LEARNING ABOUT AMBIGUOUS TECHNOLOGIES: CONCEPTUALIZATION AND RESEARCH AGENDA

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Research Paper

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Abstract

Information Technologies (IT) have gradually transformed into complex digital artefacts with blurred and constantly changing functional boundaries. While this shift offers promising venues that unfold in front of our eyes every day, it also challenges the deeply entrenched knowledge structures on which ordinary users rely to learn about unfamiliar technologies. We propose to take a step back in order to theorize the ambiguous nature of modern IT and to speculate on how users learn to use them. This paper revisits a wide array of management (BYOD, Gamification) and IS design trends (generativity, everyday computing, incompleteness) through the lens of the categorization framework. Our review of the literature on ambiguous products suggests that users exposed to ambiguous technologies may experience a categorization difficulty that disrupts the process of learning how to use them. This difficulty stems from a user's belief that there are multiple or inconsistent interpretations of why *and* how *to use an IT, as well as a perception that a given IT has some attributes in common with one or several seemingly unrelated ITs. We build on this theorization to propose a research agenda and discuss the expected practical implications of this path of research.*

Keywords: learning, categorization, ubiquitous, adoption.

1 Introduction

Information technologies (IT) that are intentionally incomplete and constantly in the making (Garud, Jain, & Tuertscher, 2008) are compelling alternatives to traditional technologies that have clearly delineated and stable boundaries (Simon, 1996). Indeed, having no fixed limits that constrain modern technologies to specific tasks makes them particularly suited to a work environment that requires dynamic adaption (Schmitz, Teng, & Webb, 2016) and constant innovation (Avital & Te'Eni, 2009; Zittrain, 2008). However, as the range of possibilities offered by a given technology expands to fulfill everyday needs (Yoo, 2010), forming an exhaustive, clear and stable representation of a technology's "structure and function" (Bostrom, Olfman, & Sein, 1990) is increasingly difficult. One may wonder how learning occurs in an era characterized by the absence of clear frames of reference (Orlikowski & Gash, 1994) from which knowledge can be derived and transferred.

A fundamental observation from the discipline of psychology is that categories are central to the process of learning because they provide the infrastructure against which unfamiliar items are classified and learnt about (Markman & Ross, 2003). A basic tenet of this perspective is that individuals naturally divide the world of objects into categories to make their environment intelligible, and to efficiently process new information (Bruner, 1957; Smith & Medin, 1981; Sujan, 1985). Provided that a new item fits with an individual's knowledge structure, learning about it is facilitated. If the unfamiliar item does not have clear and stable boundaries, the process of learning about it is hindered. Therefore, given that modern technologies are characterized by indistinct and evolving boundaries, we expect that learning how to use them pertains to specific mechanisms that have not yet been explored.

With this conceptual paper, we seek to contribute to the understanding of the micro-level mechanisms that drive IT use in the age of ubiquitous and purposively incomplete technology. We specifically focus on the process of learning, although numerous other mechanisms related to the use of ambiguous technology could have been addressed. We decided to narrow down the scope on learning because "ease of learning" is a central facet of the concept of "ease of use" (Davis, 1989), which is particularly influential in the field of IS. Besides, an increasing amount of individuals are faced with generative technologies that provide little usage guidance even in productive environments in which such directions are traditionally expected (Avital & Te'Eni, 2009). As a result, users are expected to devise their own learning strategy through trial and error. We are also intrigued by the pace with which Millennials learn how to use novel new technological products, which seems to counter previous findings about the importance of end-user training in learning (Carroll & Carrithers, 1984).

Our contribution to the field of IS hinges on the introduction of the theoretical framework of categorization, which has shown to be robust over many years of use in other management disciplines such as consumer behavior. We attempt to show that this theoretical lens could prove beneficial to apprehend IT-related phenomena in the age of blurred and multifaceted technology. From a practitioner perspective, our research suggests that the quest towards designing protean and open technologies entails a shift in the end-user learning process. In the future, this project may provide guidance on which strategy is appropriate to train users in these technologies, without hindering the necessary exploratory component this process entails. The question is rife, as companies may be tempted to discontinue the training efforts that traditionally goes along with the roll-out of a new technology.

In this manuscript, we present a review of the micro-level research on categories and how they are used to learn about novel items. After a brief review of the notion of end-user information system learning, we propose a definition of the concept of "perceived IT ambiguity" by adapting existing models of learning to the IT context. To substantiate our definition, we turn to the recent discussions in the field of IS, and isolate the properties of the IT artifact that contribute to its ambiguity. Finally, we suggest several directions for future research about ambiguous technology in the area of learning, IT adoption, and technostress.

