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Navigating in the Digital Jungle: Articulating Combinatory Affordances of Digital Infrastructures for Collaboration

Completed Research Paper

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Abstract

During digital transformation, companies integrate digital technologies creating large and complex digital infrastructures. These digital infrastructures hold combinatory affordances enabling companies to achieve outcomes that are more than the sum of their parts (i.e., the individual digital technologies). Owing to the complexity of digital infrastructures, these combinatory affordances are ever-present but hidden in the thicket of the infrastructure making their effective use a challenge. We report on an ethnographic study of a large German car manufacturer (Car Inc.) that increasingly integrated digital technologies into its infrastructure as part of its digital transformation strategy. With its infrastructure growing into a 'digital jungle', the combinatory affordances remained hidden impeding the infrastructure's effective use. To facilitate effective use of their infrastructure, that is, support employees to navigate the digital jungle, Car Inc. created a digital compass as a tool to articulate the affordances hidden in the thickets of the digital jungle.

Keywords: Digitalization, Digital Transformation, IT infrastructure, Affordances, Effective use, Automotive; Combinatory Affordances

Introduction

Exploiting digital technologies' potentials for business is becoming one of the decisive factors for companies to survive and compete in the digital economy (Bughin and Van Zeebroeck 2017; Horlacher et al. 2016). Consequently, companies increasingly pursue to generate value by digitally transforming their business model (Bharadwaj et al. 2013; Loebbecke and Picot 2015), organisational structure and how people work (Duerr et al. 2018; Fuchs and Hess 2018; Yoo et al. 2010). Recent research on digital transformation strategies revealed that companies' digital transformation strategies focus on four dimensions: use of technology, changes in value creation, structural changes and financial aspects (Matt et al. 2015). Matt et al. define the first dimension, use of technology, as *"a company's attitude towards new technologies as well as its ability to exploit these technologies"* (Matt et al. 2015). In other words, a key to digitalization is a company's ability to effectively use technologies, that is, such that their use supports the attainment of relevant organisational goals (Burton-Jones and Grange 2013). With the number of digital technologies increasing, effective use, however, becomes a challenge.

Increasingly integrating digital technologies, companies create large and complex IT artefacts, namely, digital infrastructures (Hanseth and Lyytinen 2010; Tilson et al. 2010). Digital infrastructures hold combinatory affordances for actions enabling their users to achieve outcomes that are more than the sum of their parts. For instance, a communications technology may enable users to communicate but when combined with a spreadsheet and a calendar, it may enable effective project management. Yet, given their complexity, these combinatory affordances often remain invisible; stashed in the thicket of the infrastructure. Being invisible, employees cannot leverage these potentials and thus, effective use of digital infrastructures is impeded (Burton-Jones and Volkoff 2017). In fact, in their review on the barriers of digital transformation, Vogelsang et al. (2019) identified a lack of transparency about current and available technologies, that is, information about and decision on technologies, as a barrier to digital transformation. Therefore, we address the following research question:

How can an organisation facilitate effective use of its digital infrastructure?

We build an ethnographic approach studying a large German car manufacturer (henceforth, Car Inc.; a pseudonym) that was experiencing issues with leveraging its digital infrastructure's combinatory affordances. Reflecting its digital transformation strategy, Car Inc. procured numerous digital technologies with a focus on providing affordances for the context of collaboration. As a result of these digitalization efforts, Car Inc.'s digital infrastructure evolved into a 'digital jungle' – an almost impenetrable, dense thicket of a montage of digital technologies. Seeking to unveil the infrastructure's combinatory affordances, the company's digital unit engaged in articulation work to construct a tool, known as 'digital compass', facilitating employees to navigate in this thicket and actualise these combinatory affordances for collaboration.

In the next section, we provide a discussion on extant literature on digital infrastructures, the theory of effective use and articulation work. In section three, we outline our research approach including data collection and analysis as well as a description of the empirical site. Subsequently, we present our observations from our ethnographic study and discuss these observations against the theory of effective use. We conclude our paper by providing both practical and theoretical implications of our research as well as limitations and angles for future research.

Theoretical Background

Digital Infrastructures

Infrastructure studies have a long history within IS research (e.g., Ciborra and Hanseth 2000; Star and Ruhleder 1996). These studies have established infrastructures as separate objects of inquiry from traditional IS. What exactly an infrastructure is, has proven to be a thorny task. As already shown by Star and Ruhleder (1996), infrastructures seem not amenable to normative definitions. We take infrastructures to be a linchpin tying together constellations of both material and social dimensions that provide opportunities for action (i.e., they both enhance and limit agency) that are more than the

sum of their individual parts (Niemimaa 2016). Thence, digital infrastructures are constellations of digital technologies (Henfridsson and Bygstad 2013) and social actors together with the necessary material (e.g., facilities, cables, hardware) and social ties (e.g., social relations, organisational arrangements) that unite the parts (without unifying them) into whole.

