual decision about whether to engage in the strategic alliance.

4.3.2 Observed Measures

Team performance. In order to assess this construct, we have developed a set of observed measures based on the solution of the two team tasks, reported in the teaching note of the case game [Comi, 09]. As a measure of *team productivity*, we have counted the number of i) organizational competences, ii) market developments, and iii) innovation opportunities matching with the task solution. In parallel, we have elaborated a measure of *team precision* in solving the tasks, by dividing the number of correct items by the number of total items documented by team members.

4.3.3 Control Measures

A number of factors pertaining to the characteristics of team members may influence the dependent variables of our study, therefore confounding the effect of visual support. To rule out alternative explanations, we have controlled for the following variables: 1) the facilitator's skilfulness, 2) the individual experience with strategic alliances, 3) the individual knowledge of the building industry, 4) the individual mastery of the English language, 5) the individual preference for teamwork, 6) the individual preference for visualization, 7) team cultural and 8) gender diversity. To measure control variables 1-4, we have developed ad-hoc items on a 7-point Likert scale (e.g., for control variable 1, "the facilitator did a good job in moderating the discussion"). To measure teamwork preferences (5) we have used an instrument by [Campion, 93], whereas to assess visualization preferences (6) we have validated a 3-items scale (e.g., "I like working with visual techniques such as graphing, sketching, mapping"). As a measure of cultural and gender diversity (7-8), we have computed diversity indexes based on the proportion of different nationalities/genders represented within each inter-organizational team. As suggested by [Zoogah, 08] diversity characteristics of inter-organizational actors – such as race and gender – may hinder group cohesion, and potentially lower performance. On the other hand, [Wolley, 10] found that the proportion of females in the team is associated with higher collaboration, as women generally score higher in social sensitivity.

5 Results

5.1 Experimental Study

5.1.1 Sample Description

Our sample is composed of 36 inter-organizational groups (N=145 individual cases), distributed uniformly across the experimental conditions (12 software-supported, 12 poster-supported, 12 control groups). The inter-organizational teams were generally comprised of 4 individuals (2 playing the role of Beacon managers, and 2 playing the role of Dioguardi managers). Although we strived to compose teams of equal size for comparability purposes, we have formed two teams of 3, one team of 5, and one team of 6 in order to accommodate for an uneven number of enrolled participants. However, these teams do not differ significantly from regular-sized ones, and are fairly distributed across the experimental conditions.

The participants (N=145) had prior experience in the management field, and were recruited as students enrolled in an Executive Master (N=109) or in a Master of Arts (N=36) in Business Administration. The average age is 33, and the gender is predominantly male (64.8% males, 35.2% females). The sample exhibits high national diversity, with 46 different nationalities spread across the five continents. The sample characteristics are fairly distributed across the three experimental conditions.

A power analysis performed with G*Power 3 has revealed that the current sample is not sufficiently large, since – assuming a moderate effect size of the independent variable – we would need 60 cases per condition (N=180) to detect significant effects. Although we plan to conduct an additional experiment run, we have performed a preliminary analysis of our dataset, and we have found initial support for two of our hypotheses (i.e., H2 and H3). In the next sections, we therefore report the results of our data analysis, starting with the validity and reliability test of the self-reported measures.

5.1.2 Validity and Reliability Testing

As a preliminary step in our data analysis, we have performed a validity and reliability analysis of the self-reported measures used to assess the outcome variables of our research model. Prior to conducting the principal component analysis, we have verified the sampling adequacy by computing the Kaiser-Meyer-Olkin measure (.872) and the Bartlett's test of sphericity (F= 1391.197, p=.000). After verifying the feasibility of the test, we have performed a principal component analysis with varimax rotation [see the Appendix]. We have deliberately excluded the dimension *attitudes towards alliance making* since the two items are measured on different scales (7-points Likert and dichotomous scales) and therefore cannot be reduced to a summative index.

Knowledge sharing quality. Two items of the KSA scale by [Kichul, 00] loaded on a different component, and it was not possible to distinguish the 3 sub-scales of *conflict resolution*, *collaborative problem solving* and *communication*. The items of the BOS scale by [Taggar, 01] loaded on the same component, with the exception of 1 item of the facet *focus on the task at hand*. We have therefore re-run the principal component analysis after exclusion of two items from the KSA scale, and one item

from the BOS scale. The excluded items were either reverse-worded (e.g., BOS item "team members went into off-topic discussions"), or double-barrelled (e.g., KSA item "team members communicated ideas clearly and effectively"). Even after exclusion of the above said item, we could not establish confidence in the BOS scale, since the Cronbach's alpha was .500 – therefore below the threshold value of .7. While excluding the BOS scale from further analyses, we have retained the reduced KSA scale (7 items) with a Cronbach's value of .728, and we have accordingly built a summative index (inter-organizational team KSA).