2 Theoretical framework

2.1 Learning to use information technologies

Former research in information systems has pointed at the importance of mental models in end-user training (Bostrom et al., 1990). According to Bostrom et al. (1990), a user's mental model is "his/her internal representation of the system structure and function that provides explanatory and understanding power" (*ibid*: 103). Training is a form of learning though which the structure and function of a given system are made explicit to the end-user so that they can confidently learn how to use it (Compeau & Higgins, 1995). Whether learning occurs through lecture-based instructions (Simon, Grover, Teng, & Whitcomb, 1996), computer-aided instructions (Carroll & Carrithers, 1984; Gist, Rosen, & Schwoerer, 1988), or self-study manuals (Simon & Werner, 1996), an implicit assumption is that such mental representation exists, is stable, and is shared between designers and users.

There are reasons to suspect that none of these assumptions is fully met with modern technologies that have no precise purpose, and which structure is constantly in the making. In fact, we propose that ubiquitous technologies transcend the very mental representations on which effective learning depends. Tablets (eg. iPads) are a case in point, for end-users could form a mental construction of this technology as an entertaining device to relax at home, a professional tool to engage with customers, or a media to read books when commuting on the train. The question of stable mental representations not only pertains to ubiquitous devices but also to application software that straddle the business and consumer segments. The recent release of *Facebook Workplace* is illustrative of this trend towards the blurring of mental representations, with the proliferation of business solutions that borrow the visual and functional attributes of consumer products[1].

The emergence of ubiquitous technology that transcend physical, temporal and mental boundaries raises two main issues for learning. One is the absence of a clearly delineated mental model of a technology's purpose and structure. In other words, of a clearly defined and unique *technological frame* that carries a set of assumptions, expectations, and knowledge that shapes subsequent usage (Orlikowski & Gash, 1994). The other one is the co-existence of potentially conflicting representations of the technology that suggest the co-existence of a multitude of equally possible usage alternatives. In both cases, neither the learning path to achieve the desired usage goal, nor the interdependences between the usage alternatives are clearly defined.

[1] http://qz.com/806064/facebooks-workplace-is-set-to-give-slack-and-yammer-some-competition-in-enterprise-software/

Neither the notion of *mental representation* (Bostrom et al., 1990), nor the concept of *technological frame* (Orlikowski & Gash, 1994), are explicit about the micro-level processes through which users learn to use an IT. Besides, these concepts stem from a view of the IT artifact as a clearly bounded and relatively stable entity, that differs from the fluid systems that have emerged in recent years (Ekbia, 2009; Garud et al., 2008; Kallinikos, Aaltonen, & Marton, 2013; Leonardi, 2017). Therefore, we suggest to start by proposing a new conceptualization of the IT artifact as an ambiguous (technological) object, to then expend our understanding of micro-level learning processes.

2.2 Summary of the literature on ambiguous products

Our review of the literature has been conducted with the following objectives in mind: 1) identify the key attributes of the concept of "ambiguous technological objects" from a cognitive perspective 2) identify the conceptual domain on which these studies are grounded, and 3) understand the nomological net in which the concept of ambiguous perceptions has been mobilized before.

We started by reviewing the information systems literature using the *AIS electronic library*[2] and found no evidence of such concept in the behavioral stream of IS. Following Webster and Watson (2002)'s suggestion that one must also look outside the field of IS when reviewing and developing theory, we extended our search using *Google Scholar*[3] and the keyword combination "ambiguous", "product", and "perception". It quickly appeared that a relatively mature stream of research dealing with ambiguous products existed in the consumer behavior literature. We focused our initial review on the key papers dealing with the development of attitudes towards ambiguous products and published in leading consumer behavior journals such as *Journal of Marketing Research*, *Journal of Consumer Research*, and *Journal of Consumer Psychology*. The rest of the review has been conducted in concentric circle: after having identified a small set of highly relevant publications, we tracked the associated papers based on the articles that cite them (Boell & Cecez-Kecmanovic, 2014). As we narrowed down the scope of the concept, we shortlisted eleven papers dealing with the notion of ambiguous objects from a cognitive perspective. The eleven studies are reported in Table 1.