A key aspect of infrastructures is that they are dynamic (Niemimaa 2016). Infrastructures change as new connections are established, boundaries re-enacted, and new component parts added. Extant research has identified the dynamic nature of infrastructures as a key challenge for their design and development (Hanseth and Lyytinen 2010). Especially, the top-down governed development (Constantinides and Barrett 2014) often fails as infrastructures start to drift away from management control (Ciborra and Hanseth 2000) due to their inherent generativity (Hanseth and Lyytinen 2010; Henfridsson and Bygstad 2013). Thus, in lieu of development of infrastructure, it is more accurate to speak of their evolution (Henfridsson and Bygstad 2013) that often unfolds in surprising and unexpected ways – as the evolution of the Internet testifies (Campbell-Kelly and Garcia-Swartz 2013).

While the use of infrastructures has gained less attention than the design issue, the evolving nature of infrastructure bears also important implications for the affordances an infrastructure provides (Niemimaa 2016, 2018). As infrastructures evolve, so do their affordances. By combining new technologies into an infrastructure collective, new opportunities emerge that open space for infrastructure innovations (Grisot et al. 2014; Pipek and Wulf 2009). However, for the affordances to exist, employees need to be aware of and conceive the new opportunities (Gibson 1979).

From a phenomenological stance, a key characteristic of infrastructures is that they remain invisible (Star and Ruhleder 1996). We rarely notice the WiFi infrastructure that provides us wireless connection or the heating infrastructure that provides us warm air in the middle of winter. According to Star and Ruhleder (1996), infrastructures transform into visible either when they break down or they become an object of attention. Break downs can thus be significant sources of learning about infrastructures (Star and Ruhleder 1996). These break downs can be related to technologies (i.e., a system failing) or routines (i.e, emergent/surprising situation that initiates an expansion of the routines or the technologies (Leonardi 2011; Madsen 1988). However, organisations seek to minimize such moments as they can be costly, and even if choices are made based on rational calculus, break downs are acceptable only to the extent that the learning outcomes outbalance incurred costs (La Porte 1996).

For any infrastructure specialists involved in maintenance and repair tasks, such as plumbers or electricians, an infrastructure routinely appears as an object of attention rather than as an invisible background for action (Graham and Thrift 2007). By treating infrastructure as an object of attention, the specialists are able to perform maintenance work and to learn about it (i.e., an object of attention), often with the aid of symbolic representations of an infrastructure such as diagrams, plans, etc. (Orr 1996). Learning about infrastructures can take place directly, vicariously, or through the symbolic representations thus aiding organisational learning.

Effective Use of Digital Infrastructures

IS can increase productivity only when used in the flow of organisational practices. (Orlikowski 2000). Use of an IS is defined as using technology while completing a goal-directed activitiy (Burton-Jones and Grange 2013). Burton-Jones and Grange (2013), however, argue that mere use of technology does not hold any merits; *only effective use does*. According to their definition, effective use is using technology such that its use supports the attainment of a relevant goal. That is, effective use does not imply accomplishing the relevant goal, but for use to be effective it should support its attainment. This notion of effective use reaches beyond use *per se* emphasising that use for the sake of using does not hold any merits for attaining relevant goals and thus, for increasing productivity.

Building on this theory, Burton-Jones and Volkoff (2017) develop an approach for conceptualising contextualised theories of effective use. They demonstrate their approach in the context of an electronic health care record drawing on the theory of affordances. Affordances, a neologism originating from ecological psychology, are the action capabilities that an environment furnishes for action (Gibson 1979). In other words, affordances are action potentials for achieving goals (Zammuto et al. 2007). Being potentials for action, their effective use is achieved by purposefully actualising

these potentials (Burton-Jones and Volkoff 2017). Hence, in the context of effective use, *actualising* means leveraging the affordances offered by an IS to support the attainment of a relevant goal.

