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Punctuated Multi-Layered Liminality in Digital Transformation: The Case of an Automotive Platform

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Abstract

Digital transformation is often characterized as a liminal process as organizations move from established practices to new ways of organizing afforded by digital technology. Two contrasting views exist, however, on the liminality of digital transformation. One view sees liminality as a discrete transient process, while the other sees it as an on-going continuous transition. Building on a case study around a digital innovation initiative of an incumbent automotive car manufacturer, we offer a third view. We find that digital innovation triggers a phase of punctuated, multi-layered liminality that has a material, structural and temporal layer. We explain how material, temporal and structural tensions unfold at the level of practice, triggering new forms of liminal practices. We further develop three mechanisms (boundary testing, temporal bridging, and structural recoupling) that underpin punctuated multi-layered liminality. We contribute by unpacking the relationship between digital innovation and digital transformation.

Keywords: Digital innovation, digital transformation, liminality

Introduction

Digital transformation requires that organizations depart from their traditional modes of operation (Wessel et al. 2020) to generate value in new ways with digital technology (Yoo et al. 2012). Thus, digital transformation is fraught with potential tensions between new modes of organizing afforded by constantly evolving digital technology on one hand, and the well-established routines and institutionalized practices shaped by the material conditions of technology infrastructure on the other hand (Fischer and Baskerville 2022; Hinings et al. 2018; Lyytinen and Newman 2008).

Existing research characterizes the process of digital transformation through the lens of "liminality" (Henfridsson and Yoo 2014, Orlikowski and Scott 2021). Liminality refers to a state of the in-between, a coming-of-age period where an entity (i.e. human, organization, etc.) simultaneously embodies past and future states (Turner 1969). During digital transformation, organizations engage in intense, iterative processes of ideation and experimentation with new ways of organizing afforded by digital technology, while at the same time continuing to operate in their traditional ways of doing business. Existing research provides two contrasting views on the nature of liminality of digital transformation. Henfridsson and Yoo (2014) emphasizes how liminal digital innovation processes involve discrete transitions from one set of organizational practices to another. Orlikowski and Scott (2021), on the other hand, characterize the liminality of digital transformation in terms of ongoing continuous sociomaterial practices. Building on these two contrasting views of the liminality of digital transformation, we offer a third view. Rooted in an empirical study, we argue that the liminality of digital transformation is discrete and continuous at the same time, following a punctuated form. The key to understand this punctuated liminality of digital transformation is its multi-layered nature.

In this paper, we report on a case study of an automotive manufacturing company, "PremiumCar" (pseudonym), that is undergoing a digital transformation as it faces a disruptive competitive landscape with the introduction of electrification, autonomous driving, rapidly shifting regulatory conditions and consumer demands. PremiumCar has a long history of designing, building, and implementing digital artifacts even before the current wave of digital transformation. However, many of the innovation practices evolved over decades to support the manufacturing of well-understood physical goods, high-performing vehicles with highest quality standards. All of a sudden, as digital technology becomes the very focus of innovation, the organization is facing unique challenges of navigating the constant waves of digital innovations, while continuing to produce a physical car with uncompromising quality standards and a unique driving experience.

In studying this transformation, we unpack structural, material, and temporal tensions and propose three mechanisms for how organizations deal with these tensions. We contribute by explaining how digital technology triggers change on the practice level. Further, we illuminate how these practices are anchored in the materiality and result in a continuing state of what we refer to as *punctuated multi-layered liminality*.

We observe that the liminality of digital transformation occurs across different layers and progresses in temporally punctuated increments. Due to the generative and malleable nature of digital innovations, organizing with digital innovation is indeed dynamic and highly iterative. However, we also note that, in part because the physicality of automobiles requires that innovators actively bind practices to the existing material conditions of products and their physical architecture as anchoring point. The physical architecture and its implications for traditional operations assert themselves in the liminal processes and anchor the digital innovation activities pursued. This results in three tensions across levels of analysis (structural, temporal, and material) that are addressed through three practices - boundary testing, temporal bridging, and structural recoupling. Overall, we introduce the notion of punctuated multi-layered liminality to describe this state and discuss this with regards to the literature.

The paper is structured as follows. We review existing work on liminality and digital innovation and describe our study. We then present our findings and briefly discuss their implications.

Liminality, Digital Innovation, and Digital Transformation

Digital innovation is "the carrying out of new combinations of digital and physical components to produce novel products" (Yoo et al. 2010, p. 725). Digital innovation is generative due to its unique characteristics of reprogrammability, homogenization of data, and its self-referential nature (Yoo et al. 2010). Digital innovations often necessitate and unleash new organizational practices and forms of organizing (Wessel et al. 2020). We refer to digital transformation as the "combined effects of several digital innovations bringing about novel actors (and actor constellations), structures, practices, values, and beliefs that change, threaten, replace or complement existing rules of the game within organizations, ecosystems, industries or fields" (Hinings et al. 2018, p. 53).

Digital transformation efforts are not trivial. Often they need to overcome substantial organizational inertia (Haskamp et al. 2021), potentially resulting in tensions that organizations experience in undergoing this shift (Svahn et al. 2017). Scholars draw on the concept of liminality to conceptualize how organizations

reconcile such tensions as they navigate transitions associated with digital phenomena (Henfridsson and Yoo 2014; Orlikowski and Scott 2021).

The term liminality is typically used to describe cultural transitions (Turner 1969). The word liminal comes from the Latin "limen" (i.e. "threshold"). A "liminal state" arises between the separation and detachment of someone from a structure toward the individual being reincorporated into something new (Turner 1969). The respective period of time to which we refer to as "liminal period" is shaped by ambiguity as liminal entities also referred to as "passengers" are "neither here nor there, they are betwixt and between the positions assigned" (Turner 1969, p. 359). Thus, a liminal period has attributes of both the previous and the new state and is temporarily undefined (Tagliaventi 2019; Turner 1969).

Liminality has been used to describe the process of digital innovation (Henfridsson and Yoo 2014; Mertens 2018; Orlikowski and Scott 2021), albeit with subtle differences. Henfridsson and Yoo (2014) refer to the "liminality of institutional entrepreneurship as a state of ambiguity faced by institutional entrepreneurs when their new possible innovation trajectory is not fully formed but coexists side-by-side with established trajectories" (Henfridsson and Yoo 2014, p. 946). For them, the liminal period is contingently shaped by three generative mechanisms, reflective dissension, imaginative projection, and proactive elimination. Through these three mechanisms, innovators take mindful actions by willfully suspending the commitment to the existing social and material conditions that underpin organizing practices to envision a different, albeit fragile, future. Thus, they argue, a liminal period concludes with a shift in innovation trajectory and constituting organizing practices. Orlikowski and Scott (2021), on the contrary, built on the concept of liminal innovation practices (Mertens 2018) to argue that digital innovations lead to ongoing and continuous transitions between experimentation and implementation. Therefore, liminal innovation practices "are open-ended, fluid, and flexible, ensuring that "innovations remain malleable, even after implementation" (Mertens 2018, 286). Digital innovation practices involve different forms of tensions, situations in which the existing way of doing becomes no longer possible due to feasibility aspects. A tension in innovation practice "creates the conditions of possibility for experimenting with new activities, products, and services that take advantage of the sociomaterial enactments that continue to be feasible and available, thus repurposing existing capacity in new ways (Orlikowski and Scott 2021, p. 4). Thus, for them, liminality is not a singular, discrete transitionary period. Rather, it is an ongoing and continuous modality of organizing.

