A Framework for the Acceptance of Gerontechnology in Relation to Smart Living

Don G. Bouwhuis

Contents

Abstract

Despite the wide availability of telecare devices, the economic pressures, and the claimed benefits, the uptake of telecare services by older people is disappointingly limited. Much research is spent on finding out why the telecare acceptance is so much less than expected.

Ease of use, or rather lack of it – a seemingly likely cause – is difficult to assess since the traditional usability criteria do not apply well to the daily life of older people. Acceptance in the social environment plays an important role, sometimes

D.G. Bouwhuis (✉)
University of Technology Eindhoven, Eindhoven, The Netherlands

Nan Kai University of Technology, Tsao Tun, Taiwan
e-mail: d.g.bouwhuis@tue.nl

J. van Hoof et al. (eds.), *Handbook of Smart Homes, Health Care and Well-Being*,
DOI 10.1007/978-3-319-01583-5_3

in a positive sense, but mostly in a negative one; however, social environment is all but impossible to manipulate.

What does delay acceptance is the lack of standardization, which, in turn is also due to the fact that the impressive technological progress of the past decades has largely bypassed the field of assistive technology and health care. Another negative factor is cost. Though the price of devices has come down appreciably in recent years, system architecture and installation are getting more expensive and increased functionality goes hand in hand with higher cost. Next, during the actual running of telecare systems, successful operation has to compete with inherent difficulties of decision making in a noisy context. Making correct diagnoses is necessarily connected with false alarms, which may render the telecare system unusable. This is exacerbated by sources of unreliability in the system as a whole, like falling sensors, disconnected leads, empty batteries, and erased memories.

In the light of these difficulties, traditional Technology Acceptance Models (TAMs) are focusing on a very small part and then probably the wrong one of the whole complex multistage decision process in implementing a telecare system.

As it is, the comparatively immature state of telecare systems is up to now a multisectoral issue, in which stakeholders of different economic sectors operate mostly independently. Early stakeholders take decisions which later ones have to accept, up to the client as the end user, who also has to accept, but often does not. In a confusing situation like this, where the client is confronted with a system he or she has not chosen, it is doubtful that models based on a theory of rational behavior like the TAMs or Innovation Theory are valid at all.

What should be minimally done on the basis of these observations are three things.

First, an effective business case should be developed to run a telecare system – currently absent. Second, in addition to regulation, there should be a strong effort in the area of standardization. Finally, telecare should become a product that older people want, not one they have to accept.

Keywords

Telecare • Usability • Rationality • Technology acceptance • Business model • Standardization • Reliability

Introduction

When Oedipus encountered the Sphynx at the gates of the Greek city of Thebes, an apocryphal event that may be dated around 1000 BC, he had to solve a riddle in order to enter the town. The Sphynx asked: What creature goes on four feet in the morning, on two on midday, and on three in the evening? Oedipus answered: It is man; as a baby it crawls on all four, as an adult he walks on two legs, and when old he needs a stick as a third foot. This observation qualifies the walking stick as the earliest assistive technology for older people. In the 3,000 years since then, only very few

Fig. 1 An older man sitting in a wheelchair, depicted in the London Illustrated News of 1894. In the background another old man is walking with difficulty, holding a cane. Note the strange coincidence with the Sphynx riddle that the baby pram has four wheels and the wheelchair three

other assistive products were introduced: dentures, lenses for reading glasses, and ear trumpets. Pictures of wheeled chairs in China date from as early as 525 AD, but practical wheelchairs were only introduced around 1900 and were primarily intended for disabled people rather than for older people with mobility problems (Sawatzky 2002), who used them if they could anyhow (Fig. 1). The earliest use of eyeglasses, mostly to correct for farsightedness, dates from the thirteenth century (Ilardi 2007). The first foldable tubular steel wheelchair, similar to current ones, was designed in 1932 by Jennings and Everest in the USA (Sawatzky 2002). One other example, the first stairlift was created by C. Crispen in the 1920s, who called it the Inclinator, but practical devices of this kind came on the market from the mid 1970s (Baker 2006). While practically all of these products were passive physical devices, one of the first applications of electronics was in the area of hearing aids. Alexander Graham Bell, in 1876, had intended his speech transmission system in first instance as an aid for the deaf. Though the telephone application overtook other interests, his invention was turned by Miller Hutchison into the electric hearing aid in 1898, called the Akouphone. Electronic amplification was introduced in the 1920s, and in the course of the twentieth century, even more improvements like miniaturization and noise suppression were introduced. Yet, also considering this one product, it is remarkable that while technology, including electronic technology and specifically medical technology, made such giant strides in the twentieth century, so few assistive products for older people were proposed or developed until the 1990s. It is telling that the wheeled walker, mostly known as rollator, invented by Aina

Wifalk in 1978 is considered by many users as the best invention of the century, or, since the wheel.