Digital infrastructures offer various affordances (Niemimaa 2018). Each component of an infrastructure provides some affordances. A water tap provides affordances for opening and closing a valve. When the water tap is part of a water distribution infrastructure, it can provide *combinatory* affordances emerging from the combination of water pipes, valves, taps, etc. to regulate the flow of water. In the case of the water tap, the combinatory affordances are rather obvious. Digital technologies are often more complex and realizing their combinatory affordances is less obvious. Burton-Jones and Volkoff (2017) refer to network affordances as potentials that emerge from a specific use sequence of a digital technology. For instance, for a system to provide certain network affordances, the user must perform a sequence of actions; a spreadsheet provides affordances for calculations only after the user has first used the spreadsheet syntax to create formula for the calculations. However, systems may also be combined. Some of these combinations we perform intuitively – like when using pen and paper to write down notes from a system to support using that system effectively – whereas others are less intuitive and often less visible; infrastructures tend to hide in the background and become invisible (Star and Ruhleder 1996). It can be difficult to know exactly what systems are available for use (especially, nowadays with the abundance of cloud-based systems) not to even mention the affordances emerging from the possible combinations of these systems. However, for infrastructures to be used effectively as infrastructures, organisations need to actualise their combinatory affordances. Regardless of the pervasiveness of digital infrastructures and the resources organisations invest in them, there is a short shrift of studies focusing on aiding organisations for effective use of infrastructures.

Articulating Combinatory Affordances of Infrastructure for Effective Use

Given the above, we build on the idea that a precondition for effective use is to transform an infrastructure into an object of attention such that an organisation may learn about it and its affordances. When designing cooperative work, organisations engage into articulation work to explicate both implicit and explicit aspects needed to perform coordination (Schmidt 1994; Schmidt and Bannon 2011). That is articulation work involves:

> *"First, the meshing of the often numerous tasks, clusters of tasks, and segments of the total arc. Second, the meshing of efforts of various unit-workers (individuals, departments, etc.). Third, the meshing of actors with their various types of work and implicated tasks."* (Strauss 1988, p. 8)

Articulation involves simplifications of the reality in the form of plans, figures, diagrams, etc. that themselves require articulation work to materialize (Gerson and Star 1986). The material objects *"conceived of as mechanisms in the sense that they (1) are objectified in some way (explicitly stated, represented in material form), and (2) are deterministic or at least give reasonably predictable results if applied properly"* (Schmidt 1992, p. 56). Such work requires making visible invisible aspects of work to articulate design of systems that support effective cooperative work (Suchman 1995). Articulation may also perform visible other hidden aspects of organising such as tensions in infrastructure development (Ribes and Finholt 2009). Similarly, we see that articulation is a necessary aspect of effective use of infrastructures as organisations need to articulate their infrastructures' affordances to support achieving work-related goals effectively. However, in lieu of meshing tasks, clusters of tasks and unit-workers, articulating the combinatory affordances of an infrastructure involves the "meshing" of digital technologies and work-related, goal-oriented tasks.

After outlining our research approach, we will turn to our empirical material on how Car Inc. engaged in articulation work to explicate combinatory affordances of their digital infrastructure by developing a digital compass for navigating in the thicket of its digital jungle.

Research Approach

Our study follows an ethnographic approach. Following an ethnographic approach, a researcher goes to *"where the action is"* and *"develops an intimate familiarity with the dilemmas, frustrations, routines, relationships, and risks that are part of everyday life."* (Myers 1999, p. 5). Ethnography is

about studying what people do rather than what they say they do. By this and entering the field for an extended period of time, ethnographic research allows for collecting vast amounts of empirical data. Therefore, ethnography is an in-depth research approach best suited for unpacking black boxes (Gherardi 2018; Van Maanen 2011a; Myers 1999). Since ethnography is a single-sited research approach, it aims for plausibility, authenticity and truthfulness in thick description providing in-depth insights into the studied phenomena in lieu of statistical generalisations. (Golden-Biddle and Locke 1993; Klein and Myers 1999; Van Maanen 2011a; Myers 1997, 1999).

Empirical Material and Analysis

The first author entered the field for an extended period of time from July 2017 until December 2018. Access was gained via a research contract with Car Inc.'s internal organisational development unit. As part of this research contract, the first author was observing similar work responsibilities as his colleagues (Van Maanen 2011b). Observing similar work responsibilities but also attending to both the organisation's and the department's formal and informal arrangements (e.g., department and team meetings; coffee and lunch breaks), he immersed in the field building strong rapport with his peers (van Maanen 2011b). Allowing himself time to build this rapport and familiarise with his work responsibilities, he started structured data collection after 4 months in the field.

