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New Frontiers in Analyzing Dynamic Group Interactions: Bridging Social and Computer Science

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Abstract

This special issue on advancing interdisciplinary collaboration between computer scientists and social scientists documents the joint results of the international Lorentz workshop, "Interdisciplinary Insights into Group and Team Dynamics," which took place in Leiden, The Netherlands, July 2016. An equal number of scholars from social and computer science participated in the workshop and contributed to the papers included in this special issue. In this introduction, we first identify interaction dynamics as the core of group and team models and review how scholars in social and computer science have typically approached behavioral interactions in groups and teams. Next, we identify key challenges for interdisciplinary collaboration between social and computer scientists, and we provide an overview of the different articles in this special issue aimed at addressing these challenges.

Keywords

interdisciplinary collaboration, group and team dynamics, interaction processes, social science and computer science

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Groups are intriguing social phenomena. They are at the core of organizational functioning across all sectors and society at large (e.g., Gastil, 2009; Kozlowski & Ilgen, 2006). Group members share an identity as a group and need to interact with one another to fulfill one or more group or team goals, which can be task-related or relational. From a task perspective, they produce a result for which they share responsibility, and this result can be identified, measured, and evaluated by others (e.g., Kozlowski & Bell, 2003). Creating and sustaining relationships is also an outcome of groups and teams (Keyton & Beck, 2009). Both task and relational outcomes are accomplished as group members work interdependently (i.e., depending on one another to accomplish these outcomes). Thus, at the center of any group or team model is the interaction (verbal and nonverbal) among members (e.g., Bonito & Sanders, 2010). Because the task and relational interdependencies cannot be predicted, groups are dynamic. Coined by Kurt Lewin (1943, 1948), the term *group dynamics* encompasses those behaviors and psychological processes that occur within a group (intragroup dynamics) or between groups (intergroup dynamics).

Groups consists of at least three members, and therefore dyads are not groups: "dyads are qualitatively different than groups, which means that people who study dyads are not really studying groups, as some of them claim (and more of them may believe)" (Moreland, 2010, p. 252). As discussed in detail by Moreland (2010), dyads often form and dissolve more easily than groups, and people experience different emotions in dyads than in groups (with emotional experiences in dyads often being stronger than in groups; for example, consider the case of close personal relationships). In addition, group interactions are generally more complex and, therefore, much harder to study than individual behavior. Studying dyads is typically easier, but results from dyads do not map onto group interactions. In dyadic interaction, conversation can only go back and forth between two individuals. In group interaction, conversation by one member may be directed to all other members, or it may be singled out for a specific member but said in front of others. Moreover, groups can create coalitions (i.e., usually based on influence attempts or preference for a particular alternative in decision making). In sum, dyads are simpler social structures than groups, and many group phenomena cannot be studied in dyads. These include intragroup constructs such as group cohesion (see, for example, Salas, Grossman, Hughes, & Coultas, 2015 for an overview), groupthink (for a review, see Esser, 1998), and any phenomena that require the study of subgroups, such as group diversity and inclusion or majority/minority opinion (e.g., Shore et al., 2011), minority and majority influence (e.g., Smith, Tindale, & Dugoni, 1996; Ten Velden, Beersma, & De Dreu, 2007), and coalition formation in groups (e.g., Mannix, 1993).

Although research on communication processes and interaction dynamics has made some important contributions toward understanding the microprocesses that constitute group (rather than dyadic) interactions (e.g., Keyton & Beck, 2009; Paletz, Schunn, & Kim, 2011; Zijlstra, Waller, & Philips, 2012), dynamics in groups are still difficult to capture (for detailed critiques, see Cronin, Weingart, & Todorova, 2011; Kozlowski, 2015; Leenders, Contractor, & DeChurch, 2016). One reason for this continuing research challenge is that group dynamics are fluid and can change from minute to minute—or millisecond to millisecond—which makes them notoriously difficult to reliably identify and validly measure. To understand why a particular behavior occurs within a group interaction, researchers need to account for the temporal sequencing of the behaviors of all group members and for multiple predictors that can explain why a certain behavior occurs, including previous behaviors, individual characteristics, group characteristics, or other context factors (e.g., Chiu & Lehmann-Willenbrock, 2016; Herndon & Lewis, 2015).