Forms of Technology Acceptance

All of the products mentioned have in common that they were meant to cope with disabilities, not specifically in relation with aging. That they were often seen as a sign of old age is caused by the fact that perceptual functioning and mobility are negatively correlated with age. So, as aging progresses, the proportion of older persons needing assistive devices will increase. Because in many countries the population is aging, the majority of assistive devices will ultimately be used by older persons. Another aspect is that the assistive products satisfy a personally felt need; they are, in fact, required. In the case of a dysfunction, e.g., low vision, magnifying glasses are not a product that is accepted or not, they are demanded or required, as otherwise the intended activity of the affected person just cannot be executed. Acceptance in such a case is a default. Even if a person who needs perceptual or mobility assistance is averse to the assistive product, the need to use it anyway will overcome the felt objection. This held, for example, for the early ear trumpets that could be very bulky and expose the deafness of the person spoken to an unwanted degree. Up to this day, much value is attached to the near invisibility of a hearing aid, as showing a dysfunction is considered to be embarrassing for the person, whether this is justified or not. The high popularity of contact lenses can also partly be explained by the desire not to wear glasses that give away some sort of a vision problem. Personal choice for an assistive device, then, is a balance between acceptability and need, where usage that is considered unacceptable will be enforced by sheer need.

Acceptability has two extremes, rejection on the negative side and attraction on the positive side. So any product will be situated on this subjective acceptability scale, on which there may be unwanted products, indifferent ones but also products that are highly attractive. Inasmuch as this is a subjective scale, the attraction value may not be dependent on objective or formal criteria at all. To some extent this scale can be called irrational (Tversky and Kahneman 1981) which is not to say that it cannot be rational and supported by formal argument, but it need not be, and frequently is not rational.

Usability and Acceptance

Usability is commonly seen as an important determinant of acceptance. Although the concept of usability, that has been standardized by the ISO (1993), originally was focusing on Video Display Terminals, it has since then adopted a much broader field of application and is currently the most important set of guidelines on product usability extant. Still, the guidelines are typically suitable for a work situation in which product users are controlling systems that produce useful output. In this way the guidelines are less applicable to leisure activities, like watching TV, where the users do not have to produce useful output and where control is mostly limited to switching the set on and off. The main three properties of usability are:

1. Effectiveness
2. Efficiency
3. Satisfaction

Next there are two other requirements that have not yet been formally standardized, but intuitively are sufficiently important to take into account

4. Memorability
5. Learnability

If a task situation in which products have to be controlled satisfies the three main criteria, they have a high usability, but products may also be lacking in one or more of the three, leading to lower usability. Pitting these criteria against assistive devices leads to unexpected conclusions.

Effectiveness cannot be expressed in a measure of output, but only in the extent to which the user can execute tasks with the assistive device that he could not without them. As a rule, this effectiveness is lower than that attained by people without a dysfunction. People who have to walk with a stick are invariably slower than people who do not need one. People who have their vision "restored" by glasses that bring their vision onto a nominally good level do still read considerably slower than people with normal vision (Aberson and Bouwhuis 1997). Measuring effectiveness is easy in the case of observable output, but much more difficult when it is individual functional effectiveness. Moreover, effectiveness is not only assessed by the person; a nurse, doctor, or other carer can judge the effectiveness differently than the challenged person.

Efficiency is determined by the resources expended in relation to the accuracy and completeness of goals achieved. As for effectiveness, it is not easy to assess the efficiency of the use of assistive devices. Assistive devices are resources and have to be used in order to perform a task or function. In this way their control, if any, requires more mental or physical effort than not having to use them. Hearing aids and glasses require hardly any control, but many interactive devices, like video communication require pressing buttons, touching screens, making choices, and dealing with waiting times. So the usability component "efficiency" is more suited to comparison between similar products that may vary in efficiency, whereas an assistive device is usually the only option offered.

Satisfaction is described as the comfort and acceptability of the **work system** to its users and other people affected by its use. Especially in the area of assistive technology satisfaction is not independent of effectiveness and efficiency. Suppose that a person with serious hearing loss employs a speech recognition system that presents speech in the form of readable text. If the effectiveness of the system is low, it will lead to dissatisfaction of the user, while the speaker may be annoyed by the low success rate of his communication, exactly the situation of low satisfaction. Generally this holds for all assistive technology; if its success rate is low, its effectiveness is low and correspondingly user satisfaction will be low. If the effectiveness is low, this may induce the user to spend more effort in making the technology work, which, in turn, will decrease the efficiency.

Memorability becomes important when devices become more interactive. There is nothing to remember for a walking stick or reading glasses, but adjusting a hearing aid may be so complex that often a specialist has to be called in. Battery changes, which almost all mobile devices require, may involve a number of actions that have to be remembered from the previous change, if only to remember how to insert the batteries. Despite being not yet standardized, memorability is relatively easy to measure; as soon as users forget necessary control actions or device properties they may need, memorability is undesirably low. If users intuitively pick invariably the right control actions, memorability is high. Memorability, therefore, stands as an important and reliable measure of usability of assistive technology.

Learnability is a slightly more complex issue. If interaction patterns have to be learned, they also have to be remembered, which taxes memory and will affect memorability. With the current state of assistive technology, it will consistently be required to perform some control actions to make it operate successfully, and these will have to be learned. Learnability is also relatively easy to measure by the amount and frequency of training that the users get. In many "work systems," this is less easy, as learnability may affect effectiveness and efficiency, as work systems are usually more complex than a single-purpose assistive device.

In contrast to the technical specifications of a device, which is a product-oriented approach, usability is a user-oriented approach. While effectiveness can to some extent be described by technical specifications, this becomes more difficult, especially for more complex devices for efficiency. Satisfaction cannot be specified in a technical sense. Memorability and learnability largely evade technical specification.

