# Constitutive Tensions of Transformative Research
# – Infrastructuring Continuity and Contingency in Public Living Labs

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## Abstract

Living labs and *Reallabore* are policy attempts to provide infrastructures for societal transformation towards sustainability. They attempt to do so through facilitating experimental modes of societal learning and innovation in inter- and transdisciplinary environments. We suggest that building and maintaining such infrastructures includes simultaneously rely on continuity by following conventions of knowledge production and allow for contingency as a resource for surprise. Both are necessary, inevitably prompting a 'constitutive tension'. Based on a study of two living labs on urban mobility in Austria, we ask how specific labs inscribe continuity and contingency into their infrastructures. Our analysis shows that the living labs attempted to connect to diverse communities, providing a source for contingency. At the same time, however, we observe a tendency to mitigate contingency when the production of outcomes is at risk. Based on the discussion of this exploratory case study, we reflect upon the transformative potential of living labs.

**Keywords:** transformation, tensions, collaboration, innovation, infrastructure

## Introduction – Living Labs as transformation infrastructures

Policy and research actors are prompted to develop ever new avenues and models for addressing 'grand challenges' (European Commission, 2009; Kuhlmann and Rip, 2014). They are faced with pressing, overarching and complex societal problems that can neither be clearly pinned down nor ignored. The ultimate goal becomes facilitating transformation towards more sustainable futures. To reach this goal, policy actors in particular (see European Commission, 2011) consider innovation to be indispensable (Felt, 2016; Van den Hove et al., 2012). Innovation is deemed "today's go-to resource for bringing about the future" (Pfotenhauer and Juhl, 2017: 85), with ever-new settings for facilitating innovation emerging and being experimented with. Living labs are one such example.

Acknowledging the increasing relevance of and political focus on living labs[1], this article puts an explicit focus on those labs' approaches toward facilitating innovation, such as enabling experimental modes of societal learning. The promise of living labs is to enable societal transformation by integrating different societal actors into the innovation process (see Engels et al., 2019; Liedtke et al. 2015; Rose et al., 2018; Schliwa and McCormick, 2016; Schneidewind et al., 2018). The selling point is to facilitate experimentation in real but adaptable 'innovation-friendly environments' (Dickel et al., 2019; Felt, 2016), which could be upscaled if needed. Indeed, some authors have argued that living labs not only test new technologies and solutions, but the readiness of societies to accommodate new socio-technical arrangements (Engels et al., 2019).

In this vein, we suggest that living labs establish specific infrastructures, understood as socio-technical arrangements (Bowker and Star, 2000; Slota and Bowker, 2017), which facilitate the production of transformative knowledge. By this we mean knowledge which contributes to societal transformation towards sustainability. Transformative knowledge implies a transformation of how such knowledge is produced. On the one hand, living labs rely on continuity with the sense-making conventions of the different actors involved (researchers, policy makers, citizens, practitioners,

etc.). This is precisely what facilitates their engagement in unfamiliar participation and innovation activities. On the other hand, living labs aim to enforce contingency which holds the promise that things could be otherwise. Contingency, rooted in a proliferation of (mostly unknown) influencing factors, might cause uncontrollable and unpredictable courses of events, might yield surprising questions and observations and thus holds the potential to overcome lock-ins and established pathways.

This understanding of continuity and contingency as constitutive of innovation is not entirely new. It rests on Kuhn's (1977) 'essential tension of research' and on Rheinberger's (1997) and Hackett's (2005) use of the notion for analysing social and material research arrangements. In our study, we extend this idea to the workings of living labs. We ask how such 'constitutive tensions' are inscribed into their infrastructures. Following Bowker & Star (2000) and Slota & Bowker (2017) we understand infrastructures as spatially situated arrangements of interrelated organisational, material and symbolic elements which both facilitate and constrain lab activities. Throughout this paper, we argue that the constitutive tension between continuity and contingency may be regarded as a central socio-epistemic component of lab infrastructures. At the same time, however, the orchestration of infrastructural dimensions tends to make invisible the labs' tendency to temper contingency in favour of enabling useful solutions for specific actors.

By analysing how continuity and contingency are inscribed into lab infrastructures as constitutive tensions, we aim to advance existing literature on tensions in and of transformative research. Critical empirical contributions often describe transformative research as inherently contradictory and even paradoxical (Bijker and Bijsterveld, 2000; Felt et al., 2016; Maasen and Lieven, 2006; Polk, 2014). For example, in relation to inter- and transdisciplinary research, this literature mentions 'enduring tensions' (Parker and Crona, 2012), 'essential tensions' (Turner et al., 2015), 'inherent tensions' (Schikowitz, 2020) or 'border troubles' (Petts et al., 2008). A few studies (Engels and Rogge, 2018; Leminen et al., 2015) also address tensions in real world labs or living labs.

These authors agree that such tensions cannot be resolved but need to be dealt with or even 'embraced' (Engels and Rogge, 2018; Scoones and Stirling, 2020) permanently. We contribute to this literature by addressing not only political or ideological tensions inherent in participatory settings, but also epistemic tensions. We develop an analytical frame for analysing such tensions in a differentiated and comprehensive manner.

For this contribution, our empirical cases are living labs on urban mobility in Austria[2]. In particular, we analyse two contrasting cases in the same funding program, which focus on either participation or innovation as main leverage points for transformation. We use these two cases as a pilot study to explore different ways of infrastructuring, which we understand as building and maintaining infrastructures. According to the funder, the overall purpose of the living labs is

> [...] [to] increase the practical impact of research and enable societal transformation processes according to the program targets, the initiative urban mobility laboratories complements the program portfolio with a structural component. Urban mobility laboratories - in the sense of a "living laboratory" - should develop suitable spaces, structures and processes for this, and build a solid participation-, coordination- and cooperation platform for accompanying and complementing research and development initiatives. (5f)

Due to this positioning in particular, the Austrian urban mobility labs provide a fitting example for broader developments and reasonings for living labs as defined above (see also Liedtke et al., 2015). They have been introduced to support infrastructures for transformative research that go beyond single projects and should specifically facilitate cooperation between different actors in innovative research and development.