Team satisfaction. Although they represent logically distinct constructs, in our sample the sub-scales *process* and *outcome satisfaction* seem to reflect an identical and overarching construct (i.e., team satisfaction). The eight items loaded on the same component and correlated heavily (r >.530**), with some items presenting higher correlations between – rather than within – constructs. For each sub-scale, we have built a summative index by averaging the four items scores, and we have therefore computed the correlation between the two summative indexes. A correlation value of .750** provided legitimacy for the decision to aggregate the eight items into a single variable, i.e., team satisfaction. The Cronbach's alpha for the aggregated scale of team satisfaction is .938, which is well above the threshold value of .7.

In the next section, we proceed by discussing the results of the hypotheses testing. Our analysis approach consists of fitting a general linear model, whereby we perform pairwise comparisons of the three experiment conditions (i.e., software vs. flipchart, poster vs. flipchart, software vs. poster). For each hypothesis test, we report the results of both the *unadjusted model* which accounts for the treatment effects (ANOVA), and of the *adjusted model* which accounts for both the treatment and the covariate effects (ANCOVA). If not explicitly indicated, we comment on the unadjusted model, since our primary intent is to account for the treatment effects of visual support.

5.1.3 Hypothesis Testing

H1. Visual facilitation positively influences the quality of knowledge sharing in inter-organizational teams. This effect presents greater intensity when the visualization is created by means of mapping software, rather than on a poster-based support (annotated with post-it notes).

Hypothesis 1 was not supported, since the analysis of variance between groups returned a non-significant value for both the unadjusted (F=1.268, p=.285) and the adjusted model (F=1.641, p=.198). At a descriptive level, knowledge sharing quality is reportedly higher in the software condition (Mean=6.1726, SD=.57970), followed by the flipchart (Mean=6.0904, SD=.55688) and in turn the poster condition (Mean =5.9845, SD=.58494). Although the mean comparisons are non-significant, the focus group results provide a tentative explanation for the lower knowledge sharing quality associated to the poster condition. As we will discuss in greater detail in [Section 5.2.2], team members in the poster-supported condition tended to write down post-it notes on an individual basis, and in turn experienced a lower communication quality (because of their focus on their own notes, rather than listening to the other team).

H2: Visual facilitation leads to greater inter-organizational team productivity (2a) and precision (2b). This effect presents greater intensity when the visualization is created by means of software, rather than on a poster-based support.

Hypotheses 2a and 2b were both supported, therefore confirming the positive impact of visual support – and in particular software support – on inter-organizational team performance. In the next paragraphs, we discuss separately the results of the hypothesis testing for H2a on inter-organizational team productivity and H2b on inter-organizational team precision.

H2a (inter-organizational team productivity). The analysis of variance between groups returned significant values for both the unadjusted (F=73.117, p=.000) and the adjusted model (F=71.950, p=.000). In terms of mean values, flipchart groups identified 11.84 valid items, whereas poster and software groups identified 20.36 and 22.49 valid items respectively. Therefore, visual facilitation (software- and poster-based) leads to greater productivity in inter-organizational meetings, with visual-supported teams identifying 9.59 more valid items than text-supported teams. Compared to the control condition, software groups identify 10.65 more valid items, whereas poster groups identify 8.52 more valid items. When considering the adjusted model, also the mean comparison between the visual supports is significant, with software-supported teams identifying 2.68 more valid items than poster-supported teams.

		Unadjusted model		Adjusted model†	
Treatment I	Treatment J	Mean difference (I-J)	Sig.	Mean difference (I-J)	Sig.
Visual	Textual	9.589*	.000	9.598*	.000
Software	Flipchart	10.65215*	.000	10.940*	.000
Poster	Flipchart	8.52497*	.000	8.256*	.000
Software	Poster	2.12719	.087	2.684*	.006

† For: facilitator's skilfulness, individual knowledge of strategic alliances, individual knowledge of the building industry, individual knowledge of the English language, individual preference for teamwork, individual preference for visualization, team cultural diversity and team gender diversity.

Table 1: Mean Comparisons for Inter-organizational Team Productivity

H2b (inter-organizational team precision). The analysis of variance between groups returned significant values for both the unadjusted (F=64.733, p=.000) and the adjusted model (F=61.113, p=.000). Visual facilitation (software- and poster-based) leads to greater precision in inter-organizational meetings, with visual-supported teams scoring 28.40% better on task precision than textual-supported teams. Compared to the control condition, software groups are 39.78% and poster groups are 17.01% more precise in solving the task at hand. Also the mean comparison between the visual supports is significant, with software-supported teams outperforming the poster-supported teams by 22.77% in task precision.

