A Multidisciplinary Concept to Evaluate Acceptance of Innovative Domestic Technology

BY

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ABSTRACT

This paper describes a concept to measure acceptance of smart home solutions, developed in a diploma thesis, which was funded by Electrolux Group. The first implementation was developed especially in regard to the process of food preparation in households, which bears complex relations of household-technology interaction; i.e. to regard sociological, technological and physical impacts on everyday life.

Merging approaches from sociology, home economics and information technology, a set of criteria is developed that attempts to cover the diverse aspects and is intended for practical use. Tests persons were shown three virtual scenarios for food preparation and asked to evaluate these.

BACKGROUND

Technology acceptance is defined as a combination of a person's attitude towards technology, the actual use of technology in the household and the patterns of acquisition of appliances. Further acceptance depends on the context, and observed acceptance does not necessarily have to cope with expected acceptance [9][8][7].

However technology acceptance is defined, in practice acceptance factors have to be known that are relevant for the purpose. When exploring acceptance of solutions for domestic food management, it is necessary to describe food management first.

Food management

At first sight, domestic food preparation is a chain of physical activities, a part of the "household production". Household-technology interaction takes place. Several authors agree that it consists of a broad range of activities like meal preparation, consumption, washing dishes, grocery and shopping and involves technologies like "kitchen appliances, automobile, computer, home-shopping". [10]

Thus, food management is defined here as all activities related to planning, acquisition, storing, preparation, serving, consumption and clean-up.

At the second sight, food management is more: Besides the global functions of households, several social, cultural and psychological aspects characterize it as well. [4]

Food management - as most other domestic processes - is characterized by its physical dimensions (place, resources), its technical dimension and its social dimension (household group, culture). See figure 1. "The meeting point of these three define how families carry on their everyday life".[13][14].

Smart cooking - food management supported by advanced technology -

can offer a connection between appliances, but also a connection between surrounding systems. With the bridging possibilities of information technologies, new dimensions of appliance use arise: For example, internet ordering and home delivery establish the connection between the planning, the acquisition and the storing.

Acceptance factors

Aspects of acceptance in a broader sense have been researched, but few to none sources are available to determine consumer acceptance on specific products in sociotechnical environments.

The major source of acceptance factors are the works on technology dependable design. Yet technical aspects are not the only to be considered (see below) and there are numerous undiscovered, direct and indirect effects implicated with the use of technology when it comes to interaction between humans.[12][1]

It should be mentioned that some factors may have similar contexts and some might not be applicable in all cases. Selected factors are explained in the following.

The social space

Concepts reflecting the social dimension of technology use in households considers approaches ranging from systems theory, social constructivists, new-home economists, to time budget studies. Later, these approaches have been adopted by computer science. [12][10]

Processes and timing functions: The possibility to save time or to waste time is an important aspect in dependability, namely ”Availability”. The ability to save time is also mentioned as characteristic of smart home and is a way to improve household work. [12][9][11]

Affects on health: How is the use of the solution expected to affect health? This non-technical characteristic of technology is surely worth being examined, as it is a public concern. Earlier research reveals ”health” as an important aspect of smart home, too. [5][9]

Information and overview: Gathering and evaluating information is a part of household management. Thus transparency is a key requirement as well of the interface as of the solution when providing information to its user. Educative aspects are taken into regard as well. [2]

Patterns and routines: ”Technology [...] should promote patterns and routines that are already established within the home.” Also, patterns of relationships between humans and things reveal the patterns of technology usage as well. ”Individual freedoms” are demanded from usable systems to adopt to user needs. [6][2][12]

Communication: As the household, especially the kitchen, is the family activity center, the influence on communica-

