Readiness for Living Technology: A Comparative Study of the Uptake of Robot Technology in the Danish Health-Care Sector

Jean-Paul Peronard*
Aarhus University

Keywords
Readiness, robotic, health care, survey

Abstract This article is a comparative analysis between workers in health care with high and low degree of readiness for living technology such as robotics. To explore the differences among workers' readiness, statistical analysis was conducted in a data set obtained from 200 respondents. The results showed important differences between high- and low-readiness types on issues such as staff security, documentation, autonomy, and future challenges.

1 Introduction

Currently, there is strong interest in living technology such as robotics as a new kind of assistive technology in the Danish health-care sector. The reason is that such technologies are assumed to alleviate sector problems. Robots have been found to compensate for a growing number of people in need of care and fewer staff to provide the necessary assistance [8, p. 321]. Also, robots have been shown to increase the quality of life, particularly in the area of rehabilitation [26], and are also believed to reduce stress and anxiety and to provide a safer environment [10]. In addition, it is expected that there will be many applicable technologies that will be less costly than, for example, hospitalization or other intensive personal care [16; 28, p. 2], which will be welcome in times of demand for public savings. In turn, these positive effects and others may furthermore influence the way society at large perceives and values living technology and thus speed up the rate of adoption. Reasons for easy acceptance of living technology are related to the five characteristics of adoption as identified by Rogers, namely, living technology provides relative advantages, compatibility, low complexity, trialability, and observability [23].

Although the advantages of living technologies are much needed, it is not an easy task to introduce new technology. It has long been known that new technology often meets resistance in the market [17]. However, it seems that health care in particular lacks successful implementation of new technology [13]. According to Leonard, research into adoption of new technologies in health care has been focused on specific topics such as patient records or on physical characteristics related to slowness and resistance to change. On the topic of resistance to change, this is exacerbated when no added value is expected from the new technology [15]. Furthermore, in a broad review of the literature within various disciplines, Leonard [14] found some references to motivational, leadership, culture, and other management concepts as having an influence on sector implementation, but at

* Birk Centerpark 15, DK-7400 Herning, Denmark. E-mail: jeanpaul@hih.au.dk

the same time no serious progress in widespread deployment of new technologies has been documented throughout the health-care service. Consequently, as stated by Leonard [14], more research is needed on the issue of robotics in health care.

Furthermore, using health care as the test bed for researching the adoption of robotics may arguably be relevant for other sectors as well as for society in general. The reason for this is first that the health-care sector includes some of the most radical innovations in the field and with the greatest impact on people's lives (not counting the armaments industry and the military). This is because it deals with basic human needs for living, which constitute a much wider field than that of robotics for mere entertainment. Secondly, the permeation of robotics into health care is widespread and increasing, and although the prospects are fascinating and compelling, they are also controversial (see, e.g., [7, 25]). In health care people are by definition vulnerable, and because of their weakness they are easily manipulated, which naturally makes them anxious and resistant. Therefore we are more likely to find stronger opinions and attitudes toward living technology in health care than in any other field. Thus, this study will provide important knowledge of the demarcation of the fuzzy boundaries of living technology in areas that demand great sensitivity and societal attention.

In order to understand the pros and cons of introducing living technology as a new assistive tool in the Danish health-care system, this article examines health-care workers with various degrees of experience with and attitudes toward new types of robotics. Dividing health-care workers into groups of high and low readiness for living technology provides a more nuanced analysis of the conditions that favor or hinder the implementation of robotics in the health-care sector. Not only will such knowledge contribute to an increased understanding of how to support that implementation, but also, when care is viewed in a service perspective, it will provide knowledge of research interest [3].

Various researchers within the field of technological innovation have applied the concept of readiness as a way of understanding the adoption of new technology. For instance, Parasuraman defines people's readiness for technology as their propensity to embrace and use new technologies for accomplishing professional and private goals [20]. Others have characterized readiness in relation to innovation as involving people's beliefs, attitudes, and intentions, according to which they perceived the innovation as both necessary and manageable [1]. And in his diffusion theory, Rogers argues that people vary in their degree of readiness for innovation, as research continually shows there are large differences between the individuals who are innovative and those who lag behind [23]. The success of an innovation depends on the conditions under which it is introduced, the people who are exposed to it, and their perception of its usefulness. Rogers categorizes the readiness of people according to five specific types: innovators, early adopters, early majority, late majority, and finally laggards [23]. In this study, the construction of the two readiness types is done using attitude and experience parameters as mentioned above (see Section 3.1 for a detailed description of the construction of the types).

