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Overcoming the Binary Logic of Adoption

On the Integration of Diffusion of Innovations Theory and the Concept of Appropriation

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Introduction

When opting for communication studies as a basis to integrate existing traditions of diffusion research, Rogers (1962) had fed the complex field of research with a rich set of theoretical and methodological approaches. Today, diffusion research is struggling again to meet the complexity of innovations and their uses—namely in the field of new information and communication technologies. Hence, a realignment to recent progresses of communication studies and neighboring disciplines is recommended.
The chapter demonstrates how the traditionally one-directional and binary concepts of diffusion and adoption can be complemented by a closer look at implementation as a process of personal and social appropriation. While Rice and Rogers (1980) concede that users reinvent innovations in the course of implementation, scholars have since neglected this point to the profit of ever more elaborated models for predicting individual adoption decisions (Theory of Planned Behavior, Technology Acceptance Model, etc.) and social processes of diffusion (Social Network Analysis). The chapter discusses how to overcome these drawbacks by combining adoption and diffusion approaches with traditions that permit to consider the implementation of innovations as a dynamic, multi-dimensional process.

"I remember interviewing an Iowa farmer during my Ph. D. dissertation research at Iowa State University in 1954. I inquired about his adoption of 2,4-D weed spray. The farmer described in some detail the particular and unusual ways in which he used the weed spray on his

farm: At the end of his lengthy remarks, I simply checked "adopter" in my interview questionnaire." Everett Rogers (2003, p. 17)

As illustrated by this anecdote from Everett Rogers' early fieldwork, empirical diffusion research has always had a somewhat limited view on adopters and what they do with innovations. The present chapter responds to this shortcoming on several levels: by describing how mainstream diffusion theory, from its earliest days, has considered adoption from a binary perspective; by explaining the methodological and theoretical reasons for this approach; by showing how the phenomenon of Re-Invention has always challenged this view, even more so today with the increasing complexity of innovations; and finally by outlining approaches that may lead to a new and broader perspective on what users do with innovations in the course of the diffusion process.

The evolution of diffusion of innovations theory and its binary logic

A closer look at the history of diffusion research reveals that the idea of adoption as a binary decision cannot be traced back to the very beginning. The French sociologist Gabriel de Tarde, generally considered a forefather of diffusion research, had a much wider understanding of what constitutes an innovation and what users could do with an innovation. Thinking in terms of metaphors rather than hypotheses and operationalizations, Tarde considers innovations as waves that spread among society. Using this metaphor, he expresses two advanced but long-forgotten ideas:

- Innovations may change in the course of diffusion. This may happen when they reach new users (just as waves change their form when entering a new medium) or when they interfere with other innovations.
- The importance of adopters for the evolution of innovations is much greater than generally thought. In an extreme case, the inventor generates only a quasi-accidental impulse that develops its force in the course of spreading throughout society, just as a butterfly flapping its wings may lead to a landslide, in the words of Tarde (1902, p. 562).

These ideas have been largely forgotten (the article in question has yet to be translated into English), as most scholars focus on Tarde's early reflections on opinion leaders and the S-like shape of the adoption curve. The reason for this limited view on Tarde may lie in the way in which diffusion research has evolved since his time.

The first half of the twentieth century was marked by a variety of parallel traditions in various disciplines ranging from anthropology (Wissler, 1914) and rural sociology (Ryan & Gross, 1943) to public health and medical sociology (Menzel & Katz, 1955; Rogers, 2003, pp. 44–45), involving a wide spectrum of theoretical and methodological approaches. However, when Everett Rogers consolidated these approaches to what is considered today as "the traditional approach" (Dearing & Meyer 2006, p. 39), he opted for a rather tight framework, both theoretically and methodologically.

With respect to methodology, Rogers leaned on the practice adopted in agricultural sociology, which he knew from his own studies in this field at Iowa State University, in particular the seminal study by Iowa State sociologists Bryce Ryan and Neal Gross (Ryan & Gross, 1943; cf. Lowery & DeFleur, 1995; Meyer, 2004; Rogers, 2003). In the summer of 1941, Ryan and Gross interviewed 259 farmers regarding their adoption of a new hybrid seed corn during the 1930s. Drawing on these data, they identified factors that influence a single adoption decision and proposed an S-shaped diffusion curve.