The relatively conservative number of shortlisted papers can be explained by the following reasons. First, because of our endeavor to develop a conceptually robust definition, we focused on papers published in leading journals. Indeed, six of the eleven papers reported below stem from the same three high quality marketing journals. Second, we focus on the perception of ambiguous objects in cognitive and behavioral science. The topic is arguably limited in scope, with few leading authors. Third, we have reached a stage where there is some redundancy in the definitions, which signals that we have achieved a certain degree of saturation (Podsakoff, Mackenzie, & Podsakoff, 2016).

[2] http://aisel.aisnet.org
[3] https://scholar.google.com

Source	Design	Framework	Definitions of ambiguity	Exemplar item
(Uekermann, Herrmann, Wentzel, & Landwehr, 2010)	Experiment	Categorization	Ambiguity refers to a state of uncertainty, where a stimulus (e.g., a word, a picture, or another person's behavior) may not have a fixed value or meaning and may be interpreted in more than one way.	Mainstream products (cars)
(Meyers-Levy & Tybout, 1989)	Experiment	Categorization	Ambiguity is a function of the incongruity between the attributes of a product and the attributes of its category of belonging (atypical products)	Mainstream products (beverages)
(Noseworthy & Trudel, 2011)	Experiment	Categorization	Ambiguous products differ from normative expectations either conceptually (adopt the functional features of more than one product category) or perceptually (differ from a consumer's existing mental representation. Ex. A round, rather than square, camera)	Mainstream products (drinks, cars, wrist-watch)
(S. Hoch & Ha, 1986)	Experiment	Experiential learning	Ambiguity is a function of a product's (1) lack of distinctiveness with comparable products and (2) the number of possible interpretations of a product performance	Mainstream products (cloths)
(Yi, 1993)	Survey	Experiential learning	Products that are difficult to evaluate are considered ambiguous. Ambiguity stems from a lack of objective criteria or the potential for multiple interpretations of product quality.	Mainstream products (insurance, camera, cloth, etc.)
(Nyer, 1996)	Experiment	Experiential learning	Ambiguity arises in the absence of objective criteria to assess the quality of a product and can manifest before (expectation) and after (satisfaction) experimenting with it	Mainstream products (cloths)
(Ha & Hoch, 1989)	Experiment	Experiential learning	Ambiguity is "the potential for multiple interpretations of overall product quality" that occurs when equivocal evidences are presented (cf Hoch & Ha, 1986)	Mainstream products (TV)
(Gregan-Paxton, Hoeffler, & Zhao, 2005)	Experiment	Category-based learning	Ambiguous products are hybrid products that cover multiple functions	Hybrid product (PDA-mobile phone)
(Kim & Yoon, 2013)	Experiment	Experiential learning	Ambiguity is defined as "the potential for multiple interpretations of overall product quality" (see Hoch and Ha, 1986) and occurs for products with uncorrelated attributes	Mainstream brands
(Moreau, Markman, & Lehmann, 2001)	Experiment	Category-based learning	Ambiguous products are new products that do not fit neatly into existing categories	Innovative products (digital camera)
(Goode, Dahl, & Moreau, 2013)	Experiment	Category-based learning	Ambiguity is associated to the uncertainty in categorization that results from the absence of typical category attributes	Innovative products (vacuum cleaner)

Table 1. Definitions of ambiguous products from a cognitive perspective

We notice that the literature that deals with ambiguous products started to develop in the late 80's through two relatively independent research streams, namely experiential learning and categorization. Early work on the effect of information acquired through indirect means (eg. advertising) suggests that learning and experimentation are intimately related (Ha & Hoch, 1989; Hoch & Ha, 1986; Hoch & Deighton, 1989). Although this stream does not postulate the prevalence of categories in learning, it assumes that learning occurs when *a priori* formed expectations about ambiguous objects are validated in practice. While experiential learning is concerned with the psychological difficulty of developing robust attitudes towards ambiguous products, the categorization stream focuses on the way individuals cope with objects with incongruent properties (Meyers-Levy & Tybout, 1989; Noseworthy & Trudel, 2011; Uekermann et al., 2010). The category-based learning model emerged as an integration of these two streams at the millennial turn, in recognition of the trend towards hybrid products that embrace multiple functions (ex: smartphones, wearables, etc.). This model focuses on the way individuals categorize unfamiliar items and learn about them knowing that they belong to a given category. We now turn to describing this model.

