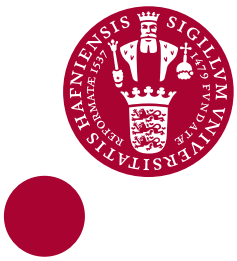

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Haman, Magdalena; Hertzum, Morten

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Collaboration in a Distributed Research Program: Islands of Intensity in a Sea of Minimal Interaction

Magdalena Haman, University of Copenhagen, Copenhagen, Denmark, magda.haman@gmail.com

Morten Hertzum, University of Copenhagen, Copenhagen, Denmark, hertzum@hum.ku.dk

Abstract

Purpose – Researchers need to collaborate to address grand challenges such as climate change, poverty, and sustainable food production. We investigate how the researchers in a globally distributed research program interact to move their research forward.

Design/methodology/approach – We interviewed 14 participants in the research program.

Findings – In spite of the spatial distribution of the researchers the output from the research program is predominantly collaborative; as much as 79% of the publications are co-authored by researchers from multiple countries. However, the researchers mostly work alone on their contributions to their joint work and spend minimal time interacting. This strategy of minimal interaction is punctuated by islands of intense interaction when they occasionally meet in person. Interaction feels natural, productive, and satisfying to them when they are co-located but less so when they are distributed, probably because they experience technology-mediated interaction over a distance as somewhat impoverished. The interviewees mention that the minimal-interaction strategy incurs the risks of cracks in common ground and of misconstruing minimal interaction as lack of commitment. But the strategy is generally well-liked.

Research limitations/implications – The experience of technology-mediated interaction as impoverished points to an explanation for the finding of less interaction in distributed than co-located research. It should be noted that the study is restricted to one research program.

Originality/value – By questioning widely touted recommendations for ongoing, regular, and sustained interaction this study provides a fresh look at scientific collaboration.

Keywords: Scientific collaboration, Global research, Team science, Distributed work, Minimal interaction

Paper type: Research paper

1 Introduction

No single research institution can address all the interdependent issues posed by challenges such as climate change, poverty, and sustainable food production. To engage these challenges researchers must collaborate. While scientific collaboration has become increasingly common and researched (Bennett et al., 2010; Olson et al., 2008; Sonnenwald, 2007; Stokols et al., 2008a), large-scale scientific collaboration remains a challenge in its own right. This challenge stems, in part, from the spatial distribution of the collaborating researchers (Olson and Olson, 2014). In this study we investigate a globally distributed research program and ask how the researchers interact to move their research forward.

Previous work on scientific collaboration finds that "without ongoing communication, tasks will not be coordinated, scientists will not learn from each other, research results will not be integrated, and perceptions of distrust may emerge" (Sonnenwald, 2007, p. 667). This finding summarizes the widely held conviction that in scientific collaboration more interaction is better (e.g., Cummings and Kiesler, 2005; Larivière et al., 2015; Stokols et al., 2008b; Vasileiadou, 2012). In contrast, the research program we investigate in the present study keeps the interaction among its distributed participants at a minimum in order not to waste time on secondary issues. This minimal-interaction strategy is complemented with islands of intense interaction, such as face-to-face meetings. We note up front that minimal interaction is not a panacea. That said, it should be noted that minimal interaction is not an attempt to circumvent collaboration; it is the participants' strategy for scientific collaboration. The studied research program for example mainly produces co-authored papers.

In the following we review related work on scientific collaboration and success in distributed work (Section 2). Then we present the studied research program, which is in sustainable agricultural food production, and describe how we conducted and analyzed the interviews that constitute our method (Section 3). The results of our study concern the minimal-interaction strategy, the islands of intense interaction, and the technologies through which the researchers interact (Section 4). Finally, we discuss the results, their implications, and the limitations of this study (Section 5).

2 Related work

Scientific collaboration has been defined as the "interaction taking place within a social context among two or more scientists that facilitates the sharing of meaning and completion of tasks with respect to a mutually shared, superordinate goal" (Sonnenwald, 2007, p. 645). Typically, such collaboration involves distributed work because the collaborating researchers are in different spatial locations all or part of the time.

2.1 Scientific collaboration

Researchers collaborate for a variety of reasons, including to access expertise (Thorsteinsdottir, 2000), to access equipment or other resources (Finholt, 2002), to exchange ideas across disciplines (Heinze and Kuhlmann, 2008), to acquire funding (Pao, 1992), to obtain prestige or visibility (van Rijnsoever et al., 2008), to enhance productivity (Vasileiadou, 2012), to mentor students or junior researchers (Bozeman and Corley, 2004), to professionalize science (Beaver and Rosen, 1978), and for fun or enjoyment (Melin, 2000). There are, however, also challenges that limit collaboration or make it more difficult. For example, interpersonal conflicts among researchers may undermine trust and hinder collaborative processes (Sonnenwald, 2004). The sources of such conflicts include that leadership styles can foster conflicts or allow them to escalate (Stokols et al., 2008a). In addition, collaboration may lead to problems with assigning credit for research outcomes, thereby causing disputes that adversely affect researchers' motivation to collaborate (Wray, 1996). Studies also point to the high cost of coordination when the collaborating researchers are spatially distributed (Bruns, 2013; Cummings and Kiesler, 2007; Walsh and Maloney, 2007). For example, Cummings and Kiesler (2005) report that multi-disciplinary collaboration had many positive effects whereas multi-institutional collaboration was problematic, thereby indicating that spatial distribution is a larger challenge than disciplinary distribution.

