EXTENDED PAPER

Communication in international collaborative research teams
A review of the state of the art and open research questions

Kommunikation in international kollaborativen Forscherteams
Eine Bestandsaufnahme des Forschungsstandes und offener
Forschungsfragen.

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Abstract: In Communication Science, international scholarly communication and collaboration practice still remain unknown territory. Therefore, a systematic review of the state of the art on scholarly communication practice in international research collaborations (IRCs) was carried out that included a broad spectrum of disciplines and research fields such as Communication Science, Business and Management Studies, Sociology, science studies, and the science of team science. A sample of 168 contributions focusing on IRCs were identified. The paper outlines focus and methodological designs of those contributions, provides insights into the composition of the observed IRCs, summarizes the perspectives of the disciplines and research fields, presents the insights into communication structures and processes in IRCs, and discusses the aspect of team diversity, which some studies indicate as relevant for communication practice in IRCs. Overall, research largely focuses on the structural dimension of communication, while empirical analyses on the actual communication processes among scientists in IRCs are still rare. Secondly, research is missing on how team complexity is dealt with in IRCs and what impact it has on collaboration processes and success. A third and fourth research gap are identified regarding the use of a joint collaboration language and the communication processes in Social Sciences and Humanities. Future research should broaden its analytical focus to fill those gaps. This would provide important insights from an epistemological and a practical perspective, by offering the foundation for the development of guidelines and toolkits for future IRCs, thus contributing to the success of such forms of research and knowledge creation.

Keywords: Scholarly communication, project communication, international research collaboration, scientific teamwork, team diversity.

Zusammenfassung: In der Kommunikationswissenschaft ist die internationale interne Wissenschaftskommunikation bisher ein noch wenig beforschtes Feld. Eine systematische Literaturstudie soll deshalb den aktuellen Forschungsstand über die Kommunikationswissenschaft hinaus erfassen, und dabei das Spektrum an Disziplinen und relevanten Forschungsfeldern berücksichtigen, die sich internationaler Wissenschaftskollaboration widmen, wie Organisations- und Managementforschung, Soziologie, Wissenschaftsforschung und die Team Science-Forschung. Ein Sample von 168 Beiträgen wurde identifi-

ziert, die sich internationalen Forschungskollaborationen (IFKs) widmen. Der Artikel stellt Fokus und methodologisches Design der Beiträge vor, gibt Einblick in die Zusammensetzung der analysierten IFKs, fasst die Perspektiven der einbezogenen Disziplinen und Forschungsfelder zusammen, präsentiert die bereitgestellten Erkenntnisse zu Kommunikationsstrukturen und -prozessen in IFKs und diskutiert den Aspekt von Teamvielfalt, welchen einzelne Studien als relevant für die Kommunikationspraxis in IFKs herausstellen. Die bisherige Forschung fokussiert stark auf strukturelle Aspekte von Kommunikation, während empirische Analysen zum eigentlichen Ablauf von Kommunikationsprozessen zwischen Wissenschaftlern in IFKs noch rar sind. Zweitens fehlt es an Forschung zum Umgang mit Teamvielfalt in IFKs und dem Einfluss derselben auf Kollaborationsprozesse und -erfolge. Drittens finden sich noch wenige Analysen zur Rolle und dem Umgang mit einer gemeinsamen Kollaborationssprache. Zudem liegt der Fokus bisher kaum auf der Analyse von Kommunikationsprozessen in den Sozialwissenschaften. Zukünftige Forschung sollte deshalb ihren analytischen Fokus dahingehend erweitern, um die skizzierten Forschungslücken zu schließen. Diese analytische Erweiterung ist aus wissenschaftstheoretischer aber auch aus praktischer Sicht wichtig, denn sie bildet die Basis für die Ableitung von Handlungsanleitungen und Toolkits für zukünftige IFKs und trägt damit zum Erfolg solcher Formen von Forschung und Wissensgenerierung bei.

Schlagwörter: Interne Wissenschaftskommunikation, Projektkommunikation, internationale Forschungskollaboration, wissenschaftliche Teamarbeit, Teamvielfalt.

1. Introduction

International research collaborations (in short: IRCs) have become one of the main characteristics of academic knowledge production, and international research teams today are a widespread and growing mode of scientific collaboration, aiming at the joint compilation and development of research products such as data sets or publications. Throughout the last 50 years, coauthored publications and multi-national grant proposals have increased significantly and steadily in most disciplines (Gaillard 1992, Leydesdorff & Wagner, 2008; Olson et al., 2008; Persson, Glänzel, & Danell, 2004; Price, 1963). For Communication Studies, the formation of specific research networks such as the *International Communication Association* (ICA) or the *European Communication Research and Education Association* (ECREA), as well as the establishment of new scholarly journals especially devoted to international and comparative research (e.g., the *Journal of Intercultural Communication Research*, founded in 2006; the *Journal of Global Mass Communication*, founded in 2008) also indicate this increasing international connectedness (Hanitzsch, 2007, p. 43).

The reasons for this development are manifold: New forms of technological accessibility have supported a faster knowledge circulation and global connectivity, triggering the rise of global institutionalized networks of scientists. They have also provided the global availability of and possibility to exchange data and ideas. At the same time, cheaper and faster global mobility infrastructures have facilitated easier international data collection and the personal contact among international research communities and collaboration partners (Brewster, Mayrhofer, & Reichel, 2011; Esser & Hanitzsch, 2012a). Finally, yet importantly, international collaboration has become essential as well as imperative to solve

social problems and answer global research questions (Janich & Zakharova, 2011; Kosmützky, 2017; Pelikan, 2015b).

In addition, governments and funding organizations at both the national and supranational level actively support international collaborative research (Katz & Martin, 1997; Melin, 2000; Wagner, 2008). Particularly, the funding schemes of the European Union (e.g., the Framework Program, currently see FRP *Horizont 2020*) and its sub-schemes have contributed significantly to the dissemination of IRCs, since they often require collaborators from different countries in order to be eligible for funding (Kosmützky, 2018; Slipersæter & Aksnes, 2008; Smeby & Gornitzka, 2008; Smeby & Trondal, 2005). Furthermore, national funding agencies have opened up their funding schemes to international collaborative research constellations, for example by creating joint, regionally focused, funding schemes, such as the *Open Research Area for the Social Sciences* (Cuntz & Peuckert, 2015).

As a result, in the last three decades a number of small and short-term, but also large-scale and long-term IRCs and international networks have emerged. One example is the *Worlds of Journalism* study – a collaboration that exists for more than a decade now and has collaboratively analyzed and compared the work of journalists and news organizations in more than 67 countries (e.g. Hanitzsch et al., 2011).

However, despite this growing popularity, IRCs are not solely praised as the new form of research and knowledge production. They often have become an imperative and the impression can arise that nowadays scholars would often chose to collaborate "for the sake of collaborating" in order to meet national as well as international requirements of excellence and success, assuming that collaborative knowledge production necessarily produces more profound knowledge. This expectance is also reflected in the current forms of research funding (as already outlined for the EU's FRP *Horizon 2020*), with an increasing number of funding instruments asking for an international research consortium in order to receive funding, such as the EU Research and Innovation Actions which are requesting joint projects with international consortia[1].

Overall, IRCs offer a number of benefits: They entail a large intellectual freedom for all participating scientists, while at the same time bringing together academic resources that are unevenly distributed (Esser & Hanitzsch, 2012b). They provide access to a larger variety of different expertise and knowledge than individual scientists may have (e.g. Beaver, 2001; Fiore, 2008; Katz & Martin, 1997; Sonnenwald, 2007; Vanrijnsoever, Hessels, & Vandeberg, 2008), especially about other national or cultural contexts. They also allow for the exchange of those ideas, expertise and knowledge, and for their combination in order to develop new creative solutions for complex research problems (e.g. Cooke & Hilton, 2015; Melin, 2000), and thereby also offer broader access to international data, research instruments, or funding sources (Beaver, 2001). Research collaborations are often more productive (e.g. Lee & Bozeman, 2005), produce results of higher scientific quality (e.g. Rigby & Edler, 2005), and help scientists to gain academic

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1   See https://www.horizont2020.de/einstieg-verbundforschung.htm.

acknowledgement, reputation and visibility, for example through higher citation rates (e.g. Bukvova, 2010; Esser & Hanitzsch, 2012b).

At the same time, individual expectations, motivations for collaboration or goals may differ (Easterby-Smith & Malina, 1999; Segalla, 1998). Therefore, scientists in IRCs face the challenge of having to coordinate their collaboration, their goals and procedures, as well as the division of tasks and responsibilities, and have to find a common denominator. At the same time, on a social level, a team must be formed and joint forms of communication and behavior have to be found, that are acceptable to and applicable for all collaborating partners (Finley, 1979). Scientists must interact over spatial distance and must establish and sustain "long-distance" social relationships and trust in their collaborations.

One crucial basis for handling those challenges is the establishment of a functioning communication. As Sonja Livingston points out in her highly cited article *On the challenges of cross-national comparative media research* (2003), international comparative and collaborative research faces multifaceted and multi-layered communicative and social challenges and, based on her observations, is sometimes even described as "exhausting," "a nightmare," and "frustrating" (p. 481). She therefore argues that international collaborative research teams rely „heavily on communicative (often, email) etiquette" to create mutual trust and reciprocal understanding (p. 482). From this perspective, communication thus plays a crucial role in IRCs and goes far beyond using a joint language. It is not only a crucial factor in the process of knowledge generation and the common production of research outputs (e.g. publications), but also forms the foundation for self-organization and cooperation in international collaborative teams (Lüthje, 2017).

Communication processes among collaborative research teams thereby fall under the conceptual framework of *science communication*. Following Bonfadelli et al. (2017a), this concept refers to "all forms of communication that are focused on scientific knowledge and scientific work, either within or outside of institutionalized science, and including its products, content, application and impact" (p. 5, own translation). In the English-speaking research region, *external* (public) communication of scientists is labeled as *science communication*, while *internal* communication is referred to as *scholarly communication* – a term that will be adopted in this paper (Lüthje, 2017).

So far, the *science of science communication* (Fischhoff & Scheufele, 2013) traditionally has focused predominantly on external science communication towards the public or other areas of society (e.g. Bonfadelli et al., 2017b; Jamieson, Kahan, & Scheufele, 2017; Schäfer, Kristiansen, & Bonfadelli, 2015). Internal science communication, i.e. communication processes by which scientific knowledge is produced, verified, and circulated (e.g., in publications or at conferences), is still paid minor attention to (Lüthje, 2017). This research area has so far been covered by the Sociology of Scientific Knowledge, the Information Science, the Science of Team Science, or Science and Technology Studies, but not by Communication Science. At the same time, when scholarly communication processes are analyzed, it is predominantly with regard to formal communication among academics in the process of producing joint publications (e.g. Crane, 1972; Garvey & Griffith, 1967, 1972; Price, 1963), or by analyzing the publication output itself

(e.g. Borgman, 1990; Kling, 2004; Kling & Callahan, 2001; Paisley, 1989; Taubert, 2017). Another focus lies on informal scholarly communication, but here is limited to the analysis of the structural use of digital communication tools (e.g. Bader, Fritz, & Gloning, 2012; Barjak, 2006; Costa & Meadows, 2000; Fry, 2004a, 2004b; Fry & Talja, 2007; Kling & McKim, 2000; Lievrouw, 2010; Matzat, 2004; Tuire & Erno, 2001; Voigt, 2012; Vowe, 2016). The informal communication practice among scientists, e.g. direct or indirect forms of communication to control the cooperation, division of tasks, exchange of knowledge, ideas and research results, or the reciprocal coordination of information and research procedures, have so far been largely ignored (Kaden, 2009). One exception here are the scientific ethnological laboratory studies, as they were first introduced in the 1970s in the field of *sociological science studies* by Latour and Woolgar (1979) or by Knorr-Cetina (1981). Those studies aimed at describing the genuine patterns of order for observable processes of knowledge. They focused on participant observation of scientific activity, i.e. of research teams that carried out experiments in laboratories, analyzing the routinely occurring interactions and scientific activities – and thus the social and communicative processes – in the actual research practice (Lüthje, 2017; see also Amann & Knorr-Cetina, 1996). However, the focus hereby was on laboratories in the Natural Sciences (e.g., Chemistry, Physics, and Biology), and has only more recently taken into view the Social Sciences and Humanities (Reichmann, 2013). Furthermore, by focusing on laboratories, the studies did not include the dimension of collaboration over spatial distances.

Consequently, in Communication Science, international communication among scientists/researchers remains an unknown territory and the communication processes and structures of IRCs, as well as the interplay of communication, collaboration practice, teamwork, and project success in such collaborations, so far remain a black box (Baurman & Vowe, 2014). Lüthje (2017) assumes that especially for the German-speaking research area, one reason lies in the fact that Communication Studies traditionally focus on public communication. However, Paisley (1989) argued already 30 years ago, that research on formal and informal scholarly communication should fall within the domain of Communication Studies, because it also focuses on communication events and the flow of information through interpersonal networks, as well as informal and formal media (pp. 701–703).