To summarize, the contribution of this research is threefold: first, by drawing on the concepts of continuity and contingency we advance a differentiated account of constitutive tensions in infrastructuring processes. In our view, their epistemic implications need to be acknowledged. Second, by combining the concept of constitutive tensions with a heuristic for analysing infrastructuring in its organisational, material and symbolic

aspects, we provide the means for researchers and practitioners alike to analyse and reflect upon such tensions systematically. That is, we propose to work with them productively instead of neglecting, externalising, or even attempting to resolve them. As *constitutive* tensions, in our view, they cannot be resolved but must be processed. Third, building on tensions as potentially productive moments, we add an important implication to the concept of infrastructuring: we understand it as a process characterized by ongoing efforts to stabilise and standardise contingent elements, although contingency is explicitly sought in living labs.

## Infrastructuring constitutive tensions - analytical approach & materials

In the following, we first develop our analytical approach. It combines the notion of constitutive tensions of continuity and contingency with the concept of infrastructuring. We then introduce our case and empirical material.

Through convening actors from different scientific and societal fields, transformative research aims to find new kinds of solutions as well as ask entirely new questions. According to our hypothesis, attempts to develop infrastructures for facilitating transformative research, such as living labs, inevitably include a tension between continuity and contingency – continuity with the communities included in the lab and their knowledge traditions, and discontinuity and contingency that arise from the limits of single disciplines and the inclusion of societal actors. We build this assumption on Kuhn's (1977) notion of an 'essential tension':

> I shall therefore suggest below that something like "convergent thinking" is just as essential to scientific advance as is divergent. Since these two modes of thought are inevitably in conflict, it will follow that the ability to support a tension that can occasionally become almost unbearable is one of the prime requisites for the very best sort of scientific research. (Kuhn, 1977: 226)

Kuhn describes tradition (meaning following the conventions and pre-formulated questions within

a specific paradigm) and innovation (understood as readiness to break with these conventions when they do not hold) as mutually constitutive: continuity with a paradigm and its conventions is the prerequisite to acknowledging its anomalies and discontinuities. Herein lies the seed for disruption and transformation. This 'essential tension' becomes even more acute in interdisciplinary research which is challenging *"established intellectual doctrines founded in the classical disciplines"* (Andersen, 2013: 3).

To address how the 'essential tension' is inscribed (Akrich, 1992) into living labs and their infrastructuring activities, we mobilise concepts which apply the notion to the organisation of research groups (Hackett, 2005)[3] and to experimental set-ups (Rheinberger, 1997; Hackett et al., 2004). Both of these are important elements of research infrastructures and can be understood as socio-material arrangements that facilitate specific kinds of research in organisational, material and symbolic ways (see below). Throughout our empirical research, we observed how living labs build infrastructures which are compatible with the sense-making conventions and practices of policy makers and funders on the one hand, as well as different research communities and societal participants on the other hand. These activities are based on an "ensemble of research technologies" (consisting of "materials, methods, instruments, established practices, and the like", Hackett et al., 2004: 748) and on an alignment with policies and the wider research field. While living labs serve as instruments to produce answers to established questions, thereby continuing established sense-making conventions (such as: does a specific technology work and how is it taken up and used?), they are, at the same time, expected to produce surprising observations, signpost new possibilities, and raise awareness that things could be different. In living labs, the encounters and interactions of different actor groups with their different stocks of knowledge, experiences, and values serve as a trigger for contingency and transformative knowledge (see Turner et al., 2015 on interdisciplinary research centers). How these interactions develop and which new questions and ideas are provoked is regarded as contingent.

Subsequently, each lab interprets and translates, for example, the funding criteria, the diverse conceptual literature they build on, and the heterogeneous actors' expectations. These expectations are then aligned with the lab's own ideas of what a living lab is or should be and should achieve. This sense-making process is materially inscribed into the lab infrastructure, which includes different ways of creating continuity and contingency. By implication, the labs themselves are permanently institutionalised *and* innovated. In that sense, we argue that tensions are important elements of the lab infrastructure itself instead of relegating them to the category of unwanted side-effects.

On these grounds, we suggest the term 'constitutive tensions'. These tensions are inscribed into living labs as transformation infrastructures, which operate as socio-technical arrangements (Slota and Bowker, 2017). Living labs create and employ an interconnected set of materials, technologies, people, practices, standards and classifications (Bowker and Star, 2000) which facilitate as well as constrain activities in both intended and in unintended ways. Drawing on pertinent research literature on infrastructuring, we identified three kinds of interrelated dimensions that make up infrastructures and which we used as a guiding heuristic for coding and analysing our material:

(1) Organisational and operational aspects, such as classifications and standards (Bowker and Star, 2000): adhering to certain standardised forms allows the use of infrastructure in the first place, but it includes moral and power relations. We thus regard the lab's organisational model as well as the standardised formats and methods which the labs develop and use as one part of their infrastructure. This also includes the personnel structure and the lab coordinators' and employees' roles.

(2) Material and technical aspects, such as place, buildings, tools and instruments (see Bijker et al., 1987; Winner, 1986; Amin and Thrift, 2002): the selection of the concrete physical places where the labs are located and how these surroundings are shaped and designed to provide a specific frame for the lab activities are crucial aspects of infrastructuring. Likewise, the physical lab venue and how it is equipped with furniture, decorative elements, and technology shape how and by whom the labs can be used.