As argued before, acceptability is not merely the sum of technical capability and usability (Melenhorst 2002). For human choice, more aspects and more subjective considerations enter into establishing a preference. Norman (2004) has proposed a different type of assessment of products, which he termed "three levels of experience."

Three Levels of Experience

Apart from technological and usability aspects, products are also evaluated in terms of how they are experienced, in which the design aspects (1) visceral, (2) behavioral, and (3) reflective are distinguished.

Visceral design concerns itself with appearances, and the term "visceral" already implies that the design of a product leads to a purely subjective and emotional experience. As the looks of a product are mostly unrelated to its purpose (see also Michl (2009) on "form follows function"), there are a wide variety of designs for the

Fig. 2 The antique can opener (*left*) is much inferior in handling and result to the modern one (*right*), which also requires less force, all of which lead to a positive behavioral experience

same product type and a correspondingly great variety of opinions about those. Many devices, e.g., those providing telecare, that are installed in the home of older people are seen as an eyesore, which have to be hidden from view as much as possible. Worse even, most of these devices have to be connected to other ones, which leads to a seemingly random mess of wires against the walls of the room, generally strongly abhorred by the tenants. In the course of their life, older persons have developed their own preferences and have created a living environment to their own taste. Logically, assistive technology is new, and alien in shape and design in comparison with their daily environment, and will generally not be positively appreciated.

Behavioral design serves to create a high effectiveness of use that, in turn, leads to satisfaction with the product. A good example is the difference between antique and modern can openers illustrated in Fig. 2. The old-fashioned can opener required considerable force, adroitness in moving the handle around the rim of the can, which then raised the lid with jagged and sharp edges. In contrast the modern can opener requires little force and no complex movement and does result in a relatively smooth and much less dangerous lid. Older people, accustomed to the antique can opener, are without exception pleasantly surprised by the ease and pleasantness of use of the new version. Basically, behavioral design, and concomitant experience, combines effectiveness, satisfaction, and efficiency in a single concept.

Reflective design already refers to reflection, a personal cognitive experience. Norman (2004) calls it the rationalization and intellectualization of a product. The product becomes a statement of the person who owns it. Norman (2004) gives the Mini, the restyled version of the original BMC Mini car as an example, but it can also be exemplified by a large screen HDTV, design furniture, or luxury kitchens. Ownership of such products is a source of pride, which definitely moves this concept out of the work situation from which the usability standards evolved. Interestingly, the usage properties of such products seem not to be particularly relevant. It is a well-known fact among kitchen suppliers that sophisticated luxury kitchens are hardly ever used. Maserati and vintage cars only hit the road on special occasions and in favorable conditions, and TV shows recorded by multifunctional video-recording systems are almost never watched afterwards. More recent technological products, like smart phones, are a prominent example of reflective design. Rather than being only a communication device, they also often function as personal decoration, as a contemporary version of jewelry with which one can show off (Juhlin and Zhang 2011; Fortunati 2013).

So for assistive technology, it would be optimal if indeed the users would really be proud of it, but at the same time use it extensively to their own advantage.

Social Conformance

There are, of course, many other factors that determine or affect choice of products, but not all of those seem to be relevant for assistive technology. Fashion is one example, which is of almost overriding importance for clothing and interior design, but hardly affects the design of technology per se. There are, however, two factors that, in combination, may play an important role in dealing with assistive technology.

These are "custom" and "social conformance." Both relate to the perception of what other people do and want, especially in the broad social circle of people. This is an old phenomenon. At the occasion of the opening of the railway between Bakewell and Buxton in 1835, the Duke of Wellington is quoted as saying: "Every fool in Bakewell wants to be in Buxton, and every fool in Buxton wants to be in Bakewell," adding that ". . .railways are to be opposed as they will encourage the lower classes to move about. . .." Around 1890 high-ranking ladies were complaining about their maid servants who were driving a bicycle on Sundays, quite likely with their lovers, which until then was only relegated to the higher classes due to the high price of bicycles.

While class differences petered out in the twentieth century, owning a personal computer in 1980 was seen by many as frivolous uselessness, somewhat later the mouse was derided as silly, and 10 years later the same was claimed about the mobile phone. When no one in one's social circle has any form of telecare installed in the home, and its function is largely alien to the older person, having such a system installed will, in a sense, have to compete with the felt social pressure not to have one. Additionally, it will expose the vulnerability of the person, which is not seen as anything to be proud of, leave alone that it will be intellectualized as reflective design.

Regulation and Standardization

One factor that is completely unrelated to any of the above is still one of the most powerful to introduce products into society as a whole, which is legal regulation. The variety of products and systems which it covers is very large, and practically always for good reasons. The safety regulation for installing electricity in homes is one early example; driving on only one side of the road is another. More recent examples include helmets for motorcyclists and safety belts for motorists, and in many countries, there are legal obligations to supply medical aids, like crutches, wheelchairs, and other products to persons who need them.

As a rule standardization does not originate from the government, but it can play an important role to enforce it, while industry, professional, and consumer organizations will draft the standards for a product area. Standardization is of inestimable value for installing effective and affordable technology. Regulation and standardization essentially take away many of the subjective barriers that exist to adopt technology and not only assistive technology. It will appear in the following sections that it is in fact the lack of standardization that has been one of the most important barriers in the take-up of telecare and related assistive technology.