2.3 The category-based learning model

Categories are omnipresent in our daily lives: firms are clustered into sectors of activity, movies are categorized into genres, cars are classified into types, marketing campaigns target consumer segments, etc. We refer to categories as bounded units of knowledge that can be accessed, mapped, and transferred to learn about unfamiliar items (ie. new technologies) (Gentner, 1983; Gregan-Paxton, John, Gregan Paxton, & John, 1997; Markman & Wisniewski, 1997; Smith & Medin, 1981). According to the category-based learning model, learning is a three-stage process during which 1/ categories are *accessed* by comparing the similarity between the category and the item, 2/ the features of the item are *mapped* and their relationships defined, and 3/ category knowledge is *transferred* to the item (Gregan-Paxton et al., 1997). The basic principle of the model can be summed-up by the following statement "when a novel item is classified as a member of an existing category, information in that category is transferred to the novel item and used to structure the new representation" (Moreau, Markman, & Lehmann, 2001: 490). A fundamental assumption of the model is that existing knowledge structures serve to facilitate the achievement of specific learning objectives. Therefore, categories do not only serve as cognitive devices to organize knowledge, but also (and rather) as tools to draw from to learn about the world and the objects that are part of it. The model we use, adapted from Gregan-Paxton & John (1997), is presented in Figure 1.

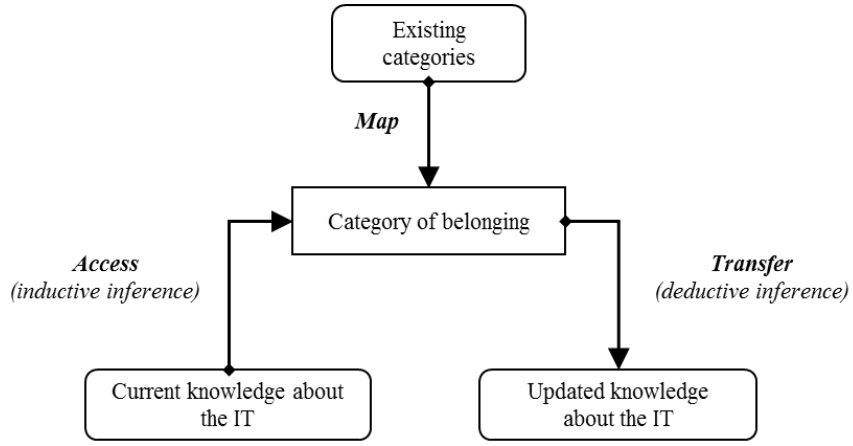

Figure 1. The category-based model of learning (adapted from Gregan-Paxton & John, 1997)

Features are constitutive components of these units of knowledge. They vary from perceptual features (eg. flat, rigid, plain, horizontal) to abstract features that are disconnected from the perceptual experience with the item (eg. designed with the intent of human usage) (Smith & Medin, 1981: 18-21). Functional features are an in-between type of feature that is neither abstract nor perceptual, yet essential to characterize a category or concept (Miller & Johnson-Laird, 1976). In the context of learning about novel IT, features refers to the typical attributes of the IT of the same category. This could pertain to the perceptual attributes of the ITs in the category (shape, interface layout, ergonomic attributes), its functional attributes (purpose, functions), as well as attributes associated to its use (context of use, frequency of use, norms associated to the use, etc.). Features and attributes are used indistinctively in the categorization literature, although the term "attribute" tends to lean to the more objective characteristics of an object, whereas "features" generally encompass a subjective appreciation. From this perspective, "ideal" features are features that are shared by all the items that belong to the same category, but not by items that belong to other categories (Loken, Barsalou, & Joiner, 2008).

We have shown so far that users that are exposed to a novel IT are expected to attempt to categorize it on the basis of abstract and perceptual information about it and, in turn, learn about the IT based on prior knowledge they have about its category of belonging (Yamauchi & Markman, 2000). Inference processes, which are either inductive (placing a technology in an existing category) or deductive (derive knowledge from category membership), are therefore central to processes of learning about unfamiliar IT.