Typically, *social science scholars* researching groups (i.e., *groupies*) who have a background in anthropology, communication, organizational behavior, psychology, or sociology pursue a behavioral approach and want to study group interactions dynamically and temporally. As such, they are quickly struggling with the sheer volume of data. For instance, consider Table 1, which shows an excerpt from a typical team meeting that lasted 1 hr. In this example, units of verbal behavior including time stamps were identified using INTERACT software (Mangold, 2010). Onset and end times of each behavior are shown in minutes, seconds, and milliseconds. This short excerpt illustrates the high granularity of this approach, but also the sheer volume of data that researchers pursuing this fine-grained approach tend to end up with, leading to substantial manual labor. For instance, an in-depth analysis of the 1,003 verbal communication behaviors observed on average during such a team meeting requires approximately 7 hr of intense human coding effort per meeting (e.g., Lehmann-Willenbrock, Chiu, Lei, & Kauffeld, 2017); these efforts multiply when the research goal is to understand group interactions across multiple occasions and in multiple groups.

Identifying and documenting the nonverbal behaviors of group members add even more time. For example, identifying and coding individual team member's nonverbal behavior along the two dimensions of *pleasure* and *activation*, which are considered basal dimensions of nonverbal affect (e.g., Barsade, 2002; Bartel & Saavedra, 2000; Lehmann-Willenbrock, Meyers, Kauffeld, Neininger, & Henschel, 2011), a videotaped 1-hr meeting will require many hours of human coding effort. As important, current methods of capturing nonverbal behavior are restricted to viewing the group interaction through a proscenium arch. The positioning of group members relative to one

Table 1. Sample Transcript Annotated With the Act4teams Coding Scheme.

Onset	End	Speaker	Act4teams code	Transcript
00:07:18:02	00:07:23:17	A	Connections with problems	The other thing is that the management has caused this whole problem.
00:07:23:18	00:07:26:22	A	Criticizing	I said right from the start, you can't really talk to [name of supervisor].
00:07:26:22	00:07:29:03	A		But then, that's what I'm saying, we still gotta run that machine.
00:07:29:03	00:07:31:11	E	Criticizing	They're denying and covering up the facts.
00:07:31:11	00:07:35:01	E	Complaining	No one feels responsible for anything, I'm sorry but that's how it is.
00:07:35:01	00:07:36:11	D	Providing support	Yup.
00:07:36:11	00:07:40:02	E	Complaining	They just lay the blame on someone else, when there's a problem anywhere.
. . .	. . .	. . .		. . .
00:32:02:10	00:32:03:11	G	Separating opinions from facts	But I mean, I'm used to that.
00:32:03:11	00:32:03:19	F	Providing support	Uh-huh.
00:32:03:20	00:32:05:04	G	Complaining	I'm always the fool.
00:32:05:04	00:32:06:12	F	Empty phrase	Yeah keep on dreamin'.
00:32:06:12	00:32:08:19	E	Laughter	(laughs)
00:32:08:19	00:32:18:04	A	Problem	Well the thing is, he [points to speaker G] has a different opinion, and we have another opinion. That's the problem here, isn't it though.
00:32:18:04	00:32:19:12	G	Laughter	(giggles)
00:32:19:12	00:32:25:10	A	Positivity	But I think it's good to hear your opinion because we need to change something.
00:32:25:10	00:32:26:18	E	Providing support	Yeah well.
00:32:26:18	00:32:29:21	A		I think you should contribute your opinion, and you should let us know in the future when that [machine error] happens so we can react quickly.

Note. Transcript of original data published in Lehmann-Willenbrock, Chiu, Lei, and Kauffeld (2017). Time stamps (unitizing) implemented using with INTERACT software. Behavior onset and end times in minutes, seconds, and frames per second. Act4teams codes were annotated by human coders. Interrater reliability for this sample was $\kappa = .81$.

another blocks the viewing of the full range of nonverbal cues. This results in group researchers evaluating the nonverbal behaviors that can be easily seen or heard. Thus, nonverbal signals outside the range of the eyesight of the researcher or the camera typically remain unknown and uncoded. If the researcher cannot see a behavior, that behavior and its influences cannot be captured and considered in analyses. Again, the choice to restrict the range of behaviors under study is often driven by the limited availability of time, research funds, and human coding hours. What is lost is the exploration of behavior beyond the specific research hypothesis at hand. Thus, social scientists who study groups and teams could benefit dramatically from applying automated behavioral analysis via intelligent sensing and analysis technologies. Furthermore, many group scholars would rather collect data in the field rather than in laboratories, as data collected from concocted groups are void of the rich context that influences naturally occurring group members' behavior.