In tradition with the ethnographic trade, the first author conducted participant observations as the primary method for constructing the empirical data (Ingold 2014). Since he assumed both work responsibilities and research, he conducted his observations on an ad-hoc basis. That is, whenever something struck him as interesting, surprising or related to the phenomena of interest, he started writing a field note. At first, these field notes were written as jottings, that is, brief notes grasping the essential part of an observation (Jarzabkowski et al. 2014). Afterwards, he elaborated these jottings into full textual accounts of the observations made in the field. For this, he applied a set of conventions marking verbatim speech in quotation marks and direct interpretations in italic font. Further, he kept different logs for emerging ideas, descriptive or analytical field notes. By this, he gradually constructed a vast body of field notes capturing his participant observations on the phenomena of interest (Emerson et al. 2001; Van Maanen 2011a; Myers 1999). Besides participant observations, the first author was able to capture other employees' expressed thoughts on the phenomena under study in informal interviews. Afraid of risking the rapport built with his peers, he did not tape record these informal interviews but recorded them in writing shortly after (Schultze 2000). In addition, he collected archival documents reaching back to 2015 such as strategy reports, annual reports, internal and external news, posts on the internal enterprise social media platform and the company's website to add to his understanding of the organisation and people under study.

Data analysis was informed by qualitative data analysis techniques (Silverman 2014) and started already in the field with the first author writing memos on emerging ideas and analytical field notes. At the same time, we regularly discussed the collected empirical data and consulted extant research to inform and sharpen our analysis of the observations made in the field. In other words, our data analysis was constituted by an iterative process of analysing empirical material on-the-fly, consulting extant research and noting down emerging ideas and patterns which then informed the first author's focus for further empirical material. Consequently, data collection and analysis were not two separate processes but iteratively fed-back to each other (cf. Cecez-Kecmanovic et al. 2014). Drawing on the literature on digital infrastructure, we identified what we consider as articulation of a digital infrastructure's combinatory affordances in order to assist users in actualising these affordances.

Empirical Site

The first author conducted the study's field work at a large German car manufacturer (henceforth, Car Inc.). With more than 285,000 employees worldwide, Car Inc. operates in four business fields producing cars, vans, trucks and busses under its various brands targeting the premium segment. As Car Inc.'s founding fathers pioneered in crucial technological developments enabling today's automobiles, it pictures itself as stepping in its founders' foot-steps. This invokes an organisational belief, spirit and enthusiasm for re-inventing the future of mobility. To live-up to this self-conception and as a response to external factors (e.g., new competitors as Tesla or technological trends as

autonomous driving), in January 2016, the car manufacturer's board of management decided for a strategic change initiative transforming its work culture.

> *"The purpose of [the strategic change programme] is to change our culture, to put us, as an organization and as a team, in a position to face the challenges of changing market conditions, new competitors and a new generation of employees. The goal, among other things, is to become faster, to be able to react more flexible to change, to gain new knowledge and to put our potential for innovation to good use."* – Internal document

Historically, Car Inc. had grown into a large organisation constituted by strong hierarchical structures and bureaucracy. Being an engineering company, projects for developing products were planned well in advance and new features were only released upon their perfection. In the context of cars and safety related parts, such an approach is required. However, with a surge of new digital technologies and new competitors entering the market, the car manufacturer's board of management recognised a need to adapt the organisation's work culture. Therefore, as part of this programme, the car manufacturer established a digital transformation squad tasked with initiating and pushing efforts for digital transformation. The squad seeks to provide the car manufacturer's employees with the digital technologies they require for their work but also to empower them to participate and shape the car manufacturer's digital transformation. Hereby, the strategic change initiative sets a particular focus on improving information sharing, collaboration and cooperation on the basis of digital technologies:

> *"In our new virtual community all employees are able to connect with their colleagues worldwide. Employees are able to share information and solve problems as a group much faster and easier by using our new tools for communication and cooperation."* – Internal document

In addition to this initiative, Car Inc. founded a digital unit. This unit was already founded in 2011 and is led by the car manufacturer's head of digital strategy. Over time, it evolved into a strategy unit reporting to the car manufacturer's CEO. It orchestrates and fosters initiatives for digital transformation within the organisation and therefore, collaborates with various units including the digital transformation squad and the corporate IT function. In the context of the car manufacturer's digital transformation, its digital unit defines and operates four fields of actions, namely, ideate, change, transform and collaborate with the last focusing on empowering *"communication and collaboration with digital tools [...]. Because 'change' isn't something you can command. We want to empower people to explore new ways to improve their work- experience"* (Internal document).