Cost and Pricing

Cost and pricing have to be differentiated as cost of technology is not always reflected in the price. This holds especially for medical technology and for other professional products. The reason is that those standardly have to conform to specifications that are mostly irrelevant or unnecessary for consumer products. Medical technology has to conform to strict regulations, i.e.:

- European Union laws – the Medical Devices Directives and Regulations
- UK laws – the Medical Devices Regulations

As an example a small section is presented here outlining one of the many procedures (note the number 39!) to be followed for biological safety, as prescribed by the Medicines and Healthcare Products Regulatory Agency (MHRA) of the British Government (2013)

> **39. Detailed information on the device**
>
> Detailed description of how biocompatibility and biological safety have been addressed. The risk assessment should cover the rationale for the decisions adopted. It should be apparent from the risk assessment, how hazards were identified and characterised and how the risks arising from the identified hazards were estimated and justified in relation to anticipated benefits. Particular attention should be paid to biological safety issues, especially for devices containing new materials that will come into contact with patients or where materials are used in a situation involving a greater degree of patient contact.

Often the investment in making the product conform to regulations is higher than developing the product itself, which drives up the price to a considerable amount. Likewise, specifications for professional use also increase the price of product development; military specifications are a case in point. Another reason for a high cost is the mostly limited production runs; minimal production runs for consumer products are 10,000 but can easily exceed millions.

Even so, this does not necessarily imply that consumer products are by definition less reliable than professional products. The sheer number of products allows carrying out extensive reliability testing such that consumer products may be appreciably more reliable than some professional products. At the time when devices for home automation became available for disabled and older people, the price of these devices was a considerable barrier for installation. One example is automatic door openers that technically were not very complex and well affordable. When they were installed, there was a regulation that the opener must include a protective system that prevented someone to be crushed between an opening door and a wall. This pushed up the price to almost four times the device cost itself. At the same time, however, automatic garage door openers, commercial products, had featured such a provision for years and carried a purchase price of less than one tenth of the automatic door opener.

Usefulness and Effectiveness

As mentioned before the effectiveness as described in the ISO usability standard cannot be directly transferred to an assistive technology situation, as there is no measurable production by the system. However, when the system, e.g., a medical alarm system, has to function and indeed does function, it does what it is expected to do and thereby is very useful for the client. Usefulness seems, therefore, a better term than "effectiveness" in this context. It is, however, not the case that clients having such an alarm system installed perceive its functionality as useful. First, in general, the alarm has been installed more as a precaution as the client has a raised likelihood of developing a serious medical incident. Still, as long as the client is deemed to be able to be living in his own home, such incidents are rare, and the system has only to be activated rather infrequently, or not at all. As long as the system is not activated, the client does not intrinsically perceive the system as effective and essentially cannot perceive its usefulness.

Second, the current state of technology cannot prevent false alarms to occur. False alarms in this situation occur on two levels rather than one. All diagnostic systems have a sensitivity that is limited to some extent; no system is infinitely sensitive. Consequently, there will occur hits, misses, false alarms, and correct inaction. A quantitative example may illustrate the behavior of an alarm system with its consequences.

Suppose that the sensitivity of a diagnostic system has a discrimination power of $d' = 2.5$, which is a pretty good performance (see for an explanation of d': Peterson et al. 1954, and note that null sensitivity has a d' of 0). The sensitivity is system bound, the user cannot adjust it, but the criterion level, above which the system produces an alarm, can be set relatively arbitrarily, though extreme high and low values should be avoided. Setting the criterion low means that an alarm will already be produced when there is a little evidence for a health incident, and a high criterion will trip only the alarm when there is strong evidence. In the first case, there will be a lot of false alarms but also a high hit rate; in the second case, there will hardly be any false alarms, but also many incidents will be missed – a low hit rate. Now with a sensitivity of $d' = 2.5$ and using a moderately low criterion of 1.65 (the criterion is expressed in the same units as d'), we obtain the following results:

	System response		
State of health	Alarm	No action	Sum
Real incident	0.80	0.20	1.00
Everything normal	0.05	0.95	1.00

Obviously, one wants to optimize the number of desired outcomes, which consists of the sum of the hit rate and the correct rejection. In the above example, this would be 0.80 + 0.95 = 1.75. This is, however, not the highest possible value of desired outcomes. The highest value that can be attained is by setting the criterion somewhat lower, to 1.25, leading to the following outcomes:

	System response		
State of health	Alarm	No action	Sum
Real incident	0.89	0.11	1.00
Everything normal	0.11	0.89	1.00

In this example the false alarm rate (11 %) has more than doubled, which is why the previous criterion setting is preferable. It is useful to see what would happen if we try to reduce the false alarm rate even more, say to 1 %. This leads to the next outcomes:

	System response		
State of health	Alarm	No action	Sum
Real incident	0.56	0.44	1.00
Everything normal	0.01	0.99	1.00

While the false alarm rate has been reduced now to only 1 %, almost half of the real incident occurrences (44 %) will be missed; clearly an undesirable criterion setting.

