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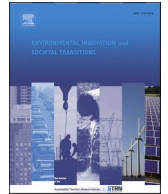
Research article

Assessing change agency in urban experiments for sustainability transitions

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ABSTRACT

Experimentation has become one of the prevailing modes of governing the transition toward sustainable practices in urban environments. The spatial variation of urban sustainability transition has been attributed to a variety of conditions erected at different spatial scales. What remains less well-understood is how spatial situatedness shapes agency in urban experiments and the shapes agency can take is a field that requires further research and frameworks. The paper addresses this gap by introducing a framework from the literature on regional development, identifying three distinct types of agency that shape regional development processes. Combining this framework with a process perspective on urban experiments, we develop an analytical framework, which allows for a more granular understanding of agency in urban sustainability transitions. The analytical framework is then brought to use in a case study of an urban experiment aiming to electrify public transport in Gothenburg, Sweden.

1. Introduction

The threat climate change poses against life around the globe forces societies to rethink and recalibrate current practices in virtually all aspects of society. A major transformation of technological, social, environmental and political practices is necessary in order to reduce greenhouse gas emissions, build resilience against the unavoidable consequences and prevent further damage from climate change. At the same time a global demographic change leads to massively growing urban areas. The UN expects 70% of the world population to live in cities by 2050 (McCormick et al., 2013). This means that cities have a particularly important role in the shift towards more sustainable practices. These structural changes in cities are referred to as Urban Sustainability Transitions (UST) (Frantzeskaki et al., 2018a, 2018b; Hodson et al., 2018; Ehnert et al., 2018). UST are understood as deliberate actions in, of and by cities that transform urban systems toward more economically, ecologically and socially sustainable practices and patterns of production and consumption (Hölscher and Frantzeskaki, 2021). Examples of such transitions include shifts in the provision and consumption of energy, mobility and food which are among the largest emitters of greenhouse gases in the EU (EEA, 2021).

Our understanding how urban sustainability transitions are governed carries a strong legacy from research and experiences accrued in the formative years of sustainability transitions. Seminal frameworks such as strategic niche management and transition management have heavily emphasize 'governing through experimentation' (Raven, 2005; Loorbach, 2007; Bulkeley and Castán Broto,

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2013; Ansell and Bartenberger, 2016). Consequently, climate change experiments, demonstration-oriented pilots, urban living labs, experimental districts and grassroots initiatives engaging with tactical urbanism play a prominent role in the repertoire of practical and policy approaches to UST (Torrens and von Wirth, 2021). These approaches share an emphasis on the niche-level as a designated site for initiating and scaling transformative change highlighting protected spaces where new technology or practice can be developed, tested and established protected from market mechanisms, in collaboration between users, private sector and governments in real-life environments (Voytenko et al., 2016).

'Governing through experimentation' holds the compelling promise that 'small-scale' actions can leverage transformative, systemic change (Wolfram and Frantzeskaki, 2016) through processes and mechanisms of upscaling niche innovation (Raven et al., 2010). According to Raven et al. (2019) experimentation lends situated strategic agency to cities to drive transformative change processes. In spite of a seemingly generic recipe to engage in experimentation, its situatedness highlights a variety of spatial settings on differing scales shaped by institutional set-ups, social networks, infrastructures, resource endowments and actors. These factors, among others, are used to understand the spatial variation of sustainability transitions. What remains less well-understood is how spatial situatedness shapes agency in urban experiments and the forms agency can take is a field that requires further research and frameworks (Köhler et al., 2019).

Fuenfschilling (2017) have asked to what extent urban experimentation contributes to overall institutional change and how these processes play out across space. Also a recent commentary and future outlook on urban sustainability transitions by Torrens et al. (2021) calls explicitly attention to better understand the change agency in urban experimentation to transform urban governance and planning regimes geared to largely reproducing models of urban development that intensify ecological pressures (Rapoport, 2014). Even though experimentation may have become a new normal in climate urbanism Bulkeley (2021) points out that governing by experimentation is highly malleable for diverse interests and a multiplicity of actions. Moreover, some of these experimental actions and policies may be susceptible for short-termism and unambitious incrementalism (Torrens and von Wirth, 2021; Davidson et al., 2019). To borrow the terminology of Smith and Raven (2012), too much fit-and-conform and too little stretch-and-transform?

The purpose of this paper is thus to contribute to a better understanding of agency in urban experiments for sustainability transitions. To do so, it adopts a familiar strategy in the literature on sustainability transitions, drawing in insights, concepts and theory from economic geography to lend spatial sensitivity (Binz et al., 2020; Coenen et al., 2012). Within economic geography one strand of research has recently turned attention from the role of structures for regional economic development toward the influences of actions of individuals and sets of individuals, i.e. human agency, on processes of change. One approach has identified three theoretically distinct types of change agency (place-based leadership, institutional entrepreneurship and innovative entrepreneurship) that actively shape regional development paths on different scales (Grillitsch and Sotarauta, 2020). This framework has already been applied to regional economic transitions (Jolly et al., 2020) and holds potential to provide insights into the ways agency shapes urban experiments for sustainability transitions. *The aim of the paper is to develop an analytical framework that allows for a more granular understanding of change agency in urban experimentation.*

In addition to this theoretical contribution to sustainability transitions, the paper also provides an empirical contribution. To this end, it illustrates the use of the analytical framework by means of a case study focusing on a project of urban mobility transition in Gothenburg, Sweden. The ElectriCity collaboration is understood as an urban experiment lead by Volvo and the City of Gothenburg aiming at developing and testing sustainable solutions for urban public transport, first and foremost electric busses. It complements existing studies addressing the electrification of urban public bus systems, which provide insights on organisational learning processes where knowledge sharing and accumulation play together in scaling experiments (Borghei and Magnussen (2018); on constraints to upscaling (Dijk et al., 2018), and on pre-commercial demonstration to access niche markets and commercial demonstration to access mass markets (Werner et al., 2021). The current paper is complementary as it does not primarily zoom in on learning but on why and how actors have engaged in the process, and to what outcomes. Whereas learning is an important outcome, the focus is more on socio-technical changes such as new urban transport systems made possible through innovation and institutional changes. The agency perspective also provides insights into the social engagement necessary to establish urban experiments and mobilise multiple actor groups.

