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Article

Experimenting organization: the politics of precision oncology

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Abstract

Drawing on an ethnographic study of French precision oncology clinical trials, this paper introduces the notion of "experimenting organization" to investigate recent developments in the clinical research domain but also, concurrently, in routine treatments and care. Experimenting organizations simultaneously engage in experimental activities by producing new knowledge and practices, while also experimenting with new ways of organizing the production of knowledge. We discuss a number of elements that characterize this kind of organization, namely: a close intertwining of routine and experimental activities; the search for a balance between continuity and discontinuity and, relatedly, logistical flexibility and robustness; a micropolitics of cooperation as defined by soft organizational design and interrelations between organizations scattered across different socio-technical spaces, including international ones and, relatedly, a micropolitics of boundaries. All these processes are further defined by their reflexive nature—both vis-à-vis organizational design and the validation of experimental results—and by the central place attributed to coordination issues. This case is relevant beyond the field of oncology because many contemporary challenges in public policy can only be addressed by relying on, creating, and transforming the organizations—both public and private—that are responsible for producing public goods. Our article contributes to the analysis of both public policy and the organizations that implement these policy objectives.

Keywords: biomedical innovation, precision oncology, organizational innovation, social policy

Introduction

Precision medicine, as featured in a growing number of clinical, research, and health policy publications (e.g., Collins & Varmus, 2015; Garraway et al., 2013; National Research Council, 2011), represents one of the most recent examples of organizational and institutional change in the healthcare field, while also embodying a major epistemic shift in biomedical knowledge and practices. Backed by substantial public and private investments, the rapid development of genomic technologies since the

early 2000s has contributed to a profound transformation of biomedical activities, particularly in oncology domain. Genomic technologies are associated with the introduction into clinical practices of new therapeutic strategies targeting specific molecular abnormalities. Taken together, these elements open up new, uncharted areas of biomedical intervention.

Empirically, the paper focuses on precision oncology, a domain that has played and continues to play a pioneering role by spearheading the adoption of genomic technologies (and other kinds of "omics") within the medical field. Our fieldwork was carried out in France, where this development has been highly promoted by major public institutions, including the French National Cancer Institute, at the turn of the 2010s. Rather than imposing a public policy from above, public institutions expected healthcare professionals and their organizations to help shape and promote the emerging field of precision medicine and provided funding for that purpose (Castel, 2020).

This paper introduces the notion of experimenting organization to investigate these recent developments, namely the emergence and development of translational research (see below) but also, concurrently, the reconfiguration of routine treatments and care. We focus on innovative clinical trials at the core of precision oncology that take place both within and across healthcare organizations. The term "experimenting organization" is deliberately designed to entertain two intertwined meanings: organizations that engage in experimental diagnostic and therapeutic activities, and whose practitioners concurrently and reflexively explore new organizational arrangements for doing so (see Batist & Shinder [2008] for an early example of reflexivity). We thus use the term "experimenting" both as a verbal adjective to describe the type of organization and as a present participle referring to what is being experimented with. As argued by Leonardi (2009), technological and organizational change are mutually constitutive. Through this case study, we draw on the perspectives outlined by Vaughan (1999), who called for incorporating the role of "formal organizations as contemporary machineries for knowing" and, thereby, for integrating science and technology studies (STS) and organizational sociology approaches. However, rather than on formal organizations *per se* such as hospitals or academic research centers, our focus, as embodied in the empirical choice to investigate clinical trials, is on the relational processes that underlie experimenting and organizing activities.

Cancer clinical trials have been defined as "laboratories without walls" (NCI, 2003, p. 29) insofar as they are often designed and conducted by networks of clinicians from different institutions, and they can be said to be located both within and outside those clinical settings. In other words, they are situated at the intersection of two kinds of organizing and experimenting activities, namely those concerning the design of innovative forms of clinical research and their necessary interaction with (and reconfiguration of) the institutions from where the patients required for this type of research are to be accrued. Accordingly, discussions surrounding the choice of available sociotechnical and organizational options take place at different sites, namely the steering committees of the trials, as well as the clinical research departments and the general direction of cancer hospitals, not to mention the national and international cancer agencies and the industry units that sponsor the trials. These polycentric arrangements are made more complex by the fact that a same practitioner may simultaneously belong to different organizations. The issue is less one of divided loyalties than one of operating within and across fuzzy boundaries, with no clear hierarchical lines or formal rules.

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In France, cancer clinical trials are often conducted by practitioners at comprehensive cancer centers characterized by a triple mission—care, research, and teaching—that requires the articulation of these different activities. It is important to emphasize, at this stage, that research activities cannot be automatically categorized as experimental, nor can care activities be reduced to routine, standard treatments. Insofar as research activities are a defining feature of comprehensive cancer centers, clinical research predicated on the existence of relatively stable and often formalized protocols can be considered routine. New kinds of precision oncology trials that disrupt traditional trial designs qualify, by contrast, as experimental. Similarly, the routine/experimental tension can be found within care, insofar as the results of research activities are quickly translated into clinical practice, disrupting traditional care protocols. An ethnographic perspective is key to describing such "a granular view of boundaries" (Raisch & Birkinshaw, 2008, p. 401) faced by organizations that must simultaneously manage these different processes.

In what follows, after a literature review and a description of our fieldwork, we will discuss a number of elements that characterize experimenting organizations in the biomedical field, namely: a close intertwining of routine and experimental activities; the necessary balance between continuity and discontinuity and, relatedly, logistical flexibility and robustness; what we term a micropolitics of cooperation as defined by soft organizational design and, relatedly, a micropolitics of boundaries. All these processes are further defined by their reflexive nature—both vis-à-vis organizational design and the validation of experimental results—and by the central place attributed to coordination issues.

Our case study is relevant beyond the field of oncology insofar as many of the contemporary challenges facing public policy can only be addressed by relying on, creating, and transforming the organizations—both public and private—that are responsible for producing public goods (Bergeron & Castel, 2024). Our article thus contributes to the analysis of both public policy and the organizations that implement ensuing policy objectives.

Literature Review and Conceptual Framework

Precision medicine may be fruitfully understood as "a socio-ecological space open to uncertainty, unknowingness and surprise" (Clegg et al., 2017). In order to analyze its development as an epistemic innovation, it is crucial to simultaneously explore "what constituting such spaces means for [healthcare] organizations that seek to learn and account for their actions" (*Ibid.*). The deployment of innovative clinical trials designed to validate genomic biomarkers and evaluate novel therapies is one of the main drivers of precision medicine. Their design and management entangle experimental activities with preexisting care and research activities.