In this paper, we attempt to resolve this theoretical tension building on our empirical study. To begin, we start with the common thread across prior works on liminality in digital innovations (Henfridsson and Yoo 2014; Orlikowski and Scott 2021; Tagliaventi 2019; Turner 1969), focusing on three concepts (see Table 1).

Key Concepts	**Explanation**
Liminal period	A time span which is characterized by a state of in-between two states that shares some of the previous and some of the coming state (Turner 1969, Henfridsson and Yoo 2014)
Liminal innovation practices	Open-ended, fluid, and flexible processes of experimentation and implementation during the continuous transition (Mertens 2018; Orlikowski and Scott 2021).
Tensions	Contradictions difficult to reconcile between traditional and new practices (Henfridsson and Yoo 2014; Orlikowski and Scott 2021; Seo and Creed 2002)

Table 1. Key Concepts of Liminality

First, a liminal period which we understand as a period of time characterized by an in-between state in a given transformation that shares some characteristics of the previous state and also some of the coming state (Turner 1969, Henfridsson and Yoo 2014). Second, liminal innovation practices which we understand as open-ended, fluid, and flexible practices defined through the continuous transition on both sides of the threshold between experiment and implementation (Mertens 2018; Orlikowski and Scott 2021). Third, tensions which we understand as triggers for liminal practices as within these tensions, the existing way of doing becomes no longer feasible, thus producing a tension that may afford action to realize the intended change (Orlikowski and Scott 2021, Seo and Creed 2002).

To summarize, digital transformations do not involve a singular change caused by digital innovation, but rather, a set of digital innovations that change the very way that organizations operate in a very fundamental

way (Wessel et al. 2020). Yet, we still lack clarity in the liminal nature of digital transformation of incumbent organizations. In this research, we look to investigate how liminal processes associated with important digital innovation trajectories contribute to the process of digital transformation.

Research Design

Case Context

We conducted an in-depth case study (Yin 2011; Eisenhardt 1989) of *PremiumCar*, as the company endeavors to develop the platform for its vehicles critical for its digital transformation. This case is appropriate because it involves multi-year complex digital transformation efforts. Further, the automotive context is helpful in understanding the challenges associated with the digital transformation of an incumbent organization that produces physical products. In what follows, we go into details regarding the case context, data collection, and data analysis.

PremiumCar is a car manufacturer specializing in producing high-performance cars for the luxury segment. PremiumCar is known for its innovative design and development of cars, supported by rigid and lengthy development cycles for each car model. Traditionally, these cycles do not focus on the embedding of digital technologies in the car. However, increasingly disruptive market entrants such as Tesla alter the game by focusing on digital technologies first and thereby, threatening PremiumCar's market position.

Our unit of analysis within PremiumCar's digital innovation activities is the integration of Over-the-Air (OTA) services into their cars. OTA is an essential element within the digital transformation of automotive companies. It serves as a foundational infrastructure for the realization of different services and features such as allowing car manufacturers to fix software bugs remotely, to serve predictive maintenance of vehicles, and to sell new digital services on-demand that customers can buy while driving the car. In current models of vehicles of PremiumCar, the OTA infrastructure is only rarely implemented as the integration would require to touch upon the multiple decentralized electronic control units embedded in the architecture of the vehicle (Hylving and Schultze 2020). These control units are small devices attached to components that control one or several mechatronic systems in that vehicle.

Data Collection and Analysis

We collected data with PremiumCar from March 2021 – April 2022. Our set of data sources builds on multiple sources, such as interviews, observations from meetings and workshops and internal and external material (Table 3) to triangulate our data sources (Yin 2011).

We conducted semi-structured interviews following a guideline to ground the interviews in the participants' experiences and to allow the theory to emerge from data (Gioia, Corley, and Hamilton 2013). To identify the suitable interviewees, we first talked to our two persons of contact (Director Digital Transformation and Director Digital & Innovation) who allowed us access to key stakeholders of the initiative (Head of IT & Electronics and Senior Product Owner 1). From this point on, we followed a snowball sampling strategy to recruit a broad range of interviewees of our case study (Seawright and Gerring 2008).

The interview guideline consisted of two parts. In the first part, we asked participants to explain the OTA journey from the past until today from their perspective. In the second part, we asked participants to identify key challenges. Each interview lasted 35-120 minutes. We recorded and transcribed the interviews. When interviewees referred to specific events, we asked for documentation. We also collected additional materials to get familiar with the context. To further complement our learnings from the interviews, we reviewed publicly available material around blog posts, press material and external presentations given by management members.

We followed a process approach to analyzing data (Langley 1999). Based on interview statements complemented with the internal and external material, we created a timeline of all OTA events. Then we clustered the events into three different phases – something referred to as temporal bracketing (Langley 1999). We then coded the interviews for practices and activities that were assigned to the phases and events. We validated the timeline with team members from the case (Senior Product Owner 1 and 2). Though car development cycles presented clear indicators to distinguish between different distinct phases, this was hardly possible for the development of the OTA platform. This led us to the idea to look for tensions involved

between the different approaches to vehicle development and the software development in the context of OTA. We then identified different tensions emerging along the different phases.

The concept of liminality emerged as we compared our findings to the literature on digital innovation as a way of conceiving of how organizations navigate the tensions, which we identified. Liminality resonated with the reports from interviewees, who often described their experiences as being in a *hybrid world*. Reviewing the liminal innovation literature, we went back to the empirical data and identified corresponding tensions and liminal practices for each phase. Finally, to generalize our observations we draw on mechanism-based theorizing, which showed its benefits in theorizing cause-effect-relationships of the multi-faceted digital phenomena (Henfridsson and Yoo 2014). By doings so, we distilled three distinct mechanisms that were activated by the identified tensions. The mechanisms explain the resolution of the tensions into a situation which we refer to as punctuated multi-layered liminality.

Data	Interview	# Interviews	minutes
Primary Data	**Digital Innovation Team**		
1	Director Digital Transformation	1	120
2	Director Digital & Innovation	2	108
3	Head of Connected Car	1	37
4	Head of Software Eng. & Mgt. of Digital Lab	1	44
5	Head of Dept Data & AI Systems	1	44
6	Innovation Manager 1	1	39
7	Innovation Manager 2	2	97
8	Innovation Manager 3	1	44
9	Innovation Manager 4	1	52
	Platform Technology Team		
10	Director of IT	1	60
11	Head of IT & Electronics	3	142
12	Senior Product Manager	3	177
13	Senior Solution Architect	4	210
14	Release Train Engineer	2	102
15	Scrum Master	1	49
16	Senior Product Owner 1	2	83
17	Senior Product Owner 2	1	35
18	Senior Product Owner 3	1	51
19	Junior Testing Engineer	1	51
	Total interviews	30	1545
Secondary Data External Material	51 external documents including two videos such as press material, external presentations, blog posts from PremiumCar and Mobility Group around their digital transformation journey and specifically, OTA activities such as feature releases and updates ⇒ Σ 704 pages		
Secondary Data Internal Material	13 internal documents such as management slides around the digital transformation strategy of PremiumCar, the implementation of a scaled agile framework and OTA activities ⇒ Σ 150 slides		
Secondary Data Observations	32 hours of observations on quarterly planning meetings of OTA teams ⇒ Σ 10 pages		

Table 3. Data Sources for the Case Study

Results

We present the results in two main parts. We first describe the three phases of the digital innovation initiative that unfolded at PremiumCar. We then describe three liminal tensions, liminal innovation practices triggered through these tensions and our derived mechanisms.