Given and Willson (2015, p. 139) conclude from a study of humanities researchers that they were at times "working quite independently within a collaborative project", that is, they formed collaborative projects but largely continued to work as solo scholars. This illustrates that scientific collaboration may occur at different levels – from complementary to integrative (Hara et al., 2003). In some cases the collaboration will be restricted to the overarching research project and rarely involve the co-authoring of research papers. In other cases, the collaboration will be about planning and organizing an event, such as a conference (Verouden et al., 2016). However, the importance of paper writing in research means that research collaborations, and studies thereof, often have the co-authoring of papers as a central component. Measured on this parameter, scientific collaboration has become increasingly predominant. For example, Larivière et al. (2015) show that

in the period from 1900 to 2011 the proportion of single-authored papers has dropped from 87% to 7% in the natural and medical sciences and from 97% to 38% in the social sciences and humanities. In the most recent decades the proportion of papers with two or three authors has also started to drop because the number of papers with four or more authors is increasing.

The ways in which researchers approach collaboration obviously influence the process and its outcomes. Bozeman and Corley (2004) propose that researchers can be categorized on the basis of how they select their collaborators. The six categories suggest very different kinds of collaboration: (1) *taskmasters* choose collaborators on the basis of their reliability and work ethic, (2) *nationalists* prefer collaborators fluent in their own language and of the same nationality, (3) *mentors* collaborate to support junior colleagues and students, (4) *followers* mostly collaborate because it is expected of them and because the collaborator has a strong reputation, (5) *buddies* prefer collaborators they know from previous collaborations that were successful and fun, and (6) *tacticians* choose collaborators with skills complementary to their own. While one of these categories, the nationalists, is defined by spatial distribution, the others are not. Yet, scientific collaboration appears to be subject to a proximity effect in the sense that collaboration decreases with increasing distance between the researchers. For example, Hennemann et al. (2012) find that intra-country collaboration is 10-50 times (depending on the research field) more likely to occur than international collaboration. Havemann et al. (2006) find that intra-city collaboration is more frequent than inter-city collaboration within the same country. And Kraut et al. (1990) find that researchers at the same floor of a building are about six times more likely to collaborate than researchers on different floors or in different buildings.

2.2 Success in distributed work

On the basis of studies of both scientific and industrial collaboration Olson and Olson (2014) identify five factors that lead to success in distributed work. These factors resemble those discussed by Stokols et al. (2008b) as influencing transdisciplinary scientific collaboration. The five factors are (Olson and Olson, 2014):

The nature of the work. A key characteristic of work is whether it is tightly or loosely coupled. In tightly coupled work the components of the work are highly interdependent. Frequent and complex interactions are needed among the collaborators because the situation is ambiguous and the way forward yet to be determined. In contrast, loosely coupled work has fewer interdependencies and clearer goals. It requires fewer and more routine interactions because it can be divided into components that can, to a large extent, be performed one after the other. While research tends to be tightly coupled, at least during its formative stages, Olson and Olson (2014) recommend that work components are only distributed if they are loosely coupled. That is, they predict that for the tightly coupled components of research existing communication technologies are insufficient to compensate for spatial distribution.

Common ground. Effective communication presupposes some level of shared situational understanding among the collaborators (Clark and Brennan, 1991). Such shared understanding – common ground – may in part be supplied by a disciplinary background common to the collaborators or by shared experiences from previous collaboration. However, collaborators also glean common ground from each other's appearance and behavior during their interactions. That is, they ultimately establish common ground on the fly from whatever cues they have at the moment. If the collaborators use lean media, such as email, then fewer cues are available and mistakes are more likely (Trevino et al., 1987). On this basis Olson and Olson (2014) warn that common ground is fragile and can only be sustained through frequent interactions in rich media, such as videoconferencing or face to face.

Collaboration readiness. Collaboration is imperative to the success of organizations and projects. In research it is even mandated by an increasing number of funding bodies (Sonnenwald, 2007). Yet, collaboration will remain partial and halfhearted unless the incentive structure rewards collaboration and the individual collaborators trust each other (Olson and Olson, 2014). If people for example compete for rewards, including prestige, then they will be less inclined to collaborate. In contrast, trust facilitates collaboration (Jarvenpaa

and Leidner, 1999) and determines the selection of information sources (Hertzum, 2002), but it also breaks down more easily than it can be built. Olson and Olson (2000, p. 164) go as far as to consider it futile to introduce technologies for supporting collaboration in "organizations and communities that do not have a culture of sharing and collaboration."

Organization and management. Distributed work "goes more smoothly with at least some hierarchical authority" (Olson and Olson, 2014, p. 49) because the hierarchy reduces the need for on-the-fly, technology-mediated interactions to negotiate goals and responsibilities. This recommendation appears delicate in research collaborations, which may be leaderless and participatory in their organization (Chompalov et al., 2002). Olson and Olson (2014, p. 51) emphasize that distributed collaboration requires "regular planned meetings", often virtual, during which the project leader can communicate goals, ascertain progress, and get feedback. These meetings must combat the risk that the collaboration disintegrates, for example as a result of the finding that when people have two equally important tasks to perform, one with local collaborators and one with remote collaborators, the local task gets most of their time and attention (Fussell et al., 2004).

Technology readiness. While some research collaborations are established to get access to specialized technological equipment, all distributed research collaborations depend on information and communication technologies. Unless the collaborators are ready and able to use such technologies appropriately their collaboration will falter (Olson and Olson, 2014). Constellations of simple technologies are often preferred because only some collaborators have the inclination, resources, and infrastructure required by more advanced technologies (Star and Ruhleder, 1996; Thomas, 1998). This may especially be the case in collaborations that span multiple regions of the world.

3 Method

We investigated scientific collaboration by conducting a case study of a globally distributed research program. Data were collected by means of interviews and analyzed through a process of theme building.