The Base Rate Problem

Now the health state of a client is not a series of discrete events, each with its associated probability, but rather a continuous variable, which is why some approximations are needed to clarify the analysis given here. This relates to what the likelihood is of an incident and of a normal state of health, which is hard to define on a continuous variable. A helpful approximation is to express the likelihood as number of occurrences per time unit, say incidents per week. Now suppose that a health crisis occurs once a year, then there are 51 weeks without an incident: in other words the “everything normal” situation is 51 times as likely as a health incident. The probability of occurrence of a health incident would then be 1/52, or less than

2 %, which is called the base rate. If the base rate is low, the criterion at which an alarm has to be produced has to move up, as otherwise too many false alarms will occur. If the criterion is now set so high as to produce an equal number of "hits" as "false alarms," the probability of a "hit" – a real health incident correctly detected – has come down to 1.2 %, and it is a small consolation that the chance of a "false alarm" is then also 1.2 %. This is because the quantity of time slots without an incident is counting so heavily in the monitoring process. The rarer the incident occurrences are, the higher the sensitivity of the system has to be, which is often not easy to realize. Of course, there are obvious situations where the physiological status is evident, like a heart that stops beating, or no detectable breathing. Many physiological indicators can, however, be rather variable, which makes correct identification of a serious incident uncertain.

The Reliability Problem

The second level of false alarms has nothing to do with sensitivity, but with the reliability of the system as a whole. The growing amount of wireless signals, especially in areas with a high population density may emit interfering signals that may intrude on the correct functioning of the system. System-born software glitches may also cause interference with functioning, and so there may be several sources of harmful interference that can give rise to an alarm. It may be that a sensor gets detached without being noticed by the wearer, or leads are disconnected accidentally by house cleaning. In that case the output of the diagnostic system is bypassed, and whatever its output is, the alarm state is always produced: there is no decision matrix involved. In actual practice this does not happen often, but its likelihood may be of the same order as that of a real health incident, but may also be higher. Again a quantitative example may be useful.

Suppose that a true health incident occurs on average once a year, and a system glitch leading to an alarm also once a year, where the true hit rate is 80 % and the false alarm rate 5 % as before. Again we take as quantification of the likelihood the number of weeks in which an incident occurs. Leaving out the computational details, it can be found, with the given sensitivity of the diagnostic device, that when an alarm is given, it is justified in 25 % of the cases, and therefore, 75 % consists of false alarms. Now if a fluke false alarm occurs only once a year, then the probability of notifying a valid health incident drops to 18.5 %, so that false alarms are more than five times as likely than valid alarms.

Understandably, prospective clients, hardly aware of the possibility and frequency of occurrence of false alarms, both of the first and the second kind, may find the system useful and reassuring. However, as soon as the installed system is operational, false alarms may occur, and observing the associated consequences, clients rate its usefulness much lower and lose trust in the system, which, in turn, may lead to discontinuation of the service. This phenomenon of shifting attitudes as a result of experience is not new; it was already found by Ehrlich et al. 1957. Consequently, the rating of usefulness is first based on insufficient information and subsequently will change into a negative direction as soon as the daily operation with its associated false alarms is experienced. Usefulness, therefore, appears not to be a reliable predictor of use of telecare systems.

Technology Acceptance

Two approaches to describe the adoption of new technology in the population have received widespread attention. The first, the Innovation Theory, was proposed by Everett Rogers in 1962 and has become quite influential. The main idea is that the adoption process of a particular novel product, like an electric motor, an electric shaver, or refrigerator is following a fixed sequence of stages. The first is *knowledge acquisition*, next follows *persuasion*, e.g., by social peers, after which a *decision* is taken to purchase the product. The next step then is *implementation*, which is concluded by *confirmation*. An expanded model was presented 20 years later (Rogers 1983), the schematic representation of which is shown in Fig. 3. In this scheme there are two problematic components in the case of assistive technology and telecare. First, older people do not actively try to acquire knowledge about assistive technology; mostly they are confronted by it by external parties. Due to the rapid technology advances, older people usually have no knowledge about the existence of assistive technology and have little or no knowledge at all about the control of such technology and about its exact function (Docampo Rama 2001). The second problem is the decision stage, where it is assumed – as a default – that the user takes the decision to adopt an innovation. In telecare this is not nearly always the case, as it is often the caretaker, the care organization, or the relatives who take the actual decision.

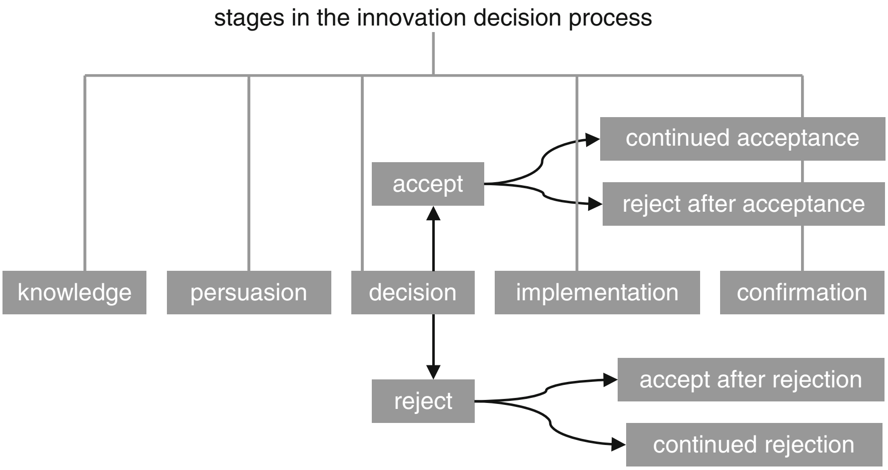

Fig. 3 The expanded innovation model by Rogers (1983), showing the five basic stages and a more detailed decision process than the earlier model (1962)