Meyer (2004, p. 59) summarizes the applied methodology in terms of the following five points: "1. quantitative data, 2. concerning a single innovation, 3. collected from adopters, 4.

at a single point in time, 5. after widespread diffusion had already taken place." This methodology enables a description of the evolution of cumulated adoption decisions over time, but it requires a reduction of the farmers' activity to a simple dichotomy between adoption and rejection. Nonetheless, the authors were themselves highly skeptical as to whether it would be possible to formulate the general shapes of diffusion curves, as the diffusion processes relevant to various innovations are vastly different in terms of the nature of communication among the adopters: "but it seems doubtful if any theoretic pattern can adequately conform to situations involving all degrees of interaction and isolation; to economic practices as well as to styles" (Ryan & Gross, 1943, p. 24). Although Ryan and Gross applied this caveat mainly to the question of which shape a diffusion curve may take (e.g., normal distribution, logistic curve), it can also be understood as a general warning against reducing the complex evolution of diverse innovations to allembracing theories, not to mention mathematical models.

While Ryan and Gross's approach appears satisfactory in terms of the specific question regarding how to spread a singular, unalterable, and clearly superior innovation among a hesitant population, it neglects many aspects that become more important for other innovations: How do users implement the innovation into their everyday practices? What symbolic meaning does the innovation have for them? How do they communicate these aspects among each other (and not simply communicate the adoption decision)? When Everett Rogers chose to adopt the Ryan and Gross methodology as a basis for consolidating the various existing streams of diffusion research to a single integrative approach, he initiated a development that led to a long-lasting neglect of these questions and cemented the focus on binary adoption decisions (be it on the level of individual adopters or on the cumulative level of social systems) (Meyer, 2004).

This narrowing of the perspective was mirrored by the theoretical basis on which Rogers built the new diffusion research. In the course of looking over various disciplines for a theoretical harbor for his new Diffusion of Innovations Theory, Rogers opted for the relatively young field of communication studies. As noted by Dearing and Singhal (2006, p. 20), the lack of theoretical complexity was the main advantage of Rogers' decision, as communication studies was "sufficiently new and undetermined" to permit a new research field to evolve. The main theoretical achievement of communication that Rogers incorporated into Diffusion of Innovations Theory was the well-known Lasswell formula (Lasswell, 1948).

In their book with the programmatic title *Communication of Innovations*, Rogers and Shoemaker (1972, p. 20) propose a diffusion process parallel to the SMCRE model (Source–Message–Channel–Receiver–Effect): the inventor replaces the "source," the innovation the "message," diffusion channels the "channels," the adopter the "receiver," and adoption the "effects." While this formula fully satisfied the need for a loose structure capable of integrating a large variety of results, this approach also cemented a strongly linear understanding of communication and, hence, of the communication of innovations.

Communication studies have since come up with new models that attribute a more active role to the receiver/adopter and that consider the message as the object of negotiation between the sender and receiver (Hall, 1980). However, at its heart, diffusion research has kept true to the linear Lasswell formula, with a linear understanding of diffusion from the inventor to the late adopters, with a static understanding of the innovation and with a passive perspective on the user, whose only choice of action lies between adoption and rejection.

This approach has the advantage of opening diffusion research to other approaches that work based on binary variables, such as Social Network Analysis or the Theory of Planned Behavior. For example, Social Network Analysis (SNA, Coleman, Katz & Menzel, 1957; Valente, 2006) helps to trace the channels through which innovations spread within interpersonal networks. Behavioral theories from social psychology, such as the Theory of Reasoned Action (TRA, cf. Fishbein & Ajzen, 1975) and the Theory of Planned Behavior (TPB, cf. Ajzen, 1985), facilitate the modeling of factors that influence the individual's adoption decision.

Despite these theoretical advancements, Katz (1999, p. 145) states "There is an apparent paradox at work: the number of diffusion studies continues at a high rate while the growth of appropriate theory is at an apparent standstill."