2.4 Categorization difficulty

Preliminary findings in consumer behavior reveal that learning is a process during which initial expectations derived from abstract information about a new product are updated through the experimentation with it (Hoch & Deighton, 1989). During this phase, individuals adapt their beliefs to make sense of new data, a process that is hindered when the product lacks distinctiveness or has many potential performance interpretations (Hoch & Ha, 1986). This likely arises for products that cannot be easily classified because they have fuzzy boundaries or because they belong to multiple categories simultaneously (Gregan-Paxton et al., 2005). The difficulty IS scholars encounter when attempting to categorize contemporary technologies is symptomatic of this categorization ambiguity. In their meta-analysis, Wu & Lu (2013) recognize that "the boundaries among utilitarian, hedonic, and dual-purposed systems are not as apparent as their names suggests" (Wu & Lu, 2013: 155). Similarly, Gerow et al. (2013) acknowledge the difficulty they faced when categorizing the types of systems that IS researchers have studied since 1992. As a remedy, they have created a "mixed" category of system for uncertain cases that the raters could not confidently classify (Gerow, Ayyagari, Thatcher, & Roth, 2013). Communication technologies, email systems, Internet, mobile communication technology/device, mobile Internet, personal computers, Web site/service technology, etc. are as many technologies that could easily fall into more than one single existing category. These arguably represent the daily IT ecosystem of many people. Whenever one is unable to confidently categorize an unfamiliar item, the knowledge contained in existing categories cannot be easily accessed and transferred to it, which makes it difficult to learn about the item (Moreau et al., 2001).

3 Conceptualizing ambiguous technological objects

Learning in the context of IT refers to the acquisition of information that is relevant to formation of attitudes about an IT. Therefore, ambiguity is a perception rather than an objective attribute of the IT, which means that we expect users to vary in the extent to which they believe an IT is ambiguous. The perception of ambiguity manifests when categorization is ambiguous, namely when one unable to confidently categorize an IT into a single known-category (Gregan-Paxton et al., 2005). In the context of experiential learning, Hoch & Ha (1986) suggest that the ambiguity of a product is a function of (1) the lack of distinctiveness with comparable products, and (2) the number of possible interpretations of what constitutes a high or low product performance. Contrary to the consumer experience of product learning, the user experience of learning about an IT occurs in the course of recursive interactions between the IT and the user. Moreover, learning about an IT involves a specific form of exploration and customization that makes the interaction ontologically different from that of physical objects (Ekbia, 2009). Drawing on Hoch & Ha (1986), we therefore turn the definition of ambiguous products to a new terrain and propose that perceived IT ambiguity is a function of three factors: the perception that there are multiple or inconsistent interpretations of *why* to use a technology (ambiguity of purpose), the perception that there are multiple or inconsistent interpretations of *how* to use it (ambiguity of use), and the perception an IT has some attributes in common with one or several seemingly unrelated ITs (relative ambiguity). We define these dimensions and describe their relationship with the focal concept in the following section.

Focal concept	Definition	Dimensions	Definitions
Perceived IT ambiguity	A categorization difficulty that disrupts the process of learning about a new IT	Ambiguity of purpose	A user's perception that there are multiple or inconsistent interpretations of *why* to use an IT
		Ambiguity of use	A user's perception that there are multiple or inconsistent interpretations of *how* to use an IT
		Relative ambiguity	A user's perception that an IT has some attributes in common with one or several seemingly unrelated ITs

Table 2. Summary of the concept and its dimensions

3.1 Ambiguity of purpose

This dimension relates to a user's perception that there are multiple or inconsistent interpretations of *why* to use an IT. It is associated to a lack of definite understanding of the overarching purpose of an IT. Smith & Medin (1981) have advanced that functional features tend to constitute the core of many natural categories. Provided that it is clearly defined, the function of a given IT is thus expected to play an instrumental role in the way it is categorized. In the absence of a clearly defined and stable purpose, an IT will likely be difficult to learn about. We thus expect digital technologies that are purposively incomplete and constantly in the making (Garud et al., 2008) to be equivocal artefacts subject to numerous possible interpretations that are conducive of the ambiguity of purpose. With this type of technology, the intentions of designers are undetermined and system boundaries are often unclear (Garud et al., 2008). Digital technologies tend to adhere an *evolutionary design* (Janssen, Frazer, &

Ming-Xi, 2002) characterized by the fact that their makers have a general sense of where they are going but do not have a precise target or goal in mind, and they leave to the users to define the trajectory of the system. In fact, *in situ* accounts of the design of modern technology report the chaotic and improvised nature of the IT development process because part of it is handed to the user (Bansler & Havn, 2004). Consequently the goal of digital technologies is likely to remain a continually moving target open to wide array of possible user interpretations.

There may also be instances when salient goals are promoted but those are perceived by users as being incompatible, meaning that they are not ought to be achieved concurrently. This likely occurs for technologies that cover multiple functions such as the iWatch that is "designed with both utility and beauty in mind"[45], pointing to both the aesthetic feature of the wristwatch and the practical feature of an IT. Similarly, enterprise social media (Leonardi, Huysman, & Steinfield, 2013) and enterprise social networks (Koch, Gonzalez, & Leidner, 2012) are positioned as hybrid technologies that enhance productivity on the task and offer an inspirational experience generative of ideas. Turning to digital media, Burgess & Green (2009) have pointed at the singular property of Youtube to blend together the "user" and the "traditional media" categories of content creation in a unique system. They state that this is "problematic for understanding Youtube as a site of new convergences and mutuations of these categories" (Burgess & Green, 2009: 4). A user who is confronted with an IT that blends together two or more seemingly antagonistic functions will be unable to confidently resort on existing knowledge structures to learn about it.