With reference to Rogers [23], Moore argues that the greatest barrier to the diffusion of innovation is when it has to spread from the early market segment, consisting of the technology-fascinated and visionary types, to the mainstream market, consisting of conservative and pragmatic types [18]. This is a cultural gap to be crossed, and it coincides with the transition between the two types, early adopters and early majority, in Rogers' diffusion model [23]. According to Moore, this gap is critical for the spread of an innovation and requires a holistic understanding of the transition to the mainstream market in order to make it a success [18]. In addition, Norman examined the differences between the early and the mainstream market, and found the innovative and technology enthusiasts are willing to make a tradeoff between deficiencies, difficulties in use, undesirable design, and high price of the technology, and their need for new stuff: better technology with more options [19]. In contrast, the group of people that adopt the innovation later are highly pragmatic and conservative when it comes to innovation, and they demand convenience, reliability, and low cost, whether or not the technology offers better technical quality.

In order to assess important differences, the aim of this article is to conduct a comparative analysis between workers with high and low degrees of readiness for robotics in health care. The research question is: What differences exist among groups with high and low readiness for living technology in health care? By exploring attitudes toward new types of technologies in health care, the aim is to provide critical success factors that may increase the likelihood of successful adoption of robotics, and thus living technology, in the health-care sector.

As living technology covers many types of needs and concerns many different parts of the care sector, it is desirable to obtain clarification of what is meant by "living technology." Living technology is defined as technology that shares fundamental properties with living systems, such as containing elements of self-organizing, purposeful action, or adapting to changing circumstances [2]. Examples of such living technology found in health care are the robotics presently used in operations, transportation, cleaning, and alleviating cognitive impairments.

The reason for categorizing such robots as living technology is that they offer flexibility and adaptability to their surroundings that are not caused by any external control mechanism, but by the ability of the robot to autonomously act on self-interest. Based on key features of living systems, this article defines living technology as robotics that possess the following lifelike elements: (1) the performance of tasks requiring independent capacities, (2) the presence of a sensory system, which puts the technology in contact with the surroundings, to inform about both the environment and the technology's own behavior, and (3) the presence of a feedback mechanism that allows the technology to adapt its future behavior based on past performance—a kind of learning mechanism. Following Bedau et al. [2], this definition places health-care robotics in the realms of both the "artificial" and the "natural" in that the technology is created through intentional human activity as well as having a life of its own.

In order to better understand the concept of living technology, Bedau et al. [2] not only make a distinction between three main synthetic methodologies in artificial life—chemical (wet), software (soft), and robotic (hard)—but also between primary and secondary forms of living technologies. Primary living technology is constructed out of components that were never alive (nor derived only from living organisms), and therefore are purely artificial. An example of the primary living technology in relation to robotics in health care is the artificial baby seal called PARO. This advanced interactive robot was developed by the Japanese manufacturer AIST. It provides a kind of animal therapy to patients in hospitals and other health-care facilities, but is used mainly to stimulate cognitively impaired elderly persons.

Secondary living technology depends on living components to function. Examples of robotics in health care that can be categorized as such are various forms of human prostheses such as the robot suit HAL. HAL is a cyborg device that helps improve a person's ability to use limbs by interception of nerve impulses—weak signals detected on the surface of the skin—sent from the brain to the muscles. It can be used in various fields, such as rehabilitation support and physical training support in medicine, and can also be used to support heavy labor.

In this article, however, no distinction is made between the two forms of robotics. Although the different forms of robotics should continue to be studied on their own terms and within their own research fields, there is a need to understand the increasing complexity that results from the emergence of new robotics in general.

2 Method

The data collection was conducted at the Health & Rehab fair in Fredericia, from May 12 to 14, 2009. The method used to collect the data is called the *consumer intercept survey*: the informants for this study were selected randomly and asked to fill out a self-explaining questionnaire (see Appendix 1) while passing by the interviewers. This data collection method has the advantage of the interviewer and the respondent being present simultaneously, so that it is possible to explain the factors relevant to completion of the otherwise self-administering questionnaire. This is especially useful when the target population, as in the case of this study, is not accustomed to filling out questionnaires of this magnitude and complexity. By providing thorough preliminary explanation to each participant, both verbally by the interviewers and with supporting video examples of the types of robotics in question, it led to fewer misunderstandings, incomplete forms, and incorrect responses.

The intercept survey method represents a way to get in contact with specific segments of the target population that would otherwise be difficult to survey. Furthermore, data collected through intercept surveys have proven to be of good quality [5, 9]. In addition, people feel more anonymous than in telephone interviews [5]. Although the intercept survey method has great advantages as outlined above, it should be noted that respondents are not necessarily representative of the given geographical area, and the data may be skewed because informants may want to impress the interviewer.

Generalizability is thus limited, but may increase as a larger number of respondents are included and information on the demographic composition may help determine how generalizable the data are. Nevertheless, it should be emphasized that in relation to the subsequent data analysis, the problem of representation was not considered a major one. The reason is that tests are conducted according to the readiness typology, which has emerged from a priori specified criteria, and are therefore independent of how the overall population is spread across each type in the typology.

3 Data Analysis

A total of 200 respondents participated in the study, out of approximately 7,000 visitors during the entire fair. There were continuously conducted preparatory data checks for logical errors. Then the respondents' answers were typed into SPSS for Windows, following a series of descriptive statistical tests for all variables and, wherever required, also tests of significance (F-tests). The survey data analysis method will mainly rely on cross-tabulations and tests of variance.