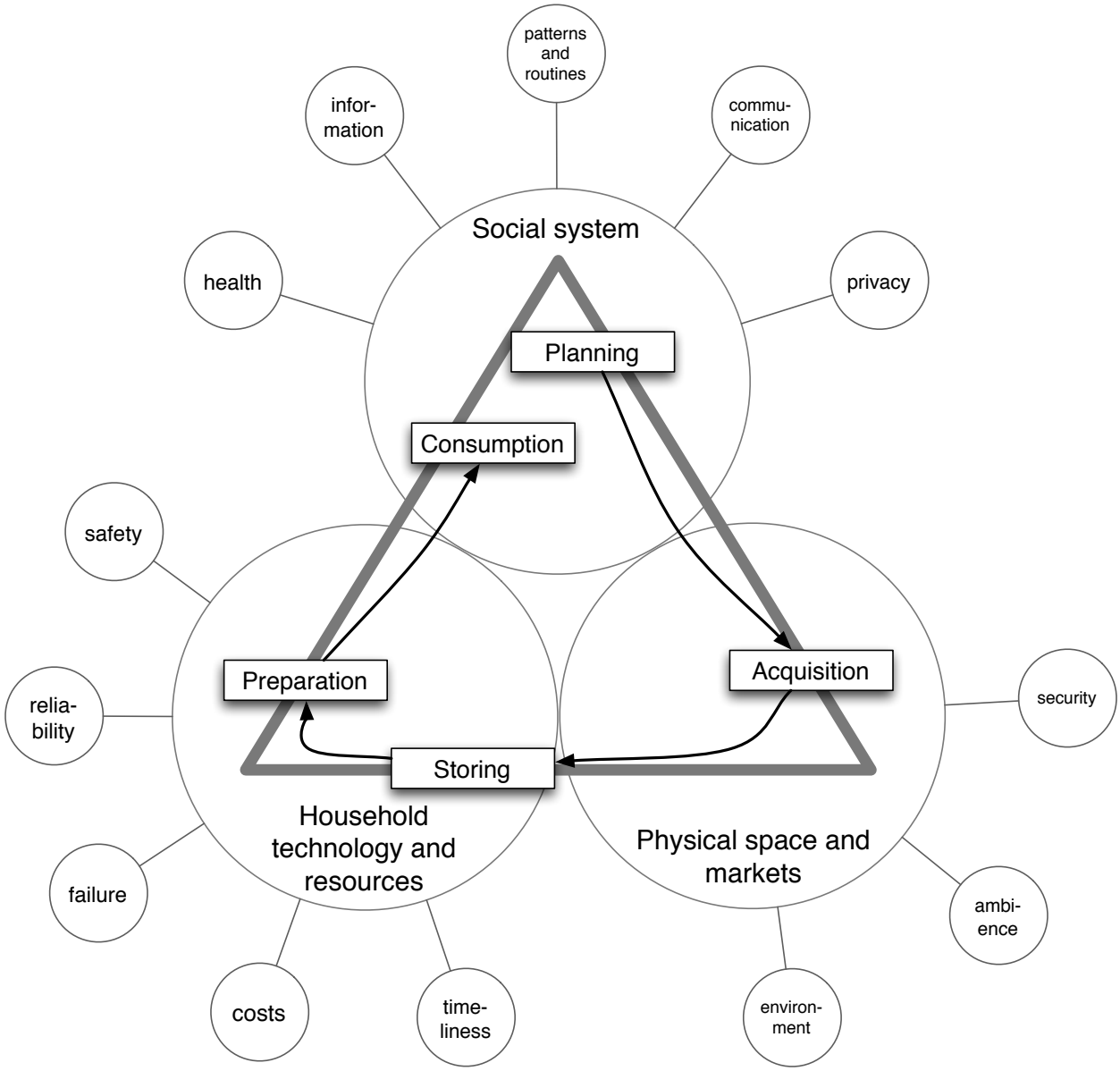

Figure 1: Food management in the context of living spaces, extended after [13] and [14]. Only the measured factors are shown adjacent to each living space.

tion between humans is regarded as well. In the case of food management, it is not only the communication between family members, but also between the household and vendors, deliverers and servicemen. [4][10]

Privacy: There is a ”surprisingly high” number of people that feel hampered by an increasing transparency of private areas. This might influence the success of such models: ”Users grapple with their desire for new forms of access and con-

trol versus their worries about losing traditional forms of control, such as the privacy of the home." [9][10]

Entertainment The brown goods industry makes many efforts to bring entertainment into smart environments and this is what some people expect from Smart Home. [9]

The technological space

The technological space of the household gains "particular importance" in smart home environments. [13]

Reliability can be seen as the probability of failure-free system operation over a specified time in a given environment for a given purpose. In other words: How far can a user trust a system, and how far is he willing to trust it? [12]

Utility and usefulness determine whether "the functionality of the system in principle can do what is needed". Usefulness is utility in daily life: "Will the technology remain useful for a considerable time or become redundant?". Other authors describe this as "ease of everyday life". [12][9]

Security has become an important aspect of networked computing, and since smart systems will probably be connected as well, they are opposed to similar threats as computers. Therefore, security is an essential prerequisite for availability, reliability and safety. [12]

Safety: Do failures have worse effects with today's system, the same, or are they less harmful? Dependency from systems can be felt severely when failures occur; therefore it is important to know how the test person thinks about being dependent of the system.