We are, of course, not the first to have noticed the reconfiguration of clinical activities following the emergence of genomics (see, e.g., Ackerman, 2022; Bourret et al., 2021; Crabu, 2018, 2021; Polk et al., 2023; Tempini & Leonelli, 2021). Of particular relevance for the present purpose is the notion of "entrepreneurial hospital" introduced by Miller & French (2016); see also French & Miller (2012) for an earlier formulation. Building on previous contributions that characterized hospitals as a hidden research system (Hicks & Katz, 1996; Hopkins, 2006; Lander & Atkinson-Grosjean, 2011),

Miller and French define the entrepreneurial hospital as a hybrid organization that seeks to combine a logic of healthcare policy with a logic of innovation policy, the former aiming at improving health outcomes, while the latter focuses on research-driven goals "where industry is the key customer and client." Although the conflation of the two logics is justified by its proponents not merely in terms of potential financial and reputational rewards, but also of potential gains for patients, Miller and French see the two logics as conflicting or, at least, extraneous to each other, warning that the attempt to hybridize them could lead to dystopic consequences or even "monstrous outcomes."

Miller and French's approach is predicated upon policy and bioethics considerations, but it also resonates with a well-known, albeit controversial topic in the organizational and management literature. Indeed, the logic of care and the logic of research can be related to the distinction between exploitation and exploration introduced by March and Levinthal in two seminal articles about organizational learning (Levinthal & March, 1993; March, 1991). The hybridization of the two logics would then correspond to the establishment of ambidextrous organizations (Simsek, 2009; Simsek et al., 2009). Gupta et al. (2006, p. 694) define exploitation as the "local search, experiential refinement, and selection and reuse of existing routines," whereas exploration amounts to "processes of concerted variation, planned experimentation, and play," including risk-taking, flexibility, discovery, and innovation. As it is the case with Miller and French's logics of healthcare and innovation, in most of the management literature exploration and exploitation are treated as incompatible or independent activities (Auh & Menguc, 2005; Jansen et al., 2006), or as resting "at the opposite ends of a continuum" (Lavie et al., 2010, p. 118), the interplay between them occurring in the form of a zero-sum game with scarce resources being distributed either to one or the other (Gupta et al., 2006, p. 695).

A number of organizations, however, appear to combine these two processes to varying degrees of success. Levinthal and March did in fact suggest that organizations were better served by striking a balance between exploration and exploitation rather than by adopting an either/or approach. To that end, organizations may end up buffering exploration from exploitation, i.e., by securing boundaries—be they domain-based, organizational (spatial), or temporal boundaries—between those two activities, and differentiating organizational units that pursue exploration from those accomplishing exploitation (Benner & Tushman, 2003; Tushman & O'Reilly, 1996). Some authors have sought to develop a more integrative view resorting to the notion of ambidexterity, according to which exploration and exploitation should not be considered as competing but as complementary (Gupta et al., 2006; Raisch et al., 2009; Wang & Rafiq, 2014).

Because of their focus on for-profit organizations, organizational scholars have mostly confined their discussion of the exploration/exploitation tension and their studies of ambidextrous organizations to mass-production industries, linking these processes to the search for comparative market advantages and economic profitability. Yet, as Peng (2019) and Patrick (2018) have shown, issues surrounding the relationship between exploration and development are also highly relevant in the case of not-for-profit organizations, as these organizations also need to innovate while continuing to produce public services, and as they have to be accountable and create value, albeit not always financial value (Peng, 2019). In the same vein, we argue for the heuristic value of a return to the "empirical open-mindedness" of the original claim by March and Levinthal: by diversifying

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the types of organizations and sectors under study, scholars will enrich the discussion about the exploration/exploitation tension, in particular by applying it to instances of the public sector. Peng's and Patrick's articles, however, focus on sectors strikingly different from ours (job search and theater, respectively). Our case also differs from existing research on ambidextrous organizations insofar as the sector's nature requires a more nuanced examination of the knowledge produced. This is why we prefer the concept of an "experimenting organization", which refers to organizations that simultaneously engage in experimenting by producing new knowledge and practices, and within which new ways of organizing the production of knowledge are experimented.

With regards to the healthcare domain, the conflicting logics of exploration and exploitation have long characterized this sector, where they continue to play an important normative role (Dunn & Jones, 2010), even during the recent Covid-19 pandemic (Angus, 2020). Beyond its more immediate normative concerns, and in spite of different disciplinary origins and terminology, Miller and French's work on the entrepreneurial hospital adopts a similar perspective. It is noteworthy, however, that the empirical referents of their investigations are the Technology Transfer Office (French & Miller, 2012; Miller & French, 2016) and the biobanking facilities (French et al., 2018) of the entrepreneurial hospital, i.e., ancillary activities rather than conditions of possibility for performing key hospital tasks, in particular offering patients state-of-the-art treatments. In contrast, we focus on a number of organizational arrangements—such as the establishment of molecular boards, molecular pathology units, and bioinformatics pipelines—that have become a sine qua non for treating cancer patients.

Historically, two types of organizations were separately in charge of research and care: routine treatment and care took place within (community) hospitals, and experimental treatments and investigations within academic research laboratories and university hospitals. The development of biomedicine and translational research has questioned this division of labor, as the epistemic and organizational boundaries between research and treatment have become increasingly blurred (Cambrosio et al., 2018; Petty & Heimer, 2011). This is particularly the case in the field of oncology. The movement towards clinical trials that function like experiments designed to generate novel and unanticipated biological and clinical insights, rather than machines for testing drugs as part of industrial drug development has intensified a long-standing tension in the field (Nelson et al., 2014, p. 82). The main goal of genomic clinical trials, in other words, is to produce new knowledge and new clinical practices, whereby these activities take place within institutions characterized by the presence of a motley of protocols, routines, and other established procedures grounded in the use of things already known.

Experimenting organizations engage in the production of various forms of "experimental care" (no longer an oxymoron; Cambrosio et al., 2018) as a condition of possibility for getting their clinical job done. Recent clinical guidelines for treating lung cancer, for instance, recognize that "lung cancer by itself does not exist anymore, it's a constellation of diseases, some of which are very rare" (fieldnotes, MAP meeting 10 October 2020). Its (or rather: their) management requires the design and implementation of a new "architecture of knowledge" (Amin & Cohendet, 2004) consisting of drugs none of which were available only 15 years ago, and, correlatively, the deployment of genomic tests, knowledge bases, and other "theranostic" decision support tools that conflate diagnosis and

therapy (Bourret & Cambrosio, 2019; Cambrosio et al., 2020). As discussed by Castel (2020), the human component of this bio-clinical assemblage includes, at its core, "physician-organizers" who pursue their clinical activities while engaging in experimental cooperative endeavors (rather than jurisdictional struggles) with non-medical practitioners such as molecular biologists and bioinformaticians. Experimenting and organizing occur at the same time (simultaneity), and within the same socio-technical space (spatial conjunction) that cuts across care and research. One activity is not possible without the other, which is why we consider exploration/exploitation as fundamentally interdependent and reciprocally heteronomous processes. In other words, "continuity and discontinuity" (Rheinberger, 1997), or revolutionary and evolutionary change (Tushman & O'Reilly, 1996) are consubstantially linked. In short, while the notion of "entrepreneurial hospital" focuses on the analysis of socio-economic hybrids (public and private, or academic and biotech hybrids), a second kind of hybrids, namely bio-clinical platforms and strategies, need to be examined and articulated with the former in order to account for the rise of experimenting organizations (Cambrosio et al., 2009). While the present paper centers on the ethnography of French bio-clinical settings, we encourage readers to compare these results with those of a similarly detailed investigation of the introduction of precision oncology in a major US cancer institution (Cambrosio et al., 2024; Polk et al., 2023).