3.1 Development of a Readiness Typology (Independent Variable)

From the definitions of people's readiness for technology outlined in the introduction section above [1, 20, 23], the degree of readiness is in this study expressed by a typology consisting of a type labeled "high readiness" (HR type) and a second type labeled "low readiness" (LR type). In order to develop this typology, two variables from the questionnaire are used. The first variable is the attitude toward living technology in health care, and the other is experience with living technology (e.g., robots). Identifying readiness for innovation in this way is based on two assumptions. First, individuals who typically are the first to adopt are also inclined to adopt still more innovations [23]. In this study, this translates into the level of experience with living technology. Second, a more positive attitude toward living technology reflects a fascination with this technology, which particularly characterizes Rogers' innovators, but also the category of early adopters (see, e.g., [1]). In developing the HR type, respondents that fall in the attitude categories "somewhat positive" and "very positive" toward living technology are selected, which are 93% ($n = 183$) of the sample. Also selected for the HR type are respondents belonging to the experience categories "some experience" and "great experience" with living technology, which represent 17.1% ($n = 34$) of the sample. By extracting the subset of the two chosen variables and categories, a total of 31 respondents (16% of the sample) are finally selected in order to form the HR type. Those respondents not selected for the HR type are then assigned to the LR type. This second type consists of 167 participants, representing 84.3% of the sample. To sum up the two types, those in the HR type have a positive attitude as well as being experienced in the use of robotics, whereas those in the LR type hold a negative attitude and are not experienced in robotics.

Although the classification of two types used in this article does not correspond to Rogers' categorization, it can nevertheless be used as a typology of innovation processes, because, as Rogers [23] points out, innovation is a continuous concept, and discrete types are only conceptual tools in understanding this process. Thus, high-readiness and low-readiness types are in this study identified in a looser manner, through the theoretical selection of types in the data.

3.2 Developing Categories of Major Challenges

The data were assessed concerning the open response options: "In your opinion, what are the three most important challenges for applying new technologies?" in which people could list major challenges associated with robot technology in health care. A classification scheme was developed with 16 non-overlapping categories for a total of 412 answers (see Appendix 2). However, to strengthen the reliability of this categorization further, researchers might make a classification of answers to see if it matched the categories developed in this study. This would allow calculating the statistical compliance rate (percentage agreement statistic) for the coding of major challenges [21].

3.3 Characteristics of the Sample

This section describes and compares the two types in the typology with respect to demographic characteristics. First, descriptive analysis of informants' relations to the various care areas was carried out. As seen in Table 1, the two types have different composition of care areas. The HR type includes more respondents from elder care (+18%) and youth care (+12%), and the LR type has a larger percentage of consultants in assistive technology (+10%), specialties (+10%), and elder care in the home (+9%).

Differences between the two types are found in the composition of roles (see Table 2). The HR type has a higher proportion of managers (29%) than the LR type (9%). In contrast, the LR type has a larger proportion of consultants (51%) than the HR type (39%). The proportionally greater distribution of managers in the HR type than in the LR type is consistent with studies showing that early adopters typically have a higher job position in the organizational hierarchy [23]. The LR type is further differentiated from the HR type by containing users (8%).

Turning to the distribution of age between the two types (Table 3), it is worth noting that the older caregivers are more innovative, since there are significantly higher percentages of HR type over 50 years than of the LR type. This is not unexpected, as research has been unable to demonstrate that readiness for change increases or decreases as a result of aging [23]. However, what is in particularly interesting in relation to age is that both types, with high mean values of 5.39 for the HR type and 5.28 for the LR type, indicate that younger workers have a more positive attitude to robotics than older ones. This suggests that there exists a myth about youth and readiness for new technologies. More specifically, the informants' age for the HR type had a mean of 46.3 years and a median of 48.5 years, and for the LR type a mean of 42.4 years and a median of 43 years.

Table 1. Care types.

	Typology (*n*=)		
	High readiness	Low readiness	Total
Elder care	50% (13)	32% (41)	35% (54)
Home care		9% (12)	8% (12)
Handicap	12% (3)	12% (15)	12% (18)
Youth	19% (5)	7% (9)	9% (14)
Assistive technology	4% (1)	14% (18)	12% (19)
Specialist	15% (4)	25% (32)	24% (36)
Total	100% (26)	100% (127)	100% (153)

Note: Item labels are grouped occupational areas. $\chi^2 = 10.592$, $p < 0.06$.

Table 2. Occupation distributed over readiness categories.

	Typology (*n*=)		
	High readiness	Low readiness	Total
Care receivers		8% (12)	6% (12)
Nursing staff	32% (10)	33% (52)	33% (62)
Managers	29% (9)	9% (14)	12% (23)
Consultants	39% (12)	51% (81)	49% (93)
Total	100% (31)	100% (159)	100% (190)

Note: Item labels are categorization of care function. $\chi^2 = 4.559$, $p < 0.008$.

