

Entering the World of Individual Routines: The Affordances of Mobile Applications

Completed Research Paper

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Abstract

The IS discipline has a long tradition in investigating how new technologies affect work practices, but has mostly focused on the organizational level. With mobile applications, we are facing a new technology wave that is centered on the individual users. Despite their popularity, mobile applications' possibilities to enhance an individual's knowledge, skills, and competence in daily work practices have not been studied in a systematic way. Building on the concept of routines from organizational theory and insights from two field studies, we investigate mobile applications acting as material artifacts and their possibilities of goal-oriented actions in individual routines. Our main contributions are the extension of Pentland & Feldman's generative system model and a set of affordances that mobile applications bring to individual routines. Our findings complement recent studies on routines at the organizational level and contribute to enhance artifact design knowledge for mobile applications beyond "interaction design".

Keywords: Individual routines, mobile applications, affordances, artifacts, qualitative research

Introduction

The information systems (IS) discipline has a long tradition in investigating how new technologies affect work practices. However, prior research has mostly focused on IT-induced organizational change (Markus 2004), emphasizing the design of organization-wide business processes and business applications (Davenport and Short 1990; Rosemann and Brocke 2010). Today, we face a new technology wave that is centered on individual users: With smartphones and tablet computers, the second generation of mobile devices provides not only anywhere, anytime access to information, but also new means to support individual work practices (Yuan et al. 2010). Mobile applications increasingly change and shape the ways individuals perform their daily tasks: In the context of maintenance and inspection, for instance, mobile applications allow workers to perform remote diagnostics, to locate and document identified failures onsite, and to immediately update the maintenance history (Thun 2008). In healthcare, mobile applications improve health professionals' decision-making, reduce the numbers of medical errors, and enhance their learning (Lindquist et al. 2008). Despite the increasing number of mobile applications, literature on their design and use in an organizational context is still scarce. Moreover, their possibilities to enhance an individual's knowledge, skills, and competence in daily work practices have not been studied in a systematic way.

Our research builds on the concept of routines from organizational theory, denoting recurrent work patterns in organizations (Becker 2004; Nelson and Winter 1982; Pentland and Feldman 2008). An organizational routine is composed of multiple individual routines, each with a precise goal-oriented sequence of activities performed by a single employee (Polites and Karahanna 2013). It is at this level that we study how mobile applications support and how they influence an individual's routine execution. Specifically, we address the following research questions: (1) *What are the roles of mobile applications in supporting individual routines?* (2) *How should mobile applications for individual routines be designed?*

In view of our research objectives, we opted for an explorative qualitative research design based on interpretative field studies (Klein and Myers 1999). Via immersion in the field over a long time, this research design allows researchers to gain an understanding of the "context of the information system, and the process whereby the information system influences and is influenced by the context" (Walsham 1993). As 'involved researchers', we closely collaborated with users and designers of two mobile applications, thereby collecting detailed insights on the individual routines and the design of innovative artifacts. Although the field studies were independently conducted and cover very diverse domains (routine patient care vs. automotive customer service) and different executant types (physicians vs. mechanics), we detected similarities and patterns, which motivate this study. To analyze and interpret our empirical observations, we choose two theoretical lenses: First, Pentland and Feldman's (2008) generative system model to investigate the role of material artifacts in relation to the routine; second, the concept of affordances to analyze how mobile applications are interpreted by users in terms of their possibilities of goal-oriented action in performing routines. Our study's main outcomes are an extension of Pentland and Feldman's model to individual routines supported by mobile applications, along with a set of affordances. By revising existing theoretical foundations to account for a new context (Mueller and Urbach 2013; Steinfield and Fulk 1990), we provide a first contribution towards closing the gap related to individual routines and their support by IT artifacts, outlined by recent studies (Polites and Karahanna 2013). Through proposing a set of affordances, we also contribute to enhance artifact design knowledge for mobile applications beyond "interaction design".

The remainder of this paper is structured as follows. First, we review prior work on organizational and individual routines as well as the concept of affordances, and identify the research gap. We then present our research methodology. The next section describes the two field studies, and summarizes the mobile applications' roles in executing individual routines. We then analyze our field observations to identify the relevant affordances and extend the generative system model. Finally, we summarize the contribution of our paper, describe the limitations of our research, and provide an outlook into future research.

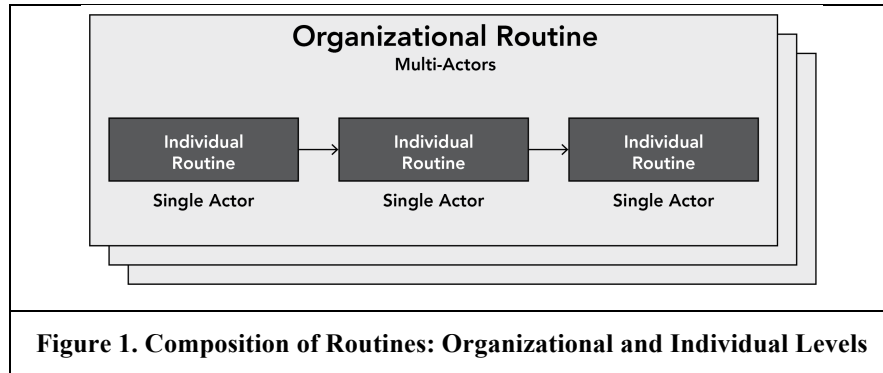
Prior Literature

Our research builds on two theoretical lenses: the concepts of organizational and individual routines, and affordances. Organizational theory informs us about routines as repetitive patterns of activity that rely on