Research Settings, Data Sources, and Methods

As part of a collaborative research project that began in 2013, we investigated a set of genomic-driven clinical trials, focusing on their design, organization, and performance. We were able to simultaneously observe both research and clinical activities related to precision oncology. The present paper focuses on three French trials. Their principal investigators (PIs) were medical oncologists working within three French comprehensive cancer centers. Two trials (β and γ) were sponsored and managed, respectively, by centers B and C, whereas the third one (α) was overseen by the National Federation of comprehensive cancer centers (Federation) and its PIs were members of center A in collaboration with two oncologists from other centers. Clinical trials, especially genomics-driven ones, involve organizing processes that mobilize the centers' resources (their patients, practitioners, and technological platforms). Analyzing the conception, design, and implementation of clinical trials also involves examining how these trials relate to the broader activities of the three centers- that is, the interaction between the two organizing processes (Petty & Heimer, 2011).

Given their tripartite mission, the centers sponsoring the trials and the Federation have a directorate devoted to clinical research, staffed with specialized professionals and equipped with standard procedures, dedicated digital tools, and infrastructures. During the 1980s and early 1990s, clinical research in oncology became increasingly formalized, with the staging of large clinical trials testing different drug combinations according to more or less stable protocols (Keating & Cambrosio, 2011). This kind of routinized research activities reached a plateau in the 1990s, with a number of highly influential reports complaining that no real progress was being made and that the existing approach should be overhauled and rebuilt on an entirely new basis. In parallel, the

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traditional distinction between basic and clinical (patient-oriented) research was being increasingly questioned (Flier & Loscalzo, 2017) by a set of initiatives aimed at bridging the gap between bench and bedside and accelerating the transfer of research findings into clinical care (Fontanarosa & DeAngelis, 2002). As a result, after the turn of the century clinical researchers introduced a flurry of proposals for new clinical trial designs and for the reorganization of comprehensive cancer centers.

Beyond their local and national dimensions, the trials we investigated are pioneering endeavors and, as such, have gained international visibility. They all resorted to high-throughput genomic technologies to identify molecular abnormalities to be targeted with experimental therapies. These shared features, and their strong experimental component set them apart from traditional clinical trials. While it may seem obvious that the presence of the relevant biomarker is necessary for the drug targeting it to act, one of the goals of several recent genomic trials was precisely to test this hypothesis. Additional elements that contribute to uncertainty in this domain range from "micro" issues—e.g., whether a given biomarker is in fact the appropriate one, and, vice versa, whether the drug actually targets it—to "macro" issues, e.g., the extent to which the deployment of a targeting strategy is warranted by the existence of "large enough" patient populations.

As it can be seen, genomic trials are characterized by the fact that they no longer test drugs *per se*, but, rather, a therapeutic strategy, i.e., the matching of drugs and biomarkers vs. the prescription of drugs to all comers. Moreover, they imply a profound transformation of the organization of clinical research. Ascertaining the presence of biomarkers, for instance, requires molecular biologists and bioinformatics specialists to run the new high-throughput technologies and interpret the results. In other words, these trials require the mobilization of an unprecedented degree of multi-disciplinary and inter-specialty collaboration. To manage such a collaborative endeavor, new institutions have been established, such as molecular tumor boards (MTBs) that create a space where the different specialties can interact and jointly reach therapeutic decisions (Bourret & Cambrosio, 2019).

In spite of their shared characteristics, the trials we investigated differ on various aspects, a fact that points to their experimental dimension: single-center vs. multi-centric trials; randomized vs. non-randomized trials; treatment trials vs. triaging trials (i.e., trials that refer patients to other treatment trials); centralized vs. distributed genomic analyses; and trials testing experimental drugs vs. the off-label prescription of approved drugs. They also differ in size and scope and use different modalities for managing workflows and interpreting results. The MTBs for the three trials also followed different operational rules. Nonetheless, taken together, these trials are all part of a same set of complementary initiatives, and they often refer to or even build on each other. Each trial was managed by a PI (a physician) and a science project leader with a biology degree. Trial α consisted of two sub-trials, each devoted to a different type of cancer, and it had a relatively complex and formalized governance structure, with up to 40 people attending its steering committee. The umbrella committee supervising both sub-trials met twice a year, while each specialized steering committee met once a year. In contrast, the steering committee of trial γ met only once. In the case of trial β, the activities of its steering committee seemed to revolve around two persons, namely the PI (a medical oncologist) and the science project leader.

Between 2013 and 2018, we interviewed a total of 77 practitioners. They included the main actors of each trial, namely PIs, co-investigators, methodologists, project managers, data managers,

biologists, clinical research associates, bioinformaticians, and pathologists. We asked about their specific tasks within each trial and their relations with other actors. Beyond this core set, other interviewees included practitioners from the three centers—namely medical oncologists, department heads, computer engineers, and hospital information system managers—who, although less directly involved in the trials, were associated with the socio-technical infrastructure that made the trials possible, We were also able to observe a large number of meetings, including MTBs, steering committees, and other meetings attended by the main actors of the different trials, during which they presented and discussed each trial's (shifting) objectives and progress. Finally, we had access to all relevant documents and archives related to the trials. Our extended fieldwork period allowed us to closely follow the evolution of the trials, including changes and adjustments to the trials' protocols. Interview transcripts and fieldnotes were coded for recurring themes using qualitative data analysis methods (e.g., Bourgeault et al., 2013). In particular, we processed the information we collected "against a background of cultivated theoretical expertise" (Timmermans & Tavory, 2012, p. 180).

Results

The genomic clinical trials under investigation can be conceptualized as both instances of conceptual innovation—since they embody new experimental strategies and simultaneously mobilize and explore novel biomedical entities—and as instances of experimenting (temporary) organization, since the organizational design that accompanies their deployment has not only changed over time in order to adapt to emerging problems and to a rapidly changing socio-technical environment, but has also introduced innovative organizational solutions. In what follows we will analyze a number of characteristics of these joint processes.

The close intertwining of exploration and exploitation

Since the very inception of the genomics-driven trials, clinical practitioners quickly realized that experimental activities were closely dependent on the mobilization of elements derived from routine care activities. In a very trivial way, a necessary condition for the couduct of genomics-driven trials is access to metastatic cancer patients within the participating centers. Only a routine flow of patients will allow for the planning and initiation of new experimental projects, as treating physicians are expected to refer their advanced cancer patients to the trial sponsors.