Also, if the innovation is rejected, the confirmation state is not attained at all. The question is therefore whether the linear sequence of stages is valid. Beal and Rogers (1960) found that innovation adopters often skipped stages or changed the order, suggesting that the model is not universally applicable. Rogers himself stated that the sequential model was not based on empirical research, but seemed a logical and rational description of the stages of innovation adoption. However, in recent decades, strong doubt has been shed on the assumption that human choice behavior is indeed rational. Criticism of such an assumption has come from social philosophy, economics, and most strongly from psychology. Bourdieu (2005) states that social agents do not continuously calculate according to explicit rational and economic criteria. Rather, social agents operate according to an implicit practical logic – a practical sense – and bodily dispositions. In psychology the doubt about logical decision making goes as far back as the research of Narziss Ach (1905). In recent years most empirical research on the irrational aspects of decision and choice has been published by Kahneman (2011) and Ariely (2008). On the basis of such research, the sequential stage model by Rogers (1962, 1983) is untenable; it appears that buyers behave very differently from following a logical and predictable decision and usage process.

This state of affairs has consequences for other theories as well, notably attitude theories, of which the Technology Acceptance Model (TAM; Davis 1989) is the most relevant here. Like its follow-up, the UTAUT model (Venkatesh et al. 2003), it is based on the Theory of Reasoned Action (Fishbein and Ajzen 1975), where the word “reasoned” refers to a rational and logical sequence of processes that lead to a decision or an action. Central in attitude theories is the concept of “intention” that is taken to lead automatically to a choice or action. This assumption is so strong that quite often “intention” is taken to be almost equivalent to the choice or action. In reality this is hardly the case in choice for assistive technology or telecare (Sponselee 2013). Generally speaking, the factors that according to TAM and similar models lead to “intention” need not to be involved in the choice process, or in a different order, or with a different chain of causation. A final argument to treat the predictive value of Technology Acceptance Models with caution is that the proportion of explained variance for applications in telecare and assistive technology rarely exceeds 50 %, whereas the highest values overall hover around 60 %. Inasmuch as this holds only for the prediction of intention (to buy), the actual predictive value for actual usage must be still lower.

Choice and Stakeholders

Most Technology Acceptance Models consider the telecare client by default as the sole agent who makes the choice to acquire a telecare system. Though the consent of the client is usually taken seriously by care organizations, the installation of telecare comprises a great many stakeholders with their own interest at heart, which may separately or collectively block delivery and/or installation, irrespective of the intentions of the client. Alternatively, the client can be asked to allow telecare installation in the home, where the client's consent is seen as a default. Mahoney (2010) gives a sometimes startling rendering of the events that may take place during the introduction of a telecare service. A number of quotes from this paper:

> The project had been formally blackballed by the union representatives for the case managers because they perceived the technology to be a threat to their jobs.
>
> [..] Friedman and Wyatt (1997), [..] note that completely different questions arise when an information resource is still in the lab, versus when it is in the field, and it can take *many years* (Mahoney's italics) for an installed resource to stabilize within an environment.
>
> The greatest barrier, however, was the pharmaceutical company's ban prohibiting caregivers from participating in another Alzheimer's disease-related study, even non-drug interventions.
>
> Several [gatekeepers] deemed the technology as a-humanistic and of no-value to their members, without letting the members even learn about the project.
>
> Findings revealed that the main reasons study participants declined use of the home monitoring technology related to concerns about the care-recipient's home environment and loss of familial privacy.

Observations like these reveal the older client as an accidental stakeholder somewhere at the end of the process. Seen in this sense, it is less important to what extent the older client accepts the technology, but rather how all stakeholders do so.

Telecare: A Multisectoral System

An interesting if not dramatic example of a failed business case is supplied by the bankruptcy in 2009 of the care organization Meavita in the Netherlands. Meavita had 100,000 care clients, 20,000 employees, and, in an attempt to lower the care costs, ordered 30,000 TV-phones. These video devices enabled video communication between nurses and clients and would also transmit clients' blood pressure values and glucose levels. This order was the main cause of insolvency of the care organization in the wake of production problems in China, inability of the technology developer to attain reliable operation, installation difficulties, and lack of cooperation by the network provider (and many other troubles). Ultimately only 1,500 clients received a TV-phone, short-lived as it was, due to the bankruptcy.

Apparently, assuming that technology with suitable specified capabilities can directly be plugged in into a telecare system is mere wishful thinking. The reasons are multiple, but the most striking property of assistive technology and telecare provisions is that they are multisectoral products. Without going into the details of economic sector theory, we may note that assistive technology is associated with the industrial sector, running the operation is part of the care sector, processing client data is part of the medical sector, and doing the investments is the area of the financial sector. Too much telecare and assistive technology is seen as a product that you can buy, install, and enjoy, while it is a system consisting of many components of widely differing kinds, not controllable by the user.

In fact, all products lie on a dimension of dependency of infrastructure. A chair does not depend on infrastructure, if one disregards the means to manufacture it. A radio, however, depends on a whole system of program providers and transmission stations. The situation for the telephone is even more complex. More physical products, like automobiles, seem to be separate products, but rely heavily on the existence of paved roads, an extensive network of fuel providers, a well-organized service network, and state-run traffic safety provisions as well as a legal system for traffic regulation. It is the existence of the traffic infrastructure that makes it possible for the individual to consider and use the car as a separate and (almost) fully controllable device. The car does not need a business case: to most users car usage is transparent and affordable, fitting in, and often enabling the lifestyle and/or professional life of the owner.