The respondents' gender and educational background do not differ between the two types of readiness. Women account for approximately 90% and men for approximately 10% of the sample. That there is no difference in educational level is atypical, since studies suggest that education is typically higher for the early adopters [23].

3.4 Critical Factors for Adoption

Table 4 presents mean scores and statistical differences segmented by readiness types. As can be seen from the table, only variables with statistical differences are included (see Appendix 1 for a complete list of variables in the survey), and they are remarkably few. There may be several explanations for this. First, widespread rational discourse may exist in health care due to its subjection to strong performance control, and such discourse may be used to flesh out quantitative goals in a language that favors a practical-functional perspective, rather than more subjective attitudes and norms. Second, when robotics in health care is debated, societal discourse of an economic and rational nature is often used, which may affect the perception of what is relevant in connection with these technologies. Third, the reason for the scarcity of differences may be sample bias, which translates into an overall more positive attitude to living technology than among the target population.

Overall, the HR type differs from the LR type on seven critical factors. First, with a mean of 4.74 ($p < 0.044$), the HR type attaches more importance to the interests of securing public safety when implementing robotics in the health-care sector than does the LR type, with a mean of 4.62. This is an important result, since it is generally believed that innovators and technology enthusiasts, that is, types involved in the early phase of the adoption process and similar to the HR type, are willing to take more risks and thus may compromise more on safety issues than types involved in later phases

Table 3. Age distribution on readiness categories.

	Typology (*n*=)		
Age (yr)	High readiness	Low readiness	Total
<50	50% (15)	70% (112)	67% (127)
>50	50% (15)	30% (48)	33% (63)
Total	100% (30)	100% (160)	100% (190)

Note: Item labels are age data grouped into age intervals, $\chi^2 = 17.462$, $p < 0.033$.

Table 4. Summary for statistical differences between readiness types.

Variable	High readiness Mean	High readiness S.d.	Low readiness Mean	Low readiness S.d.	*F*	Significance
Concern for public safety.	4.74	0.445	4.62	0.557	4.121	0.044
The newest technology has improved the working environment.	6.06	0.854	5.55	1.437	10.498	0.001
The newest technology provides ability to take care of oneself.	4.60	1.380	4.15	1.126	4.390	0.038
The effect of the newest technology is well documented among the best care organizations.	5.32	1.661	5.01	1.341	3.597	0.059
The newest technology is very important for the best care organizations' image and reputation.	4.29	1.918	4.36	1.473	5.102	0.025
The staff at the best care organizations explains exactly how the newest technology works.	4.55	2.030	4.61	1.397	10.967	0.001
You have contributed to the selection of the newest technology.	4.28	1.162	2.97	1.571	8.948	0.003
New technologies create insecurity among the nursing staff.*	4.35	1.959	3.68	1.439	8.026	0.005

Note: All mean values are on a 7-point scale (1 = absolutely disagree to 7 = absolutely agree) except in the last row. *Here the mean is on a 6-point scale (1 = not at all, 2 = to a low degree, 3 = to a lesser degree, 4 = to some degree, 5 = to a high degree, 6 = to a very high degree). All variables in the questionnaire (see Appendix 1) that are not significantly different are omitted from the table.

in the adoption process [19, 23]. This result shows that people in general (especially the HR type) are taking the safety measures quite seriously and are not willing to take chances.

Second, in connection with safety, the HR type pay greater attention to robot technology that creates improved working conditions for caregivers. Thus, the HR type attributes (mean = 6.06) significantly ($p < 0.001$) more importance to the work environment than the LR type (mean = 5.55). However, it is not only individual users and staff safety that are more important to the HR type; when it comes to robotics, providing better ability for care recipients to take care of themselves also matters significantly more ($p < 0.038$) to the HR type (mean = 4.60) than to the LR type (mean = 4.15).

Third, a weak statistical difference ($p < 0.059$) exists between the HR type (mean = 5.32) and the LR type (mean = 5.01) with regard to whether "the effect of the newest technology is well documented among the best care organizations." This fact seems to support the hypothesis that the HR type is focusing to a greater extent than the LR type on quality factors in relation to robot technology. A possible explanation for this difference is that the HR type, to a greater extent than the LR type, is involved in a decision-making process connected to robot technology and thus has a greater insight into the legal requirements.

Fourth, the LR type (mean = 4.36) is significantly ($p < 0.025$) more inclined than the HR type (mean = 4.29) to believe that robot technology has great importance for the image and reputation of the best care organizations. This may be due to a combination of an unclear understanding of technology's possibilities by the lesser experienced and submission to a discourse that favors new technology. Robot technology is, in other words, a signal of status and development.

Fifth, the LR type (mean = 4.61) is significantly ($p < 0.001$) different from the HR type (mean = 4.29) with regard to the belief that the staff in the best care organizations explain exactly the functioning of robot technology. This may be taken as an expression of the idea that innovation and training go together in the ideal situation.

