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A Review of Relevant Literature and an Exploration into Innovation and Aging

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Abstract

This paper deploys a research agenda on innovation in aging societies. It identifies an important yet under-researched question concerning the relationship between technology and aging. How is knowledge about individual and societal aging exploited in innovation processes? To approach this question, the paper reviews different bodies of literature that explore the presence and representations of users and use in innovation. The review reveals that the well-known approach to categorize innovation processes according to their source of innovation should be complemented by a second dimension – the source of use information. A two dimensional space can thus be identified in which innovation projects can be positioned. This has a number of implications for further empirical research on innovation in aging societies. In particular, the paper proposes to investigate how "the elderly user" is constructed across a variety of types of innovation projects.

Keywords

Innovation, aging society, elderly user, silver market, gerontechnology, mediation junction.

The Sources of Use-Information:
A Review of Relevant Literature and an Exploration into Innovation and Aging

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1. Introduction

In a seminal publication, Eric von Hippel was able to show that the "sources of innovation" can differ considerably across sites in the innovation process (von Hippel, 1988). Von Hippel, and the prolific body of literature his initial work spawned, has conclusively established that users as well as manufacturers actively participate in the innovation process as innovators. His work revised the then standard assumption that innovative activities only take place at the sites of manufacturers, and that selling innovations is the prime motivation for innovative activities. In a nutshell, the work of von Hippel has established that user-innovations are as common as manufacturer-innovations, and that users actively participate in the innovation process in many ways.

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This paper reviews various bodies of the literature that have explored the role of users and use in innovation processes and proposes an interpretative framework for further empirical research. In addition to von Hippel's work, it suggests that not only do the sources of innovation differ across innovation projects, but the sources of use information also vary considerably across such projects. The main thrust of the argument is built around the notion that users, use and needs are constructed along with the technical object in innovation. The paper calls for more attention to be paid to this process of constructing "the user", and, in particular, to the kinds of real and represented users that inform this process. In order to achieve this, the paper concentrates on the "writing" (Woolgar, 1991) or "encoding" (Akrich, 1995) phase of a technical object where a limited set of actors makes technical decisions before the object is adopted by a larger set of users. In particular, it systematizes the wealth of empirical studies on users in innovation along the dimensions *source of innovation* and *source of use information*. Based on this framework, an empirical agenda is sketched to investigate how knowledge about aging is influencing innovation processes.

This paper proceeds as follows. Section 2 provides a brief introduction to the empirical field of technology and aging. In particular, it illustrates a number of conceptual issues that are worth debating if, according to a prominent claim, a "new vision of a vibrant and productive aging population must be presented to technological researchers, corporations and policy makers" (Coughlin, 2006). Section 3 revisits a number of classical studies about innovation and demand. It establishes a distinction between market demand and user needs, and it summarizes different forms of learning in the diffusion phase of a technology. Section 4 reviews different bodies of recent literature that have dealt with users and use in innovation. In particular, it develops the conceptual model that underlies the work of von Hippel along four propositions, and it complements this model with insights from social science research into technological change. Section 5, then, orders these studies according to the sources of innovation and use information and proposes to look more closely into the types of users and user involvement that account for the construction of "the user". Finally, Section 6 develops an empirical agenda. In particular, it works out a set of empirical questions that constitute a research agenda on "Innovation and Aging".

2. Technology and Aging – A Brief Introduction

This section summarizes a particular area of research that investigates how technology, i.e. newly developed technical objects and technology-based services, affect aging. It is the purpose of this section to point out a number of issues that challenge our understanding of the innovation process in general. The overall thread of the research area labeled Gerontechnology (Graafmans et al., 1998) or Gerotechnology (Burdick and Kwon, 2004) is to explore the impact of technology on the quality of older adults' lives and the process of individual aging. Wahl and Mollenkopf (2003) have provided an overview of different approaches within the field of Gerontechnology. They argue that at the general level all these approaches conceptualize technology and human development (aging) as an interactional relationship "placing the person and his or her environment (including technological devices) in a dynamic and reciprocal interchange system" (p. 234). At the heart of this approach are thus person-environment dynamics.

However, there are many ways to operationalize this perspective, and, indeed, many such ways have been elaborated, usually from the perspectives of single disciplines. Particularly widespread, as Wahl and Mollenkopf show, are micro-perspectives in the realm of basic research, i.e. "research based on human factors models" and "research based on information processing models" (p. 235). These approaches have in common the fact that they "place strong emphasis on the role of age-related decrements in perception, attention, memory, and (fluid) intelligence" (p. 234). They focus on "normal" aging, i.e. individual aging without chronic conditions and diseases. However, "normal" aging is modeled as a decline of competences that has to be compensated for. And this is exactly the role technology can have vis-à-vis individual aging – to compensate for age related deficits and shortcomings. Wheelchairs, hearing aids, walking frames and the like are good examples for such *assistive technologies* (cf. Mann, 2003).

An instance of the micro-perspective is the human factors approach described in Rogers and Fisk (2003). The basic model underlying this approach centers on the demands of a technological system (hardware interface, software interface, instructional support) vis-à-vis the capacities of individual operators or users (perceptual, cognitive, psychomotor). "The degree of fit between the demands of the system and the capabilities of the user will determine performance on the system as well as attitudes, acceptance, usage of the system, and self-efficacy beliefs about one's own capabilities to use the system." (p. 2). If there is a misfit between the demands of a system and the capacities of a user, errors are likely to occur during operations, and the usability of the system is not optimal. Especially, task analytical approaches have produced a wealth of data showing that even the most common everyday products pose severe usability problems. Against this background, the human factors approach is introduced by Rogers and Fisk as an important design factor that will help to anticipate errors and influence design and instructional support to prevent such errors.

From a sociological perspective, however, the human factors approach is not without difficulties due to a number of underlying assumptions about the relationship between technical objects and human actors:

(i) The model assumes that there is a "correct" usage of a technological system. Deviations from this use result in errors. However, as I will discuss in subsequent sections, there are always many ways to use an artifact and this may lead to numerous redefinitions of the "correct" use during use. Below I will show that artifacts indeed contain a script for a "correct" use, but that this script is often renegotiated and adapted in real use. In other words, while there might be a prescribed use for most artifacts, real use often deviates from the prescribed use. Against this background, the notion of *a* correct use of an artifact seems to be somewhat simplistic.

(ii) The model defines usability as a fit between engineers' conceptions of use and the users' actual use. In this sense, it measures the quality of an artifact in terms of how well it enforces compliance with the script it contains. Again, this seems to be a somewhat simplistic perspective that neglects the many uses human actors invent with regard to an artifact. In fact, numerous commonplace technologies, such as the telephone or the radio, would not have come into existence without creative deviations from engineers' conceptions of use. Below I introduce the notion of domestication that describes the process by which human actors "tame" technical objects to become part of their daily lives (Silverstone et al., 1992). The human factors approach simply excludes such forms of identity building from the analysis that can only be measured across many subsequent instances of artifact usage.

(iii) Finally, the model carries somewhat static notions of demand and capacities, thereby ignoring learning that takes place while demand and capacities are aligned in interaction of the system with the user. Again, one should not neglect that users build up capacities with regard to a system while they try to fulfill or alter the demands posed on them by this system. Hence, both the capacities of users and the demands of a system change when intended uses are altered and realized *over time*.

These limitations are likely to play out differently depending on whether one is compelled to use a certain artifact, or one wants to use a certain artifact. Indeed, Wahl and Mollenkopf have pointed out that there are important differences between everyday technology, i.e. products and services that populate our homes, such as classic household technology and a wide range of information and communication technologies, and assistive technology. According to Wahl and Mollenkopf, the former calls the deficit model into question and asks for a more balanced view focusing on over- as well as underdemands of technology (p. 235). In other words, technical objects in the private home may as well provide stimuli for learning precisely because they are challenging to use.[2] It is the domestication of artifacts into one's life (and the learning that comes with it) that may improve individual aging as much as overdemand may frustrate it.

This goes back to the classic idea of successful aging introduced by Baltes and Baltes (1990), which, in a nutshell, points out that individual aging is not a solely biologically determined process but a process that can be influenced. In fact, biological aging in the form of cognitive and physical decline becomes predominant only beyond the age of 80 (the so-called fourth age). As a consequence, individual aging is not only a process of developing shortcomings and deficits, but also a process in which competences and skills simply change.