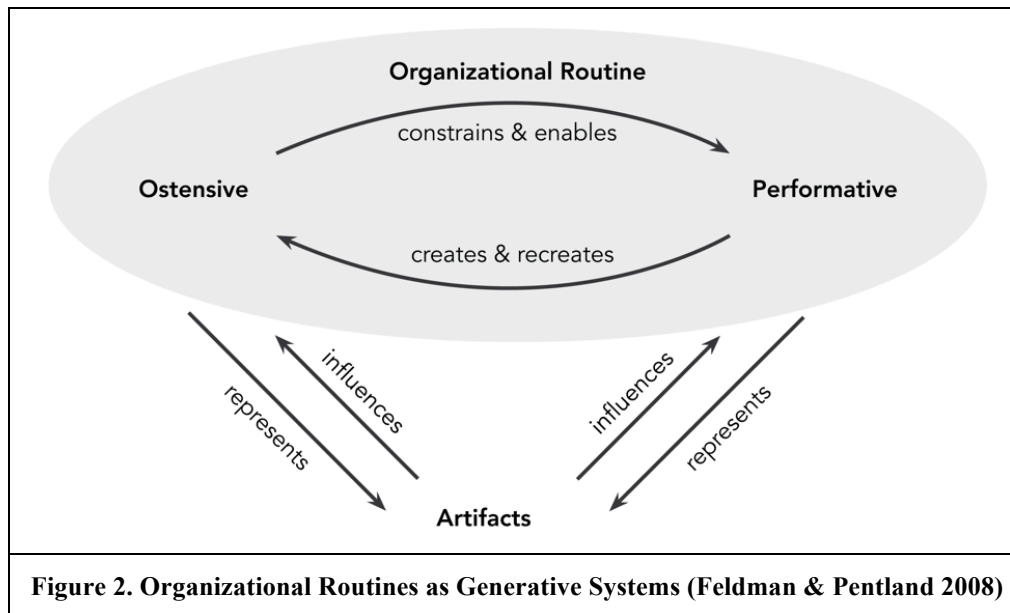
artifacts, such as written procedures, forms, or checklists. Affordances, on the other hand, help us to understand the possibilities for goal-oriented actions arising from material properties of an artifact, particularly when implemented using information technology.

Organizational and Individual Routines

Organizational routines refer to repetitive patterns of activity that occur throughout an organization (Feldman and Rafaeli 2002; Nelson and Winter 1982). They describe “how organizations accomplish their tasks, how they change and how organizational capabilities are accumulated, transferred and applied” (Becker and Lazaric 2009). Organizational routines serve as a key repository for organizations (Becker 2004), and are at the origin of organizations’ reliability and performance (Cohen and Bacdayan 1994). Most of the existing research focuses on organizational routines that involve multi-actors in a series of interlocking activities (e.g., Feldman and Pentland 2003; Gaskin et al. 2012). However, routines are built at an individual level, since they emerge and are modified from the experience of individuals (Cohen and Bacdayan 1994). Individual routines are defined as “specific goal-oriented task sequences performed by a single employee and are often embedded within larger organizational (or group) level routines” (Polites and Karahanna 2013). Organizational routines are thus composed of multiple individual routines, each of them with a precise sequence of activities, which interact with other individual routines (see Figure 1).



Early research in organizational theory considered organizational routines as sources of inertia and stability (Nelson and Winter 1982), promoting regularity and continuity of activities regardless of the experience of executants. From this perspective, once a routine has achieved high performance according to an organization, it remains stable over time. Later, organizational routines have been found to also be a source of change and flexibility (Cohen and Bacdayan 1994; Feldman and Pentland 2003; Pentland and Rueter 1994). Through their ongoing performance, organizational routines have the capability to learn from workers’ experience and to generate change in organizations. Thus, Pentland and Feldman (2005, 2008) describe organizational routines as generative systems composed of three key elements (see Figure 2): (1) The *ostensive aspects*, which are abstract patterns that reflect the general principles underlying a routine (i.e., routines as understood). They represent the ideal or schematic form of a routine, although the latter may be interpreted differently by different people. (2) The *performative aspects* describe actions taken by specific people in specific places at specific times (i.e., routines as performed). They describe how a routine eventually occurs in practice, which depends on an executant’s choices. The performative aspects thereby represent instantiations of the abstract patterns. Ostensive and performative aspects are interlinked, so as to enable change in routines: on the one hand, by defining patterns of activity, the ostensive aspects constrain and enable the execution of routines; on the other hand, the ongoing performance of routines creates and recreates new patterns of activity. (3) *Artifacts* are physical representations and range from written rules and machines to software applications. They are material traces that enable and constrain the ostensive and performative aspects of a routine. Artifacts represent both aspects of a routine: They materialize the ostensive aspects by for instance describing the patterns of a routine, and the performative aspects by for instance collecting data on the individual execution of a routine. Similarly, artifacts influence ostensive aspects, for instance by prescribing the patterns of a routine, but they also influence the performative aspects, for instance supporting executants during a routine.



Artifacts and the Roles of Information Technology

The nature and use of artifacts in organizational routines has evolved over time. In early contributions, artifacts were simply seen as the external memory of an organization, with the aim to help humans to solve complex problems (Nelson and Winter 1982). Artifacts were then later considered as an enabler for the evolution, transfer, and replication of routines (Cohen et al. 1996). More recently, artifacts are seen as central to organizational routines by actively enhancing an actor’s knowledge, skills, and competence (D’Adderio 2011). With the democratization and evolution of technology, IT artifacts play an increasingly significant role in organizational routines. They provide many capabilities, such as bringing people together in a distributed context and serving as a mediator for codifying and transferring knowledge of routines across organizational boundaries (D’Adderio 2001).

Although manifold artifacts are involved in a routine and are critical to its performance, they have not been in the focus of prior research. Existing studies mostly emphasize on ‘cognitive’ or ‘representational’ artifacts to codify organizational knowledge, such as written rules or procedures, forms, and checklists (e.g., Becker 2005; Pentland and Feldman 2005). There are, however, some exceptions: In his research, Beverungen (2014) suggests a meta-framework explaining the interplay of the design and the emergence of business processes as organizational routines. He views business processes as a typical artifact to document patterns of actions that occur in diverse organizational units, which contribute to the creation and recreation of the ostensive aspects. Other studies focus on implemented IT artifacts such as business applications (Pentland and Feldman 2008), specifically, highly structured enterprise resource planning (ERP) systems (Volkoff et al. 2007) that implement business processes.

Gaskin et al. (2011) as well as Polites and Karahanna (2013) criticize that prior research has mostly investigated the use of (IT) artifacts at an organizational level, thereby neglecting IT artifacts’ roles in individual routines (see Table 1). From existing studies, we also know that (IT) artifacts used at the organizational level put a lot of emphasis on standardizing and integrating processes (Volkoff and Strong 2013) and therefore do not necessarily match with individual work practices and habits. For instance, Pentland and Feldman (2008) illustrate that business applications have limitations in adapting to individuals’ work and often force users to change their behavior, sometimes at the expense of an organization’s performance and competitiveness.