Digital Innovation Initiative PremiumCar: Integrating Over-The-Air Services

PremiumCar's initiative on the integration of over-the-air ("OTA") services unfolded over three successive generations of cars and in between 2010 and 2022 (see Figure 1). With OTA generations we refer to different stages in the maturity of OTA services integrated within PremiumCar's vehicles.

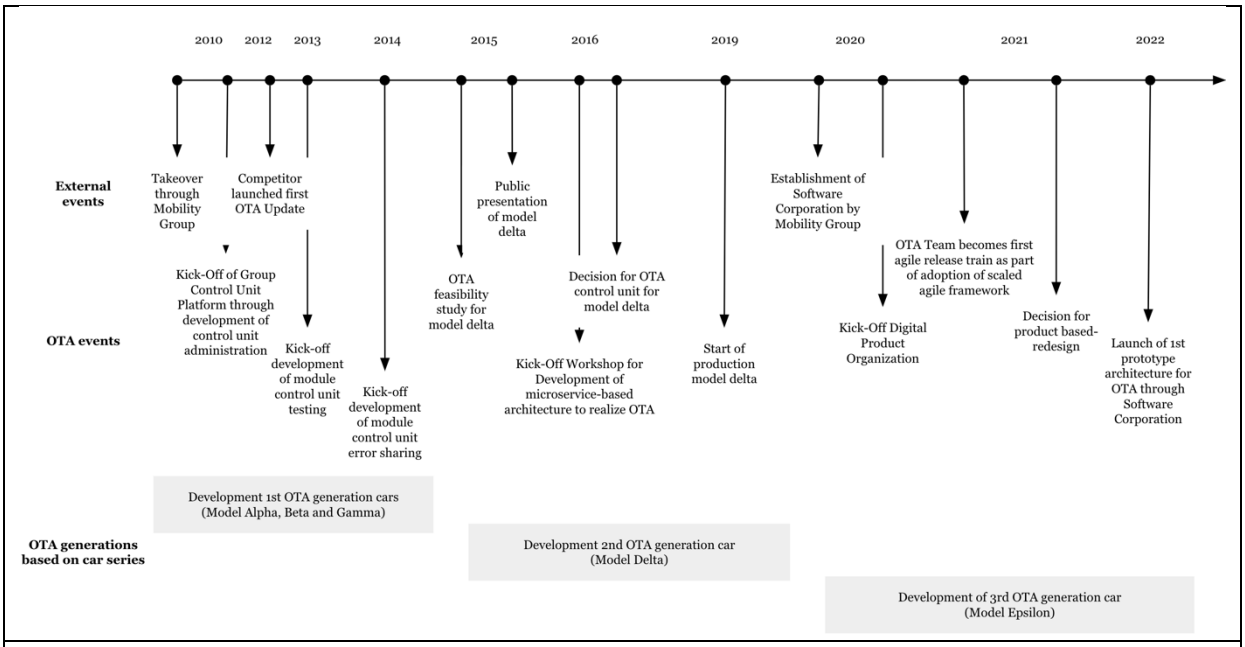

Figure 1. Chronology of Events: Integration of Over-the-Air Services (2010 - 2022)

1st OTA Generation (2010 - 2015): The first OTA-related event was triggered by a takeover of PremiumCar by Mobility Group - one of the largest multinational mobility providers - in 2010. To realize synergies across Mobility Group's different car brands by standardizing the administration of electronic control units along the vehicle development process, a Group Control Unit Platform was proposed across different brands of Mobility Group, including PremiumCar. This platform evolved to what latter became the basic OTA architecture. As the senior solution architect explains: *"The decision was made at that point in time within [PremiumCar] to join mobility groups' efforts to establish a coherent IT system for the administration of control units of vehicle projects. Before this, people were sending packages partially via mail, so it was a good step forward."* Thus, in 2012, the development of a module - control unit administration - was initiated serving data managers in product development, sales, and manufacturing to access and manage the different software versions of control units. As a product manager explained: "*With the control unit administration module a first interface was developed that helped the data managers to navigate the jungle of software versions of control units*" (Senior Product Manager).

However, in 2013 data managers from the departments expressed a further need for more transparency, regarding the identification of differences between software releases of control units, among other issues. This resulted in the creation of another module - control unit testing - that served different business functions (manufacturing, sales, and product development) to master the complexity of the development of the multiple control units that are part of the vehicle. Lastly, in 2014 another system module - the module control unit error sharing - to manage and share bugs identified during the testing of control units with suppliers of control units - was developed.

The three modules - control unit administration, control unit testing and control unit error sharing together - formed the Group Control Unit Platform. Each of these modules were developed as a monolithic system that was continuously extended based on the needs of the data managers as someone from the project team recalled: *"We always further developed these three single applications based on a typical three-layer architecture, with common libraries, and we added feature by feature"* (Senior Solution Architect).

However, this evolving architecture resulted in several challenges regarding the complexity of the system: *"Then, we noticed at some point in time that this monolithic architecture was too complex, so it was hard to add additional features. Further, while working with these systems, production and the other departments noticed more and more bugs, and we realized that we could not handle these systems anymore*" (Senior Solution Architect).

While with the development of the platform Group Control Unit the basic architecture was laid for the management of control units, a key competitor in the market had launched the first OTA-capable vehicle for customers in 2012. As someone from the project team described: "*Although [LuxuryCar (Competitor)] had launched the first OTA update for customers, at [PremiumCar], no one anticipated the importance of OTA."* (Senior Software Engineer 2)

2nd OTA Generation (2015 - 2020): Pressures from competitors and the growing Asian market of younger, tech-savvy customers triggered PremiumCar to launch a new car model - Delta. This was intended to trigger a new digital era for the company. As a director explained: "*With the launch of Delta, we wanted to send a clear message to the community that we could compete with new market entrants and that we were also able to develop an electric-powered car that is fun to drive."* Thus, Delta was designed to be powered by an electric powertrain that met customer expectations for digital service offerings. OTA was a key part of this infrastructure.