Therefore, this paper has two goals: First, it aims at providing a systematic review of the current state of the art and knowledge with regard to scholarly communication practice in international scientific research collaborations, in order to provide an overview of what we know so far about communication processes and challenges in IRCs. It identifies the focus of the research so far and summarizes the major insights the literature provides on the communication practice in IRCs. Furthermore, the review also identifies discussed challenges in the literature with regard to the international communication practice, as well as offered solutions to handle those challenges. The literature review will be transdisciplinary, considering that contributions to the research on (international) scientific research practice so far has come mainly from other disciplinary perspectives and still presents a newly developing sub-field in Communication Science.

The second goal of this paper is to identify the research gaps from this systematic literature review, in order to develop an agenda for future research areas on international scholarly communication that Communication Science could tackle to expand the research field on scholarly communication. This is regarded as relevant not only from an epistemological but also from a practical perspective, since scientists in IRCs need to be prepared to set up a successful communication practice, and thus must reflect upon their own communication processes. If this reflection is missing, IRCs may run the risk of not making full use of the different skills, scientific expertise, and the deeper context knowledge on specific countries or cultural backgrounds that each of the collaborating scientists contribute to the collaboration. A broad literature review also allows for the combination of the different disciplinary experiences and approaches to international scholarly communication and collaboration and may thus offer helpful insights and materials to develop guidelines (e.g., best practice examples, toolkits, and workshops) for future IRCs. This again may contribute to the future success of such forms of research and knowledge creation.

The article has the following structure: In the second chapter, the conceptual framework of the paper is outlined again in more detail. Here, a definition of research collaboration and IRCs is provided that also includes the distinction of task level, team level, and structural context level, based on which IRCs can be examined in more detail. In addition, the idea of research communities is introduced as a relevant context IRCs are embedded in. Secondly, the relevance of communication is outlined, here arguing mainly that communication does not only serve as a structure and tool for information exchange, the discussion of research goals and content, or the coordination of collaborative tasks. It is also regarded as the basis for social interaction, the formation of an IRC team, the establishment of functioning relationships among the collaborating scientists, and trust building. Furthermore, communication practice in IRCs is broken down into its relevant components, which include the specifically developed structures, the used tools and channels, the content, and the processes of communicative interaction that can be identified in IRCs.

The third chapter introduces the methodological design of the systematic literature review that was carried out and the results of which are presented and discussed in this paper. The literature sample is introduced, listing the disciplines and research fields as well as the publication formats that were included in the analysis. In addition, the procedures for data collection and data analysis are explained.

In the fourth chapter, the results of the systematic literature review are presented. First, the focus and methodological design of the identified contributions on IRCs is outlined. Secondly, the composition of the observed IRCs is outlined, by presenting the disciplinary background as well as the countries of origin of the participating scholars. Subsequently, the perspectives and foci of the different disciplines and research fields are summarized, followed by a thorough presentation of the main insights on communication structures and processes in IRCs, as it can be derived from the literature corpus. Finally, the aspect of team complexity in IRCs is discussed, since the insights given in the literature indicate that this aspect adds an important factor involved in the communication practice in IRCs.

The concluding chapter summarizes the main results of the analysis, identifies four major research gaps, and drafts a future research agenda for international scholarly communication analysis, by suggesting four research foci for future studies on international scholarly communication.

2. Conceptual framework

2.1 Research collaborations

The term *research collaboration* refers to relationships between individual scientists or organizations, between individuals and organizations, or between countries. Following Kosmützky (2018, p. 3), in this study the term is used to describe interactions between scientists on the micro-level, defining it as "a temporary social process in which scientists pool their complementary skills and expertise and become functionally interdependent in order to produce knowledge they could not have generated on their own" (see also Bozeman, Fay, & Slade, 2013). Thus, it can refer to a variety of activities, including the integration and transfer of knowledge, the division of research tasks, the provision of access to research requirements, or bilateral feedback formats (Jeong, Choi, & Kim, 2014; Katz & Martin, 1997, Kosmützky, 2018; Laudel, 2002, Lewis, Ross, & Holden, 2012). Thus, research collaborations among scientists can vary from fluid ad-hoc teams to stable temporary research projects or long-term research networks, which are based on shared goals and project funding (López-Yáñez & Altopiedi, 2015). Overall, research collaborations are largely voluntary, self-governed and substantially autonomous social entities, and are based on mutual interests of the participating scientists (Kosmützky, 2018; Wang & Hicks, 2015; Weiss & Hoegl 2015).

Furthermore, three levels of the collaboration processes are distinguished (adapting Kosmützky, 2017): On the *team level*, collaboration takes place between a more or less defined number of individuals who build and maintain relationships among each other and thus form a collaborative team. Here, interaction and communication may take place to form a collaborative group and team, to coordinate the team composition, deal with social interaction and team dynamics, build trust, or manage conflicts.

On the *task level*, those collaborative teams must set up collaboration goals, define their collaboration designs and procedures, and manage the collaboration process. Here, interaction and communication may take place to coordinate and agree upon work tasks, timeframes, and work schedules, or to discuss the character and complexity of the research pursued in the collaboration. Collaborating scientists also must decide on the division of work tasks or the structure of their collaboration. They may have to agree upon the used theoretical approaches and concepts, the methods of analysis, as well as the modes of operation or distribution of personnel, data, and research results.

Finally, on the *structural context level*, collaborating research teams are often embedded in different institutional contexts that form the framework parameters for the project implementation. Here, interaction and communication may take place to determine and integrate the respective institutional framework condi-

tions into the own collaboration strategy and structure. Differing work ethics or institutional legal frameworks and conditions (e.g., for the protection of research subjects, data ownership, or copyright), as well as differing institutional modes of research governance or the measurement of success have to be communicated and integrated (Bakker, 2010; Kuster et al., 2011).

2.2 International research collaborations

The outlined criteria do apply for both national as well as international research collaborations. In addition to that, a research collaboration defines as *international* when they involve scientists whose primary employment affiliations are in different countries (Anderson & Steneck, 2011; Kosmützky, 2018). Since IRCs do not take place at one central location but divide among different internationally distributed scientists or teams, they heavily rely on non-face-to-face communication and are limited in their direct daily interaction. Thus, they must develop communication structures and practices that are able to bridge not only the spatial distance, but also additional structural context as well as cultural differences. On the *structural context level*, IRCs are also embedded in different national contexts that form the framework parameters for the project implementation. This requires the collaborative team to interactively and communicatively determine and integrate different national, research policy-related framework conditions, differing national research ethics, legal frameworks, or different national modes of research governance or the measurement of success (Bakker, 2010, Kuster et al., 2011).

Finally, and in addition to disciplinary affiliations, IRCs and its members are also embedded in *research communities*, who have developed unique perspectives on their research area and a body of common knowledge, practices, and epistemological approaches (Wenger, McDermott, & Snyder, 2002). Research communities are not necessarily limited to national boundaries. They share their own forms of communication and forums for exchange (e.g., academic conferences), have developed their own media (e.g., professional journals), have established their own networks (e.g., disciplinary and sub-disciplinary associations), and provide the public sphere for reciprocal observation and feedback, using their own technical language (Gläser, 2012; Wenger et al., 2002). Thus, IRCs also establish their social cohesion via a cognitive bond and an intrinsic motivation for commitment based on their common research interest and perceived affiliation to such research communities, while at the same time using the outlined forums of exchange, networks, technical languages, feedback forms and media.

2.3 The relevance of communication in IRCs

Communication forms a crucial basis for the implementation of IRCs – as it does for research collaboration in general. For the Social Sciences, Schütze (1978) labels this as the „basic communicative character" (own translation) of social research, since here empirical data are predominantly generated communicatively, because their investigation requires the establishment of communicative relation-

ships not only between researchers and research subjects, but also among researchers (Schütze, 1978, quoted from Pflüger, 2013). Adopting this perspective and applying it to science in general, communication therefore is regarded as the "essence of science" (Garvey, 1979, quoted from Lüthje, 2017). It allows not only for the development of common ideas and research initiatives, and for their implementation, but also for the social exchange and interaction among the collaborating scientists (e.g. Voigt, 2012).

For interdisciplinary research collaborations, substantial research has already been carried out with regard to the interdisciplinary group processes and dynamics in such teams, as well as the challenges they may face (e.g. Benda et al., 2002; Klein, 2003; Kostoff, 2002; Pickett, Burch, & Grove, 1999; Turner & Carpenter, 1999; Wear, 1999). The concept of disciplinary cultures was developed to capture how scientific practices result from a socialization process (Albert, Laberge, & Hodges, 2015), and the idea that there are a number of methodological and epistemic differences across disciplines is not new (e.g. Becher, 1989; Clark, 1983; Kekale, 2002; Snow, 1964; van Gigch, 2002). Disciplinary cultures may manifest themselves through perceptions of and approaches to research practices, particular forms of knowledge production, related values and beliefs, differing expectations about protocols, treatment of subjects, ownership of and access to data, or publication protocols (e.g. Bosch & Titus, 2009; Eigenbrode et al., 2007; Knorr-Cetina, 1999; Leibowitz, Ndebele, & Winberg, 2013; National Research Council, 2008; Neumann, 2001; Neumann, Parry & Becher, 2002).

The literature on interdisciplinary collaborative research teams points out that the success of those teams strongly relies on effective team communication processes (Thompson, 2009). In the following, a few of the key results of those studies on interdisciplinary research collaboration will be presented to conceptualize the layers and functions of communication in national and international collaborative teams in more detail.

First, in all research collaborations, communication structures and processes must be newly established, since they are in most cases temporary enterprises. Thus, communication not only helps generating research output and scientific publications, but also supports the "creation of a communicatively closed community" (Lüthje, 2017, p. 112, own translation; see also Kaden, 2009). In addition, research collaborations in general are autonomous work formats and are thus responsible for their own communication tasks, even though they rarely have a specific budget to coordinate those (Freitag, 2016).

Thus, a constructivist perspective on communication is adopted here: Communication does not only serve as a structure and tool for information exchange, the discussion of research goals and content, or the coordination of collaborative tasks. It also forms the basis for social interaction, the formation of a collaborative research team, the establishment of functioning relationships among the collaborating scientists, trust building, and the creation of a commonly shared project reality (e.g. Clerke & Hopwood, 2014; Freitag, 2016; Siemens, 2010). However, scientists may not be aware that they constantly shape the relations with their team members through communication (Alnajjar, Pelikan, & Wassermann, 2016). Here, not only the quantity of communication contributes to a suc-

cessful collaboration, but also its quality, which must be established on different dimensions:

On the dimension of *communication content*, topics and issues have to be made visible and discussed or negotiated that are relevant for the collaborating researchers, in order to guarantee that collaboration goals are reached, and that a mutual understanding and knowledge is achieved that is rewarding for all collaborating partners. This does not only include research-related but also team-related content, i.e. interpersonal topics, issues, or occurring conflicts.

However, this semantic level of communication does bring some challenges with it. With regard to academic writing styles, for interdisciplinary collaborative research teams, Bracken and Oughton (2006) have outlined, that researchers with differing disciplinary backgrounds may frame research question differently or develop different theoretical contexts around observed research phenomena (see also Mirowski 1994; Pryke et al. 2003; Quinn & Holland, 1987). They may use the same word to mean (slightly) different things and may think about analyzed phenomena in different conceptual ways (Bracken & Oughton, 2006). As a result, those differences may lead to situations in which researchers feel challenged by their collaborators, because it becomes difficult for them to make themselves understood. This may lead to frustration, defensiveness, feelings of superiority, or disciplinary competitiveness, and can thus limit the effectiveness of the collaborative research (Bracken & Oughton, 2006).

Furthermore, Janich and Zakharova (2014) point out that how research objects, subjects and phenomena are defined also influences the methodological level of how researchers of different disciplines analyze them. Depending on what semantic meanings and methodological approaches are agreed upon, this decision may put those researchers in an advanced position whose approaches are chosen, thus creating a social hierarchy within the collaborative team (Janich & Zakharova, 2014). Therefore, collaborative research teams should try to talk not only about tasks but also about language and semantic differences. It is not only crucial for a collaborating team, that the content of the communication is understood correctly, and is comprehensible by all its members. In addition to that, all members need to feel equally comprehended, and need to develop an awareness of the potential individual variety of perspectives, evaluations and meanings that may come with the international team diversity (Akkerman, Admiraal, Simons, & Niessen, 2006).

Janich and Zakharova (2014) argue that a *joint collaboration language* has to be established, that is understood and mutually used by all collaborating scientists, and that bridges the gap between different "professional languages" of the collaborating disciplines, and the sematic, methodological and hierarchical differences that are accompanied by them.

For IRCs, the outlined semantic challenges also apply, especially but not only when IRC team consist of researchers with different disciplinary backgrounds. On top of that, IRC teams consist of researchers with different national backgrounds and different mother tongues. Consequently, the semantic level of communication (e.g. the definition of subjects, objects, and phenomena of investigation) as well as the resulting methodological implementation of research can

become even more complex. Thus, IRC teams, like interdisciplinary collaborative teams, need to talk not only about tasks but also about language and semantic differences. Furthermore, the language skills of collaborating researchers must be considered: English is used most often as the collaboration language, but not all collaborating scientists may be equally fluent in this language.