Since individual routines are considered as a subclass of organizational routines, one can however deduce certain elements in order to better understand (IT) artifacts at an individual level. Written procedures, forms, and checklists considered as artifacts at the organizational level (Pentland and Feldman 2005) can be seen as candidates to support individuals in their routines. This is also underpinned by Ockerman and Pritchett’s (2000) study on artifacts for task guidance. When it comes to the specific (IT) artifacts

supporting individual routines, Leonardi (2011) argues that current technologies are more flexible and allow contemporary organizations to work with flexible routines. As smartphones and tablet computers are permeating every aspect of people’s work, there is also evidence that mobile applications play important roles in executing individuals’ work by providing them with mobile checklists or forms. For instance, Schmitz et al. (2011) compare checklists implemented as a mobile application instead of traditional paper copies and reveal that mobile checklists provide more comfort-of-use and increase individuals’ effectiveness. In another study, mobile applications have been shown to guide physicians who are discharging patients in task execution and therefore improve the quality of information within hospitals and with external physicians (Maher et al. 2013).

Table 1. Current State of Research on Routines at Organizational and Individual Levels		
	Organizational level	Individual level
Definition	Multi-actor, interlocking, reciprocally-triggered sequences of actions (Cohen and Bacdayan 1994)	Specific goal-oriented task sequences performed by a single employee (Polites and Karahanna 2013)
Actors	Multiple actors	Single actor
Embedding and emergence	Emerge and are modified from the experience of individuals (Cohen and Bacdayan 1994) Are composed of multiple individual routines, which interact with other individual routines	Often embedded within larger organizational-level (or group-level) routines (Polites and Karahanna 2013)
Representational artifacts	Business processes (Beverungen 2014) Written rules or procedures, forms, and checklists (Pentland and Feldman 2005)	<i>Not specifically covered by prior literature. Candidates to support individuals: written procedures, forms, and checklists</i>
IT artifacts	Business applications (Pentland and Feldman 2008), including Enterprise resource planning (Volkoff et al. 2007)	<i>Not specifically covered by prior literature. Candidates to support individuals: mobile applications</i>

Affordances: Studying the Relationships between Artifacts and Routines

In IS literature, the concept of affordances has gained popularity recently as means to study socio-materiality, i.e., the manifold work and social interactions involving technology (Faraj and Azad 2012). Affordances are denoted as “the possibilities for goal-oriented action afforded by technical objects to a specified user group understood as relations between technical objects and users” (Markus and Silver 2008). While analyzed at the individual level, the study of affordances seeks to unpack socio-material assemblages and thereby get an in-depth understanding of emergent relationships between human and nonhuman technologies (Gaskin et al. 2014).

IS researchers have started to use affordances to investigate in detail the relationship between artifacts and actors in routines, often inspired by observed real-world phenomena (e.g., Gaskin et al. 2011; Leonardi 2011). Leonardi (2011) uses the concept of affordances to study the interactions between flexible technologies and flexible routines. Viewing routines as goal-oriented action, he suggests that perceptions of affordance lead people to change their routines. More recently, Volkoff and Strong (2013) suggest that IS scholars use affordances to investigate one specific type of generative mechanism in order to explain the “concrete outcome that arises from the relation between an artifact and a goal-oriented actor”.

Research Gap

Existing studies show that artifacts play a fundamental role in the production and reproduction of organizational routines by representing their ideal form and influencing the rate and direction of change in routines. Since routines are the product of explicit attempts to design efficient, effective work practices, the IS discipline has extensively looked into business processes as representational artifacts at the organizational level and into their implementation by means of ERP and other business applications.

From our review of prior literature, we identified two research gaps: First, we lack studies on routines and (IT) artifacts at the individual level. As mentioned earlier, existing business applications have shortcomings in adapting to individual employee’s habits and work practices (Pentland and Feldman

2008; Polites and Karahanna 2013). A recent survey with more than 2 200 workers in Europe shows that only 46% of them are satisfied with the IT tools provided by their companies (Dransfeld et al. 2013). Since current technologies have become more flexible (Leonardi, 2011), employees have started to use their own devices and applications at work. They fit better with their individual ways of working, which ultimately increases their productivity (Shim et al. 2013). Second, we have little understanding how mobile applications should be designed to afford goal-oriented actions. Existing guidelines for mobile application developers mostly focus on interaction design and ignore the specific context, i.e. they do not consider that mobile application's use is embedded in routines enactment. This motivates our study's focus on mobile applications as IT artifacts supporting individual routines, with the following research questions: (1) *What are the roles of mobile applications in supporting individual routines?* (2) *How should mobile applications for individual routines be designed?*

To study these research questions, organizational theory and affordances offer valuable theoretical lenses and complement each other: From organizational theory, we can conclude that mobile applications create the material aspects of a routine and act as artifacts that influence and represent individual routines. The theory on affordances allows us to examine how individuals (i.e., a specified user group) interpret mobile applications (i.e., technical objects).

Research Method

To study the roles and design of mobile applications for individual routines, we opted for an explorative qualitative research design based on interpretative field studies (Klein and Myers 1999). Through immersion in a real-world context over a long time, field studies allow for “producing an understanding of the context of the information system, and the process whereby the information system influences and is influenced by the context” (Walsham 1993). For this reason, IS scholars are increasingly relying on interpretative field studies, which have become well represented in top journals (Walsham 2006).

We conducted two field studies, which we consider to be revelatory on at least three counts: First, they cover two different domains, customer service and healthcare, which are among the most representative domains for mobile applications (York and Pendharkar 2004). Second, in both field studies, organizations have begun to use mobile applications to support their employees in performing recurring and individual routine work. Prior to implementing the mobile applications, the routines were not fully formalized and were supported, if at all, by paper-based forms. We were thereby able to gain insights into the evolution of daily routines over time and their representation in the mobile application. Third, both cases can be considered as revelatory, since they have been recognized as innovative and forward-looking mobile applications by experts: The Mobile Service Advisor (MSA) was awarded best mobile application by a primary software vendor for its innovativeness, functionality, usability, and customer feedback (Suter-Crazzolara 2012). The Legon Clinical Solution (LCS) is considered by senior physicians to be one of the most advanced and innovative mobile applications used in Swiss hospitals, as underpinned by the feedback and interest from other hospitals and disciplines.