The new OTA effort involved trying to access as many control units as possible over the air while having mainly four different use cases in mind. The first one involved the capability to fix software bugs over the air that normally requires the customer to visit the repair shop. Second, serving on-demand features that customers could subscribe or purchase were seen as a potential source of new income. Third, the ability to offer a live diagnosis for issues that customers experience while driving. As a project team member explained: *"The customer could call our customer service and complain about an issue with closing his trunk, in which customer service could check remotely whether they can fix it or if it requires a customer workshop"* (Senior Product Owner 2). Lastly, serving predictive maintenance features was the fourth feature that motivated the implementation of OTA within Delta. Thus, the objective was set to update as many control units as possible with the initial goal of trying to update 75% of all control units within the car.

By 2015 the question emerged as to who and exactly how OTA was supposed to be executed given the physical legacy architecture of the car. The team decided on a twofold approach. For Delta's back end, the product development wanted to rely on a solution from an external vendor that also a competitor was using. In a second step, the internal IT department was tasked to ensure that the external solution could be incorporated within PremiumCar's digital platform architecture. The IT team at that time had limited experience in how to implement OTA within the given architecture of the vehicle, but they could build from the knowledge gained in the management of control units around the Group Control Unit platform. Thus, a small project team started with 3-5 members in end of 2015/beginning of 2016 to develop an IT architecture that could deliver OTA capability to the vehicle. The development of the underlying architecture was very much hands-on and driven by the use of microservices as one of the pioneers of the project explained: "*Looking backward, we did not have much knowledge of how to set up OTA, so we started with doing workshops in which we together thought about the different microservices necessary to execute OTA. So, we knew that to realize OTA there needed to be something that sends something to the vehicle, and we came up with a microservice of a package generator. We then thought, ok, we need to know what kind of package each vehicle holds, and we added a package manager. So, step by step we added different microservices required to deliver OTA"* (Senior Software Engineer 2).

Beyond the development of the microservices that were required to deliver OTA, the team also needed to touch upon the physical product infrastructure of the car. This was due to the architecture of the vehicle in which nearly every component of the car holds a single control unit, often from different external suppliers. This architecture brought a tremendous challenge to the team as a project team member explained: *"Consider for example the parking example. Normally, the car's control units are in sleep mode while the car is parked to save energy. With the OTA updates now there needed to be someone that could notify all existing control units all the time to tell them to be awake in case an update needed to be performed"*. To address these issues the team decided to embed a dedicated OTA control unit. The purpose of this OTA control unit was to receive information and to distribute and master the more than 100 control units of the vehicle. As the person formerly responsible for integrating the OTA control unit into the vehicle explained

the challenges: "*The different development cycles were a major issue. They rely on waterfall planning and we on agile. That means we want to quickly build and test things whereas they try to plan thoroughly and execute"* (Head of Department IT & Electrics). While the product development process for the vehicle considered quarterly synchronization points in which both software and hardware elements were tested and released, these synchronization points did not allow for enough opportunities for testing developed software artifacts as someone explained: *"We are only able to test our code during these synchronization points. And in case this did not go well we couldn't change and fix things quickly. Instead, we needed to wait three more months for the next synchronization point in which then again the software did not work"* (Senior Solution Architect). Thus, during the development process, the OTA team struggled to access the vehicle throughout the development. For the OTA team, this situation was very disappointing: "*They don't understand that software development is a continuous process, which requires continuous testing releases. We are not done at a certain point"* (Senior Solution Architect). This led to problems: "*There were many problems with the car which we were not allowed to fix anymore because the car was produced. And that's something we don't understand. For us there is no "done". For the car development there is this moment of "done"!"* (Senior Product Manager OTA). Thus, the OTA team needed to fix many issues after the car was already launched which resulted in the new practice of fixing issues after the start of production, something the team referred to as backarounds.

Until the start of production in 2019, the outcomes of the OTA integration efforts into Delta were limited and bounded by the rigid structures and technologies. As someone explained: *"Originally, we wanted to access 75 percent of the control units through the new OTA control unit, but in the end, we only reached roughly 30 control units which would be around 30%*" (Senior Solution Architect). As consequence, the first version of OTA with model Delta was launched with very limited OTA features. The public reaction was negative, with articles in the press indicating PremiumCar's struggles with OTA (External Material 42). This was seen as the result of the multiple challenges regarding integration efforts and lack of time for testing and release of features. Further, in a later relaunch of the vehicle, the decision was made to kick-out the external vendor and its module due to a lack of compliance regarding cybersecurity standards and issues around communication. Thus, the new emerging software company of Mobility Group, Software Corporation was supposed to take over this task together with PremiumCar engineers.

3rd OTA Generation (2020 - 2022): With growing success of competitors, PremiumCar as well as the entire Mobility Group needed to strengthen its OTA efforts. As the chairman of Mobility Group explained in an internal town hall meeting: *"We need to develop the car as the most complex tech product. If we don't do it, others will! Therefore, we established [Software Corporation] that will together with our brands become our own software company. We will only succeed with the new competitors if we are able to build software and continually update software. Unfortunately, our competitors perform better and are the benchmark. They build the car around the software. For their customers, OTA updates are daily business. And they are way more productive than we are. We need to speed up our efforts!"* (External Material 36). Thus, at that point in time, the OTA topic has gained importance at PremiumCar that led to strategic actions on two levels.

First, in 2020, Mobility Group established Software Corporation as a new subsidiary to spur the development of digital capabilities to drive the digital transformation of its brands and to realize synergies and scaling features of digital technologies across brands. Software Corporation was also tasked together with PremiumCar to pioneer a new car architecture for the entire Mobility Group. Thus, while Software Corporation started its operations, also Mobility Group aimed to develop a new vehicle architecture that should in the long-term enable autonomous driving capabilities of vehicles and also serve OTA functions by design. In terms of architecture, instead of relying on the decentralized control unit architecture responsible for realizing OTA, now only a few centralized high-performance computers within the vehicle were supposed to offer OTA capability (External Material 25). The promise of the new car architecture was to replace the old, decentralized approach through a few centralized computing engines.

Second, PremiumCar itself refined and extended its internal strategy around digital innovation. At the beginning of 2020, they kicked off a digital product organization, which was supposed to be a new organizational layer. Instead of replacing the old one, the digital product organization was about extending it by coordinating all digital activities. As the Director for Digital Transformation responsible for the digital product organization explained: *"The digital product organization is the idea to coherently organize all our digital activities along with the scaled agile framework across different board areas. The core idea*

here is to think, manage and budget digital products instead of single projects." This digital product organization was not supposed to be a dedicated digital innovation unit. Rather, the digital product organization was a virtual organization that did not replace the existing organigram but added another virtual layer to it. Thus, the intention was to align the organizational structure towards the development and launch of digital products and services. As the Head of Digital Innovation understood the digital product organization: *"For me, the digital product organization is also a move away from these heavy vehicle projects towards thinking in products and services that provide value for the organization."*