Conversely, experimental activities regularly impacted routine treatment activities. In recent years it has become inconceivable for specialized cancer hospitals not to offer precision-oncology treatments, lest their reputation suffers. The ability to attract patients even for routine care depends on the supply of innovative therapeutic strategies. One of the explicit goals of the trial PIs and other trial leaders was to use genomics-driven trials to change the organization of their center. In particular, the centers' professionals were expected to implement new collaborative and coordination activities that would allow them to produce clinical-grade, quality controlled molecular analyses in real time. The communication of trial results also reveals this intertwining. Negative results in terms of treatment outcome were presented as having a positive component,

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insofar as they showed the ability to overcome serious logistical problems and perform molecular analyses in clinically meaningful time (Le Tourneau et al., 2015; Trédan et al., 2019; Tsimberidou et al., 2014). A less obvious, but essential connection between these mutually constitutive activities, as explicitly acknowledged by the trial PIs and their closest collaborators, had to do with the dual purpose of experimental bio-clinical studies: to treat patients and to learn about the biopathology of cancer.

The performance of genomics-driven trials intersected on a daily basis with the routine activities of the practitioners located in either the research or care units of the cancer centers. The trials contributed to shift boundaries of expertise and organizational jurisdictions, a process that can be more broadly equated to the shifting of the boundaries between research and care. Pathologists, biologists, and IT specialists, whose activities were mainly oriented towards care, had to devote human and material resources to the trials. They had to explore new ways of performing molecular analyses, while continuing to engage in routine diagnostic activities. In the trials α and γ, pathologists came under fire for their delays in producing their reports. In turn, pathologists considered that the trials generated an overload of work that imperiled the fulfillment of their diagnostic core mission. Practitioners from the Healthcare Systems IT Departments also complained about work overload caused by the trial, arguing that their core mission was routine healthcare. Furthermore, they considered that the increasing volume of data generated by the trials constituted a threat to the safety and stability of the information system developed to secure medical files. Traditionally more oriented towards research, biologists and bioinformaticians now produced results likely to impact patients' trajectories. Those same biostatisticians were now being asked to shift away from more traditional research activities in order to participate in the new, genomics-driven trials. State-of-the-art next-generation sequencing (NGS) equipment was used both for biological research and for generating data for inclusion in the trials.

This kind of intertwining raised questions about the day-to-day allocation of human and material resources across departments (the time spent on different tasks), while also requiring a different management of temporality: biologists, for instance, had to carry out analyses in a shorter time frame than usual. Therefore, in two of the three trials, the local IT platform for research data management ("bioinformatics platform") developed tools for digital workflow monitoring. As noted by the head of the bioinformatics platform of center C:

> *[The trial practitioners] really appreciated the notion of follow-up. This is very important in the context of a clinical study for which a therapeutic decision has been made (…) there is a maximum duration for processing the data. When you get a sample, you can't give the answer to the patient six months later; in some cases, it's far too late. It also allows us to know where we stand with each patient, to raise an alert if we exceed a duration threshold we set for them. If the threshold is exceeded, a small light turns on and warns us: "Be careful, for this patient there is a blockage somewhere."*

The new requirements also included the development of specific data management circuits. Should molecular (raw) data and their interpretation be stored in the (hospital) medical record or in

research information systems? What clinical data should be extracted from patients' medical records to be shared for research purposes, and how should this sharing be managed to ensure personal data safety and anonymity? Hesitations on the part of the actors show the entanglement of these two activities. In each of our three cases, albeit in different ways, some of the data collected were stored in an *ad hoc* database for analysis of trial results, in a research database for future analysis, or in the medical file. The standardization of data exchange procedures is still an open question, both within and between institutions. As noted by the head of the bioinformatics platform of center A:

> *I proposed to [the trial α group] other IT solutions for the transfer and exchange of data (…) in both directions. (...) The problem also concerns how to communicate with the clinician and the biologist, how to make the results of the analysis available to them and therefore I proposed to [the trial α group] to use computational resources that had been developed by the group for which I worked [at a US Center], and therefore when I showed them how it worked, the level of security it offered and the level of flexibility it also offered finally they all agreed with the trick and we adopted that solution.*

This quote brings us to the next section, since it points to a very important characteristic of these trials: the linkage between continuity and discontinuity and its management.

Continuity and discontinuity

In contrast with traditional clinical trials, genomic trials investigate not only drugs but new entities, namely molecular biomarkers and mutations. These entities are unstable and shifting, given that their nature and properties are constantly redefined by the results of parallel, intensive research activities. Studies introducing new biomarkers, new targeted drugs, and new strategies for targeting a given biomarker or for characterizing it as a "good" or a "bad" drug target are frequently published. These developments are closely linked to the rapid evolution of high-throughput technologies (e.g., gene expression profiling, DNA and RNA sequencing), and the diversification of the available tumor material sampling techniques (from the more traditional paraffin-fixed tissue, to frozen tumor tissue and 'liquid biopsies' of circulating tumor DNA). In other words, genomic trials take place within a rapidly changing scientific and socio-technical environment.

Clinical trials, however, can take several years to accrue the required number of patients, and there is thus an important temporal disjuncture between the relatively slow temporality of the trial and the rapid evolution of scientific knowledge and technical know-how. This is even more the case with genomic trials given the sometimes exceedingly small patient populations whose tumors harbor a given biomarker, and the non-negligible rate of genomic testing failures among the recruited patients. A central rule of the canonical model of clinical trials stipulates that the unchanging nature of their protocols is a condition of the validity of their results. Thus, the rapidly evolving nature of the knowledge, entities, and technologies on which genomic trials draw raises a critical question: to what extent could or should these trials take into account new developments without necessarily altering their objectives and protocols, and consequently also jeopardizing the robustness and validity of their outcomes? Our investigations clearly show the presence of a

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strong tension between two opposite imperatives: keeping the trial components stable for its entire duration vs. integrating new knowledge and adapting the trial to the evolution of its environment. It is worth noticing that there is no single or optimal methodological solution to this conundrum. Rather, actors involved in the different trials provide different answers to this problem, which translate into different ways of (re)organizing and conducting trials. The following excerpt from one of our fieldnote memos exemplifies the situation:

> *Trial α is a multicenter randomized trial designed to evaluate whether treatment with targeted agents guided by genomic analysis improves patient survival. For each cancer type, the initial protocol listed a set of drugs and the molecular alterations targeted by each. During a 2017 steering committee meeting, participants discuss what to do in light of the results from a concurrent study showing that one of the experimental drugs was ineffective when prescribed to patients harboring the matched biomarker. Based on a dual commitment to individual patient care and to experimental work, the members debate whether to remove this drug for if it has no efficacy it will reduce patient survival chances, while also decreasing the likelihood that the trial will lead to positive results. Not all members agree, considering that the proposed change is an important modification of the protocol. The PI counters that "since the beginning of the trial we stated that the protocol should be open to evolution, meaning that we will be able to include new drugs or exclude others if new knowledge becomes available." The real issue is whether "the knowledge we have in 2017 leads us to think that this experimental drug works better than the standard chemotherapy." The state of knowledge in 2014 is no longer the same in 2017, given the new information provided by several recent clinical trials: "This is why the protocol should evolve, if evidence is no longer available that this drug works for cancers displaying [these molecular alterations], we can no longer give it." An immutable protocol only makes sense within the framework of a shorter (one year or so) study, but "not to take into account the evolution of knowledge in a trial whose accrual is going to last 4 or 5 years, this is impossible!"*

