Open Covid-19: Organizing an extreme crowdsourcing campaign to tackle grand challenges

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This article presents an extreme crowdsourcing case to tackle grand challenges such as Covid-19. Researchers became more interested in crowds’ involvement to deal with grand challenges and scholars reported the use of crowdsourcing in producing innovative solutions to solve these challenges. Driven by recent calls for more research to examine forms of socially motivated interaction options in order to support crowds in dealing with these ill-defined problems, this research conducts a qualitative study of how an extreme crowdsourcing program – Open Covid-19 launched by Just One Giant Lab to develop and test low-cost solutions to tackle the pandemic – was organized. By examining conditions for coordination and knowledge exchange in the Open Covid-19 case, we present an open structure where the challenges of predictability and common understanding have to be managed continuously and the participants themselves gradually build accountability; multidisciplinary knowledge integration is achieved by exchanging efforts and skills, and extreme transparency contributes positively in building a collective project memory. These findings are theoretically important because they clarify how extreme crowdsourcing can be organized to deal with grand challenges.

1. Introduction

This research investigates how extreme crowdsourcing can accelerate progress on grand challenges such as Covid-19. By extreme crowdsourcing, we define crowdsourcing where participants collaboratively contribute to problem definition, data collection and analysis, interpretation, and knowledge development (Franzoni and Sauermann, 2014).

In recent years, management scholars have joined the effort to understand and tackle grand challenges (Eisenhardt et al., 2016; George et al., 2016). Grand challenges are characterized as complex, uncertain, and evaluative (Ferraro et al., 2015). The Covid-19 crisis is not simply the latest addition to this list but is interconnected with other challenges, such as sustainable growth and health. Covid-19 has triggered a global health crisis, whose direct impact is exacerbated by its wider social impact on local communities and the global economy. The Covid-19 outcomes are difficult to predict and society faces a high level of uncertainty when it comes to identifying plausible scenarios.

People often perceive grand challenges as wicked because the problems are ill-defined and the characteristics of solutions are unknown (Majchrzak et al., 2020). As Majchrzak et al. (2020) pointed out, these problems are so ill-structured that one cannot easily turn them into structured problems or decompose them into a more solvable problem. To deal with the grand challenges, society and organizations cannot depend on any individual organization (Randhawa et
Researchers become more interested in crowds’ and communities’ involvement to deal with wicked problems (Afuah and Tucci, 2012). Extreme crowdsourcing differs from well-structured broadcast search in that broadcast search entails crowd members providing solutions independently to address a well-formulated problem (Afuah and Tucci, 2012), while extreme crowdsourcing entails ill-defined problems requiring an interactive approach. Traditional crowdsourcing does not integrate multiple perspectives needed to address the various issues to ensure both novelty and usefulness (Majchrzak and Malhotra, 2013; Piezunka and Dahlander, 2015). Sun et al. (2020) indicate that developing a novel and useful solution requires that participants not simply share their ideas, but incorporate the knowledge of others to formulate comprehensive solutions (Füller et al., 2014). The authors call for more research to examine forms of socially motivated interaction options to support crowds in dealing with the ill-defined problems (Viscusi and Tucci, 2018; Malhotra and Majchrzak, 2019; Porter et al., 2020; Sun et al., 2020). Furthermore, Dickel and Franzen (2016) argue that the individuals or organizations running these extreme crowdsourcing projects have a limited understanding of the types of coordination that are needed when multidisciplinary contributions are at stake. We know little about how these extreme crowdsourcing programs should be organized to tackle grand challenges such as Covid-19.

To explore this gap, we conducted a qualitative study of an extreme crowdsourcing initiative that aims to develop low-cost, open-source solutions to combat the virus – Open Covid-19. On March 1, 2020, a community of biologists, developers, and data scientists – Just One Giant Lab (JOGL) launched the Open Covid-19 project. JOGL is a collaborative open platform aimed at designing a virtual, open, and distributed research institute to develop solutions in order to meet the Sustainable Development Goals (SDGs) defined by the United Nations. With the spread of Covid-19, the team decided to launch Open Covid-19. Within only 1 month, there were over 60,000 visitors from 183 countries, including 3,000 active contributors generating more than 90 projects ranging from mask designs to low-cost ventilator prototypes and cough-classification artificial intelligence apps. JOGL presents a case of extreme open crowdsourcing: Solvers collaborate openly, can join at any time, contribute with projects, skills, and resources, and have access to all the projects and ongoing conversations.