3.2 Ambiguity of use

Ambiguity of Use (AU) refers to user's perception that there are multiple or inconsistent interpretations of *how* to use an IT. Ambiguity of use relates to perception of ambiguity that is a situational and arises in practice during instances of use. It is associated to the degree of perceived indetermination that surrounds the actual experience of the IT in practice. We expect the versatility of digital technologies that can be constantly adapted to changing conditions in the environment of the user to induce ambiguity of use. Adaptability refers to "how easily the system can be built on or modified to broaden its range of uses"(Zittrain, 2008: 71). Numerous technologies can be endlessly diverted during mundane use situations to new activities that their makers did not envision in the first place. This property of recent technologies has been referred to in the IS literature as *editability* (Kallinikos et al., 2013), also called *malleability* (Schmitz et al., 2016) to emphasize the continuous modification of the functionalities of the technology in the course of normal usage episodes. Aside from the property of being pliable, modern technologies tend to integrate a wide array of seemingly different functions that contribute to this versatility in use. Collaboration tools are cases in point for they blend all possible forms of communication features (synchronous or asynchronous, and private or public) together with file sharing features (Pillet & Carillo, 2016), which in practice questions the divide between communication and content management systems.

[4] Source (as of 20/04/2017) : www.apple.com/apple-watch-hermes

Ambiguity of use is also expected to manifest when interacting with *generative systems* that have the capacity to produce something new and unexpected through the unfiltered contributions of a broad and diverse audience (Zittrain, 2008). Such systems open up for new ideas and possibilities but some users may find themselves stuck because of the absence of a clear pathway towards an even more uncertain outcome (Remneland-Wikhamn, Ljungberg, Bergquist, & Kuschel, 2011). The American psychologist Kenneth Gergen approaches generative capacity in the context of knowledge generation as a form of radical boundary-spanning logic that transcends the "myopia of univocality" (Gergen, 1982: 110) that characterizes social groups. Inducing equivocality, or deliberately allowing the possibility of several different meanings, is therefore inherent to technologies that afford generative capacities. Besides, the specificity of generative technologies lies in their ability to "reframe the way we see and understand the world, to think out-of-the-box and to challenge the normative status quo" (Avital & Te'Eni, 2009: 362), which leaves users with little guidance when it comes to interpreting what is allowed and what is not, what is appropriate or not, etc.

3.3 Relative ambiguity

Relative Ambiguity (RA) refers to a user's perception that an IT has some attributes in common with one or several seemingly unrelated ITs. When exposed to an unfamiliar item, an individual compares the attributes of the item with the attributes of the items that belong to existing categories in order to determine its category membership (Gregan-Paxton et al., 1997). In the context of IT use, the attributes of the technology may comprise of (but are not restricted to) its function, its perceptual attributes (shape, interface layout, ergonomic attributes), and the contextual attributes associated to its usage (setting of use, frequency of use, norms associated to the use, etc.). Relative ambiguity arises when a user is confronted with an IT that possesses the same attributes as an IT that does not belong to the same category. Such incongruity is likely to be perceived as an ambiguity that influences the formation of beliefs (Meyers-Levy & Tybout, 1989). In their study of new products, Goode et al. (2013) have shown that ambiguity arises when a product is placed in a given category but does not possess the typical visual attributes of that category.

Such incongruity is expected to arise in the wake of *everyday computing*, which is concerned with "the use of computing resources both within and beyond managerial and organizational boundaries" (Yoo, 2010: 224). Provided that the scope of organizational computing expands to everyday life, we can expect the design principles that guide the development of business solutions to converge with those of consumer applications. This would result in frequent exchanges of attributes between the two categories of systems. Facebook's "Workplace" is an extreme manifestation of this trend, for this business version resorts on the exact same visual and functional attributes as its iconic consumer counterpart. In fact, numerous business solutions emanate from the public sphere and are introduced into firms in later stages, which contributes to the combination of attributes from seemingly unrelated categories into unique systems. Similarly, the trend towards gamified apps, which consists in incorporating attributes from the video game category in a variety of contexts in order to drive engagement (Deterding, Dixon, Khaled, & Nacke, 2011), illustrates the mixing of attributes from multiple categories of IT.