Thus, instead of relying on projects as key vehicle of operations, the intention was now to align teams based on value streams within the organization of which OTA served as perfect example. OTA was understood within the organization as boundary spanning and continuous activity across departments. As the Senior Product Manager stressed multiple times: "*OTA is not a project!"* What he meant with that was that OTA was affecting different departments. He imagined that everyone involved in OTA within the organization would be part of what was referred to as an agile release train. This agile release train was supposed to deliver digital artifacts every 3 months. Managing the commitment of employees from non-IT departments such as production or sales became a permanent challenge as well as securing funding for the continuous development of OTA. While the second generation of OTA was shaped by a huge amount of microservices that resulted from the exploratory approach taken, the 3rd generation of OTA offered the chance to redesign and bundle microservices into small, easily manageable products. However, while Software Corporation made progress with the development of the new architecture, the collaboration still faced some major challenges beyond the ones that already had emerged in the first phase. As someone explained: *"It's really hard as we have with Software Corporation a new stakeholder of whom we are not the only customer. Then further their product architecture is still a work in progress, its continuously rescoped and a very unstable construct which is kind of challenging for us as we need to deal with continuously changing expectations and changing interfaces. And then we have our own OTA struggles and collaboration issues"* (Senior Product Manager). Thus, the development of the new vehicle architecture also impacted Premium's car project schedule for the new vehicle. Originally, Software Corporation was supposed to develop a car architecture that could be modified and customized by each brand, even sold to other brands. However, this was not the case as the software teams from the other brand customized the new architecture closely to their needs, which led to user interfaces having the internal competitors' brand and other issues. This made it hard for PremiumCar's development teams to test their features against the new platform leading to many delays and errors of certain OTA features. Only in the beginning of 2022, was Software Corporation able to launch a first prototype on their new architecture - way behind schedule.

Punctuated Multi-layered Liminality

Our analysis of the phases and innovation practices at PremiumCar in realizing the vision of OTA suggests that their intentions to introduce OTA into the different vehicle models unfolded over time. On the one hand, this unfolding along the different generations of vehicles is punctuated as the timespan between each generation can be identified as someone explained: "*Our OTA activities evolved continuously over the past years, with each vehicle generation we further developed new elements, but in the beginning, looking backwards to the [Group Control Unit] platform, no one would have predicted that this was the starting point of our activities"* (Senior Product Owner 1). On the other hand, our analysis suggests the existence of a somewhat liminal stage that, in which at the same time, the organizational members try to realize affordances of the digital technology, while also being anchored by the physical materiality of the vehicle architecture. Both on a strategic and operational level, interviewees mentioned multiple times that they are now in a transitionary hybrid phase. This phase seems to be permanent as a member of the leadership team explained: *"We will always be a hybrid company and never operate like be a full software company because we also will be required to operate both, the hardware vehicle world and the software world with its different velocities"* (Head of Digital & Innovation). This was also confirmed by the ones involved in the daily operational activities: "*If I look at our agile release train, we are still kind of a hybrid. We still have milestones from the vehicle development cycles but also run-on sprints and retros. We also have a lot of people from different departments as part of this agile release train but are still funded through 13 projects. So, it's kind of a hybrid scenario, and I am not sure if it will change or stay like this"* (Senior Product Owner 1). Both examples reveal that the case organization finds itself in a state that of in-between, in which the organization and its members have left the previous fully vehicle centered operations mode. However, they also have not reached the new targeted, fully agile state as the processes and practices tied

to the hardware development anchor the teams OTA development activities. Thus, it is a simultaneously transient state and ongoing continuous status that we conceptualize as punctuated liminality.

Furthermore, our analysis suggests three distinct layers of liminality: material, temporal, and structural layers. The material layer in the case context is composed of two dimensions. Firstly, a form of physical materiality. This refers to "*artifacts that can be seen and touched, that are generally hard to change, and that connote a sense of place and time"* (Yoo et al. 2012, p. 1398). This form of physical materiality appeared in the case in the form of the vehicle as recombination of mechatronic systems and material components such as the brakes, the chassis or the components of the power train which consist out of material stable elements. The second dimension deals with materiality of digital technologies - the material form and function of digital technologies (Leonardi 2012) in which homogenization results in analogue data being converted into digital data (Yoo et al. 2010). This is driven by the malleability of the resulting software artifact and appears in the case in the form of the software artifacts (e.g., microservices) around the OTA implementation. Second, with the temporal layer, we refer to the behavior and perception of temporal dimensions through human agents (Ancona et al. 2001). This is manifested in the case with the interviewee's experiences of different development cycles between the physical materiality and the materiality of the digital artifact and its technologies. Third, we introduce a structural layer, with which we refer to organizational structures, rules and resources that shape and are shaped by human actions to fulfill work (Orlikowski and Baroudi 1991). In the case context, this refers to processes and informal rules in place (e.g., budgeting processes, projects as vehicle of organizing work).

Taken together, we argue that liminality of digital transformation at PremiumCar is punctuated and multi-layered. The organization is in the on-going, yet punctuated state of trying to balance the requirements of the rigid physical materiality on one hand, and the flexible and fluid materiality of digital technology on the other hand. This process is to certain extent punctuated and stable: punctuated due to new external events or technology developments that trigger action and stable in the sense that this liminal state will be permanent as the conflict between physical materiality of the vehicle and the materiality of digital technology can be hardly dissolved.

To explain our concept of punctuated multi-layered liminality further, we identified a set of tensions and resolution mechanisms associated with each layer. First, on the material layer, we identified the architectural tensions and boundary testing as a resolution mechanism. Second, on the temporal layer, we identify a form of pacing tension, of which we found temporal bridging as a resolution mechanism to address these. Lastly, on the structural layer we identified a decampment tension and structural recoupling as a mechanism to deal with the tensions. An overview of the tensions and the identified mechanisms is given in Table 4.

Layer	**Tensions**	**Mechanisms to resolve tension**
Material	*Architectural tension:* The tension between the available existing IT-architecture and technical product architecture.	*Boundary testing:* A mechanism explaining how teams explore boundaries of feasibility digital innovation while the existing product architecture limits this potential exploration.
Temporal	*Pacing tension:* The tension between rigid and predefined temporal work practices to the iterative and evolutionary realization of digital innovation.	*Temporal bridging:* A mechanism explaining how teams reduce temporal interdependencies between digital innovation and traditional projects by rationalizing, or mapping activities between two structures to manage different time requirements.
Structural	*Decampment tension:* The tension between the organizational roles anchored to the materiality of the core product and the alternative roles of digital innovation.	*Structural recoupling:* A mechanism explaining how the teams dealt with the "stickiness" of traditional roles rooted in physical materiality of the product by changing organizational structures. This opens up new experimentation spaces and new structures with ambiguous new roles.

Table 4. Tensions and Identified Mechanisms

Below, we explain each tension by showing how it unfolded within the daily practices of PremiumCar and how it triggered new liminal innovation practices within the OTA context. Building on these liminal innovation practices, we introduce and explain the mechanism through which PremiumCar's OTA team members addressed each tension.

Material Architectural Tension and Boundary Testing

The first tension – *material architectural tension* - is a tension between the available existing IT-architecture and the product architecture for the digital innovation. This tension was apparent in the case across two dimensions and affiliated practices.