		Unadjusted model		Adjusted model†	
Treatment I	Treatment J	Mean difference (I-J)	Sig.	Mean difference (I-J)	Sig.
Visual	Textual	.284*	.000	.285*	.000
Software	Flipchart	.39776*	.000	.399*	.000
Poster	Flipchart	.17006*	.000	.172*	.000
Software	Poster	.22770*	.000	.227*	.000

† For: facilitator's skilfulness, individual knowledge of strategic alliances, individual knowledge of the building industry, individual knowledge of the English language, individual preference for teamwork, individual preference for visualization, team cultural diversity and team gender diversity.

Table 2: Mean Comparisons for Inter-Organizational Team Precision

H3: *Visual-supported teams report greater satisfaction with the inter-organizational meeting. This effect presents greater intensity when the visualization is created by means of software, rather than on a poster-based support.*

The analysis of variance between groups returned significant values for both the unadjusted (F=4.457, p=.013) and the adjusted model (F=4.215, p=.017). However, Hypothesis 3 is only partially supported, since greater satisfaction is associated not with the visual support in general, but with the software support in particular. In this regard, inter-organizational teams working with software support are significantly more satisfied than inter-organizational teams using poster and flipchart support. On the other hand, there is no significant difference in mean satisfaction between poster- and flipchart-supported teams. This unexpected finding suggests that satisfaction is associated with the specific features of the software support, rather than with the general advantages of visual facilitation.

		Unadjusted model		Adjusted model†	
Treatment I	Treatment J	Mean difference (I-J)	Sig.	Mean difference (I-J)	Sig.
Visual	Textual	.256	.084	.087	.444
Software	Flipchart	.45897*	.025	.269*	.042
Poster	Flipchart	.05208	.989	-.094	.475
Software	Poster	.40689*	.026	.363*	.006

† For: facilitator's skilfulness, individual knowledge of strategic alliances, individual knowledge of the building industry, individual knowledge of the English language, individual preference for teamwork, individual preference for visualization, team cultural diversity and team gender diversity.

Table 3: Mean Comparisons for Team Satisfaction

H4: Visual facilitation induces inter-organizational teams to overrate the value potential of their collaboration. This effect presents greater intensity when the visualization is created by means of software, rather than on a poster-based support.

Since the outcome variable was measured with different scale ranges, we have tested Hypothesis 4 by performing an analysis of variance on the 7-points Likert item (i.e., perception of alliance potential to create value) and a logistic regression on the

dichotomous item (i.e., decision about whether to engage in the strategic alliance). While Hypothesis 4 was not supported by any of the two statistical tests, we briefly report below on the results of the analysis of variance and of the logistic regression.

Perception of alliance potential to create value. The analysis of variance between groups returned a non-significant value for both the unadjusted (F=1.505, p=.226) and the adjusted model (F=.655, p=.521). At a descriptive level, software- and poster-supported teams present more favourable perceptions of the strategic alliance compared to text-supported teams. In particular, software groups perceive the highest value potential (Mean=5.49, SD=.845), followed by poster groups (Mean=5.30, SD=1.121) and in turn by flipchart groups (Mean=5.13, SD=1.123). Although the treatment effect is not significant, the descriptive results provide support for the overall direction hypothesized in H4. Therefore, we will enlarge the sample to N=180 as indicated in the power analysis test, and verify if the group mean differences become statistically significant.

Decision about whether to engage in the strategic alliance. The logistic regression returned a non-significant value (Wald=1.142, p=.565), therefore failing to provide support for Hypothesis 4. At a descriptive level, a cross-tabulation of the treatment and the outcome variable indicates that only 21 individuals out of 144 would not go ahead with the strategic alliance (1 missing data, N=145). While the support condition does not influence the decision significantly, only 5 individuals using the software support would not engage in the strategic alliance. The remaining individuals who would not go ahead with alliance making (N=16) are equally distributed across the poster and the flipchart conditions.