Sixth, the HR type (mean = 4.28) participate significantly more ($p < 0.003$) in decision making connected with the selection of robot technology than the LR type (mean = 2.97). The fact that people of the LR type play a minor role in the introduction of robot technology may have a negative effect on their motivation for new technical solutions.

Finally, a statistical difference ($p < 0.005$) exists between the HR type (mean = 4.35) and LR type (mean = 3.68) with regard to whether robot technology creates insecurity among caregivers. To some degree this calls into question the general understanding of innovative types as risk-takers. This result shows that those in the HR type in the Danish health-care sector are more attentive toward others' needs and wants than otherwise could be expected of a group inclined to trade off technical quality of the technology for new features [19].

3.5 Sources of Information for Living Technology

When an innovation is going to be implemented in an organization, research shows the importance of how information about initial experiences is spread throughout the population [4, p. 321]. Therefore, this study examines various types of sources favored by the respondents when learning new technologies such as robotics (see Table 5). The respondents were asked the following question: "Where do you get your knowledge of new technical devices for health care?" The respondents could check one or more sources from a list containing mass media, branch letters, education, management, users, coworkers, and others. The most important source of information for both types is mass media (e.g., TV, WWW), with 58% for the HR and 61% for LR. However, the HR type view education (58%) as equally important, and for the LR type colleagues are almost as important (60%) as mass media. A notable difference (12%), though not statistically significant, between the two types is in relation to trade magazines, where 55% of the HR type as opposed to 43% of the LR type indicated that they used this source for new information on robot technology. In the overall assessment of information sources, attention should be paid to the relatively limited role of management, users, and caregivers in the spread of knowledge, although a χ^2 test of the two readiness types and the use of several information channels revealed that the HR type make significantly ($\chi^2 = 6.712$, $p < 0.01$) more use of their access to management than do the LR type.

Table 5. Sources of information about robotics.

	Typology (*n*=)		
Information channel	High readiness	Low readiness	Total
Mass media (TV, Internet)	58% (18)	61% (102)	61% (120)
Trade magazines	55% (17)	43% (72)	45% (89)
Courses and education	58% (18)	55% (91)	55% (109)
Management*	29% (9)	11% (19)	14% (28)
Care receivers/relatives	19% (6)	19% (32)	19% (38)
Colleagues	55% (17)	60% (100)	59% (117)

Note: Item labels are communication channels people use to acquire knowledge of new types of technologies in health care, such as robotics.

*The two types are significantly different at $\chi^2 = 6.712$, $p < 0.01$.

Table 6. Major challenges perceived in connection with living technology.

	Typology (*n*=)		
	High readiness	Low readiness	Total
Care receiver resistance	13% (4)	9% (15)	10% (19)
Personnel resistance	16% (5)	10% (17)	11% (22)
Participation	7% (2)	5% (9)	6% (11)
Cultural habits	13% (4)	10% (16)	10% (20)
Knowledge base	32% (10)	44% (73)	42% (83)
Insecurity	13% (4)	11% (19)	12% (23)
Human contacts	7% (2)	16% (26)	14% (28)
Service level	19% (6)	13% (21)	14% (27)
Effectiveness*	52% (16)	17% (29)	23% (45)
Implementation	16% (5)	11% (19)	12% (24)
Economy	26% (8)	31% (51)	30% (59)
Management**	10% (3)	0.3% (1)	2% (4)
Ethics	3% (1)	6% (10)	6% (11)
Legal issues	—	2% (3)	2% (3)
Time resources	13% (4)	8% (14)	9% (18)
Other	—	9% (15)	8% (15)

Note: Item labels are challenging hurdles that need to be surmounted when introducing robotics into health care (see Section 3.2 for an account of developing categories of major challenges).
*$\chi^2 = 17.462$, $p < 0.000$.
**$\chi^2 = 10.887$, $p < 0.001$.

3.6 Major Challenges for Robotics

Sources of resistance to robotics are revealed by the challenges they are perceived to present. Research has found that such resistance is not much related to the technique in itself, but rather due to general uncertainty about change per se [6]. Our studies support this, as can be seen in Table 6, which presents a list of major challenges as perceived by the respondents. Appendix 2 elaborates each entry in more detail, with examples of statements from the respondents. In descending order the most important challenges are associated with: knowledge (42%), economics (30%), effectiveness (23%), human contact (14%), and service (14%).

For the HR type, the most important challenge associated with robot technology is effectiveness. An entire 52% of this type falls into this category, which suggests a concern for quality and more measurable aspects of robot technology. This is followed by the need for knowledge (32%) and the economy (26%). The main challenge connected to robot technology for the LR type is knowledge (44%), suggesting a commitment to necessary training and technical knowledge. The second most important challenge is economic (31%). The main concerns here, as elicited from the respondents' answers, relate to the possibility of obtaining funding for applying new robotics.