The first dimension involves the limits that the existing IT-architecture put on integrating or adding new features and services such as OTA. In order to realize OTA, the development team largely needed to rely on existing data and IT systems that were used by production, sales, and product development. They were originally intended to exchange information and administer the control unit development process. OTA was not anticipated in the design of these systems. Those systems were set up as monolithic IT systems, mirroring needs and resulting features from production, sales, and product development. These IT systems in their design were largely driven by the reproduction of the organizational structure within the IT landscape as the senior product manager explained: *"We are the embodiment of Conway's Law. You can find the same application for production, sales and product development within our IT landscape with the same basic functionality. Just because the business partner requests something, we turn it into a ticket and develop"*. As a result, the team had to access 13 IT systems when trying to integrate OTA into the car. This conflicted with the product delivery approach of OTA. Thus, with the start of incorporating OTA within Delta, a liminal period emerged for the development team which started with the development of microservice-based architecture. This was the case as the OTA requirements were not possible to realize given the limitations of the existing IT infrastructure of the Group Control Unit Platform. Then in the third generation, the team was trying to reorganize the microservice-based architecture into small independent products as part of the implementation of OTA in a new vehicle model epsilon.

The second dimension was between the distributed existing product architecture around the vehicle and a preferred integrated material product architecture necessary to realize OTA. Within the early OTA generations, the product architecture of the 1st generation OTA cars relied on an architecture in terms of having distributed control units attached to single components that were often fabricated through a decentralized supplier structure. As someone explained: "*If you want to integrate OTA today, you would need to touch upon each single control unit of the car which are more than 100"* (Head of Department IT & Electronics). Mobility Group and PremiumCar followed their competitors by pushing towards an integrated approach with few key centralized computing engines which reduces much of the complexity that the team needed to deal with as someone explained: *"Mobility Group has addressed this issue around the distributed control unit and has promised to deliver an integrated vehicle architecture that can perform OTA by design. But it's not yet there"* (Senior Product Manager). Therefore, PremiumCar found itself in a somewhat liminal state for the required integration of OTA for Delta. PremiumCar experimented and decided in that context for the development of an intermediate solution - as a matter of feasibility - in which a new dedicated OTA control unit served as the master control unit accessing all other control units.

We found that the team engaged in the mechanism that we refer to as *boundary testing* to address the architectural tension. Through this mechanism single teams or actors try to find a way of dealing with the existing distributed product architecture, which anchors their potentialities of future behaviors, by testing and exploring out the boundaries of feasibility. Specifically, we refer to two liminal innovation practices underlying the mechanism: experiential exploring of service architecture and architectural integrating.

Firstly, experiential exploring of service architecture refers to the continuous ideation, development, and exploration of the necessary IT architecture to realize OTA. Specifically, the OTA team builds up a microservice-based architecture to realize OTA as part of Delta. This happens continuously through workshops and in meetings in which team members generate new microservices in a sequential manner. They discuss what OTA requires in terms of microservices and how that can be incorporated and integrated into the existing IT landscape. Then in a second step as part of generation three, the microservice architecture is reconfigured and redesigned towards a stronger focus on the provision of single services that can generate value. As a software developer explained: *"We firstly had these modules which were large monoliths, we then moved into microservices to build OTA and now we are trying to move towards an architecture that embodies the idea of a product, meaning that the group of microservices can provide a dedicated value which wasn't the case in the first phase"* (Senior Solution Architect). Thus, the liminal innovation practice of experiential exploring of service architecture reflects this ongoing experimentation and redesign of the IT architecture away from reproducing the organizational structure to exploring

potential products that the IT architecture could potentially afford. A second liminal innovation practice is around architectural integrating. This refers specifically to activities in which single teams or actors try to find a way of dealing with the existing distributed product architecture by testing out the boundaries of feasibility. A natural result of this continuous experimentation is that teams begin to explore the architecture in a way that begins to push against the limits and constraints of the architecture, resulting in efforts to span these constraints. In working around and spanning the limitations of the architecture, these teams essential add a "meta" layer to the architecture. In the case, this was evidenced by the creation of the architecture-spanning OTA control unit during the development for delta.

Temporal Pacing Tension and Temporal Bridging

The second tension – *pacing tension* - is defined as a tension between rigid and predefined temporal work practices due to the imbricated anchoring to the product' materiality which contrast the iterative and evolutionary realization of digital innovation. This unfolded in the case based on two elements.

Firstly, the start of production as a temporal fixpoint for finalizing the physical product dominates the flexible temporal development of the digital artifact around OTA. This first tension also describes differences between fixated understandings of time for the physical development of the car and the development of digital services driven by the ideas of continuous delivery. The start of production date marks a key instance in managing the multiple internal and external stakeholder groups involved in the development process. Thus, the attention of project managers is directed towards aligning all stakeholders towards this date. This is deeply rooted in the material structure of the vehicle, as changes of the physical architecture involve high investment costs as the Director of IT explained: *"You can't change the design of a car like to you can do it with the app. Setting up a plant for the vehicle productions alone costs the company half a billion and once steel and metal is pressed, changes are expensive*".

Secondly, the product development process, including its demarcated product development stages with quarterly synchronization points over 48 months, conflicts with the need for continuous testing and launch of digital artifacts. This is also shaped by the different ideas of projects and digital products as vehicles for organizing work and an avoiding attitude towards changes, which distinguish the two forms of development. The physical materiality of the car and its implications for the process, to ensure sticking to the plan to avoid expensive change, is embodied by the car development teams with a clear focus on meeting certain milestones. In contrast, the flexibility of the digital artifact, expressed by the microservice based development in the OTA case, allows for editability and continuous development. Thus, the OTA team complained about reactions from the product development team: *"They always ask once OTA is done and I tell them it's never done"* (Senior Product Manager*)*. Consequently, the OTA team, which was set up as an agile delivery team, embraced the idea of continuous delivery, trying to redesign and relaunch new versions of software artifacts constantly. While PremiumCar had dedicated synchronization points as part of the process in place, still the software teams complained about lack of testing opportunities as a team member explained: "*We can only a test a few times during the development process at these synchro points which is not enough to eliminate all the bugs involved"* (Senior Solution Architect*)*.

We describe the mechanism for addressing these tensions as *temporal bridging*. Temporal bridging is the process by which actors try to find ways of reconciling and transcending new temporal practices and perceptions with the old. These practices are imbricated and anchored to the product's materiality. This mechanism builds on two enacted liminal innovation practices, backarounding and synchronizing practices. Backarounding refers to fixing bugs in the backend after the start of production date. Synchronizing practices refer to the activities that help to harmonize software and hardware and two achieve combability. Thus, temporal bridging relates to practices in which actors try to find ways of dealing with the temporal pacing tensions arising from trying to combine and organize around the characteristics of the material and digital artifacts. Reconciliation practices are practices around the recurring mapping of value-generating cross-functional activities, through which actors try to expand their digital innovation reach and reduce interdependencies within IT landscape. Together, they form the mechanism of temporal bridging.

Structural Decampment Tension and Recoupling

The third main tension – *structural decampment tension* –is about a tension between the identity and organizational structure anchored to the materiality of the core product contrasted by competitive threats requiring an alteration of identity and organizing of the organization. It unfolded in the case setting in questions of roles and identities, and secondly around organizational structure, budgeting, and reporting.

Firstly, identity and role tensions emerged over the process of OTA integration within the vehicle. The identity tension emerges through different groups of people and their views on the emerging competitive threats and around different views regarding the implications for organizing.