5.2 Focus Group Study

5.2.1 Focus Group Participants, Facilitators, and Instrumentation

As mentioned in [Section 4.1], we have conducted two focus groups with 17 experiment participants with the purpose to gain further insights on the relationship between visual facilitation and inter-organizational teamwork. As a complement to the experimental study, the focus groups were directed primarily to clarify unexpected findings arising from the data analysis. The two focus groups were conducted in parallel by the experimenters, immediately after the debriefing session and the students' presentations of their case game solution. The focus group participants were equally drawn from the three experiment conditions, in order to allow for a comparative discussion of the different group support systems (i.e., software, poster, flipchart). In facilitating the focus group discussion, we adhered strictly to a facilitator's guide that we had previously developed through an iterative draft and revision process. The facilitator's guide contained detailed instructions about the interviewing procedures, therefore ensuring consistency and comparability of data collected across the two focus groups. The focus group duration was 45-50 minutes; each session was audio-recorded with the explicit consent of the participants. As the focus groups rooms were equipped with computer and beamer, we used the visualization software let's focus for real-time documentation of the participants' discussion. By visually documenting the group discussion, we ensured that the participants stayed on topic and built on each

others' contribution when joining the discussion. As a procedure for data analysis, one of the authors listened to the audio-recordings and identified common themes that emerged in the two focus groups. Finally, an overview document was produced with a descriptive summary of the discussion for each focus group question. In the next section, we present the themes covered in the focus group, and we subsequently summarize the answers provided by the participants.

5.2.2 Focus Group Results

The focus group questions centred around four main themes, namely i) a general assessment of the advantages and disadvantages of the group support systems, ii) a comparative discussion of the influence of group support systems on team processes, iii) an exploration of the reason why visual support – and in particular software support – enhances team productivity and iv) a final discussion on the adoption of group support systems in a real-life inter-organizational context. In the next paragraphs, we report these questions and summarize the common themes across the two focus group sessions.

I. General assessment of group support systems advantages and disadvantages: What are the advantages and disadvantages of the group support systems that you have used in the case game?

The focus group participants were requested to first discuss the advantages and disadvantages of visual facilitation – either software or poster-based – compared to text-based facilitation. At a later stage, the users of software and poster templates were invited to evaluate the two group support systems, by focusing on the comparative advantages and disadvantages provided by software interactivity.

As regards the comparison between visual and text-based facilitation, the focus group participants consistently pointed out that the main advantage of visual templates lies in providing a structure for the team discussion. By displaying the building blocks of the team discussion, visual templates ensure that team members cover relevant themes and stay focused on the task. At the same time, visual templates allow for a more effective documentation of the team discussion, therefore enabling team members to build on each other's contribution. Besides, visual templates make it easier to see inter-connections among discussion topics, and facilitate a back and forth movement among inter-related themes (e.g., market developments and innovation opportunities).

On the other hand, text-supported teams had to invest additional effort in creating an overall structure, and went more frequently into off-topic discussions about how to document their task solution. While having several disadvantages, the blank flipchart allowed team members to think out of the box, and to discuss a number of relevant themes not indicated in the task assignment. Conversely, visual-supported teams were somehow trapped in the cognitive categories provided by the visual templates, and ignored issues such as inter-cultural problems in alliance making. In effect, the visual templates provide an affordance to fill out empty categories, therefore inducing team members to jump into the task solution. A final theme discussed by the focus group participants concerns the facilitator's role in visual versus text-supported meetings. According to the participants, the visual structure eases the documentation task, and

gives the facilitator more time to listen to the team members' inputs. Since the visual templates provide facilitation functions by themselves, the meeting effectiveness is less dependent on the facilitator's ability, therefore reducing the failure risk in inter-organizational collaboration.

As regards the comparison between software and poster support, the focus group participants mentioned that the software allows for greater revisability, and makes the documentation more visible and clear. On the other hand, poster-based visualization is intuitive to use, and does not require any technical skills on the facilitator's side. However, once the facilitator has overcome technical difficulties, the software support becomes more user-friendly, and less time-consuming compared to post-it note taking on a poster template. Finally, the focus group participants observed that the software files can be printed and sent out to the team members, with the advantage of creating a "commitment documentation" for the outcomes of the inter-organizational meeting.

II. Group Support Systems and Team Processes: How did the different group support systems influence your inter-organizational team dynamics?

This question was formulated with the purpose to shed further light on team processes, and to clarify unexpected findings as regards the impact of visual support on knowledge sharing quality (H1). The focus group discussion covered the three subtopics of communication, conflict management, and balanced participation, which coincide with the facets of the KSA scale used to measure knowledge sharing quality.

