Collective Intelligence, Crowd Dynamics, and Co-Creation: preliminary insights from a Case Study in Robotics Innovation Facilities (RIFs)

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Abstract

This article investigates crowd dynamics in co-creation settings. In particular, it aims to provide an understanding of how those dynamics eventually shape collective intelligence in co-creation activities, either enabling or bounding their capacity of scaling. Furthermore, different value perspectives are questioned through the shapes that co-creation practices may assume once moving from local groups and communities to a population assuming the dimension of the crowd. Thus, the article aims to contribute to the research on cooperative strategies involving users as innovators, with a specific focus on high tech industries and co-creation in experimental settings, suitable to lead to innovation related to emergent technologies. To this end, the article considers the early insights from the specific case of a robotics innovation facility based in Italy, where an ethnography has been carried out in 2018-2019 and presents the results from an early analysis of the data.

Keywords [1]

Collective intelligence, crowd-driven innovation, co-creation, robotics.

1. Introduction

This article studies crowd dynamics in co-creation settings. The aim is to provide an understanding of how those dynamics eventually shape collective intelligence [1], [2] in co-creation activities, either enabling or bounding their capacity of scaling. Furthermore, different value perspectives are questioned through the shapes that co-creation practices may assume once moving from local groups and communities to a population assuming the dimension of the anonymous crowd. Thus, the article aims to contribute to the research on cooperative strategies involving users as innovators, with a specific focus on high tech industries and co-creation in experimental settings suitable to lead to innovation related to emergent technologies. In particular, this article presents a set of early insights from an exploratory case study on robotics innovation facilities. To this end, the article considers the specific case of a robotics innovation facility based in Italy, where an ethnography has been carried out in 2018-2019. The theoretical argument is empirically developed through the analysis of the early data from the case of a Robotics Innovation Facility (RIF) based in Tuscany, Italy, in the town of Peccioli. The RIF is one of three similar initiatives funded by the European project ECHORD++ (The European Coordination Hub for Open Robotics Development) [3] to provide access to businesses as well as a general audience to high-tech equipment and expertise, thus eventually promoting and enabling co-creation in robotics. Those facilities are laboratories with a specific configuration of open physical or virtual infrastructures for collective efforts of ideation, invention, research, and development innovation [4]. It is worth noting here that a RIF has a set of characteristics that are also eventually shared by living labs and testbeds [5].

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Taking those issues into account, the tension with the common-sense definition of "facility"[2] as well as the implicit dialectic with other experimental spaces (e.g., living labs or testbeds) makes "facility" worth questioning together with the crowd and co-creation mechanisms. These latter especially act when facilities scale to eventually become infrastructures [6] for the design and development of new systems, having societal impacts, such as the robotic ones [7], [8]. Consequently, the paper tries to address this specific gap through an empirical analysis of a facility for robotics innovation and its testing activities involving various kinds of crowds, thus clarifying their main characteristics and the linkages between them and crowd-driven innovation. Furthermore, the data have been analyzed also for eliciting how the different actors make sense of their participation in the facilities' activities as "organized artful practice" [9, p. 11]. Thus, the inductive and interpretive stance for the exploratory case study presented in this paper is guided by a set of general research questions: what are the characteristics of facilities compared to other testing environments? How those characteristics are configured in the case of facilities for robotics innovation? Are their users considered individually or else they form different collective units engaged in testing and experimenting with robotics innovation? How do they make sense or understand their participation in those activities? When forming a collective, how this does eventually act or impact on the outcomes of the testing and experimenting facilities?

The research is framed under the tradition of sociotechnical-design [10] for its investigation of how human factors enter the specific domain of the design and development of robotics artifacts and their consequent impact on the innovation they should introducing, e.g., in healthcare, production processes, or well-being. In the research presented in this article, specific attention is dedicated to the spaces where the design and testing of those artifacts take place, thus, particularly focusing on two of the principles of sociotechnical design stated by Cherns [11, p. 790]:

- *the principle of "boundary location"*, which in our case study aims to consider the "departmental" boundaries drawn within and by the facility, in terms of technology and territory (not considering the time dimension here) [10, p. 788];
- *the principle of "support congruence"*, which states that "the system of social support should be designed so as to reinforce the behaviors which the organization structure is designed to elicit" [10, p. 790]. This principle is relevant to understand the implications of co-creation on the alignment between the RIF management general philosophy and its actions.

Then, those two principles are especially important for the question of which values are enacted by the artifacts through the involvement of different kinds of crowds in their design and testing. Taking these issues into account, the paper is structured as follows. First, an outline of the research method followed for this study is provided. Then, a discussion presents the early results coming from the analyses carried out during and after the fieldwork before concluding remarks end the paper.

2. Method

Although the article adopts some specific lenses coming from sociotechnical tradition, its goal is not to produce an artifact, but rather to conduct interpretive research to problematize [12] the design principles coming from that tradition as also instantiated in the user-centered design perspectives adopted in robotics for the requirements engineering activities [13]–[15]. Accordingly, this article presents an exploratory interpretive case study [16], [17] that at this stage aims to provide an early understanding of the substantive domain subject of the analyses. Also, the case would eventually lead to an early conceptual description, shown in Figure 1.