(3) Symbolic aspects, such as visions, metaphors and stories, which imbue the labs with meaning and which guide and frame their activities (what Deuten and Rip, 2000; and Felt, 2017, describe as 'narrative infrastructures'): we consider the recited stories about the living labs and the aims and visions which we encountered in interviews, the labs' public communication at events and workshops, and their self-presentation on their websites and in brochures as part of their infra-structures.

Organisational, material and symbolic infra-structuring are of course overlapping and inter-twined. We use the distinction of these three dimensions as a heuristic for directing our analyt-ical attention but do not regard them as exclusive or exhaustive analytical categories.

In the following section, we apply these three dimensions in our analysis of the empirical case of the Austrian Urban Mobility Labs (https://mobili-taetderzukunft.at/de/artikel/mobilitaetslabore")[4]. The labs' double-purpose is to facilitate the participation of different stakeholders in research and innovation activities as well as to foster the practical (and market-) implementation of research and development outcomes. In so doing, the labs are also expected to create knowledge about co-creative transformation and innovation processes.

In this paper, we contrast two of the five funded labs[5], one of which focuses on participation while the other focuses on innovation. Empirical literature on living labs across Europe (Liedtke et al., 2015; Engels et al., 2019) suggests that these lab types occur regularly. The cases might offer insights into contrasting ways to infrastructure constitutive tensions with the intention to render research transformative. The main data collec-tion for this paper took place throughout the year 2019 and was continued throughout the first half of 2020. The data collection took place in a phase where the conceptualisation and development of the lab structures had largely been finished and the first projects had started within the labs. Our empirical data therefore reflect exactly the passage between preparing the lab infrastruc-ture and testing and adapting it with the arrival of the lab users. The material therefore provides valuable insights into the process of infrastruc-turing tensions.

The empirical material consists of semi-struc-tured interviews with members of the coor-dinating team of each lab (1 interview with a member from lab 1, and 1 interview with 2 members from lab 2). We also conducted two interviews with members of a project which was based in lab 1, and one interview with a member of a project which took place in lab 2. The inter-views were recorded and transcribed verbatim. This was complemented by participant observa-tion during two field tests of prototypes in lab 1, and during one event in lab 2 where the lab and different projects and their prototypes were intro-duced and could be tested, as well as a citizen workshop for a project, which was organised and moderated by lab 2. Participant observation included informal conversations with lab and project members. From the participant obser-vations, we produced observation protocols including field notes, photos, and ethnographic vignettes. With the arrival of the Covid19-crisis and the related measures and contact restrictions from March 2020 onwards, many lab-activities went online. We conducted participant observation of three online-workshops in lab 1, and one virtual European-level network meeting of different mobility labs. We also analysed lab documents and the labs' self-representation on their websites and in brochures.

While our interest in tensions and infra-structuring emerged from the initial empirical analysis, the conceptual frame for this article is based upon existing research in this field and is enriched by our empirical observations. For the focused analysis, we coded the materials in terms of organisational, material and symbolic aspects of infrastructuring, looking for the ways in which continuity with different actors as well as contin-gency was facilitated.

## Findings

In the following, we first analyse how the two labs respectively inscribe constitutive tensions between continuity and contingency into their lab infrastructures. To this end, we present a 'neighbourhood lab', which attributed its main transformative potential to the participation of cit-izens, and an 'innovation lab', which, by contrast, attributed its main transformative potential to the

possibility of emergent disruptive innovation. We then compare the two labs based on our heuristics of organisational, material and symbolic infra-structuring and critically reflect on their modes of infrastructuring constitutive tensions vis-à-vis their transformational focus.

### *Infrastructuring a neighbourhood lab*

Lab 1 is located in a city development area that is specifically configured as a model for creative and innovative city development. The area is located in the outskirts of the city and is currently being built and populated. Overall, the infrastructur-ing practices of lab 1 aim to create continuity with the knowledge-conventions of two main actor groups: a research community engaged in developing and systematically testing sustainable mobility solutions, and the local residents of the lab area whose awareness for sustainable mobility is being raised through their situated daily prac-tices and personal relations.

The lab establishes continuity with the research community mainly through their organisational entanglement with a university and by providing a real but less complex material test area, technical equipment and services for supporting the users' research conventions. The lab is operated by members of two university departments, which are part of the consortium. However, the operating members are (for the most part) perma-nently located in the lab in a city development area while the lab coordinator goes back and forth between the university and the lab. The main users of the labs are research projects located at the same university, and sometimes individuals simultaneously work for the lab and are members of research projects using the lab.

To establish a material and technical test area for mobility technologies and solutions, lab 1 is mainly concerned with selecting and shaping its specific material features. Part of these material infrastructuring practices is, for example, to choose and prepare a fitting test route, and customise the local residents as a "test-popula-tion" (website of a project). In this case, the test route starts and ends at the lab venue, where the researchers are accommodated during the tests, where equipment is stored, and test subjects are prepared and briefed. On the route itself, obstacles

which could disturb the tests in unforeseen ways are removed as best as possible – this concerns permanent and temporary physical obstacles like overgrown traffic signs or suppliers who park their trucks at the bike lane. The fact that the residents are used to seeing strange vehicles or people who carry tech-equipment on that route further constitutes it as a test area. Within the lab area, a material venue has been established, where the staff works and workshops as well as events take place, and which is accessible for local residents. Through providing a "basic set" (L1, coordinator) of material and technical equipment such as furniture, workshop and design materials, cables and technical tools, etc., which can be arranged and extended for different purposes, the venue constitutes a 'flexible basis' of the material lab infrastructure. The rationale for this material infrastructuring of a test area is threefold: it tests the technical functionality of mobility solutions, monitors and evaluates their social uptake as well as acceptance by specific user groups, and abstracts these observations toward the creation of generalised knowledge.