Secondly, on the *process dimension*, open and direct communication can prevent dysfunctional intergroup dynamics (Seibold, Kang, Gailliard, & Jahn, 2009), and enable the team to agree upon common research questions, a certain methodology, a specific task sharing and coordination structure, as well as operating structures for information exchange (Siemens, 2010). An open communication atmosphere here allows all collaborating scientists to bring their own content to the fore and have it communicatively negotiated (Cleland & Ireland, 2006; Hoegl & Gemünden, 2001).

Based on her ethnographic study of an interdisciplinary collaboration at a U.S. university, Thompson (2009) argues that certain communication processes are foundational for building team cohesion, such as spending time together, practicing trust, discussing language differences, engaging in team tasks and demonstrating presence, engaging in reflexive communication, sharing laughter and personal experiences, and thus engaging in interpersonal bonding once in a while. This social dimension of the communication process thus forms the crucial "glue that helps to unite the team" (Thompson, 2009, p. 284).

For IRC teams this also applies, especially since the spatial distance between team members is often large, and most collaborative activities take place at a spatial distance. Thus not only for interdisciplinary but also for international collaborations, reserving time for building trust and engaging in reflexive talk, but also for members to build relationships, should be borne in mind already when international collaborative projects are planned and should form a central part of the project agenda and work plan (Thompson, 2009). At the same time, the communication process may also be irritated by aspects such as incompatible forms of humor (e.g. sarcasm), unproductive debates of researchers' expertise, expressions of boredom, or power struggles, which all can have a challenging and deteriorating effect on the collaborative team (Thompson, 2009). Especially humor is culturally shaped and can lead to misunderstandings instead of united laughter. Thus, collaborative teams should make effort to confront such challenges before they become a group norm and lead to larger conflicts.

Overall, the challenging factors in the communication processes force collaborating international research teams to negotiate their content as well as their rules of interaction continuously. Backen and Oughton (2006), as well as Thompson (2009), argue for interdisciplinary collaborating teams, that understanding the role of language will not prevent the occurrence of conflicts that revolve around those differences. However, the authors make a key point when emphasizing that language and communication offers a way to making them visible. To make the communication processes successful requires the development of mutual trust and respect (Backen & Oughton, 2006). This holds true in the same way for IRC teams.

The authors emphasize the relevance of *communication competence*, i.e. that researchers of different disciplines are able to imagine the knowledge outside of

their usual working context and practice, and that they develop an awareness of the language, communication and behavioral differences in their collaborative teams, if they want to communicate effectively. This means that interdisciplinary and even more so international collaborations need to allow for time for their collaborating researchers to develop a mutual understanding (Backen & Oughton, 2006). Janich & Zakharova (2014) were able to show in their case study, that the participating researchers already had an awareness for the outlined challenges and were willing to reflect on them. At the same time, their disciplinary cultural imprint still had a strong impact on how they collaborated and negotiated the outlined differences. Thus, training to change your perspective (and even consulting a professional moderator) could be one crucial step towards gaining communication competence (Thompson, 2009).

From Intercultural Studies, we can furthermore derive, that this (intercultural, interdisciplinary) communication competence is not only a knowledge competence, but also a process and action competence (Bolten, 2011). It includes the motivation (e.g., the desire to make a commitment in the collaborative relationships by learning about one's own and the other collaborators' views, strengths and weaknesses), the knowledge (e.g. about the different views and approaches that come together in an international collaboration), the right attitudes (e.g., empathy for others, a tolerance towards ambiguity, or a non-judgmental view on the other collaborators' perspectives and actions), as well as the competent behavior that results from the former three components (Martin & Nakayama, 2010).

Finally, on a *structural dimension*, especially in large and geographically distributed IRCs, *communication structures* must be set up. They can maintain a constant connection among collaborating researchers, and provide an overview over who is part of the collaboration network, who is responsible for what tasks in the collaboration, and who would be the contact person for the exchange of specific information or feedback (Finley, 1979). The communication structure should also reflect the semantic and process-related aspects outlined before. When researchers, in national as well as international teams, have negotiated a common research procedure and commonly used terms and concepts, and have agreed upon commonly shared rules of interaction - clear task divisions and responsibilities with regard to communication processes should form the framework that implements those agreements, and provide guidance for all researchers. This is especially important in spatially distributed teams, in which issues related to research but also administration often must be solved and decided "from a distance", and rarely with all team members in one room at the same time.

To bridge those spatial distances, especially IRCs thereby heavily rely on functioning *communication channels* and *tools* (Freitag, 2016). Here, the research and literature on virtual teams may offer interesting insights into how those techniques could be and already are used in IRCs to bridge spatial distances. Therefore, this literature was included in the systematic literature study, the results of which are outlined in chapter 4.

Overall, the outlined features of communication – to a significant extent – do apply for research collaborations of all forms. Interinstitutional, interdisciplinary as well as international research collaborations all have to find a common ground

of understanding with regard to the content of their communication; they have to find a commonly accepted way of how they want to communicate with each other, and have to find an appropriate structure and tools that implement their communication.

However, most of the outlined literature especially emphasizes the relevance of disciplinary differences that may be challenging for the communication in collaborating teams. The dimension of cultural or academic (or even disciplinary) differences between researchers from different national backgrounds are often mentioned but are not necessarily regarded as the root for conflict or communication issues (see Pelikan, 2015a). This paper argues, however, that even though those national differences can also add more challenges to collaborating research teams, they are often not recognized as the root for conflict and misunderstanding. Alternatively, they are interpreted as interdisciplinary challenges, when IRC teams also consist of researchers form different disciplines.

However, to define, whether misunderstandings or conflicts are interdisciplinary or intercultural, more light should be shed on the international and intercultural dimension of IRCs. Therefore, as a first step, this paper carries out a systematic literature review beyond the dimension of interdisciplinary research collaboration. Two research questions guide this review:
- What insights does the literature provide on the communication practices in ICR teams?
- What challenges are pointed out in the literature about those communication practices, hereby especially focusing on the international and intercultural dimension of such collaborations, and what solutions are developed or applied that address the identified challenges?

3. Methods

3.1 Sample of the systematic literature review

To identify the current state of the art and knowledge with regard to scholarly communication practice in IRCs, a systematic literature review of scholarship on international research collaboration and the work in international (collaborative) research teams was carried out. The sampling of relevant disciplines and research fields was based on the author's knowledge with regard to research fields that traditionally have a research interest in international collaboration topics, in international research processes, or in specific aspects of those collaborations such as team dynamics, project management, or team communication. Furthermore, colleagues from other disciplines and with a specialization in science communication or science studies were consulted for additional crosschecks.

Information Science was not included in this sample, despite it being one of the first contributing disciplines regarding the analysis of scholarly communication, and thus addressing the thematic focus of this article. However, as Lüthje (2017) points out, Information Science so far predominantly focused on structural aspects of scholarly communication, i.e. analyzing the structural networks in the context of the preparation of scientific publications, but thereby mainly relying

on bibliometrical data and thus the reconstruction of communication processed via the formal outputs of such communication. Another focus lies on informal scholarly communication, but here is limited to the analysis of the structural use of digital communication tools (see also page 7). Overall, international research collaboration is not explicitly observed in the outlined contexts. Therefore, for the following analysis, the outlined limitations of the discipline's focus is used as the main argument for not including it in the literature sample, especially since it focuses on structure instead of communication practice. Nevertheless, the relevance of this discipline for the development of a research focus on informal communication processes among scientist must be acknowledged. Here, the paper of Lüthje (2017) presents an important reading discussing the relevance of this discipline as a founder of scholarly communication research.

Based on those considerations, the following disciplines and research fields were included for the literature review:

In *Communication Science*, it was assumed that relevant literature could be found in the context of communication management research, international and intercultural communication research, organizational communication research, or science communication research. In *Business and Management Studies*, relevant literature was expected in the context of organizational studies, business administration studies, or the area of virtual team research, which forms a border research field with Communication Science, Business and Management Studies, and Computer Science. In *Psychology*, relevant literature was assumed in the context of industrial psychology, organizational psychology research, psychology of leadership and of teamwork research, as well as in the broader context of social psychology. In *Sociology*, relevant literature was expected in the subarea of the sociology of organizations, industrial sociology, the sociology of scientific knowledge, as well as the sociology of social sciences. In addition to that, several interdisciplinary research fields were considered as relevant, such as *Science and Technology Studies*, *Higher Education Studies*, *Science of Team Science (SciTS)*, or *Intercultural Studies*.

Only English scholarship was included in the literature review, since it is argued that literature reflecting on IRCs only becomes visible for the respective international collaborative audience if it is published in English. Furthermore, leading international (English) journal publications are assumed to represent the "mainstream" and the state of the art in each analyzed discipline and research field.

The literature review concentrated on the publication formats *handbooks, anthologies, book chapters*, and *journal articles*. Altogether, for the listed disciplines and research fields, 103 academic journals were systematically scanned (see Table 1).

The presented categorization of the journals according to the disciplines and research fields was based on the overall self-acclaimed orientation of the different journals as well as the disciplinary affiliation of the listed authors of the identified publications. However, a definite categorization is often not possible, since journals have an increasingly interdisciplinary focus and author spectrum. Thus, the presented categorization should be understood as an orientation, to provide an overview of the analyzed journal sample.

Table 1. List of journals included in this review

Communication Studies

- Communication Education
- Communication Monographs
- Communication Research
- Communication Theory
- Communications: The European Journal of Communication Research
- Human Communication Research
- International Communication Gazette
- Journal of Applied Communication Research
- Journal of Business Communication
- Journal of Communication
- Journal of Science Communication
- Management Communication Quarterly
- Science Communication
- Scholarly and Research Communication

Business and Management Studies

- Academy of Management Journal
- Administrative Science Quarterly
- Cross-Cultural Management – An International Journal
- European Management Journal
- Human Relations
- International Journal of Business and Social Science
- International Journal of Cross-Cultural Management
- International Journal of Human Resource Management
- International Journal of Information Management
- International Journal of Managing Projects in Business
- International Journal of Project Management
- Journal of International Business Studies
- Journal of Management
- Journal of Management Inquiry
- Journal of Communication Management
- Journal of Organizational Behavior
- Journal of World Business
- Management Science
- Management Communication Quarterly
- MIS Quarterly
- Organization Science
- Organization Studies
- Organizational Dynamics
- Project Management Journal
- Research in Organisational Behaviour
- Strategic Management Journal

Psychology

- Conflict Resolution Quarterly
- Group Processes and Intergroup Relations
- International Electronic Journal for Leadership in Learning
- International Journal of Psychology
- Journal of Applied Psychology
- Journal of Applied Social Psychology
- Journal of Cross-Cultural Psychology
- Journal of Managerial Psychology
- Journal of Occupational and Organizational Psychology
- Leadership Quarterly
- Personnel Psychology
- Psychological Review
- Small Group Research
- Social Networks
- The Leadership Quarterly

Sociology

- International Social Science Journal
- Sociology
- Social Studies of Science

Science and Technology Studies

- Bulletin of Science, Technology & Society
- Journal of the American Society for Information Science and Technology
- Journal of Informetrics
- Minerva
- Public Understanding of Science
- Research Evaluation
- Research Policy
- Science and Public Policy
- Science as Culture
- Science in Context
- Science, Technology & Human Values
- Scientometrics

Higher Education Research

- Comparative Education
- Comparative Education Review
- European Journal of Education
- Higher Education
- Higher Education Policy
- Higher Education Quarterly
- Higher Education Research & Development
- Journal of Higher Education
- Journal of Studies in International Education
- Research in Higher Education
- Review of Higher Education
- Studies in Higher Education

Science of Team Science

- American Journal of Preventive Medicine
- Clinical and Translational Sciences
- Qualitative Health Research
- Research Evaluation
- Science
- Science Translational Medicine
- Translational Behavioral Medicine

Intercultural Studies

- Cross-cultural Research – The Journal of Comparative Social Science
- Intercultural Pragmatics
- International and Intercultural Communication Annual
- International Journal of Intercultural Relations
- Journal of Cross-Cultural Communication
- Journal of Intercultural Communication Research
- Journal of International and Intercultural Communication
- Journal of Multicultural Discourses

Other journals

- Frontiers in Ecology and the Environment
- Human-Computer Interaction
- International Journal of Applied Linguistics
- International Journal of e-Collaboration
- Journal of Aging Studies
- Technical Communication Quarterly

3.2 Data collection procedures

Following the methodological principles for conducting literature reviews (Cooper, 1988; Webster & Watson, 2002), in a first step, the relevant literature was identified:

- To identify relevant handbooks, anthologies, or book chapters for each of the listed disciplines and research fields, a literature search in the library database of the University of Leipzig (https://katalog.ub.uni-leipzig.de/Search/Advanced) was carried out, using the key search string [collaborat*] and limiting the search results to [books] and [e-books]. Subsequently, in a hand-coding selection process, the book title and the table of content were read in order to identify books or book chapters specifically focusing on international research collaboration, projects, or research teams. If those selection criteria applied, the respective books or book chapters were archived.
- To find relevant journal articles, first, relevant journals in the listed disciplines and research fields had to be identified that publish articles on international collaboration topics. Therefore, a search was carried out in the library database of the University of Leipzig for existing literature reviews published in academic journals, using the key search strings [collaborat*] and [review*] and limiting the search results to [articles]. Subsequently, in a hand-coding selection process, the titles and abstracts were read to make sure that those review articles focus on international collaboration (here, however, not limiting the search to research collaborations). If articles fit that search pattern, their reference lists were scanned, and relevant journals referred to in those lists were compiled. A similar search was carried out in the reference lists of the identified books and book chapters. This snowball procedure led to a preliminary list of relevant journals in which publications on international collaboration (in or outside of academia) are placed. Using a broader search framework of international collaboration here was done intentionally to make sure that for the different disciplines and research fields those journals are identified, in which scientists publish and thus also read about international collaboration topics. This search was complemented with a systematic search on GoogleScholar, using the same search strings.
- Subsequently, in order to identify relevant journal articles, for each of the selected journals a systematic search was carried out in the respective journal databases, using again the key search string [collaborat*] and limiting the timeframe to articles published between 1990 and 2018 (deadline: March 2018). In a hand-coding selection process, subsequently the titles and abstracts of the found articles were scanned. Articles that focus on international research collaboration, projects or teams were archived. Articles were not considered if they focus on non-research collaboration (e.g., in other areas such as business, health care, or politics), or on national or interdisciplinary research collaboration only.
- Through a snowball procedure, the list of relevant journals was completed throughout the review process of the identified literature, when additional journals were traced that are frequently quoted as references in the reviewed

texts. Those journals were added to the literature sample and were also searched systematically. Furthermore, the reference lists of the analyzed articles were scanned for additional prominently quoted literature references. Those were also added to the sample and reviewed – also, if they were published before 1990.