Table 2 provides an overview of the two field studies. The first study relates to the Mobile Service Advisor (MSA), which guides mechanics in the interactive service reception routine in car dealerships. MSA is a mobile application developed by proaxia consulting group AG, a Swiss IT consulting company with expertise in innovative solutions for sales and service in the automotive and other technical industries. MSA has been co-developed with Autohaus Bald, a German group of car dealerships with more than 20,000 customers, and is currently used by more than 20 of their mechanics in eight different locations. The second case describes the Legon Clinical Solution (LCS), a mobile application that guides physicians during routine patient care. This mobile application was developed in collaboration between a Swiss cantonal hospital and Legon Informatik AG, a Swiss IT company that specializes in the development of forward-looking software solutions for healthcare. LCS was designed and developed in a novel end-user-driven approach and has a strong focus on a physician's individual way of practicing. Physicians at the rheumatology department are currently testing the LCS in their daily work.

Immersion of researchers in the life of the subject under study is one of the main characteristics of field studies (Klein and Myers 1999). In the two field studies, the authors were either part of or collaborated with the mobile applications' development teams over a period of more than one year, during which data was collected. One of the authors was fully involved in the conceptual design and the development of LCS.

Over more than one year, he attended regular meetings (on an average every third week) with senior rheumatologists at a Swiss cantonal hospital and several workshops with three senior physicians from Swiss and international hospitals. The other two authors were part of a project team analyzing the MSA and its usage in car dealerships in order to identify future customers and areas of application. They followed the development and rollout of the mobile application for more than one year and participated in discussions and workshops with potential customers. The data collected comprises field notes, specifications, and documentations of the mobile application as well as user testimonials. Through participation in discussions with future users as well as with software developers and graphic designers, the authors could get detailed insights into user requirements and organizational contexts, as well as an understanding of mobile application design and usage.

Table 2. Overview of the Two Field Studies		
	Mobile Service Advisor (MSA)	Legon Clinical Solution (LCS)
Routine	Interactive service reception of customers	Routine patient care
Provider	proaxia consulting AG, Switzerland	Legon Informatik AG, Switzerland
Users and context	Mechanics/Car dealerships (here, Autohaus Bald)	Physicians/Hospitals (here, the rheumatology department of a Swiss cantonal hospital)
Frequency of use	Approx. 15 000 cases per year	Approx. 3 000 cases per year; average consultations per case are approx. 2.7 per year
Mobile platform	Apple iOS: Native iPad application	Apple iOS: Native iPad application
Technology	SAP Mobile Platform	Hybrid: iOS SDK and HTML5

To interpret the empirical observations from the field studies, we used organizational routines and affordances as “sensitizing” concepts and followed iterative hermeneutical circles. We started by coding our empirical observations for the three main constructs outlined by Feldman and Pentland’s (2008) generative system model, i.e., the routines’ performative and ostensive aspects, and the mobile application as artifact. Drawing on the concept of affordances, we analyzed our insights from the iterative design process in the two field studies to identify the perceived affordances of mobile applications from the perspective of the end-users. From our detailed analysis of empirical data, we were able to extend Feldman and Pentland’s model for individual routines supported by mobile applications, thereby extending existing theories to explain a new context (Steinfeld and Fulk 1990). Since our findings were derived from analyzing individual routines and innovative artifacts in very diverse and complex domains (routine patient care vs. automotive customer service) and for different type of executants (physicians vs. mechanics), we argue that our study allows for analytical generalization.

Field Studies

Mobile Application for Interactive Service Reception in Car Dealerships

Routines in Interactive Service Reception

Traditionally, when customers bring their car to the dealership for service maintenance, they give the car keys to a mechanic, exchange few words about problems they detected or specific parts that must be repaired, and then leave. This approach is increasingly replaced by the so-called interactive service reception (ISR), which seeks to guide mechanics in serving the customer in a more professional way. Recent studies in the automotive industry demonstrate that without a consistent service reception routine, only one-quarter of cars’ problems are detected and eventually repaired (Koller et al. 2010). Often, inspections focus only on the most urgent issues, while all other work that needs to be carried out is forgotten until the vehicle later fails. As a result, customers are unsatisfied by the work performed on their car, and half of them must return to the dealerships, sometimes shortly after a service or maintenance (Koller et al. 2010).

Interactive service reception establishes a dialogue between the two parties in order to overcome the lack of systematic car inspection and the lack of interaction between mechanics and customers. ISR guidelines (Brachat 2003) advise dealerships to receive their customers in a room with a lifting ramp and to follow a systematic procedure to ensure that all issues reported by customer are recorded and inspected. It is recommended that mechanics start by consulting warranty and recall cases, since these can impact an inspection. The subsequent inspection comprises pre-defined checkpoints. For each of checkpoint, the mechanic documents the issues reported by the customer and advises him or her on repairs and possible extra work. At the end of the routine, the customer is notified of the work required today and of future service needs, and approves the service order.

Many dealerships are currently in the process of introducing ISR, most often by providing their mechanics with paper-based checklists. Despite listing the activities that must be performed in the ISR routine, paper-based checklists have many drawbacks: If, they support mechanics in documenting the outcomes of ISR, they require one to re-enter the manually collected information after the inspection in the dealership's information system. Also, to correctly complete the routine, mechanics need to look for and to copy much information related to a specific customer and vehicle. Additionally, paper-based checklists cannot constrain mechanics to follow a strict sequence of activities (e.g., check the warranty's expiration before the inspection), and they cannot adapt to specific situations (e.g., some cars require specific checkpoints). In view of these drawbacks, the use of mobile applications as support for the ISR routine is seen as very beneficial.

Mobile Application: Mobile Service Advisor

Mobile Service Advisor (MSA) is a native iOS application designed for the Apple iPad. Its primary role is to guide mechanics through the inspection process and to explicitly document the inspection results in order to ensure high work quality and full transparency for the customer. MSA is built on the SAP Mobile Platform in order to leverage the connection and data transfer between the mobile application and the dealer management systems (here, SAP Dealership Business Management).