3.1 Setting

CGIAR (formerly, the Consultative Group on International Agricultural Research) is a consortium of international agricultural research centers (see http://cgiar.org). Since its establishment in 1971 CGIAR has pursued the goal of a world free of poverty, hunger, and environmental degradation. In pursuing this goal CGIAR works to advance agricultural research and innovation in order to enable poor people, especially women, to nourish their families better, and it works to enable these people to share in economic growth while managing natural resources in a sustainable manner. CGIAR has an annual research portfolio of US$900 million and staff in more than 70 countries. It is funded by national governments, super-national unions, development agencies, and private donors.

CGIAR is organized into research programs, which in turn are organized into research flagships. Each flagship has its own budget, staff, and projects. This article is about one of these flagships, in the following termed the Flagship. The Flagship conducts research into the policies necessary to change agriculture in response to the challenges posed by climate change. To foster a shift toward sustainable behaviors such policies must support the diffusion and adoption of interventions that research predicts to be climate friendly. With an annual budget of about US$17 million the Flagship runs projects in Africa, Asia, and Latin America. These projects for example research ways of scaling up locally successful interventions and ways of performing ex ante evaluations of interventions and policies. That is, the projects conduct research by applying it to the real-world conditions and challenges that must be met in devising sustainable solutions to agricultural food production. The partners in the Flagship include CGIAR research centers, government agencies, regional organizations, international NGOs, private research institutions, and academic institutions. Several Flagship participants hold positions outside CGIAR, including at European and US universities, and take part in the Flagship for the duration of their CGIAR funding.

3.2 Interviewees

We interviewed 14 Flagship participants, see Table 1. The interviewees included the Flagship leader, its two science officers, and seven leaders or coordinators of Flagship projects. All these interviewees were active researchers. In addition, we interviewed four people in support functions. These interviewees were knowledgeable about the research collaboration in the Flagship, but not researchers themselves. Seven of the interviewees held a PhD and three more were pursuing PhD degrees. The remaining interviewees also held advanced degrees. As an illustration of the global distribution of the Flagship the interviewees were based in nine different countries. In addition, five interviewees were not based in their country of citizenship.

Table 1. Profile of the 14 interviewees

Job title	Education	Nationality	Location
Flagship leader	PhD, 1983	UK	UK
Science officer	MPS, 2010	USA	Kenya
Science officer	MSc, 2007	Greece	USA
Project leader	PhD, 2011	The Netherlands	The Netherlands
Project leader	PhD, 2013	Uganda	Uganda
Project leader	PhD, 2009	Benin	Philippines
Project coordinator	PhD, 2006	The Netherlands	The Netherlands
Project coordinator	PhD, 2008	Cambodia/France	Cambodia
Project coordinator	PhD, 2017	Bangladesh	UK
Project coordinator	MA, 2005	The Netherlands	Costa Rica
Accountant	MSc, 2015	Kenya	Kenya
Communications consultant	MSc, 2017	USA	USA
MEL consultant	BA, 1998	Germany	Germany
Administration assistant	Graduate diploma, 2012	Kenya	Kenya

MEL – Monitoring, evaluating, and learning

3.3 Procedure

Prior to the interviews the study was approved by the Flagship leader, its science officer, and their research program management. After the approval the science officer assisted in the selection of the interviewees. The interviewees were initially contacted by email; the actual interviews were conducted as audio-only conversations on Skype. All interviewees gave their informed consented to take part in the study, including their permission for us to record the interview.

The interviewees received an introduction to the interview a couple of days before the interview to give them a sense of what it would be about. The interviews proceeded as conversations guided by the questions; additional questions emerged from the interviewees' answers. To get started the interviewees were initially asked to describe their responsibilities and daily tasks. The remainder of the questions were informed by Olson and Olson's (2014) five factors for success in distributed collaboration. Interviewees were, for example, asked whether there was a clear division of labor among the Flagship sites (nature of the work), how and how well they knew their Flagship colleagues (common ground), what they expected from their colleagues in terms of interaction and motivation (collaboration readiness), how they communicated and made decisions (organization and management), and what they considered in choosing the communication

technologies they used (technology readiness). The interview questions were partly directed toward the interviewees' collaboration in general and partly toward their collaboration during the specific activity of writing research papers.

The interviews were conducted by the first author, who worked as a part-time consultant for CGIAR. She was not involved in the Flagship. Her knowledge of CGIAR was helpful in asking questions in a terminology familiar to the interviewees and in understanding the interviewees' answers. All interviewees were familiar with Skype conversations and appeared at ease with this communication medium.

3.4 Data analysis

The interviews lasted 30-60 minutes and were transcribed from the audio-recording. The analysis of the interviews was a three-step process. In the first step we organized each transcript into themes. We arrived at the themes by identifying key interviewee statements and collecting topically related key statements into groups. This way we retained the interviewees' exact words (rather than abstracted them into codes) and grouped them into themes of related content. Eleven themes emerged from this analysis: communication, cultural and time-zone differences, decision making, expectations, motivation, organization and management, relations, roles, tools, working together, and writing publications. While the first step of the analysis exposed relations within each interview, the second step looked for cross-interview relations. To this end we focused on one theme in turn. By reading all interviewees' statements about a theme we got a richer understanding of it and of the ways in which the interviewees' different responsibilities in the Flagship influenced their perspective on the theme. This cross-interview analysis of the transcripts also served to validate individual interviewee statements against those of the other interviewees. In the third step of the analysis we read across the themes to identify a pattern that tied them together. A friction that recurred in multiple themes was the interviewees' simultaneous mention of how infrequently they interacted and how much they valued their interactions. Rereading the transcripts with this friction in mind showed its pivotal importance to the collaboration in the Flagship and led to the final focus of the analysis on minimal interaction with islands of intensity.

4 Results

As a precursor to the analysis we determined the level of distributed collaboration by looking at the number of co-authored Flagship publications for the period 2015-2017. As much as 106 (79%) of the 135 publications from this three-year period were co-authored by researchers from multiple countries, 10 were co-authored by researchers from multiple institutions within the same country, and the remaining 19 were by authors from the same institution and in the same country. Only 10 (7%) of the publications were single-authored.