Re-invention challenging diffusion of innovations theory

In the 1970s the adoption process was differentiated by the concept of "Re- Invention," a term used mainly in political science (see Charters & Pellegrin, 1973; Glick & Hays, 1991; Goodman & Steckler, 1989; Hays, 1996a, 1996b; Lewis & Seibold, 1996) and seldom applied in communication science (Rice & Rogers, 1980; Rogers, 2003; Schenk, Dahm & Sonje, 1996). Re-Invention extends the binary adoption decision to a possible change in the innovation during its implementation and analyzes the factors that support a high degree of modification (see Glick & Hays, 1991; Hays, 1996a, 1996b; Lewis & Seibold, 1996; Majchrzak, Rice, Malhotra, King & Ba, 2000; Orlikowski, 1993; Rice & Rogers, 1980; Rogers, 2003).

However, the accomplishments of Diffusion of Innovations Theory in analyzing Re-Invention remain extremely limited. Rogers (Rice & Rogers, 1980; Rogers, 2003, pp. 180–188) focuses mainly on identifying those factors that influence whether Re-Invention will occur and assessing its consequences. On the innovation side, complexity and a loosely bundled structure, as well as a wide spectrum of potential uses, make Re-Invention more likely. On the users' side, either ignorance or a very high technical knowledge (von Hippel, 1986) are often accompanied by Re-Invention, as well as local pride of ownership (Havelock, 1974) or a complex inner structure of the adopting unit (such as a large company adopting a new communication system and needing to adapt the system to its own hierarchy and work processes). The third instance that could push Re-Invention is a change agent, such as a company that counts on its users to actively integrate the products into their everyday lives. This idea is expressed by the use of a slogan such as "You make it a Sony." Finally, Re-Invention also depends on the amount of time that has passed in the diffusion process: Rogers considers that Re-Invention is more likely to occur late in the diffusion process, when members of the social system have become accustomed to the innovation.

The evaluation of Re-Invention is double-edged: on the one hand, it could represent a danger for the user (i.e., when security-sensitive innovations such as electronic devices are re-invented), and it could threaten the producer's business plans. This is the case for the Re-Invention of the "missed call" function for mobile telephones, which is used to communicate without paying for a phone connection (Donner, 2007). On the other hand, Rice and Rogers (1980, p. 504) emphasize the positive effects of Re-Invention when it serves for adapting an innovation to a user's specific needs, leading to a higher likelihood of confirmation after the implementation phase. Hence, Rogers acknowledges the existence of Re-Invention and explores its causes and consequences. However, this acknowledgment requires a rethink of the linear concept of diffusion and its replacement with a communication model that assigns an active role to the recipient/adopter, although this has yet to be done in diffusion research. Instead, the findings about Re-Invention only serve as a marker that highlights the boundaries of traditional diffusion research. Therefore, we need to look beyond diffusion research to find ways of overcoming existing limitations to diffusion of innovations theory.

Recent digital, interactive, and/or mobile media innovations commonly constitute a bundle of technological functions and services that lead to a variety of applications. Such technologies are commonly status symbols of high relevance to the user's self-perception (see Ling, 2004; Oksman & Turtiainen, 2004). Consequently, these technologies, from early word processing software (Johnson & Rice, 1984) to today's mobile telephones (Donner, 2007), are likely to be re-invented by users. Until now, diffusion of innovations theory has been unable to describe this change beyond the concept of Re-Invention, largely concentrating on the factors that support modification.

Overcoming the binary logic of adoption

In response to the phenomenon of Re-Invention, Rogers (2003, p. 181) suggests that "The fact that Re-Invention may happen is a strong argument for measuring adoption at the implementation stage, as change that has really happened." Because implementation is a more complex phenomenon than adoption, this demand would consequently mean that we must go beyond the binary logic of adoption. Accordingly, research into the "change that has really happened" would be more than just stating whether a certain user adopted an innovation: it should be about analyzing the circumstances and effects of the users' creativeness in the course of making sense of the innovation in question, i.e., appropriating the innovation. Below, we consider theories and findings from other research traditions that are highly compatible with Diffusion of Innovations Theory and that may aid our understanding of "adoption at the implementation stage, as change that has really happened" (Rogers, 2003, p. 181).