Jointly with Car Inc.'s corporate IT function, its digital unit and the digital transformation squad, push the implementation of new digital technologies for collaboration. In other words, they continuously extend the company's digital infrastructure, offering its employees a surging number of digital technologies for collaboration as well as organising and performing their work. Realising that employees were struggling to keep-up with or find information about the changes and extensions performed to the firm's digital infrastructure, they created a 'Digital Collaboration Tools Compass' (hereafter referred to as Compass). This Compass provides an overview and guidance on the digital technologies supplied by corporate IT and the affordances these digital technologies provide in the context of collaboration. Therefore, Car Inc. presents an interesting and important site for studying the articulation of combinatory affordances of a digital infrastructure.

Navigating in the Digital Jungle

Integrating Digital Technologies: Cultivating a Digital Jungle

Historically, Car Inc.'s digital infrastructure had evolved into a large IT artefact governed by its corporate IT function. Driven by costs, the corporate IT function sought to provide the best possible support within set budget limitations. Consequently, business units describe the processing of demands as slow and corporate IT turning down these demands for various reasons (e.g., IT security regulations, licensing or costs). The corporate IT function followed a one-size fits it all strategy in regard to employees' IT equipment. Hence, in 2016, when the digital transformation squad started its work with Car Inc.'s digital infrastructure as the object of its attention, it did not start on a green field. In line with the strategic change initiative's aim to transform the way people work, the digital

transformation squad aims *"to turn [Car Inc.] into an outstanding digital work place in the mobility industry.* […]. A*ll employees in all areas get empowered to* **work digitally** *– from the office to the production plant. They receive the necessary instruments and tools to organize their work as efficiently as possible."* (emphasis in original) (Internal document). Besides providing 'the necessary instruments and tools', the digital transformation squad also set to enable employees *"to decide for themselves, what technical equipment they need to perform as good as possible"* (Internal document). Hence, the digital transformation squad seeks to not only provide Car Inc.'s employees with technologies for working digitally, but also to enable its employees to decide for themselves which digital technology they need for performing their work. In its strategy presentation, it sets the focus on digital technologies for communicating and sharing information as well as collaboration:

> *"Digital transformation requires a culture of digital cooperation. Intelligent networks and platforms, that encourage the sharing of information and experiences, enable digital communication and cooperation."* – Internal document

Table 1: Digital Technologies Integrated into the Digital Infrastructure

Year	Digital Technology Integrated	Excerpts from Internal Documents
2016	iOS and iPhones are introduced as the only mobile platform	• *"We standardize the devices we use and switch to iPhones only."* • *"[…] we will be expanding our service for personal smartphones and simplifying the request process."* • *"This decision is a crucial step toward seamless collaboration among our employees."*
2017	Instant Messaging App for mobile phones	• *"[It] is a proprietary encrypted instant messaging application for iOS, Android and Windows Phone. In addition to text messaging, users can send multimedia, locations, voice messages and files."*
2017	ECHO Feedback app	• *"The aim of ECHO is to encourage a positive Feedback – culture that supports the motivation and personal development of every employee. The app facilitates the exchange of feedback since it makes it easy to get in touch and share your thoughts right away."* • *"ECHO is an app you can use to provide and receive feedback at any time. […]. ECHO is not intended to replace personal feedback. But the app helps break the ice or subsequently obtain feedback."*
2017	Development of AskCarInc begins	• *"For (almost) every question there is someone in our company, who knows the answer. [AskCarInc] is an application that aims to make that (implicit) knowledge accessible: from colleagues, for colleagues."*
2018	Agile Project Management Tool	• *"Digital KanBan Board for agile project management."* • *"Flexible project & task management"*
2018	Instant messaging platform is rolled out	• *"Communication & sharing of information/pictures/files within teams & agile projects"* • *"Workplace messaging (persistent chat) in public or private channels with search and integrations."*
2018	Enterprise Social Media Network (final switch)	• *"It integrates the functionality of online communities, microblogging, social networking, discussion forums, blogs, wikis, and IM under one unified user interface."*

Delivering on these goals, in October 2016, the digital transformation squad suggested to Car Inc.'s board of management, that the car manufacturer shift its mobile platform strategy from offering a range of devices run with various operating systems to only one mobile platform. Approved by the board of management, the corporate IT function exchanged all mobile phones with iPhones by the end of 2018. Further, the digital transformation squad and the digital unit suggested the implementation of three digital technologies: an enterprise social media network; an instant messaging app for mobile phones and an instant messaging platform for project groups and teams which can also be operated on a computer. Car Inc.'s board of management approved the implementation of these digital technologies at the end of 2016. Implementation of the enterprise social media network then started in February 2017. The first pilot-beta was launched in July 2017 followed by an open-beta phase that started in November 2017. A year after, in November 2018, the final switch to the new enterprise social media platform was performed. The instant messaging app for mobile phones was rolled-out in the middle of 2017.