The physical space

Environmental effects: Protection of the environments is not a fundamental aspect of food preparation, but some people might think about effecting their environment by using the system.[9]

Ambience is affected by the presence of technology. How it is perceived depends on its user and on the emphasis laid on the asthetics/design of his environment.

METHODOLOGY

Recruited test persons have been given a brief introduction into the world of smart cooking. Then three scenarios have been presented to them. Due to the lack of real prototypes the test persons were presented a slideshow with texts, photographs and films of real ones.

Scenario "Good Morning": This is a concept intended to be used for planning of the breakfast, the preparation of it and partially for consumption. It has been presented as an alarm clock that starts appliances like toasters or the coffee machine at programmed times.

Scenario ”Smart storage” is the concept of an intelligent fridge that recognizes contents and use-by dates and additionally is able to place orders automatically to replenish the stock.

Scenario ”Live-In kitchen”: Live-In kitchen is an Electrolux prototype offering remote control of appliances over a central PC (in the kitchen, see figure below). In the presentation, features of cooking-related content have been added. The image below gives an impression:

Data collection

After each presented solution a questionnaire had to be filled in to evaluate and weigh each factor. The approach is to divide perception into cognitive and affective components, therefore each factor is split into two measurings. First, the ”evaluation” factor of the shown system, secondly, the ”importance” of it; i.e. how much the test person requests of it. [3]

Once having gathered this data, the affective component (a) and the cognitive component (c) are multiplied.

$$B = \sum^{i} a_i c_i \qquad (1)$$

The sum over (i) products is an indicator for the expected acceptance B for the test person.

After having presented the solutions a free interview was held with the test persons. Most welcomed the chance to express their opinions and thereby provided a means to control the results of the questionnaires.

Evaluation

The test persons have been categorized into consumer segments, both from hard (gender, age, household type) and soft criteria (attitudes - the Electrolux consumer segmentation model). The first is presented here in extracts.

Figure 2 shows the distribution of the parts of the acceptance sum for the smart storage scenario and segmentation by age.

RESULTS

The sample of test persons consists of 38 persons (21 f. / 17 m.), aged between 20 to 70 years. The sample further contains 15 members of single households, 12 members of empty nest households, 8 family members and only 3 dinks (”double income no kids”).

Applying the segmentation models it can be seen that the household type correlates to the test person's age. Therefore if household types are examined, it should be kept in mind that results are probably influenced by age as well.

Gender differences

Comparing the views of the two genders to the prototypes, several differences appear. The female ratings spread wider, the male ratings appear more concentrated in the slightly positive area.

Within negative acceptance sums, it is remarkable that obviously the worst perceptions only appear with females. Also the best perception is from a female person, although positive perception seems equally distributed between the genders.

Outstanding is the ”Live-In kitchen” prototype, which seems to separate the females into several groups, while the male rate it exceptionally good. A closer look reveals that men expect a much better savings of time and appreciate communication features while women reject these. Vice versa, women expect the Live-In kitchen to support their patterns and routines better than men expect it. Information and overview features are rated extremely well in both groups.

Age differences

Higher benefit is expected more from younger persons than from elders. Nearly 75% of the younger rate neutral to positive. As with the female group, the acceptance of elders varies more than of the younger, and again also negative perception can be found in this group.

This observation also applies to the single prototypes. Only the ”Good Morning” prototype is evaluated similarly. Both Smart Storage and the Live-In kitchen are perceived very positively by younger and slightly negative by the elder.

The most remarkable differences appear with Smart Storage, which is shown in figure 2. Most aspects of this solution seem to be shifted towards the negative area for the elders, though the maxima do not differ that much.

The most remarkable aspect is usefulness: Persons under 40 years of age see a good usefulness for the Smart Storage, while older persons merely reject it.

Dividing by household type

Keeping in mind that the household type roughly corresponds to age the expected can be seen: Singles seem to have a high acceptance, Empty Nest households a rather bad acceptance. Ignoring the small sample size, families, surprisingly, show the most positive acceptance.