Cultural studies

Cultural Studies emphasizes the importance of interpersonal communication when adopting innovations. In the nomenclature of this field, this is called the process of appropriation. Media appropriation is a constructive process of sense-making among the users of the content of any media, including, for example, text in literature (see Certeau, 2002) or television (Brown, 1994; Hall, 1980). These ideas basically rest upon the Encoding/Decoding Model proposed by Hall (1980). In opposition to any linear communication model, Hall postulates that the transmission of a certain message is a process of encoding and decoding. The sender first encodes the message in a certain set of symbols before the symbols are decoded by the receiver ("appropriated"). Only once the receiver has decoded the transmitted message may any effects of the message occur. Crucial to this idea of encoding and decoding is the assumption that these processes are shaped by the sender's and receiver's respective meaning structures. As these meaning structures are shaped by the social environment and the communication processes, the sender's and receiver's meaning structures may be quite different. Consequently, the meaning of a message could be altered during this process of transmission.

Hall (1980) describes the following three types of alteration ("readings") during the communication process. First, in the *dominant/hegemonic reading*, the sender's and receiver's meaning structures are similar enough that the message's intended meaning is retained, i.e., the receiver decodes the message in the same sense as it was encoded by the sender. When the receiver decodes the message in the opposite way to the sender's intentions, this is called *oppositional reading*. Finally, *negotiated reading* is intermediate between dominant and oppositional reading, whereby the receiver in general decodes the message in the overall intended sense but makes certain alterations.

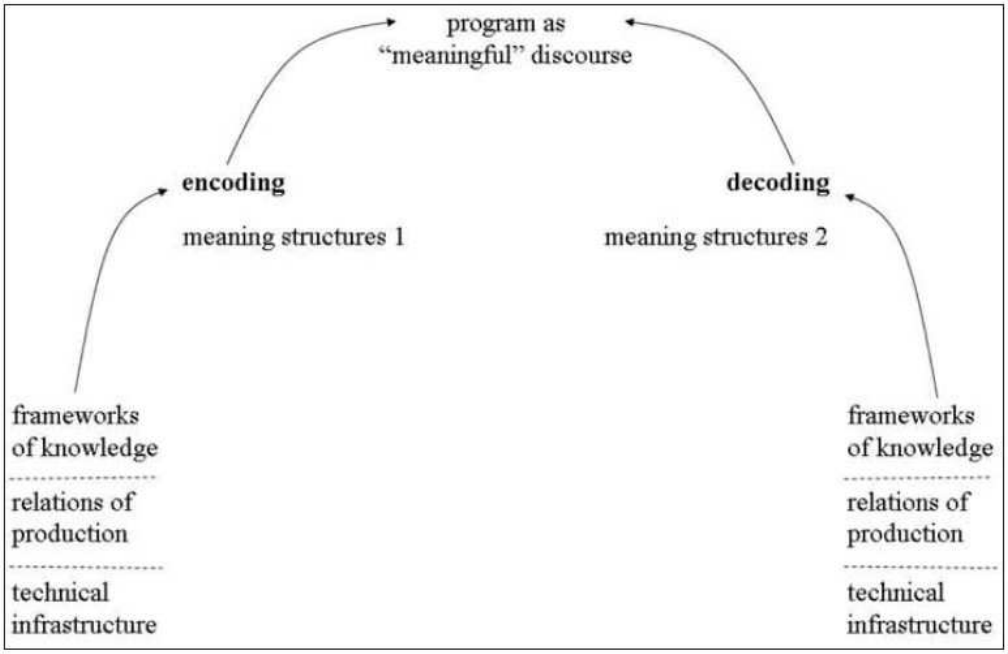


Figure 1: Encoding/Decoding Model (Hall, 2003, p. 168).