The final sample included 168 identified texts (i.e., either books, book chapters, or journal articles) that focused on international research collaboration, projects, or teams (see Appendices 1–5).

3.3 Data analysis

The identified literature was systematically reviewed with regard to the insights provided into the communication practices in IRCs. Each text was fully read, and the overall thematic focus and methodological approach of the presented study was identified. In addition, the composition of the observed IRCs was identified by collecting any information given on the disciplinary background and the countries of origin of the participating scholars. This allows for a more detailed interpretation of the results on communication practices. Finally, relevant passages were extracted that referred to the teamwork level, research practice and communication processes in IRCs. Subsequently, the excerpts were read again and summarized with regard to the central insights they provide on the communication practice, its challenges and applied solutions.

Based on the listed criteria, the literature corpus was structured and systematized. Chapter 4 summarizes the main results by introducing the overall thematic spectrum and methodological approaches of the reviewed literature, by characterizing the observed IRCs with regard to their disciplinary backgrounds and their countries of origin, by outlining the perspectives and foci of the different disciplines and research fields, and by presenting the main insights on communication structures and processes in IRCs. It also discusses the aspect of team complexity in IRCs, since the insights given in the literature suggest that this aspect presents an additional influential factor involved in the communication practice in IRCs.

4 Results

4.1 Focus and methodological design of studies on IRCs

Altogether, five thematical foci appeared in the state of research, according to which the sample of the 168 studies could be sub-categorized (see Table 2):

Eight texts provide literature reviews on the *state of the art* regarding international research collaboration, or form editorials to journal issues. The largest subset of the literature sample focus on the *conceptualization of IRCs*, strive for an overview on current *international collaboration structures and patterns* (with differing regional foci), or identify *motivations* for international collaboration. As Table 2 illustrates, most of those studies carry out bibliometric analyses and measure IRCs solely based on co-publications. Regarding the analysis of collaboration

motivations, also survey or interview data are used, while for the conceptualization and description of collaboration structures, some studies apply mixed-method approaches, using a combination of the aforementioned methods. Two studies use document analysis (e.g. based on data from project databases) to map collaboration structures. Most of those studies stay on a macro- or meso-level of analysis, and do not take into view the interactions, research processes, or communication practice on the team level. Also, by focusing on the description of international collaboration patterns based on co-publications, they look at formal communication aspects and collaboration outputs, not the communication practice itself.

Table 2. State of research on international research collaboration

State of the art articles	
Literature reviews Editorials	Bagshaw et al. (2007), Bozeman, Fay & Slade (2013), Brooks & Brooks (2015), Bukvova (2010), Butler (1998), Fishman (1968), Kosmützky (2018), Salazar & Salas (2013)
Conceptualization of collaboration, collaboration structures, patterns and motivations	
Bibliometric analyses	Abramo, D'Angelo & Murgia (2014), Ahlgren, Persson & Tijssen (2013), Bordons et al. (1996), Choi (2012), Chuang, Wang & Ho (2011), Coccia & Bozeman (2016), Coccia & Wang (2016), Davis & Wilson (2001), Defazio, Lockett & Wright (2009), Finardi (2014), Frame & Carpenter (1979), Franz Hoppen & de Souza Vanz (2016), Furukawa, Shirakawa & Okuwada (2011), Gautam (2017), Georghiou (1998), Glänzel (2001), Glänzel & Schubert (2004), Guilera, Barrios & Gomez-Benito (2013), Guns, Liu & Mahbuba (2011), Hassan, Sarwar & Muazzam (2014), He (2009),He, Geng & Cambell-Hunt (2009), Heidler (2011), Hoekman, Frenken & Tijssen (2010), Jeong & Choi (2012), Jeong, Choi & Kim (2011), Kahn (2018), Kato & Ando (2017), Katz & Martin (1997), Kliegl & Bates (2011), Knobel, Simoes & de Brito Cruz (2013), Kwiek (2017), Levitt (2015), Luukkonen, Peterson & Siversten (1992), Mamun & Rahman (2015), Meriläinen et al. (2008), Moed (2016), Okubo et al. (1992), Ossenblock & Engels (2015), Parreira et al. (2017), Prathap (2013), Puunska, Muhonen & Leino (2014), Ribeiro et al. (2018), Rigby (2009), Ronda-Pupo & Guerras-Martin (2010), Russell, Hernandez-Garcia & Kleiche-Dray (2016), Shin, Lee & Kim (2013), Shirabe & Tomizawa (2002), Smith et al. (2014), Stefaniak (2001),Tong & Ahlgren (2017), Ukrainski, Masso & Kanep (2014), Velden, Haque & Lagoze (2010), Wagner & Leydesdorff (2005), Wang & Wang (2017), Wang et al. (2014), Wang, Thijs & Glänzel (2015), Wang, Wang & Philipsen (2017), Zanotto, Haeffner & Guimaraes (2016), Zhai et al. (2014)
Surveys	Bozeman & Corley (2004), Horta & Austin Lacy (2011), Iglic et al. (2017), Kirchner et al. (2017), Smeby & Gornitzka (2010), Smeby & Trondal (2005), Uhly, Visser & Zippel (2017)
Interviews	Cassi et al. (2008), Currie-Adler, Arvanitis & Hanafi (2018), Genuth, Chompalov & Shrum (2000), Isabelle & Heslop (2011)
Document analyses	Jeong, Choi & Kim (2014), Lewis & Ross (2011)
Mixed methods Case studies	Jappe (2009), Jonkers & Tijssen (2008), Leite & Pinho (2017), Mattsson et al. (2010), Oleksiyenko (2013), Ulnicane (2015), Zdravkovic, Chiwona-Karltun & Zink (2016)
Impact of collaboration on research output	
Bibliometric analyses	Aksnes (2003), Glänzel & Schubert (2001), Katz & Hicks (1997), Persson, Glänzel & Danell (2004), Polyakov, Polyakov & Iftekhar (2017), Sa, Ribeiro & Carvalho (2017), Schubert & Glänzel (2006), Sooryamoorthy (2009), Turati, Usai & Ravagnani (1998)
Task level aspects of IRCs	
Auto-ethnographies	Anderson & Steneck (2011), Barrett, Crossley & Dachi (2011), Bourgeault, James & Packer (2015), Bournois & Chevalier (1998), Brew et al. (2013), Brewster, Mayrhofer & Reichel (2011), Di Castri (1976), Esser & Hanitzsch (2012), Jonsen et al. (2012), Lombe et al. (2013), Lyman (2011), Siemens (2014)
Case studies	Bammer (2008), Hantrais (2009), Shore & Cross (2005), Vasileiadou & Vliegenthart (2009)
Surveys/Interviews	Vinkler (1993), Youtie & Bozeman (2016)
Literature reviews Editorials	Cornish, Zittoun & Gillespie (2007), Hornikx & O'Keefe (2011), Peterson (2001), Segalla (1998)
Team level aspects of IRCs	
Auto-ethnographies	Easterby-Smith & Malina (1999), Finley (1979), Gardner et al. (2012), Goddard, Cranston & Billot (2006), Haak et al. (2013), Hanges, Lyon & Dorfman (2005), Hoffman et al. (2014), Hwang (2013), Jacobs (1998), Lakic, Zivkovic & Vukovic (2015), Livingston(2003), McGinn (2005), Milliman & von Glinow (1998b), Müller (1998), Nolan (2011), Sarapata (1985), Sauquet & Shore & Groen (2009), Smith (1968), Stead & Harrington (2000), Sugden & Punch (2014), Tartas & Muller (2007), Teagarden et al. (1995), Thomas et al. (2009)
Case studies (mixed methods)	Akkerman et al. (2006), Barinaga (2007), Gonzalez-Aranda et al. (2010), Gray, Bright & Cheng (2012), Hwang (2005), Jarvenpaa & Leidner (1999), Jeong & Choi (2015), Lawrence (2006), Pelikan (2015), Rasters, Vissers & Danbaar (2002), Ray, Reilly & Tirrell (2016), Teagarden (1998), Teng (2007), Yu, Lang & Kuman (2009)
Surveys/interviews	Kollasch (2012), Kumar (1985), Mabey, Kulich & Lorenzi (2012), National Research Council (2008), Pischke et al. (2017), Popescu, Suciub & Raoultc (2014), Wells (2013)
Literature reviews	Fussell & Setlock (2012), Milliman & von Glinow (1998), Nason & Pillutla (1998), Okamoto (2015), Teagarden, Drost & von Glinow (2009)

Note: Studies are listed according to thematical focus and methodological designs

The same observation can be made for the third group of studies, which focus on the *impact of collaboration on research output*, since this impact is only measured based on the bibliometric analysis of co-publications and their citation rates.

More insights into the team level of IRCs and the communication, research practice, and teamwork are provided by the fourth group of studies. Those texts focus on the *task level of IRCs*, taking into view various aspects of project management in international collaborative research projects, or looking at communication structures in IRC teams.

Similar to that, more detailed insights are also provided by the fifth group of reviewed studies, which focus roughly on *team-level aspects of IRCs* and here also touch issues of interaction or communication among scientists of such teams. Both sets of studies mainly derive their insights from auto-ethnographic reflections of the respective authors, that are based on their own international collaboration experiences. In some cases, also co-collaborators from their own projects are interviewed. It is especially those insights into scientists' own research practice and their reflections of the challenges that provide the broadest and most detailed insights into IRC teamwork and communication so far. Besides that, several survey and interview studies were identified, as well as a few case studies that applied a mixed method approach. All the studies on the task and team level thereby mainly focused on one IRC example. A broader overview and comparative summary of analyses of task or team-related topics was provided by a few literature reviews, editorials, and handbook articles.

4.2 Disciplinary and national composition of observed IRCs

When looking more closely at the composition of the observed IRCs, overall, the 10 most frequently occurring disciplinary backgrounds are Economics (32 observed IRCs), Social Sciences (27; including Sociology, Social Work, or Communication Studies), Physics (25), Medicine (25), Information Science (22), Psychology (20), Chemistry (18), Biology (13), Education Sciences (15), and Mathematics (11). This result reflects a stronger focus on IRCs in the Natural Sciences, Engineering and the Life Sciences in the analyzed literature sample. However, in a large number of the observed studies, the disciplinary background of the collaborating researchers is not explicitly specified by the respective authors (24), or authors would take a broad view on the international collaboration patterns of all disciplines (19) – here mainly in the context of studies analyzing international co-publications.

For the types of studies as they have been distinguished in the previous subchapter, a more detailed list of the disciplinary background of researchers in the observed IRCs is provided in Table 3. Here, all disciplines are listed for each subgroup of studies that appeared in more than one IRC[2].

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2   Disciplines that appeared in only one IRC-related study were identified as follows: For (1) the state of the art articles, these included Economics, and Health Sciences; for (2) articles on the conceptualization of collaboration, collaboration structures, patterns and motivations, these included Political Science, Philosophy, Materials Science, Language & Linguistics, International Relations/Global Studies, History, Geography, Civil Engineering, Archaeology, and Anthropology; for (3) articles on the impact of collaboration on research output, this included Chemistry; for (4) articles on the task level aspects of IRCs, these included Civil Engineering, Computer Science, Electrical Engineering, Health Sciences, Mathematics, Medicine, and Psychology; and for (5) articles on the team level aspects of IRCs, these included Chemistry, Law, Linguistics, Mechanical Engineering, and Social and Behavioral Sciences.