Given the exploratory nature of this study to describe the coordination mechanisms in multidisciplinary open science initiatives, we adopted a digital ethnography method (Kozinets, 2010) based on nonintrusive virtual participant observation of Open Covid-19 where the researcher limited herself to observing the community’s interactions (Caliandro, 2014) during 5 months since the beginning of the program.

Our analysis resulted in a new theoretical understanding of organizing extreme crowdsourcing challenges. Especially, we shed light on both emergent coordination and open and efficient knowledge exchange mechanisms necessary to develop high-quality team products (Montoya-Weiss et al., 2001) in extremely open settings. First, for individuals to produce a collective performance, organizational arrangements should integrate conditions of accountability, predictability, and common understanding (Okhuysen and Bechky, 2009). We present an open structure where onboarding and building a common understanding play an important role in transforming outsiders into insiders at least temporarily, thereby allowing them to assimilate the produced knowledge. Furthermore, predictability is built gradually through familiarity with the platform and its features, such as skills, needs, and the onboarding page. In fact, platform participatory architecture in itself helps improve the initiative’s predictability. Coordination through a hierarchy is not feasible. We observe that the urgency of the pandemic itself, together with the incorporated platform features, helped participants develop a form of self-accountability. Second, we show that multidisciplinary knowledge integration can be achieved by exchanging efforts and skills, and extreme transparency allows to contribute to the collective project memory (Von Krogh et al., 2003). These findings are theoretically important because they clarify how one can organize extreme crowdsourcing to tackle grand challenges. This study responds to recent calls for more research on socially motivated interaction options to support crowds in dealing with these ill-defined problems (Majchrzak et al., 2020; Sun et al., 2020). The results are of practical relevance for organizations and individuals seeking to deal with grand challenges by using open forms of organizing.

2. Background and literature review

2.1. Dealing with grand challenges

George et al. define grand challenges as global problems that are only effectively addressed through
a coordinated and collaborative effort (George et al., 2016). These challenges are highly significant, require technical and societal components to deal with them (Eisenhardt et al., 2016), and involve a range of actors inside and outside the organization (Voegtlin and Scherer, 2017). There are many organizational constraints placed on actions that are taken to address grand challenges, such as coordination and transaction costs between the different parties involved, expectations and incentives for the managing teams, and information asymmetry (George et al., 2016). Grand challenges are subject to enormous complexity because of the many interactions and nonlinear relations, and the outcomes and problem spaces are highly uncertain (Ferraro et al., 2015). Working on grand challenges involves collaboration on complex questions that require multidisciplinary contributions (Sun et al., 2020). Participants generally belong to different communities with different practices and approaches. Therefore, the collaboration needs to evolve and includes new contributors who may introduce new skills and data into an open and complex research design (Van Rijnsoever and Hessels, 2011; König et al., 2013). When crowdsourcing platforms consider more complex questions, open knowledge sharing within the scientific community appears to be highly beneficial (Friesike and Schildhauer, 2015).

Grand challenges usually require going far beyond the span of formal organizational control where clear hierarchy is absent, making typical top-down approaches to management ineffective in resolving these problems. Owing to the limits of top-down approaches, academics turn to alternative forms of organizing, such as crowdsourcing, open innovation, or communities.

2.2. Governance and coordination mechanisms in extreme crowdsourcing projects

The research community has shown a growing interest in open innovation, crowdsourcing, and communities as tools to help solve grand global challenges (see, for instance, Ahn et al., 2019; Kohler and Chesbrough, 2019; Sims et al., 2019; Smart et al., 2019). In these initiatives, participants solve problems without prior contracts and predefined expectations of who will solve which problem, openly deciding whether they will join and what they will contribute (Afuah and Tucci, 2012; Viscusi and Tucci, 2018). Participants are mainly volunteers collaborating for a short period of time for a particular purpose (O’Mahony and Ferraro, 2007). Participants work in a context where interactive interpersonal richness, explicit commitment mechanisms, and management oversight are absent at the beginning. Therefore, the minimal conditions for collaboration and team effort toward a collective goal appear sparse and highly risky (Malhotra and Majchrzak, 2019). Despite these issues, it becomes increasingly common to observe large-scale mobilization of participants in these settings (O’Mahony and Ferraro, 2007; Faraj et al., 2011).