4.1 Minimal interaction

The Flagship participants were globally distributed. For example, the interviewees' locations spanned 15 time zones. In addition, four of the interviewees worked from their home and were, thus, also locally distributed to the extent of not seeing any of their Flagship colleagues unless they made arrangements to see them. In spite of this distribution the Flagship leader believed in keeping interaction at a minimum:

> Everyone works for different organizations. Everyone has endless meetings. At the end, if things are going reasonably well then I'm reluctant to add more regular meetings on top of that. Of course I check in with them every few months and try to see if things are going with the plan.

His rationale for this minimal-interaction strategy was that "*when you have a person to do a job, you leave them to the extent possible to get on with it.*" For this strategy to work the Flagship participants must know their responsibilities, be self-motivated, and have access to support when needed. With respect to responsibilities, the interviewees agreed that the work did not require constant coordination because the tasks and roles were fairly clear. For example, one of the science officers said that "*I think we have a really good way of dividing up things. I think everyone knows their role.*" While clarity about responsibilities was a

necessary condition for a minimal-interaction strategy, it was not sufficient. However, the interviewees also appeared highly self-motivated. Major sources of this motivation were a shared passion about improving the food security of poor people through changes in agricultural policies and a feeling of contributing to something important and meaningful. The accountant added that "*My colleagues' motivation also motivates me.*" In addition, the Flagship participants experienced the Flagship leadership as supportive. One of the project leaders explicitly acknowledged that whenever he had needed support, it had been available: "*The Flagship leader and science officer have been very supportive. They are always there to assist and to help us.*" That is, the minimal-interaction strategy was combined with a readiness to interact and provide support when needed.

While the Flagship leader was comfortable with the minimal-interaction strategy, one of the science officers would prefer more frequent interactions with the projects:

> We should do some more regular skypes with the projects to find out what they're doing, maybe quarterly or something like that. We just haven't implemented it.

This interviewee expressed some reservation toward the strategy and implied that it would be adjusted once they got around to it. Yet, the proposed adjustment (i.e., quarterly skypes) appeared consistent with a strategy of minimal interaction, not in opposition to it. The minimal interaction between the Flagship leadership and the projects was reiterated by one of the project leaders, who stated that "*We just had a webinar last week for all the Flagship project leaders. This is the only one we have had so far.*" While the minimal interaction reduced the Flagship participants' awareness, at least across projects, of what their Flagship colleagues were doing, it meant that they experienced considerable freedom in performing their tasks. They valued this absence of micromanagement. For example, the communications consultant said that "*I feel respected, I have a say, and my ideas are valued.*" One of the project leaders voiced a similar sentiment when she stated that "*I don't like anyone to tell me what to do, so I expect everyone to work without supervision as well.*" Besides, several interviewees mentioned that the minimal-interaction strategy practiced in the Flagship stood in rather sharp contrast to their experiences from other employments. This might reflect differences in different managers' leadership style but it might also reflect that the strategy was, in part, made possible by the focus of the Flagship on policies. The focus on policies entailed a long-term perspective, in the words of one project leader: "*Policy formulation takes years. You're lucky if you see results of your project in three or four years.*" Maybe, the slow changes and long temporal horizons associated with policies made minimal interaction a more apt strategy than under dynamic, fast-response conditions.

While minimal interaction was generally a well-liked strategy, it was not without its problems. An interviewee for example said: "*So sometimes everything cracks when we're not informed about stuff that is happening and I do wish we were. And I don't know how to deal with that*". Examples of such cracks included fairly ordinary issues such as not knowing when Flagship colleagues were travelling and therefore unavailable. However, it also involved serious issues such as receiving so little information about the activities in a project that the science officer started wondering what the project was doing with the money it received: "*Are they actually working on the Flagship's project?*" At an overarching level a project coordinator pointed out that spending time on an issue was also a way of indicating its importance and showing commitment to it. This way, minimal interaction might suggest a lack of importance and commitment. The project coordinator was particularly concerned with spending more time on interaction through increased physical co-presence, which she saw as central to building trust among the partners in a project:

> I would expect the Flagship leader or other people to actually come to Cambodia. But not for one day, not for one workshop. To really stay one week or ten days and go through all of the donors and all of the partners as well, so that you can really see that there is a presence. So my expectation is having more valuable time being shared. It's about credibility and building the trust, not just about scientific input.

4.2 Islands of intensity

Without regular interactions during which the Flagship participants could keep in touch with each other, it became increasingly important to them to cultivate the interactions they did have, especially their face-to-face meetings. One interviewee for example mentioned that "*Whenever we have face-to-face meetings I really look forward to it.*" Meeting other Flagship participants in person was experienced as necessary to build relationships that extended beyond exchanging information. Several interviewees mentioned that they were more in touch with Flagship colleagues they had met face to face and, conversely, that they had less trust in Flagship colleagues with whom they had only interacted via email and other electronic media.

Face-to-face meetings were experienced as islands of intense interaction. When describing such meetings the interviewees assigned key importance to the social component: "*We don't only talk about work, we also talk about personal stuff, and we just hang out*". Knowing each other better made working together more fun. However, it also improved their professional relationships and their ability to do good work together. In the words of one project coordinator they became ready "*to go the next mile*" for each other. Another interviewee implicitly assigned substantial value to face-to-face interaction when he mentioned that he particularly enjoyed visiting the accountant and the administration assistant because they shared an office and therefore knew each other really well: "*They're a lot of fun. They get along very well. I think they are really good friends because they share an office"*. That is, visiting these two people was particularly nice because they enjoyed a close relationship that had grown from overseeing and overhearing each other's work activities and having plenty of opportunities for informal communication.