Table 3. Disciplinary scope of observed IRCs

State of the art articles		
• Psychology (3)	• Education Sciences (2)	• Social Sciences (2)

Conceptualization of collaboration, collaboration structures, patterns and motivations		
• Medicine (22) • Physics (18) • Chemistry (14) • Biology (13) • Mathematics (10) • Economics (8) • Earth and Space Sciences (6) • Environment Studies (6)	• Agricultural Sciences (5) • Education Sciences (5) • Health Sciences (5) • Information Science (5) • Psychology (5) • Social Sciences (4) • Mechanical Engineering (3) • Computer Science (2)	• Law (2) • Engineering (10) • Natural Sciences (3) • Life Sciences (1) • Social Sciences & Humanities (1) • All disciplines (16) • Not specified (9)

Impact of collaboration on research output		
• Economics (2)	• Engineering (2) • Life Sciences (2) • Natural Sciences (2)	• Social Sciences and Humanities • All disciplines (3) • Not specified (1)

Task level aspects of IRCs		
• Economics (6) • Physics (4) • Social Sciences (4) • Biology (3)	• Information Science (3) • Earth and Space Sciences (2) • Chemistry (2) • Education Sciences (2)	• Heat and Process Engineering (2) • Materials Science (2) • Mechanical Engineering (2) • Not specified (4)

Team level aspects of IRCs		
• Social Sciences (17) • Economics (15) • Information Science (14) • Psychology (11)	• Education Sciences (6) • Health Sciences (3) • Physics (3) • Medicine (2)	• Engineering (3) • Natural Sciences (2) • Not specified (10)

With regard to the collaborating countries in the observed IRCs, the 10 most frequently occurring countries are the United States (42 IRCs), the United Kingdom (34), Australia (30), France (26), Germany (25), Canada (22), The Netherlands (21), China (21), Japan (19), Sweden (17), and Finland (17). In 17 IRCs, collaboration takes place between all EU countries (here, it is assumed that the projects involved collaborating partners from all EU member states, at least given the specifications in the respective articles). Furthermore, in a considerable number of the observed studies (82), the respective authors do not explicitly specify the collaborating countries. Overall, the results show a strong focus on the collaboration patterns of Western countries (i.e. North America, Australia, and Europe), with China and Japan being the only non-Western countries among the top ten.

For the different types of studies as they have been distinguished in the previous subchapter, a more detailed list of the country affiliations of the observed

IRCs is provided in Table 4. Here, all countries are listed for each subgroup of studies, that appeared in more than one IRC[3].

For both tables, it must be noted that the lists are not equivalent with the number of analyzed publications, since in some articles, no specific details are given on the countries or disciplines that collaborated. This was the case, for example, when bibliometric analyses are carried out, in which the exact combination of internationally collaborating authors is not explicitly pointed out, or when the article only focuses on the overall collaboration politics of a specific country. In some articles, collaborations are summarized under 'international' but not further specified, or the focus lies on individual scientists or country (e.g., their overall publication history) and their international collaborative network ties. Finally, especially regarding the task and team level studies, articles often analyze more than one IRC example.

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3   Countries that appeared in only one IRC-related study were identified as follows: For (1) the state of the art articles, these included Kenya, Kosovo, Mexico, Philippines, and Thailand; for (2) articles on the conceptualization of collaboration, collaboration structures, patterns and motivations, these included Bangladesh, Belarus, Botswana, Burkina Faso, Colombia, Croatia, Cuba, Czech Republic, Dominican Republic, Ethiopia, Gabon, Hong Kong, Hungary, Iceland, Indonesia, Jordan, Lebanon, Liberia, Liechtenstein, Morocco, Mauritius, Mongolia, Morocco, Oman, Qatar, Republic of North Korea, Romania, Samoa, Saudi Arabia, Senegal, Slovakia, Slovenia, Sudan, Tanzania, Tunisia, Yugoslavia, Zambia, Zimbabwe; for (3) articles on the impact of collaboration on research output, these included Argentina, Australia, Austria, Belgium, Brazil, Canada, China, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, India, Ireland, Israel, Italy, Japan, Mexico, New Zealand, Poland, Russia, Singapore, South Africa, South Korea, Spain, Sweden, Switzerland, Taiwan, The Netherlands, Turkey, United Kingdom, USA; for (4) articles on the task level aspects of IRCs, these included Austria, Belgium, Brazil, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, Ghana, Greece, Hungary, Iceland, Israel, Lithuania, Mexico, Nepal, New Zealand, Norway, Philippines, Poland, Portugal, Serbia, Slovakia, South Africa, South Korea, Spain, Sub-Saharan Africa, Switzerland, Taiwan, The Netherlands, Tunisia, Turkey, Turkish Cypriot Community, Uruguay; and for (5) articles on the team level aspects of IRCs, these included Algeria, Argentina, Chile, Colombia, Cyprus (Greek), Czech Republic, Eastern Europe, Estonia, Europe, Guatemala, Hong Kong, Jordan, Lebanon, Libya, Lithuania, Morocco, Norway, Pakistan, Palestine, Poland, Romania, Singapore, Slovakia, Syria, Thailand, Tunisia, Turkey, Uganda, Uruguay, Vietnam.

Table 4. Geographical scope of observed IRCs

State of the art articles			
United Kingdom (2)		USA (2)	
Conceptualization of collaboration, collaboration structures, patterns and motivations			
• USA (14) • United Kingdom (11) • Germany (11) • China (10) • Canada (10) • Brazil (9) • France (9) • Japan (8) • Finland (8) • Australia (7) • Spain (7) • The Netherlands (7) • Italy (7)	• India (6) • Norway (6) • Russia (5) • Argentina (5) • Switzerland (5) • Poland (5) • New Zealand (5) • Belgium (5) • Austria (5) • Ukraine (3) • Israel (4) • Sweden (4) • Portugal (4)	• Mexico (4) • South Africa (3) • Singapore (3) • Nepal (3) • Malaysia (3) • Korea (3) • Egypt (3) • Chile (3) • Turkey (3) • South Korea (3) • Venezuela (2) • Thailand (2) • Taiwan (2)	• Ireland (3) • Greece (3) • Denmark (3) • Bulgaria (2) • Malawi (2) • EU countries (6) • European countries (2) • All countries (6) • Not specified (37)
Impact of collaboration on research output			
• Norway (2)	• Portugal (2)	• All countries (5)	• Not specified (3)
Task level aspects of IRCs			
• USA (8) • United Kingdom (8) • Japan (3) • Germany (3) • France (3)	• Canada (3) • Sweden (2) • Slovenia (2) • Russia (2) • Italy (2)	• Ireland (2) • India (2) • China (2) • Australia (2)	• EU countries (2) • Not specified (14)
Team level aspects of IRCs			
• Australia (21) • USA (18) • France (14) • The Netherlands (13) • United Kingdom (13) • Germany (11) • Sweden (11) • Denmark (10) • Canada (9) • South Korea (9) • China (8) • Finland (8)	• Japan (8) • Mexico (8) • Taiwan (7) • Austria (6) • Israel (6) • Brazil (5) • India (5) • Philippines (5) • Spain (5) • Ireland (4) • Italy (4)	• Scotland (4) • Switzerland (4) • Bolivia (3) • Costa Rica (3) • Indonesia (3) • New Zealand (3) • Nigeria (3) • Belgium (2) • Bulgaria (2) • Egypt (2) • Greece (2)	• Hungary (2) • Latvia (2) • Portugal (2) • Russia (2) • South Africa (2) • Turkey (2) • Africa (3) • Asia (3) • EU countries (3) • North America (3) • Not specified (28)

Regarding the consortium size of the observed IRCs, only the articles with a focus on the task level and on the team level of IRCs provide useful details. Overall, the largest number of the observed consortia in those two subgroups are of medium size, thus including researchers from 5 to 20 different collaborating countries, while smaller consortia (2 to 4 collaborating countries) and large-scale consortia (with more than 20 collaborating countries) are taken into view less often.

4.3 The disciplinary perspectives on IRCs

For the disciplines and research fields that were included in this literature review (see 3.1), a heterogenous picture can be derived about the overall research perspective on IRCs:

As has been outlined already in the beginning of this paper, in *Communication Studies* communication among scientists/researchers still is an unknown territory, and the communication processes and structures of IRCs receive almost no attention so far (Lüthje, 2017). This observation can be supported based on the present literature review. Apart from few exceptions (e.g. Compton 1973; Paisley, 1984, 1989; Small, 1982), communication processes among scientist in general did not receive much attention in the communication literature. The research field on international and intercultural communication research, which does have a focus on theory and practice of cross border communication in all its forms (i.e., communication crossing national or/and cultural borders, global communication, or its role in national development processes), at the same time limits this focus to mass-mediated communication. The literature review revealed that the research field does not focus on communication phenomena related to international research collaboration. Organizational communication research as well as strategic

communication research focus mainly on processes, prospects, and challenges of communicating and organizing in a global society, and on how communication shapes and is shaped by international organizational contexts in non-scientific contexts, such as in government and non-government agencies, global corporations and businesses, non-for-profit organizations, or media (e.g. Barley & Weickum, 2017; Jablin, 2008; McKenna, Callan, & Gallois, 2012; Zerfaß & Piwinger, 2014). Thus, aside from few exceptions (e.g. Esser & Hanitzsch, 2012b; Livingston, 2003; Walsh & Maloney, 2007), Communication Studies overall still largely ignore the collaboration and communication practice in IRCs.

In *Business and Management Studies*, we do find profound insights into international and intercultural collaboration and communication for the business sector or other international organizations, accompanied by the development of strategies for successful international and intercultural project management and teamwork (e.g. Binder, 2007; Brocke & Lippe, 2015; Shapiro, von Glinow, & Cheng, 2005). However, this perspective does not include IRCs, or is limited to collaborations between scientific institutions and industries (e.g. research and development projects).

A similar perspective was found in the field of *Intercultural Studies*: Here, empirical research also mainly focuses on processes and characteristics of international and intercultural communication phenomena in international business or political organizational settings (e.g. Bolten, 2007; Kotthoff & Spencer-Oatey, 2008). Those results offer important empirical and theoretical foundations for the understanding of international and intercultural contact, but they may not fully grasp the specialties of IRCs. Scientific research collaborations usually do not have a profit orientation and have a less hierarchical structure than business collaborations. Furthermore, the collaboration is characterized by larger individual freedom and autonomy of the individual scientists, who can also be simultaneously involved in other collaborations and be bound to other obligations such as teaching, or academic self-administration (Mayrhofer, 1998). Finally, (international) research collaboration often takes place between scientists who use differing research procedures and methods, theoretical concepts and terminology, or data sets while collaborating and solving a shared research question (Siemens, 2010). Thus, the work in such collaborations is seldom identical to previous IRCs and research designs cannot be simply reproduced.

In *Psychology*, studies looking at research collaborations – on a national or international scale – do examine social relations on the micro-level of research teams, but hereby mainly focus on leadership styles and effects, as well as the impact of leadership and team dynamics on the research efficiency (e.g. Flory, 1998; Guenter et al., 2017). Another focus lies on the analysis of team conflicts and conflict management (Bagshaw, Lepp, & Zorn, 2007), while the underlying communication processes are considered only indirectly.

In the context of *sociological research* on scientific knowledge or Social Sciences, as well as in the research fields *Science and Technology Studies* and *Higher Education Studies*, the research perspectives do provide a larger number of empirical studies on IRCs, thereby also focusing on different Natural and Social Sciences. However, international collaboration here is predominantly measured

based on bibliometric data or surveys measuring international co-authorship (e.g. Kwiek, 2015; Ossenblock & Engels, 2015), while the actual communication practice that may precede those co-publications is rarely observed (e.g. Bammer, 2008; Brew, Boud, Lucas, & Crawford, 2013; Hoffman et al., 2014, Kumar, 1985; Ulnicane, 2015).

The research field on *Virtual Team Research* investigates teams with geographically dispersed members, that are coordinated mainly via electronic media. The focus hereby lies predominantly on the business sector (e.g. Hertel, Geister, & Konradt, 2005; Lipnack & Stamps, 1997; Townsend, DeMarie, & Hendrickson, 1998), but not on scientific virtual teams (for exceptions see Jarvenpaa & Leidner, 1999; Ponti, 2010; Wang & Hicks, 2015). Furthermore, interpersonal processes in teams present an area in which major gaps exist in the literature on virtual teams (Martins, Gilson, & Maynard, 2004). Instead, research primarily focuses on conflict and trust in virtual teams. In addition to that, only few studies focus on effects of different national or cross-cultural experiences on virtual teams, or on multinational teamwork in a virtual setting (Han & Beyerlein, 2016), with even fewer studies taking into view the scientific research context here (e.g. Gray, Bright, & Cheng, 2012; Yu, Lang, & Kuman, 2009).

The currently evolving new interdisciplinary research field of the *Science of Team Science* (SciTS) provides the most complex perspective on IRC team practice. The research interest here lies on scientific teamwork, i.e. the processes by which scientific teams organize, communicate, and conduct research (e.g. Fiore, 2008; Helbing, 2010; Stokols, Hall, et al., 2008), and on understanding the effects of the structures and processes of collaborative teams on team productivity and creativity (e.g. Cummings, Kiesler, Zadeh, & Balakrishnan, 2013; Hemlin, Allwood, Martin, & Mumford, 2013; Lee, Walsh, & Wang, 2015; Levine & Moreland, 2004), in order to understand and manage large-scale collaborative research in particular (Jones, Wuchty, & Uzzi, 2008). However, the focus so far lies on the Natural and Health Sciences, and is limited to a national perspective, since SciTS research often accompanies national research funding schemes in the Natural Sciences.