The paper is structured as follows. The next section comprises a literature review focusing on the dominant approaches in transition studies, the spatial and specifically urban aspects of sustainability transitions and the roles different actors have in them as well as introducing the trinity of change agency concept. In a summary both approaches are compared, a hypothesis of how change agency can be applied to urban experiments is developed and specific research questions guiding the case study are derived. Section 3 then introduces the methodology and the case ElectriCity Gothenburg. Section 4 presents the results and Section 5 discusses the results and limitations of the case study and the applicability of the trinity of change agency concept to urban experiments. Section 6 then presents a conclusion.

2. Theoretical framework

2.1. Urban experiments as multi-actor processes

Urban experiments can take many shapes aimed at developing, testing, demonstrating, and scaling new socio-technological solutions, generating and spreading new policies and modes of governance, and providing space for interaction between multiple actors, the building of social networks, and learning (Bulkeley and Castán Broto, 2013; Bulkeley et al., 2019; Fuenfschilling et al., 2019). Most experiments intervene in the urban infrastructure, building practices, transport or urban planning. The focus had been on developing means to reduce the climate impact rather than adapt to the effects of climate change (Bulkeley and Castán Broto, 2013), however this

may be changing as cities increasingly need to adapt and increase their resilience to more extreme weather events.[1]

Urban experiment is defined as "an inclusive, practice-based and challenge-led initiative designed to promote system innovation through social learning under conditions of uncertainty and ambiguity" (Sengers et al., 2016, p. 21). This definition emphasises the ambition of urban experiments to lead to system innovation, i.e. reach further than singular, piecemeal technological innovations. Even though many local experiments and niche innovations may not live up to delivering system innovation (Bulkeley et al., 2018; Scholl et al., 2022) and tend to emphasise more practical solutions to better fit and conform with existing regimes (Smith et al., 2016), urban experimentation in practice typically promises "a short cut to rapid urban transformation" through inclusive multi-actor social learning process (Evans et al., 2021, p. 172). Social learning emphasises that an urban experiment is not limited to technological learning but includes institutional learning such as the development of business models, regulations or user and social practices. Furthermore, an urban experiment is practice-based, meaning it is carried out in real-life conditions, and oriented to solve a societal challenge. This societal challenge can be seen as a problem frame formulated by the participating actors. Finally, urban experiments are carried out under the conditions of uncertainty and ambiguity. Ambiguity is the result of inclusiveness that entails that multiple interests, motivations and values that may be conflicting are combined in the experiment. Uncertainty is connected to problems, solutions and changes that emerge during the experiment (Sengers et al., 2016).

Urban experiments are multi-actor processes, which commonly involve the public-sector, private companies, universities and research organisations, civil society, and intermediaries (Avelino and Wittmayer, 2018). Conceiving urban experiments in the context of tensions between regimes and niches, actors are expected to vary in interests and intentions depending on their position in regimes and niches. It is commonly argued that regime actors tend to resist transformative change while niche actors are expected to actively push for change (Fischer and Newig, 2016). However, there are accounts of regime actors actively shaping transitions and the discourse around them (Späth et al., 2016). This suggests that even though actors will differ in their stake in the current state, simple dichotomies do not reflect the dealings and wheelings of multiple-actor groups. Intentions and roles of actors may change over time, with some actors exiting the experimentation processes and new ones entering (Flanagan and Uyarra, 2016). Importance is also ascribed to local actors who push for change and develop networks of collaborators (Essletzbichler, 2012; Bulkeley and Castán Broto, 2013; Fastenrath and Braun, 2018). However, not all urban experiments contribute to system innovation. Common threats to this goal are design faults, defensive behaviour by incumbent actors to protect vested interests or attempts to greenwash existing regimes.

In the literature, a variety of different types of urban experiments have been identified (Bulkeley et al., 2018), applying increasingly a process perspective in which multiple actors engage (Hodson et al., 2018; Torrens and von Wirth, 2021). The focus on key processes surfaces in the various expressions of urban experiments as for instance evident in the study of Sengers et al. (2019). In *niche experiments*, for example, the emphasis is on the role of nurturing processes like the building of networks, articulation of expectations and learning. Furthermore, protective processes like shielding (referring to the protection from selection mechanisms), nurturing (supporting the development of radical innovations) and empowering (enabling competiveness between niche innovation and regime). In *transition experiments* focus lies on three processes. First, deepening concerns learning about an experiment and its conditions, which is facilitated by the provision of space for experimentation in specific contexts. Second, broadening refers to learning from related or similar experiments that were conducted in different contexts. This process benefits from the provision of resources and increasing interaction and improving networks between projects. Lastly, scaling-up implicates learning about regime change and broader developments by including frontrunners. Frontrunners are conceptualised as individuals that have the motivation and ability to drive change, are involved in the challenge the experiment addresses and transcend organizational boundaries.

Another common mode of experimentation that has recently gained more attention is the Urban Living Lab (ULL) (Marvin et al., 2018). ULL are characterised by their geographic embeddedness in an urban context, the participation of users, the intention to learn, evaluate and improve (Voytenko et al., 2016). Important processes are the development and testing of technologies, the building of capacities necessary to adapt the tested technologies and the connection to the local context, i.e. addressing specific problems in the place the ULL is located. Examples include public-sector led and co-financed projects aimed at achieving transformation where private-sector actors can test products in the real-life environment of the city (Bulkeley et al., 2019). Diffusion processes include firstly embedding, which refers to the adoption and integration of parts of an ULL into existing structures. Second, translation refers to a horizontal diffusion where the ULL or specific elements of it is reproduced in a different (spatial) context. Common strategies for translation are the replication of lab structures as well as education and training of ambassadors. Third, scaling describes the (spatial) growth of a ULL that can entail an extension of resources or toward more actors (von Wirth et al., 2019).

According to Sengers et al. (2019) the various conceptions of urban experiments differ in their normative orientation, reflecting different ideals and mechanisms, their theoretical foundations, and analytical emphasis, even though all build on the notion of niche experiment. However, the authors argue that there are also high similarities between the different conceptions, so that the different conceptions rather serve as different analytical lenses for the study of specific urban experiments.