Lab 1 has developed a repertoire of strongly standardised and regularly occurring workshop and communication formats and methods, defining most of the contacts between researchers and the residents of the lab area. These formats are controlled by the lab. It prescribes how the formats are announced and organised, how the material spaces in which the events take place are equipped and arranged and the lab employees act as hosts and moderators. According to the coordinator, this standardisation intends to create continuity and predictability for both the residents and the lab. In other words, standardised partici-pation formats and spaces contribute to turning the residents into part of the lab infrastructure, as a pre-formed population, well informed to partici-pate in a foreseeable way. In turn, completely unexpected interventions are rather unlikely as the lab-environment is infrastructured toward gradual increases in complexity but not towards prompting completely new perspectives or avenues. Contingency triggered by radically different or even subversive ways of discussing or using prototypes or mobility solutions becomes unlikely.

A prime route to create continuity with the local residents and their ways of knowing (in contrast to their role as compliant test-population) is by developing personal trusting relations. The lab employees interact and communicate with the lab's neighbourhood in a way that, ultimately, triggers "a sustainable mobility culture" (L1, coordinator) [6] and "awareness" (L1, coordinator). Developing awareness is hereby understood as internalized understanding, which impacts practices and routines in the long run, yet in ways that cannot be completely predicted but might unfold in contingent ways. Here, innovative mobility services and technical innovations serve as a means for "activating residents" (L1, coordinator). Residents and their awareness are regarded as a contingent factor that - acted upon by the staff, albeit respected as equals - might develop in potentially unpredictable ways. Making sense of sustainable mobility and its specific translation into everyday practices is being entrusted to the residents, yet remains based upon continuous exchange with the lab. As the coordinator explains:

> I mean, the residents, they do carry the lab to a degree – I'd say that without the exchange with the residents, the lab would not make any sense. This exchange, this level of reflection, those discussions, this input, that's our main asset, fundamentally. […] Which means that [a core team] are permanently present around the lab, working around the lab and acquire knowledge around the lab […] because then a different kind of profoundness develops, a profoundness in relation to the place, a relation to the residents as well, very strong personal relations actually. (L1, coordinator)

This quote emphasizes the central role of relations between the lab, its staff, the city quarter and its residents. Creating awareness does not only concern the residents, but also the lab. By gradually acquiring a high degree of local knowledge and a close understanding of the social dynamics, the awareness of contingencies increases as well. Despite the standardised nature of its engagement events, the personal relations between lab staff and residents provide possibilities to challenge routines, e.g. research conventions. For example, after an (online) event informing the

participants of a field test about its outcomes, the participating residents voiced alternative explanations for certain data, based on their local knowledge of the city area and its material properties. Even though the format itself did not provide official possibilities to take on this feedback, the participating members of the lab made sure that it was forwarded to the project team and considered in the further interpretation of the data. Another example is the format of a competition for ideas, based upon strict criteria to evaluate which ideas, eventually, receive funding. Through the personal engagement of the lab staff, however, contributions which did not fit the format but were considered promising, still got recognised and were followed up on. In the coordinator's view, this relationship beyond engagement formats is precisely what distinguishes a living lab from opinion research in an isolated workshop-setting. The standardised formats which create continuity for the lab activities with a research community also serve as informal contact points with residents to enable more flexible exchange that could eventually lead to new ideas. In this way, contingency can emerge.

To sum up, lab 1 creates both continuity as well as potential for contingency. Continuity and generalisable knowledge are created with the research community that conducts user tests of mobility solutions. Meanwhile the potential for contingency is upheld by working with local residents who are developing situated and embodied ways of making sense of sustainable mobility. In this way, the lab acts as both a gatekeeper and a mediator between the research projects and the local residents. It brings them together but also keeps them separated. Standardised communication and engagement formats become a means to position both sides and to shape, yet not determine, the ways in which they can interact.

This dynamic explains the ambiguous impression we got from our empirical observations of lab 1: an apparent lingering between strict standardisation and more flexible mutual relations. The lab simultaneously mobilises the local residents as a predictable part of the test infrastructure for the research projects and as co-creative producers of contingent new questions. The constitutive

tension of lab 1 is between continuities with diverging actors and their potentially discontinuous ways of knowing.

Continuity with a research community contributes to comparable and generalisable user tests; continuity with the local residents leads to situated and embodied ways of sense-making that raises awareness for contingency and thus enables the emergence of transformative knowledge. However, while bringing the two groups together, the lab also keeps them apart by controlling their encounters. Manoeuvring between strict standardisation on the one hand, and encouraging personal relations and individual engagement on the other hand, leads to balancing acts on both sides. For instance, on the contingency-side, lab 1 allows informal individual engagements at the fringes of formal engagement; and on the continuity-side, it turns individual contributions into new standards. While embracing both sides, in lab 1, the constitutive tension is perceived as an uneasy state.

### *Infrastructuring an innovation lab*

Lab 2 is positioned as an innovation lab. Overall, it creates continuity with the ways of knowing of one central actor group: the professional field of logistics. At the same time, it tries to challenge the field's established ways of thinking and of approaching problems, instead provoking disruptive and contingent innovations which would bring about the potential for transformation. Continuity with the field of logistics is created through the lab's material infrastructuring, which includes the physical location of the lab within a logistics area, through the inclusion of a logistics hub as a main sponsor and through providing services and technical support mainly for logistics actors. Furthermore, lab 2 follows a business logic in the way it expresses its self-understanding and language, including elements from the start-up scene and specific engagement formats and aesthetics.