Silverstone and Haddon's (1996) Domestication Approach widens this concept of appropriation used in Cultural Studies by adapting it to the adoption of new information and communication technologies in the household (see also Lehtonen, 2003; Oksman & Turtiainen, 2004; Quandt & von Pape, 2010). The authors develop a dynamic concept of appropriation. In a first dimension, called *Commodification*, the potential user gains a first impression of the innovation based on the input from advertising, mass media, and other users. The second dimension, *Appropriation* itself, contains a spatial and a temporal aspect. Objectification is spatial appropriation; thus, the object must be placed in the user's apartment. Incorporation, on the other hand, deals with the temporal integration of an innovation in the user's habits. The third dimension, *Conversion*, is about the user's self-expression based on the innovation.
As with the concept of Re-Invention, Cultural Studies point out that an innovation doesn't necessarily have to be understood and "appropriated" by the adopter in the way intended by the developer. Rather, each adopter has a unique style of appropriating a certain innovation, depending on the second point brought up Cultural Studies: the negotiation of meaning. According to Hall's (1980) idea regarding "meaning structures" shaping the individual appropriation process, the adopter's communication with his or her social environment (i.e., metacommunication about the innovation) affects the way in which the adopter implements the innovation (see also Frissen, 2000; Ling, Nilsen & Granhaug, 1999; Silverstone & Haddon, 1996).

Social learning theory

Research into diffusion at the implementation stage involves analysis of the spread of certain forms of behavior. Social Learning Theory is based on the idea of vicarious learning (i.e., adopting certain forms of behavior) by observing modeled behavior supported by different motivational aspects. Bandura (1977) describes four sub-processes of observational learning (see Figure 1):

1. Attentional processes manage the selection of modeled events. This process is influenced by salience, affective valence, complexity, prevalence, accessibility, and

the functional value of the modeled event, as well as by the observer's perceptual set, cognitive capabilities, cognitive preconceptions, arousal level, and acquired preferences (see Bandura, 1977, 1986).

2. The retention of modeled events is the second precondition for observational learning. Thus, the observer must transform the modeled events into cognitive structures by the use of symbols. In this way, the retention is facilitated by repeated observation of a modeled event (see Bandura, 1977, 1986).
3. Production processes are concerned with the transfer from cognitive structures to behavior. In this context, Bandura emphasizes that the individual can rearrange the learned behavioral elements, thereby creating new behavioral patterns:
"When exposed to models who differ in their styles of thinking and behavior, observers rarely pattern their behavior exclusively after a single source, nor do they adopt all the attributes even of preferred models. Rather, observers combine various aspects of different models into new amalgams that differ from the individual sources" (Bandura, 1986, p. 104).
4. Motivational processes control which observed events are imitated. These motivational aspects may be external or vicarious incentives. The individual may also reward him/herself (self-incentives) by anticipating positive outcomes arising from the behavior in question (see Bandura, 1977, 1986).