To deal with grand challenges, a higher level of collaboration is helpful (Riedl and Woolley, 2017). For crowds to incorporate others’ knowledge and perspectives, a number of studies reported cases where organizers asked crowds to form teams and to solve the problem through extensive synchronous interactions (ibid). More collaborative crowdsourcing requires a different approach to coordination and governance and expands the advantages of teamwork observed in traditional settings and communities (Riedl and Woolley, 2017).

One can define governance as a process of social organization and coordination, and define coordination as a process of interaction that integrates a collective set of interdependent tasks. Governance and coordination is a central purpose of organizations (Okhuysen and Bechky, 2009; Jarzabkowski et al., 2012). Coordination mechanisms, such as plans and rules, objects’ and representations’ roles, routines, and proximity, contribute to establish coordinated activity through accountability, predictability, and common understanding (Okhuysen and Bechky, 2009). In situations requiring coordination, combinations of all three characteristics are observed and support each other (ibid). For instance, prior research argues that teams with a high degree of common understanding and accountability perform more effectively (Reagans et al., 2005; Edmondson et al., 2001) and that accountability ensures better predictability (Okhuysen and Bechky, 2009).

When it comes to online communities, prior research studied their formal control structures (Füller et al., 2014) including norms (Bagozzi and Dholakia, 2006), task modularization (MacCormack et al., 2006), organizational hierarchy, and formal leadership (O’Mahony and Ferraro, 2007). While communities vary in both form and function, all communities rely on shared authority and participation, informal relationships, and egalitarian norms (Rothschild-Whitt, 1979). They have voluntary membership and meritocratic governance processes that allow participants to seek and obtain leadership roles (Lee and Cole, 2003). In all communities, participation is crucial for value creation, as it enables,
Prior research has explored how communities can be used to deal with grand challenges. In a study of 245 US communities, Berrone et al. (2016) report the need to deal with issues of competition, institutional alignment, and community support. Sims et al. (2019) presented a case where community founders’ vision, extrinsic motivation, and community governance facilitate the growth of an open-source community that aims to tackle a grand challenge. Still, the members of communities share a common identity and a sense of belonging (Von Hippel, 2007); communities often control what they produce – such as software in the case of open-source software communities – which affects the degree of transparency that enables community participants to follow the community’s collective process of development and the participants’ contribution to code development (West and O’Mahony, 2008).

When it comes to extreme crowdsourcing, work arrangements and boundaries are different and centralized structures are absent. In extreme crowdsourcing, crowds contribute to problem definition, data collection and analysis, and to interpretation and knowledge development (Franzoni and Sauermann, 2014). If, in communities, participants often share common beliefs, have social ties, and so forth, and therefore, benefit from higher transparency since the beginning, crowds do not share interpersonal ties, which might result in limited openness (2018).

A particularity of crowdsourcing initiatives is the extent to which collaboration emerges from sophisticated team processes that evolve organically instead of platform owners or community managers organizing direct architecting, governance, or ordering (Boudreau and Hagiu, 2009). Academics have referred to this process as emergent interdependence in research on more traditional teams (Wageman and Gordon, 2005) where individuals have a certain level of autonomy in influencing the intensity of an interaction as is very much the case in voluntaristic collaborations on permeable online platforms. Majchrzak and Malhotra (2016) indicate that with online crowds, formal control structures that govern how knowledge is shared should be minimized. Yet, we know little about how coordination and knowledge sharing should be organized in extreme crowdsourcing when multidisciplinary contributions occur (Dickel and Franzen 2016). Our research question is: Which coordination mechanisms facilitate the work of extreme crowdsourcing projects that deal with grand challenges like Covid-19?