Nothing of this holds for assistive systems and telecare. Assistive systems often do not have to be controlled by the user, e.g., automatic ventilation, fall detection, and remote monitoring of vital signs. In most cases they are not purchased by the client as consumer, but installed on the recommendation of care organization or medics.

For assistive systems and telecare, the client is not the only user, since the care organization can monitor the vital signs or entertain communication and so is using the system as well.

But the care organization is certainly not equipped to take care of the technological components and installation requirements, and this is where assistive technology and telecare are fundamentally different from other, common, products.

Six different parties can be distinguished

1. The equipment manufacturer
2. The software developer
3. The program provider (which may be the care organization)
4. The communication network provider
5. The installation firm
6. Financial services for the investment

The agreements, authorizations, and dependencies between the six parties for the new products in a novel type of application have not yet been consolidated to a degree where dependable service is possible.

Suppose that a home-installed device is defective. The interesting question that arises is who is going to take care of the repair and who is going to pay for it. In fact, the situation is even more convoluted, as it is often not clear why an installed system is not operational. The cause may be located in a device, in the Home Area Network, there may be interference by nearby powerful routers, there may be a glitch in the communication network, and there may be a software error. In actual practice it appears (Sponselee 2013) that repeated visits by technicians, whether for installation difficulties or for repair, are a main source of discontent from the part of the clients, who often discontinue the teleservice for that reason.

Seen in this perspective, it is clear that the regular questions concerning the experience with the system, as there are “perceived usefulness” and “perceived ease of use,” are mostly not applicable, but also miss a multitude of factors that make their presence felt in a multitude of stakeholders. Inasmuch as TAM (Davis 1989) was applied to finished and operational products within a stabilized application environment, it is certainly totally inadequate to make even approximate predictions about usage, leave alone by what party.

Conclusions

Recent developments in technology are not all a bad sign for assistive technology and telecare. What can be seen is that a large group of products has moved from professional deployment to consumer usage. One of the most telling products is that of video cameras that, once only affordable for broadcast agencies, now are featured in the cheapest products and even toys. Successful deployment of assistive systems and telecare will therefore be dependent on devices that will be produced for the consumer market, not for the professional market. These consumer products will be more reliable and far less expensive than professional products.

While around 1995 device communication in the home was planned for wired home networks, like the ill-fated European Home System (EHSA 1997), and many more, currently the Internet protocol (2013) abbreviated to IP is almost universally employed for wireless communication between devices in the home. Two striking advantages come with this adoption: no expensive cabling in the home and interoperability between devices equipped with IP.

These two developments alone will not create a stable platform for assistive technology and telecare, as there are still too many unrelated parties involved in implementation.

This essentially means that a business model has to be developed that includes the activities necessary to pay, implement, install, and run such systems.

So far extremely few successful telecare systems of any reasonable size have come to light, and even here, if the client moves from one area to another, it is impossible to take the telecare system with them, as they do with a car, their glasses, and their hearing aid. The largest system extant, the CCHT system of the Veteran Health Administration (Darkins et al. 2008), is an attempt to incorporate the maximal number of specialized services, medical and technical, in the telecare system. Though it is difficult to get information concerning the current number of clients, there were more than 30,000 in 2007, with numbers growing. Yet the CCHT system shows many unresolved problems (Hopp et al. 2007) that demonstrate that the chosen business model is not optimal.

It is unlikely that as long as a stable telehealth infrastructure does not evolve, a successful business model can be maintained. So far, the absence of resilient business models in telecare and assistive technology is a well-established fact.

Where does this leave the most important end user, the client, who receives some form of care or assistance? Most often the client has to take whatever is offered, and there is no choice between alternatives. This makes perceived usefulness (PU) and the perceived ease of use (PEoU) rather academic, especially as almost always the client has no prior experience with the devices.

Even armed with full documentation and extensively briefed in meetings, older people with some form of assistive technology are normally unable to operate successfully more than one device, while maintaining that all devices are easy to use (Eyck 2004). Here the critical issue is that enquiries and surveys are taken in a different context than when operating the systems. Older people may well have the feeling that their devices are easy to operate, but whenever they have to control those in experimentally controlled conditions, it appears standardly to be much harder than they anticipated, (Eyck 2004; Ebeli 2005). This phenomenon is another reason for the insufficiency of the TAM framework in predicting technology acceptance.

Finally, it should be noted that considering the state of the art in telecare and assistive technology, the diffusion model of Rogers (1962, 1983) appears to be unsuitable for any prediction of usage and consequently diffusion. Apparently, in order to make even approximate predictions, much more detail of the type of technology and its usage should be included. For the time being, the Technology Diffusion Model will not have any use for the technology acceptance in telecare and assistive technology.

All of this, with admittedly some pessimistic overtones, does not take away that for a number of care activities, telecare can be particularly effective and actually is effective in quite a number of cases (Darkins et al. 2008). Glucose measurement for diabetics seems currently both one of the more popular and more effective telecare applications. This will undoubtedly grow, only we do not know how fast this will be.