Regarding the material infrastructuring, the lab coordinator argues that the location of the lab in a logistics area would make logistics - which is normally hidden - visible and obvious, with all the cranes, ships, and trucks standing around: "we are sitting in the middle of logistics here" (L2, coordinator 1). Such a surrounding constitutes a familiar

environment for members of the logistics field. The physical venue of lab 2, where the employees work and where events take place, is located in one of the company buildings and resembles a start-up hub, with an exhibition area for prototypes, a stage, and an open kitchen. Some of the seating furniture is built from dustbins and parts of moving stairs, further leaning into the start-up aesthetics. As in lab 1, the room serves as a storage room of all kinds of equipment which can be flexibly combined and adapted to create different settings. What differs is the more explicit staging of prototypes and innovation projects within the room.

Lab 2 invested a lot of effort to compress its central mission into one single sentence, which is written onto the wall of the lab venue. This mission is described as "developing, testing and implementing logistic innovations in [the city]." Likewise, their understanding of innovation is an almost textbook-definition of market-innovation, which they relate to the definition of the European Commission. In their view, societal utility expresses itself in market success – as proof of something being wanted or needed – which would ultimately contribute to sustainability.

The lab established itself as a platform seeking to mainly support business actors through providing services, networking activities (e.g. bringing them together with researchers or other firms), and technical support, coordinated primarily by one individual with established expertise in the practice field. Accordingly, lab 2 built up a service infrastructure for supporting innovation processes and for connecting different actors. In the highly competitive field of logistics, lab 2 presents itself as a neutral platform to act as a trustworthy partner. When asked how they would describe themselves in the interview, their reply was:

> [as a] Network node in logistics, [as a] catalyst. There are firms approaching us, have an idea and we know, we understand their side and the other side, and we say: hey, you have an idea, and you have a solution, please talk to each other! We help to moderate this process. Or multiplier, that we spread ideas amongst people. And also translator, yes, that we can help firms or help people with ideas, so that others can understand their ideas

who probably need a solution. And these are for me currently keystones of the lab, network node, multiplier, translator. And this is what we offer.[7] (L2, coordinator 1)

For cultivating the network, the main coordinator located at the lab venue plays a crucial and active role. He is, in fact, characterised as the primary representative and embodiment of the lab, as "a nucleus […] who collects, compiles and further mobilises from all kinds of groups and actors" (L2, coordinator 2). The main coordinator is also described as "strongly incarnate" (L2, coordinator 2) of the lab's mission, holding the crucial practice-based expertise that is needed to legitimately speak to practitioners and to betrusted by them. He explains:

> But – within logistics – I need to create this trust, so they know that I know down to the last detail how something works, why it works and what problem we have and how it works. Because only then, they will talk to me. […] And this is an essential point since I can only bring up provoking theses and question things once I understood them beforehand, because otherwise they might say that we have no clue what is actually happening out there. (L2, coordinator 1)

Here, the coordinator describes continuity with the ways of thinking of the logistics field as a basis for being able to "discussing provocative theses" (L2, coordinator 1). He is thus acting as *agent provocateur* who is triggering new ideas and challenging established ways of thinking. This more *provocative* and *radical* stance is meant to introduce contingency and put a counterweight to the more continuous and incremental improvements to existing technical solutions that they also foster. Passionate pleas for setting up 'radical experiments' for bringing about disruptive change triggered by technological solutions testify to the lab coordinator's vision:

> One just needs to do it, for once! One eventually needs to get radical. For my dream-scenario, I would find a city that said "Alright, we lock down the city for five years – Google, Amazon, come here everyone and live it up! I want 98% of my mobility to be autonomous within the next five years" […]. We could make huge technical progress if we

created such a test-area and everybody came here. (L2, coordinator 1)

The coordinator bemoans political despondency as a key hindrance to having a chance to be and ultimate learn from being radical. Triggering disruptive innovation, *strictu sensu*, implies allowing for mistakes, detours and failures to occur and to learn from them. However, in the coordinator's view, policy makers lack courage to take these risks, only reacting to immediate affordances and engaging in nothing but "… continuous improvement process – I don't want to dismiss that, but this is not how we can achieve this, this shift." (L2, coordinator 1)

While lab 2 achieves continuity with the business sector and public policy concerned with logistics, they found it harder to create continuity with citizens as users of logistics. The lab strives to engage citizens, regarding their contribution to the logistics system as crucial to its transformation in a sustainable way. The lab does so for example through attending to (online) shopping behaviour, or through supporting and contributing to policies. However, the staff finds it difficult to get citizens to participate at all. This is despite their attempts to conduct citizen workshops in a location in the inner city that is easier to reach than the lab itself. Moreover, even when citizens take part, the lab struggles with how to engage them. In one instance they recounted, citizens fundamentally challenged the initiative at stake instead of discussing how it could be best implemented. The lab staff regarded this as a failure and tried to get the citizens back on track to respond to the prepared questions. In another workshop which we observed, citizens were guided through a closed questionnaire. In this instance, the staff wondered why no one spoke up when they were asked about ideas and questions afterwards.

The constitutive tension, which is inherent in the innovation-lab's infrastructuring, is mainly one between creating continuity with a specific professional field and their established ways of creating solutions which are of utility on existing markets, and contingency that might emerge from provoking these field to develop all kinds of new ideas in the hope that one of them would turn out as a game-changer. While this set-up

allows for triggering contingency through provocation and through strategies from the start-up scene, its vision of radical innovation is surprisingly centred on economic actors and technological innovation – Google and Amazon are explicitly mentioned, and in another quote, Elon Musk is named as a model innovator. Citizens do not occur in this vision, neither do they in the methodological arrangement. This might explain the difficulties to engage them in an active way which would trigger contingent ideas.