Computer science scholars (i.e., *geeks*) working in the area of social signal processing (see Vinciarelli, Pantic, & Bourlard, 2009 for a review) or affective computing (see Picard, 1997 for an introduction and Gunes & Pantic, 2010; Gunes & Schuller, 2013; and Sariyanidi, Gunes, & Cavallaro, 2015 for more focused surveys) have been making significant advances in the identification and analysis of small group interaction, particularly in controlled settings (see the survey by Gatica-Perez, 2009). Thus, it has been possible to provide fine-grained analyses of group interaction patterns and use these to automatically determine social constructs such as agreement/disagreement (e.g., Bousmalis, Mehu, & Pantic, 2013), cohesion (e.g., Hung & Gatica-Perez, 2010), dominance (e.g., Hung, Huang, Friedland, & Gatica-Perez, 2011), leadership (e.g., Scherer, Weibel, Morency, & Oviatt, 2012), or emotion (e.g., Mou, Gunes, & Patras, 2016) in group interactions. However, these innovations remain out of the reach of group scholars as considerable expertise is required to understand the practicalities of how data captured for human interpretation differ from data captured for automation. This gap has limited the flow of ideas from one discipline to another and kept geeks and groupies from collaborating with one another. Hence, this gap could be better exploited for both research outcomes and practical applications.

Geeks prefer to conduct research in controlled or laboratories to maximize control. Conducting research in less controlled (i.e., field) settings leads to poorer data quality than is required for state-of-the-art automated systems, as that technology is unable to cope with the challenges of noisy data captured in the wild. This misalignment has thus far been underexplored in group research (for similar critiques, see Frauendorfer, Mast, Nguyen, & Gatica-Perez, 2014; Schmid-Mast, Gatica-Perez, Frauendorfer, Nguyen, & Choudhury, 2015). Although many automation methodologies have been developed by researchers in social signal processing (Gatica-Perez, 2009; Vinciarelli et al., 2009) and affective computing (Gunes & Pantic, 2010; Gunes & Schuller, 2013; Sariyanidi et al., 2015) that could have substantial benefits beyond the scope of computer science, they tend to stay in prototype form and require computing expertise to apply, adapt, or reimplement for data collected by groupies.

The interdisciplinary workflow between group science and computer science can be considered in a much more complex manner than a simple service provision role. In particular, as geeks develop more sophisticated methods to automatically capture and interpret human social behavior, they reach an impasse where the interpretation becomes too complex to be learned automatically without help from group scholars (and their theories). Some of the state of the art in computer science research on automated social behavior relies on findings in social science from almost four decades ago (e.g., Hung & Kröse, 2011). This lack of research in observation-based and behavior-driven phenomena also leads to a deceleration in the progress of computer science as the theories and patterns of behavior that can help inspire the computational models do not exist. Part of the task has therefore been addressed by the computer scientist themselves (e.g., either explicitly Cassell, Gill, & Tepper, 2007 or implicitly Hung & Gatica-Perez, 2010), which requires a different type of research design and expertise than that of geeks who work on social signal processing and affective computing are traditionally trained. Likewise, groupies typically lack the expertise for developing and automating data analytic tools.

Finally, and perhaps the most challenging to distinguish are the many phenomena in small group interactions that cannot be easily investigated because it is simply beyond the current state-of-the-art methodologies in both disciplines to measure (either manually or automatically). Therefore, *a core interdisciplinary challenge* concerns finding ways to enable groupies to dare to ask questions that they might think are currently impossible on the one hand, and to enable geeks to be challenged to consider fundamental new questions in computer science to find solutions to answer these questions on the other hand.