2.2. Change agency in regional development

While the relevance of heterogeneous actor networks is thus well established, it remains unclear how the actions of individual and sets of individual actors influence the outcome of experimental processes (Hansen and Coenen, 2015; Fuenfschilling et al., 2019; Köhler et al., 2019). A similar concern was raised when analysing change processes in the regional development and economic

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[1] We thank an anonymous reviewer for this observation.

geography literature (Boschma, 2017; Hassink et al., 2019; Uyarra et al., 2017). Responding to this research gap, an increasing number of publications about regional development zoom in on the role of agency in processes of change (Bækkelund, 2021; Beer et al., 2021; Isaksen et al., 2019; Rekers and Stihl, 2021). This literature goes beyond the idea that multiple actors engage in change processes to conceptualising and empirically studying why and how actors engage, what empowers (or disempowers) actors to make a change, and what the intended and unintended, potentially unwanted consequences are.

In this line of research, human agency refers to "intentional, purposive and meaningful actions, and the intended and unintended consequences of such actions" (Grillitsch and Sotarauta, 2020, 707). Actions may be intended at realising a change, or maintaining existing structures (Jolly et al., 2020). The former has been labelled as transformative or change agency and the latter as maintenance or reproductive agency (Coe and Jordhus-Lier, 2011). It is important that transformative change should not necessarily be perceived as revolutionary, with a rapid disruption of previous practices. Frequently change comes in more gradual, "creeping" form (Streeck and Thelen, 2005), where continuous smaller changes accumulate to a larger change over time (Grillitsch et al., 2021; Evans et al., 2021). If the outcome of interest is the realisation of a change (as is the case with urban experiments as well as much of the recent interest in regional industrial transformations), then a particular focus on change agency is justified. Grillitsch and Sotarauta (2020) identify in the Trinity of Change Agency (TCA) three theoretically distinct forms of change agency that hold particular relevance for regional development, namely innovative entrepreneurship, institutional entrepreneurship, and place-based leadership.

As regards innovative entrepreneurship, Schumpeter (1911), in developing a theory of economic change, foregrounds the importance of actions that are driven by a belief in not yet realised opportunities, for which markets or technological solutions are still unknown. Shane and Venkataraman (2000) view entrepreneurship as nexus of opportunities and actors perceiving and wilfully pursuing such opportunities. Institutional entrepreneurship and place-based leadership are important in shaping opportunities and enabling the diffusion of innovations. Institutional entrepreneurship is about changing existing or introducing new formal (e.g. laws and regulations) or informal (e.g. norms and values) institutions (Battilana et al., 2009). Institutional entrepreneurship plays a role for instance in legitimising newly created paths (Heiberg et al., 2020). Place-based leadership acknowledges the multi-actor constellations typical in regional development processes, and is concerned with engaging versatile actor groups, guiding development work, and ultimately mobilising collective action and pooling resources for a benefit that goes beyond individuals' interests (Gibney et al., 2009; Sotarauta and Beer, 2021). These three types of change agency often play together in regional development processes as shown by a number of recent empirical studies (Bækkelund, 2021; Grillitsch et al., 2021; MacKinnon et al., 2019; Sotarauta et al., 2020).

While the role of Schumpterian innovative and institutional entrepreneurship is well understood in the urban experimentation literature, the "sense of place" in which such experiments are embedded is important but still unexplored (Frantzeskaki et al., 2018a, 2018b; von Wirth et al. 2019). Therefore, the introduction of place-based leadership holds potential to enhance the analytical leverage when studying urban experiments. It refers to how actors in particular contexts, formally and informally exercise their influence and engage other actors in processes of change. "It is also about revealing the types of social processes involved in 'making things happen' and in 'get-ting things done' (or not getting things done) (Sotarauta et al., 2017: 188)." Given that urban experimentation is a multi-actor process, the success of which largely depends on building coalitions, identifying common interests and aims, and jointly mobilising resources, place-based leadership is expected to be important in such processes.

To account for the structural embeddedness of agency the TCA uses the notion of opportunity space, which is understood as the "time or set of circumstances that make a change possible" (Grillitsch and Sotarauta, 2020, 713) and stratified in time-specific, region-specific, and agent-specific opportunity spaces. The time-specific opportunity space refers to what is possible given the existing global stock of knowledge, resources, and institutions at any given point in time. Region-specific opportunity space reflects the local preconditions influencing also the experiences and encounters of actors. Lastly, agent-specific opportunity space considers the individuals' capabilities and perceived opportunities to invoke change. The agent-specific opportunity is influenced by an agent's competences, position in social networks, expectations, past encounters and experiences.

To be sure, outcomes in change processes result from combinations of change and maintenance agency (Bækkelund, 2021; Jolly et al., 2020). This includes institutional maintenance work aimed at reproducing existing conventions, norms and values (Lawrence and Suddaby, 2006). It also covers a range of actions aiming at exploiting existing markets and coupled with this economies of scales and learning processes producing increasing returns (Klitkou et al., 2015), downscaling and retention activities in periods of declining markets (Grillitsch et al., 2021).

2.3. Combining the process and change agency perspectives

The novelty in this paper is to combine the process perspective in the existing literature on urban experiments with the human agency perspective developed in the literature on regional development, contributing to a better understanding of the governance and management of urban experiments. The human agency perspective is applicable to urban experiments because, firstly, urban experimentation processes as well as regional development processes are situated in a specific temporal and spatial context. Second, urban experiments and regional development are seen as multi-actor processes in which it is deemed crucial to ensure the engagement, participation, and mobilising across actor groups with varying intentions and capabilities. In this context, place-based leadership might prove useful to better understand the negotiation of differing interests, relationships, motivations and visions. Third, the agency perspective in regional development puts an emphasis on institutional change, which has recently been foregrounded as an under-studied but important aspect of urban experimentation (Fuenfschilling et al., 2019). Fourth, the agentic perspective in regional development is mainly motivated by developing a better understanding of change, which is also at the heart of urban experiments. The change agency perspective holds potential to explain why, how, and under which conditions urban experimentation processes make change outside the boundaries of the experiment possible, which is the ultimate objective of urban experimentation but has received

too little attention in the literature and policy practice (Bulkeley et al., 2018).