MSA's storyboard consists of three main screens: (a) customer selection, (b) the current service order with access to detailed customer information and vehicle history, and (c) the detailed inspection checkpoints. The customer selection screen contains a list of fields used as a filter to find customers. Once a customer is selected, previous inspections are displayed (see Figure 3 #1), and the user starts a new ISR routine. The second screen allows mechanics to update customer information and to access a vehicle's information and history, and to review the current service order's status. When previous inspections are opened, damages that were repaired are displayed. If it is a new inspection, the known customer wishes and issues are listed. The third screen, accessed from the primary navigation (see Figure 3 #2), is dedicated to the car's inspection, following the car's physical structure (Ockerman and Pritchett 2000) – the checkpoints are grouped based on their proximity (see Figure 3 #4). Activities are presented along with check boxes to indicate the state of the activity, a text field that provides predefined entry sets related to each checkpoint (free text is also possible) if damage is observed, and a switch button to indicate whether or not the customer wants to repair the damage (see Figure 3 #5). For activities that require specific documentation and that are also car-specific, MSA embeds different visual graphics. For the tire check, it provides a view of the four tires from which the type and dimension can be selected, as well as the profile depth. For the chassis check, a 3-D model of the customer's car is used to mark the potential damage (see Figure 3 #6). The car rotates using left-right gestures and a zooming-in capability allows for more precision. Each mark automatically creates a new activity that is further transferred to the service order if a customer decides to repair the damage.



To summarize the inspection results and the work to be done, MSA automatically generates a report. The latter, accessed from the secondary navigation elements (see Figure 3 #3) is signed directly by the customer on the mobile device and sent to him or her per e-mail. This avoids much administrative work and reduces potential errors that can occur during manual reporting a posteriori.

Mobile Application Supporting Routine Patient Care in Hospitals

Routines in Patient Care

Routine patient care comprises the activities a physician performs to cure a patient’s disease. These routines are very specific and sensitive to context, particularly to the medical discipline. In this field study, we collaborated with physicians in the rheumatology department, which is a subdiscipline of internal medicine focusing on the diagnosis and treatment of rheumatic diseases (e.g., problems with joints, autoimmune diseases, or soft tissues). As in other medical disciplines, rheumatologists’ ways of working are very individual, since physicians often practice in a particular way or style similar to that in which they were trained (Chau and Hu 2002). Their activities are thus characterized by a high degree of variations and exceptions.

Despite being highly improvisational, routines in patient care are mainly structured through the anamnesis, the examination, and the routine documentation. During the anamnesis, a physician gathers information about a patient’s medical history by asking specific questions. The written and visible part of this activity includes structured forms for various specialties such as regular medication, allergies, family diseases, social history, and past illnesses and surgeries. While the anamnesis seeks to provide useful information for the diagnosis and treatment, information gathering is limited to the fact that a patient or his or her family can only report symptoms that are known to them. The anamnesis is therefore complemented by an examination. Thereby, a rheumatologist captures information by directly investigating a patient’s body. Anamnesis and examination provide the basis for the routine documentation. In this last step, rheumatologists document the patient outcome (e.g., diagnosis, therapy plan, and follow-up examinations). The final medical report targets various stakeholders such as the patient, his or her general practitioner, clinicians in other medical specialties, and patient administration.

Previously, the routine at the rheumatology department was entirely supported by paper-based forms. There were two primary reasons for the development of a mobile application. First, mobile devices were perceived as a technology that would not distract physicians from direct communication with patients. A mobile application should be as easy and convenient to use as the paper-based artifact. Second, the digitization of the collected data would enable new possibilities for quality control in clinical routines. The physician-in-chief was particularly interested in using the datasets captured during routine execution to gain new insights into clinical research and to advance personalized medicine.

Mobile Application: Legon Clinical Solution

The mobile application's storyboard is composed of two separated screens. On the first screen (see Figure 4 #1), a rheumatologist searches for a patient. Administrative data about patients is provided by the hospital's centralized ERP system. Through the selection of a patient, the physician triggers a transition to the second screen, where he or she can access a patient's medical history (see Figure 4, #2), document routine execution (see Figure 4, #5) and report the routine outcome.

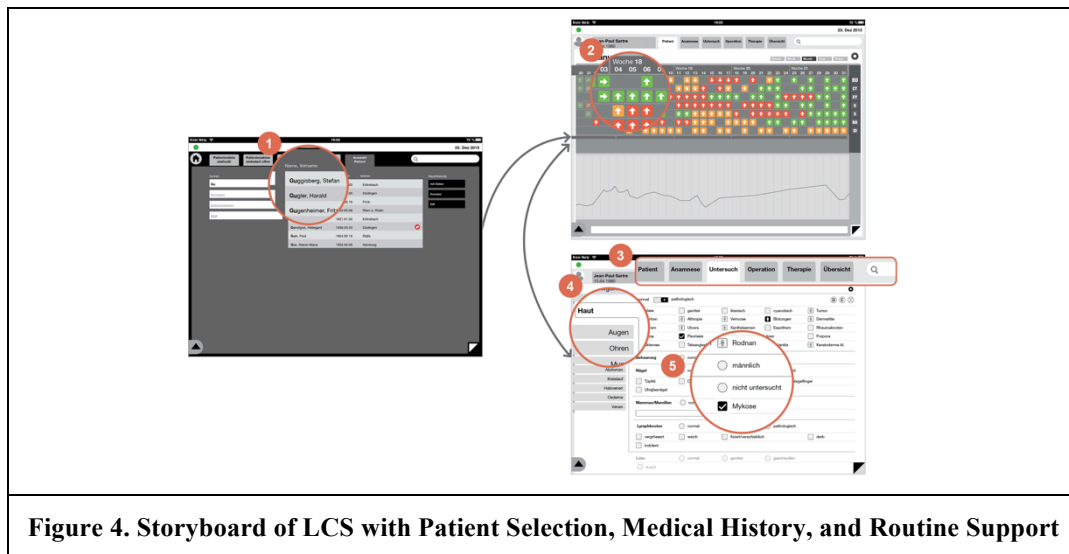


Figure 4. Storyboard of LCS with Patient Selection, Medical History, and Routine Support

A tab-based menu on the top of the second screen is the primary navigation element (see Figure 4 #3). This menu describes the physician's main activities during the routine, i.e., anamnesis, examination, and documentation. The list menu on the left is the secondary navigation element, and its items adapt to the selected primary navigation item (see Figure 4 #4). Items in the secondary navigation are generally named after anatomic terms (e.g., skin, eyes, abdomen) and represent specific parts of the body. A form describes each item in the secondary navigation and provides details for asking questions during anamnesis and for investigating a patient's body (see Figure 4 #5). Physicians basically use check boxes and free-text fields to document a routine. Furthermore, rheumatologists rely on anatomy sketches to draw in a patient's specific pain points and inflammations. These sketches show detailed and specific parts of the body, such as joints or muscle groups.