The two communities are developing largely independently to date. To bridge this interdisciplinary divide, we conducted an interactive international workshop aimed to investigate the nature of collaboration in this setting, to put forward a joint research agenda, and to decide upon concrete steps for this intriguing interdisciplinary research area. This initiative took place in July 2016 at the Lorentz Center, which is part of the Netherlands Institute for Advanced Study in the Humanities and Social Sciences in Leiden, The Netherlands. The workshop was entitled "Interdisciplinary Insights into Group and Team Dynamics." The workshop was intended to (a) inspire new interdisciplinary approaches that embrace automation and (b) consider the trade-offs between obtaining clean controlled sensor data and accurate data interpretation in less controlled and more ecologically valid settings. Under the working title "Geeks and Groupies," 12 groupies (social science scholars) and 13 geeks (computer science scholars) spent an intense 3 days to lay the ground for new interdisciplinary work that brings together groupies and geeks to break new ground in group interaction analysis. This special issue of *Small Group Research* documents the results of the workshop and the derived research agenda.

Bridging Disciplinary Boundaries to Advance the Science of Group Interaction

This article, along with others in this special issue, outlines a number of goals of combining social science and computer science. Throughout the workshop, it became clear that good interdisciplinary or transdisciplinary research (Börner et al., 2010) could only come about through the strong presence of both disciplines. Figure 1 provides an example showing how the two disciplines currently link together in terms of furthering research on group processes. Along the horizontal axis, we see the extremes of computer science represented on the left side and the extremes of social science represented on the right (and representative publication venues on the bottom). Publications in one set of disciplinary venues have little influence in the other discipline. Much of the current research activities in both domains are carried out in this way: The two disciplines are working on similar or closely related issues; scholars may collaborate but maintain a strong presence in their disciplinary area.

As we head toward the central part of the figure, more expertise from the other discipline is required and shows some interdisciplinary (Börner et al., 2010) workflows where one discipline provides expertise to benefit the research questions of the other discipline (e.g., geeks creating tools for groupies; groupies providing social theory for geeks in developing tools). As we move further into the center of the figure, we expect the expertise from one discipline to flow into the other. Currently, this tends to occur within the collaborative discourse between geeks and groupies but is typically lost and not easily reproducible or transferable for others wishing to embark on the interdisciplinary collaborative journey.

We argue that Figure 1 provides an unsatisfactory view of how researchers can truly exploit and mutually benefit from the other domain. One of the early discussion points in the workshop was identifying the way in which the two groups of scientists were working together, and how they could work together in the future. However, transdisciplinary research is the ultimate goal.

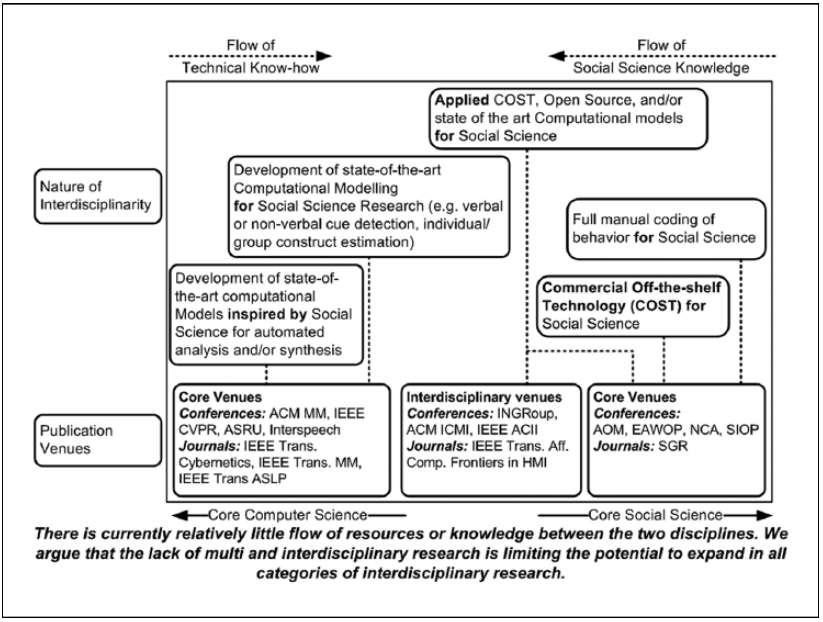

Figure 1. Illustration of different degrees of interdisciplinarity between computer science and social science.