Furthermore, the research at the basis of the case study has included desk research on documents and websites providing information on the RIF of Peccioli, the ECHORD++ project in general, the other related organizations, as well as memos and materials from an 11 days ethnography at the BioRobotics Institute and the Assistive Robotics lab, where the RIF is located. It is worth noting that

[2] According to what could be considered as a common-sense definition as the one by Wikipedia, a laboratory is "a facility that provides controlled conditions in which scientific or technological research, experiments, and measurement may be performed" [30]. Furthermore, a facility seems to be, on the one hand, a general "virtual" class of entities, including "laboratory" as a specific kind of facility; on the other hand, it appears as one of its many forms of "actualization" [31], thus, not strictly related to the domain of scientific research and experiments.

the days of the ethnography were distributed along with different visits from September 2018 to March 2019. Besides extended involvement and observation, 12 people have been interviewed, including post-docs working on projects at the Assistive Robotics Lab, a former Ph.D./project manager at RIF-Peccioli, senior scientists, professors at the BioRobotics Institute, its former head, and the chief executive officer (CEO) of a local firm who actively participated as project manager of the RIF, likewise.

The selection of the interviewees has started with the managers and directors of the RIF and people involved directly in the activities of the RIF within ECHORD++, then following a respondent-driven sampling. The interviews were semi-structured, whose average length was 30 minutes, resulting in nearly seven hours for transcription, including one interview of ~83 minutes with a key informant, being the former head of the Institute at the time of ECHORD++ and a key figure in the consortium of the project as well as in the substantive research area. Memos and field notes taken during the fieldwork are part of the corpus of data that have been analyzed following the sequence of open coding, selective coding, and theoretical coding of the classic or glaserian grounded theory [18]. However, it is worth noting that the research presented in this paper is not a grounded theory, but rather an interpretive case study [16] and it is the result of a first exploration of the data, where coding is still ongoing, being actually completed mainly the open coding and part of the selective coding steps.

3. The Case Study

3.1. Definition of the context

The case study considers the Robotics Innovation Facility (RIF) based in Peccioli, a small town close to Pisa (PI) in Italy. Together with Bristol in the United Kingdom and Paris-Saclay in France, this is one of the three RIFs promoted by the ECHORD++ (The European Coordination Hub for Open Robotics Development) research project, the follow-up to a former ECHORD project [19], [20]. The goal of the RIFs was the opening to businesses and interested users of labs equipped with state-of-the-art robotic hardware and software as well as scientific and technical expertise [21]. The case study also includes an analysis of the unit of The BioRobotics Institute of Scuola Superiore Sant'Anna (SSSA) based in Pontedera (PI), Italy involved in ECHORD++ (the RIF being one of its innovation services) as well as of the BioRobotics Institute's Assistive Robotics Lab located in Peccioli (PI), physically hosting the RIF.

3.2. Discussion of the preliminary insights

This Section presents the main insights from the analysis of the results of the open and selective coding activity. The results have been early interpreted through a framework adopted in a former publication co-authored by the author of this paper for mapping crowd dynamics in innovation [22].

As a preliminary remark, the RIF of Peccioli is regarded by the informants as an *"idea"* and not a specific space: "the overall BioroBotics institute" is a RIF where companies can find the expertise and spaces for their innovation needs. In general, while developed through separate silos, the different laboratories of the Institute seem to create a unified *virtual environment* in the form of a large innovation facility for businesses and society. Whereas facilities such as the above-mentioned Assistive Robotics Lab are tied to the internal *users' acquaintance* and *recognition*, the RIF is actually abstracted from the Lab situatedness for *naming* a set of functions and affordances worth promoting in the ECHORD++ project and eventually designating new potential actual instantiations for them. Thus, naming the RIF makes it virtually exist, becoming *ideally real* for the actual interactions of the ECHORD++ projects - promotional videos, tweets on Twitter, while abstracted from the local acquaintance of the place. Two entities in one.

Furthermore, the actors directly or indirectly involved in the RIF design activities, testing, and experiments include a wide range of people and organizations, spanning from local inhabitants of Peccioli and other nearby towns like Florence, local politicians (e.g. the mayor of Peccioli), spin-offs, start-ups, small and medium enterprises (e.g. a local winemaker). This diversity leads to the different types of crowds that intervene in the activities of the RIF as shown by Figure 1 with various degrees of *seriality*, here defined by the independence ad anonymity of the individuals making up the crowds. In

particular, those types span from restricted (i.e., respectively, "*crowd crystals*" as the selected groups of people involved in the design of the artifact in the "domotics" room internal to the facility, and "*closed crowds*" as, e.g., the testing set in hospitals, etc.) to unrestricted forms as the ones exhibited by "*communities*" (made up by the inhabitants of the small town close to the facility, providing the sample of users during the design phase at the facility) or "*open crowds*" (when robots are tested openly in the streets of the small town surrounding the facility). Accordingly, the diversity of crowds that intervene in the testing activities has specific effects on the "*values*" embedded in the design of the robotics products and services (through groups and local communities' sample of users) and the value (economic, public, and social) created or eventually captured through the testing and experiments on open and closed crowds, not necessarily including the same sample of users but a larger population (e.g., tourists passing through the villages where co-creation happens or people in external settings different from the rooms of the Assistive Robotics Lab).