As PremiumCar was deeply rooted into racing cars and was also quite successful as the most profitable car brand of Mobility Groups portfolio, the organization had developed a strong and proud identity. This involved a form of frugality, a strong and rigid ways of doing things and high ambitions in product engineering. With the success of new emerging market entrants, this identity was now threatened. This raised the question whether the preexisting capabilities would suffice in the new era and how the organization should deal with the new competitors. While not many people doubted the necessity to advance the digital capabilities of which OTA was an essential element, still the management team experienced a lot of struggles between different groups and their sensemaking of the competitive environment: *"I have one group that pushes the agile and digital thing and another one that makes the agile things responsible for the issues we have. What am I supposed to do?"* (Director Digital and Innovation). These conflicts were reflected in the high sensitivity of middle management members and with some of them that reacted very cautiously with regards to digital topics.

In connection with the identity topic, also several role tensions between established roles, their tasks and the requirements of the digital product organization in combination with the implementation of OTA emerged. For example, with OTA's second generation, the technology afforded multiple opportunities that were hard to assign to a specific department. This offered a space in which existing roles from product development, IT, sales and also external stakeholders were rebalanced. For instance, product development teams around the car were challenged by the OTA team. Precisely, product development teams feared IT interfering with the design of product components through the integration of the OTA control unit. Additionally, their key engineering expertise was more and more challenged through new emerging views favoring decisions for OTA. Beyond this, also designing and embedding digital services into vehicles was not their key expertise as some omitted: *"Many of us are premium engineers and not app designers!"* (Head of Connected Car). Thus, also a lack of capabilities emerged that could now be filled either with the internal IT department signing up for these activities or with external parties such as external suppliers or new emerging players within Mobility Group.

Secondly, structural tensions around the organizational structure and affiliated practices such as budgeting and reporting appeared. The budgeting practices in place were very well aligned with the delivery of physical products. Teams needed to provide a robust business case which then got approved through several steering committees of projects. These budgets were always tied to specific activities ensuring that money is spend well, but constraining the team's flexibility as some explained: *"Our budget process is quite straight! You need to have a strong business case, then you apply, you get 30% less of what you have planned for and then you need to do exactly what the budget was provided for. If not, you get serious issues in the next steering committee!"* (Release Train Engineer). This budget process worked quite well for vehicle development and the rigidity and fixed processes made sense given the large resource investment required for product development of cars. However, during the development of OTA acquiring budget became a major challenge and issue: *"We are currently funded through 13 projects which means 13 reporting meetings and applications for funding and within the team we don't have the chance to flexibility reallocate resources depending on priority. We need to stick to the agreed things in the beginning"* (Senior Product Manager). This often led to the delivery of features that were at the point of delivery not relevant anymore as someone explained: "*By the day we deliver on the promise made with the budget application, the requested feature is often not needed anymore. For the delivery of products, we need to step away from funding specific projects or features, rather investing in long-term capabilities such as OTA that allow us to reprioritize flexibly given the needs of our environment"* (Head of Department IT/Electrics).

Regarding the organizational structure, the idea of the digital product organization pioneered by the OTA team conflicted with the project approach chosen for the vehicle's physical development. Initiated through

implementing a scaled agile framework within the digital product organization, the OTA team which before was a loose coupling of different agile IT teams now became a value delivering entity of the new virtual organizational structure. As part of this journey, the OTA team engaged in several liminal productification practices. Within these practices team members reflected their work and activities towards what creates value for different stakeholder groups. This unfolded through multiple workshops in which the teams mapped their processes and IT landscape reflecting interdependencies and trying to detangle these interdependencies by changing processes and responsibilities. As someone explained: *"You can understand the implementation of a scaled agile framework also as way for us to expand our reach. So, over the past years we multiple times mapped our processes around OTA, recognized many interdependencies with other departments that were also visible in the IT landscape and then tried to reorganize and motivating teams from other departments to move towards the idea of delivering products"* (Senior Product Manager). While the boundaries of the different departments were a clear issue and challenge to them, the team also struggled with the changing attitude regarding the delivery of products as a team member explained: *"In earlier times, people came to us with a specific solution in mind, a mock-up, a power point visualization of their wishes that we were supposed to execute. Today, we want to understand the underlying problem and test and validate the assumptions around the problem before we then together think about a potential solution that we can build. And this is hard to get for people as they still come with mock-ups and so on to the planning meetings" (Senior Product Owner 2).* The explained recalibration and reorientation towards the delivery of products required teams to change these fundamental assumptions around collaboration. Originally, many of those steamed from a project-oriented way of working as the same person continues to explain: "*Most of the people grew up in the project world with dedicated timelines and working packages that were done and as long you delivered its fine. And we need to challenge that attitude towards delivering internal or external customer value through the delivery of products*" (Head of Department IT & Electronics). Thus, the intended move away from projects to product thinking had a strong impact on the enacted practices, the IT infrastructure, the organizational structure and the mindset that came along with it.

We identified a mechanism to address, which we refer to as *structural recoupling*. The mechanism explains how a new organizational structure emerges based on the materiality of digital innovation, which is overlayered to the old structure opening up experimentation spaces, e.g., new structures that lead to unstable structures, identities and new roles. Structural recoupling involves liminal innovation practices of reducing of interdependencies and creating space. With reducing of interdependencies, we refer to activities of redesign and reduction of dependencies between IT systems that go along with the change of several activities around process mapping and the change of certain responsibilities and tasks. With creating space, we refer to activities of the digital team that try to build on the existing identity and aim to complement them creating a sense of urgency. Thus, for example the digital team organized several events in which management leaders talked about new competitors, their role within the market. Thus, digital leaders continuously explained the need for change and the resulting strategic actions while the same time stressing the importance of strong roots and combining innovation and tradition. For example, one core marketing slogan was about *"Bringing the PremiumCar experience car into the digital future"* (Internal Material 2). This was supposed to highlight the need to keep the premium engineering expertise and complement that with digital capabilities rather than replacing the existing world. Further, by space creation we refer to liminal practices around filling a role vacuum and experimenting with a new role that emerged. This manifested in the case through single actors representing a small team that volunteered for the IT department to take over the development of OTA although their experience and knowledge was limited.

Discussion

Punctuated Multi-layered Liminality

Our findings show how PremiumCar experienced a form of punctuated multi-layered liminality which can be understood as a temporal state in which the physical materiality of the product anchors possible socio-technical futures of the organization. We displayed a schematic representation of this process in Figure 2. With digital innovations, PremiumCar had to decouple elements of a tightly integrated traditional process perfect to build high-performing physical cars. At the same time the materiality of their core product – the car – constrains and opens up the range of possibilities for new sociotechnical futures afforded by

constantly evolving digital technology. This in turn, relates to both PremiumCar's future of temporality and structure.