Besides the open-beta phase, Car Inc. also launched ECHO in November 2017. As part of the strategic change initiative, ECHO is an internal app developed to enable and establish a new feedback culture. Using ECHO, employees first set their preferred feedback type and by this, configure how they receive their colleagues' feedback. Moreover, they can share feedback on an ad-hoc basis or ask for feedback from direct colleagues or colleagues working in a different department or function. At the end of 2017, a project team formed to develop the internal application AskCarInc. AskCarInc allows employees to ask questions to all employees at Car Inc. At first, it was developed as a web application and piloted in specific business units. Over the course of 2018, however, it was gradually rolled-out organisation-wide and in December 2018, the project team announced the release of a native iOS application. Over the course of 2018, Car Inc. also rolled out the approved instant messaging platform for teams and a tool for agile project management. Overall, the digital transformation squad, the digital unit and the corporate IT function continue to roll-out and integrate an increasing number of digital technologies (not all can be mentioned here) extending the existing corporate digital infrastructure in particular in relation to digital technologies for collaboration (see Table 1).

As mentioned above, the procurement of digital technologies is one of the digital transformation squad's objectives. The second objective is to enable employees to decide themselves which technologies they need and use in their daily work. Taking measures to enable employees, the digital transformation squad altered the IT equipment ordering process. Prior to this alteration, employees had to contact their IT admin to enquiry about the possibility to order new or additional IT equipment. Once ordered, an approval workflow was started including at least an employee's direct superior and her head of department. With this alteration performed in February 2017, employees were enabled to order their IT equipment themselves. Moreover, for ordering basic equipment such as mice, keyboard or laptop bags, Car Inc. dropped the management approval workflow.

These actions taken at Car Inc. make salient the company's efforts in procuring and providing digital technologies as well as enabling employees to decide themselves which IT equipment they require. Moreover, the kinds of digital technologies introduced reflect the aim and focus on digital collaboration. In the past two years, announcing this aim and introducing digital technologies, the car manufacturer succeeded in building a momentum in its digital transformation. Employees and entire business units are inspired to try and test digital technologies for their daily work and in settings of collaboration. However, the digital unit, the digital transformation squad and the corporate IT function (henceforth, we refer to these three units by only using the term digital unit) recognised that the range of collaboration tools available grew into a 'digital jungle' stashing their affordances from employees' eyes. Resembling a 'digital jungle', an impenetrable thicket, the corporate digital infrastructures' effective use became impeded as employees needed to cut through and navigate in this thicket to actualise hidden combinatory affordances lying dormant in the shadows of the jungle's treetop.

Creating a Compass to Navigate in the Thicket

For business units, keeping track of the digital technologies introduced is a laborious task. Identifying and actualising the potentials for actions residing in the digital infrastructures is difficult and most significantly – at first – not value creating. Realising that business units and employees were

struggling to find their way through the cultivated 'digital jungle' – that is, actualising the provided affordances, the digital unit introduced the Compass. As a figure, the Compass simplifies the cultivated digital jungle of digital technologies forming part of Car Inc.'s digital infrastructure:

> *"A wide range of tools is available throughout the company, facilitating digital cooperation. Some of them function in a variety of application areas, while others are specialized for one specific use case. So far, just a few people have had a clear overview of all of these tools. [The Digital Collaboration Tools Compass] will help you find the right tools for optimizing your (digital) cooperation."* – Internal document

The Compass was first posted to the enterprise social media network in its open-beta phase in March 2018. Since then, the digital unit has continuously revised and improved it. It contains a circle shaped image with the graphic of an actual compass at its centre. Its outer circle is sliced to seven segments which contain icons of the available digital technologies. In each segment, employees find digital technologies which serve the defined use case of this particular segment. In other words, digital technologies in a respective segment offer employees affordances for achieving a particular outcome. Overall, the compass includes 17 different digital technologies. In addition to this post, the digital unit published an explanatory article on the Compass in October 2018. They published this article in their open virtual community space on the enterprise social media network explaining the *why*, *how* and *where* of the Compass.