4.4 Communication structures and processes in IRCs

Only a minor sample of the identified studies focuses specifically on the communication practice in ICR teams, as well as on challenges in this communication. Hereby, the main interest lies in the language use in IRCs, the communication structures that are set up, as well as the communication tools and channels that are used. Whereas the former can be regarded as an IRC-specific feature, communication structures, tools and channels are communication aspects that can be found in all collaborating research teams. Therefore, to distinguish those general and IRC-specific aspects, in the following subchapter, the respective results from the literature review will be discussed separately.

Regarding general communication aspects that need to be considered in collaborative research teams – also for IRC teams, several of the analyzed studies emphasize the relevance of functioning *communication structures*. One featured necessity of this

communication structure is that it should support frequent communication, an aspect that is particularly important in IRCs, since they often must bridge large spatial distances. Here, Jonsen et al. (2012) further recommend the use of brainstorming sessions as a strong tool for the benefit of creating new perspectives on research objects. Pelikan (2015a), who analyzed an international research project in the area of public health, suggests that when projects are planned, they should also include an extra work package concerned with communication, and that communication optimization should also be part of the defined milestones and deliverables. As the author argues, when capacity building concerning project communication is started already at the beginning of IRC projects, it can raise the awareness for possible conflicts and communication problems, too.

Overall, Segalla (1998) suggests, that principal investigators or coordinators in IRCs should be the central "communication point" for the team, which also requires "constant and consistent communication policies" (p. 136). According to the author, this becomes especially necessary in large IRCs, where communications can quickly become overwhelming for the team and thus should be organized. A similar suggestion is made by Jonsen et al. (2012), who, based on their own collaborative writing and research experience in the field of international organizational studies, argue that it can be useful to actively manage the forms of communication in a collaboration, especially the discussions and the number of scientists that should be involved in them.

As for helpful *communication tools*, direct face-to-face communication is regarded as the most important and effective form of exchange in collaborations. For IRC teams it is said to create social team cohesion, enhance trust and the quality of relationships among IRC team members, and lead to better research productivity (e.g. Gardner et al., 2012; Jonsen et al., 2012; Pischke et al., 2017; Vasileiadou & Vliegenthart, 2009). A number of authors also emphasize the importance and helpfulness of regular personal meetings of all collaborating partners for IRC teams (Brew et al., 2013; Gardner et al., 2012; Haak, Himmelsbach, Granbom, & Löfqvist, 2013; Hantrais, 2009; National Research Council, 2008; Pischke et al., 2017). They are regarded as particularly helpful for communication that may be ambiguous or complex, or that may have potential for conflict, as Goddard, Cranston, & Billot (2006) conclude from their own collaboration project in the field of education studies. However – like national research collaborations – IRCs may not always have a specific budget or only minor financial and time capacities to arrange direct meetings (Lawrence, 2006). Here, Brew et al. (2013) recommend conferences and workshops, since they allow scientists in IRCs to get to know each other internationally, while also presenting and discussing ideas and research results, as well as practicing feedback forms.

If face-to-face communication is not possible, the use of rich media is suggested (e.g. telephone, video conferences, skype), especially when uncertain, complex or equivocal knowledge is shared, or ambiguous topics are discussed (Goddard et al., 2006; Pelikan, 2015a, 2015b) – a suggestion that applies for all forms of research collaborations (Walsh & Maloney, 2007). Many IRCs also rely heavily on indirect communication in form of e-mails or written reports. However, for national research teams, Cummings & Kiesler (2005) and Duque et al. (2012) warn that here

the risk of misinformation, misunderstanding and misinterpretations among the different collaboration members is higher, also due to the absence of body language, tone of voice, and slow or missing feedback loops. This may also apply for the context of international collaboration teams. Furthermore, not all team members might be able to use all (digital) communication tools properly, due to a lack of technical infrastructure, technical skills, or financial reasons, as Siemens (2010, 2014) concludes for all forms of geographically dispersed teams.

One benefit of written communication formats like e-mail, research notes or reports for international collaborations is, that they allow scientists to read and re-read the messages of their IRC team members, which gives them more time to process the communicated content and meaning. Written documents are good tools for more structured communication such as information sharing and progress reports. Members from diverse cultures may grasp the content and meaning of text-based communication more easily than real-time, voice-based communication (Goddard et al., 2006). As Cooke and Hilton (2015) argue in their report[4] on scientific collaboration in general, written communication allows people to write out what they are thinking and allows other members to read (and re-read) those communicated messages to process their meanings. According to Goddard et al. (2006), the use of email and teleconferences for the first discussion among team members about the project's nature, focus and scope was proved effective in developing an understanding of each scientist's perspective. It also supported the decision-making process about how the project could be structured and how those different perspectives could be integrated. Finally, written documents and reports are also helpful tools for more structured communication, for example, when information needs to be shared among a larger audience. Here, Pelikan (2015a) reports that project management meetings were documented via minutes, which were shared with all project members to keep everyone updated on the status of the project's progress.

Pelikan (2015a) also emphasizes that the IRC team strongly relied on internal web-based communication, and here used different media, such as emails for the daily one-to-one communication and for addressing all project members by using the mailing list of the project, or Skype calls or videoconferences. One special feature of her project was the use of a document management system, which was not only used for storage and sharing of documents and other data, but also as a collaboration platform of the project, including different communication features such as a wiki used as project specific glossary, a discussion forum, a calendar and a blog (Pelikan, 2015a, 128).

Regarding the usefulness of specific communication tools, the research field on virtual teams focuses on digital technical communication devices (e.g., Skype, Facebook, messenger services) (e.g. Anandarajan & Anandarajan, 2010). Rasters, Vissers, and Danbaar (2002), based on their case study on a European research

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4   The report reviews the social science research on teams outside of science, as well as relevant scientific research from the SciTS. The literature study was carried out by a committee of authors (appointed by the U.S. National Research Council) and was requested and funded by the U.S. National Science Foundation.

project focusing on digital technology use in organizational communication, show that digital communication tools do not only bridge spatial distances but also compensate for the lack of social interaction and exchange.

However, as in national collaborations, in IRCs those tools may not be equally (well) used, since the collaborating scientists may lack the technical infrastructure, the financial or time budget, or the technical skills. This is observed by Barrett, Crossley, and Dachi (2011) in their auto-ethnographic study on an IRC in the area of education studies, by Pelikan (2015a), or by Vasileiadou and Vliegenthart (2009) in their case studies on two IRCs in the area of Information Sciences. Or, communication preferences among the team members may differ, with some preferring e-mail communication, while others favor face-to-face meetings, as Rasters et al. (2002) summarize in their study. The authors also point out that the use of the different communication media did not necessarily produce enormous differences in the way the project members communicated. Rather, the way of communication changed with the various stages of the project and the state of team formation that was accompanied by it.

Only a few studies address the actual *communication processes* taking place among IRC team members in the course of the collaboration. Based on their own research experience in an IRC in the area of environment studies, as well as a survey carried out among their collaboration team members, Pischke et al. (2017) argue that room for a frank and open discussion environment and a safe communication climate is crucial for research collaborations. It allows for the discussion of research topics but also social and organizational issues and helps reaching a mutual agreement and understanding among all collaborating partners (see also Katz & Allen, 1988). Open discussion here also refers to the possibility of equal contribution by all IRC team members – an aspect that is crucial for open communication processes in all collaborating teams, since it improves the creativity and error detection in such forms of teamwork, as DeSanctis and Jiang (2005) point out.

Jarvenpaa and Leidner (1999) – in their descriptive case studies on student collaborations in graduate business programs around the world – show that communication behaviors that facilitate trust in IRC teams are, for example, social communication (i.e., exchange of social information about weekend activities, hobbies or family), the communication of enthusiasm towards team colleagues, and predictable communication (see also Stead & Harrington, 2000). Teagarden, Drost, and von Glinow (2005) argue that this social communication enables IRC teams to become more cohesive, since it provides "interpersonal glue" and increases a "sense of group identity and commitment", which again fosters the sharing of ideas and knowledge among the scientists (p. 313).

In another study, Popescu, Suciub, and Raoultc (2014) use a survey among scientists with collaborative research experience at a French university to gather details on different communication styles in IRCs. The authors illustrate that most of those scientists used one specific communication style, that was either action-oriented, process-oriented, people-oriented, or idea-oriented, and that they were open-minded, flexible, and pro-active (p. 581).

Furthermore, Hanges , Lyon, and Dorfman (2005) observe that the intensity of communication among the members of their IRC team was not steady, but that communication activity took place in changing waves, and that team members also differ in their corresponding frequency, promptness, and format, e.g. the privacy or openness of communication formats. Here, Jarvenpaa and Leidner (1999) argue that prompt responses also support the development and maintenance of trust in IRC teams.

Overall, Müller (1998), based on her own research experience in management studies, develops a theoretical framework that argues that the personal characteristics of IRC team members need to be considered more thoroughly. According to the author, those include their cultural and professional background, their state of mind, the team hierarchies, or the actual interaction settings. Those factors shape the context in which communication activities take place and collaboration manifests itself. Therefore, Müller (1998) argues that IRC teams need to focus on and discuss aspects such as context demands of the institutional or national contexts that IRCs are embedded in, the goals of the participating scientists and the joint goals of the IRC, the different perceptions that scientists have in mind with regard to the other participating countries and cultural features, how to perceive and express criticism and appreciation, or how to solve conflicts. However, so far, the outlined state of research does not offer deeper insights into whether and how those aspects are negotiated in IRCs.

One feature that can be regarded as IRC-specific is the diversity of *languages* (i.e. mother tongues) in those international research teams. Language skills or a joint working language are not only regarded as crucial for the understanding of terminology across countries, but also for the coordination and management of the research process, for the creation of team cohesiveness and effectiveness, and for the production and dissemination of research results (Hwang, 2013; Knorr-Cetina, 1999; Pelikan, 2015a). However, few studies so far have investigated how language affects international collaboration processes and results.

One of those studies comes from Wells (2013), who looks at the language use of (national and international) analytical chemists in the United States. The author argues that in many international collaborations, English is used as a joint project language, which gives English native speakers (e.g. from the United States, Australia, or the United Kingdom) an advantage over non-native speakers. Scientists who lack good English language skills may even be considered a burden to the collaborating group, since their skills to express themselves linguistically, but also culturally and socially, are limited, and may lead to inaccurate or even inappropriate language use in team interactions, as Bagshaw et al. (2007) summarize based on their literature review.

In the case study of Pelikan (2015a), the analyzed IRC used English as a lingua franca and considered it the common language for collaboration. However, the author points out that no language training was offered before or during the project implementation. Instead, "all project members were expected to communicate efficiently in this setting from the outset" (Pelikan, 2015, p. 129).

Gardner et al. (2012) report in their auto-ethnographic reflections from a cross-national project in the Health Sciences that communicating in a foreign

language can be exhausting or frustrating and can thus diminish the collaboration motivation of collaborating scientists. Scientists may not be able to fully take part in the research activities, academic discussions about research procedures, the interpretation of data or results, or the social interactions in the collaborative team. Last but not least, language may also present obstacles for publishing in international journals, since high-ranked international journals in the different disciplines may tend to follow the Anglo-Saxon academic writing norms, while not all scientists outside of the Anglo-Saxon research area are familiar with those norms or can apply them as easily (Bournois & Chevalier, 1998; Lakic, Zivkovic, & Vukovic, 2015).

Hanges et al. (2005) reflect upon their own collaborative research experience in the context of the GLOBE project, which analyzes global leadership and organizational behavior effectiveness. The authors report that in this collaboration significant miscommunication was caused by language difficulties, especially in the first stages of their project. Several solutions were implemented to solve these problems, such as discussion rounds to define central concepts of the study, or joint translation procedures to ensure adequate translation and retranslation into the different languages of the team members.

At the same time, power imbalances can develop among collaborating scientists: Collaborative team members with sufficient language capacities also have a communication privilege, and thus are able to better participate in the joint work or project. They can fully express their opinions and ideas, present and publish their data, and are considered for proper recruitment, retention, and promotion (Hwang, 2005, 2013; Lyman, 2011; Wells, 2013). The language barrier also limits the possible communication channels and can make communication less intensive and structured. It can cause operational difficulties in the exchange of ideas and technical details and can reduce the efficiency of informal communication. Overall, language fluency may be equated with scientific competence (Bournois & Cheavlier, 1998), and may lead to constellations in which scientists with good English skills work as key communicators, not those who conduct the research and possess technical knowledge and experience (Hwang, 2013).

Last but not least, Peterson (2001) and the summary report of the National Research Council (2008)[5] point out, that on the cognitive level, language differences can also be accompanied by different communication styles, which may present a challenge for the communication in IRCs (see also Fussel & Setlock, 2012). Communication styles here are understood as writing styles, i.e. diverse ways of academic writing and etiquette, for example regarding the order of authorship in co-publications or the revision procedures for manuscripts (Bosch & Titus, 2009).

Altogether, Hantrais (2009), by drawing on illustrations from international literature on social research as well as on her own research experience, suggests that

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5   The report summarizes the results of a workshop organized by the U.S. National Committee for Psychological Science and the results of a survey of social scientists who have led cross-national projects. It was funded by the U.S. National Science Foundation and aimed at naming the benefits of IRCs, as well as the factors common among successful collaborations.