On a similar note, Lawton (1998) has discussed the relationship between technology and aging along two dimensions. First, there may be an "individual lag" that opens up between the demands posed on an individual by the technical objects that surround her. Individual lag causes frustration and negative feelings, and is affected by cognitive decrements and shortcomings that come with individual aging. Secondly, there may be a "socio-structural lag" that opens up between the needs of an individual and the opportunities to fulfill these needs offered by the artifacts surrounding it. Socio-structural lag does not immediately cause negative emotions, but rather suppresses the development of positive emotions.[3] It is, therefore, less obvious than individual lag, and has, indeed, often been neglected within the field of Gerontechnology. Combining the dimensions of individual and socio-structural lag, Lawton summarizes a bi-directional view on the relationship between individual aging and technology:

> "If we can decrease individual lag we can increase function and thereby decrease negative emotional states. If we can decrease social-structural lag we can increase fun and personally fulfilling activities and thereby increase positive emotional states." (Lawton, 1998: 13)

Hence, Gerontechnology has to take into account both learning that is stimulated by "domesticating" technical objects and decrements that can be compensated for by

[2] Elsewhere, we have labeled such a perspective the *salutogenetical* approach towards senior appropriate technology (Dienel et al., 2004; Peine and Dienel, 2002).

[3] Lawton was heavily influenced by Riley's notions of individual and structural lag. Her work is based on a sociological understanding of the aging process where human development is determined by the roles society offers us over our life span. It is beyond the scope of this paper to discuss Riley's influential work, which runs up against limits of its own. A good overview, however, is provided in Riley and Riley (1994) as well as Dannefer et al. (2005).

technical objects. Most importantly, the “demands” of a technology must not only meet the capacities of older people, but the technological environment must provide sufficient learning stimuli for the “right” capacities to develop. This approach highlights the process through which the capacities of users and the demands of a technology are aligned. Additionally, it does not take “demand” as given but sees it rather as a flexible dimension to the various contexts of use in which a technology is “domesticated”.

Against this background, Figure 1 illustrates two stylized types of technical objects and their implications for the relationship between technology and aging. On both sides, technical objects and their use provide learning opportunities and contribute to identity building. They do so, however, in markedly different ways. The predominant view is depicted on the right side where assistive technologies are defined as technical objects that one has to use, i.e. in contexts where one needs to compensate for age related decrements. Health care products and services that have an “out of home” component, i.e. that are dependent on maintenance or operation by service providers, are the main area of application. Here, the human factors or usability approach is most relevant, because correct usage and easy accessibility are, indeed, of primary importance. Failing to ensure usability and correct use may result in frustration and negative emotions. Thinking about new products is based on individual lag theory, i.e. age related deficits are the basis for specifying new product characteristics. Public service providers are likely to play an important role, and, therefore, suppliers of assistive technologies have to deal with clients rather than the end users themselves. Technical objects are part of the social structure elderly people are confronted with, and this structure provides only little room for agency.

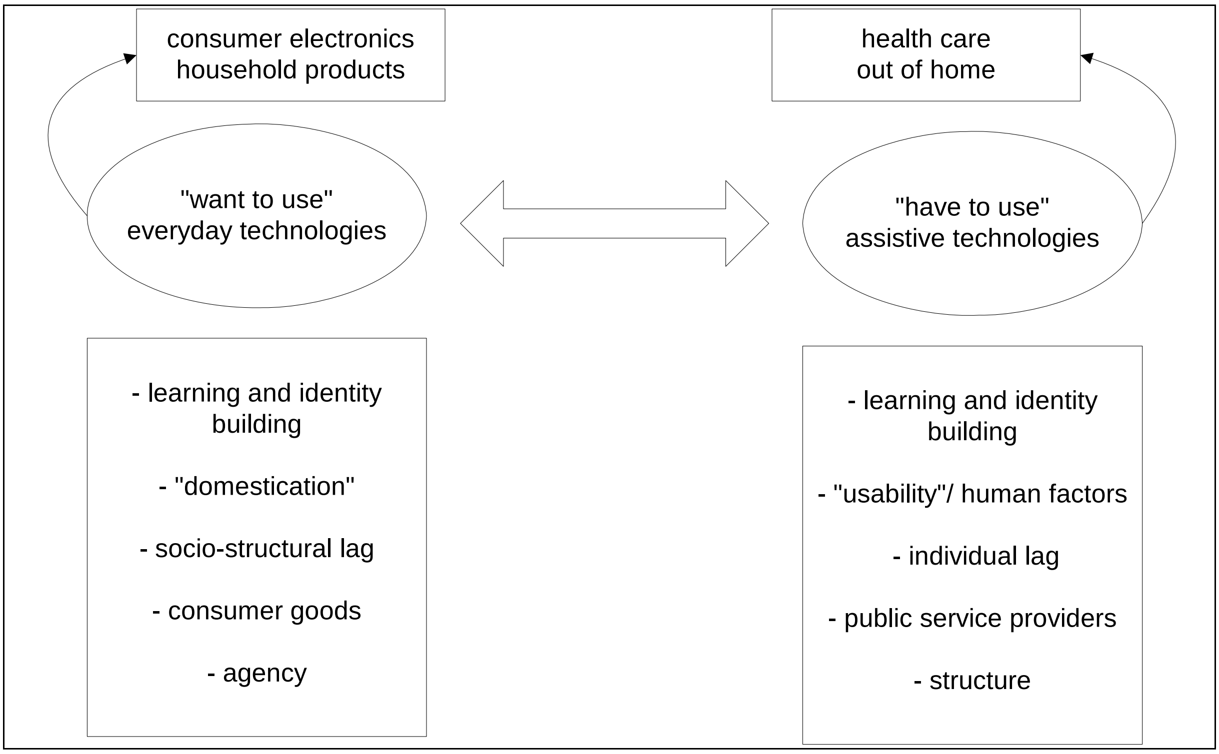

Figure 1: Technology and aging – a bi-directional perspective

On the left side, an alternative perspective is portrayed which is not fully addressed in the gerontechnological literature. Here, everyday technologies are defined as those technical objects one wants to use, and classical household products as well as new and old consumer electronics are good examples (cf. Wahl and Mollenkopf, 2003). For such products or services it is the process of creative use and domestication which is the basis for learning and identity building rather than “correct” use and easy accessibility. It is the ways through which elderly people integrate an unknown technical object into their daily life that defines this object’s effect on individual aging. Hence, thinking about new products should be based on socio-structural lag theory, i.e. the needs elderly people have vis-à-vis technical objects which contribute to personal fulfillment. Suppliers of everyday technology are likely to deal with end users directly, i.e. public service providers can be expected to play a minor role with regard to everyday technology. Technical objects open up room for agency through which elderly people manipulate the social structure in which individual aging takes place.

These types of technical objects constitute extremes on a continuum that represent two complementary views on how technology and individual aging are related. For the context of this paper, these extremes indicate a possible range of knowledge that can be exploited in new product development and that pose a range of challenges with respect to the representation of users and use in innovation projects. I develop this notion in the subsequent Sections 2-5. In Section 6, finally, I sketch out the cornerstones of a research agenda on “Innovation and Aging” that illustrate the pertinent issues for understanding how innovation processes may exploit knowledge about individual aging.

3. Early Comments on Demand, Innovation, and the Market

In neoclassical models of economic life, markets mediate between supply and demand by transmitting information on prices (and volume) between producers and buyers. In this tradition, theories of technological change and innovation typically explain the emergence of new technologies either as a result of technology-push (most prominently in the tradition of Schumpeter) or demand-pull (most prominently in the tradition of Schmookler). That is, two sorts of disequilibria account for the creation of new technologies by manufacturers – the availability of new technological opportunities, or the recognition of an unsatisfied demand. Economists in the neo-schumpetarian, evolutionary tradition have long criticized such models of technological change to show that innovation is a *process* that responds to supply and demand side factors simultaneously (just see Dosi, 1984; Nelson and Winter, 1982; Rosenberg, 1982). While it is not my intention to recapitulate this broad debate here (but see Andersen, 2007), I want to focus on two particular criticisms that have been raised with regard to demand pull models of innovation – the confusion between demand and user needs, and the inability of pure markets to communicate user needs.