For the statistical differences between the two types, a χ^2 test reveals that the HR type, more than the LR type, view efficiency (+35%) and management (+10%) as main challenges. In contrast, the LR type is more concerned with human contact (+9%) and knowledge (+12%), although the differences are not statistically significant. All in all, when the two types are compared with respect to perceived challenges, it appears that the HR type are more concerned with aspects of compliance with organizational requirements. In contrast, the LR type are more concerned with factors that involve education and norms of dignity in old age. One explanation for these differences in perceived challenges may be the mental stress of having to change behavior as well as learning to use living technology, which is a typical barrier for organizational innovation [29].

4 Discussion

It is generally believed that living technology, such as in various kinds of robotics for the health-care sector, may improve living conditions as well as stimulate the growth of technology as a way to cut overhead costs in a stagnant economy. The increasing interest in robotics calls for a study of people's readiness for adopting new technology.

This article has focused on the Danish health-care sector's potential for adopting robot technology, by undertaking a comparative analysis of groups of high readiness and low readiness. A comparative study of readiness is believed to be the best way to support change agents (national, regional, and local) with information on how to help the implementation and use of robot technology in the sector. Ensuring this connection between health-care actors and technical developers for the sector is an essential part of the marketing function, but also, when viewed in a broader societal perspective, hopefully will provide a better understanding of challenges and motivational factors that may lower costs and improve care. Although a general positive attitude toward robotics exists in the market, there are some discrepancies in perceptions between the HR and LR types, as revealed in this study.

The results of the analysis show that there exist a number of differences between the two types, which relate to behavior, attitude, and the importance of possible barriers. The first difference relates to the composition of types. It turns out that there are significantly more persons aged over 50 years in the group of high readiness than in the group of low readiness, despite the fact that in general the readiness types are biased in the opposite directions, namely, younger workers are more innovative than older workers. This suggests that a myth may exist concerning youth involvement in new technology.

Table 7 presents the main differences between the two types, which form a gap that arguably needs to be closed, if the interest in robotics is going to be spread rapidly and widely in the Danish health-care sector.

Table 7. Characteristics of types.

HR type	LR type
Older persons with involvement in management who are involved in decisions concerning living technology in the organization. They are mainly concerned with user and personnel safety, documentation, and autonomy; and less concerned with insecurity. The major challenges for adoption of living technology are associated with efficiency, economy, knowledge, and service.	Younger persons with less involvement in management and in decisions concerning living technology. They are less influenced by trade magazines and management, associate living technology with good image and reputation and with education, and perceive major challenges to involve human contact, finance, and knowledge.

With the knowledge presented here in a readiness typology, there is now a basis for a more nuanced approach to the actions that will provide the best effect on the deployment of living technology in the health-care sector. First, it is important to build support and understanding among individuals in the HR type and use them to advocate the benefits of robot technology among individuals in the LR type. The personal influence individuals in the HR type have on others because of their opinion-forming power can be an important factor in promoting new technology. Second, employee training in using robot technologies is necessary as support for the HR type's efforts in promoting, for instance, robotics. Living technologies may have difficulty penetrating the sector unless the LR type learn to use them effectively. Furthermore, change agents should be asking themselves: How ready is our customer? What communication programs do we have in place, and how can we react to workers' and users' demands? How do we communicate about specific needs? These questions are fundamental to supporting the adoption of living technology in the Danish health-care sector. If clear answers to these questions are provided, then the future for living technologies in all areas of health care looks promising.

4.1 Limitations and Future Studies

Although the intercept method was deliberately chosen for this study because it increases the possibility of collecting data from the sector's high-readiness respondents, who may be difficult to reach even with a large sample, it must nevertheless be stressed that the method has certain limitations with respect to generalization and bias that should be corrected in future studies of readiness for change. Future studies should seek to involve a larger share of skeptics, especially with regard to service improvements, in order to better balance the data. Also, one should seek to make the selection of respondents more random, so that possibilities of generalization may increase.

In this study the objective was to examine different types in terms of general characteristics across the entire sector. However, success in adoption is not just related to individual characteristics or readiness types, but also depends on the context in which the new technology takes place. Therefore, actors' local conditions in each organization play a significant role in adopting living technology. Such conditions, which cannot be deduced from the results presented here, require a local adaptation of the conclusions that this study suggests. In fact, contextual factors that influence the organizational framework in relation to readiness for change have been found to have great importance [12]. Future studies within the Danish health-care sector should therefore focus on creating better understanding of various types of local contexts, how they are composed, and what influence they have on the change process.