The modification of treatment-decision rules is not only a matter of scientific judgment. It has an impact on the choice of technologies and analytic procedures, as different categories of biomarkers require different techniques and platforms, which in turn can impact the logistics and organization of the trial. Discussions concerning gene panels and drugs took place during each steering committee of trial α. Trial oncologists often suggested adding or subtracting biomarkers or drugs, which led to debates that display the intricacy of techno-scientific and organizational issues, as exemplified by this excerpt from a 2016 steering committee:

> *A proposal is made to add new biomarkers and related drugs and to remove others. The representative of the sponsoring agency argues that changing these elements during the conduct of the trial "is not so easy (...) to add a mutation requires us to also change all the other components [of the sequencing panel] (…) and to do that means that we are introducing a good measure of heterogeneity in the panel." A biologist agrees, adding that "we, on the platforms" cannot afford to change the panel too often and too deeply, especially because other modifications have already been*

planned that imply important changes in the organization, functioning and amount of work of the platforms. The clinical PI immediately counters that "we modify the algorithm [by which he means the strategy for treatment allocation] on a regular basis, and we absolutely have to modify it … we said from the very beginning that we could modify it."

As previously hinted, not all trialists share this approach. While the trials we investigated partake in the experimental turn, flexibility is neither necessary nor an intrinsic component of these trials. Indeed, other oncologists involved in genomic clinical studies maintain that to keep the protocol stable during the entire course of the trial is a basic principle. They concur that genomic trials are no longer testing the efficacy of a drug or drug combinations, as traditional trials did, but rather testing a "strategy"—and this is precisely why, in their view, the algorithm has to remain stable during the entire trial. A biologist who played a key role in devising the algorithm for trial β stated in an interview that "with the team here, we stuck to the algorithm, we did not modify it, we defined rules at the beginning and did not modify them." While acknowledging that, as claimed by the PI of trial α, a degree of flexibility may be considered legitimate in the case of selected trials, he insisted that given the large amount of money invested in genomic trials, trialists had an obligation to deliver robust results, and the condition for this to happen was to minimize changes.

This articulation between flexibility and continuity is present at all levels of the trials. In terms of statistical analysis, biostatisticians while trying not to move too far away from the canons of their discipline, also conceded that it was necessary to explore new ways of doing things. In parallel to their participation in the trials, which required the production of short- to medium-term interpretations of incoming data, the biostatisticians of the three trials also engaged in research initiatives to address long-term methodological issues raised by the new trials. As noted by a biostatistician of trial α:

[the continual modification of the protocol and the algorithm] is a real issue, yes, how do we take that into account? Because, as statisticians, we like things that don't move too much. But in this case, we already had four, five successive versions of the trial algorithm. So, together with [another statistician involved in the trial] we launched a research project to explore statistical methods that would allow us to take that into account.

As previously mentioned, the genomics-driven trials disrupted the routine activities of the pathology departments in the three centers. Not only did they generate additional work; they also required different activities (e.g., the recovery of archived tumor material), and, most importantly, a different work organization. As a result, center C decided to specifically assign a number of people within the pathology department to the performance of molecular tasks. In the end, however, this new division of labor—which has been adopted by other cancer centers in several countries—did not work out, insofar as according to the head of the pathology departments, his staff had to be proficient at both activities, which he regarded as mutually informing. As the PI of trial γ told us (emphasis added):

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The path to be taken by biopathology [a neologism that began circulating during the trial] is obvious for all of us. The diagnosis is not only pathological, it is pathological but also molecular. (…) An important discussion we had at the beginning was: Where do we draw the line [between diagnosis and research]? "This boundary is always a problem for us. I'm sure it will be a problem for us forever." At what point is it diagnosis, and at what point is it translational? At what point do we move from translational research to diagnostic routine? And when we translate, who is responsible for that translation? (…) "We adjust, and we do not want to propose a final solution as long as we adjust." (...) We have a biopathology department and a translational research department, "with many people working on both sides". And tensions all the time. Not tensions in the sense of conflict (…) but where do we place the cursor, how do we optimize, how to do well, how to meet needs? The basic vision, compared to the original vision, did not change much. We walk in this direction; "we shift it all the time." Translational activities permanently feed routine activities.

On the other hand, department heads involved in the trials sought to further standardize some processes realizing that in order to experiment one should be able to rely on robust, stable technical platforms. Here again, experimental activities could only be developed in connection with routine treatment activities, but, at the same time, the exploration process continuously involved reflexive adaptations of routine operations. As noted by the head of pathology of center B:

With personalized medicine, as we call it today, one must recover frozen tissues, extract nucleic acids, etc., and we need to screen a lot of patients in order to treat only a few of them. I reckoned that this would not be doable without industrializing the process. In practice, this means to buy robots to extract nucleic acids, to purchase automated equipment, computer-controlled freezing units, and then we need to develop IT systems.

Bioinformatics provides another example of this type of interdependence and cross-fertilization. The PIs of trials β and γ told us that the presence of bioinformatics units in their center accounted for the fact that they were able to start genomics-driven trials so early compared to other institutions, in spite of the fact that these units had not previously been involved in clinical research but only in basic projects. The head of the bioinformatics platform of center B added that they had already started thinking about a local system for integrating research data as early as 2009, but that the trial acted as a "catalyst" to accelerate its development. They developed a specific module to monitor the trial:

We launched a project in 2009 about data integration, interoperability, and centralization of asset [data] management. We were well aware of these issues before people started talking about personalized medicine. We were aware that much data was being generated, that they were complex, that different actors processed it and that it was important to guarantee their indexing and traceability. (…) Therefore, I would not say that trial β was an opportunity, it was a catalyst. We had built a system [for data integration] (…) When trial β started, we had this system, which

was not in production yet, but which met these needs for traceability and for queries (…) Trial β incited us to start production earlier than expected, because, without [that system] it would have been painful to monitor the trial in real time. But even with it, it was much more difficult, we had to engage in manifold exchanges with other actors.

In the case of center C, the team's participation in an international cancer genomics consortium enabled them to develop new modules for trial γ by borrowing and adapting procedures and know-how. As noted by a bioinformatician from that center:

Well, when I started with the project, I did not have any specifications; I did not know at all in which direction I should go. I relied on the IT system developed by [my colleague], who is working for [the International Cancer Genome Consortium] to develop my own system. We are working with [him] on the same bioinformatics platform. And, thus, he was doing much tracking [for ICGC], because he had many samples originating from many hospitals.

Conversely, because trials led to treatment decisions for patients, bioinformatics teams had to incorporate quality procedures specific to care activities, in terms of anonymity issues, data reproducibility, and deadlines, all points with which they were less familiar in their basic research activities. The manager of center B's bioinformatics platform decided that these regulatory elements should also benefit future research activities, and consequently led his unit through a quality accreditation process:

It was a paradigm shift on our side. We were originally mostly involved in [basic] research projects, more artisanal ones. Trial β acted as an accelerating factor, leading us to improve quality and adopt more industrial-type procedures. (…) The clinical side promoted this kind of good practices. Now, I would like to apply them also to the research part, to the procedures we put in place when we develop data analysis pipelines, even if it's a mouse, there's no reason to do things wrongly because it's a mouse!