A first criticism was expressed with regard to the notion of market demand itself. Most prominently, Mowery and Rosenberg (1979) reviewed a series of then frequently cited studies in support of a demand-pull model of innovation and found that these studies failed to establish an analytically sharp definition of demand in the first place. In particular, Mowery and Rosenberg organized their critique along two major points. (i) In general, all investigated studies propelled an extremely broad definition of demand that rendered the claims based on this definition virtually pointless. While the studies could show that demand is necessary for the success of an innovation, this is, of course, a tautological statement. What these studies, according to Mowery and Nelson, should have shown instead is that demand is sufficient to explain the origins and the success of an innovation. Indeed, for Mowery and Rosenberg the incorporation of both demand and supply side factors were necessary conditions for the success of an innovation. It was, therefore, essential to conceive of innovation as an iterative *process* in which supply and demand side factors are aligned (p. 143). (ii) All investigated studies confused the formally very specific notion of demand with the broadly defined concept of user needs. While Mowery and Rosenberg did not deny that market or customer needs influence the directions of innovation, "[i]t is the identification of 'needs' with 'market demand', and the dominant role in commercial innovation ascribed to this amorphous variable" (p. 130) that they criticized. In fact, as Mowery and Nelson pointed out, the relationship between recognizing needs and market demand is a rather tenuous one (p. 140).

Mowery and Rosenberg argued that, while the reviewed studies had frequently been cited in support of demand-pull models, none of them specifically dealt with demand. Rather, less strictly defined notions of "latent" or "anticipated" user needs were at play when scholars had looked into demand side factors.[4] User needs, however, are a completely different matter than market demand, mostly because they refer to a quality rather than a quantity. Lundvall (1988), in another seminal publication, more systematically explored the quantitative and qualitative information hidden behind demand and supply curves. In particular, he proposed to look at *interactive learning* that occurs between producers and users in innovation processes. For Lundvall, innovation would not be possible if pure markets separated producers and users of a technology. Indeed, he argued, pure markets, while suitable to convey quantitative information about volume and prices, fail to communicate the *quality* of demand (p. 357). In other words, markets fail to transmit the intimate information user *and* producers have and that is combined in innovation. Here, more direct relationships between economic actors are necessary in the process of innovation. Lundvall identified the *organized market* as the primary organizational form of product innovation. For him, the organized market is a "bastard form" (p. 352) that combines organization elements with market elements; the concept highlights the interdependent nature of most inter-organizational relationships that include quantitative information flows as well as qualitative information flows and direct cooperation. On real world markets, producers and users of a technology are *interdependent*, i.e. they are linked through a blend of market like, hierarchical and cooperative relationships. Through these links, firms regulate the uncertainties of innovative activities and engage in a process of interactive learning that could not be accommodated by pure market relations alone.

Of course, the implementation and diffusion phase of a technology has long been recognized as an important source of learning (cf. Georghiou et al., 1986; Leonard-Barton, 1995). In particular Arrow (1962) looked into the knowledge underlying a production function, and demonstrated that experience in producing a certain commodity can lead to a reduction of labor costs. This *learning by doing* occurs when manufacturers encounter and solve unanticipated problems of the production process (p. 156). Rosenberg (1982) identified a similar process that occurs during the use of a product. While Arrow was concerned with learning how to operate a given production

[4] For an early formal distinction between market demand and user needs see Teubal (1979). In support of Mowery and Rosenberg's argumentation, Teubal also found that need determination, i.e. the increasingly specific definition of user needs in terms of product class, performance dimensions, and features, is a process contingent on supply side factors.

process, and, indeed, has hidden much of the details of this process “behind the learning curve” (Adler and Clark, 1991), Rosenberg established an important distinction between embodied and disembodied forms of learning (Rosenberg, 1982: 124). *Learning by using*, he argued, can indeed result in an improved understanding of the optimal use of a product (disembodied learning), but it may also result in actual design modifications (embodied learning). In fact, most real world cases of learning by using will include elements of both.

Learning by using is possible when there is an initial misfit between product characteristics and its use environment that leaves room for improvements through operating experience (von Hippel and Tyre, 1995; Rosenberg, 1982).[5] This, however, assumes that there is an initial product that can be operated. Against this background, Fleck (1994) added a third form of learning, that he called *learning by trying* and that is particularly relevant for complex and systemic technologies. Doing and using, he claimed, refer to the operation of already functioning production entities. For systemic technologies, however, users often have to try to make a particular system operable (and quite often, he showed, this process would fail). The learning that takes place during these attempts often constitutes a significant source of novelty as well.

Especially the more recent empirical studies about learning by –doing, -using, or –trying have shown that these forms of learning are initially a local phenomenon (Foray, 2004). It is thus an important question to determine how these local forms of learning and the knowledge thence produced spread among a wider set of actors in the innovation process. Already Rosenberg (1982) has indicated that the results of local learning both in its embodied and disembodied forms find their ways into non-local knowledge bases.[6] Lundvall (2006) has recently argued that *learning by interacting* allows to generalize local knowledge produced by ‘doing’ or ‘using’. Frequent and diverse user-producer interactions, he claims, are crucial to transform local learning into widespread novelty embodied in new products, services, and solutions. Peine (2006) has specifically looked into learning by trying. He has argued that *field learning* is crucial in transferring local knowledge about a specific configuration of a system into general knowledge about that system. Field learning proceeds as originally one-off and local projects are clustered into fields where similar projects are repeatedly implemented.

These studies have established that pure market relations cannot account for the creation of technological novelty. Rather, innovation is a process that involves various forms of interdependent relationships and learning. In particular, such relationships link users and producers in innovation processes, and they are the channels that facilitate the diffusion of local learning. A common theme can thus be derived from these early examinations of the pure market: innovation is a process that is distributed about manufacturers and

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[5] Von Hippel and Tyre also established that, once it is understood that *producing* a good is *using* the production process,. the boundaries between doing and using become blurred. Thus, producers that learn to produce a good learn to use a process.

[6] Rosenberg described this for the aircraft industry. Disembodied forms of local learning, such as optimized maintainence procedures and cycles, influenced instruction manuals within the industry. Embodied forms of learning, such as longer fuselages made feasible by enhanced engine performance, quickly became common within the industry. Rosenberg did not go into much detail about the diffusion mechanism. However, the aircraft industry is unusual because it comprises only a few big actors. Studies of other industries, in particular Tyre and von Hippel (1997), have reminded us to look more carefully into the diffusion mechanisms.

users, and that combines information from the sites of manufacturers and users. In the following Section 4, I return to this theme in greater detail.

I shall now discuss another, less obvious implication of the studies reviewed here. At the outset of new product development, the knowledge about demand is as poorly articulated as the knowledge about the new product itself. For new products, demand is not just “out there” to be elicited, but it co-evolves with the specification of the design for a new product. Hence, the market not only fails to facilitate information transfer between users and producers in innovation processes, but a genuine market from which user information could be drawn does normally not exist for new products. Clark (1985) most prominently illustrated this point showing that, in the perception of customers, the car gradually *evolved* from the “horseless carriage” to the “roadster”, the “touring car” or the “coupe”. Such concepts of use could only evolve once basic design decisions specifying early versions of the “horseless carriage” had facilitated first customer experiences.

Hoogma and Schot (2001) have made a similar point in their critique of learning by doing and using. Within these approaches, they claim, “[u]sers are mainly perceived as knowledge providers for manufacturers, who consequently learn to make better products.” (p. 229) In essence, learning by doing or using regards users’ preferences as a static unit that can be understood. In the case of electric vehicle innovation, Hoogma and Schot demonstrate that users’ preferences were not static and that during use, users learn as much about their needs as they learn about the product itself. Moreover, users communicate with producers about these needs, and how they can be met. This “double-loop learning” (p. 229) is an important knowledge source within the innovation process. It can only be harnessed, however, when the interactions between users and producers are conducive to the exchange of intimate information. Hence, they conclude that the innovativeness of users not only depends on mere use, but also on the quality of the interactions between users and producers.

Summing up, the perspective discussed in this section presents innovation as a process in which users and producers are linked through interdependent relationships. Furthermore, the process of innovation includes various forms of learning – from the local learning at the sites of manufacturers and users, to the spread of the knowledge thus gained among other actors. In the literature on technological change and innovation, a great deal of attention has been devoted to knowledge about design and production; in contrast, knowledge about use and demand has received far less attention. Yet, it is the latter body of knowledge and its incorporation into innovation that determines the success of new technologies (Coombs et al., 2001). This brings an important general question to the fore: what are the sources of knowledge about use and users in innovation? In the following section, I review the available literature. In particular, this review unravels two important continua that allow the classification of specific innovation projects – from manufacturer to user innovation, and from real users and use to constructed users and use.

