End User Creativity: A Critical Realist Perspective

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Abstract

There has been a recent trend in the IS literature toward viewing IT systems less as material artifacts and more as imbricated, socio-technical assemblages. This suggests that greater attention must be paid to the detailed processes behind the interaction of users with systems.

In this thesis, I explored the creative process that occurs when end users discover or develop novel and useful ways to appropriate IT systems. I used Eisenhardt (1989)'s framework for inducting theory from case studies, and conducted an embedded multiple-case study of users who have implemented creative ways to apply existing IT systems. I applied Critical Realist assumptions and employed theoretical lenses drawn from cognitive science (distributed cognition), cognitive psychology (dual-process theory) and Markus and Silver (2008)'s variant of Adaptive Structuration Theory (AST). I addressed the research question: What are the causal mechanisms that explain the creative appropriation of IT systems by end users?

Using AST as a foundation, I developed a theoretical framework to represent the problem space that must be traversed by users making appropriation moves, which I have named Affordance Field Theory. I employed Narrative Networks (Pentland & Feldman, 2007) for my primary retroductive analysis, then re-analysed the data using Framework Matrices (Ritchie & Lewis, 2003). The complementary logical forms (processual and thematic, respectively) of the analytical tools provide empirical corroboration for the findings. I have derived a set of cognitive mechanisms that describe the information-processing operations involved in end user creativity. Using metaphors provided by distributed cognition, I have demonstrated how these mechanisms can be used to explain information processing at both the individual and collective levels. I have also developed an integrative model to explain how the mechanisms work together to explain creative action at the individual level.

I have maintained my primary case study database in NVivo 10.

Keywords

Affordance Field Theory, Creativity, Critical Realism, Cognitive Science, Dual-Process Theory.

Introduction

One of the most frequently-cited priorities for modern organizations is fostering creativity and innovation (Nambisan et al. 1999). Despite this, the topic of creativity has been consistently understudied in the IS discipline (Couger et al. 1993). In addition, there has been a strong bias in the IS literature toward a focus on creativity on the part of system developers and implementers, rather than end users (see Seidel et al. 2010). This is anomalous, as end users can be an important source of creative innovations (Zhou and George 2003). In this thesis, I address this gap in the literature by investigating end user creativity in the appropriation of IT systems.

Research Method

Given the understudied nature of the topic, I chose an exploratory, theory-building approach: an embedded multiple-case design, guided by Eisenhardt (1989). *A priori* constructs drawn from the work of Amabile (1996) were used. A theoretical sampling strategy was applied, and a wide variety of cases involving different types of systems, users, and contexts, were investigated. As an illustration, I will briefly summarize one case:

"Delta", a medical device manufacturing company, needs to keep detailed test records for their products for certification purposes. Test documentation was initially kept in flat files, which became unwieldy. The product engineers evaluated several potential solutions, and selected "Tracker", a requirements management tool. However, Delta's products contained shared components. If a component was modified, test documents for all the products that contained (or 'owned') that component had to be updated at the same time. The concept of 'ownership' did not exist in Tracker. Engineers at Delta worked on the problem for several weeks, and finally devised a way to use a data visualization feature in Tracker to functionally simulate ownership.

In the next section, I will review the paradigmatic assumptions and theoretical lenses being applied.

Theoretical Framing

Critical Realism

Critical Realism is a philosophical paradigm that is designed to support in-depth causal explanations for complex chains of events (Wynn and Williams 2012). It focuses on identifying and describing causal *mechanisms*, which consist of *structures*: internally related physical, social or conceptual objects; *powers*: capacities for action; and *tendencies*: typical actions. The mechanisms involved in events under study are identified through a process of *retroduction* (Bhaskar 1975).