As we can see, the advent of genomic trials has not led to a single solution for their design and organization, but has instead highlighted the presence of a number of possible alternatives and, one might add, fault lines between contrasting options, in particular between, on the one hand, flexibility and thus also learning and experimenting, and, on the other, stability and thus framing and structuring.

The micro-politics of cooperation via soft organizational design

Trial management teams searched for an equilibrium between the exploration of innovative solutions and the need for overall routine coordination, including a tighter coupling of cognitive and organizational activities. Their work was rendered more difficult due to the fact that a number of participants were not formally under their supervision and thus retained some legitimate leeway regarding their involvement in the trial. For instance, the management team did not have any formal

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authority over the bioinformatics, biology, and pathology platforms. Several practitioners, however, took an active part in the development of innovative coordination tools, implementing a number of more or less formal rules and procedures, and developing organizational and digital infrastructures to deal with emerging problems.

A novel institution, MTBs, played a key role in this respect. Attended by trial clinicians and scientists, MTBs are designed to assess the clinical significance of the results of genomic tumor profiling and make therapeutic recommendations on that basis. In addition, and by the same token, MTBs acted as coordination bodies by creating a space where different practitioners could interact and reach therapeutic decisions with the help of dedicated software platforms and databases. As discussed by Bourret & Cambrosio (2019), MTBs are a key locus for discussions about the nature, appropriateness, and characteristics of drugs and molecular entities, sometimes leading to protocol modifications, and for discussing new experimental avenues to be subsequently vetted by the trial's steering committee. MTBs also facilitate collective learning processes across different specialties, and simultaneously provide an opportunity for identifying pressing epistemic or organizational issues. As explained by trial β's science project leader:

> *The goal was that physicians became aware of this, that they get used to this new [genomic] vocabulary and all that stuff. Thus, when we wrote the protocol, we provided for a [biological board] and a [clinical board], but then we merged them, because we thought that, well, with two committees it would not be that easy to gather people twice a week (…) and we also found that there would be a lack of interaction [between biologists, technicians, and physicians]. (…) Actually, we ended up never holding them separately. (…) We said: "Let's do them together." And it became a single discussion.*

The three trials also prompted practitioners to experiment with "boundary occupations." Units that were not accustomed to working together now had to do so, and this was accomplished by resorting to facilitators who understood the needs of the different units, could translate them, and were adept at finding compromises. While traditional clinical trials are controlled by clinicians, in trials β and γ, scientists also held leadership positions, thus playing an essential role in the implementation of the trials. Their biology Ph.D. turned them into privileged interfaces between clinicians and research platforms. Center B subsequently established a "clinical bioinformatics" team to smooth collaborations between the clinic and bioinformaticians who were more used to working with researchers. Finally, center C following the conflict with the pathology department, dispatched a technician to the anatomical pathology laboratory, who reported to the trial management unit. Initially in charge of the logistics of tumor sample management for trial γ and, subsequently, all the other precision and early-phase clinical trials, the technician had a "mixed" profile, as the laboratory manager explained:

> *We found [her], who had a slightly hybrid profile (…). She knew biology, oncology and secretarial skills, typing, drawing, etc. That's why she is kind of a hybrid.*

Mention of "drawing" may sound somewhat puzzling. Visual devices, however, are important tools for coordinating trial participants and technologies (see Cambrosio et al. [2024] for a detailed discussion of visual tools as vetting devices for precision oncology trials). Indeed, we were struck by the profusion of the (sometimes ephemeral) graphs and diagrams produced by a number of different actors, who then redesigned and circulated them. Workflow and information flow charts circulated from service to service and were part of slideshows during internal or external meetings. A few also ended up in scientific journals or conference posters. Workflow charts primarily address two linked issues: data sharing and tumor processing and analysis. Quite often, interviewees used slides or printed diagrams to explain how the clinical trial was organized or "ought ideally to be organized." This visual display of organizational structures and informational flows turned out to be a core organizing activity. As a kind of heuristics (Newell & Simon, 1972), trial organizers used it to reduce the complexity of the workflow and for planning purposes. A scientific leader of trial γ showed us two workflow charts, explaining that the one they had drawn before the start of the trial had to be modified:

> *I tried to somehow sketch a flow of patient accrual (…) But actually it's complicated to sketch, because so many different people get involved. There are so many toing and froing between units.*

In addition to their role as internal and external communication devices, these graphs act as negotiation support tools. During the aforementioned internal crisis with the pathologists, five different workflow charts circulated inside center C, each representing an alternative description (or, rather, prescription) of the flow of tumor samples from collection to analysis. During a meeting of the executive committee of center C, the science project leader presented two slides, one titled "current operational flows," the other "desired operational flows." The latter advocated the transfer of a number of tasks from the Pathology Department to the Biological Resource Center, the development of a new computerized interface to automatically analyze high-throughput data, and the creation of a new "hospital information department" for gathering data from the translational research platforms before MTB meetings.

These flow charts are quasi-formal organizational structures: less institutionalized than formal organization charts, they amount to organizational manifestos (see Polk et al. [2023] for a discussion of the role of programmatic papers promoting precision oncology). As cognitive entities, they represent and organize knowledge production, while also acting as semi-formal political tools to negotiate cooperation and coordination initiatives. Insofar as they define the organizational, human, technological, and relational environment that actors consider favorable for implementing bio-clinical innovations, flow charts can be related to the notion of "script" developed by Akrich (1992) to analyze how new technical objects embed the description (but also the prescription) of the kind of world they are supposed to operate within. They represent the organization as a process of "organizing" by placing it within a temporal horizon of discontinuity and change. Actors use them as desirable scenarios, while being aware of the difficulty of introducing organizational changes and of the probable rapid obsolescence of these scripts. Yet, their flexibility and low degree of institutionalization turn these visual devices into sites for negotiation and adaptation, thus

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contributing to experimentation while joggling with pre-existing structures.