For developing the analytical framework combining the process with the agency perspective, we faced the challenge that the processes described in the literature (see Section 2.1.) do not pay much attention to timing, i.e. when the processes happen. For instance, shielding, nurturing, and empowering in niche experiments, or deepening and broadening in transition experiments may but do not necessarily occur simultaneously. However, studies on human agency show that the sequence of actions and events matter and the causality between structure and agency needs to be studied over time (Archer 1982; Sotarauta and Pulkkinen, 2011; Grillitsch and Sotarauta, 2020). Therefore, we propose to sequence urban experiments in three phases, the first one capturing conception and development processes, including the framing of the problem and developing of a (set of) solution(s), the second covering testing and demonstrating of the developed (set of) solution(s), and the third phase being about scaling and diffusion processes. To be sure, urban experiments do not need to evolve in a linear manner. For instance, during testing and demonstrating, the actors may realise that the framing of the problem is not adequate or that the developed solution does not work, which means either moving back to phase 1 or quitting the urban experiment without scaling (but possibly with diffusing the lessons learned). However, a successful urban experiment, we argue, will go through all the three phases. We cross the three phases in urban experiments with the three types of change agency and structural maintenance agency as introduced in Section 2.2, resulting in the analytical framework presented in Table 1. The empirical study will interrogate how the different types of agency play together and result in the observed outcomes in each of the phases, as well as how the respective outcomes in preceding phases shape the conditions for agency in the subsequent phases.

3. Methods and case

3.1. Data collection

We investigate change agency in urban experimentation processes with a qualitative case study research design (Yin, 2003) of the ElectriCity project in Gothenburg, Sweden. First, we traced the urban experimentation process using archival sources and documents, chronologically capturing the development of ElectriCity and the relevant context. Key events were identified that influenced the trajectory of ElectriCity, including those that led to its initiation, as well as the relevant context covering institutions, technology and markets. Process tracing helped to identify important actors and the causality of their actions on the subsequent process (Collier, 2011; Bennett and Checkel, 2014). Here, the interactions between different actors, their intentions, motivations and interpretations were of specific interest (Grillitsch et al., 2021).

Second, crucial actors identified through the document analysis were interviewed to gain deeper insights into their interactions, intentions and actions. Semi-structured interviews allowed interviewees to speak freely about their actions and perceptions. Questions revolved around why actors were involved, their roles and competences and who they worked with and why. Furthermore, participants were asked about specific challenges they perceived during the project and how these were resolved, what they perceived as supporting mechanisms and the broader effects of the project. This was facilitated through reminding about key events identified in the process tracing (Grillitsch et al., 2021). Interviewees were also asked about suggestions for further persons to interview. In total eight interviews were held with representatives of the involved organizations. Each interview after the initial five provided a decreasing amount of new information so the decision was made to stop data collection. Table 2 shows the anonymised interviewees and their positions.

3.2. The case: electricity

ElectriCity was initiated in 2013 by Volvo and the City of Gothenburg (CoG) as an effort to develop, test, and demonstrate the use of fully-electric buses in the public transport (PT) system in Gothenburg, Sweden. It includes a variety of actors from regional and national government, academia and the private sector but without noticeable involvement of citizens. The major component of the ElectriCity was Route 55 dedicated to testing and demonstrating fully-electric buses and related infrastructure such as charging facilities and indoor bus stops. Various technologies were developed, tested and integrated into Gothenburg's PT system. In addition to Route 55, ElectriCity comprised an innovation platform that was designed to allow external companies to use data generated by the project to develop new technologies. In 2016, a second line was added (EL16) where high capacity, articulated electric buses were tested. ElectriCity allowed insights into the technologies necessary to operate fully electric PT, consequences emerging for urban planning as well as benefits and downsides connected to electric busses. By the end of 2020, Route 55 was terminated and an order of 160 new electric buses was placed for widespread use in CoG. However, this did not mark the end of the ElectriCity cooperation. The participating organizations have turned attention to other parts of Gothenburgs' transport system, testing fully electric and autonomous ferries as well as delivery trucks and utility vehicles.

Table 1
Analytical framework.

	Phase 1: Conception and Development	Phase 2: Testing and Demonstrating	Phase 3: Scaling and Diffusion
Innovative Entrepreneurship			
Place-based leadership			
Institutional Entrepreneurship			
Structural Maintenance			

Table 2
Interviews.

Interviewee	Position	Date
I2	Project coordinator, Science park	31.03.2021
I2	Project coordinator, Business Region Göteborg	01.04.2021
I3	Project coordinator, City of Gothenburg	01.04.2021
I4	Project coordinator, Volvo Busses	06.04.2021
I5	Consultant	07.04.2021
I6	Project coordinator, Ericsson	14.04.2021
I7	Project coordinator, Energi Göteborg	21.04.2021
I8	Traffic planner, Västtrafik	28.04.2021

3.3. Analysis

Using the analytical framework developed in Section 2.3, we used key events to identify the phases of the ElectriCity experiment. The conception and development phase started in 2012 when Volvo and CoG signed a memorandum of understanding. Activities in this phase focused on formulating a vision, organizational development, finding relevant partners, identifying regulatory and technological requirements, and the development of a PT solution. The conception and development phase ended in 2015 with the start of route 55, which marked the beginning of the testing and demonstration phase in which activities focused on running the two test lines, learning about and developing the tested technologies, finding new business models for the provision of electricity but also redeveloping the collaborations' organization. The testing and demonstration phase ended in 2020 with the termination of route 55. Västtrafiks' order of 150 fully-electric busses preceded the termination of route 55 but marked the beginning of the scaling and diffusion phase when the electric busses were used to replace older diesel busses. Furthermore, the partners of the ElectriCity collaboration turned their attention toward electrifying other means of urban transport. The timeline of events in the ElectriCity experimentation process is summarised in Fig. 1.