## Comparative reflection of the cases - tempering contingency

In the following, we systematically compare how the two labs create continuity and contingency in relation to different actors. We first look at the organisational, material and symbolic dimensions of infrastructuring respectively, comparing the two labs' differences and similarities in each of them. Second, we reflect on how each lab orchestrates these three dimensions so as to allow for transformative knowledge to emerge, and how continuity and contingency are distributed across their organisational, material and symbolic infrastructuring activities. This comparison leads us to the insight that in both labs continuity and contingency do not occur in a balanced way in each of the three dimensions. While the labs' organisational and material infrastructuring focusses on the creation of continuity with specific actors' ways of knowing, introducing potential for contingency almost exclusively occurs on a symbolic level, and through the personal engagement of lab employees. In the current funding regime, this leads to a marginalisation of alternative ways of knowing and to considerably tempering contingency in living labs (cf. Discussion & conclusions).

To begin with, the *organisational infrastructuring* in both labs consists of convening a consortium of heterogenous partners who are anchored in specific institutions, and of allocating specific roles and responsibilities to the main lab coordinator and the employees. While for both labs, a university is the main institutional sponsor where most of the employees come from, lab 2 has a huge logistics hub as their second large sponsor while the main coordinator has a background in

both research and professional practice. Accordingly, the main target group for which services are provided is research in lab 1, and the logistics field in lab 2. In lab 1, engagement formats as part of the organisational infrastructure are highly standardised. They consist mostly of workshops and discussion formats linking research projects to the local residents for testing and discussing mobility solutions and technologies. In contrast, lab 2 mainly provides consulting and networking to companies. It is the main lab coordinator who enjoys the trust and appreciation of the logistics actors. He plays a central role in cultivating a network and in connecting actors from business, policy and research, using engagement formats from the start-up scene.

Putting the organisational infrastructuring in a nutshell, lab 1 creates continuity with a research community and their ways of conducting user engagement in the development and testing of mobility solutions. It also mobilises the local residents as test population. Lab 2 creates continuity with the business field of logistics and their knowledge conventions via consulting and networking.

Regarding the *material infrastructuring* of the two labs, both are located in remote city areas – lab 1 is located in a new city development area and lab 2 in a logistics hub. Both areas are isolated from the inner city and appear as less complex in terms of density of buildings, roads and residents. Both labs are composed of permanent staff and lab venues that can be flexibly equipped and used. Lab 1 established a physical test area to be used by research projects as well as an accessible permanent location to establish cooperative relations with the local residents on site. By contrast, lab 2 is located in a logistics hub which is a familiar environment for their main target group from the field of logistics, but hardly accessible for citizens – both spatially and socially. The lab venue resembles a start-up hub and is the main location for the lab activities. While prototypes are staged in the venue and can be tried out there it is not a test area alike lab 1. Instead functions as a promotional space, resembling the exhibition of prototypes at a fair.

We can see that, in its material infrastructuring, lab 1 also creates continuity with a research

community and their testing practices. In addition, through being materially attached to the lab area, it establishes continuous relations with the local residents. Similarly, Lab 2 is clearly located in the field of logistics materially. The start-up style and aesthetics of the venue further create continuity with a business community. Although citizen workshops are conducted in the inner city to increase accessibility, this spatial outplacement further emphasises the detachment of the lab from wider publics.

When it comes to *symbolic infrastructuring*, both labs' central vision of their goals and contributions is of crucial concern. Lab 1 continually refers to an implicit "lab logic" (L1, coordinator), which needs to be acquired through relationship building by new staff and the users of the lab, i.e., the research projects. This vision emphasises the lab's relation to the local residents by means of supporting them in developing an awareness of sustainable mobility as a leverage point for transformation. By backing up its self-understanding with scholarly literature on transformative research and different lab types, lab 1 also creates continuity with research communities. Lab 2, in contrast to the more implicit sense-making of lab 1, condensed its central vision into one sentence, serving as their mantra and guideline. This vision is anchored in a market-definition of innovation. In addition, and more informally, they repeatedly express the hope for more disruptive innovation that might emerge contingently.

In sum, while the symbolic infrastructuring of lab 1 creates continuity with research communities and their theoretical ways of making sense of lab types, it stages the local residents as a source for contingency that might generate incremental transformation on a social and cultural level. By contrast, the symbolic infrastructuring of lab 2 creates continuity with business understandings of market innovation. It claims that pushing and provoking such innovations could bring about contingency, causing one of the innovations to overcome established pathways, leading to disruptive transformation.

Comparing the infrastructuring of the two labs vis-à-vis their organisational, material and symbolic aspects provides insights into their specific translation and inscription of the consti-

tutive tensions between continuity and contingency. We take this as a starting point to critically reflect upon potentials and constraints of each case.

Lab 1 creates continuity with a research community and the local residents of the lab area. However, while the research community's way of knowing is mainly addressed through the lab's organisational and material infrastructuring (the creation of a test infrastructure), the local residents' ways of knowing are mainly addressed on a symbolic level (referring to the 'lab logic' of creating awareness). Both are, to a large extent, kept apart. The particular role of the research community as a customer who pays for a specific service might play a decisive role in hindering the engaged citizens to provide contingent ideas. As a result of this gap, lab 1 hesitates to disclose that 'its citizens' more often act as a passive test population than as co-creative participants. At the same time, however, the lab considers itself a protected space where researchers can engage in profound and trusting relations with the local area and its residents - apart from potentially conflicting confrontations with the research projects and their possibly diverging interests and knowledge claims. As a consequence, the lab's infrastructuring formally focuses on the standardisation of engagement and shifts the relation-building with residents to an individual and informal level. Thus, possibilities for contingency mostly occur at the fringes, depending on single individuals and their initiative.