IRC teams may try to make sure that the selected scientists for the collaboration all have prior experience of working with other scientists across languages and cultures, since this would increase their awareness of the outlined issues.

4.5 Team complexity in IRCs

In addition to the outlined insights into communication structures and processes in IRCs, some of the reviewed literature shows that the (international) team complexity also has a significant impact on the communication processes in IRCs. Here, not all authors explicitly drew a direct linkage between team diversity and communication (for an exception, see Pelikan, 2015a). However, in a number of studies, the complexity of IRCs with regard to the national, institutional, or disciplinary contexts that the participating scientists are embedded in, as well as the individual, social or cultural differences of those scientists, are mentioned as additional challenges for such collaborations. Those reflections were found especially in the auto-ethnographic reports (e.g. Anderson & Steneck, 2011; Bagshaw et al., 2007; Gardner et al., 2012; Jeong & Choi, 2015; McGinn, 2005).

On the *task-level*, a number of authors refer to differing expectations of collaborating scientists and with regard to research and collaboration goals, publication authorship, research designs, differing work styles (e.g. work pace, work load, meeting deadlines), differing expectations with regard to levels of supervision or the degree of independence in the collaboration process, as well as differing research traditions and quality criteria with regard to data collection, data analysis, or research documentation (e.g. Easterby-Smith & Malina, 1999; Fussel & Setlock, 2012; Hantrais, 2009; National Research Council, 2008; Segalla, 1998).

On the *team level*, several authors point out, that views, values, interaction norms, and behavioral sensitivities may also differ. This can become visible in differing communication styles, differing leadership and teamwork preferences, differences in decision-making strategies, or in differing conflict styles (e.g. Kumar, 1985; Fussel & Setlock, 2012; Turati, Usai, & Ravagnani, 1998; Walsh & Maloney, 2007). Finley (1979), for example, points out that regarding conflict styles, sometimes disagreement is indicated by the absence of comment rather than by its presence. The outlined differences not only affect the social relationships in an IRC team, but may even lead to insecurities in the research process, especially if those features prevent the establishment of a mutual relationship of trust and a sense of security that allows all scientists to communicate effectively and more easily to overcome misunderstandings (Easterby-Smith & Malina, 1999; National Research Council, 2008; Pischke et al., 2017; Popescu et al., 2014; Teagarden et al., 2005).

Overall, and based on the reviewed literature, team complexity can be substructured with regard to the following features that may have an impact on the communication practice in collaborative research teams: differing structural national or institutional contexts of the participating team members; differing sociological features of the individual researchers, such as gender, differing age and education, status, tenure diversity and different career stages; differing psychological features such as intellectual capacities, linguistic skills and motivations to

communicate and collaborate; or differing academic, disciplinary, or national cultural[6] backgrounds (see also Roelcke 2010). Again, most of the listed diversity features are applicable for all collaborating teams. However, especially the national structural and cultural backgrounds of researchers are assumed to be diversity dimensions that add a special level of complexity to IRC team performance. Therefore, in the following sections, general features and IRC-specific aspects will be pointed out.

First, one specific feature of IRCs is that they are embedded in diverse *national or institutional contexts*. Here, Bosch and Titus (2009) and Lakic et al. (2015) point out that national research policies and formal guidelines, for example concerning ethical standards or research conduct, data access and ownership, or publication procedures may differ. Also, the national budgets and research resources in IRCs may differ, which may lead to status hierarchies and asymmetrical power relationships, may inhibit the effective communication of knowledge and may complicate the communication of criticism and challenges (National Research Council, 2008; Salazar, Lant, Fiore, & Salas, 2012).

Differing expectations and obligations may also be connected to funding and resources, as Peterson (2001) points out for international collaborations in the field of organizational behavior research. Thus, international structural variations in these areas can lead to different assumptions and expectations of collaborating scientists about how IRCs should be planned, performed, and reported on (Anderson & Steneck, 2011; Goddard et al., 2006). In addition to that, the respective universities or other academic institutions that scientists are embedded in, may have their own research or work policies and guidelines, accompanied by specific communication structures, decision-making processes, hierarchies or leadership models (Tierney, 1991; Välimaa, 1998).

Secondly, sociological features may add another level of team complexity to all forms research collaborations and may shape scientists' perceptions and practice in collaborative teamwork. For IRC teams, the reviewed literature for example mentions the diversity category of *gender* in IRC teams (Sauquet & Jacobs, 1998). Lyman (2011) points out, for example, that due to diverse cultural backgrounds, female scientists may differ in the way that they challenge male collaborators. Similar to that, Jeong and Choi (2015) argue that we may find differing gender-related leadership styles, with the female leadership style being more cooperative and transformational, and in contrast the male leadership style being more competitive and transactional, thus leading to more hierarchical structures.

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6   Culture here defines as a pattern of deep-level meanings, values, beliefs, interpretations, norms, and orientations that is collectively shared by an interacting group of people, while at the same time shaping the perceptions, attitudes, value systems, and practices of individuals (e.g. Aritz & Walker, 2009; Hofstede, 1980; Kuckhohn & Strodtbeck, 1961; Maznevski et al., 2002). Culture is regarded as a multidimensional and multivalent construct, e.g. individuals may have more than one cultural affiliation and be shaped by diverse cultures (Jameson, 2007). In communication, culture becomes visible in communication style (including dialects or languages), communicated rules, or shared meaning or perceptions - which others may or may not recognize as culturally linked (Ely & Thomas, 2001; Larkey, 1996).

When looking at academic work in general, Conrad and Phillips (1995) find gender-related communication patterns, as well. Here, male communication patterns are said to be more competitive, straightforward, and confrontational, focusing on information rather than the personal or emotional dimension, and strongly expressing opinions, while using silence as a self-defense mechanism. Compared to that, the authors show that female communication patterns are more cooperative and laterally organized, including more turn-taking in conversations, and using silence to allow others to speak.

Another diversity dimension referred to in the reviewed literature is that of differing *status, tenure diversity and different career stages* of scientists in IRC teams. According to Teagarden (1998), who carried out a comparative case study of IRCs in the research field on human resource management and also added reflections on her own collaboration experience, asymmetry in career stages of collaboration partners can pose potential problems because of differing reward needs, constraints or expectations towards the collaboration outcome that may be attached to them (see also Kosmützky, 2018).

Third, with regard to the cultural complexity of IRC teams, the dimension of the different *disciplinary cultures* of the participating researchers is pointed out in some of the reviewed literature: Similar to the results of the research field on interdisciplinary research teams, Salazar et al. (2012, p. 531–534) argue that scientists in IRC teams may also identify strongly with their disciplines and hold allegiance to the discipline's values, approaches, and norms. Those disciplinary differences may provide the foundation for novel perspectives and solutions, but they may also make it more difficult for IRC teams to communicate and absorb the potential contributions of each scientist, for example, because members' use of technical or scientific language that is unique to their area of expertise and therefore unfamiliar to other members (Bark, Kragt, & Robson, 2016; Fiore, 2008).

However, IRC teams not only may be confronted with interdisciplinary challenges, but also have to deal with cultural differences that go beyond disciplinary affiliations, and may also manifest themselves through perceptions of and approaches to research and communication practices, knowledge production, related values and beliefs, and differing expectations about the international collaborative work.

For example, Okamoto (2015) discusses how the Social Sciences in Japan create and distribute knowledge, and what influence the national academic environment has on knowledge production, also in the context of international collaboration. The author argues that *national academic cultures* form a relevant framework for collaborations, since they shape the ways in which academic work is carried out. Similar to that, Tennom (1995) contrasts French and British researchers, arguing that while French scholars tend to operate in a closed self-contained world of discourse and debate, British scholars are more likely to hold an Anglo-centric view of the world. They usually expect other research communities to adopt their work style in international networks, also because they use an international language (Tennom, 1995; see also Hantrais, 2009).

Similarly, referring to Galtung (1982), Hantrais (2009) argues that national academic cultures can differ according to their "intellectual styles": Whereas in

the Western world, we find a Saxonic, Teutonic, and Gallic style, the Nipponic style is located in the Oriental world (pp. 150–151). The author argues that those styles differ with regard to the way intellectuals perform certain tasks such as the exploration of paradigms, data collection, empirical description, explanatory or theoretical derivation and theory formation, or based on how they give feedback and commentary on the performance of other scientists. She emphasizes that the differences in intellectual styles and research cultures can help to explain many of the obstacles to international cooperation and understanding between national research communities (see also Sorensen, 2003, Birnholtz, 2007; Lakic et al., 2015; Wells, 2013).

Turati et al. (1998) compare researchers in North America and Europe and show that some paradigms are more commonly used by researchers in both Europe and North America, while other paradigms are used only in certain areas or groups of thought, which reduces the commonalities and the efficiency of coordination among IRC teams. Thus, national academic cultures can also affect the coherence and integrity of IRCs and should therefore not be ignored in data collection, analysis, and interpretation, since it affects all those aspects (Hantrais, 2009).

Furthermore, beyond the academic dimension, other *national cultural differences* can shape scientists' collaboration practice in IRCs. For example, Gardner et al. (2012) report for their own IRC experience, that "different cultures have their own norms about who should initiate communication, what constitutes an affront, and how polished an idea should be before it is exposed", and that "in some cultures maintaining harmony and respect within the group is more important than individual expression" (p. 256). Thus, a scientist's thinking, perceptions, values or actions may also be partly conditioned by national culture, due to previous life experiences in the family, the own (professional and academic) education, and the own national work experiences (Thomas, Ravlin, & Wallace, 1996). Lyman (2011) furthermore points out that IRCs must reflect upon different culturally shaped communication norms among the participating scientists, for example for expressing criticism. Here some scientists may prefer more implicit forms of criticism, while others expect explicit and directly addressed critical feedback for their work or ideas.

According to Wells (2013) and Pischke et al. (2017), national cultural differences may become visible most often in misunderstandings in everyday collaborative interactions. They may show through differing expectations of workloads, sensitivity to deadlines, levels of supervision, and mentoring among team members (Lewis & Ross, 2011; National Research Council, 2008). Or, they may affect team dynamics, conflicts and problem-solving (Salazar & Salas, 2013). Hanges et al. (2005, pp. 353–355) – by referring to their own collaborative experience in the GLOBE project – point out that they also faced differences in the understanding of time, which led for example to missed deadlines. Kumar (1985), who interviewed faculty members of U.S. universities (from the disciplines sociology, economics and psychology) with international collaborative research experience, illustrates that different nationalities of scientists can also lead to hierarchical researcher roles, when certain countries are regarded as more relevant (e.g. the United States or United Kingdom), and thus have more influence in decision-

making processes in an IRC. Finally, key concepts used in IRC's theoretical framework can be charged politically or ideologically, which can influence the interpretations of data (Hantrais, 2009).

However, Shore and Cross (2005) explain, that it is often difficult to link culture directly to project outcomes, because so many other factors are involved. Nevertheless, Gardner et al. (2012) emphasize that a heightened awareness of cultural differences and efforts to value these differences can help to consciously develop a team environment in which members feel comfortable. The authors argue that this requires a style of communication that can support the solving of problems and the building of relationships to achieve the goals of the collaboration.

Here, Pelikan (2015a) or Fussel and Setlock (2012) suggest pre-project training in intercultural communication and collaboration, a practice that is already common and successfully applied in the business sector. Researchers in science often do not see the need for communication optimization if they do not have any experience with it, or they neglect internal communication and only focus on communication tasks aiming at the dissemination of project information and results into the broader research community or the public.

Hanges et al. (2005, p. 353) summarize with regard to their own international collaboration experience that they „naively did not expect the function and structure of the project itself to be affected by the very constructs (i.e. leadership and culture) that we were studying." Similarly, Segalla (1988, p. 133) argues that "developing truly international academic research means bridging more than an ocean. One must bridge languages, theoretical paradigms, methodological traditions, and different styles of analysing and reporting empirical results." Brew et al. (2013, p. 94) therefore conclude that "when major cultural differences, or language differences are obvious, then there is a continual reminder to renegotiate understandings. When these are not apparent, the problem becomes apparently simpler, but the potential for disruption becomes no less."

The authors thus indicate, that negotiations on team complexity should take place in IRCs in order to find a common ground for the collaborative research efforts, since "good intentions are not sufficient to cope with these challenges" (Hoffman et al., 2014, p. 473). Therefore, to interact and communicate among each other successfully in IRCs, the team complexity must be recognized, understood, and communicatively negotiated.

The outlined studies indicate, that those personal, sociological and cultural dimensions of each researcher participating in IRCs form an important individual *backpack* that each of them brings into the collaboration enterprise, that contributes to an IRC's team complexity, and also shapes the communication in those teams. Here, it is especially the national structural and cultural differences among IRC team members that form an additional layer of complexity to IRC teams and thus distinguish them from national and/or interdisciplinary collaborative research teams.

On the one hand, these individual backpacks shape the IRC's research and communication practice and the interaction among the team members. Differences among researchers thereby can become visible in different ways of doing research, different communication styles in the discussion of research-related top-

ics or social issues on the team level, as well as different forms of implicit (non-verbal) forms of communication (e.g., body language, physical appearance, behavior) when IRC teams interact, and when task- or team-related issues and topics are discussed and negotiated. Thus, those backpacks shape the mentalities as well as the social behavior of scientists (Välimaa, 1998). Scientists may need to acquire a certain degree of social or intercultural sensitivity and reflexivity, if they want to be able to notice and understand those different facets in an IRC team (Pischke et al. 2017; Stokols, Misra et al. 2008).