The analysis of the documents and interviews were then coded to capture i) the main phases of ElectriCity and ii) the three types of change agency and structural maintenance agency as per the analytical framework. The interpretation and subsequent coding of
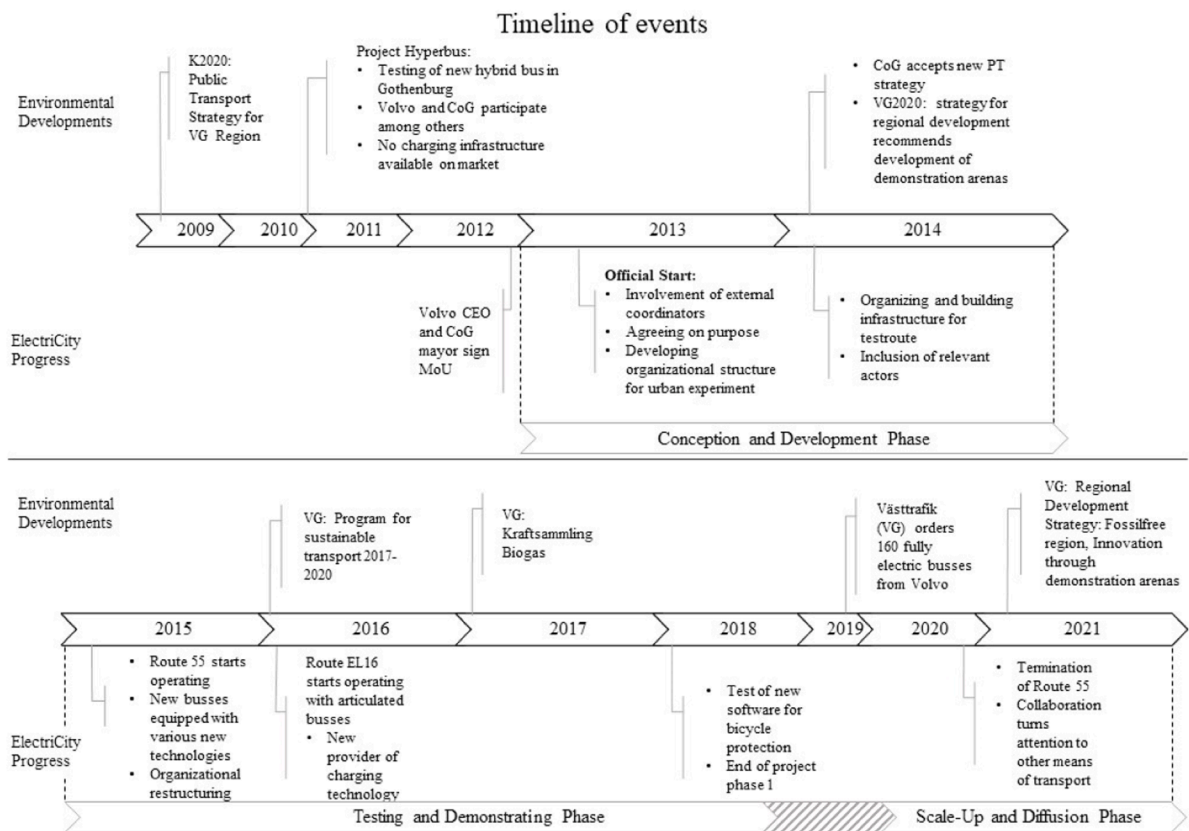

Fig. 1. Timeline of Events.

responses was firstly guided by the temporal dimension, allowing to assign specific statements to the three phases. Secondly, responses concerning specific actions were assigned to the types of TCA if they could be associated to the definition of one of the four types of agency, e.g. a statement about the development of a new technology was coded as innovative entrepreneurship. The assignment procedure allowed associations of particular statements with more than one type of agency. However, since the TCA was developed not specifically to explain urban experimentation, rival explanations had to be considered as well. We compared the insights emerging from the data with the theoretical propositions (Yin, 2003). Data that did not match the initial categories, e.g. when actions were described that did not fit the TCA, alternative explanations or categorizations were considered. Contextual developments were collected in a separate document. The chronology of the urban experimentation process, the information about change agency, and theoretical propositions were then brought together in a narrative approach with the aim to go beyond "an idiosyncratic story of marginal interest" (Langley, 1999, p. 697).

4. Results

The following subsections are dedicated to the analysis of how the three types of change agency as well as structural maintenance influenced the progress of ElectriCity during the three phases described above. Within the phases, the subsections are arranged according to their relevance.

4.1. Institutional change preceding electricity

Electricity was preceded by two contextual events. First, in 2009 Västra Götaland County (VG) published the new public transport strategy 'K2020' (Göteborgsregionens et al., 2009), marking a change in local thinking about PT. Car-based individual traffic is described as unsustainable and no longer seen as a priority in planning. Instead, measures are suggested to grow the share of cycling and PT in the modal split, including restrictions but also improvements to infrastructure and vehicles. K2020 can be interpreted as a first vision of the future of urban transport, requiring both institutional and technological change. This opened a time- and region-specific opportunity space in the Gothenburg region that traditionally has a strong presence of vehicle manufacturers and suppliers, including Volvo. In 2011, Volvo initiated the project HyperBus in Gothenburg in order to test a newly developed hybrid bus in cooperation with the local development agency, the energy agency, the city's traffic department and the region's public transport company (N.A., 2011). The project was described as crucial experience in collaborative projects between the public and private sector by several interviewees (I2; I4).

4.2. Conception and development (2012–2014)

4.2.1. Place-based leadership

Place-based leadership in the first phase focused on processes of capacity and constituency building as well as the articulation and development of expectations and vision. Here, firms and local governmental actors took leadership roles.

CoG and Volvo can be identified as the key actors. At first, Gothenburg's mayor and the Volvos' CEO merely agreed on starting a collaboration but were lacking a clear thematic focus (I4). One aim of CoG and Volvo was to grow Volvo's and the region's competitiveness and attractivity. Volvo stressed the importance of carrying out activities in its hometown (I1; I2; I4). CoG articulated a strong interest in Volvo's economic future due to its role in the local labour market and financial weight (I2; I5). CoG and Volvo engaged an external consultant firm experienced in the field and well-connected locally. Together, they developed a vision for the collaboration and concretized the idea of focusing on testing, demonstrating and learning about electric busses (I5; I4). In the later course of phase one, new actors and resources were mobilised. First and foremost, this was a task of the external consultancy firm. The consultants actively introduced new organizations to the project that provided capabilities crucial for the projects' success. The inclusion of VG and its transport company Västtrafik as well as Chalmers University of Technology can be traced back to this engagement (I5). However, Volvo also actively extended the collaborations' network. One example of this is the inclusion of Ericsson, a Swedish telecommunications and network company.

The funding of ElectriCity can also be connected to place-based leadership. The project was mainly funded by VG, CoG, Chalmers University and Volvo (N.A., 2016). For this purpose, Volvo was granted financial support from the Swedish Energy Agency (Energimyndigheten, 2014). However, this funding benefited other participating parties as well such as the consultants who were initially co-funded by Volvo and CoG and later by Volvo alone (I5).