The mobile application automates the documentation and the creation of medical reports. When a physician activates a check box during a routine, a predefined text module is added to the medical report together with content of the free-text fields. During the routine, the medical report is updated in real time, providing the physician with a constant overview of his or her current activities. When a rheumatologist finishes a routine, the related medical report, which is finally represented in a formal PDF document, is immediately ready to be sent to the various stakeholders (e.g., the patient and a general practitioner).

Analysis and Synthesis

To interpret and analyze our field observations, we first compare them to the characteristics of individual routines from literature. We then examine the affordances of the two mobile applications along with the relationships of Pentland and Feldman's model. Finally, we synthesize our findings into an extended generative system model for individual routines supported by mobile applications.

Properties of Individual Routines

In a first step, we compare our empirical insights to the principles suggested by Polites and Karahanna (2013) to characterize individual routines. The analysis (see Table 3) underpins that the routines observed

in our case studies may be seen as individual routines according to current literature. At the same time, we observe specific characteristics for individual routines that distinguish them from organization-level routines and, specifically, business processes (see Beverungen 2014): First and foremost, individual routines are less rigid than business processes and often do not specify complete task sequences, but only groups of activities that should be performed by the experts. Moreover, individual routines have to support significant variations in individual working styles as well as to adapt to the context (e.g., the specific customer/patient or the executant’s experience).

Table 3. Analysis of Individual Routines in the Two Field Studies		
Individual Routines’ Properties (Polites & Karahanna 2013)	Interactive service reception	Routine patient care
Specific goal-oriented task sequences	An interactive service routine comprises tasks in customer service encounters, from preparing customer visits to welcoming customers and inspecting the car, with defined checkpoints to define the required work for the maintenance of a car.	Routine patient care comprises a pre-defined task sequence to treat the patient, namely anamnesis (i.e., ask the patient specific questions), examination (i.e., investigate the patient’s body), and report the outcome.
Performed by a single employee	The ISR is performed by one mechanic, while interacting with the car’s owner and recording the required work.	The clinical routine is performed by a single rheumatologist, who interacts with the patient to gather information and examine him or her.
Desired effect to guide the performance of behaviors	The pre-defined checkpoints, sequentially distributed in subgroups (e.g., vehicle chassis check, outside check) guide mechanics during the routine.	Primary (anamnesis, examination, and medical report) and secondary (e.g., representations of specific body parts) navigation elements as well as structured forms guide the rheumatologist during routine execution.
Behaviors that are carried out consciously and intentionally	The ISR routine prescribes a standardized way of working and specifies checkpoints that need to be evaluated; mechanics rely on their experience to execute them and to investigate deeper when it is necessary.	The patient care routine prescribes a standardized way of examining patients. Based on his or her specific knowledge and past experience, the rheumatologist adapts routine execution to take into account a patient’s specific disease and his or her social and medical history.
Triggered by events that occur at an organizational level	The routine is triggered when a receptionist welcome a customer who brings in his or her car for maintenance or when a problem has occurred with their car.	General practitioners typically refer patients to the specialist in the rheumatology department, where the rheumatologists’ secretary will organize the appointment.
Embedded within larger organizational-level (or group-level) routines	The ISR is part of the maintenance and inspection routine, which starts with the scheduling of an appointment and finishes with an invoice being sent to the customer.	The examination routine is part of a patient treatment process, which involves various actors such as the clinic’s secretary, the clinical laboratory, clinicians in other medical disciplines, and general practitioners.

Affordances of Mobile Applications in Individual Routines

In a second step, we examine how the two mobile applications under investigation afford individual routines. To classify the identified affordances, we link them to the different relationships in Pentland and Feldman’s generative system model. For each of the four relationships – namely 1) represents (ostensive aspects to artifacts), 2) influences (artifacts to performative aspects), 3) represents (performative aspects to artifacts), and 4) influences (artifacts to ostensive aspects) – we derived the capability of mobile applications to afford goal-oriented actions. In total, we find 10 affordances that we describe in Table 4.

Table 4. Affordances of Mobile Applications Supporting Individual Routines

Relationships Feldman and Pentland (2008)	Affordances of mobile applications	Interactive service reception	Routine patient care
1. Represents (ostensive aspects to artifacts)	Knowledge codification affordance		
	a) Codify the patterns of activities through the mobile application's storyboard and navigation elements.	Primary navigation elements structure the main activities, while the secondary elements group the activities' inspection along the physical car's structure.	Primary and secondary navigation elements structure the activities implemented by forms, which provide detailed guidance during anamnesis and examination.
	b) Codify the activities via forms and checklists.	Checklists codify the activities of a car inspection. Each checklist's task describes a checkpoint.	Use of structured forms to capture information during patient examination.
	c) Codify the objects via interactive visual graphics.	3-D models of cars.	Anatomy sketches.
2. Influences (artifacts to performative aspects)	Guidance affordance		
	a) Guide executants by constraining the way of working and standardizing instances of organizational routines.	Mechanics start the routine by selecting a customer and car. They are then guided through groups of checklists, which are divided in parts that fully cover the car.	Rheumatologists start the routine by selecting a patient, and are then guided in their information gathering through navigation elements and pre-defined structured forms.
	b) Guide executants by validating the work performed.	Checkpoint statuses indicate when an activity is done, not done, or result a problem on the car.	Real-time form validation: a yellow background on a form element indicates a false data entry.
	c) Guide executants in individual ways of working by generating context-dependent routine instances.	Mechanics can adapt the activity patterns based on their experience, physical object, and interaction with customers.	Rheumatologists are free to navigate from one form to another; there is no pre-defined order and physicians are not forced to fill out specific forms.
3. Represents (performative aspects to artifacts)	Document and trace affordance		
	a) Document the outcome of a routine during execution.	A report is automatically generated to summarize the inspection and the work that will be done. During the routine, a checkpoint's status is updated and pre-defined values or free- text document the outcome. Pictures complement the documentation.	Medical report is automatically generated based on pre-defined text modules and content of free-text fields. During the routine, the medical report is updated in real time, providing the physician with an overview of his current activities.
	b) Trace the observable behavior of individuals through logs.	Order in which the checkpoints are performed is logged. If necessary, each inspection can be retraced.	Timestamps are used to log when a specific form element was changed, each action is related to a specific user, i.e., physician.