Apart from the importance of the local context for adoption, the technology itself—its types and properties—may also affect individuals' propensity to use it, as suggested by Rogers [23, p. 204], who writes, "much effort has been spent in studying 'people' differences in Innovativeness … but … relatively little effort has been devoted to analyzing 'innovation' differences." This is noteworthy, considering the importance that innovation has in adoption. According to Rogers [23, p. 206], between 49% and 87% of the variation in adoption is attributable to characteristics of the innovation. More specifically, whether a technical developer, an operator, or a manager is responsible for ensuring dissemination of innovations in a health-care organization, attention should be given to how robotics is perceived by those who are going to use it. Studies should in particular be concentrated on uncovering meaning associations and on the social strategies that have an influence on opinion formation [22]. Furthermore, the uncovering of meaning associations is related to a final point, namely, that local subcultures may influence the implementation process in various ways [24]—not explicitly, as by agreements between actors, but because of the social control mechanism in organizations, that is, rules of behavior gradually developed on the basis of workers' common values [27]. Such an influence may hamper the adoption of living technology if the technique goes against the set of common values. The likelihood that workers will accept the new technology will then be small, regardless of prior interest in living technology. Thus, the way that subcultures make sense of a living technology as they interpret the purposes and methods of a change becomes of vital importance [11]. To further understand the readiness for living technology in the Danish healthcare sector, the characteristics of these subcultures should be studied in more detail and from a sense-making perspective.

Acknowledgments
This research is supported by the Danish Ministry of Science and Technique as part of the Intellicare project.

References

1. Armenakis, A., Harris, S., & Mossholder, K. (1993). Creating readiness for organizational change. *Human Relations*, *46*(6), 681–703.
2. Bedau, M., McCaskill, J. S., Packard, N., & Rasmussen, S. (2010). Living technology: Exploiting life's principles in technology. *Artificial Life*, *16*(1), 89–97.
3. Bitner, M. J. (2000). Technology infusion in service encounters. *Journal of the Academy of Marketing Science*, *28*(1), 138–149.
4. Bloem, J., Boreel, M., & van Doorn, M. (Eds.). (2006). *Explorations in new technology.* Institute for the Analysis of New Technology.
5. Bush, A. J., & Hair, J. F., Jr. (1985). An assessment of the mall intercept as a data collection method. *Journal of Marketing Research*, *22*(2), 158–167.
6. Carnall, C. (2003). *Managing change in organizations* (4th ed.). Harlow, UK: Pearson Education.
7. Dautenhahn, K. (2007). Socially intelligent robots: Dimensions of human-robot interaction. *Philosophical Transactions of the Royal Society: Biological Sciences*, *362*(1480), 679–704.
8. Decker, M. (2008). Caregiving robots and ethical reflection: The perspective of interdisciplinary technology assessment. *AI & Society*, *22*(3), 315–330.
9. Dupont, T. (1987). Do frequent shoppers distort mall-intercept survey results? *Journal of Advertising Research*, *27*(4), 45–51.
10. Fong, T., Nourbakhsh, I., & Dautenhahn, K. (2003). A survey of socially interactive robots. *Robotics and Autonomous Systems*, *42*(3–4), 143–166.
11. Gallivan, M. (2001). Meaning to change: How diverse stakeholders interpret organizational communication. *IEEE Transactions on Professional Communication*, *44*(4), 243–266.
12. Graham, P. (1995). *Mary Parker Follett, prophet of management: A celebration of writings from the 20s.* Boston: Harvard Business School Press.
13. Leonard, K. J. (2000). Information systems for healthcare: Why we have not had more success—The top 15 reasons. *Healthcare Management Forum*, *13*(3), 45–51.
14. Leonard, K. J. (2004). Critical success factors relating to healthcare's adoption of new technology: A guide to increasing the likelihood of successful implementation. *Electronic Healthcare*, *2*(4), 72–81.
15. Leonard, K. J., & Winkelman, W. (2002). Developing electronic patient records: Employing interactive methods to ensure patient involvement. In *Proceedings of the 28th Meeting of the European Working Group on Operational Research Applied to Health Service (ORAHS)* (pp. 225–239).
16. Mann, W. C., Offenbacher, K. J., Fraas, L., Tomita, M., & Granger, C. V. (1999). Effectiveness of assistive technology and environmental intervention in maintaining independence and reducing home care costs for the frail elderly: A randomized trial. *Archives of Family Medicine*, *8*, 210–217.
17. Mansfield, E. (1969). *Industrial research and technological innovation*. New York: Norton.
18. Moore, G. A. (2002). *Crossing the chasm: Marketing and selling high-tech products to mainstream customers.* New York: Harper Collins.
19. Norman, D. A. (1998). *The invisible computer: Why good products can fail, the personal computer is so complex, and information appliances are the solution*. Cambridge, MA: MIT Press.
20. Parasuraman, A. (2000). Technology readiness index (TRI): A multiple-item scale to measure readiness to embrace new technologies. *Journal of Service Research*, *2*(4), 307–320.

21. Perreault, W., & Leigh, L. (1989). Reliability of nominal data based on qualitative judgments. *Journal of Marketing Research*, *26*(2), 135–148.

22. Pfaffenberger, B. (1988). The social meaning of the personal computer: Or, why the personal computer revolution was no revolution. *Anthropological Quarterly*, *61*(1), 39–47.

23. Rogers, E. M. (1995). *Diffusion of innovations* (4th ed.). New York: Free Press.

24. Schein, E. (1996). Three cultures of management: The key to organizational learning. *Sloan Management Review*, *38*(1), 9–19.