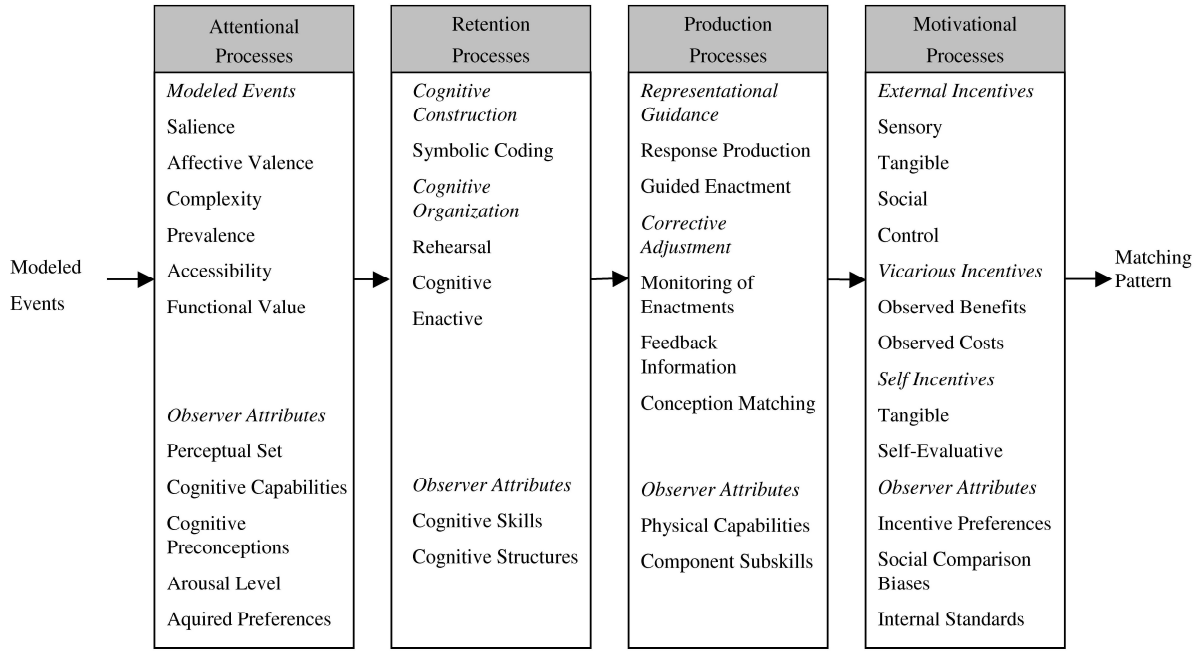


Figure 2: Four Sub-processes of Observational Learning (Bandura, 2001, p. 273).

According to Bandura (1986), the modeled events may be either observed in the direct surroundings of an individual or in the mass media, without any basic difference in the resulting effects. Observation in the mass media is termed "symbolic modeling." Although Bandura (1986) doesn't define the term "media", it can be argued that he acts on the assumption of mass media, as he defines symbolic models by their transmission to a large number of recipients: "it can transmit simultaneously knowledge of wide applicability to vast numbers of people through the medium of symbolic models" (Bandura, 1986, p. 47).

Consequently, Social Learning Theory could add different aspects to Diffusion of Innovations Theory. First, it agrees with Cultural Studies regarding the importance of the cultural environment in the implementation stage. Second, it adds the dimension of mass communication as a source of modeled behavior. Rogers himself argues that imitation of modeled behavior is a central process in diffusion: This interdependence on the experience of near peers suggests that the heart of the diffusion process consists of the modeling and imitation by potential adopters by their network partners who have previously adopted. Diffusion is a very social process that involves interpersonal communication relationships (Rogers, 2003, p. 19).
This implicit connection to Social Learning Theory is picked up by Bandura (2006) himself, who also argues that symbolic modeling is a core process of diffusion (Bandura, 2006, p. 125) and refers to the creative side of the adopter in the diffusion process:

> Creativeness rarely springs entirely from individual inventiveness. Indeed, Selective modeling is often the mother of invention. People adopt the modeled beneficial elements, improve upon them, synthesize them into new forms, and tailor them to their particular circumstances. (Bandura, 2006, p. 117)

Consequently, Bandura uses the term *social diffusion* rather than diffusion. Although these acknowledgments were widely used in establishing edutainment TV and radio serials supporting healthy lifestyles in developing countries (see Rogers, Vaughan, Swalehe, Rao, Svenkerud & Sood, 1999; Singhal, Cody, Rogers & Sabido, 2004; Vaughan & Rogers, 2000), the influence of modeling (interpersonal and via mass media) on the diffusion of media innovations is generally overlooked.

MPA model

The Mobile Phone Appropriation Model (MPA model) (Wirth, von Pape & Karnowski, 2008) deals with the question of how mobile phones are integrated into the user's daily routine. The model was developed on the basis of adoption and diffusion research (e.g., Diffusion of Innovations Theory, Rogers, 2003; Theory of Planned Behavior, Ajzen, 2005; Technology Acceptance Model, Davis, 1986) as well as appropriation research (e.g., Frame Analysis, Goffman, 1974; Domestication Approach, Silverstone & Haddon, 1996; Uses-and- Gratifications Approach, Katz, Blumler & Gurevitch, 1974). It can be understood as an extension of the model applied in Theory of Planned Behavior (Ajzen, 2005), which differentiates the TPB model's structure in order to grasp the various forms of appropriation (see Figure 2; for a detailed description see Wirth, von Pape & Karnowski, 2008):