Generally, singles and families rate all prototypes quite good and empty nest members rate all worse, but an outstanding observation is that the ”Good Morning” prototype is perceived positively by the empty nest members. Even possible

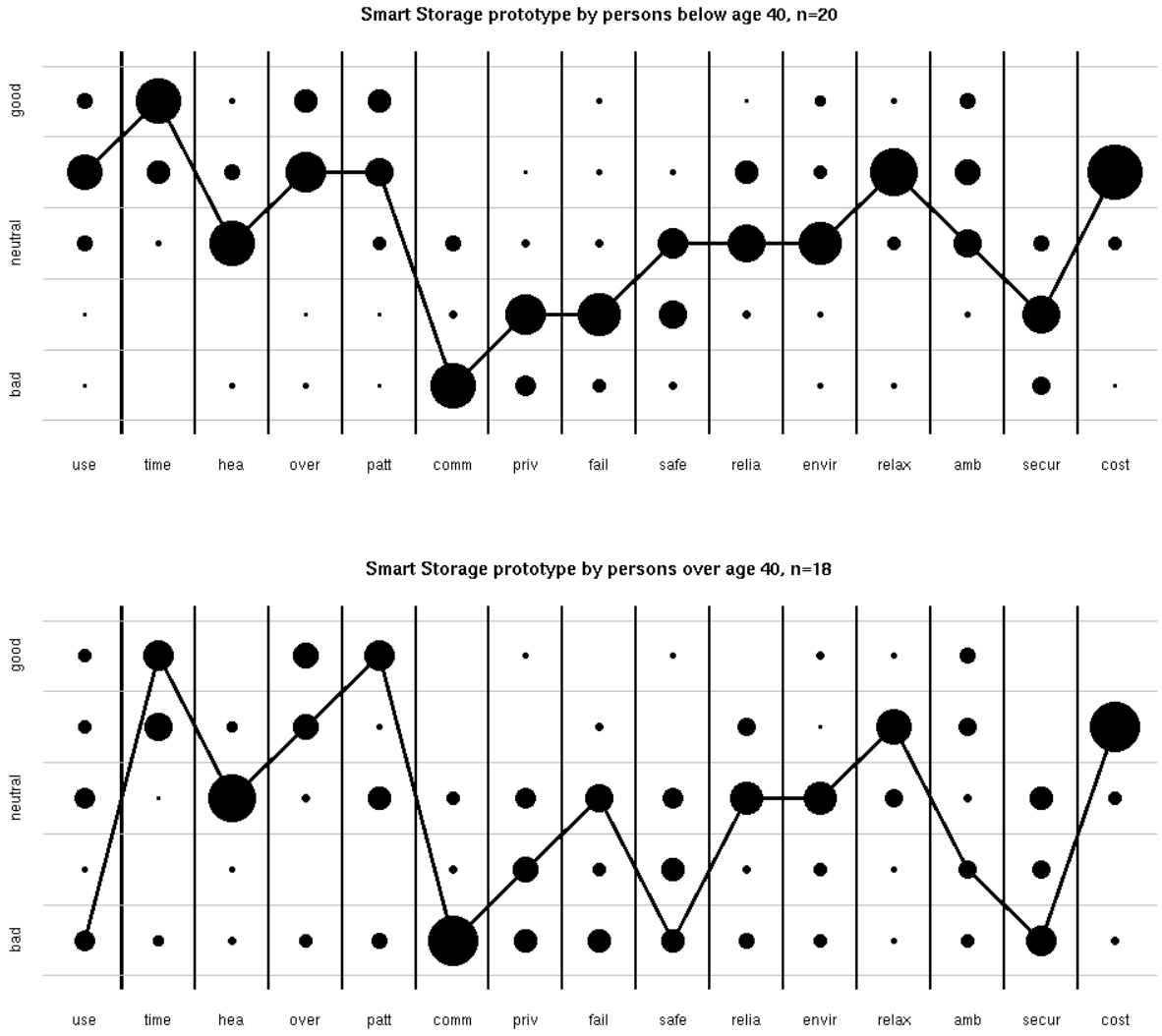

Figure 2: Acceptance factors for the Smart Storage divided by age . The top graph shows perceptions of younger persons, the bottom graph those of elders. The position of the circles in a column indicates the evaluation (effective) part. The bigger the radius of a circle, the more people weighed it ”important”. The maxima are connected with a line. Abbreviations: use=usefulness, time=timeliness, hea=health effects, over=overview, patt=support of patterns and routines, comm=communication, priv=privacy, fail=impacts of failures, safe=safety, relia=reliability, envir=environmental effects, relax=relaxation, amb=ambience, secur=security, cost=expected total costs of ownership

threats like loss of privacy and safety are rated better.