3. Method and data

Given the exploratory nature of this study on how extreme crowdsourcing should be organized to deal with grand challenges, we adopted a digital ethnography method (Murthy, 2008; Kozinets, 2010) based on nonintrusive virtual participant observation of the Open Covid-19 initiative where the researcher limited herself to observing the community’s interactions (Caliandro, 2014). As Kozinets (2010) indicated, digital ethnography is relevant for human understanding in social technological interaction. Digital ethnography requires interpretation of human communications under realistic contexts in native conditions of interaction, when new technologies and tools shape those human communications. A grounded approach allows us to examine the case in its natural setting and is relevant because our goal is to gain insights about the coordination of such initiatives rather than validate hypotheses.

3.1. Research setting

With the spread of Covid-19, JOGL decided to launch an Open Covid-19 initiative resulting in more than more than 90 projects proposed. The first project, sought to develop an open-source methodology to test for the presence of SARS-CoV-2, the virus that causes Covid-19, by using tools that are as common and open as possible. This first project was initiated by one of JOGL’s cofounders, who is based in France, in collaboration with an MIT Media Lab scientist and a data scientist from SoundBio Lab, both of whom are located in the United States. From Day 1, they aimed for global collaboration. As one of the JOGL founders put it: ‘When the first project related to Covid-19—a low-cost, open-source diagnostic test—was born in early March, there was a rush on the platform. The number of contributions per minute kept increasing: hundreds of interactions, project creation, communications ... So much so that the server hosting the platform couldn’t hold it anymore!’ (source: platform).

The team organized the program across five challenges (see Table 1). All of these challenges are still open as of September 2020. Table 1 provides an overview of the number of: projects submitted, members, needs indicated, and claps received. The program’s objective was to develop alternative designs for the equipment, to test and manufacture them by building a community of partners, and to share resources in order to provide complimentary R&D support. JOGL...
presents a case of extreme open crowdsourcing: Solvers collaborate openly and can join at any time. JOGL is a platform of full disclosure where results are documented openly and shared with anyone. This case is relevant to study the coordination of extreme crowdsourcing for grand challenges.

3.2. Data collection and analysis

The researcher collected data through virtual community observation combined with secondary data collection on the platform and connected tools that the community used, including Slack, Facebook, Twitter, and Medium over 5 months (March 2020–August 2020) (see Table 2). She joined or watched recordings of all the community calls, analyzed data from the communication channels, project descriptions, and tutorials, and collected communications on media channels.

In alignment with the study’s inductive nature, I followed a bottom-up approach when analyzing the data. Rather than trying to fit the data into any pre-existing framework, I coded the collected material openly. I thereby relied on a thematic coding procedure to identify, analyze, and report emerging themes from our data, acknowledging the data’s contextual focus (see Table 3). A theme thereby represents a pattern in the data that captures relevant elements of the response to the research question. In this context, the emerging themes are the set of coordination principles and knowledge exchange mechanisms. The themes emerged through a multistep process (Charmaz, 1996), starting with an initial coding phase in which I tried to identify coordination mechanisms (evident in team members’ contributions) and the quality of the interaction between participants (information they share with each other, formats, etc.). Throughout this process, I iterated between the data and memo writing about emerging ideas. Furthermore, at this stage, I also compared the data with prior literature to iteratively develop and organize the results. Finally, I shared my observations with two of the JOGL platform’s founders to further refine and complement the data.

4. Findings

4.1. Emergent coordination: building common understanding, improving predictability, and gradually building self-accountability

During the first Zoom call to announce the challenge, one of the founders argued that the
Organizing an extreme crowdsourcing campaign

Table 2. Data collected

| Data sources | Description |
|--------------|-------------|
| JOGL platform; different articles in the media | Open JOGL platform—access to projects, members, archives, etc.; observations for a period of March-September 2020; Documents shared by coordinators and community members |
| JOGL Slack | Community discussions on the platform |
| JOGL Facebook page | Group posts, discussion |
| Video recording | 31 video recordings: 21 weekly community calls + JOGL live videos |
| JOGL Twitter | 1,331 tweets |
| JOGL medium account | 10 articles |
| Articles published by various media sources on the Open Covid-19 initiatives | 15 different articles collected |