4. Approaches to Users and Use in Innovation

4.1. The Sources of Innovation: Exploring the Conceptual Model

Eric von Hippel and other scholars working in his tradition have presented a prolific body of literature that has established the notion of *user innovation*.[7] In particular, they could show that users are not only important in innovation, but that they are often the main source of innovation. In this section, I show that the "von Hippel school" not only presented a wealth of empirical material to support the notion of user innovation, but also elaborated a conceptual model of innovation. In this section, I summarize this model along the lines of four propositions underlying the empirical studies of user innovations:

(i) Economic agents in innovation can be distinguished according to the *functional relationship* they have with a technology (von Hippel, 1988). If an agent manufactures a technology to sell it, he is a manufacturer; if he uses a technology, he is a user; if he supplies input to produce a technology, he is a supplier, and so forth. While economic agents normally are manufacturers, users, or suppliers at the same time in different contexts, they only have one such functional relationship with a particular technology. The process of innovation is distributed across these classes of economic agents, and the profit motives of innovators differ according to the functional relationship they have with a technology. To illustrate this point, von Hippel primarily focused on manufacturers and users of a technology. While the former benefits from selling an innovation, the latter profits from the enhanced functionality of an innovation ("in-house profits"). For instance, in the development of scientific instruments, users may innovate to enhance the scientific value of an instrument, while manufactures may innovate because of the commercial value of a particular improvement (Riggs and von Hippel, 1994).

(ii) Von Hippel defined the source of an innovation according to the functional relationship the innovator has with the improved technology (von Hippel, 1988). Hence, the *functional sources of innovation* can vary considerably among innovation processes. In particular, von Hippel and his collaborators have conducted a wealth of empirical studies to establish that users are often the main source of innovation, both for industrial and consumer goods.[8] Hence, user innovations are defined as those innovations whose functional source is the user. While manufacturer innovations are tailored to suit a large number of potential customers, i.e. they have to have a commercial value, user innovations are suited to the particular needs of the innovator, i.e. they have to have a functional value (von Hippel, 1988: 17). However, user innovations often bear a particularly high economic value, since user innovators are often particularly knowledgeable users ahead of market trends. User innovations thus often stem from so called *lead users* (von Hippel, 1986; Urban and von Hippel, 1988).

(iii) User innovators inscribe the results of learning-by-doing or –using into equipment (von Hippel and Tyre, 1995; Tyre and von Hippel, 1997). This points to a critical aspect of the model: user innovations are, at the outset, a local phenomenon, i.e.

[7] Von Hippel (2005) presents a book-length overview on the notion of user innovation. For a concise introduction see von Hippel (2006).

[8] Note that the studies of user innovations of consumer goods have been restricted to (extreme) sports equipment and software (see Franke and Shah, 2003; Lüthje, 2004). While these are highly specific areas of technology, the meaning of user innovation for the development of mass consumer goods such as white goods, consumer electronics, etc. remains yet to be explored.

they initially constitute an adaptation of a generally available piece of equipment to a local use environment. However, because user innovations are normally of high functional value, they are normally also attractive to manufacturers and other users; this creates incentives to commercialize or simply imitate the original innovation. Indeed, manufacturers often pick up user innovations in order to commercialize them (classical: von Hippel, 1977; von Hippel and Finkelstein, 1979; Urban and von Hippel, 1988). Baldwin et al. (2006) have identified three steps that are important for the commercialization of user innovations:

Step 1: Users develop an innovation to obtain its direct use value, and develop that innovation further by freely sharing the necessary information with other users (exploration of the innovation within a user community). In this step, users reproduce other users' innovations to improve them in their own right.

Step 2: Reproducing an innovation, however, is a costly process even when the necessary information is freely available. Therefore, some users might not be willing or able to spend the time and effort themselves to reproduce an innovation, but instead might be willing to purchase the innovation from one of the original innovators. When such a demand is met, some users have turned into user-purchasers while others have become user-manufacturers. While this step can be of no significance to the commercialization of user innovations in well-established industries, it has been shown to be particularly relevant in emerging industries (Hienerth, 2006).

Step 3: Established manufacturers join the process when the time between new versions of the user innovation increases, and they perceive a version of the user innovation to be attractive enough for a large amount of customers. They can then produce this version using mass production methods to reduce variable costs. Often the market will remain segregated with user-manufacturers serving a small amount of extraordinarily demanding customers (low capital/ high variable costs), and large manufacturers serving a mass market (high capital/ low variable costs).

Even though this is a highly stylized description that still awaits further empirical testing, it explains two important mechanisms in the diffusion of user innovations. First, users often share information so that other users can replicate their original innovation. The innovation thus becomes diffused within a community of users, some of which might turn into small-scale manufacturers. This mechanism can contribute considerably to diffusing, developing, and stabilizing user innovations (Slaughter, 1993) including across "horizontal networks" without the involvement of large manufacturers (Franke and Shah, 2003; von Hippel, 2007). Secondly, large manufacturers pick up a particular version of user innovation and produce it for a large set of users who are not willing or able to reproduce the original innovation themselves.[9] The diffusion of a user innovation need not involve both steps. Either can function separately – i.e. user innovations can be diffused among users without subsequent commercialization, and

[9] Two mechanisms have been identified for both the diffusion of innovation-related information among users and between users and manufacturers: informally trading and freely revealing information. Thus, von Hippel (1987) has established that user innovators often informally trade innovation related information, and he has provided a model that explains the economic rational behind such a behavior. Moreover, Harhoff et al. (2003) as well as von Hippel and von Krogh (2006) have shown that also freely revealing the details of an innovation can be economically rationale, and indeed is a widespread phenomenon. Note the difference between informally trading information and freely revealing it: the former excludes non-traders from the access to proprietary information, i.e. it is based on reciprocal relationships. The latter turns proprietary information into a public good by making it available to the whole user community.

user innovations can be commercialized by large manufacturers without prior improvements within the user community. The latter is normally the case when firms apply the lead user method (Franke et al., 2006; Herstatt and von Hippel, 1992) or innovation toolkits (Franke and von Hippel, 2003; von Hippel and Katz, 2002; Thomke, 2006) to tap into user information.

(iv) Two types of information are important in any innovation process – use information and solution information. These types of information are "sticky", i.e. they can not be normally transferred from site to site at reasonable costs (von Hippel, 1994). In real world innovation processes, use and solution information is asymmetrically distributed among manufacturers and users. Indeed, this is the reason why manufacturers are often unable to satisfy user needs and one of the reasons why users innovate themselves. Hence, real world innovation processes often progress through a series of iterative steps where tentative versions of an artifact are transmitted back and forth between user and manufacturer sites (von Hippel, 1994). The user innovation model stresses that users derive their particular strength as a source of innovation from intimate knowledge about the local use environment (cf. Lüthje et al., 2005; Slaughter, 1993). Ultimately, however, each innovation has to align local use information with generic solution information. In particular, von Hippel (1994) points out that, while these bodies of information can be concentrated solely at manufacturer or user sites respectively, they are normally distributed over both of these sites. Hence, innovation processes normally involve some sort of interaction between users and manufacturers to align local use and generic solution information.