1. The model considers appropriation to be a creative and active process, ending up in individual usage and meaning patterns. Thus, behavior is differentiated into its object-related and functional aspects. The object-related aspects include fashion aspects (e.g., ring tones and accessories), handling aspects, and the general usage frequency of different functionalities such as telephony, text messaging, and online services. The functional aspects represent the large variety of uses of the mobile telephone known from appropriation research and the Uses-and-Gratifications Approach (e.g., the management of daily life, maintaining relations; see Höflich & Rössler, 2001; Leung & Wei, 2000), with an emphasis on the symbolic dimension (e.g., status; see Leung & Wei, 2000) of this process.
2. The model takes into account the symbolic value of the object mobile telephone and its usage.
3. The model no longer takes TPB's independent variables of behavioral beliefs, normative beliefs, and control beliefs to be static; instead, they are understood as the constantly evolving results of the appropriation process (Jonas & Doll, 1996;

Kendzierski, 1990). Consequently, the model is conceptualized as a cycle, with appropriation being a constantly renewed process. Pragmatic and symbolic use is not only the result of behavioral, normative, and control beliefs, but also their basis (Ouellette & Wood, 1998).

4. The model comprises the impact of communication on the appropriation process: meta-communication. Thus, behavioral, normative, and control beliefs, as well as symbolical and practical behavior, are negotiated via communication among users, producers, and mass media, be it mass communication, personal influences, or the simple demonstration and observation of one's mobile phone use.

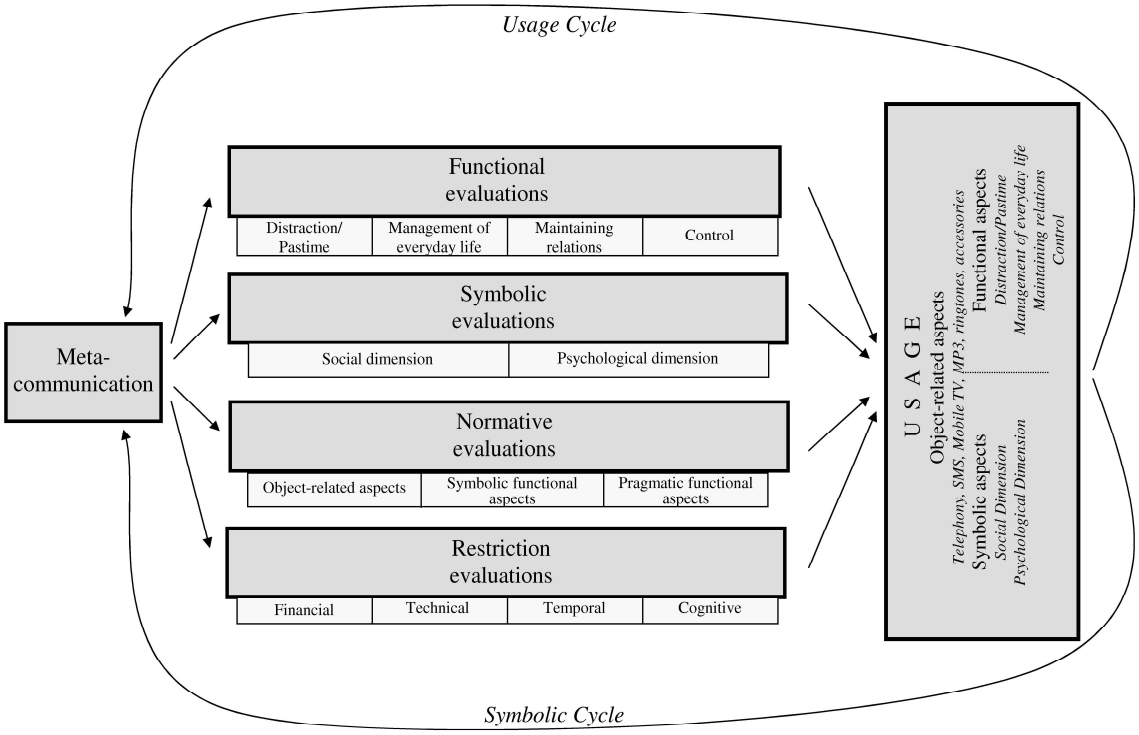


Figure 3: The MPA Model (Wirth et al., 2008, p. 606).