As a first impression, the focus group participants observed that visual facilitation has several advantages for inter-organizational knowledge sharing, yet makes the communication flow less natural. This may be the case since visual templates invite for a greater focus on the task at hand, and leave less room for spontaneous conversations among team members. On the other hand, the de-personalization provided by the visual support leads to conflict avoidance, since responsibility shifts away from the individuals to the objects displayed in the visual template. As individual contributions are crystallized on the visual templates, potential disagreements arise around impersonal objects, rather than taking personal undertones. This feature is particularly prominent with the software support, where the facilitator indicates items in an indirect way, by means of a mouse pointer. At the same time, the presence of a visual structure – either software or poster based – leaves less room for conflict about how to organize the team discussion, and to document the task solution. A final remark concerns the balanced participation of team members – with focus group participants consistently pointing out the advantage of the software support. The software support is described as the most collaborative support system, favouring a balanced discussion around the visual template. Without assuming a central role in the team conversation, the facilitator could prompt contributions from all the participants, by taking advantage of the circular distribution of team members around the projected template. On the other hand, team members in the poster condition tended to write their post-its on an individual basis, and gave their notes to the facilitator for inclusion in the template. While the facilitator was de-empowered in the poster condition, team members in the flipchart condition were prone to the risk of facilitator's dominance. Due to the lack of a clear structure, flipchart moderators often tended to document a number of irrelevant items, or to give more space to one side of the inter-organizational team.

The focus group results provide tentative explanations for the unexpected findings observed in the experiment data (i.e., a non-significant group mean difference in knowledge sharing quality). While the factor analysis did not allow disentangling the three scale facets, the focus group data reveals the mixed advantages of visual facilitation in terms of communication, conflict management and balanced participation. As visual facilitation presents both advantages and disadvantages on the three scale facets, the effects may offset each other in the hypothesis test. However, the focus group participants indicated software support as the most conducive to knowledge sharing, consistently with the descriptive data reported in [Section 5.1.3].

III. Group Support Systems and Team Outcomes: In your view, why is visual support – and in particular software support – found to enhance team productivity?

On this follow-up question, the focus group participants repeatedly mentioned the potential of visual templates to streamline teamwork, by providing an overarching structure for organizing the team discussion. In particular, the interviewees explained the enhanced productivity of visual-supported teams by making reference to the salience of the cognitive categories displayed in the visual structure. The textual support provided the same cognitive categories, although without bringing the advantage of visibility. In this regard, the advantage of having a logical structure for organizing the task solution is realized only when such a structure is visible, and salient to all the team members. As regards the comparison between software and poster support, the focus group participants mentioned that the greater rigidity of the software support leads to increased focus and attention to details. In addition, the software interactivity enhances team productivity by allowing to display relevant interconnections through the zoom and replay functions.

IV. Appropriation of Group Support Systems: If you had to organize a real-life inter-organizational meeting, which support system would you adopt (i.e., software, poster, or flipchart)?

As regards the final question on the adoption of group support systems, the interviewees agreed that text-based support is suboptimal for inter-organizational teamwork. Nevertheless, a participant observed that team productivity with flipchart support may be enhanced by having two flipcharts, one for convergent tasks (e.g., competence mapping), and the other one for divergent tasks (e.g., idea generation). Finally, a participant mentioned that software and flipchart support may be used together; the software as a main tool and the flipchart as a side tool to capture emergent themes, or to document items that cannot be displayed in the visual templates. In this way, the multiple advantages of the software support may be integrated with the "thinking outside of the box" effect prompted by the flipchart support.

6 Conclusions

6.1 Discussion of findings

In this study, we have investigated the advantages and disadvantages of visual facilitation for inter-organizational teamwork, while also exploring the impact of different support systems used for visual facilitation (i.e., software and poster). The experiment data provided support for our hypothesis on the positive impact of visual facilitation on inter-organizational team performance (H2). In fact, visual-supported teams outperform text-supported teams on performance measures, with software groups receiving the highest scores on productivity and precision. On the other hand, our hypothesis on the positive impact of visual facilitation on inter-organizational team satisfaction received mixed support (H3). At odds with our expectations, satisfaction is associated not to visual facilitation per se, but rather to the support system used for visual facilitation: While software-supported teams experience the highest satisfaction with the inter-organizational meeting, there is no significant mean difference between the poster and the flipchart conditions. This unexpected result suggests that the technical features of software support (e.g., interactivity, revisability, restrictiveness) are the main drivers of users' satisfaction with visual facilitation.

Finally, the hypothesized effects of visual facilitation on inter-organizational knowledge sharing (H1) and alliance making attitudes (H4) were not confirmed by the experiment data. However, the focus groups conducted with experiment participants provided a tentative explanation for the non-significant group mean differences in knowledge sharing quality (H1). As pointed out by the interviewees, visual facilitation brings mixed benefits on different aspects of knowledge sharing quality (i.e., communication, conflict management, and balanced participation). In particular, visual facilitation makes the communication flow less spontaneous, although favouring balanced participation and facilitating the management of interpersonal conflict. In comparison to software support, poster support is considered as less suitable for facilitating knowledge sharing. As we observed during the experiment, poster-supported team members tended to write down post-it notes in a solipsist way, without engaging in an intense knowledge-sharing process. We may have failed to detect significant effects in the quantitative data, since the factor analysis did not allow us to discern the three facets of communication, conflict management, and balanced participation. The positive and negative effects of visual facilitation may offset each other when using a mono-dimensional scale, thus making the hypothesis test non-significant. As regards the test of H4, the non-significant result suggests that visual facilitation does not exert a manipulatory effect on inter-organizational actors. The development of favourable attitudes towards alliance making seems to be independent of the group support system used in inter-organizational meetings. Albeit unexpected, this finding represents a further argument in favour of the adoption of visual facilitation in inter-organizational collaboration. In fact, visual facilitation produces considerable advantages for alliance team management, without the risk of distorting individual perceptions of the alliance value potential.