4. Influences (artifacts to ostensive aspects)	Enrichment affordance		
	a) Enrich the representation of routines.	3-D models provide more details to describe activities.	Anatomy sketches show detailed parts of the body, such as joints or muscle groups.
	b) Enrich routines through seamless access to information.	Access to customer and car information as well as history (located on the dealership's enterprise systems) complement the description of activities.	Administrative patient data is delivered from the hospital's centralized ERP system; patients' medical history is accessible via rheumatology-specific systems.

From Table 4, we then synthesize the 10 affordances in four affordance categories:

1. **Knowledge codification affordance:** Mobile applications' storyboard, task descriptions, and visual graphics of key objects codify knowledge of the ideal or schematic form (*ostensive aspects*) of individual routines. We find that mobile applications, afford organizational knowledge codification in three ways: (a) The mobile application's storyboard, its different screens, and primary and secondary navigation elements structure and shape the activities into patterns; (b) Activities are codified by means of task descriptions and input elements (e.g., forms, checklists); (c) Objects are codified along with interactive visual graphics. The formalization and standardization of organizational knowledge establishes a common vocabulary for executants using the mobile application. At the same time, it facilitates the communication between executants and makes organizational knowledge more accessible to less experienced workers.
2. **Guidance affordance:** Mobile applications guide individuals in executing routines (*performative aspects*) by constraining their way of working, validating outcomes, and allowing for controlled variations. The mobile application's storyboard, navigation elements, and groups of activities structure a routine and guide workers during routine execution. The suggested structure provides a recommended solution concept to solve a particular organizational problem. For instance, workers might be 'forced' to perform a group of activities before they are allowed to access the next group of activities. Input validation ensures that an activity's outcome is correctly achieved. Such an approach standardizes the patterns of some activities and ensures quality and consistency of routines. However, the mobile application needs to balance the stable and flexible part of a routine. The higher the variation and the number of exceptions during routine execution, the more flexibility an individual needs in navigating the routine's structure and to change the order in which activities are performed. Each instance of a routine is inherently context-specific. Mobile applications are therefore designed in a way to adapt the routine instance to various context factors such as a worker's experience, customer interaction, or to the object (e.g., customer, patient), which is in focus during routine execution.
3. **Document and trace affordance:** Mobile applications afford documenting the outcomes of routines carried out by individuals and tracing the concrete instances (*performative aspects*) during routine execution. More specifically, they play two key roles: (a) they trace individual behavior in a routine in the form of logs and (b) they document routine outcome and automate report generation. Logging individual behavior during routine execution provides the basis to analyze routines, learn from past experiences, and to inform the creation and recreation of a routine's formalized ostensive aspects. To facilitate and accelerate documentation during routine execution, mobile applications reduce the use of virtual keyboard and maximize the use of visual input elements as well as pre-defined values. Documentation during routine execution reduces administrative work while avoiding misunderstandings from handwritings and ensuring consistency among workers.
4. **Enrichment affordance:** Mobile applications enrich the ideal or schematic form of routines (*ostensive aspects*) by providing visualization and ubiquitous access to information. In our cases, mobile applications become very embedded in a routine and actively enhance the expert's knowledge, skills, and competence. The technical capabilities of mobile devices, such as touchscreen and camera, offer a wide range of possibilities to support and enrich the

representation of routines. For instance, compared to traditional paper-based artifacts, mobile technology allows one to document routines by means of pictures and videos, which contributes to the further improvement and evolution of organizational memory. At the same time, mobile applications leverage the use of external systems to enhance access to information and increase its accuracy.

Synthesis: Generative System Model for Individual Routines Supported by Mobile Applications

The affordances presented in the previous section allowed us to extend Pentland and Feldman’s (2008) generative system model (see Figure 5) for individual routines supported by mobile applications: The ostensive aspects of the routine are the ideal or schematic form of the routine, “as understood” by the experts, based on their individual experience as well as recommendations from renowned domain experts. The performative aspects describe the routine “as performed” by the individuals, i.e., its instantiations. The mobile application is the material representation of the routine, i.e., the routine “as implemented” and acts as IT artifact.