4.2.2. Innovative entrepreneurship

Firms acted upon the opening of a region-specific opportunity space related to the institutional changes described in 4.1 and a time-specific opportunity space related to the global need to develop more sustainable PT systems. At the same time, the available electric bus technologies on the market were not satisfying. On the one hand, there were trolleybuses constrained by their wire infrastructure and, on the other hand, fully-electric busses with batteries large enough for a whole shift of operation were produced by Chinese manufacturers. This situation provided an opportunity for Volvo as a well-established European manufacturer to develop a new fully-electric bus system, based on the knowledge gained from operating the hybrid busses. The new busses are based on opportunity charging. They are equipped with smaller batteries than the solutions developed by Chinese manufacturers that allow the bus to be operated over the length of the route at the end of which it has to be recharged (N.A., 2016, I2, I4). A substantial part of this development was the design of a new fully-electric powertrain that marks a radical change from the previous design based on

combustion engines (Nordin, 2018).

Volvo also developed a new charging system based on a rail mounted on the busses' roof and a pantograph that is lowered from the charging station onto the rail, delivering the energy. This system was called OppCharge and the intention was to market it as an open interface in order to enable other manufacturers to use the same system (N.A., 2016; I1; I4; I7). OppCharge also required a new type of charging infrastructure that was not available on the market. For this purpose, several manufacturers designed charging stations that could be included in bus stops. In the conception and development phase the German firm Siemens was chosen to deliver the technology (N.A., 2016, I7).

4.2.3. Institutional entrepreneurship

Private and public actors engaged in institutional entrepreneurship aimed at nurturing a new way of thinking not only about urban transportation but also about innovation and the public sectors' role as elaborated in the regional development strategy VG2020 (Västra Götalandsregionen, 2013) and the smart specialization strategy (Västra Götalandsregionen, no date). Here, VG emphasised the responsibility of the public sector to support development of sustainable innovations through procurement. Furthermore, both strategies ascribe an important role to arenas where new solutions can be tested and demonstrated in an environment that includes all relevant groups. Another aspect of institutional entrepreneurship concerns the establishment of collaborative testbeds as a new mode of innovating. For Volvo, the testbed strategy and active collaboration with the public sector was a novelty. While the company had previous experience in collaborative projects, the scale of ElectriCity exceeded previous projects (I4) as is the case for public actors like CoG and BRG (Business Region Göteborg) (I2).

4.2.4. Structural maintenance

For Västtrafik the ElectriCity project posed a challenge. The public company previously had not fostered a culture of innovation and consequently had problems to enable learning from the participation in ElectriCity (I8).

4.3. Testing and demonstration (2015–2019)

In the testing and demonstration phase events were shaped by institutional entrepreneurship and place-based leadership. Instances of innovative entrepreneurship can also be found but were not as pronounced as in the previous phase.

4.3.1. Institutional entrepreneurship

Institutional entrepreneurship can be connected to firms as well as regional governmental actors and focused on learning and deepening processes. In 2016, VG started a 'Programme for Sustainable Transport 2017–2020′ (Västra Götalandsregionen, 2016) with the target of achieving a fossil fuel free transport sector by 2030, for which electrification is essential. The program also recommends an integration of urban planning and PT and the collaboration of transport planning with other actors, specifically from the private sector. The latter is framed as a way to develop and export internationally competitive technologies that reduce fossil-fuel usage globally but also secure the economic future regionally.

Internally, the operation of Route 55 required changes to the organizational structure that was previously designed for Route 55. The reorganization was driven by the external consultants and researchers from Chalmers. In the new organizational structure, operation of Route 55 was clearly separated from the learning and development functions. Coordination between functions was secured by a steering group comprising VG, CoG, Volvo and Chalmers. This entailed that organizations like the university's property company, that were not previously involved in PT, had to adapt to new practices and learn about the development and operation of bus stops (N.A., 2016; Webb, 2018).

4.3.2. Place-based leadership

Maintaining directionality, extending networks and constituency as well as capacity building were important processes that can mostly be connected to private sector actors like Volvo and external consultants exercising place-based leadership.

While some decisions for the inclusion of new actors, like ABB, a Swedish-Swiss robotics and electrical equipment manufacturer, were motivated by technological necessity (I4, I7), in other instances the BRG actively engaged to open the project for new participants to enable other regional firms to benefit from the collaboration. This marked a point where the different motivations and intentions of the participating actors became apparent. On one side, the governmental actors wanted the project to benefit the wider regional economic and urban development. On the other side, Volvos' motivation was of economic nature and focus was on developing and learning from the project to later be able to collect rents from the innovations developed here (Webb, 2017; I4). This situation represented one instance where the external consultants were required to mediate between the different parties to secure progress and maintain directionality. While many interviewees did not connect the consultants' actions to specific outcomes, their coordination and promotion of a cooperative spirit and attitude was mentioned as a decisive factor for the progress of ElectriCity (I3; I4; I6). Furthermore, the consultants appeared to have developed a strong personal commitment to ElectriCity that went beyond purely economic motivation (I5).

Another aspect of place-based leadership was the acquisitions of public funding by Volvo that enabled the operation of articulated busses on Route EL16. The funding was provided by VG through its programme for sustainable transport (Fogelberg, 2021), but also from Energimyndigheten to develop a demonstration platform for high-capacity buses (N.A., 2020; I4).

4.3.3. Innovative entrepreneurship

Innovative activities were not as pronounced in the second phase as in the first phase, focusing mostly on adapting previously developed technologies to new uses. For route EL16 Volvo adapted the fully electric drivetrain to new articulated busses. This included the use of larger batteries that allowed the busses to have an energy reserve to avoid recharging in rush hours. Instead, charging happens in a depot overnight and during stops on the route when the bus is in service (N.A., 2020; I4). Based on the larger busses, Ericsson initiated the development of a cyclist safety system in cooperation with a bike sharing service in Gothenburg. The system uses geofencing technology that measures the distance between a bicycle and the bus in congested areas. In case the distance falls below a threshold, both the cyclist and the driver receive a warning. Furthermore, Ericsson installed air-quality sensors on busses operating on Route 55 to map local air-quality in real time (I6).