Most of the face-to-face meetings were within individual projects, not across projects. Thus, most project participants' knowledge of the other Flagship projects was partial at best, even though the projects in the Flagship had many issues and challenges in common. The whole Flagship team used to meet for an annual retreat but for the last couple of years the retreat had been on hold due to a shortage of funds. Many interviewees mentioned the retreat as an activity that was difficult to replace with other activities. For his own part the Flagship leader tried to replace the retreat with ad hoc meetings with the individual project leaders, but he readily admitted that a retreat for the entire team provided more opportunities for planning and cross-project insights: "*I think it's pretty useful to get everyone together to look at the plan and objectives.*" Funds permitting he would reintroduce the annual retreat.

Many of the episodes of intense interaction concerned the co-authoring of research papers. In one of the Flagship projects the co-authoring of papers was initiated by an annual, project-wide collaboration about identifying paper topics and author groups. This collaborative process made sense to the participants in this project because its structure involved that subgroups of participants worked in parallel on essentially similar research issues but in different parts of the world. The project coordinator summarized the process:

> We're meeting about once a year for a couple of days. We're bringing some key research articles, discussing what we're doing, and setting a list of what should be interesting or relevant articles we could publish. Then we choose one or two leaders and the rest would be like a co-writer.

Because the project participants worked on essentially similar issues they had lots of relevant input to each other's proposals for paper topics. In addition, similarities and differences in the challenges faced by the participants in different parts of the world often led to the identification of opportunities for comparative papers co-authored by participants working in different countries. The explicit identification of a lead author for each paper reflected that the actual writing of the papers had to happen with much less interaction than the intense interaction during the topic-identification meeting. By identifying a lead author it was made clear who was responsible for organizing and driving the writing process. The explicit distinction between lead authors and co-authors also provided less experienced project participants with a recognized role in the process. Typically, the lead author would write a skeleton draft with the framing of the paper and then solicit input for specified sections from the co-authors.

In the other parts of the Flagship the participants worked on more dissimilar issues and, consequently, paper topics and author groups were identified in a more ad hoc manner that might involve minimal interaction. The Flagship leader described the process like this:

> Somebody gets an idea, and that could be anybody: 'let's do a synthesis of that!' Then someone would take a lead and maybe do an outline or data collection, we probably have a couple of skypes about it, and then we can have a Google Doc where several people would contribute over a period of a few weeks. And then we would have a round for comments and inputs from other people.

While there were episodes of intense interaction (e.g., the couple of skypes), this description depicted the co-authoring of research papers as a rather loosely coupled process. Specifically, ideas for papers occurred to individuals without any mention of a collaborative process. Other interviewees added to this description by explaining how the person who got the idea often assigned co-authors to the paper. The assignments were open to negotiation; they aimed to expedite the process of arriving at an agreed upon group of authors by proposing who they should be, thereby reducing the interaction necessary to arrive at this decision. By making co-author decisions less dependent on interaction it was easier to assemble author groups from across the world. One reason for the feasibility of this loosely coupled process was that a sizeable proportion of the research papers synthesized material that had already been produced in individual Flagship projects. This, for example, meant that relevant co-authors could often be pinpointed quite precisely by a Flagship participant with an idea for a paper.

4.3 Technology support

The distribution of the Flagship participants made their collaboration entirely dependent on technology. For example, the administration assistant described how she received her tasks: "*I get emails with the tasks […] When more coordination is needed we have some Skype calls.*" Email and Skype were the predominant communication technologies across the Flagship. In addition, one of the projects had introduced Slack to foster more continual communication among the participants. The project leader explained that "*I introduced Slack, mostly because one of the coordinators felt very lonely, and it was to create a virtual office space where we all can talk together.*" This intention had succeeded. The use of Slack had developed into separate channels for different project activities, such as research papers and conference trips, in addition to channels for politics, random stuff, and jokes. In spite of its success in this project, Slack had not diffused to the rest of the Flagship.

Their location in different time zones meant that all synchronous communication involved some Flagship participants working odd hours. The interviewees appeared to accept this as an intrinsic element of their globally distributed work. But it did require considerable flexibility and was an argument for minimizing interaction. One interviewee illustrated the required flexibility particularly well:

> Sometimes I get Skype messages around 5 or 6pm from people in US and Colombian time zones, and that's when I'm cooking dinner and eating with my kids. But after 7pm that's when I can sit down and reply, have a meeting or something like that. It's just necessary to be flexible and to do your work also outside typical hours. Sometimes other people might want to meet with me early or late and I try not to cause any inconvenience to them. I think for me it's different because I work from home. Maybe I'm used to having different hours like that. But for somebody who goes to an office and does the work there, I don't want them to stay late.

With respect to the collaborative writing of research papers the interviewees mostly used Google Docs. While they were happy to be rid of the versioning problems associated with sharing drafts as email attachments, they expressed reservations against having multiple people simultaneously edit a paper. One interviewee explicitly expressed his reservations as a preference for a less interactive process: "*When I work on the document, I first want to work on it and then pass it on, and then someone else works on it.*" By minimizing interaction in this way the writing process became more manageable, but it was possibly prolonged. The

Flagship had previously organized 'writeshops' where participants met for a couple of days to work on papers they were co-authoring. The writeshops had been intensely interactive but in a way appreciated by the participants; the decision to discontinue the writeshops had been financial. While Skype and Google Docs made it possible to have virtual writeshops they were not perceived as providing the same benefits and had not become a way of replacing the physical writeshops.

5 Discussion

The minimal-interaction strategy cannot function without the islands of intense interaction. Together they constitute an approach to scientific collaboration in distributed settings. While this strategy is generally effective and well-liked in the Flagship, it is not a panacea.