On the other hand, the individual backpacks may also be unpacked when scientists communicate *about* them in IRC teams, to understand the different perspectives, views, and interpretations, or to solve misunderstandings and social conflicts and issues in the team. Here, authors like Easterby-Smith & Malina (1999), Haintrais (2009), McGinn (2005), or Thomas et al. (2009) emphasize the importance of a reflexive dialogue, the ability to negotiate, or the need of diplomatic skills between IRC team members, in order to create the space in which expectations, assumptions, feelings, and task- or team-related issues can be openly discussed and negotiated. As Gardner et al. (2012) emphasize based on their own collaborative experience, "a heightened awareness of cultural differences and efforts to value these differences helped us to consciously develop a team environment in which members feel comfortable," and that "this kind of environment fosters a style of communication that is more likely to achieve the problem solving and relationship building necessary to achieve the project goals" (p. 256).

Therefore, focusing on the effects of team diversity and complexity on collaboration practice in IRCs can offer a better understanding of those procedures themselves. As Mabey, Kulich, and Lorenzi (2012) argue based on the interviews they carried out with physical scientists at the European Organisation for Nuclear Research CERN in Switzerland, language and culturally-shaped ways of communication, nationality, or personal facets such as gender may all surface as "inbuilt filters to participation in 'real' knowledge exchange" (p. 2462).

5. Conclusion and open research questions

Based on the outlined state of research, the concluding chapter summarizes the main results of the analysis, identifies four major research gaps in the state of research, and suggests a future research agenda for international scholarly communication analysis, by outlining four research foci that future studies on international scholarly communication may concentrate on in order to expand the empirical and theoretical framework for this form of science communication.

Overall, the introduced literature review revealed only a minor focus on the communication practice in IRCs. In most studies, communication is mainly regarded as a management tool, that is argued to be relevant to distribute information and data, to coordinate work tasks, and to achieve collaboration goals, while its role and use for knowledge production, teambuilding and team coherence was rarely taken into view. Only few of the reviewed studies put communication at the center of their research focus and empirical analysis. Others only focus on the use of different communication channels, but do not consider the actual commu-

nication content and the way in which this content is communicated, understood, or negotiated. Thus, the identified state of research so far largely focuses on the structural dimension of communication in IRCs and pays only minor attention to the level of actual communication practice and exchange throughout the collaboration processes. While the role and usage of a joint project language is observed in some studies (e.g. Bagshaw et al., 2007; Wells, 2013), only a few detailed micro-level observations of communication practice were found, and here especially in the set of auto-ethnographic reflections on task- and team-related aspects of IRCs (see Table 2). The results of the outlined studies thereby predominantly reflect results of the studies on interdisciplinary collaborative research teams, as they have been mentioned briefly in the conceptual framework in chapter 2. However, they lack further specifications about the additional international dimension of IRC teams.

Therefore, the *first research gap* that was identified in the reviewed literature can be summarized with regard to empirical analyses on how communication processes actually take place among scientists in IRCs. Hwang (2013) offers one explanation for the lack of empirical insights into those facets of communication in international research settings. The author argues that verbal communication – especially in the Natural Sciences – is still regarded as unimportant in scientific work. Instead, scientists regard data with figures and technical terms as a more universal means of communication in scientific work than verbal communication. Furthermore, Thomas (2005) points out that scientists in all disciplines are predominantly of the opinion that scientific work and research collaborations operate according to universal rules, and are thus objective and unbiased, i.e. they are not influenced by historical, political, societal or cultural contexts. Therefore, from the perspective of most scientists, the focus of IRCs lies predominantly on research and the achievement of specific research goals and outputs, rather than on the level of social interaction and team dynamics, or the goal to successfully establish and maintain good social relationships among the IRC team members.

Nevertheless, on the task level IRCs and the involved scientists need to tackle communication practice and to plan, structure and reflect upon their communication processes. Otherwise, they run the risk of not making full use of the different skills, scientific expertise, and the deeper context knowledge on specific countries or cultural backgrounds that each of the collaborating scientists contribute to the IRC. For collaborative research in the Social Sciences this is particularly relevant, because here international collaborations are most often formed with the explicit motivation and goal to combine national or cultural expertise in order to fully understand social phenomena in different national or cultural contexts.

- Research focus 1: Therefore, the first suggestion for a future research agenda on international scholarly communication is the *development of a broader analytical focus on the actual communication practice on the micro-level of IRCs*.

A *second research gap* was found regarding the analysis of how team complexity is dealt with in IRCs and what impact it has on the collaboration process and success. On the team level, all IRCs (i.e. not just those in the Social Sciences) need to reflect upon their communication and interaction, if they want to avoid commu-

nication conflicts and misunderstandings. Bozeman et al. (2013) here also point out the lack of research on failed collaborations and the "dark side of research collaboration" (p. 5) – on a task level but also on a social level – and especially with regard to large-scale collaborations (Bozeman & Boardman, 2014). Also, most of the existing studies focus on IRCs in the Natural Sciences and Life Sciences, and do not consider that misunderstandings or conflicts do not necessarily have to be caused by research-related issues but may also be attributed to the outlined team complexity. As the literature on interdisciplinary research collaborations has already shown for disciplinary complexity, (disciplinary, academic, or national) cultural differences as well as sociological features may also have a significant impact on the team cohesion and common research practice. Several authors in the reviewed literature mention this aspect of team complexity in IRCs already, but do not empirically link it to communication processes. However, arguing with Hinds and Mortensen (2005), especially in conflict situations (e.g. conflicting views about project goals, research procedures, quality criteria, team responsibilities, decision-making processes, work ethics, differing priorities or time capacities), communication can become a crucial tool but also a crucial obstacle.

Here, conflicts may be caused by the fact that scientists only communicate selectively (e.g. by withholding information that may be useful for their counterpart) or that, unintentionally, they provide less information than would be necessary for the counterpart to fully understand the message or topic discussed. Or, scientists may not decode the meaning of information or behavior correctly, and thus misunderstand not only task-related content but also personal intentions and motivations for the actions of their collaboration partners (Akkerman et al., 2006; Hinds & Mortensen 2005). From this lack of reflexivity, conflicts may arise or deepen and threaten the success of IRCs, since they restrict the collaborating scientists in their goal achievement (Freitag, 2016).

One way of measuring the impact of team complexity on communication and collaboration in IRCs is either by focusing on the communication content and how team complexity is discussed and reflected upon here. Or, analyses may focus on how team complexity becomes visible implicitly, i.e. through the communication practice itself, and how this may influence the communication and collaboration processes accordingly.

- Research focus 2: Therefore, a second suggestion for a future research agenda is the *development of a broader analytical focus on the interrelation between communication and team complexity in IRCs*, i.e., how this complexity affects the communication practice in IRC teams, how it is communicatively negotiated, and how it thus affects the collaboration processes and outcomes, hereby focusing especially on the specific influence of the international background of the respective international teams

A *third research gap* was found regarding the use of a joint project language and the relevance of respective language skills. The studies of Hwang (2005, 2013) or Bournois and Cheavlier (1998) show that language skills may be a crucial factor for the formation of team hierarchies in IRCs, with English being the key to power in such collaborations. This role of language as a power tool should be elabo-

rated in more detail and should especially be supported by a broader empirical database. Furthermore, research still needs to explore, how language actually becomes relevant in IRCs, what issues may occur due to language deficits among IRC team members, how those deficits affect the task and the team level of collaboration, and what strategies or tools those teams develop and apply to bridge language gaps in international collaborations.

- Research focus 3: Therefore, a third suggestion for a future research agenda is the *development of a broader research perspective on language use and the impact of unbalanced language capacities on power relations in IRCs*, i.e. how project languages are defined and applied, how language deficits affect the collaboration processes, and how IRC teams deal with unbalanced language capacities.

A *fourth research gap* was found regarding the focused disciplines, since a large majority of the identified studies focus only on IRCs in the Natural Sciences, the Life Sciences and Engineering. One reason mentioned already in chapter 4.2 is that many reflections on teamwork in IRCs were found in the SciTS research field, where such studies are often carried out as accompanying research for national research funding schemes in the Natural Sciences. Nevertheless, IRCs are also a relevant and increasing form of research and collaboration in the Social Sciences and Humanities, and here modes of collaboration and communication practice may differ. International collaborations in the Natural and Life Sciences often focus on transnational or global phenomena or problems (e.g. diseases, environmental issues), whose causes, distribution or effects are often not bound to specific countries and do not need country- or culture-specific knowledge to be fully understood or explained (Anderson & Steneck, 2011; Kumar 1985; Storer, 1970; van Raan, 1997). Therefore, collaborations in those disciplines often have a universal character with regard to the targeted goals, research results and developed theories.

On the contrary, analyzed phenomena in the Social Sciences and Humanities often require respective national, cultural, social, or linguistic context determinants to be understood and explained. On the one hand, this context knowledge forms one reason for the necessity of international (comparative) social research. On the other hand, it also leads to an increased need for communication among the participating scientists, since those differing contexts need to be correctly identified, exchanged among, and made comprehensible for the collaborating scientists (Esser & Hanitzsch, 2012b; Slipersaeter & Aksnes, 2008). At the same time, international collaborative social research often also has an internationally comparative design, which leads to the necessity to also negotiate and agree upon questions of conceptual, theoretical, and methodological equivalence (Kosmützky 2018; Kosmützky & Wöhlert, 2015). Finally, based on the outlined features, the division and distribution of the process of the data collection and data analysis is limited in social empirical research (Laband & Tollison, 2000; Lee & Bozeman, 2005; Moody, 2004). Therefore, insights into IRC practices in the Social Sciences may offer an important expansion of our state of knowledge and theoretical perspective on other forms of international scholarly communication and collaboration practice.

- • Research focus 4: Therefore, a fourth suggestion for a future research agenda is the *development of a broader empirical database on international communication and research practice in IRCs in the Social Sciences and Humanities*, in order to broaden the state of knowledge and theoretical perspective on forms of international scholarly communication and collaboration practice, and to systematically compare disciplines with regard to their modes of international scholarly communication and knowledge creation.

Overall, the outlined suggestions for a future research agenda may be carried out using the full spectrum of available methods for the collection of relevant data on communication content, structures, and practices. So far, the state of research revealed a strong focus on the use of bibliometric data to grasp the types, scope, and network structures of IRCs. Regarding communication structures, studies also used interviews or surveys to gather relevant information.

The actual communication practice was less observed so far; here qualitative studies pre-dominantly focused on single-case analysis or auto-ethnographic reflections and descriptions. Those qualitative studies have provided important first insights into the communication and research practice of IRCs. Therefore, they should be implemented more systematically in future research designs. Methodologically, "diving into the IRC projects and team practice" may be a successful strategy to gain access to more profound insights on the research and communication practice on the micro-level of IRC teams – as the ethnographic case studies in the introduced literature review illustrate. Using participant or non-participant observation, being able to see communication struggles "in the making" and digging deeper in interviews with project members allows for more profound insights into the actual practices. It also may offer more insights into what dimensions of an IRC team's complexity have an impact on the team interaction and communication.

A pioneering model for future studies on the outlined questions could be the laboratory studies that have been already mentioned in chapter 1 (see Knorr-Cetina, 1981; Latour & Woolgar, 1979; Reichmann, 2013), thus adopting an anthropological perspective on how international collaborative research and communication are actually practiced in the closed settings of IRCs.

Those methods might be complemented by other qualitative approaches to gather data on communication structures and communication practices: Qualitative interviews with individual scientists or groups, or group discussions, may be used to gather more insights on communication content, reflections on, and perceptions and interpretations of communication processes and the identification of relevant impacts of team complexity. Also, network analysis may be applied to fully grasp the communication structures in IRCs. Finally, comparative case study designs may allow for the identification of general patterns of communication practice beyond individual IRCs. They may also reveal tendencies with regard to the overall relevance of certain dimension of the outlined team complexity in international collaborative research settings.

The outlined suggestions would further expand the currently still neglected research focus on international scholarly communication and may lead to a deeper understanding and conceptualizing of the international dimension of internal sci-

entific communication and project practice within the framework of the theory of science and communication theories. They may also deepen the understanding of the role of the internal team complexity in scientific teams and with regard to the production of collaborative knowledge.

This expansion is relevant not only from a theoretical, but also from a practical perspective, since scientists in IRCs need to be prepared for international collaboration and communication practices. Therefore, they should also reflect upon their own communication processes, or they will run the risk of not bridging the spatial gap as well as not making full use of the different skills, scientific expertise, and the deeper context knowledge on specific countries or cultural backgrounds that each of the collaborating scientists contribute to the collaboration. Here, the suggested research agenda may offer helpful insights and materials to develop guidelines (e.g., best practice examples, toolkits, workshops) for future IRCs. Eventually, this broader state of knowledge contributes to the future success of such forms of research and knowledge creation.

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Appendix 1. State of research on international research collaboration – Articles on the state of the art (8 total)

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Appendix 2. State of research on international research collaboration – Articles on the conceptualization of collaboration, collaboration structures, patterns and motivations (80 total)

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