Ubiquitous computing has also paved the way to the development of multi-purpose, multi-context media systems that propose novel combinations of functions and attributes, which has a distorting influence on a user's belief structure (Carillo, Scornavacca, & Za, 2014). We recognize two related phenomena. First, certain distinctive attributes such as the setting in which a given technology is used

does not appear as a salient attribute anymore. The consumerization of IT phenonma (French, Guo, & Shim, 2014; Niehaves, Köffer, & Ortbach, 2012; Schalow, Winkler, Repschläger, & Zarnekow, 2013) essentially abolishes the barriers between the work and the nonwork settings of use (Köffer, Anlauf, Ortbach, & Niehaves, 2015; Köffer, Junglas, Chiperi, & Niehaves, 2014). As a result, a corporate IT is lilekly to possess some of the attributes of noncorporate IT, and *vice versa*. Second, the proliferation of interoperable and open technologies makes it difficult to identify "inherent borders that bound them as obvious entities" (Kallinikos et al., 2013: 360). In the absence of clear and distinct borders, ascribing an IT to a known category in order to learn about it is expected to be difficult. Moreover, the integration of heterogeneous technologies results in overlay systems with boundary-crossing properties that challenge deeply entrenched cognitive structures (Boland, Tenkasi, & Te'eni, 1994). While the absence of clear boundaries may lead to the fruitful exploration of unchartered territories, it also overrides the distinctiveness of certain attributes of the IT (purpose, context, interface, etc.) that are cornerstone to the process of learning through categorization.

3.4 Summary of the sources of ambiguity

We have shown so far that some of the properties of modern technological objects are conducive of ambiguity. Table 3 summarizes the main sources of ambiguity we identified in the IS literature and articulate those to the dimensions of ambiguity we have derived from the psychology literature and adapted to technological objects.

Reference	Source of ambiguity	Definition	Dimensions primarily impacted		
			AP	***AU***	***RA***
(Garud et al., 2008)	Incomplete design	A pragmatic design approach that values fluidity more than clear boundaries and fixed design objectives.	✗		
(Burgess & Green, 2009)	Participatory culture	The user and mass-media-created categories of content production co-exist and collide on new media (eg. Youtube).	✗		
(Janssen et al., 2002)	Evolutionary design paradigm	Similarly to biological systems, IT adapt changing environmental conditions and evolve according to changing user needs.	✗		
(Zittrain, 2008)	Adaptability	The ease with which a system can be built-on or modified to broaden its range of uses.		✗	
(Kallinikos et al., 2013)	Perpetual editability	Editability can be achieved by just rearranging the elements that constitute a technological object, by deleting existing or adding new elements, or by modifying some of the functions of individual elements.		✗	
(Schmitz et al., 2016)	Malleability	Nontechnical users are empowered to adapt pliable technology to their task environment in the course of normal usage episodes.		✗	
(Zittrain, 2008)	Generativity	Systems that have the capacity to produce something new and unexpected through the unfiltered contributions of a broad and diverse audience.	✗	✗	

Table 3.1 Sources of ambiguity found in the literature on the IT artefact

Reference	Source of ambiguity	Definition	Dimensions primarily impacted		
			AP	***AU***	***RA***
(Avital & Te'Eni, 2009)	Generative capacity	Systems that have the capacity to force to reframe the way we see and understand the world, to think out-of-the-box and to challenge the normative *status quo.*		X	
(Köffer et al., 2015)	Consumerization of IT	The blurring of the boundaries between the work and nonwork technological environments.		X	X
(Yoo, 2010)	Experiential Computing	The use of computing resources both within and beyond managerial and organizational boundaries.			X
(Deterding, Dixon, Sicart, Nacke, & O'Hara, 2011)	Gamification	The use of game-design elements in non-gaming contexts.			X

Table 3.2 Sources of ambiguity found in the literature on the IT artefact

Having a clearer understanding of what a definition of an ambiguous technology under the categorization framework may be, we will now propose several research venues that can help advance our understanding of the usage processes that pertains technologies with blurred boundaries.