In this model, however, it has remained surprisingly ambiguous what actually constitutes an innovation. In particular, the model does not conclusively determine what distinguishes the fiddling at the site of implementation, i.e. a somewhat minor adaptation of a general solution, from an innovation that indeed bears a considerable economic benefit. This problem is especially evident in Slaughter (1993) where minor adaptations of stressed-skin panels were more or less spontaneously realized on construction sites by construction companies.[10] Slaughter reported that, while less than a third of these user innovations was commercialized by manufacturers, all of them diffused into the repertoire of techniques construction companies regularly employed to deal with the peculiarities of specific projects. Indeed, the original innovations spread in a way that generated a particular division of labor between manufacturers and users: the users accumulated a great deal of knowledge about how to adapt stressed-skin panels to local particularities, and the manufacturers were content with this situation and continued to provide generic solutions. That is, they refrained from commercializing the local knowledge of users, even though this knowledge was available to them. Slaughter indicated that this created a host of inefficiencies in terms of the collective learning about stressed-skin panels. "[W]hen learning and innovation are concentrated on immediate problem-solving, there is little opportunity to connect the discrete innovations to overall system changes." (p. 92)

Slaughter's study has pointed to a number of critical elements in the user innovation model, in particular with regard to the link of learning-by-using to commercially attractive innovations. While most of the work in the tradition of von Hippel has

[10] Slaughter (1993) looked into a range of construction projects employing stressed-skin panels, provided a broad definition of innovation as "anything new actually used in a project" (p. 85), and identified 34 such innovations, 28 of which she recognized as user innovations.

stressed that user innovations are commercially attractive because of the intimate use information they embody, Slaughter underlined that use information can also be too local to be commercially attractive. Manufacturers then interpret user innovations as "custom orders" that are not worth further pursuit (p. 91). The distinction between local fiddling and innovation represents an important threshold: while user innovation must embody intimate local knowledge, it also has to imply a promise that more general product characteristics will be improved.[11] The fine line between local learning and innovation, therefore, seems to be determined by the existence of cumulative learning that involves both use and non-custom manufacturing. So far, this fine line has remained somewhat blurred in the body of the literature discussed here.

4.2. Constructing Users and Use: The Semiotic Approach and Beyond

Von Hippel's work has clearly provided great insights into the sources of innovation. At the same time, however, this body of literature has downplayed a second dimension – the sources of use information across types of innovations. Not all innovations stem from users, but all innovations process use information of some kind. For these latter cases, numerous other sources of use information exist, and the conceptual model of von Hippel does not offer an answer to the question of how learning takes place in relationship to those sources. Hence, as a negative to the cases presented by von Hippel, it is possible to conceive of innovations that are to a large degree conceptualized at the manufacturer site. What we learn from von Hippel is that these "manufacturer" innovations also incorporate use information. However, how such use information is derived, i.e. where the sources of use information are located is more difficult to answer.

In this respect, Woolgar (1991) proposed to explore the metaphor of a machine as text. The strength of this metaphor, he argued, is that it allows for the distinction between the writing (construction) of a machine, and its subsequent reading (use). Just like a text, a machine, by virtue of being written in a particular way, suggests a certain reading. Interpretative flexibility is thus limited to the extent that not all interpretations of a machine are possible or even equally probable. Rather, certain kinds of usage are encouraged by the way a machine is written, while others are rendered difficult or impossible. In this sense, a machine, just like a text, mediates between its writers and readers. The essential point Woolgar derives from the analogy is that a user is socially constructed during the writing (construction) of the machine. This social construct is subsequently inscribed into the machine, so that certain types of actions are readily available to users. In this way, "the evolving machine effectively attempts to *configure* the user" (p. 61).

Woolgar investigated this process of configuring the user through an ethnographic field study in a medium-sized company. In particular, he analyzed a project for the design of a new microcomputer. For this project, he demonstrated how "the user" (singular) was constructed from multiple conceptions of users and uses (plural) that were present in the discussions among the different departments involved in the project. Woolgar showed that this construction of a user took place completely within the company. Subsequently, the company conducted a series of usability trials to evaluate if the machine together with its manual would indeed lead real users to the "correct" use of the machine. Hence, the metaphor of the machine as a text reveals how "the user"

[11] In open source software development this intricate balance seems to be represented by the decision to include a particular innovation into the "official version" of the software. The subject is one of striking the balance between the local and the global.

was co-constructed with the machine. Subsequent efforts within the company were dedicated to ensure that the machine would indeed configure real users in a way congruent with the user previously constructed. In Woolgar's case study, the company not only constructed a user, but it also dedicated a considerable amount of effort to design the machine in such a way to configure real users accordingly.

To capture the influence a technical object exerts on the relationships users can entertain with it, Akrich (1992) coined the term "script".[12] Even though she distanced herself from Woolgar's content analytical perspective (p. 208), her definition of a script offers a useful perspective on the writing of technical objects. It is designers and innovators that *inscribe* in a technical object a vision of future users, uses, and relations between them. "Thus, like a film script, technical objects define a framework of action together with the actors and the space in which they are supposed to act." (p. 208) In contrast to Woolgar, however, her analysis focuses more on the interplay between the designers' projected users and real users, i.e. "between *the world inscribed in the object* and *the world described by its displacement*" (p. 209). According to Akrich, technical objects become real only through the actual users, uses, and networks they describe, and it is, therefore, the adjustment between projected and real users that determines the fate of a technical object. Notabene, real users may not subscribe to the script presented to them, and they may even try to renegotiate the original script, i.e. choose for de-inscription rather then subscription (Akrich and Latour, 1992).

These original works have spawned a body of literature that has come to be known as the "semiotic approach to users", because it extends semiotics from the analysis of signs to things (Bijker, 1995; Oudshoorn and Pinch, 2003: 7). A number of recent studies have refined the general perspective outlined in the work of Woolgar and Akrich to reveal some details of construction and inscription work. Hyysalo (2006a), for instance, explored a project that developed a safety device for the elderly ("Wristcare"), and he investigated how multiple technological and other professional traditions informed the configuration of future use within that project. In particular, he found that *direct* representations of use, i.e. representations of use that stemmed from an explicit deliberation about users and use, were supplemented and enriched by *implicit* representations, i.e. representations of use implicit in the "models of conducting design, routinized procedures, and the messy interactions between people and materials" (p. 620). In other words, designers not only rely on explicit stories and assumptions about use, but also on implicit representations of use deeply embedded in their particular design tradition. To be sure, Hyysalo was also able to show that many real users did not subscribe to these representations, and that the Wristcare device underwent substantial adjustments after being distributed among real users (Hyysalo, 2006b). However, this took place only after an initial period of several years where the basic design decisions were implemented without any investigation of real users and use.

On a similar note, Oudshoorn et al. (2004), employing a semiotic approach, analyzed the shift of user representations in two projects for the development of Digital Cities. They showed that constructing users is a path dependent process shaped by the

[12] In fact, taking an actor-network-theoretical perspective, Akrich explored "the extent to which the composition of a technical object constrains actants in the way they relate both to the object and to one another" (Akrich, 1992: 206). That is, Akrich was not only interested in how technical objects configure use of individual users (the relationship of these users with the object), but also in their participation "in building heterogeneous networks that bring together actants of all types and sizes, whether human or nonhuman" (ibid.: 206).

technological traditions in which it is embedded. In particular, Oudshoorn et al. explored how the projects turned the original aim of designing systems "for everybody" into a strong orientation towards technological sophistication and innovativeness. This shift, they argued, "can be largely ascribed to the use of *implicit representation* techniques [emphasis A.P.]" (p. 41) employed by designers so that "designing for everybody" was gradually replaced by "designing for oneself". In other words, designers were taking their own preferences, tastes and skills as representative for users in general, something which Akrich has earlier referred to as "I-methodology" (Akrich, 1995). Oudshoorn et al. illustrated this by showing how the gender bias of Information and Communication Technologies (ICT) was passed on to the investigated project that simply inherited the "strong male connotations" (p. 53) of their core technologies. Designers, through their predominantly male gender identity, were important agents of this inheritance.

A most interesting aspect about this work is that the authors compared (technologically similar) projects from the public and the private sector. While macro-sociological explanations for the non-involvement of users, i.e. non-disclosure due to confidentiality, and the speed of production cycles, suggest that public sector projects would be more prone to an accurate and explicit investigation of users and use, the semiotic approach puts this hypothesis into question. Indeed, the public sector project investigated by Oudshoorn et al. indicates that public sector projects might actually be more inclined to neglect real users and explicit modes of user investigation. In public sector projects, after all, the relationship between supplier and end-users often is mediated by public organizations that commission the projects. In such a constellation, the construction of use becomes a political process that is likely to exclude explicit and implicit representations of use in favor of more immediate political interests of the client.

A general point made here is that users and clients do not usually coincide nor are they necessarily individuals. MacKay et al. (2000) provided a survey of different typologies that show the various facets of significance users, clients or both can have vis-à-vis design processes. These facets include notions of clients vs. end users, individual vs. organizational users, right users vs. skilled users, end users vs. maintenance users, and so forth (p. 738-739). MacKay et al. argue that the notion of the user is primarily a "boundary label to delineate developers from others" (p. 739). Designers employ this label to reduce the complexity of real world use outside their departments. Indeed, boundaries between developers and non-developers are constantly negotiated both within complex organizations and between developers and users. Hence, MacKay et al. argue the power of designers to configure users "is far more circumscribed than suggested by Woolgar's work" (p. 741), and they make a case for a bi-directional view on the configuration process, where designers configure users and users configure designers, too. However, MacKay et al. investigated a case where developers and users are within the same organization where they frequently interacted during the whole design process.