In regard to *why*, the digital unit argues that the wide range of available digital technologies for digital collaboration gave rise to a need of providing an overview of these technologies (i.e., a simplified representation of reality). This need is intensified by the fact that some tools offer affordances for specific outcomes while others offer affordances for achieving a broader set of outcomes in the context of collaboration. Therefore, the Compass seeks to *"to shed some light on the darkness of the [company's] tool jungle"* (Internal document). In other words, it seeks to picture Car Inc.'s digital infrastructure's affordances in a simplified manner allowing employees to grasp the affordances offered by the complexity cultivated in the digital jungle. Moreover, the digital unit puts forward that the Compass only comprises digital technologies that are available organisation-wide and globally. In terms of *how* the compass supports employees, the digital unit explains that by sorting the digital technologies available by achievable outcomes, users can make better-informed decisions and choices and find a digital technology that offers affordances matching their purpose of use (i.e., attaining a specific outcome or relevant goal). For this, the Compass' seven segments cover defined desirable outcomes in the context of collaboration and information sharing which are Information Management, Document Management, Task Management, Event/Meeting Management, News, Messaging and Social Networking (see Table 2). The icons of the digital technologies available for a achieving an outcome are placed within the applicable segment. Each icon holds a hyperlink to a detailed profile page of the respective digital technology. Hence, employees can look for a digital technology by browsing the seven segments, that is, articulated affordances, and then retrieve detailed information on a respective digital technology by selecting its icon in the Compass. Through this search and selection process, the Compass supports employees in findings and deciding for one or a combination of digital technologies offering affordances that assist them in attaining their set goal. Answering the question of *where*, the digital unit refers to the actual post containing the Compass and various options as bookmarking it to be kept up to date on its continuous development. Moreover, a printable version is offered as a download.

Following the link to the actual post of the Compass, employees find its graphical representation at the top of the page. Below the Compass, they find an alphabetically sorted list of all included tools. This alphabetical list shows an enlarged icon of each tool, its full name and a bullet point list of the segments in which the respective tool can be found. This list indicates, that the digital technologies captured by the Compass differ in their coverage. That is, while the digital unit articulates some tools to offer specific affordances and thus, allocated these tools to only one of the Compass' segments (where each segment represents combinatory affordances), they allocate others to more than one segment as they offer a broader set of affordances (i.e., broader in terms of achievable outcomes). The labels of the seven segments defining the category of affordances by achievable outcome are positioned around the circle shaped Compass next to the respective segment. Each label starts with *"I*

like to..." followed by a statement describing on a general level what outcomes employees can achieve with tools in the respective segment (see Table 2).

> *"Depending on the use case, you may need to look at several segments. You can decide whether to use several specialized tools or one single tool that covers all of these segments or at least most of them."* – Internal document

Table 2: Digital Collaboration Tools Compass: Combinatory Affordances, outcome and technologies offering respective potentials for action

Combinatory Affordances	Attainable outcomes	Integrated technologies offering respective affordances
Information Management	*"I like to collect and share knowledge and information"*	• Agile project management tool • AskCarInc • Enterprise social media
Document Management	*"I like to structure and manage documents"*	• Enterprise social media
Task Management	*"I like to organise tasks and task management"*	• Agile project management tool • Enterprise social media
Event/Meeting Management	*"I like to organise, structure and support meetings"*	• Enterprise social media
News	*"I like to be up-to date and share news"*	• Instant messaging app • Instant messaging platform • Enterprise social media
Messaging	*"I like to exchange chat and video calls and screen sharing"*	• Instant messaging app • Instant messaging platform • Enterprise social media
Social Networking	*"I like to network with colleagues and share information"*	• ECHO • Enterprise social media

Discussion and Conclusions

In this study, we have focused on the question of *'how an organisation can facilitate effective use of its digital infrastructure?'*. Our study was motivated by the observation that technologies, when combined as infrastructures, provide combinatory affordances but their effective use is a challenge due to complexity involved and the inherently invisible nature of these infrastructures and the affordances they provide. Our ethnographic study provides evidence that for organisations to effectively take use of the combinatory potentials provided by the infrastructure, they need to articulate those potentials as a precondition for effective use.

With digital infrastructures evolving into large, complex IT artefacts in unforeseen ways (Ciborra and Hanseth 2000), we observed employees referring to the car manufacturer's digital infrastructure as a 'digital jungle'. The digital jungle at Car Inc. was a result of the company's initiatives to exploit digital technologies (Matt et al. 2015) for their internal processes by introducing more technologies supporting cooperative work. As a result of the efforts, the infrastructure had evolved into a large and complex thicket of technologies such that actualising its affordances effectively became a challenge. While the concept of digital jungle originates from a single site, we see that it provides much potential beyond the studied site. The increased interest toward digitalization (Urbach and Röglinger 2019) together with easy provisioning of technologies provided by cloud services and platforms (e.g., Atzori et al. 2010) is likely to accelerate the organisational adoption of technologies and create digital jungles widely across organisations. Thus, we see that digital jungles will only become an increasing and more

costly concern for organisations in the future.