Distributed Cognition

Cognitive science holds that human cognition is, fundamentally, a computational activity involving the transformation of inputs and outputs, in the form of mental *representations*. Hutchins (1995) demonstrated that these representations are not necessarily restricted to the mind of a single individual. Cognitive representations, and the operations that transform them, can be held in both neuronal (brain) and non-neuronal (paper, objects, spreadsheets) media, and can be shared across individuals (Perry 2003). The field of distributed cognition studies this activity.

Dual Process Theory

The human mind is best conceptualized as being composed of two parallel but distinct reasoning systems (Osman 2004). Stanovich (1999) coined the labels *System 1* and *System 2* for these systems. System 1 is associative, automatic, fast and non-conscious; System 2 is rule-based, volitionally controlled, relatively slow, and conscious. Human behaviour is driven by both systems, but conscious awareness is only capable of monitoring System 2 (Sloman 1996).

Affordance Field Theory

In *Adaptive Structuration Theory* (AST), DeSanctis and Poole (1994) proposed that task contexts contain *structures* which are encoded into technologies, and can be analysed in terms of *structural features*–rules and resources offered by the IT, and *spirit* –the intents, values and goals underlying the features. The features can be *appropriated* by users, either faithfully (in accordance with the spirit), or unfaithfully (not in accordance with the spirit).

In response to critiques of DeSanctis and Poole (1994)'s conceptualization, (see Jones and Karsten 2008), Markus and Silver (2008) proposed a reformulation of AST. They replaced the concepts of Spirit and Structural Features with three new concepts:

- *Technical Objects*—IT artifacts and their component parts.
- *Functional Affordances*—A type of relationship linking a user to a TO that determines what the user can do with the object, given the users' capabilities and goals (Gibson 1977; Gibson 1979).
- *Symbolic Expressions*—Messages to the user (from design processes, cultural symbols, etc.) about how to interpret and use the TO (De Souza 2005).

The goal of this reformulation of AST was to enable researchers to create better hypotheses about IT effects (Markus and Silver 2008p. 627-628). However, since my study was about exploring possible causal paths rather than testing hypotheses, it was necessary to extend Markus and Silver's model in order to represent the full problem space of user interaction with systems. After reviewing the source literatures that they cited for their concepts, I extended Markus &Silver's AST with the following further concepts.

- *Affordance Types*—Gaver (1991) proposed that since affordances are separate concepts from perceptual information about the affordances, the following types of affordances can exist: *Correctly Perceived*; *False*; *Hidden* and *Correctly Rejected*. Affordances can also be *Serial* (in time) and *Nested* (in space). These types can be used to increase the granularity of the concept.
- *User Effectivities*—The specific capabilities of a user that create affordances given a technical object's properties (Chemero 2003; Shaw et al. 1982).
- *System Representations*—The mental representation of the system held by the user at a given time (Davern et al. 2012). Symbolic expressions may influence them, but are a distinct concept.

It is possible to combine these extension to (Markus and Silver 2008) and the new concepts into an integrative framework that enables us to conceptualize and visualize how users identify and enact appropriation moves at a conceptual level.

I borrow Gibson (1979)'s metaphor of a visual field as the context in which affordances are perceived. The field represents the domain of all *tasks* – that is, all possible ways in which a technical object (TO) can be used. A technical object has properties which create *action potentials*, the scope of which are large, but finite. We can therefore represent all the tasks that can be performed with a given TO by a bounded area: an *Action Potential Field* (APF). When a user accesses the TO and decides to use it, the user and the TO form a sociotechnical construct, which we may label a *Technology-in-Practice* (TIP), after Orlikowski (2000). The user side of the TIP has effectivities, which together with the properties of the TO create affordances. We can represent them with an elliptical area—an *Affordance Field* (AF)—which represents all tasks that this user can perform with this TO. For most TOs an AF will always be a subset of the APF since no user will have all possible effectivities. Although the AF is determined by the intersection of user effectivities and TO action potentials, the user will not necessarily have perfect information about either of those constructs. The user will be guided by *Symbolic Expressions* (SE) to form a mental *System Representation* (SR) which will determine her *Perceived Affordance Field* (PAF). The PAF may extend beyond the AF, creating *False Affordances* (FA) or fail to cover part of the AF, creating *Hidden Affordances* (HA). Every TO will have a typical range of uses, which we represent with a *Normative Affordance Field* (NAF). Affordance fields are dynamic, and can be *stretched* (developing or discovering new properties) or *widened* (applying existing properties in new ways) in orthogonal axes. Creative appropriation will typically involve making an Available Affordance Space Search (AASS) for available *Appropriation Moves*. These concepts are visualized in Figure 1.