25. Shibata, T., & Wada, K. (2008). Robot therapy at elder care institutions: Effects of long-term interaction with seal robots. In A. Helal, M. Mokhtari, & B. Abdulrazak (Eds.), *The engineering handbook of smart technology for aging, disability, and independence* (pp. 405–418). New York: Wiley.

26. Tejima, N. (2000). Rehabilitation robotics: A review. *Advanced Robotics*, *14*(7), 551–564.

27. Tompkins, P. K., & Cheney, G. (1985). Communication and unobtrusive control. In R. McPhee & P. Tompkins (Eds.), *Organizational communication: Traditional themes and new directions* (pp. 179–210). Thousand Oaks, CA: Sage.

28. Venkatesh, A. (2003). Smart home concepts: Current trends. In *I.T. in the home*. Center for Research on Information Technology and Organizations, UC Irvine. http://www.escholarship.org/uc/item/6t16p6pf

29. Weick, K. (1990). Technology as equivoque: Sensemaking in new technologies. In P. Goodman & L. Sproull (Eds.), *Technology and organizations* (pp. 1–44). San Francisco: Jossey-Bass.

Appendix 1: Variables Included in the Survey

Variables marked with an asterisk are used in this article, because in them a statistically significant difference exists between readiness types.

A1.1 Background Information

- Which care field are you employed by/associated with.*
- Type of relation to health care.*
- Age.*
- Sex.
- Education.

A1.2 Innovativeness

- General attitude to the use of the newest technology.*
- Degree of experience with the newest technology.*
- Concern for safety when using the newest technology.
- Concern for public safety.*
- Perception of the speed of technical development.
- You have contributed to the selection of the newest technology.*

A1.3 Information Channel

- Your source of knowledge concerning the newest technology in health care.*

A1.4 Discomfort

- The newest technology makes heavy demands on the training of workers.
- The newest technology has improved the working environment.*
- New technologies create insecurity among the nursing staff.*
- Management has a more positive attitude toward the newest technology than other staff.
- Younger employees have a more positive attitude to the newest technology than older employees.
- The newest technology has improved services in the organization.
- The extent to which problems are associated with the selection and introduction of the newest technology.
- The newest technology has been an irritation and unpleasant.

A1.5 Ideal Outlook

- The best care organizations have the newest technology available on the market.
- The best care organizations are committed to the newest technology and smart design.
- The best care organizations have a staff that has extensive knowledge of the newest technology.
- The staff of the best care organizations explains exactly how the newest technology works.*
- The staff of the best care organizations is never too busy to help with the newest technology.
- The best care organizations meet individual needs with the newest technology.
- The effect of the newest technology is well documented among the best care organizations.*
- The newest technology is very important for the best care organizations' image and reputation.*
- The best care organizations prioritize the newest technology higher than personal contact with the user.

A1.6 Future Challenges

- The three biggest challenges for the application of the newest technology in health care.*

A1.7 General Impressions

- Increased use of the newest technology will improve care.
- Increased use of the newest technology will make care more efficient.
- The introduction of the newest technology has improved your daily life.
- The newest technology is aligned with user needs and quality of life.
- The extent to which the newest technology has replaced traditional ways of performing care.
- The newest technology has affected loyalty among caregivers.
- There were concerns in advance about the newest technology.
- The newest technology gives more freedom to the individual care recipient.
- The newest technology provides the ability to take care of oneself.*
- The newest technology leads to better documentation.

Appendix 2: Major Challenges in Connection with Living Technology

Challenges	Examples of respondent statements
Care receiver resistance	"Mindset" among users
	That care receivers know how to use living technology
	Technical skills on the part of the user
Personnel resistance	Devotion to interpersonal aspects of nursing
	Motivating the staff
	Convincing the staff that living technology is safe
Participation	Getting everyone to be dedicated to the process
	To have both users and staff committed to implementation
	User involvement
	Involving care receivers
Cultural habits	Overcoming old habits
	Elderly employees tend to do as they have always done
	Prejudices among staff and users
	Culture and attitudes
Knowledge base	Technical skills of staff
	Everyone gets optimal training
	To educate caregivers
	Optimal use requires knowledge/training
Insecurity	That all become familiar with the technologies
	Courage to use
	Confidence in technology
Human contacts	Maintain personal contact
	Human contact is replaced by technology
	Accommodate user needs for human contact, and care

Appendix 2: (*continued*)

Challenges	Examples of respondent statements
Service level	That the public wants, needs, and safety are met
	Better service for the individual
	More quality of life for residents
Effectiveness	Making sure that the technology is actually available and easy to learn to operate
	To identify areas where it is most appropriate
	Simple to use
	For the benefit of users, staff, security
Implementation	That it is being implemented so that all benefit
	Integrating living technology into the nursing sector
Economy	Financial support by the municipality
	Convincing the budgetary authorities in the municipality
	Price
Management	That politicians know what they want from it
Ethics	Equality
	Dignity for all
Legal issues	Laws and regulations in relation to the use of technical devices
Time resources	Taking time for all to learn to use the new technology
	Time for implementation
	Time for reflection