SCENARIO PROFILES

Good Morning

The average acceptance of this solution is better than those of the others, with a relatively concentrated spreading of the total benefit values.

Especially security and relaxation are perceived much better compared to the other solutions, and the aspects of dependability are most often rated neutrally instead of negatively.

This observation also corresponds to the statements the test persons made during the interview, where positive opinions prevail.

Chances are seen in automatic processing; i.e., comfort and saving of time. Several mentioned the ready-made coffee and presence simulation.

Issues Several persons expected that the programming preparation in the evening consumed too much time. Network connection was unnecessary. Also, persons see a high liability and low security. It is requested that the coffee machine should only start if filled; i.e. requests high safety from the system.

Smart Storage

Smart Storage is appreciated more by females and persons under 40 years of age, but throughout all divisions the upper 50% of the benefit sums lie in the neutral to slightly positive range (excepted the empty nest members).

It is remarkable that the majority of test persons believe that communication and personal relations deteriorate. Security is perceived negatively as well.

Furthermore, the potential to save time is seen by most groups; also, the potential to support their life patterns and routines. Even empty nest members expect to save time, but feel that their overview on the everyday life affairs will become worse.

Chances are seen in delivery. The management of the shopping list in combination with an intelligent cart at the supermarket is appreciated. The recognition of use-by dates and the reminding functions are perceived positively as well.

Issues: Some interviewees fear support of lazyness, decreased communication, loneliness or degeneration. The creation of the shopping list is seen too complicated and in some test persons' opinion does not justify the outcome.

Consequences of failure or intrusion were seen as very bad by three persons, network connection in general was rejected by two persons. Surveillance of the deliverer is feared by one person. A

few persons also felt that spontaneous shopping became impossible and shopping fun would get lost.

Live-In kitchen

The Live-In kitchen evaluation is contrary to the Smart Storage evaluation concerning the genders. Male persons perceive it very positively, while females rate it most differently. The worst possible evaluation is found in the female group, too. The age comparison looks similar: younger like the LiveIn kitchen very much compared to indecisive elders.

Time savings, overview, ambience change and relaxation features are seen quite positively. The reliability of the system is estimated slightly positive, regardless of the division method. Again, this does not apply to empty nest members.
The dependability issues (safety, consequences of failure, security, privacy loss) appear to be the trade-off again.

Chances: Information and overview are appreciated by many interviewees, especially the calculation of the remaining process time, the recipe database and the help system. Meal schedules are requested by one person. The central control is welcomed by one person, and another person expects to save time.

Issues: The main concerns observed are impacts of failure and dependence. Networking is rejected and in one case intrusion feared.

Post-interview talks

Several test persons declared themselves as rejective to technology; fewer expressed their interest in new and maybe experimental technology explicitly. At least two persons said that technology cannot be judged beforehand; it has to be tested by use and operation. That is the hurdle that has to be taken, then success brings fun.

A major concern seems to be dangers introduced by networking. Many people fear being spied upon or manipulated through networks. Furthermore, some state that a whole new system meant too much change in life and ”experience can never be replaced by technology”.

CONCLUSION

The measured criteria show differences between the solutions as well as between groups, and the findings mostly correspond to results of other research. Further, these differences reflect the test persons’ opinions as expressed in the personal interviews afterwards.

Summarizing the approach, it can be concluded that it may be useful in acceptance research. The profiles as a visualization of the acceptance of specific factors are easy to read and to compare, even for people who are alien to the subject.

Future improvements include the refinement of the measured factors and

taking into account the further aspects like usability, availability, repairability, learnability, configurability, openness or standardization (as far as feasible).

Future tests will be carried out using a real prototype, maybe with a reference solution, but in no case three solution for different purposes of food management at a time. The intention is to have the test persons perform tasks like preparing a meal. Simulating a real situation, the results are expected to become clearer and more reliable.

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