The bioinformatics teams of the three centers, in collaboration with trial PIs and scientific leaders, developed a number of digital devices to improve coordination and task efficiency. Deploying graphical interfaces, they included digital tracking systems to monitor the different sub-tasks into which the whole process had been decomposed. These systems were not part of the initial trial design but emerged as a potential solution to the difficulties encountered when coordinating actors and monitoring processes. As explained by a bioinformatician from center B:

> *Trial β incited us to develop a specific digital application (…). This application was designed to allow different actors who play different roles in the trial to follow each step. And, first, to be aware of the step reached by patients in the process: did they receive NGS data? Was the pathology report generated? Was it sent? It was really trial β that incited us to develop such a tool.*

Bioinformaticians were also tasked with developing numerical and graphical interfaces to facilitate the joint interpretation of clinical and biological data during MTB meetings. In addition to being long and difficult to conceive, visual interfaces were sometimes contentious, since they needed the approval of all actors, including the biologists. As explained by a member of the trial β bioinformatics platform:

> *Since the beginning of trial β, we [bioinformaticians] have been at the forefront! The role of bioinformatics has been much criticized, because everyone wants to keep their power and expertise. (…) [Conflict] occurred primarily with biologists. Not so much with clinicians, but with biologists (…). It was extremely tumultuous at the beginning. And why did it happen so? Because biologists waited until the first patient was accrued to wake up and tell us what they wanted, although we had waited for their feedback for months. (…) We developed a numeric tool and they rejected it as a whole, although we thought it fitted their needs very well. (…) In the end, we kept [our tool] but we sent them another file which they can install on their workstations and visualize using their favorite software.*

Bioinformaticians also faced problems when developing automated pipelines for genomic raw data analyses. A bioinformatician from trial γ explained that automation was needed because since the beginning of the trial the biologists had modified their analytical approach, and only automation could ensure that all patients would "be analyzed in the same way, with the same standards, in order to be able to compare them." These developments, however, had to be negotiated with the biologists, who had their say about system settings and who needed to be convinced of the relevance and reliability of automated pipelines. As a compromise, automated analyses were controlled *ex post* by biologists who thus had the last word. A trial γ bioinformatician recalled that "at the beginning the NGS biologist was very reluctant to utilize our algorithms. She used [software] developed by the producer of the sequencing equipment, and It took me about six months to convince her that it was better to use our pipeline." According to a trial β bioinformatician, pipeline development was "an incremental process, a continual discussion (with the biologists)." All these exploratory

IT developments, of course, were not built from scratch; they benefited from parallel initiatives at the local, national, and international levels. Yet, they took much longer than expected by the trials' management teams, who complained about delays when they realized that improvements were an ongoing process.

The micro-politics of boundaries

In addition to their reliance on new actors, such as bioinformaticians and bio-pathologists but also "physician-organizers" (Castel, 2020), experimenting organizations build on and lead to changes in organizational and field boundaries (Scott et al., 2000), including epistemic changes in the objects and evidential criteria mobilized by the new style of practice (Hacking, 2002). The design and staging of the three trials necessitated an expansion of existing collaborative ventures, the establishment of new ones, and the crossing of certain boundaries. For instance, in spite of being known for their fierce competition in matters of research and care, centers A and B agreed to collaborate, albeit within certain limits. The redefinition of boundaries involved a number of *ad hoc* adjustments. The PIs and co-PIs of the three trials knew each other well and had multiple occasions to exchange their views on genomics in general and on their trials in particular. They jointly attended national meetings on precision medicine organized by the French National Cancer Institute and the Federation. Center A had performed two pioneering genomic trials a few years earlier, which prompted physicians from other centers to launch their own trials with similar yet distinct designs. As mentioned by the PI of trial γ:

> *Generally speaking, center A's trials did not influence me in a major way, for the simple reason that they were centered on specific pathologies, and since I am not working on those pathologies … But yes, it was interesting to do that, let's go in the same direction, but let's do things somewhat differently. So, they did influence me because it's thanks to them that I ended up wanting to do our trial. (…) So, trial γ has a slightly different approach that made it more original, and also complementary with respect to previous trials.*

The PI of trial β and a biologist who was instrumental in designing it attended the initial meetings of the MTB of trial α to share their previous experience and alert their colleagues to a number of issues such as keeping decision rules stable and clearly defining the molecular alterations investigated by the trial. Their center, together with other centers, was involved in trial α as a patient accrual site and a genomic analysis platform. The trial β biologist played a major role in devising prioritization and decision rules for trial α and was subsequently coopted by its steering committee. The PI of trial α was invited by the director of the center C to become a member of the scientific advisory board of this center, in order to assess and advise on the center's personalized medicine trial program. In addition to these formal exchanges, informal contacts were also frequent. The PIs of trials β and γ envisioned their trials at the same time and interacted during this process. They even considered at one point combining the two trials:

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When I proposed [trial β] I contacted [center C], they wanted to become involved with us, but they also wanted to develop their own trial, we briefly tried to merge the two trials, but the resulting design did not make any sense. In the end they designed their own trial, a slightly different design, but the molecular targets and the drugs are quite similar. But in the end all trials are different, and they explore similar issues in a slightly different way.

An oncologist, who was simultaneously active in trials β and γ, argued that the fact that his center sponsored the former did not prevent him from actively participating in the latter. He acknowledged that in a domain where patients are a precious clinical resource, he often confronted the choice of having to decide whether to accrue individual patients to his organization's trial or to the "competing" one. While those trials did not involve the exact same methodology and drugs, they did try to answer a similar question and recruited patients from a similar population pool. But he immediately added that the opportunity of attending the MTB of the two institutions allowed him to borrow ideas from one and use them for the other.

We could multiply these examples but let us simply mention that a large number of genomic trials are not only multi-centric, but also rely on the use of complex genomic technologies available on a limited number of national platforms. This has spurred the emergence of an expanding web of collaborations, so that these kinds of trials are simultaneously located within and outside cancer centers. There is, of course, a temporal aspect to this dynamic. Pioneering genomic initiatives in France were sponsored by individual institutions that did not attempt to develop a common approach or share technical platforms. This strong competitive dimension, however, was to a large extent subsequently replaced by the staging of national initiatives, to which, one should add, some institutions contribute more than others, thanks, for instance, to the experience gained during their initial forays into the field.

The presence and role of bioinformatics are a distinctive characteristic of genomic trials, but also a strategic locus where the complex issues of collaborative endeavors, in particular with regard to data sharing, are most acutely felt. The bioinformatics unit of each institution had developed its own approach and tools for data analysis and data management. As a result, subsequent attempts to interface results in order, for instance, to conduct meta-analyses had to face steep technical issues. Without engaging in full-fledged collaborations, practitioners from other organizations contacted their trial β colleagues to learn from their experience and use it to develop their own data infrastructure model. As noted by the head of bioinformatics at center C:

We know very well our colleagues at centers B and A, we often end up in the same national or European collaborative programs, we apply together, and we share the grants. Right now, in France on our field there is not much competition in terms of resources. (…) There is a lot of collaboration, not necessarily at the operational level. In most cases these are conceptual collaborations, we exchange, we discuss. We say: "we did this" and we share our results. But we rarely say: "This is what we did, take it and use it."

In 2013, the PIs of the three trials initiated a joint database project to allow for the sharing of clinical trial data. By 2018, the project turned into a national initiative between 6 centers (including centers A, B and C), the Federation, and two public university hospitals, led by the bioinformaticians who had been involved in genomics-driven trials.

Conclusion

As quintessential reflexive institutions, experimenting organizations as discussed in this paper share several defining elements characterizing both their organizational design and the processes for validating experimental results. They include the close intertwining of routine and experimental activities; the management of continuity and discontinuity, and, relatedly, logistical flexibility and robustness; a micro-politics of cooperation enabled by soft organizational design; boundary occupations; and visual devices performing informal coordinating tasks, in particular by securing Interrelations between settings scattered across different socio-technical spaces, including international ones. Taken together and broadly speaking, these interacting elements lead to a micro-politics of boundaries embedded in public policy interventions.