Table 3. Data structure

| First-order categories | Second-order themes | Aggregated dimensions |
|------------------------|---------------------|-----------------------|
| • Possibility to join any time: “a program to collectively develop open-source and low-cost tools and methodologies that are safe and easy to use to fight the COVID-19 pandemic. Anyone can play a role”: “We can all contribute” |
| • “Community members can join a team and contribute to building solutions and coordinate the initiatives as a member of any of the committees, such as governance, operations, communications, onboarding” |
| • Onboarding page with a summary of projects, needs, members; “Get started” and “Learn more” latest announcements; Overview of active challenges |
| • Members’ page with a possibility to “Follow” any of the community members with an overview of their skills, resources, interest in particular Sustainable Development Goals (SDGs) and their involvement in projects |
| • Praising other members with “Clap to any message” |
| • Triage system to help participants navigate through the program |
| • Possibility to share specific needs on the platform; indicate skills that participants can donate and resources (i.e., “I need data collection skills to answer a few questions on this project. If you think you can help in this area!”) |
| • Global Community Calls each Wednesday to update the community and share direction (thus far, 21 calls were organized and recorded) |
| • Shared agenda for call: Google Doc where participants can add items they want to discuss during the community calls |
| • Access recordings of all community calls (even for non-members) |
| • Tracking task completions |
| • Monitoring Slack channels |
| • An onboarding Google Doc with the outline of the goal, processes (continuously updated by everyone)—living memory of the project |
| • Structured FAQs on the platform website |
| • Guidelines with the introduction to the platform and various tools and resources, tips on how to use different Slack channels, and what their purpose is |
| • A regular snapshot of all activities by the coordination team |
| • Possibility to see how expressed needs match your skills |
| • Share the need or click on “I’ll help” |
| • A member profile with an overview of activities and projects involved |
| • Respect the bioethical and scientific guidelines of good conduct |
| • Coordination team monitored the evolution and the program’s overall progress |
| • Shared Google Docs for things that need to be improved |
| • Trello to monitor task completion for the coordination team |
| • Participants to become different committees’ members if interested |

‘community approach is faster and cheaper; we can learn from it, and it’s fun’ (source: Zoom call){-}
initiation). Participants could join at any time: ‘Community members can join a team and contribute to building solutions and coordinate the initiatives as a member of any of the committees, such as governance, operations, communications, onboarding’ (source: Onboarding page). The coordinators developed a triage system to help participants save time when seeking relevant resources or communication channels. This system was built to ask participants whether they had an idea, a project, skills, or resources to contribute. In particular, people who did not have a precise project, could join by indicating what skills they can contribute to the program (i.e., data visualization, expertise in public health, see Figure 1) and how much time they are willing to donate; they could also help review projects or just be mentors. Team members could share their specific needs on the platform. For every need listed, participants could indicate how urgent it was, which type of skills were required. A list of people who responded to the needs and simply follow the project were accessible on the platform, thereby increasing transparency and providing a form of accountability on the part of the participants who agreed to contribute. JOGL invited people with resources to be partners or help with specific requests. Interestingly, for the people who did not fit any of the categories mentioned above, they added a final triage category – ‘I am still lost’ – that directed people to specific Slack channels to find assistance. This triage system helped gain a better understanding of the community.

To facilitate asynchronous onboarding, JOGL created a landing page with an overview of needs and members; this landing page has ‘Get started’ and ‘Learn more’ links as well as latest announcements and an overview of active challenges. To help participants grasp what happens, organizers developed additional guidelines on how to join the community, such as an onboarding Google Doc, frequently asked questions (FAQs), guidelines with the introduction to the platform, various tools and resources, and tips on how to use different Slack channels. Participants could update these documents and add their reflections.

The team sought to ensure predictability for participants by organizing weekly calls with the community, tracking task completions, and monitoring Slack channels and requests received. The global community calls were organized each Wednesday to
update the community and discuss any challenges. Recordings were openly available and the agenda for these calls were open to participants, if they wanted to share their progress or ask the community for help. The platform itself gradually became a source of predictability for participants. As one of the participants highlighted: ‘I appreciated that Open Covid-19 had a clear structure in place, with onboarding support, weekly check-ins with the community, and clearly defined channels of support. This, I think, freed up people’s time to focus on creating solutions’ (source: participant comment).