Besides clarifying unexpected findings of the experimental study, the focus group provided further insights on the advantages and disadvantages of visual facilitation in inter-organizational teamwork. The interviewees mentioned repeatedly that the foremost advantage of visual templates lies in providing an overarching structure to guide

the collaboration process. While streamlining the teamwork process, the visual structure presents the drawback of constraining the team discussion to the cognitive categories displayed in the template background. In this regard, the visual templates do not provide affordances for documenting and elaborating on emergent themes, which may surface during the discussion. This observation is consistent with the notion of "representational guidance" or "representational bias" [Suthers, 03:186], which suggests that visual representations "constrain which knowledge can be expressed in the shared context and make some of that knowledge more salient and hence a likely topic of discussion".

6.2 Implications for Practice and Research

The findings reported above lead to important implications for both practitioners and scholars in the fields of knowledge visualization and alliance management. As a practical implication, we suggest that software-based visualization delivers the greatest advantages in terms of inter-organizational team performance and satisfaction, without biasing individual perceptions of the collaboration value. As follows, alliance professionals should adopt visual templates in inter-organizational meetings, particularly in combination with a software-based support. As a theoretical implication, we confirm the positive effects of visual facilitation for collaborative teamwork, and extend the breadth of such effects beyond the organizational boundaries. In particular, our study makes a twofold contribution to research by bridging the domains of inter-organizational collaboration and information visualization.

First, we contribute to research on inter-organizational collaboration by uncovering the micro-level of interpersonal interactions, and by showing the importance of supporting inter-organizational teams with visual facilitation. Second, we extend research on information visualization by disentangling the effects of visual facilitation and computer support. In particular, we have shown that the interactivity provided by the software support enhances the positive effects of visual facilitation on team performance. Besides, it is remarkable that satisfaction with the meeting process and outcome is driven not by visual facilitation per se, but rather by the use of a software-based support for visual facilitation.

Finally, our qualitative study provides further evidence in support of the theory of *visual boundary objects* [Carlile, 02], and of the notion of *representational guidance* or *representational bias* [Suthers, 01]. The focus group participants described visual representations as inscription devices that assisted inter-organizational actors in overcoming knowledge boundaries and building common ground. Moreover, visual representations guided the collaborative interaction, by providing an overarching structure for organizing the team work. At the same time, the focus group participants recognized the biasing effect of visual representations, observing that the visual structure makes certain themes more salient, at the expense of others. In fact, visual-supported groups failed to discuss issues that were not included in the templates – such as inter-cultural barriers – which are nevertheless relevant aspects of alliance making. Therefore, our study confirms existing theories of visual representations, while also providing an extension into the inter-organizational context.

From a methodological perspective, we have adopted an innovative approach by introducing focus groups with experiment participants in order to clarify unexpected research findings. In this way, we have been able to better understand the participants'

experience in the case game, therefore reducing the positivistic limitations inherent in experimental research. At the same time, we have experimented with visual facilitation in focus group research, by using a software support to moderate the group discussion. In our view, the *visual focus group* is a methodological innovation in itself, which warrants further investigation from both a theoretical and an empirical perspective.

6.3 Limitations and Directions for Future Research

While providing interesting insights on the relationship between visual facilitation and inter-organizational team performance, our experimental study is not without limitations. The foremost limitation concerns the sub-optimal sample size, since the power analysis indicated that a minimum sample of N=180 individual cases is required in order to confidently accept the outcomes of our statistical tests. While H2 and H3 are already supported by the N=145 dataset, we cannot exclude that the tests of H1 and H4 are non-significant due to an insufficient sample size. As a next step in our experimental research, we plan to collect additional data and to refine our data analysis by applying more sophisticated statistical techniques. In particular, we will use multilevel modelling in order to disentangle the individual level nested within the inter-organizational team unit. In parallel, we will apply structural equation modelling to detect unforeseen interaction, mediation or moderation effects among the observed variables of our research model.