Rose (2001) indicated that the social construction of users and their needs is not a process confined to single organizations, but often involves a larger set of relevant social groups (see also Limonard and Koning, 2005). In particular, he argues, users are often represented by others, and needs are frequently articulated by others than the end users. There is, however, a common weakness in the studies provided by MacKay at al. and Rose with regard to the level of aggregation. While Woolgar (i) explicitly distinguished between subsequent processes of writing and reading, (ii) delimited the scope of his approach to cases where such a distinction can justly be made, and (iii) defined the construction of users as being confined to the writing process, MacKay et al. as well as Rose deployed a considerably higher level of aggregation. In fact, they looked into the complete process of writing and reading an artifact. Given the original work of Woolgar and Akrich, it comes as no surprise that the combined writing and reading process justifies a bi-directional and distributed perspective on user-producer relations. It remains unclear, however, where the analytical gains of such an account are to be found.[13]

A recurrent theme in the works of the semiotic tradition is that new artifacts often go through a lengthy process of constructions where technical decisions are made within the boundaries of manufacturing firms. Notably, this process includes the construction of users and use along with the artifact, so that artifacts contain a script that pre-structures or "configures" the interactions real users can subsequently entertain with the technical artifact. One way to read studies within the semiotic tradition is simply to conceive of them as empirical evidence for an initial absence of real users in the design of new products. In this sense, studies in the semiotic tradition complement the conceptual model of user innovation – manufacturers often pursue a great deal of innovative work in isolation, before offering relatively advanced versions of the innovation to real users. Of course, this resembles what von Hippel has called manufacturer innovation. It adds to this notion, however, a detailed picture of how use information is created without active involvement of users, i.e. how use information is generated in manufacturer innovation.

In contrast to other approaches within the "broad church" known as the Social Shaping of Technology (Williams and Edge, 1996) where technical objects are often treated as "endlessly malleable and freely interpretable by groups of actors" (Disco and Meulen, 1998: 4), the semiotic approach underpins the structuring of real uses by constructed uses (see in particular Grint and Woolgar, 1997: 65-69), and highlights the importance of aligning constructed and real users. This, in turn, is particularly relevant when studying the sources of use information, for use information may, at least initially, be constructed solely within manufacturing firms. Determining how far this phenomenon of manufacturer innovation is more or less relevant than the phenomenon of user innovation is beyond the scope of this paper. However, it remains an important analytical category that use information may be constructed without any involvement of real users. That is, there are important categories of agents in the innovation process not covered in the work of von Hippel – the constructed user, the represented user, and the configured user.

[13] In particular, MacKay at al. do not take Woolgar's distinction between socially constructing and configuring the user into account. Woolgar's precise argument is that *machines* configure real users through the social construct of the user that is inscribed into them. This implies that Woolgar's work concentrates on cases where technical objects are the primary mediator between users and producers (Woolgar, 1991: 60). Against this background, MacKay et al.'s account of designers configured by users seems somewhat misleading. Designers may indeed be constrained in many ways, but MacKay et al. fail to specify how they are actually configured in a Woolgarian sense.

4.3. User Involvement: Generating a Range of Indirect to Direct Representations

The semiotic view on product design is empirically supported by studies of Information and Communication Technologies. For instance, Iivari (2006a: 55) has pointed out that studies on Human Computer Interactions "have produced prescriptions granting legitimacy" to the semiotic view on product development. However, another set of studies in ICT industries, originally associated with the names of Leslie Haddon, Alan Cawson, and Ian Miles, adds some refinement to the semiotic perspective. Conducted over a period of roughly 15 years, these studies sketch out a development where active forms of user involvement have gradually complemented a purely semiotic concern for the user. Indeed, for early ICT projects these studies confirmed a semiotic perspective, and looked closely into the sources from which project managers and designers constructed the user (Cawson et al., 1995; Miles et al., 1992; Silverstone and Haddon, 1996). In fact, they sketched a picture in which stories exchanged within and between firms, as well as personal experiences, were the main source of use information. While these studies brought to light a sweeping exclusion of real users from design processes, they also highlighted that only in rare instances do single firms construct users in isolation. In particular for new product development, the studies conducted by Haddon and his colleagues suggest that the construction of users and use takes place in networks of manufacturing firms.

The exploration of latter projects revealed that more systematic attempts to involve users have gained ground among firms in ICT industries. Especially among large ICT firms, formal procedures of consumer research are now commonplace within design units. However, their impact on design decisions and processes has remained limited in many cases (see chapters of Limonard and de Koning, Sarkkinen, and Joshi in Haddon et al., 2005; Haddon and Paul, 2001). Haddon (2002) has identified a number of reasons for this: ICT firms usually have a strong technological focus, they tend to measure success merely in terms of market shares, and they are inclined to take the consideration of general ergonomic principles "as sufficient to meet anything the user might want from the innovation" (p. 159). These specific barriers are, according to Haddon, fueled by a general predisposition among ICT designers and product managers to think of themselves as being representative of future users. Hence, even in firms that employ social scientists and specialized units to explore users and use, these units have considerable difficulties in actually influencing design decisions (see also Mallard, 2005; Rein, 2004).

In summary, these studies indicate that while there has been a clear growth in the commitment to user involvement among ICT companies the effects of this commitment have hitherto been limited. From an organization theory point of view this, of course, resembles the well-known theme of formal structures as myth and ceremony (Meyer and Rowan, 1977) – the challenge of user involvement is celebrated in a variety of institutional forms, such as marketing departments, multidisciplinary teams, social science research units, a company commitment to ergonomic principles, and so forth. Their actual effect on the activity structure of product design, however, remains an issue for empirical observation. Indeed, as Haddon et al. (2005: 10) have recently pointed out, "radically innovative thinking about possible ICTs often comes from designers who are able to conceive almost limitless possibilities in the far future". Against this background, the diagnosis that explicit methods of user exploration have gained great legitimacy over the past years is not sufficient to establish that these methods have also significantly altered design practices. In fact, it is this very relation between formal methods of user exploration and design practices itself that still awaits further inquiry.

5. Sources of Use Information and Forms of User Involvement: An Interpretation

The review of empirical studies sketches a picture where the user innovation model and the semiotic perspective on product development mark two extremes of a continuum. On one side of the continuum we find users that actively innovate and on the other side we find manufacturers that innovate without the involvement of users. Both sides of this continuum may imply very different types of innovation ranging from minor modifications of existing products to the development of completely new products. Hence, the sources of innovation can indeed vary greatly depending on the specific case one looks at. But so can the sources of use information across types of innovation. Manufacturer innovators might try to tap into the knowledge of real users, but they might also rely completely on in-house knowledge about users and use. Therefore, the studies reviewed above suggest that innovation projects can be categorized along two dimensions: the source of innovation and the source of use information. Table 1 illustrates the two dimensional space thus spanned, and maps the approaches discussed in Section 4 within that space. Real world innovation processes combine, exchange, and alter these sources in various ways over time. However, it is the purpose of this section to arrange the studies reviewed above into an interpretative framework for further empirical investigation.

Table 1 shows the two extremes in the top left and the bottom right box. Here, the source of innovation and use information are identical. User innovations as described by von Hippel and his colleagues, and the cases explored in the semiotic tradition represent these boxes. However, the studies reviewed above also indicate that for innovations the sources of innovation and use information often are not identical. This is especially true for manufacturer innovations where research has identified a whole range of forms of implicit, indirect, and direct user representations. Hence, the manufacturer column of Table 1 deserves further discussion, in particular with respect to the types of involvement of real and represented users.