5.1 Costs and benefits of minimal interaction

The Flagship participants approach interaction differently depending on whether they are distributed or co-located. When distributed they keep interaction at a low level; when co-located they interact intensely. Most of the time they are distributed. In spite of their global distribution the output of their research is predominantly collaborative in that a mere 7% of the Flagship publications are single-authored and 79% are co-authored by researchers from multiple countries. It appears that interaction feels natural, productive, and satisfying to them when they are co-located but less so when they are distributed. When they are distributed they prefer to work individually on their contributions to their joint work and spend minimal time interacting. This finding is consistent with Bruns (2013), who shows that collaboration across scientific domains consists to a large extent of researchers working alone together. While Bruns explains the time spent working alone with the individual researcher's need for conducting specialized work, it appears that the Flagship participants also minimize interaction because they experience technology-mediated interaction over a distance as somewhat impoverished. For example, virtual writeshops have not replaced the physical writeshops. The need for conducting specialized work arises from the domain distribution of the collaboration, not from its spatial distribution, and thus cannot explain differences between distributed and co-located collaborations. In contrast, the experience of technology-mediated interaction as impoverished provides a tentative explanation for Cummings and Kiesler's (2005) finding of less interaction in distributed than co-located research projects.

The minimal-interaction strategy stands in contrast to widely touted recommendations for ongoing, regular, and sustained communication (e.g., Olson and Olson, 2014; Stokols et al., 2008b). The main rationale for these recommendations is to facilitate the continuous creation and recreation of common ground. In addition, Vasileiadou (2012) reports that more meetings and team-wide emails increase the number of papers published, especially in complex research settings. The interviewees are not naïve about their minimal-interaction strategy and acknowledge the risk of cracks in common ground. While they acknowledge this risk and its possible negative consequences in terms of reduced trust, they simultaneously value the minimal-interaction strategy for its recognition of their ability to work largely unsupervised. That is, they construe interaction within an organizational hierarchy where people in leadership positions have the formal power to exercise control, and they perceive the absence of such control as a welcome expression of confidence. In much of the related work the leadership and control element inherent in scientific collaboration is depicted more positively as a way of focusing research efforts, or more bluntly as "a method for squeezing papers out of the rather large population of people who have less than a whole paper in them" (de Solla Price and Beaver, 1966, p. 1015).

With minimal interaction, silence becomes a frequent phenomenon and its proper interpretation becomes important to the Flagship participants' collaboration. They specifically mention the risk of mistakenly construing minimal interaction as an indication of lack of importance or commitment. Thus, in interpreting silence the participants waver between valuing it as an expression of confidence in their ability to work unsupervised and perceiving it as an expression of lack interest and commitment. For minimal interaction to

be a successful strategy the research leadership must embrace this doubleness. In the Flagship this is mainly done by catering for interest and commitment during islands of intense interaction, mostly face to face. However, the main precondition for success with minimal interaction is highly self-motivated participants. The Flagship participants' high level of self-motivation is pivotal to their experience of the minimal-interaction strategy and to their ability to work unsupervised. In addition, their uncertainty as to whether minimal interaction may also indicate limited interest and commitment has the positive side effect that it makes the participants more aware of the qualities of face-to-face interaction. Cramton (2001) argues that silence is mainly an issue in distributed collaboration because the silences are longer than in face-to-face interaction and because there are fewer cues to help interpret their meaning. The Flagship participants value their face-to-face interactions for their intensity, social content, and ability to make them a more close-knit group. However, these qualities are not guaranteed by face-to-face interactions; they result from the participants' appreciation and utilization of the possibilities afforded by face-to-face interactions.

Hertzum and Pries-Heje (2011) investigate a case in which a company that outsourced its software development to India deliberately minimized the interaction in this distributed collaboration. They find that the minimal-interaction strategy worked but also introduced extra work to overcome inequalities in business-domain knowledge and software-development practices. In the Flagship, knowledge and practice inequalities among the research sites play a different role. They are taken for granted and are part of the contextual circumstances that determine the possibilities for scaling up locally successful policies for sustainable food production. To some extent, the inequalities are collaboration barriers for the software developers but research material for the Flagship participants, who research and disseminate policies for sustainable food production. In addition, the relations among the Flagship sites are more symmetric than the client/vendor relation in the outsourcing case. More symmetric relations may be common in research collaborations. Such relations reduce the need for supervision and control but may, at the same time, complicate minimal interaction by increasing the coupling of work across sites.

5.2 Implications

This study has several implications for research and for the practice of scientific collaboration. First, minimal interaction with islands of intense interaction is a viable strategy for scientific collaboration, at least under conditions similar to those of the Flagship. This finding is important because it contests common recommendations. Future research should specify the conditions for minimal interaction in more detail to contrast them with the conditions under which scientific collaboration requires frequent, regular, and sustained interaction.

Second, regular, but impoverished, technology-mediated communication may not be worth the hassle, if occasional face-to-face meetings are an option. This finding suggests that face-to-face interaction may compensate for people's inclination to interact less while distributed. If so, technology-mediated communication can to a larger extent be used for the fewer and simpler interactions it supports well.

Third, face-to-face time should be used for interactions that cannot be accomplished well while distributed. This finding suggests that research on scientific collaboration can benefit from ideas such as the flipped classroom (Bishop and Verleger, 2013) from education research. Otherwise, scarce face-to-face time may be underutilized and the pressure on distributed interaction increased.

Fourth, interaction strategies are construed within an organizational hierarchy that, to varying extents, awards recognition and exercises control. Research should attend to the match or mismatch between, on the one hand, how a strategy influences recognition and control and, on the other hand, how it influences research output and impact. Research leaders must also balance high freedom of control against a sense of low leadership commitment.

Fifth, the Flagship achieves high levels of international co-authorship. This is out of the ordinary (Larivière et al., 2015). It probably contributes to the high level of international co-authorship that many Flagship

participants are not just globally but also locally distributed. When all Flagship colleagues are remote then the difference between intra-national and international co-authoring is drastically reduced. Future research should investigate this issue further.