Transdisciplinary research is novel scientific work that can advance both fields as well as create research synergies and advances that would not be possible if both fields work independently from one another (Börner et al., 2010).

In the case of optimal interdisciplinary and transdisciplinary science, the challenges and research questions of both disciplines should drive innovations that are mutually beneficial for both fields. Without striving for this, both disciplines are held back from knowing how to develop the truly innovative research questions that could significantly advance each field as well as forging a more accelerated interdependent path in between. There is the potential not only to understand more deeply the dynamics of group processes but also ultimately to influence and improve them for significant societal benefit. Therefore, the aim of this special issue is to analyze and identify what processes would need to be in place to maximize this form of mutual benefit.

Overview of the Special Issue

An equal distribution of geeks and groupies attended our Lorentz workshop. Using both social and task-based activities, we began by building a common language and understanding the goals of each discipline. Then, we compared and contrasted the approaches that each research domain (social science and computer science) uses to analyze small group interactions. Through this understanding, we identified a detailed future research agenda suitable for breaking new ground, sparking research synergies, and moving both the social science and the computer science domain forward—and, mostly importantly, the study of groups and teams. The sections of this white paper were invited to be compiled as a special issue in *Small Group Research*. The sections of the white paper—now as articles of a special issue—are based on the work of the interdisciplinary, international groups that were initiated at the Lorentz workshop, and continued post conference.

Following this introduction, the article, "Initiating and Maintaining Collaborations and Facilitating Understanding in Interdisciplinary Group Research," authored by Stephenson J. Beck (Communication, North Dakota State University), Annika L. Meinecke (Industrial/Organizational Psychology, Technische Universität Braunschweig), Yoichi Matsuyama (Computer Science, Carnegie Mellon University), and Jeremy Lee (Electrical Engineering, National Tsing Hua University), describes the challenges and necessary steps for successfully initiating and maintaining collaborations and facilitating understanding between geeks and groupies who want to advance our understanding of group interaction processes.

In the second article, "Theories and Models of Teams and Groups," Roni Reiter-Palmon (Industrial/Organizational Psychology, University of Nebraska-Omaha), Tanmay Sinha (Computer Science, Carnegie Mellon University), Josette Gevers (Human Performance Management, Eindhoven University), Jean-Marc Odobez (Perception and Activity Understanding, IDIAP Research Institute), and Gualtiero Volpe (Computer Graphics, Vision, and Multimodal Systems, University of Genova) identify research questions and programs that have the potential to advance both fields.

The third article, "Workflows: Comparing Social and Computer Science Processes for Studying Group Interactions," authored by Joseph A. Allen (Industrial/Organizational Psychology, University of Nebraska-Omaha), Colin Fisher (Management, University College London), Mohamed Chetouani (Signal Processing and Machine Learning, Université Pierre et Marie Curie-Paris), Ming Ming Chiu (Education, Purdue University), Hatice Gunes (University of Cambridge Computer Laboratory), Marc Mehu (Psychology, Webster University Vienna), and Hayley Hung (Pattern Recognition & Bioinformatics, Delft University of Technology), describes the workflow and design of novel research initiatives bridging social and computer science and discusses data gathering/storing and analytical issues during such initiatives.

In the fourth article, "Killer Apps: Criteria and Interdisciplinary Opportunities for Enhancing Team Communication and Effectiveness," authored by Claudia Buengeler (Leadership & Management, Amsterdam Business School), Florian E. Klonek (Organizational Behavior, University of Western Australia), Nale Lehmann-Willenbrock (Work and Organizational Psychology, University of Amsterdam), Louis-Philippe Morency (Computer Science, Carnegie Mellon University), and Ronald Poppe (Information and Computing Sciences, Utrecht University) discusses evaluation criteria for applications and related intervention opportunities based on novel interdisciplinary research initiatives.

Finally, in "Pushing Interdisciplinarity," Joann Keyton (Communication, North Carolina State University) and Dirk Heylen (Socially Intelligent Computing, University of Twente) discuss strategic issues related to such novel initiatives, including publication strategies and journal policies as well as research funding policy making.

Declaration of Conflicting Interests

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