Functional Source of Innovation

Source of Use Information	Users	Manufacturers
Users	User Innovations *Interactive Learning*	Marketing Research Usability Engineering Domestication *Indirect Representation* *Direct Representation* *User Participation*
Manufacturers	Non-Users Custom Orders	Configuration of Users I-methodology *Non-representation* *Implicit representation*

Table 1: Users in innovation processes and related approaches in the literature

Before, however, the bottom left box in Table 1 needs further clarification. Here, we find the case where users are the source of innovation, but manufacturers remain the source of use information. At first sight, this seems odd. After all, if users are the source of innovation, they build on their own "sticky" use information. However, the source of use information not only refers to forms of local learning, but also to innovation processes among a larger set of actors. The bottom left box thus indicates that local learning sometimes remains local. In the literature, this has been described for cases in which certain groups are defined as non-users (Sarkkinen, 2005; Wyatt, 2003), or local learning is framed as custom orders (Slaughter, 1993). Here, users may innovate without their innovation being recognized as such. That is, the use information contained in the innovation is not tapped into or generalized through interactive learning processes. As it stands, however, this box leaves room for further discussion.

The studies reviewed in Section 4 allow for the identification of different types of real or represented user involvement in manufacturer innovations. These types provide a variety of sources of use information informing the co-construction of use and users along with the artifact. In Table 1 they are depicted in italics; they represent a continuum in their own right:

(i) Users are simply not involved nor represented; designers refer to their own preferences and skills as a source of use information ("I-methodology"), or they infer use information from stories circulating within their professional networks (Akrich, 1995; Miles et al., 1992). This resembles the semiotic perspective in the purest possible way. I shall refer to this as *non-representation*, because any systematic investigation of users and use is absent. It remains questionable, though, whether non-representation can be singled out in real world innovation projects. The boundaries are particularly blurred between this and the next type of user involvement below.

(ii) Technical traditions can be a vital source for producing images of prospective use (Hyysalo, 2006a). These traditions contain passed down traces of use information based on earlier experiences from related fields.[14] Oudshoorn et al.'s (2004) case is a good example of this: they identified designers as an important vessel of ICT's gender bias spreading to other fields. In accordance with Hyysalo, I shall refer to this form of user involvement as *implicit representation*. There is no conscious representation of users or use, but traces of earlier attempts to do so inform the construction of users and use.

(iii) Experts can represent users. These representations can be based on expertise about users and use in general. In fact, as Haddon (2002) has pointed out, this is a widespread phenomenon when usability experts enrich a design process with basic principles of ergonomics. In such cases, it is generalized knowledge about users and use that serves as a source of use information. The generalized knowledge might be adopted within a specific innovation project; however, it is not based on empirical investigations of users and use with respect to that particular project. I shall, therefore, refer to this type of user involvement as *indirect representation.*

(iv) However, experts can not only represent users, but they can also mediate between real users and the design process. In this case, their representation of use is based on an empirical investigation of users and use in the context of a specific innovation project,

[14] In principle, of course, how these traditions have been informed about users and use remains a question to be studied . While this is beyond the scope of this study, it seems appropriate to assume that here too the sources of use information can be very different.

and a conscious and specific exploration of users and use serves as a source of use information. Many forms of marketing research fall into this category. I shall refer to this type of user involvement as *direct representation*.
(v) Finally, users can actively participate in innovation projects. I shall refer to this type of user involvement as *user participation*. This type is especially important for industrial goods, where in particular Lundvall has shown the importance of interactive learning between producers and suppliers (see Section 3). However, interactive learning borders on use innovation because the locus of innovation iteratively shifts between the user and the manufacturer site (cf. von Hippel, 1994). Indeed, user participation might also imply that external users are invited to a manufacturer's site to actively participate in innovation. This, however, is only rarely found and with reference in particular to consumer goods (Iivari, 2004).

Figure 2 portrays the different types of user involvement for manufacturer innovations. That is, it illustrates a variety of possible kinds of involving represented and real users in the "writing" phase of a technical object. It is shown that the source of use information is in fact a continuum, with non-representation at the one end and user participation at the other. It is interesting that at the far end of user participation the source of innovation also becomes affected. Where users actively participate and use information is not mediated, it becomes questionable whom to assign the innovative effort to in the first place. According to the studies discussed in Section 4, however, real user participation seems to be a rare phenomenon. Knowledge exchange between manufacturers and users, after all, is very demanding and normally facilitated through the transmission of artifacts and individuals across the boundaries of individual firms (von Hippel, 1994; Lundvall, 2006). This explains why user involvement so often relies on representation and mediation – it simply is a challenging process to articulate and translate user needs and preference, especially in new product development when these needs and preferences do not yet exist (cf. Section 3).

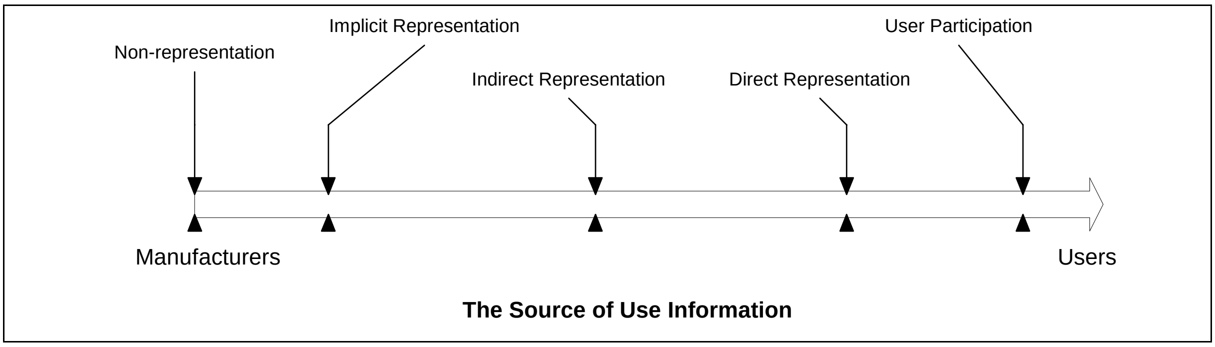

Figure 2: Types of user involvement for manufacturer innovation

Given the literature in Section 4 one must assume the forms and significance of user involvement to be markedly different for industrial and consumer goods, respectively. For industrial goods in particular, von Hippel (1994) has shown that the locus of problem solving in new product development may meander between the user and the manufacturer site. While how end users participate in this process within the user organization remains an issue for empirical investigation, von Hippel's work indicates that user participation can indeed play a significant role for the development of industrial goods. However, for consumer goods the situation is very different, and user participation is a rare if not absent phenomenon (Iivari, 2006b). For the purposes of this discussion, it needs to be borne in mind that innovation in industrial and consumer good industries is very likely to be different with regard to the facilitation of user involvement.

Another special case is, of course, in-house product development where particular units within a firm develop product or services for custom use by other departments in the firm. This is, for instance, the case when ICT units within a company develop software for the special purposes of the company. The interpretative framework presented here is not especially suited to analyze this situation. However, some authors have suggested that, at least in principle, in-house development units can be as much outsiders vis-à-vis other departments of the same company as supplier firms are vis-à-vis their customers (Mackay et al., 2000). Again, within the scope of this paper it is important to keep in mind that in-house development may differ considerably from situations where users and manufacturers are separated by organizational boundaries.

In summary, this section has developed an interpretative framework for the analysis of the “mutual shaping of design and use” (Rohracher, 2006), or how “users and use meet engineers and design” (Oudshoorn and Pinch, 2003) in innovation. Hence, it has neither presented a normative (how users should be involved) nor generalized descriptive (how users are typically involved) model of users and use in innovation. Rather, it has illuminated the many forms and types of users and use in innovation that have been found in the wealth of empirical material on this issue. It is thus the primary message that users in innovation come in a variety of real and represented forms. This implies a crucial distinction between actual users of a technical object, and “the user” that was constructed along with the object itself. Hence, the model presented here implies that technical objects go through a phase of writing or encoding where technical decisions are constructed among a limited set of actors. Consequently, this paper strives to interpret users and use in the writing phase as an important part of the innovation process. This implies that it does not concern itself with the reading or decoding phase where technical objects change their meaning - and often their shape, too, at the same time - due to the renegotiation of the script they contain.

The approach sketched out here emphasizes how end-users, i.e. those that benefit from using a technical object, are constructed in innovation. In other words, it looks into the construction of those who will have, according to von Hippel’s taxonomy, a functional relationship of use with the innovation. Given the variety of possible real users, such as clients, maintenance workers, and service providers, this constitutes a potential limitation of the approach. However, this limitation reflects a bias in the literature that tends to explore end-users and thereby downplays how these are often represented not only be designers but also by other types of users (cf. Rose, 2001). I will return to this topic in the following Section 6.