Similar to Cultural Studies and Social Learning Theory, the MPA model highlights the importance of taking into account both meta-communication and the user's creative input in the diffusion process. Although the MPA model was developed and empirically tested (von Pape, Karnowski & Wirth, 2008) to explain the appropriation of mobile phones, it has also proved successful in explaining the appropriation of other recent media innovations (Karnowski & von Pape, 2009; von Pape, Karnowski, Wirth, Klimmt & Hartmann, 2007).

Conclusion

There exists ample empirical evidence of the changing of innovations during the diffusion process; indeed, such change appears to be becoming an increasingly common phenomenon in the age of digital, interactive, and mobile technologies. The French sociologist Gabriel de Tarde, forefather of Diffusion of Innovations Theory, described this phenomenon using the metaphor of waves changing their shape while spreading from their origin.

Nevertheless, this phenomenon has largely been neglected in Diffusion of Innovations Theory. From the seminal study undertaken by Ryan and Gross (1943) regarding the diffusion of hybrid seed corn, through the subsequent editions of *Diffusion of Innovations* (Rogers, 1962, 1983, 1995, 2003; Rogers & Shoemaker, 1972), the qualitative evolution of innovations has rarely been the focus of interest.

Only during the 1970s did the concept of Re-Invention (e.g., Charters & Pellegrin, 1973; Glick & Hays, 1991; Goodman & Steckler, 1989) enter the field of Diffusion of Innovations Theory, analyzing the circumstances leading to a change in the innovation during the diffusion process. However, until today, these ideas have not led to a change in the theoretical basis of diffusion theory, which remained attached to a linear process, based on the binary logic of adoption versus rejection. As we argued above, this lack of theoretical progress is due in part to the transmission model of communication, which remains fundamental to diffusion theory today. Consequently, the way of overcoming this limitation lies in following theoretical approaches from outside Diffusion of Innovations Theory, which are based on a less linear understanding of communication. In outlining the central ideas of Cultural Studies (Hall, 1980; Silverstone & Haddon, 1996), Social Learning Theory (Bandura, 1977), and the Mobile Phone Appropriation Model (Wirth, von Pape & Karnowski, 2008), we elaborated upon two ideas that are crucial for a broader concept of adoption.

First, the creativeness of adopters during the diffusion process must be taken into account. This point is illustrated by the idea of negotiating meaning during this process, taken from Cultural Studies. In addition, Social Learning Theory conceptualizes the imitation of modeled behavior as a creative act, tailoring the imitation of the modeled behavior to the specific circumstances. The MPA model models this idea and differentiates the original binary decision (adoption versus rejection) to a variety of possible forms of actually using an innovation, thereby addressing Rogers' (2003, p. 181) suggestion to investigate "adoption at the implementation stage, as change that has really happened."

Second, this user creativity in the diffusion process is powered by meta-communication. Here, Cultural Studies emphasizes the importance of communication between either different potential adopters or adopters and inventors: the negotiation of meaning. Social Learning Theory focuses mainly on the effects of observing and imitating during the diffusion of a certain form of behavior, although also taking communication into account, e.g., in the form of reinforcement. The MPA model molds meta-communication (either interpersonal or mass-mediated communication and observation) to be power the whole process. These ideas of meta-communication go along perfectly with Rogers' (2003, p. 5) definition of diffusion being a communication process: "Diffusion is the process in which an innovation is *communicated* [emphasis added] through certain channels over time among the members of a social system." Thus, meta-communication has always been at the heart of Diffusion of Innovations Theory, although few studies have incorporated the aspect of communication during the diffusion process, confirming the influence of mass and interpersonal communication on the diffusion process. Weber and Evans (2002) found a positive relationship between media coverage of a media innovation and its diffusion. The influence of interpersonal communication on the diffusion of media innovations (e.g., the Internet, cell phones, Wi-Fi services) has also been confirmed in previous studies (see Lagos, 2008; Rhee & Kim, 2004; Wei, 2001, 2006; Zhu & He, 2002).

Media innovations nowadays are highly prone to Re-Invention, according to the factors brought up by Re-Invention research in recent years. Consequently, we argue that Diffusion of Innovations Theory will gain momentum in analyzing the diffusion of recent media innovations, as well as other innovations that are highly susceptible to Re-Invention, when seeking to overcome the linear structure of the diffusion process that is inherent in the binary logic of adoption.

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