In the pre-digital state, PremiumCar found itself in an equilibrium in which the physical materiality of the product anchored and dominated the temporal and structural layer. Both, structurality and temporality conditioned each other. The integration of digital innovation – at PremiumCar through the implementation of OTA over several generations – triggered tensions on these three layers. Thus, the tensions show how PremiumCar's ambition to embrace digital innovation is constrained through the materiality of their products and its implications for organizing. In addition, PremiumCar had to redefine specific aspects of the materiality of the car itself (e.g., product and IT architecture) to allow for digitally innovating in the context of their car. Yet, due to the fact that both the temporality and structurality was anchored and shaped by this materiality several tensions arose (i.e., architectural, pacing, and decampment tension) the resolution of which through three distinct mechanisms (i.e., boundary testing, temporal bridging, and structural recoupling) resulted in stable states of punctuated multi-layered liminality.

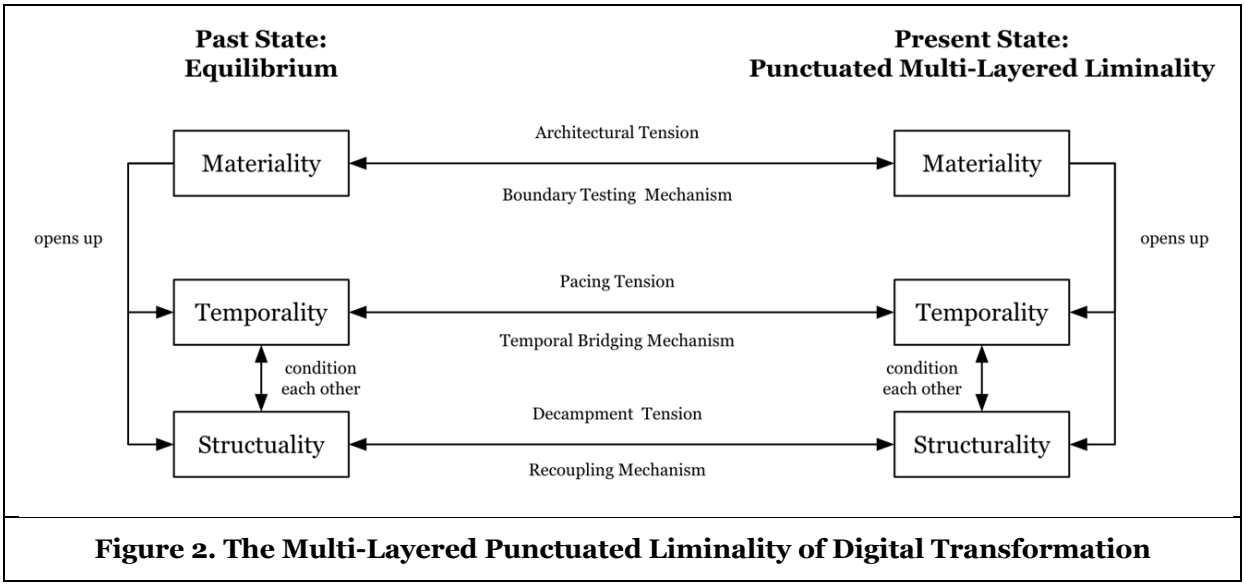

Figure 2. The Multi-Layered Punctuated Liminality of Digital Transformation

Implications for Theory

Current work on digital innovation and resulting implications for organizing has started to explore how the generativity of digital technology spurs new forms of liminal change (Hanelt et al. 2020; Henfridsson and Yoo 2014; Orlikowski and Scott 2021; Wessel et al. 2020). Current literature on the liminality of digital transformation offers to contrasting views: liminality as a singular discrete transitionary period (Henfridsson and Yoo 2014) or liminality as open-ended continuing practices (Orlikowski and Scott 2021).

Our findings synthesize these two views by showing how liminality follows a punctuated pattern across three layers. We argue that is liminal state is not transitionary as the tension between the physical materiality and the digital technologies materiality is permanent. But such on-going continuous liminal status is punctuated with multiple layers that has a sequence of shift to a different state as the organization deals with tensions arising in each layer. So, if one would zoom out and look at the digital transformation of an incumbent firm, it appears that the liminality of digital transformation is on-going and continuous. However, if one would zoom in on each layer of material, temporal and structural, we see a series of transient liminal periods each with discrete shifts.

Existing research in the automotive context has discussed tensions that emerge on different levels when new digital innovation endeavors meet the status-quo of an organization (Shahalei and Kazan 2020; Soh et al. 2019; Svahn et al. 2017; Wimelius et al. 2021). While we also show the emerging tensions that comply with this literature, we unpack the details of how organizations navigate these tensions as a process of punctuated multi-layered liminality. Further research portrays digital innovation and its effects on organization – currently also depicted as digital transformation (Hinings et al. 2018) – resulting in "episodic phases of DT (which) trigger continuous changes" (Hanelt et al. 2020, p. 20). Our findings are

consistent with this view reasoning, overcoming the either/or understanding of change and stability and instead unpacking how change and stability unfold over time.

Implications for Practice

For practice, our work shows how product-driven organizations incorporate digital innovation into their organizations, what kind of tensions they experience and how they deal with these tensions. Beyond of that, our work enforces the need to acknowledge the rooting of a product-focused organizations in the materiality of the core product.

Despite of digital transformation and respective digital innovation initiatives, organizations and decision-makers need to find ways of punctuated liminality to achieve a temporal and structural move beyond of their established practices. As such, our proposed mechanisms and respective tension on the material, structural and temporal level may help to define strategic initiatives in moving forward in digital transformation endeavors.

Our findings further reinforce the need for acknowledging the socio-technical nature of change and organizations per se. Consequently, our work may inform decision-makers in shaping the worldview on digital transformation by juxtaposing that the desired sociotechnical future of an organization as an effect to the cause of digital transformation is paved by several punctuated states of multi-layered liminality.

Conclusion

The intention of our paper was to explain how continuous sociomaterial processes of digital innovation contribute to the digital transformation of organizations. Further, we aimed to unpack how digital innovations combine to effect digital transformation. By relying on empirical data from a case study of a car manufacturer, we show how the integration of digital innovation leads to tensions on the material, structural and temporal layer. We further argue that these tensions trigger a new form of punctuated multi-level liminality and unpack this process by identifying the practices and three core mechanisms that explain how this process happens. Thus, we contribute to the literature stream on liminality and digital innovation (Henfridsson and Yoo 2014; Orlikowski and Scott 2021) by arguing that liminality is not a transition state, but can be understood as a continuous state (Johnsen and Sørensen 2015). This adds more clarity to understand how digital transformation unfolds (Vial 2019) and shows how different waves of digital innovation trigger digital transformation (Hinings et al. 2018; Vial 2019; Wessel et al. 2020).

By nature, our research is not without limitations. First, our findings are closely tied to our context, which is about a product-driven manufacturing company in Europe having clear boundary conditions for our findings. Second, while we were able to talk to interviewees involved in product development, a stronger representation of their view within the data including interview data from the Software Corporation may advance the robustness of our findings. Third, our data gathering was subject to an ongoing global pandemic, which allowed us to run all interviews and observations in an online setting. While this has simplified access to meetings, the missing personal interaction may nevertheless undermine our theoretical claims. Future research may explore other product-oriented settings in which the integration of digital technologies is also limited by the physical materiality of the product or may also investigate the mechanisms involved in such a liminal period.

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