Finally, on a more general note, this study shows that distributed work creates relationships that are sufficient for work-related purposes but lack the intimacy of friendships, unless the collaborators also meet in person. This way the increasing use of distribution in scientific collaboration risks making research a less effective source of meaningful social relationships.

5.3 Limitations

Three limitations should be remembered in interpreting the results of this study. First, the study is restricted to one research program. Generalization beyond this setting should be done cautiously. We recognize the need for validating the findings through studies of other research collaborations. The findings may, for example, depend on the extreme distribution of the flagship and it would therefore be valuable to validate them in collaborations where more people are locally co-located. The findings also need to be validated in organizations other than CGIAR, in domains other than agricultural research, and for research foci other than policies. Second, the study is based on interviews because we were interested in an account of how the Flagship participants interacted but equally interested in their reflections on their interaction practices. Interviews may however be influenced by rationalization and paint a somewhat sanitized picture of actual practices. While we cross-validated the interviewees' statements against each other, we acknowledge that method triangulation would provide a stronger cross-validation. Ideally, the interviews should be supplemented with observation. Third, we have not assessed the quality of the Flagship research. Thus, we cannot make conclusions about how the minimal-interaction strategy correlates with research quality. However, we can conclude that it enables the Flagship participants to collaborate to the extent of co-authoring 93% of their publications. The high level of co-authoring suggests quality insofar as previous studies find that increased co-authoring is associated with receiving more citations (Larivière et al., 2015) and research grants (Pao, 1992).

6 Conclusion

We have investigated how the researchers in a distributed, agricultural research program – the Flagship – interact to move their research forward. The Flagship participants display a strategy of minimal interaction punctuated by islands of intense interaction when they occasionally meet in person. The minimal-interaction strategy rests on a belief in leaving busy researchers to get on with their individual contributions to the joint work. In conclusion, this study contributes three findings:

- Minimal interaction is only a viable strategy because the Flagship participants are capable of utilizing the scarce face-to-face time effectively. It is in combination with the islands of intense interaction that the minimal-interaction strategy constitutes an approach to scientific collaboration in distributed settings. While this strategy is not without its problems, it is generally well-liked by the Flagship participants.
- The strategy means that interactions between participants may be separated by weeks or months of silence. Silences of this duration run counter to common recommendations of frequent and regular interaction to sustain common ground and produce quality research. Yet, in spite of their global distribution the Flagship participants predominantly produce co-authored papers.
- Two central qualities of the minimal-interaction strategy are that the participants perceive it as an expression of confidence in their ability to work unsupervised and as consistent with their experience of technology-mediated interaction as somewhat impoverished. In contrast, they perceive interaction as natural, productive, and satisfying when they are co-located, but they rarely are.

Future research on scientific collaboration should explicate in more detail the conditions under which a strategy of minimal interaction with islands of intensity is a viable alternative to frequent, regular, and sustained interaction.

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References

Beaver, D. and Rosen, R. (1978), "Studies in scientific collaboration: Part I. The professional origins of scientific co-authorship", *Scientometrics*, Vol. 1 No. 1, pp. 65-84.

Bennett, L.M., Gadlin, H. and Levine-Finley, S. (2010), *Collaboration & team science: A field guide*, National Institutes of Health, Bethesda, MD.

Bishop, J.L. and Verleger, M.A. (2013), "The flipped classroom: A survey of the research", in *Proceedings of the ASEE2013 Conference of the American Society for Engineering Education*, ASEE, Washington, DC, pp. 23.1200.1-23.1200.18.

Bozeman, B. and Corley, E. (2004), "Scientists' collaboration strategies: Implications for scientific and technical human capital", *Research Policy*, Vol. 33 No. 4, pp. 599-616.

Bruns, H.C. (2013), "Working alone together: Coordination in collaboration across domains of expertise", *Academy of Management Journal*, Vol. 56 No. 1, pp. 62-83.

Chompalov, I., Genuth, J. and Shrum, W. (2002), "The organization of scientific collaborations", *Research Policy*, Vol. 31 No. 5, pp. 749-767.

Clark, H.H. and Brennan, S.E. (1991), "Grounding in communication", in Resnick, L.B., Levine, J.M. and Teasley, S.D. (Eds.), *Perspectives on Socially Shared Cognition*, APA, Washington, DC, pp. 127-149.

Cramton, C.D. (2001), "The mutual knowledge problem and its consequences for dispersed collaboration", *Organization Science*, Vol. 12 No. 3, pp. 346-371.

Cummings, J.N. and Kiesler, S. (2005), "Collaborative research across disciplinary and organizational boundaries", *Social Studies of Science*, Vol. 35 No. 5, pp. 703-722.

Cummings, J.N. and Kiesler, S. (2007), "Coordination costs and project outcomes in multi-university collaborations", *Research Policy*, Vol. 36 No. 10, pp. 1620-1634.

de Solla Price, D.J. and Beaver, D. (1966), "Collaboration in an invisible college", *American Psychologist*, Vol. 21 No. 11, pp. 1011-1018.

Finholt, T.A. (2002), "Collaboratories", *Annual Review of Information Science and Technology*, Vol. 36 No. 1, pp. 73-107.

Fussell, S.R., Kiesler, S., Setlock, L.D., Scupelli, P. and Weisband, S. (2004), "Effects of instant messaging on the management of multiple project trajectories", in *Proceedings of the CHI2004 Conference on Human Factors in Computing Systems*, ACM Press, New York, pp. 191-198.

Given, L.M. and Willson, R. (2015), "Collaboration, information seeking, and technology use: A critical examination of humanities scholars' research practices", in Hansen, P., Shah, C. and Klas, C.-P. (Eds.), *Collaborative Information Seeking: Best Practices, New Domains and New Thoughts*, Springer, Berlin, pp. 139-164.