6. From “Technology and Aging” to “Innovation and Aging”: Cornerstones for an Empirical Agenda

In Section 2 I have provided a brief introduction to a research area of Gerontechnology or “Technology and Aging” that explores how technology (in the form of technical objects and services) relates to individual aging, i.e. how technology can compensate for age related deficits and how technology can provide opportunities for successful aging. In this section, I want to take this one step further and explore how the body of knowledge produced in this research area can be exploited in industrial innovation. This is essentially linked to the topic of users and user needs in innovation. In a nutshell, what I shall propose is to turn the perspective of "Technology and Aging" upside down, and ask how aging as a broad socio-economic development is translated into constructions of users and user needs in processes of industrial innovation. The ideas developed in Section 2 constitute the raw material, so to speak, that inform this construction. In other words, the results of gerontechnological research are discussed here as potential source of use information. Within the scope of this paper, I confine myself to identifying the cornerstones of a research agenda on "Innovation and Aging".

For this purpose, it is important to understand how users and use are constructed within particular innovation projects. More specifically, I contend that the "elderly user" in his or her many facets is an interesting example of how users and use are constructed across a variety of types of innovation projects. The argumentation above suggests three particular areas for further investigation of innovation projects that target elderly people:

First, it is important to identify the *source of innovation*, i.e. the functional relationship between the site of the innovation project and the innovation. The discussion presented in Section 2 suggests that this will be markedly different for everyday technology and assistive or health care technology. The former concerns consumer good industries, where user innovations are likely to be the exception rather than the rule. For the latter, however, public service providers or institutional housing are important clients for new products and services. As such, projects in these areas may well import characteristics of industrial good industries, and users may be a more frequent source of innovation.

Secondly, it is crucial to specify the *sources of use information* that inform the construction of users and use. In particular, one has to disentangle the different types of users that are present in the innovation process. In innovation projects developing products for the elderly, an interesting constellation is likely to be found: research about and experts on the relationship between technology and aging represent "the elderly" user. It is important to specify how the abstract body of knowledge discussed in Section 2 is, in its various facets, translated together with technical objects into constructions of the "elderly user" and into respective imaginations of use, users, and user needs.

Thirdly, the institutional space where "users and use meet engineers and design" (Oudshoorn and Pinch, 2003) deserves special attention. Here, I build on the metaphor of the *mediation junction* that has been introduced by Schot and Albert de la Bruheze (2003) to reconcile production-oriented and consumer-oriented studies of innovation. For them, technological change proceeds through the repeated alignment of product characteristics and user requirements. And this process, they argue, takes place in a specific institutional space in which producers, users, and mediators "meet to negotiate, articulate, and align specific technical choices and user needs" (p. 234). It is this locus that they call "mediation junction".[15]

Different types of users populate a mediation junction, and, according to Schot and Albert de la Bruheze, one can at least distinguish between three such types – real users,

[15] Previously, Schot (1992) has defined a similar locus as "nexus". For him, a nexus mediates between variation and selection within a quasi-evolutionary framework for the analysis of technological change (see also van den Belt and Rip, 1987; Schot and Rip, 1997). However, this notion is problematic within the context of this paper, in particular because it does not identify the construction of "the user" as part of technological variation. I, therefore, prefer to follow the broader notion of the mediation junction than the idea of the nexus.

represented users, and mediated users. The third type has not been discussed, yet. And indeed, for Schot and Albert de la Bruheze, the mediated user covers an aspect which has not been investigated elsewhere. Mediated users are spoken for by organizations that claim to represent a particular group of users. This is similar to the represented user described above, but differs from it in an important aspect. Mediated users, too, influence the construction of “the user”, but they do so mainly on the basis of particular interests rather than on alleged expertise on specific user needs. This is indeed a widely uncharted terrain in the literature on users and use that is biased towards representations of the end users. Mediated users may pretend to represent end users, but actually they often act from the perspective of another functional relationship with the innovation

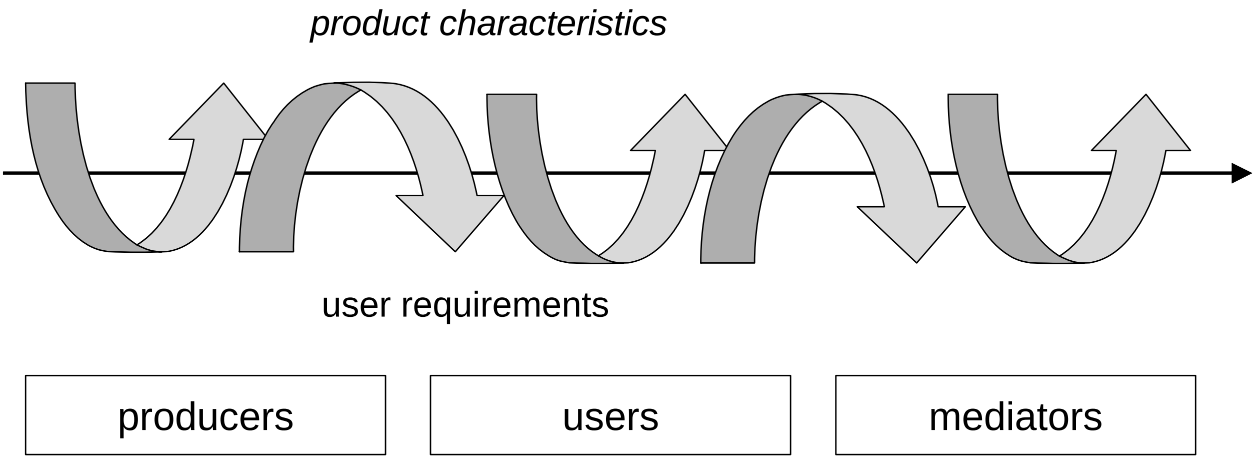

Figure 3: The mediation junction (based on Schot & Albert de la Bruheze 2003)

A mediation junction can have many institutional forms. Schot and Albert de la Bruheze illustrate this along the lines of two case stories. While in the second case one mediation junction could be identified that was confined to a single organization, the first case revealed that multiple mediation junctions spanning various private and public organizations shaped the innovation process. For the agenda sketched here, it is important that the concept of the mediation junction is open with regard to its specific institutional make-up. That is, while the idea identifies a particular function for the mediation junction (aligning product characteristics and user requirements) together with three categories of actors (producers, users, mediators) populating the junction, it does not specify its locus vis-à-vis manufacturing, using or otherwise participating organizations.[16] This remains an issue to be specified separately for each empirical case. The concept is thus flexible enough to accommodate the variety of forms in which users and use are constructed in innovation. Figure 3 illustrates the basic constituents of the mediation junction.

I use the concept of the mediation junction primarily in a metaphorical way to draw attention to the fact that it is possible to identify an institutional space in which the alignment of product characteristics and user requirements takes place. The mediation junction, therefore, is an additional ingredient to the dimensions identified in Table 1. It specifies the organizations taking part in an innovation process, and identifies where the

[16] In fact, the concept of the mediation junction has been designed to suit historical analysis and has thus a very broad scope (cf. Oldenziel et al., 2005).

construction of users and use is located vis-à-vis these organizations. The agenda proposed here thus suggests identifying innovation projects that target elderly consumers, positioning them within the two-dimensional space illustrated in Table 1, and exploring how a script is written that contains both technical specifications and a construction of "the user" and his needs. Given the complex nature of knowledge about technology and aging (see Section 2) a variety of types of innovation projects are likely to be found.

To identify suitable projects I propose two strategies. First, there is the increasingly active field of research on "Technology and Aging", which has proven to be a particularly interesting field of research for my study at hand. Indeed, it produces a rich stream of use information, i.e. information about the preferences of (present and future) elderly consumers. My investigation shall step in where this research interacts with industry to shift the focus towards industrial innovation. Secondly, the influence of aging is perceived to be particularly relevant in certain markets. This has been shown for obvious cases like health care services (Barlow et al., 2006), but also for fields like consumer electronics (Pantzar and Shove, 2005), whose subject matter is not directly linked to issues of aging. These areas constitute another starting point to identify innovation projects in which aging is addressed as an important source of use information. Altogether, an agenda on "Innovation and Aging" should explore the mediation junction of innovation projects that populate the categories sketched in Section 4. For this purpose, the present paper provides a starting point in the form of an interpretative framework.

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