As in other open systems, JOGL does not have any compliance and sanction mechanisms. The only requirement for participants is to respect the ethical and scientific guidelines of good conduct. To ensure that participants follow these guidelines, the Open Covid-19 Biosafety Advisory Board was formed, comprising a group of biosafety experts, experienced community lab members, and researchers volunteering their time to help ensure participants engaged in safe science. No incidents concerning disrespectful behavior have been reported to date. However, given the open and voluntary nature of the project, it is difficult to ensure that the communities are accountable – and yet, the global nature of the challenge and its consequences somehow pushed participants to be accountable and deliver on what they had committed to.

Given the program’s extreme openness, the coordination team experimented to find the best means to manage an open and inclusive program. The team monitored community evolution and the program’s overall progress in real time. The goal was to make the

![Figure 1. Map of shared skills across Open Covid-19 initiative (source: JOGL community).](image-url)
role of the platform, regardless of which page people land on. The organizers constantly observed which features did or did not work and documented them in a shared Google Doc. They integrated this Google Doc with JOGL’s platform to keep track of participants who added the entry. There were votes to decide whether the entry should be implemented or not. The team tracked task completion and they documented all the changes to manage accountability and ensure predictability for the community.

4.2. Open knowledge exchange: developing a Wikipedia of R&D

JOGL formulated the scope of the Open Covid-19 as ‘a program to collectively develop open-source and low-cost tools and methodologies that are safe and easy to use to fight the COVID-19 pandemic. Anyone can play a role!’ (source: platform). Organizers focused specifically on ensuring multidisciplinary knowledge integration. JOGL supports participants in using their differences to articulate complex problems utilizing the projects’ needs, the resources that are required, and the skills they can donate. This was particularly helpful, given the multidisciplinary skills of the participants who joined the program (see Figure 1).

The organizers encouraged anyone with an idea to explore projects others had posted to establish whether it was better to join projects that explore a similar idea or whether it was better to create a project by themselves. This step raised awareness of what was happening on the platform and created synergies instead of promoting separate ideas. With a project in mind, the person could ask for resources and collaboration, engage more users, or ask for funding. This allowed participants to exchange their efforts without committing directly to the entire project, or for project leaders to have flexible teams where members can contribute punctually with their skills to several projects.

For each challenge, participants could subscribe to receive news and updates about the projects that had been posted. Needs function helped to manage different requests for help: For example, ‘Currently we only have a very simple data visualization showing the wearable signals for a single user and sickness incidence over time. To make full use of the data we collect, we would need more visualizations, including (1) a user’s symptom reports over time, (2) symptom reports alongside the wearable sensor data, and (3) individual data sets compared with the background frequencies of all other users’, or ‘to help build an API to make public data visible’ (source: platform).

One of the challenges of crowdsourcing campaigns is the appropriation of the results. To deal with this challenge, the team created a partnership with the Paris Hospital Network (APHP) representing 39 hospitals in the Paris Region. This partnership led to a validation challenge entirely aimed at hospital staff evaluating and validating open-source solutions. As one of the founders mentioned: ‘What surprised us was the willingness of large institutions to trust initiatives like ours in a time of crisis and to try to establish partnerships with us to strengthen the community effort’ (source: Creative commons interview).

Furthermore, JOGL was able to partner with the French multinational insurance company – AXA and added a feature to apply for a project review in order to receive up to EUR 3,000 in micro-grants. Every project could apply for a micro-grant to support the project’s development. A community of experts organized several rounds to review these projects. The team organized these reviews as transparently as possible and evaluated the projects based on their feasibility and potential impact. The team members excluded all projects that were not in R&D but already in the production phase or not novel enough. They awarded all the projects in green (see Figure 2).

In addition to directing certain of the results appropriation, the team facilitated the creation of the project’s collective memory (Open Lab notebook) where each project is documented online, openly accessible to anyone. Given the program’s extreme openness, the team sought to capitalize on the knowledge produced and shared. As one of the founders pointed out: ‘We are a Wikipedia of R&D in a sense, since everything produced on JOGL then goes into the public domain’ (source: Founder’s interview). The initiative produced an open database of knowledge, which can serve as a basis for combating future epidemics as well.