Hara, N., Solomon, P., Kim, S.-L. and Sonnenwald, D.H. (2003), "An emerging view of scientific collaboration: Scientists' perspectives on collaboration and factors that impact collaboration", *Journal of the American Society for Information Science and Technology*, Vol. 54 No. 10, pp. 952-965.

Havemann, F., Heinz, M. and Kretschmer, H. (2006), "Collaboration and distances between German immunological institutes - A trend analysis", *Journal of Biomedical Discovery and Collaboration*, Vol. 1, article 6.

Heinze, T. and Kuhlmann, S. (2008), "Across institutional boundaries? Research collaboration in German public sector nanoscience", *Research Policy*, Vol. 37 No. 5, pp. 888-899.

Hennemann, S., Rybski, D. and Liefner, I. (2012), "The myth of global science collaboration - Collaboration patterns in epistemic communities", *Journal of Informetrics*, Vol. 6 No. 2, pp. 217-225.

Hertzum, M. (2002), "The importance of trust in software engineers' assessment and choice of information sources", *Information & Organization*, Vol. 12 No. 1, pp. 1-18.

Hertzum, M. and Pries-Heje, J. (2011), "Is minimizing interaction a solution to cultural and maturity inequality in offshore outsourcing?", in Hertzum, M. and Jørgensen, C. (Eds.), *Balancing Sourcing and Innovation in Information Systems Development*, Tapir Academic Press, Trondheim, NO, pp. 77-97.

Jarvenpaa, S.L. and Leidner, D.E. (1999), "Communication and trust in global virtual teams", *Organization Science*, Vol. 10 No. 6, pp. 791-815.

Kraut, R.E., Egido, C. and Galegher, J. (1990), "Patterns of contact and communication in scientific research collaboration", in Galegher, J., Kraut, R.E. and Egido, C. (Eds.), *Intellectual Teamwork: Social and Technological Foundations of Cooperative Work*, Erlbaum, Hillsdale, NJ, pp. 149-171.

Larivière, V., Gingras, Y., Sugimoto, C.R. and Tsou, A. (2015), "Team size matters: Collaboration and scientific impact since 1900", *Journal of the Association for Information Science and Technology*, Vol. 66 No. 7, pp. 1323-1332.

Melin, G. (2000), "Pragmatism and self-organization: Research collaboration on the individual level", *Research Policy*, Vol. 29 No. 1, pp. 31-40.

Olson, G.M. and Olson, J.S. (2000), "Distance matters", *Human-Computer Interaction*, Vol. 15 No. 2&3, pp. 139-178.

Olson, G.M., Zimmerman, A. and Bos, N. (Eds.). (2008), *Scientific collaboration on the internet*, MIT Press, Boston, MA.

Olson, J.S. and Olson, G.M. (2014), *Working together apart: Collaboration over the internet*, Morgan & Claypool, San Rafael, CA.

Pao, M.L. (1992), "Global and local collaborators: A study of scientific collaboration", *Information Processing & Management*, Vol. 28 No. 1, pp. 99-109.

Sonnenwald, D.H. (2004), "Managing cognitive and affective trust in the conceptual R&D organization", in Huotari, M.-L. and Iivonen, M. (Eds.), *Trust in Knowledge Management and Systems in Organizations*, IGI Publishing, Hershey, PA, pp. 82-106.

Sonnenwald, D.H. (2007), "Scientific collaboration", *Annual Review of Information Science and Technology*, Vol. 41 No. 1, pp. 643-681.

Star, S.L. and Ruhleder, K. (1996), "Steps toward an ecology of infrastructure: Design and access for large information spaces", *Information Systems Research*, Vol. 7 No. 1, pp. 111-134.

Stokols, D., Hall, K.L., Taylor, B.K. and Moser, R.P. (2008a), "The science of team science: Overview of the field and introduction to the supplement", *American Journal of Preventive Medicine*, Vol. 35 No. 2, pp. S77-S89.

Stokols, D., Misra, S., Moser, R.P., Hall, K.L. and Taylor, B.K. (2008b), "The ecology of team science: Understanding contextual influences on transdisciplinary collaboration", *American Journal of Preventive Medicine*, Vol. 35 No. 2, pp. S96-S115.

Thomas, R.C. (1998), *Long term human-computer interaction: An exploratory perspective*, Springer, London.

Thorsteinsdottir, O.H. (2000), "External research collaboration in two small science systems", *Scientometrics*, Vol. 49 No. 1, pp. 145-160.

Trevino, L.K., Lengel, R.H. and Daft, R.L. (1987), "Media symbolism, media richness, and media choice in organizations: A symbolic interactionist perspective", *Communication Research*, Vol. 14 No. 5, pp. 553-574.

van Rijnsoever, F.J., Hessels, L.K. and Vanderberg, R.L.J. (2008), "A resource-based view on the interactions of university researchers", *Research Policy*, Vol. 37 No. 8, pp. 1255-1266.

Vasileiadou, E. (2012), "Research teams as complex systems: Implications for knowledge management", *Knowledge Management Research & Practice*, Vol. 10 No. 2, pp. 118-127.

Verouden, N.W., van der Sanden, M.C.A. and Aarts, N. (2016), "Silence in interdisciplinary research collaboration: Not everything said is relevant, not everything relevant is said", *Science as Culture*, Vol. 25 No. 4, pp. 264-288.

Walsh, J.P. and Maloney, N.G. (2007), "Collaboration structure, communication media, and problems in scientific work", *Journal of Computer-Mediated Communication*, Vol. 12 No. 2, pp. 712-732.

Wray, K.B. (1996), "Scientific authorship in the age of collaborative research", *Studies in History and Philosophy of Science Part A*, Vol. 37 No. 3, pp. 505-514.