As a response to the ever-growing digital jungle, Car Inc.'s digital unit engaged in articulating the digital infrastructure's potentials for action. In this regard, the notion of articulation work (e.g., Strauss 1988) provided us fertile ground for analysing our context-specific observations and to conceptualise a contextualised dimension of effective use, that is, articulation of infrastructure's potentials for action. Our study contributes by providing initial evidence on how organisations may manage the digital jungle and facilitate effective use of their infrastructures – by articulating a material artefact for communicating about affordances.

At Car Inc., the articulation materialised as a figure of a Compass communicating about the combinatory potentials for collaboration afforded by the company's digital infrastructure. As materialized articulation, the compass is inevitably a simplification and a subset of the totality of affordances that the infrastructure could provide. It indicated (unused) potentials of the digital technologies forming the digital jungle; a 'digital jungle' holds manifold affordances. Yet, the aim of the compass was to communicate to employees the affordances that are related to achieving organisationally significant goals, not the totality of affordances the infrastructure could provide. By engaging in articulation, Car Inc. communicated a subset of its infrastructure's affordances translating its infrastructure from invisible background into an object of attention (Star and Ruhleder 1996). As such, articulations can provide insight into invisible aspects of technologies and organising (Ribes and Finholt 2009), such as combinatory affordances.

Our findings suggest that the articulation of combinatory affordances not only facilitates employees in purposefully actualising the articulated affordances but combinations of these. Thus, our findings suggest that effective use of *a* technology may be founded on accurate representations (Burton-Jones and Grange, 2013) and network affordances (Burton-Jones and Volkoff 2017) but effective use of infrastructure rests on the organisational ability to capitalize on combinatory affordances emerging from collectives of technologies. That is, technology affordances exist at multiple strata pertaining to at least individual technologies and infrastructures. Consequently, we contribute by distinguishing between effective use of technologies and effective use of infrastructures.

We acknowledge, however, that our focus has been on the organisational articulation of the affordances and not on whether the compass facilitated effective actualization of those affordances. That is, our focus has been on organisational articulation of affordances as *potentials* for action (Niemimaa 2018; Volkoff and Strong 2013; Strong et al. 2014). However, prior literature indicates that knowledge influences which affordances a person perceives (Hutchby 2001; Volkoff and Strong 2013) which supports our finding of the importance of articulation of potentials as a precondition for effective use. The compass provided means to communicate knowledge about the affordances to employees. As such, our findings indicate that communicating knowledge about the affordances can take place in codified form as material artefacts. That is, material artefacts may not only furnish affordances in themselves (e.g., Leonardi 2011; Leonardi and Rodriguez-Lluesma 2012; Volkoff and Strong 2013) but function to facilitate organisational learning about affordances of other artefacts.

For practitioners, our study has relevance in its thick description of the digital transformation efforts of a renowned company operating in the automotive industry. Although a single-sited ethnographic study does not provide for generalisations, we believe that our observations hold true for many companies integrating increasing numbers of digital technology in pursuance of their digital transformation. Practitioners may learn from the described observations and adapt our insights to their organisations' contexts. However, we argue that the studied organisation's approach for supporting employees in effective use of its digital infrastructure, may only be one approach. Therefore, our study's practical relevance lies in indicating the importance of providing guidance to employees to identify and actualise the affordances residing in organisations' grown (and growing) digital jungles. By this, companies can support employees in purposefully actualising these affordances (or combinations of such). In other words, they can support employees to effectively use the provided digital infrastructure and by this, improve their ability to exploit technologies (Matt et al. 2015). This effective use leads to the attainment of relevant organisational goals. We argue that our study indicates the importance of providing guidance to employees to navigate in the thickets that digital infrastructures can be.

Limitations apply to this research. Since our study takes an ethnographic approach, its central limitation is that of the generalisability of its findings. However, our aim was not to provide statistical generalisations and thus, we urge to not view this as a limitation of our study per se. Focusing our observations on a single empirical site, we acknowledge that our findings are neither applicable to other organisations nor to any statistical reference sample. By relating observations to theoretical constructs, researchers may contribute to ongoing theoretical discussions (Lee and Baskerville 2003). In this vein, our study extends the knowledge on effective use of digital infrastructures with one particular study. We believe that our findings contribute to the discussion of effective use and that it may provide a useful starting point for further research applying the lens of effective use on digital infrastructures or other IT artefacts.

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