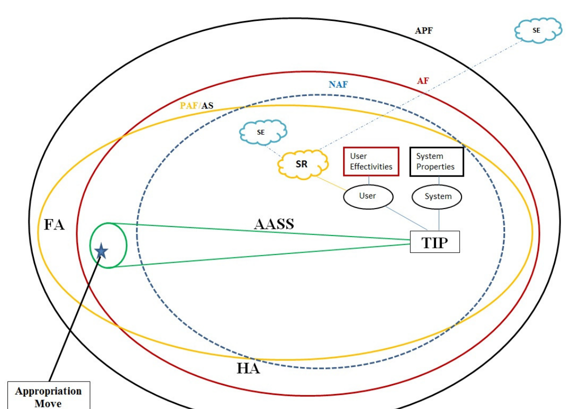

Figure 1: Affordance Field Theory

Affordance Field Theory (AFT) provides a non-deterministic framework for representing the myriad ideational, collaborational, and enactment activities that are involved in the appropriation of IT systems. It also facilitates *structural analysis* (Wynn and Williams 2012, p. 799) across the diverse case contexts.

Data Analysis

Recordings, transcripts and research notes were imported into NVivo 10 and coded using the a priori constructs. Preliminary analysis of the data led to the adoption of the paradigmatic positions and theoretical lenses that have been outlined. Selected cases were then reduced to a *Narrative Network* (Pentland and Feldman 2007). The researcher's point-of-view was used, and the nodes of the narrative networks were coded using concepts from AFT. For example, in the Delta case, the vendors of Tracker gave the engineers at Delta documentation that communicated Symbolic Expressions consistent with Tracker's Normative Affordance Field. However, one of the Appropriation Moves that Delta needed to meet its requirements—representing ownership—was not within the NAF of Tracker. They therefore engaged mechanisms, which will be described in the following section, to modify their System Representation and stretch the Perceived Affordance Field of Tracker, then to modify the System Properties of Tracker to stretch its Affordance Field. This modification enabled them to make the necessary Appropriation Moves that would meet their goals.

The coded narrative networks formed the basis of the initial retroductive analysis. After deriving the mechanisms that will be described in the next section, the raw data was recoded using AFT, and reanalysed using *Framework Matrices* (Ritchie and Lewis 2003). The complementary logical forms of the techniques (processual and thematic, respectively), help to provide empirical corroboration (Wynn and Williams 2012) for the findings.

Preliminary Findings

The findings comprise a set of information processing mechanisms which operate at both the individual and collective levels. The mechanisms are revealed in patterns of information flows which are observed across cases. Evidence for the existence of the mechanisms is also drawn from extensive findings in the literature on cognitive science which confirm the patterns of information processing that the mechanisms explain (Kahneman 2011; Leslie 1987; Morewedge and Kahneman 2010; Stanovich 2010).

Although the mechanisms operate at both the individual and collective levels, the scope of the thesis requires an explanation of user creativity at the individual level. Figure 2 visualizes the operation of the mechanisms at the individual level.