Finally, the projects did not have to be exclusive to the Open Covid-19 challenge and the team encouraged collaboration with other communities: ‘I think communities can only be successful if they operate in partnership or in conjunction with other communities. If they just operate in a silo, there’s no hope’ (source: participant comment). For instance, teams were encouraged to apply for the XPRIZE competition and four Open Covid-19 teams were selected among the semifinalists. As a Sri Lankan team developing an open-source SARS-CoV-2 detection method – CoronaHunter – indicated: ‘Initiatives such as Open Covid-19 have opened several doors with infinite possibilities, especially for the organizations and communities in the Global South. Such
decentralized scientific cooperation has taught us to create local innovations for local problems with global support’.

5. Discussion and contribution

This research sheds light on how extreme crowdsourcing can be used to deal with grand societal challenges. We frame the crowdsourcing as extreme because the participants belong to very different epistemic communities, they had different levels of expertise regarding Covid-19 (see Figure 1), and they contribute across all stages of knowledge exploration (Franzoni and Sauermann, 2014). The interest in using crowdsourcing to deal with societal challenges, including nonprofit and social innovation aspects, is growing (Holmes and Smart, 2009; Chesbrough and Di Minin, 2014). Still, prior research mostly examined how crowds contribute to simple, well-defined tasks or to a restricted part of the exploration process where broadcasted search is possible (Afuah and Tucci, 2012). Broader involvement in the co-creation might yield more novel and practical results. However, those running crowdsourcing projects have a limited understanding of the types of coordination required when multidisciplinary contributions are at stake (Scherer et al., 2013; Sun et al., 2020). In order to fill this gap, this research examined the organization of an extreme crowdsourcing program.

Our empirical investigation of the Open Covid-19 crowdsourcing program allowed us to reveal the mechanisms the coordination team put in place as a result of dealing with extreme openness. We discuss our contributions along two dimensions: emergent coordination and knowledge exchange (see Table 4).

First, we observe how the team gradually developed the coordination of the crowdsourcing program (see Table 4). Majchrzak and Malhotra (2016) indicate that formal control structures governing how crowds share knowledge should be minimized. In our case, the platform that facilitates participants’ onboarding does not control but guide knowledge sharing, thereby allowing participants from different fields and expertise to engage constructively over time. These self-styled participatory architectures allow to establish an even playing field (Ferraro et al., 2015) where different perspectives can be heard supporting participants in articulating their ideas and needs. Furthermore, the structure appears to be highly adaptive and members can learn how to interpret leadership and authority in a context (West and O’Mahony, 2008). In order to adjust coordination principles for the crowds, the coordination team flexibly monitored activities on the platform. This combination of iterative actions and learning, sometimes referred to as distributed experimentation (Ferraro et al., 2015), allow to constantly learn and adjust in order to mirror the nature of the problem and the needs of the community, and is critical when dealing with grand challenges like Covid-19.

Okhuysen and Bechky (2009) demonstrated that accountability, predictability, and common understanding enable coordinated activity. In this study,
we present emergent coordination rooted in continuous efforts by the coordination team on embedding and improving predictability for participants. Particularly, the triage system helps participants navigate the challenge, onboard participants from different backgrounds, and allow them contribute. The parties involved reach a mutual understanding when the actors develop a shared perspective of the project’s goals and outputs. To ensure the mutual understanding, the coordination team put together several documents to explain the role of the platforms and other open-source tools used; the community’s role was to regularly create a snapshot of overall activities. Prior research suggested that the open disclosure of intermediate results provides a collective memory of the project and helps individuals join the project at any stage (Von Krogh et al., 2003; Franzoni and Sauermann, 2014), leading to increased transparency and building a collective repertoire of knowledge (Puranam et al., 2006). Our research demonstrates that in extreme crowdsourcing, the challenges of predictability and mutual understanding have to be managed continuously and that participants themselves gradually build accountability. Platform features where participants indicate their interest and participation in projects, thereby donating their skills, help create a sense of accountability.

Second, ensuring open and efficient knowledge exchange and appropriation is crucial to support participants in using their differences to articulate and solve problems. Developing a novel and useful solution requires incorporating the knowledge from multiple perspectives and helping translate it into comprehensive solutions (Füller et al., 2014). This often comes as a challenge. In this case, the coordination team and the platform function as knowledge orchestrators to capitalize on participants’ inputs. The team members tasked with managing committees, gradually become knowledge orchestrators too. In extreme crowdsourcing, members can join and leave the crowd frequently over time (Dahlander and Frederiksen, 2012), resulting in misalignments in goals, lost efforts. By donating skills and responding to particular needs and not committing directly to the entire project helped participants to engage in a more meaningful and manageable knowledge exchange.