Another limitation concerns the artificial nature of the experimental research, which may constrain the extent to which our research findings can be generalized to real-life inter-organizational collaboration. While limitations in external validity are inherent to experimental research [Hoyle, 02], we have tried to reduce this shortcoming by simulating a realistic alliance-making scenario. As experimental tasks, we have selected the very tasks inter-organizational teams are faced with when deciding about a strategic alliance (i.e., to understand complementary competences, to envision joint innovation opportunities, and to assess the value creation potential of the collaboration). Therefore, our research findings should be generalizable to the earliest stages of inter-organizational teamwork, when prospect partners consider whether to join hands in a collaborative endeavour. As experimental manipulations, we have selected diagrammatic representations commonly used in the management profession (i.e., value chain and innovation mapping templates). Nevertheless, future research should replicate our experiment design with different templates – and different software – in order to strengthen confidence in our research findings. Future research may also attempt to identify which templates – besides the ones used in our experiment – are best suited for the purposes of supporting inter-organizational teamwork.

In order to compensate for the disadvantages of the artificial experimental setting, we have also collected qualitative data by conducting focus groups with experiment participants. In the future, this experimental research could be complemented with qualitative studies, such as a participant observation of inter-organizational meetings facilitated by visual techniques.

References

[Ackermann, 05] Ackermann, F., Franco, L.A., Gallupe, B., Parent, M.: "GSS for multi-organizational collaboration: Reflections on process and content"; Group Decision and Negotiation, 14, 4 (2004), 307-331.

[Bresciani, 09a] Bresciani, S., Eppler, M.J.: "The benefits of synchronous collaborative information visualization: Evidence from an experimental evaluation"; IEEE Transactions on Visualization and Computer Graphics, 15, 6 (2009), 1073-1080.

[Bresciani, 09b] Bresciani, S., Eppler, M.J.: "The risks of visualization: A classification of disadvantages associated with graphic representations of information". In Schulz, P.J, Hartung U., Keller, S.: "Identität und Vielfalt der Kommunikations-Wissenschaft"; UVK Verlagsgesellschaft mbH / Konstanz (2009), 165-178.

[Bresciani, 10] Bresciani S., Eppler M., Subramanian S.V.: "Enhancing Group Information Sharing through Interactive Visualization: Experimental Evidence"; Presented at the Academy of Management Meeting, Montreal (2010).

[Briggs, 06] Briggs, R.O., Reinig, B.A., de Vreede, G-J.: "Meeting satisfaction for technology-supported groups: An empirical validation of a goal-attainment model"; Small Group Research, 37, 6 (2006), 585-611.

[Campion, 93] Campion, M.A., Medsker, G.J., Higgs, A.C.: "Relations between work group characteristics and effectiveness: Implications for Designing Effective Work Groups"; Personnel Psychology, 46, 4 (1993), 823-850.

[Carlile, 02] Carlile, P.R.: "A pragmatic view of knowledge and boundaries: Boundary objects in new product development"; Organization Science, 13, 4 (2002), 442-455.

[Comi, 09] Comi, A., Eppler, M.J., Pietroforte, R.: "Building innovation alliances on complementary competences: The Beacon and Dioguardi case study"; ECCH collection, (2009).

[DeSanctis, 94] DeSanctis, G., Poole, M.S.: "Capturing the complexity in advanced technology use: Adaptive structuration theory"; Organization Science, 5, 2 (1994), 121-147.

[du Chatenier, 09] du Chatenier, E., Verstegen, J., Biemans, H., Mulder, M., Omta, O.: "The challenges of collaborative knowledge creation in open innovation teams"; Human Resource Development Review, 8, 3 (2009), 350-381.

[Eppler, 09] Eppler, M.J., Platts, K.: "Visual Strategizing: The Systematic Use of Visualization in the Strategic Planning Process"; Long Range Planning, 42, 1 (2009), 42-74.

[Ewenstein, 07] Ewenstein, B., Whyte, J.K.: "Visual representations as 'artefacts of knowing'"; Building Research & Information, 35, 1 (2007), 81-89.

[Fong, 03] Fong, P.S.W.: "Knowledge creation in multidisciplinary project teams: An empirical study of the processes and their dynamic interrelationships"; International Journal of Project Management, 21, 7 (2003), 479-486.

[Gray, 85] Gray, B.: "Conditions facilitating interorganizational collaboration"; Human Relations, 38, 10 (1985), 911-936.

[Hoyle, 02] Hoyle, H.R., Harris, M.J., Judd, C.M.: "Research methods in social relations"; Wadsworth / US (2002).

[Huiskonen, 02] Huiskonen, J., Pirttilä, T.: "Lateral coordination in a logistics outsourcing relationship"; International Journal of Production Economics, 78, 2 (2002), 177-185.