Innovative entrepreneurship refers also to the development of a new business model for the supply of electricity to the PT operator by Energi Göteborg. In this model, Energi Göteborg provides charging infrastructure for the operator. Costs for the electricity used are invoiced to the operator who in turn charges the purchaser of the transport services. The development of this business model can be seen as a crucial step for the later larger-scale use of electric busses and other means of electric vehicles since the fuelling is a component in electrified transport that is significantly different to traditional vehicles (N.A., 2016; I7).

4.3.4. Structural maintenance

The program "Kraftsammling Biogas" published by VG presents an initiative to support the regional biogas sector. Here, using biogas as a renewable fuel for transport is considered as an alternative to electrification of public transport (Ekengren, 2017). While the programme did not have a negative effect on ElectriCity, it was mentioned by one interviewee to have caused irritation among the participants (I3).

4.4. Scaling and diffusion (2020 and onward)

Activities focused on the electrification of a large part of Gothenburg's bus fleet, applying the learnings from the collaboration in other contexts and finding new fields of engagement for ElectriCity. This phase was mostly shaped by institutional entrepreneurship and place-based leadership.

4.4.1. Institutional entrepreneurship

Institutional entrepreneurship included the transfer of the governance model to other fields and the standardization of the technology by firms and participants from the public sector.

Several interviewees named the organizational structure of ElectriCity as a unique factor that was radically new at the time of initiation (Mattsson, 2021). Consequently, several participants actively worked to apply similar structures to other collaborations including for instance Lindholmen Science Park comprising a number similarly structured collaborative projects (Lindholmen Science Park, 2021; I1), BRG who started a testbed program for SME in Gothenburg (Bern, 2021) or VG who, in a new regional development strategy recommend demonstration platforms and real-life arenas for innovations for sustainable development (Västra Götalandsregionen, 2021).

Furthermore, Volvo has actively been engaged in standardizing OppCharge. Both, the European Automobile Manufacturers' Association and the SAE, which is an American based professional association and standard setting organisation in the field of engineering, either recommend or developed a standard for charging technology for busses that resembles OppCharge (ACEA, 2017; SAE, 2020). Other European and American bus manufacturers have adopted the standard and the technology is rolled out in other European cities (Volvo Bus Corporation, 2021). As a consequence of ElectriCity, Volvo and its partners are now able to demonstrate a successfully electrified PT system and sell a packaged solution including both busses and the charging infrastructure. In this context, Volvo interpreted ElectriCity as "a way of preparing the market" (I4).

Lastly, ElectriCity triggered changes in the organizational structure of some of the participating actors. Especially Västtrafik was initially troubled to foster an innovative culture and enable learning from the project. For Västtrafik, ElectriCity was the first time a new technology could be tested and co-developed in a testbed environment before acquisition. This required changes in the company's culture toward accepting risk and uncertainty (I8).

4.4.2. Place-based leadership

Place-based leadership allowed for capacity building that enabled the diffusion of electric busses and the broadening of the approach toward other fields of activity. In 2019, Västtrafik provided the funds for a tender to acquire 160 new fully-electric busses that started operating in late 2020 (Bussmagasinet, 2019; N.A., 2020). Subsequently, attention was then shifted to other means of urban PT and CoG suggested a project to develop autonomous electric ferries in cooperation with Ericsson (I7). In the same environment Volvo Penta, the company's heavy- and marine industry subsidiary, ABB and Chalmers University acquired funding from the SEA to test electric fast-charging ferries (N.A., 2020).

4.4.3. Innovative entrepreneurship

Innovative entrepreneurship is not as pronounced in the scaling and diffusion phase as in the earlier phases. Volvo and ABB cooperated to electrify ferries previously run by combustion engines. They plan to electrify the ship's powertrain and charge it with an HVO-run generator on board. In a second phase, the companies are planning to adapt the OppCharge technology for busses to charge the ferry (N.A., 2020). Lastly, focusing development and production on electric vehicles required Volvo to restructure its operation that

223

Table 3
Summary of results.

	Phase 1: Conception and Development	Phase 2: Testing and Demonstration	Phase 3: Scaling and Diffusion
Institutional Entrepreneurship	• New conception of sustainable transport and codification thereof • Urban experiment as collaborative testbed and demonstration arena for innovation	• Institutionalization of collaborative urban experiments and electrified urban transport	• Application of testbed/demonstration arena in new contexts • Standardization of technologies enables scaling up their use (OppCharge)
Place-based leadership	• MoU between Volvo and Mayor • Mobilisation, inclusion and coordination of additional actors and resources	• Continuous inclusion of new actors • Negotiation of differing views and motivations • Provision of funding by regional and national entities	• Using the experiments' potential to realize benefits in other modes of urban transport • Provision of funding to scale-up use of electric busses
Innovative Entrepreneurship	• Development of fully-electric buses based on newly designed powertrain • Charging system OppCharge consisting of several new components	• Application of new powertrain to articulated busses • Business model innovation for energy supply	• Electrification of ferries and application of charging technology in the same context
Structural Maintenance	• Lack of innovation culture	• Kraftsammling Biogas	

was tailored to the development of diesel fuelled busses. Producing electric busses requires different machinery, suppliers and knowledge. Thus significant changes in production and organization had and will continue to be made in order to accommodate the large scale production and distribution of electric busses (Nordin, 2018).

5. Analysis

Speaking to the process perspective in the literature on urban experiments (Hodson et al., 2018; Torrens and von Wirth, 2021) and the call to study the interplay between agency and structure over time (Archer, 1982; Grillitsch et al., 2021), the current paper proposes to analyse urban experiments in three phases by zooming in on i) conception and development, ii) testing and demonstrating, and iii) diffusion and scaling. The paper investigated change agency in each of the phases as summarised in Table 3.

Institutional entrepreneurship and place-based leadership explain why and how ElectriCity took off during the conception and development phase. This included i) the establishment of a new vision and strategy for urban public transport as an antecedent of ElectriCity, ii) the signing of a Memory of Understanding between the City of Gothenburg and Volvo, iii) the conception of a purpose and goals for the collaboration, iv) the mobilisation of additional actors and resources, and v) setting up a collaborative testbed and demonstration arena, which was at that time a new mode of governance. Then, innovative entrepreneurship led by an incumbent firm was necessary once the purpose and goals, or in other words the problem, were defined. A new powertrain and new opportunity charging systems constitute new to the world solutions to the articulated problem.