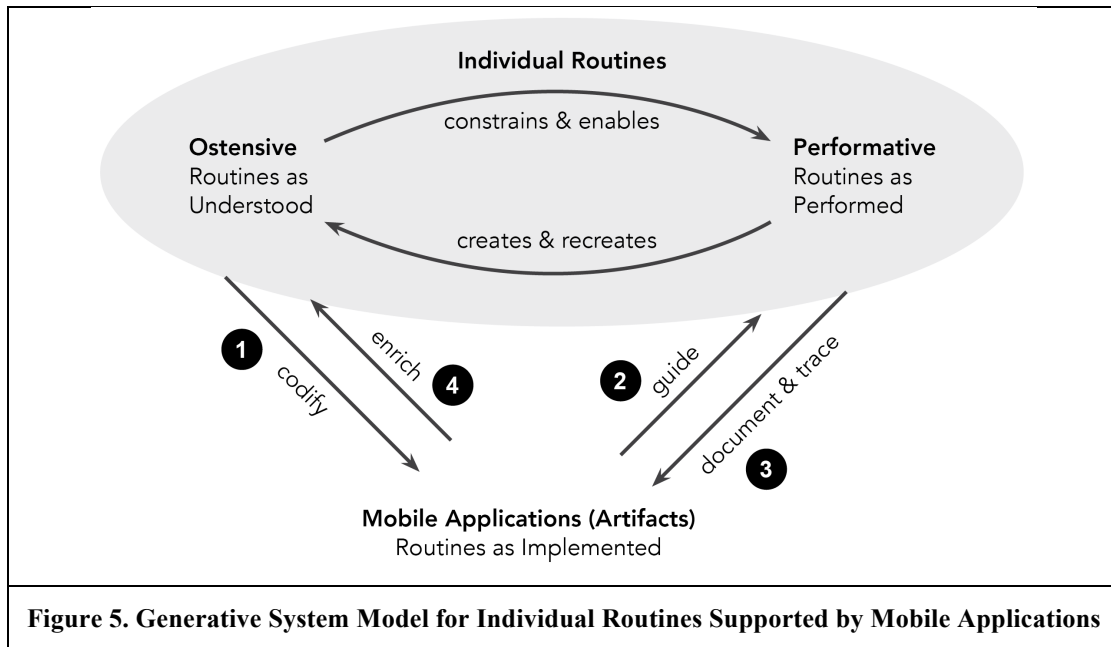


Figure 5. Generative System Model for Individual Routines Supported by Mobile Applications

The *represent* and *influence* relationships between individual routines and artifacts can be extended in the following way:

Concerning *representing the ostensive aspects*, we find that mobile applications **(1) codify** organizational knowledge via storyboards and navigation elements that shape the activities into patterns, checklists, and forms that represent activities, and visual graphics that represent objects. Compared to traditional software applications, mobile applications provide richer possibilities of codifying the routines’ ostensive aspects. They place fewer constraints on the structure and sequence of activities, but focus more on their grouping and on the essential checkpoints or outcomes. Concerning *representing the performative aspects*, mobile applications use the aforementioned forms, checklists, and visual graphics also to **(3) document and trace** the outcome of routines. By tracing individual behavior through logs, they provide the basis for organizational learning.

We observed that mobile applications have multiple *influences* on individual routines. First, they **(2) guide** workers in routine execution by standardizing the sequence of activities, they validate the outcome of activities and they individualize ways of working by generating context-dependent routine instances (*performative aspects*). Second, they **(4) enrich** the way a routine is conceived and understood by

executants by adding visual graphics and relevant information from external sources to the representation of the routine (*ostensive aspects*).

Conclusion and Future Work

The roles of artifacts in organizational routines have evolved from being an external representation of the memory of an organization to being central to organizational routines, actively enhancing actors' knowledge, skills, and competence. Here, we addressed mobile applications as IT artifact and their support of individual routines by conducting interpretive field studies in two different domains, automotive customer service and healthcare.

This study makes two primary contributions: By extending Pentland and Feldman's (2008) generative system model for individual routines, it provides answer to the question *What are the roles of mobile applications in enacting individual routines?* Specifically, it outlines four relationships between the routine and the mobile application as material artifact: codify, guide, document and trace, and enrich. Second, it answers the question *How does one design mobile applications for individual routines?* The identified affordance categories synthesize the essence of mobile applications' possibilities to afford goal-oriented actions in routines and can be related to their material properties. As suggested by Norman (1999), these affordance categories should guide future mobile application design and may even constitute the "tasks to implement" for mobile application designers. With the two aforementioned contributions, our research extend existing theoretical foundations to account for a new context (Mueller and Urbach 2013; Steinfield and Fulk 1990). We thereby contribute to closing the gap relating to individual routines and their support by IT artifacts outlined by recent studies (Polites and Karahanna 2013).

Our research complements recent studies that focus on routines at an organizational level and look into ERP and other business applications as to represent, enable, and constrain business processes (Beverungen 2014; Breuker and Matzner 2014). Compared to ERP and business applications which fail to adapt to individual habits and work practices (Pentland and Feldman 2008), we find that mobile applications provide more flexibility and possibilities of individualization. The suggested affordances contribute to the world of IS design and the *design science* community. They go beyond design frameworks, such as 'interaction design', which are limited to interactions between humans and artifacts and do not address the specificities of individual routines as patterns of actions. By synthesizing affordance categories for mobile applications, we contribute substantively to artifact design knowledge for routines.

Practitioners can benefit from our research to develop and design mobile applications that better meet individual and organizational requirements: 1) the field studies provide valuable insights into the role and design of mobile applications supporting individual routines in two different fields, healthcare and customer service; 2) the identified set of affordances provides practical guidelines to develop mobile applications that effectively support individual routines, by addressing both the ostensive (i.e., routine as understood) and the performative aspects (routine as performed) of routines.

As noted, this study is only a first step towards a more profound understanding of mobile applications' roles in individual routines. It therefore has certain limitations: Although we were able to observe the mobile applications' design and uses for more than one year, our empirical insights relate mostly to the conceptualization and early productive use of mobile applications. Thus, we lack a broader empirical validation of our findings as well as insights into the dynamics of routines in use. Since our research is qualitative in nature, we cannot claim that the phenomenon of mobile applications for individual routines has been explored exhaustively. Still, we took care that our two field studies covered diverse domains (routine patient care vs. automotive customer service) and different type of executants (physicians vs. mechanics) to allow analytical generalizability of the findings.

We see interesting avenues for future work: On the one hand, more research is needed not only on exploring the characteristics of individual routines, but also on developing conceptual models for their representation. Similar to the business process domain, these models are prerequisites to codify individual routine knowledge and implement the related IT artifacts. On the other hand, we encourage researchers to investigate the relationships between routines at the organizational and individual levels. This should include the relationships between (IT) artifacts at every level, but also the interaction of artifacts across the different levels, for instance the integration of mobile applications in business

applications. In this study, we observed that mobile applications and ERP systems complement each other. The former provides a more individualized and flexible user interface, which connects to the latter to access data and ensure consistency. However, the interaction and integration of organizational and individual levels raise new technical and organizational challenges that require more research. Finally, IS researchers should become inspired by organizational theory that emphasizes the importance of dynamic routines and the emergence of routines through workers' experience (Feldman and Pentland 2003). As IS researchers, we need to analyze how mobile technologies support "living routines" that capture and transfer organizational knowledge to establish organizational learning.

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