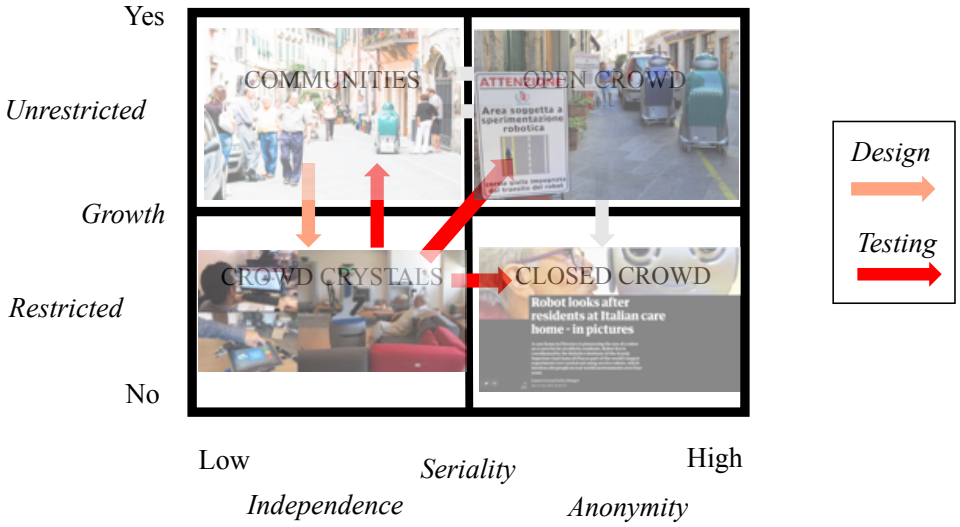

Figure 1: Crowd dynamics in the design and testing activities of the RIF, presented through the framework adapted from [22].

Consequently, the diversity in the population is also reflected in the different kinds of value created by the RIF activities. The eventual *economic value* for businesses is in the background of the general narrative promoted by the official documents, from the perspective of the high-level decision-makers and directors at the Institute as well as by researchers moved from a research staff position to a project manager role. Considering other forms of value created, *public value* is mainly exhibited by public sector stakeholders, while *social value* seems more from the side of citizens involved in the RIF experiments. However, challenges emerged, for example, during external experiments involving the mobility of robots across the streets of Peccioli for the urban characteristics of this quite typical Tuscany small venue.

Thus, the different types of value for the RIF, emergent from the case study analysis of the crowd dynamics, are shown in Figure 1, which adapts the framework proposed by [22] for tracking the movement of design and testing activities across groups as "crowd crystals"[3] [23], communities, open and closed crowds. Accordingly, the set of observable values are ranging from the *values of scientists*, *engineers*, *designers*, through the *values of laypersons* participating in the co-creation process and the *values of the context* where the co-creation process take place, to the *values actually exhibited by* the final robotics artifact. Considering now the RIF from an ecosystem perspective [24], while developed through a network of apparently separate silos, the different laboratories of the Institute seem instead

[3] We follow here the definition of "crowd crystal", provided by Elias Canetti in its book "Crowds and Power" [23] as "the small, rigid groups of men, strictly delimited and of great constancy, which serve to precipitate the crowd. Their structure is such that they can comprehended and taken in at a glance. Their unity is more important than their size. Their role must be familiar; people must know what they are there for. Doubt about their function would render them meaningless" (*Ibid.*, p. 73).

to create a *unified virtual environment* in the form of a large innovation facility for businesses and society. As a consequence, while at a glance the organizational structure seems to follow a hierarchical form, the existence of different groups developing in harmony different programs may suggest that "*heterarchy*" [25] would be an appropriate concept to describe the actual organizational forms of the RIF, including the above mentioned Institute and its associated labs.

Those elements seem relevant, on the one hand, to question and further problematize the move of the RIF from being an individual actor situated in a larger *ecosystem* to being the center for an emerging *infrastructure* [6], [26] for the design and testing of robotics innovation; on the other hand, this move asks for a further investigation on how various *social worlds* [27] outside the traditional laboratories are more and more included in that emerging infrastructure [5].

4. Conclusion

This article has presented the early insights from an exploratory case study on robotics innovation facilities (RIFs). Moreover, for the results of the study are mainly preliminary, further research will be conducted in future work. However, the paper aims to position some of the main arguments for studying the emergence of specific infrastructures from robotics innovation facilities and their ecosystems, often including research institutions, policymakers, public administration, private organizations as well as representatives of the civil society. Consequently, future work will reconsider the early analyses and results that have been presented in this paper through a preliminary conceptual description to further theorize from the case [28] and do a grounded theory following the glaserian or classic grounded theory [18], [29], with further theoretical sampling and coding also from other materials collected during the fieldwork and the subsequent year.

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