The research presented here examined a platform that led not only to better engagement and the ability to verify the results, but also to the reuse of knowledge produced in order to continue working on the grand challenge-related issues. An open knowledge repository allow for open and guided access to this knowledge. Finally, we observed that certain forms of closure make extreme openness more efficient. In particular, a coordination team strategizing around knowledge capitalization does not affect open participation but drives the result-oriented nature of the project.

These findings are theoretically important because they illuminate how extreme crowdsourcing can be organized to tackle grand challenges and respond to recent calls for more research on socially motivated interaction options to support crowds in developing ideas collaboratively (Scherer et al., 2013; Sun et al., 2020). Particularly, we shed light on both emergent coordination as well as open and efficient knowledge exchange mechanisms necessary to develop a high-quality team product (Montoya-Weiss et al., 2001; Wuchty et al., 2007).

Table 4. Overview of the results

| Organizing extreme crowdsourcing for grand challenges | Platform features |
|------------------------------------------------------|-------------------|
| Emergent coordination                                |                   |
| • Facilitate onboarding and orientation of voluntary participants | • Triage system |
| • Continuously embedding and improving predictability for participants | • Onboarding page, Guidelines, FAQs |
| • Collective building of common understanding        | • Responding to different needs online (“I’ll help”), following projects, adding claps to praise the effort and promote projects |
| • Gradual self-accountability                        | • Skills – needs matching |
| • Continuous experimentation                         | • Google docs to document ideas for potential improvements |
| Open knowledge exchange                              |                   |
| • Multidisciplinary knowledge integration            | • Needs, resources, and skills embedded in the platform to facilitate the integration |
| • Engaging in exchanging efforts and not committing directly to the entire project | • Matching skills and needs on the platform |
| • Extreme transparency in knowledge produced and targeted knowledge capitalization | • Open lab notebook for anyone to access and use |
| • Facilitated and open translation/appropriation of the results | • Dedicated challenge for appropriation |
5.1. Practical implications

Crowdsourcing initiatives like Open Covid-19 play an important role in establishing effective methods of knowledge transfer between R&D organizations seeking to address grand challenges using nontraditional organizational settings. Crowdsourcing is not organized around specific questions and projects but around challenges that require collective exploration and problem reframing when solutions are unknown.

With an increasing amount of crowd-based initiatives aiming to deal with complex societal challenges, our research provides guidelines on how these stakeholders should choose or design platforms to leverage crowd participation based on their expectations. Coordination mechanisms suggested help account for better crowds involvement in understanding grand challenges and contributing with creating shared knowledge.

This research provides implications for funding agencies that can view extreme crowdsourcing as a sustainable means to deal with grand challenges. In particular, mobilizing participants globally at the early R&D stages helps understand grand challenges from multiple perspectives and identify related issues and interesting approaches to advance our understanding of current and potential future pandemics.

5.2. Limitations and future research directions

Our findings and contributions reflect limitations and boundary conditions. We have explored one case of extreme crowdsourcing for a specific grand challenge—Covid-19. We assume that other types of organizations and other types of grand challenges like sustainable development or poverty might require different coordination and knowledge exchange mechanisms to improve the quality of collaborative research due to the nature of the problem, the level of knowledge available publicly to understand the challenge and stakeholders involved. These factors might result in higher entry barriers for participants requiring them to assimilate prior knowledge.

We suggest further studies using nontraditional organizational forms to deal with grand challenges in different settings. Such studies could extend our understanding of conditions, processes, and mechanisms to deal with grand challenges.

When it comes to crowdsourcing challenges for societal purposes, funding and durability issues appear to be a major concern. Solving grand challenges require funding on a multiple year basis. Future research in this area needs to investigate financial schemes for extreme crowdsourcing initiatives in case of complex challenges. Furthermore, the constant inflow and outflow of participants, reflecting a natural volunteering cycle where people cannot engage on a permanent basis, need to be managed.

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