References

Aberson DHA, Bouwhuis DG (1997) Silent reading as determined by age and visual acuity. J Res Read 20(3):184–204

Ach N (1905) Über die Willenstätigkeit und das Denken. Vandenhoeck & Ruprecht, Göttingen

Ariely D (2008) Predictably irrational. HarperCollins Publishers, New York. ISBN 978-0-06-135324-6

Baker PW (2006) http://en.wikipedia.org/wiki/Stairlift

Beal GM, Rogers EM (1960) The adoption of two farm practices in a central Iowa community. Agricultural and Home Economics Experiment Station, Iowa State University of Science and Technology, Ames

Bourdieu P (2005) The social structures of the economy. Polity, Cambridge, UK. ISBN 978–0745625393

Darkins A, Ryan P, Kobb R, Foster L, Edmondson E, Wakefield B, Lancaster AE (2008) Care coordination/home telehealth: the systematic implementation of health informatics, home telehealth, and disease management to support the care of veteran patients with chronic conditions. Telemed e-Health 14:1118–1126

Davis FD (1989) Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Q 13(3):319–340

Docampo Rama M (2001) Technology generations handling complex user interfaces. Doctoral thesis submitted to the University of Technology, Eindhoven. ISBN 90-386-0913-2, NUGI 719
Ebeli P (2005) Domotics, usage comfort from luxury to necessity (in Dutch), Master's thesis, Department of Technology Management, Technische Universiteit Eindhoven, Eindhoven, 2005
Ehrlich D, Guttman I, Schönbach P, Mills J (1957) Post-decision exposure to relevant information. J Abnorm Soc Psychol 54(1):98–102. doi:10.1037/h0042740
EHSA (1997) European home systems specification. Release 1.3, Zaventem (B): EHSA, March 1997
Eyck A (2004) Domotica in seriorenwoningen, (Domotics in seniors' dwellings), Master's thesis, Department of Psychology, University of Maastricht/Department of Technology Management, Technische Universiteit Eindhoven, Eindhoven
Fishbein M, Ajzen I (1975) Belief, attitude, intention, and behavior: an introduction to theory and research. Addison-Wesley, Reading
Fortunati L (2013) The mobile phone between fashion and design. Mob Media Commun 1:102. doi:10.1177/2050157912459497, http://mmc.sagepub.co/content/1/1/102
Friedman P, Wyatt JC (1997) Evaluation methods in medical informatics. Springer, New York, p 9
Hopp FP, Hogan MM, Woodbridge PA, Lowery JL (2007) The use of telehealth for diabetes management: a qualitative study of telehealth provider perceptions. Implement Sci 2:14. doi:10.1186/1748-5908-2-14
Ilardi V (2007) Renaissance vision, from spectacles to telescopes. The American Philosophical Society, Philadelphia. ISBN 978-0-87169-259-7
Internetprotocol (2013) http://en.wikipedia.org/wiki/IP_address
ISO (1993) Guidance on specifying and measuring usability. ISO CD 9241, part 11: draft
Juhlin O, Zhang Y (2011) Unpacking social interaction that make us adore: on the aesthetics of mobile phones as fashion items. MobileHCI'11 Proceedings of the 13th international conference on human computer interaction with mobile devices and services, pp 241–250. ISBN: 978-1-4503-0541-9, doi:10.1145/2037373.2037410
Kahneman D (2011) Thinking fast and slow. Farrar, Straus and Giroux, New York. ISBN 978-0-374-27563-1
Mahoney DF (2010) An evidence-based adoption of technology model for remote monitoring of elders' daily activities. Aging Int 36(1):66–81. doi:10.1007/s12126-010-9073-0
Melenhorst A-S (2002) Adopting communication technology in later life: the decisive role of benefits. Doctoral thesis submitted to the University of Technology, Eindhoven. ISBN 90-386-1867-0, NUR 810
MHRA (2013) http://www.mhra.gov.uk/Howweregulate/Devices/
Michl J (2009) E.H. Gombrich's adoption of the formula form follows function: a case of mistaken identity? Hum Aff 19:274–288. doi:10.2478/v10023-009-0041-9
Norman DA (2004) Emotional design: why we love (or hate) everyday things. Basic Books, New York
Peterson WW, Birdsall TG, Fox WC (1954) The theory of signal detectability. Proc IRE Prof Group Inf Theory 4:171–212. doi:10.1109/TIT.1954.1057460, http://en.wikipedia.org/wiki/Detection_theory
Rogers EM (1962) Diffusion of innovations. Free Press, Glencoe. ISBN 0-612-62843-4
Rogers EM (1983) Diffusion of innovations. Free Press, New York. ISBN 978-0-02-926650-2
Sawatzky B (2002) www.wheelchairnet.org/wcn_wcu/slidelectures/sawatzky/wc_history.html
Sponselee AAM (2013) Acceptance and effectiveness of telecare services from the end-user perspective: chapter 5 analysing telecare acceptance and use. PhD thesis submitted to the University of Technology, Eindhoven. ISBN 978-90-8891-643-4
Tversky A, Kahneman D (1981) The framing of decisions and the psychology of choice. Science 211(4481):453–458. doi:10.1126/science.7455683. PMID 7455683
Venkatesh V, Morris M, Davis GB, Davis FD (2003) User acceptance of information technology: toward a unified view. MIS Q 27(3):425–478