Testing and demonstration required institutional change encompassing new organisational structures separating the operation of Route 55 from the learning and development functions, as well as new practices in existing organisation. In a programming exercise, the integration of urban planning, planning for public transport, and regional development was promoted with the aim to achieve a fossil fuel free transport sector by 2030, and a competitive transport sector exporting fossil-fuel free public transport solutions globally. Place-based leadership played a role in engaging more actors, negotiating between differing views and goals of the participants and in attracting further funding for extending the experiment to articulated busses. Innovative entrepreneurship was more of an incremental nature, including the adaptation of the technology to articulated busses, requiring for instance larger batteries, and the development of a new business model for electricity supply, and charging of electric vehicles.

Institutional entrepreneurship also played a strong role in scaling and diffusion. Volvo actively engaged in standardising the new opportunity charging system, which would allow them to sell their solution globally. Within the city, the successful urban experimentation practice, and in particular the novel organizational structure, was replicated in various other collaborative urban experiments. Locally, 160 fully-electric busses were acquired and diffusion included the mobilising of actors for new urban experimentation processes covering other modes of transport such as electric ferries (place-based leadership). Innovative entrepreneurship followed the shift in attention experimenting with charging technologies and powertrains of ferries. In addition, producing electric busses at larger scale required significant organizational change and process innovation.

Surprisingly, only two instances of structural maintenance delaying the experiments progress could be identified. In the first phase one actor was slowed down by a lack of innovation culture. In the second phase a regional initiative to promote a different alternative fuel caused irritation as it signalled a diversion from the common vision. The lack of resistance could be explained by the fact that a major incumbent actor was involved in the experiment. Furthermore, the initiative was backed up by highly ranked regional politicians which may have had a streamlining influence on the progress as well as simplified the securing of sufficient funding.

6. Conclusion

From our case, we learn that influential (incumbent) local actors with strong financial resources and technological capabilities, who take a strategic, change agency-oriented perspective, can be important in urban sustainability transitions. Processes involving such influential actors may start open-ended where place-based leadership is important for the mobilisation of actors based on overlapping interests. During the process, differences of interests may emerge and cause a risk of capturing the processes by certain actors. An agency perspective draws attention to changing interests and actor engagements during an urban experiment, which are expected because different outcomes can be expected at different phases. While in the conception and development, as well as the testing and demonstration phases, all actors may have an interest to gain new knowledge, in the scaling and diffusion process firms will seek opportunities to market the solutions beyond the region and may be increasingly more concerned with appropriating the benefits. This may create differences in interests regionally, but - in our case – was also necessary of scaling beyond regional borders.

While ElectriCity constitutes just one example how change agency forms and produces effects in and beyond the urban experimentation processes, we would like to suggest that the unveiled interplay between different types of change agency expresses more general and necessary causal powers in an unfolding urban experimentation process. Actors need to engage to create new visions of socio-technical systems (in this case urban public transport), which open the opportunity space in which urban experiments may be initiated (Karvonen and van Heur, 2014). Actors need to shape the institutional arrangements of an urban experiment, including its boundaries, organisation, and shielding mechanisms. (Fuenfschilling et al., 2019). Urban experiments are multi-actor processes, and thus the mobilisation of actors is essential (Bulkeley and Castán Broto, 2013). This entails negotiating the sometimes overlapping and sometimes colliding interests of various actor groups, identifying a common purpose, mobilising actors, and pooling resources. The search of solutions to the defined problem arguably requires innovation under high degrees of technological and market uncertainty (Karvonen et al., 2014). Moving from conception and development to testing and demonstration, suitable organisational and institutional structures need to be set in place, and new actors (who take part in the testing and demonstrating) need to be mobilised. Some adaptations to the solutions (more incremental innovative activity) will often be necessary, or it may even be required that the actors

may have to develop new solutions. Institutional change in the form of standardisation may be a key mechanism in upscaling processes (Sareen and Rommetveit, 2019). However, we also see that the successful practices are diffused in new experiments (von Wirth et al., 2019).

The focus on agency in urban experimentation processes allows to connect actions and interventions – the dealings and wheelings of multiple actors and actor groups – to socio-technical outcomes such as transformed urban transport systems. It inserts a temporal logic in the analysis of structure and agency (Archer, 1982; Bhaskar, 1998), which makes possible to trace urban experiments from the construction of the niche, the experimentation process per se, to wider outcomes in terms of scaling a solution, or transferring a governance model to other contexts. Agency presupposes actors' reflexivity and possibility to learn during an emerging experimentation process, and social learning is a key outcome per se (Borghei and Magnusson, 2018). A limitation of this study is that the learning outcomes are, however, not explicitly studied, even though the documented outcomes may be considered as manifestations of learning outcomes. Given the importance of social learning (Sengers et al., 2016), it would be interesting to add a layer to the methodological approach, which studies the learning outcomes at the actor level and connects those outcomes to the way actors engaged in the urban experiment.

Combining the change agency with the process perspective of urban experiments contributes to the literature by shining light on three identified research gaps. This firstly concerns the question how urban experiments can induce larger system change beyond the boundaries of specific experiments (Bulkeley et al., 2018; Scholl et al., 2022). The interplay between the three types of change agency during an urban experiment constitutes a necessary causal power for making such system change possible, as illustrated with this case study. Secondly, as Frantzeskaki et al. (2018a, 2018b) argue, the "sense of place" is lacking in the literature on urban experiments. We suggest that this gap can be addressed with the concept of place-based leadership. We show the importance of place-based leadership for developing a shared objective, engaging various actor groups, negotiating between differing interests, and mobilising resources collectively. Thirdly, the institutional dimension requires more attention in urban experiments to better understand how institutional arrangements change during experiments (Raven et al., 2019). The inclusion of institutional entrepreneurship as type of change agency sheds light on the institutional change necessary to make urban experiments possible, as well as the institutional work conducted by actors in the various phases of the experiment. Therefore, change agency helps explaining why urban experiments take place, as well as why and how they may contribute to larger system change. We thus suggest that an agency perspective is promising for future research, interrogating, for instance, why and how agency patterns vary for different types of experiments, and in different spatial and temporal contexts; and whether, why and how different types of agency are sufficient or necessary to make possible the desired outcomes in the various experimentation processes.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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