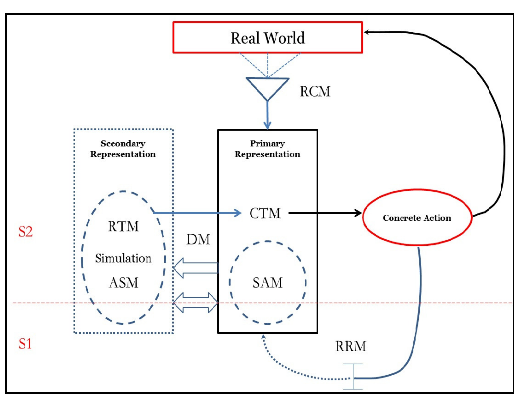

Figure 2: Mechanisms – individual-level integrative model

The model explains the creative process as follows.

Sensory inputs AND prototypical information from memory structures are combined to form a *Primary Representation* (PR) of the external world by the **Representation Construction Mechanism** (RCM). Within the PR, routine and habitual behaviours and stimulus responses are handled by the **Serial Associative Mechanism** (SAM). When a stimulus is encountered that requires conditional processing, the **Decoupling Mechanism** (DM) is triggered. The DM carries out two operations: *Copy*—to create a *Secondary Representation* (SR); and *Decouple*—to keep the SR separate from the PR. Within the SR, a process of *Simulation* takes place, in order to evaluate the expected outcomes of alternate stimulus responses. The simulation process is enabled by the **Representation Transformation Mechanism** (RTM) and the **Attribute Substitution Mechanism** (ASM). The SR is necessary to prevent *representation abuse* (Leslie 1987): the corruption of the PR so that it becomes impossible to differentiate between the simulation and the representation of reality.

When the simulation process generates an acceptable outcome, the **Concrete Transformation Mechanism** (CTM) copies the output of the simulation process over to the Primary Representation, and initiates external actions designed to change the state of the real world to match the state of the simulation output. This action may succeed, or it may fail. If it fails, the state of the real world—along with any new information gained during the failed attempt—will be added to the primary representation by the RCM. This will be copied to the secondary representation by the DM, and the process will continue cyclically until it succeeds or is terminated. While this is happening, information about the creative process is also being fed back into the system. However, this information is always incomplete. An associatively coherent—but not necessarily true—constructed narrative about the process is formed by the **Retrospective Reframing Mechanism** (RRM), using the incomplete information AND prototypical information about creative processes as inputs.

The fact that distributed cognition extends metaphors from cognitive science to teams and objects does not mean it holds that they are analogous to the human mind. Distributed cognitive systems are architecturally and functionally different from neuronal systems. However, both types of systems must perform the basic tasks of processing information and solving problems, and the same basic information-processing mechanisms that can be observed in the mind can be seen in DC systems. In the Delta example: Tracker was chosen after an evaluation that indicated it would handle the firm's routine data-handling needs (Representation Construction Mechanism). After it was implemented, it was discovered that it lacked a critical property (Decoupling Mechanism triggered). Different solutions were developed and tested (Simulation). Eventually, they realized that it was possible to use a viewing function to simulate the necessary property (Simulation output). They modified the properties of Tracker to make the viewing function perform 'ownership tracking' (Concrete Transformation Mechanism). Afterward, Tracker was rolled out to the product development teams (Simulation Terminated; Serial Associative Mechanism activated).

This model is *not* a deterministic model that describes all possible incidents of user creativity. Simulation outputs need not be 'creative', and routine operations may generate novel and useful outputs (Feldman and Pentland 2003). However, our case data suggests that creative appropriations tend to result from decoupled simulation processes as described here. It also must emphasized that – while all the mechanisms described here have been shown to operate in distributed cognitive systems, the integrative model describes only individual systems. Distributed cognitive systems have different architectures from neuronal systems and are variable in ways that individual cognitive systems are not.

This thesis makes a number of contributions. It contributes to the literature on IS-related creativity. It presents a new framework for modelling the interactions between users and IT systems, and it presents a model of how information-processing mechanisms in the mind, and in distributed systems, can explain the process of creative appropriation of IT. This has several potential applications.

Critical realist analysis is a parallel, iterative process (Wynn and Williams 2012), and does not proceed through traditional stages. However, this project is now focused on empirical corroboration deep description of the mechanisms identified.

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