4 Research Agenda

4.1 Learning processes

Do ambiguous technologies spur new forms of learning? As shared mental categories and collective knowledge structures are increasingly unstable and blurred, it appears that idiosyncratic representations mobilized on the basis of peculiar user needs represent a compelling form of mental models. Indeed, alternative conceptualizations of categories exist, notably in the consumer behavior literature. Contrary to the perspective presented in this paper, these studies emphasize on the *ad hoc* and flexible nature of categories (Barsalou, 1983; Loken et al., 2008). In their work on goal-derived categories, Ratneshwar and his colleagues (1996, 2011) argue in favor of a situated perspective on categories that individuals construct in the service of particular goals (Ratneshwar, Pechmann, & Shocker, 1996; Ratneshwar & Shocker, 1991). This would call for research on more fluid and flexible forms of knowledge that contrasts with existing conceptualizations (eg. Bostrom et al., 1990; Orlikowski & Gash, 1994).

On a more practical note, the role of traditional instruction-based types of learning is being questioned. Indeed, this learning approach is ill-aligned with the evolving nature of modern technologies, as well as their ability to afford hundreds of unforeseen usage scenarios. This makes pre-usage instructions difficult to create as well as rapidly obsolete as new uses emerge. Besides, the efficiency of this approach is under question. In a series of studies, Lakshmanan & Krishnan (2011) have shown that the use of "help" files commonly found on software or websites prevented users to engage in self-driven exploratory forms of learning that lead to tremendous competency leaps. They found that this form of learning not only improves learning, but also positively influences attitudes and future intentions of product use (Lakshmanan & Krishnan, 2011).

4.2 Adoption processes

Importing the concept of product ambiguity into the field of IS is particularly exciting because studies that come to grasp with the formation of attitudes towards ambiguous objects find mixed results. On the one hand, it appears that ambiguous products are more difficult to learn about, which has significant effects on post-use beliefs (Hoch & Ha, 1986; Hoch & Deighton, 1989), on the satisfaction towards them (Nyer, 1996; Yi, 1993), and on performance evaluations (Noseworthy, 2012; Noseworthy & Trudel, 2011; Uekermann et al., 2010). On the other hand, numerous examples of successful ambiguous innovations can be found, suggesting that ambiguity can signal novelty and prove compelling to users (Goode et al., 2013). In their seminal contribution, Meyers-Levy & Tybout (1989) demonstrate that beverages presenting a moderate level of ambiguity in their description are evaluated more favorably than beverages that are either extremely ambiguous or not ambiguous at all (Meyers-Levy & Tybout, 1989). Putting aside the specificity of the IT artifact, these findings from the marketing discipline suggest that the concept of ambiguity may prove particularly insightful to the stream of IS research that focuses on to the formation of beliefs in the early phase of IT adoption. Precisely, the concept could prove fruitful to advance research multi-motive adoption because ambiguous technologies likely tap on the attributes of multiple categories of IT (Lowry, Gaskin, & Moody, 2015).

4.3 Technostress

A number of scholars have pointed at the ubiquitous nature of modern technologies as a potential source of stress. These studies have focused on the most manifest dimension of the introduction of modern ICTs, namely greater levels of connectivity and the subsequent intrusion of professional matters into others aspects of people's life (Boswell & Olson-Buchanan, 2007; Derks, van Duin, Tims, & Bakker, 2015; Mazmanian, Orlikowski, & Yates, 2013). Early results suggest that work-life conflict arises in the wake of the consumerization of IT that intensifies the blurring between work and private life and therefore violate a user's work-nonwork segmentation preference (Köffer et al., 2015, 2014). The concept of ambiguity could complement research about the discomfort individual users may experience when interacting with ubiquitous computing devices. Existing research has also pointed to individual differences in learning styles (Bostrom et al., 1990), and insights from the discipline of psychology indicate that some individuals are intolerant to ambiguous situations (Frenkel-Brunswik, 1949). Intolerance to ambiguity may trigger a range of individual reactions, whether cognitive (artificially dissipating ambiguity), emotional (uneasiness, discomfort, dislike, anxiety), and behavioral (rejection or avoidance) (Grenier, Barrette, & Ladouceur, 2005). These insights from literature on psychology converge with recent discussions on technostress, which focuses on investigating the role of technology characteristics in inducing stress in individuals (Ayyagari, Grover, & Purvis, 2011).

5 Conclusion

We leverage on the literature in marketing and innovation to develop the concept of perceived IT ambiguity, which refers to as a categorization difficulty that disrupts the process of learning about a new IT. We elaborate on recent conceptualization of the IT artefact (Grover & Lyytinen, 2015; Orlikowski & Iacono, 2001) to substantiate our definition of ambiguous technological objects. This project provides a ground-work that will hopefully inspire scholars that a recognizant of the blurring of the boundaries of technological objects.

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