We hereby conclude that, in lab 1, the infrastructuring practices and relations, which are less valued and hard to account for in the current funding regime, are pushed to the margins. They are included in symbolic and narrative infrastructuring and, by doing so, translated into individual values and commitments of the lab members. They are hardly built into organisational and material structures, or only in ways that can be more easily accounted for. The potential to introduce contingency is mainly ascribed to the local residents. Marginalising and taming their active involvement tempers contingency and thus the transformative potential of the neighbourhood lab while upholding contingency in their narrations.

Lab 2 creates continuity mainly with the business field of logistics in its organisational, material and symbolic infrastructuring. What is embraced are traditional values and conventions of the field, such as a strong emphasis on practical expertise, personal networks and a focus on the utility of innovations, but also new impulses from a start-up scene, such as risk-taking and allowing failure as part of the learning. The latter is expected to trigger contingent ideas and innovations. However, the start-up character is inscribed into the organisational and material infrastructure mainly by copying its formats and aesthetics, rather than by embracing a failure culture. It is mainly on a symbolic level, by taking on a provocative, radical stance, that lab 2 more actively tries to trigger contingency. The constitutive tension is engaged with in a more playful way, by giving subtle impulses and trusting in the momentum they might develop. Despite these creative moves, market logics, also with regards to societal values, are taken for granted as ordering mechanisms. Although lab 2 opposes the strong orientation on monetary value, which is prevalent in the logistics field, they take an understanding of the market as interface of supply and demand at face value.

As a result, we can see that lab 2 also tempers contingency when it comes to organisational and material infrastructuring and mainly addresses possibilities for disruption on a symbolic level. In addition, lab 2 embraces a market-based innovation model that assigns a merely passive role to its citizens. Doing so, the lab excludes citizens as possible providers of contingent ideas. This approach may also be related to the perceived lack of sufficiently radical and disruptive innovation thus far (according to the self-evaluation of the coordinators). Finally, one could ask if engagement with citizens in more active roles could enable contingency in the sense of challenging and providing alternatives to this market-based understanding of innovation, and thus trigger the creation of transformative knowledge.

## Discussion & conclusions - epistemic and policy implications

Living labs promise to contribute to societal transformation through a double move. On the one hand, they are meant to facilitate and routinise innovation by providing an infrastructure that establishes continuity with different ways of knowing and innovating. On the other hand, living labs should allow for new questions and unexpected solutions to come up, for example by bringing diverse actors together as a source for contingent thought. It is the exchange of diverse stocks of knowledge, experiences and values that, according to contemporary innovation policy, holds the promise of novelty. In this paper, we analysed how – in the process of building up and maintaining living labs – this constitutive tension gets infrastructured in two specific cases. We observed efforts of including a diverse set of actors and ways of knowing to allow for contingency. However, a striking outcome of the analysis is that, ultimately, balancing occurs asymmetrically: a tendency towards continuity is prevalent and possibilities to allow different actors to introduce contingency are often marginalised.

Thus far the literature on living labs and transdisciplinary research institutions mainly addresses political or ideological tensions, and the call to embrace tensions is mostly based on a democratic argument as ample STS research on tensions in transformative research (see, for example Bijker and Bijsterveld, 2000; Felt et al., 2016, Polk, 2014, Schikowitz, 2020) and living labs (Engels and Walz, 2018; Leminen et al., 2015; Hillgren et al., 2011; Evans and Karvonen, 2011; Karvonen and Van Heur, 2014; Farías, 2016) demonstrates. We add the idea that it is not only political tensions, but also epistemic tensions that are constitutive for a lab infrastructure, if it is to produce surprising *and* legitimate outcomes. This idea is epitomized in the term constitutive tensions and operationalized with a heuristic for analysing the organisational, material and symbolic aspects of infrastructuring.

Empirically, however, we observed the tendency to temper contingency both epistemically and politically (which might, however, come along with its own contingencies and side-effects). Epistemically, the two labs we analysed invited and addressed different ways of knowing in the first place, but kept them strictly apart and mediated between them in the role of gate-keepers (which is a constitutive element of 'boundary organisations', as Guston, 2001, argues). Politically, both cases clearly endorsed participa-

tion as a crucial virtue, yet managed to circumvent the danger of contradictory values and political positions which could challenge research interests or innovation policy. Putting emphasis on maintaining continuity rather than contingency was especially the case when misunderstandings, conflicts and time-delay threatened to endanger the production of accountable output (such as publications, prototypes, or models of mobility solutions and methods) – which is the main currency both in academia and innovation policy.

Balancing the constitutive tensions towards continuity happened in three ways. First, the labs built up organisational infrastructures that create strong connections between the lab and different communities. The lab was placed between them as a mediator or 'obligatory passage point' (Callon, 1986), able to address and translate their interests separately. Second, the labs' material infrastructures were located in secluded venues, away from urban multiplicity and overlapping interests and spaces, with few options for potentially contingent encounters as well as broader resonance. And, third, the labs' symbolic and narrative infrastructure staged citizens either as drivers of contingency or as passively supporting business actors who would bring in contingency. This negates potentially controversial relations between different actors as a source of contingency. Yet in both cases, the lab staff and operators re-introduced ideas and impulses *they* got from encounters with different actors and knowledges as a source for contingency (the informal passing on of residents' ideas in lab 1, and the provocative spreading of more radical ideas in lab 2).