Our ethnographic study of the socio-technical dynamics of French genomics-driven trials lends support to the claim that, to borrow Miller & French's (2016) terminology, the logic of research that promotes cognitive and organizational innovation and the logic of healthcare that relies on established organizational routines and structures, far from competing, are in fact closely entangled. Rather than investigating the detrimental effects of the competition between these two logics, we analyze them as complementary. In fact, we would like to go much further and analytically describe the processes we investigated as instances of "experimenting organizations" by analogy with the experimental systems analyzed by Rheinberger (1997). According to this author, it is "machines for making the future." i.e., for exploring and producing novelties and surprises, experimental systems consist of two major components: the epistemic objects being explored, and the technological objects that make such explorations possible and need to remain stable. These two components entertain a functional rather than structural relation, and their status is prone to change over time, i.e. epistemic things can turn into technological objects as it has been the case with many entities generated by molecular biology. Rheinberger's approach has been shown to provide a useful heuristic for analyzing clinical practices (Nelson et al., 2014) and can act as a conceptual bridge for jointly investigating the organizing and epistemic dimensions of experimenting practices. It helps bringing to fruition the perspective outlined by Vaughan (1999), who called for a closer integration of STS approaches and those of organizational sociology in the production of knowledge.

Experimenting organizations are characterized by a mutually constitutive relationship between bio-clinical innovation and work organization, and thus by the imbrication of organizing and organization, or, in other words, the logics of exploration and exploitation, or research and healthcare. In contrast to Clegg et al. (2005) who link "experimentation" to "foolishness and randonnée," we consider that experimenting organizations—which can be described as organizations looking for new knowledge and displaying new organizational capabilities to reach this goal—question the dichotomy between continuity and discontinuity, and between "organized"

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and "non-organized." No trade-off between stability and flexibility is necessary, provided that senior teams, liaison personnel, and other boundary-spanning mechanisms manage to integrate different knowledge sources, and to do so not "across differentiated exploratory and exploitative units" (Jansen et al., 2009, p. 806), but, rather, between different units engaged in both exploitation and exploration. Organizational scholars have shown that organizing is a process that stretches from the creation of legally based and structured organizations to "partial organizations" (Ahrne & Brunsson, 2011; Ahrne et al., 2002; Brunsson, 1999). The investigation of experimenting organizations should follow this analytical path in order to examine the mechanisms and devices that allow for different degrees of collaboration between participants, in particular in situations characterized by the (quasi) absence of formal hierarchical relations as it is the case with genomics-driven trials.

We used the term "micro-politics of cooperation" to characterize those processes that mobilize "soft-organizational instruments," i.e., non-legally binding, organizational forms (such as boards, committees, non-institutional organizational charts, digital cooperation interfaces, and production process charts) that help structuring cooperation and coordination among individual or collective human and non-human actors. In particular, extending Akrich's (1992) notion of "script", visual devices may be conceptualized as soft governing tools that are less prescriptive than standard operating procedures or formal organizational charts. They do not specify rigid hierarchical relationships; rather, they visualize expected mutual exchanges between units not used to working together, encouraging cooperation and coordination between them without specifying the content of the exchanges they promote, thus avoiding possible conflicts (Boxenbaum et al., 2018).

Soft-organizational instruments are sometimes not sufficient to secure cooperation and socio-technical integration, which is needed for advancing knowledge exploration. A remedy to this situation is to create "boundary organizations," which, as an enduring organizational structure ,attenuate the most critical differences between actors while at the same time providing spaces where they can "preserve critical aspects of their native worlds" (O'Mahony & Bechky, 2008, p. 431). Our analysis does indeed highlight the presence of "boundary organizations" such as data directorates, biopathology departments, or clinical bioinformatics teams that act as coordination and cooperation mechanisms across different sub-units. MTBs, whose main purpose is to provide bio-clinical interpretations and make therapeutic recommendations—in short: get the precision oncology job done—also act as major coordinative devices insofar as they bring together different practitioners and structure their discussions according to specific, yet flexible sequences. MTBs, and the visualization tools they mobilize as part, for instance, of vetting procedures (Cambrosio et al., 2024), exemplify the cumulative dynamics of epistemic and organizing practices. As we saw, these processes are not stable, and adjustments are often necessary. Soft organizational forms can be turned into harder ones, while structured organizational forms can be displaced by the reconfiguration of exploratory activities. Organizing processes that involve the creation of more or less hard and soft organizational tools and instruments are a common practice in experimenting organizations, for the production of an experimental space requires and engenders innovative forms of organizing.

Interrelations between organizations scattered across different socio-technical spaces, often international ones, are another key aspect of experimenting organizations and organizing. These

organizations are linked through digital connections as part of a "platform-based ecosystem" that sharply departs from organizationally centered innovation (Benner & Tushman, 2015). We discussed the role of the bioinformatics units within the three cancer centers, mentioning their national and international connections via, for instance, cancer genomics networks and consortia. In these cases, instead of focusing on the false dichotomy between competition vs. collaboration, it appears more analytically fruitful to focus on the circulation of a number of entities—such as drugs, techniques, and algorithms—within the biomedical research domain. Circulation patterns can also be understood as a key coordination modality, esp. since they often involve attempts at harmonizing entities and practices (Cambrosio et al., 2017), which subsequently need to be articulated with national healthcare systems (Green et al., 2022). Circulation, however, does not mean a lack of differentiation: as we have seen, the three trials we investigated appear to be complementary rather than "me too" initiatives. Each trial embodied a specific script designed to explore, in its own way, a different aspect of the same general question, thus establishing a common translational research space whose size and boundaries change over time.

All of these processes highlight the heuristic of ethnographic approaches to explore how the relationship between exploration and exploitation is managed, whereas research on ambidextrous organizations tends to favor quantitative and macro-level approaches. Long-term fieldwork combining interviews and observations allows for the account for the different kinds of sociotechnical logic, as well as different kinds of social exchanges underlying collective action, and for the adoption of a multi-level view of organizational ambidexterity, as recommended by various authors (e.g., Birkinshaw & Gupta, 2013; Kassotaki et al., 2019; Simsek, 2009).

As argued by Bergeron & Castel (2024) many public policies can only be transformed by transforming the organizations—both public and private—responsible for producing public goods, or by creating innovative organizations. Yet, many public policies for domains such as aeronautics and aerospace, climate change, nuclear waste management, or transportation, need to be grounded in increasingly specific and complex scientific knowledge. It can therefore be argued that the mechanisms and processes analyzed in this article could shed light on efforts to build experimenting organizations, i.e., organizations that produce the scientific knowledge and the related evidence required for the implementation of many public policies. Our approach can thus also help in understanding their organizational dynamics, which is necessarily both political and epistemic. In this sense, our article is as much a contribution to the analysis of public policies as it is to the investigation of the organizations that help implement these policy objectives.

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