[Hundhausen, 05] Hundhausen, C.: "Using end user visualization environments to mediate conversations: A 'Communicative Dimensions' framework"; Journal of Visual Languages and Computing, 16, 3 (2005), 153-185.

[Husted, 10] Husted, K., Michailova, S.: "Dual allegiance and knowledge sharing in inter-firm R&D collaborations"; Organizational Dynamics, 39, 1 (2010), 37-47.

[Jung, 71] Jung, J.: "The experimenter's dilemma"; Harper and Row / New York (1971).

[Kichul, 00] Kickul, J., Neuman, G.: "Emergent leadership behaviors: The function of personality and cognitive ability in determining teamwork performance and KSAs"; Journal of Business and Psychology, 15, 1 (2000), 27-51.

[Mintzberg, 96] Mintzberg, H., Jorgensen, J., Dougherty, D., Westley, F.: "Some surprising things about collaboration - knowing how people connect makes it work better"; Organizational Dynamics, 25, 1 (1996), 60-71.

[Muller, 02] Muller, A., Valikangas, L.: "Extending the boundary of corporate innovation"; Strategy & Leadership, 30, 3 (2002), 4-9.

[Pearce, 09] Pearce, B., Weingart, L., Hinds, P.J., Rousseau, D.M.: "Inter-organizational groups: A new context for examining the triggers of group conflict"; Carnegie Mellon University Working Paper (2009).

[Pietroforte, 96] Pietroforte, R.: "Building international construction alliances - successful partnering for construction firms"; E & FN Spon / London (1996).

[Schopler, 87] Schopler, J.H.: "Interorganizational groups: Origins, structure, and outcomes"; The Academy of Management Review, 12, 4 (1987), 702-713.

[Silver, 88] Silver, M.: "User Perceptions of Decision Support System Restrictiveness: An Experiment"; Journal of Management Information Systems, 5, 1 (1988), 51-65.

[Stewart, 01] Stewart, D., Stewart, C.B.: "Group recall: The picture superiority effect with shared and unshared information"; Group Dynamics: Theory, Research, and Practice, 5 (2001), 48–56.

[Suthers, 01] Suthers, D.D.: "Toward a Systematic Study of Representational Guidance for Collaborative Learning Discourse"; Journal of Universal Computer Science, 7, 3 (2001), 254-277.

[Suthers, 03] Suthers, D.D., Hundhausen, C.D.: "An experimental study of the effects of representational guidance on collaborative learning processes"; Journal of the Learning Sciences, 12, 2 (2003), 183-218.

[Taggar, 01] Taggar, S., Brown, T.: "Problem solving team behaviors: Development and validation of BOS and hierarchical factor structure"; Small Group Research, 32, 6 (2001), 698-726.

[van Wijk, 08] van Wijk, R., Jansen, J.J.P., Lyles, M.A.: "Inter- and intra-organizational knowledge transfer: A meta-analytic review and assessment of its antecedents and consequences"; Journal of Management Studies, 45, 4 (2008), 830-853.

[Vlaar, 06] Vlaar, P.W.L., Van den Bosch, F.A.J., Volberda, H.W.: "Coping with problems of understanding in interorganizational relationships: Using formalization as a means to make sense"; Organization Science, 27, 11 (2006), 1617-1638.

[Whyte, 08] Whyte, J., Ewenstein, B., Hales, M., Tidd, J.: "Visualizing knowledge in project-based work"; Long Range Planning, 41, 1 (2008), 74-92.

[Wolley, 10] Woolley, A.W., Chabris, C.F., Pentland, A., Hashmi, N., Malone, T.W.: "Evidence for a collective intelligence factor in the performance of human groups"; Science, (2010).

[Zoogah, 08] Zoogah, D.V., Vora, D., Richard, O., Peng, M. W.: "Strategic alliance team diversity, coordination and effectiveness"; Working Paper University of Texas at Dallas, (2008).

Appendix

Rotated Component Matrix[a]

	Component		
	1	2	3
BOS focus on task at hand 2			.792
BOS synthesis of team ideas 1			.691
BOS synthesis of team ideas 2			.542
KSA conflict management 1		.540	
KSA collaborative problem solving 1		.470	
KSA effective communication 1		.457	
KSA conflict management 2		.673	
KSA collaborative problem solving 2		.757	
KSA collaborative problem solving 3		.482	
KSA effective communication 3		.685	
SP satisfaction with process 1	.611		
SP satisfaction with process 2	.640		
SP satisfaction with process 3	.661		
SP satisfaction with process 4	.644		
SO satisfaction with outcome 1	.881		
SO satisfaction with outcome 2	.854		
SO satisfaction with outcome 3	.897		
SO satisfaction with outcome 4	.900		

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 4 iterations.