As we can see, analysing the labs' infrastructuring through the lens of organisational, material and symbolic infrastructuring allows us to notice how in each of these aspects there is a balancing between continuity with specific groups and possibilities for contingency. In our cases, infrastructuring living labs appears as a meticulous orchestration of its organizational, material and symbolic aspects so as to set the stage for participation and innovation, yet simultaneously taming and demarcating them again. Demarcating different actors and knowledges, however, happens in a more hidden way. The actors are brought together, yet not evenly distributed

across all three dimensions of the lab infrastructure, and their interactions are strongly controlled and mediated by the labs. Despite all estimable efforts of single labs to navigate and balance constitutive tensions, including their epistemic ones, these insights suggest that meeting the various demands and expectations that policy makers and researchers amount on living labs is, in fact, a mission impossible. Previous research on tensions especially in boundary organisations (Parker and Crona, 2012; Turner et al., 2015) points to a similar direction. Parker and Crona (2012: 267) find that boundary organisations engage in a "continuous process of negotiating among tensions derived from inconsistent demands placed on the boundary organisation" by way of 'lingering' between addressing them at different times and in different ways.

Against this background, we encourage to refrain from attempts to optimise living labs for meeting all diverging demands at the same time, and instead to embrace agonism (Farías and Blok, 2016; Farías and Widmer, 2017; Karvonen and Van Heur, 2014; Björgvinsson et al., 2012). That is, we advocate to "host the tensions and the associated inconsistencies" (Engels and Rogge, 2018: 31). As Farías' (2015) work on architectural practice makes plainly clear: here, 'epistemic dissonance' is purposefully enacted in different situations to create alternative designs and solutions. Inspired by such approaches from design studies, we see potential to bring about agonism and allow for contingency especially in the material dimension of infrastructuring, which is often treated as merely instrumental to organisational and symbolic purposes. For example, we could ask how test areas and participation spaces might be less pre-structured and 'clean' to allow for unplanned encounters and questions to occur and irritate the interactions. This could be achieved through involving residents, users, and citizens not only in the use, but also in the design of such spaces. In this way, entrenched assumptions about what is tested, standardised ways of setting up tests and workshops, and underlying questions, could be challenged and alternatives could emerge. In addition, what may seem to be 'a failure' in one lab, might be a constructive move in another lab – addressing another problem, involving other

configurations of actors. Thus, careful documentation and analysis of infrastructuring constitutive tensions and its various instructive effects might raise awareness for 'riding the tiger' and the courage for admitting and embracing contingency.

However, more open engagement with tensions and openly learning from failure often lies beyond the scope for individual labs. Thus, this task must predominantly be relegated to the policy level. On the basis of this study, one might ask if these excessive and incompatible expectations vis-à-vis living labs do actually misjudge their transformative potential. Their unique selling point might precisely lie in their chance to create and probe incremental and situated changes that cumulatively yield alternative futures, brought about by carefully orchestrated lab infrastructures made to work with and not against the constitutive tension of continuity and contingency.

## Acknowledgements

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## Notes

1 Here, we focus on lab initiatives which (1) show a commitment to public goals related to societal transformation (in contrast to e.g. product development in firms), which are (2) located in and address specific spatial areas (which can be a street, a city part, a whole region, etc.), (3) include the cooperation and collaboration of different actors (e.g. from science, business, public authorities, and civil society), and (4) in which (social and/or technical) innovations are developed and tested, often through experimental and prototyping practices (Dickel, 2019; Karvonen and Van Heur, 2014) and design methods (Engels et al., 2019; Gross, 2018; Hillgren et al., 2011). We are aware that the different terms are used and defined in different ways and that *Reallabore* and living labs are in some discourses distinguished as different concepts and used synonymously in others (see Schäpke et al., 2017). Respectively, those different terms put emphasis on different aspects. In this article, we foreground the general commonalities of these different forms and regard their specific realisation as an empirical question.

2 The five labs in operation during this research project received funding for four years (2017-2020) initially to deal with different aspects of sustainable and innovative urban mobility (e.g. mobility of goods and people, multimodality, autonomous driving, public transport, sharing models for bikes and cars, etc.). The UMLs are located in different parts of Austria and are organisationally separated from the research and development activities (conducted in projects or by companies) that are going on within them.

3 Hackett (2005) applies Kuhn's notion of essential tensions to the choices that research groups need to make. The tensions he describes include a discrepancy between continuity (with a wider field of research, with the group profile and 'safe' research lines) and contingency (of an independent group identity, of younger researchers' individual ideas and of risky lines of research).

4 They are funded by the Austrian federal ministry in charge of mobility within the framework "Mobilität der Zukunft" ('Future Mobility'; https://www.mobilitaetderzukunft.at). This program has existed since 2012 and the 7th call that was launched in 2016 included the UML.

5 While insiders may easily recognise the specific labs we analyse, we do not use their real names or concretise their location and member institutions, as we aim to put emphasis on lab types rather than exposing individual cases. Relatedly, we take special care not to disclose the identities of lab staff and organizers to whom we assured confidentiality.

6 Quotations from the interviews are labelled with L1 and L2 for the two labs. All interviews were conducted in German and the quotes were translated by the authors. If not noted otherwise, the direct quotes in this chapter are from the interview with a lab coordinator. S/he is member of a university department. The interview, which lasted over two hours, took place in a meeting room of the local neighborhood contact-point within the targeted city development area.

7 If not noted otherwise, the direct quotes in this chapter are from an interview with two members of the coordination team. The operating coordinator 1 has a university background but worked in the field of logistics for several years. Coordinator 2 is a university professor who only occasionally comes to the lab location. The interview lasted almost two and a half hours and took place within the event room of the lab.