What Help Do Older People Need? Constructing a Functional Design Space of Electronic Assistive Technology Applications

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ABSTRACT

In times of ageing populations and shrinking care resources, electronic assistive technology (EAT) has the potential of contributing to guaranteeing frail older people a continued high quality of life. This paper provides users and designers of EAT with an instrument for choosing and producing relevant and useful EAT applications in the form of a functional design space. We present the field study that led to the design space, and give advice on using the tool.

Categories and Subject Descriptors

K.4.2 [**Computers and Society**]: Social Issues – *assistive technologies for persons with disabilities*; D.2.1 [**Software Engineering**]: Requirements/Specifications; D.2.2 [**Software Engineering**]: Design Tools and Techniques – *modules and interfaces*; D.2.11 [**Software Engineering**]: Software Architectures – *patterns*; D.2.13 [**Software Engineering**]: Reusable Software, I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence – *intelligent agents*, *multiagent systems*.

General Terms

Design, Languages, Theory.

Keywords

Older adults, Needs, Field study, Design space, Interactive agents, Software components, User involvement.

1. INTRODUCTION

It is a widely shared vision that electronic assistive technology (EAT) for older people has the potential to make a decisive contribution to coping with today's and tomorrow's demographic challenges of ageing populations. In view of shortages of formal and informal care resources, electronic devices may, added to human assistance, help a frail older person maintain (or even improve) quality of life, and increase independence in daily living to allow *ageing in place* (not having to move to an institution).

However, it is as of yet unclear how far research and development have come in fulfilling this vision. As of now, EAT is not applied on a large scale. On the one hand, users do normally not know the state of the art. On the other hand, designers – who are the ones to make the vision of EAT real – are still quite left alone when it comes to theoretical knowledge that would guide their creativity towards producing devices that are needed and useful.

In this paper, we intend to make a contribution to a better understanding of EAT application design both by users and by designers, in the hope that this can facilitate choosing and (co-) producing EAT in the future. By constructing a functional *design space* of EAT – an overview of possible applications – we intend to provide users and designers with an instrument for their tasks in design and with a common frame of reference when discussing EAT. We present the field study that led to the design space, and give advice on using the tool.

2. MOTIVATION

This section assumes the roles of users and designers of EAT, arguing from each perspective for the introduction of more empirically founded theory into the area.

2.1 The View of the User

We hear comments from carers like 'This is Utopia. Maybe in 50–100 years.' about a standard smart home scenario, or 'Certainly exciting, but I think it's an application that is a 99% disregard of the needs.' about a training software. Elders and caregivers may not be aware of what technology can do today. Or if they are, they may want different things. As Bouma et al. write, 'technology is developing so rapidly that it is practically impossible for older people to say exactly which innovations they would appreciate.' [3, p. 196] Few surveys of EAT exist. These tend to emphasise either technology [6] or needs [11]. More knowledge is needed on the mapping between these in order for users to be able to actively request the products they want.

2.2 The View of the Designer

The responsible EAT designer planning a new application will not be blinded by the latest technology opportunities, but first ask for

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elders' needs, and collect requirements. Unfortunately, only a few reusable studies of requirements are available. Haigh et al. [7] present quantitative results for their multifunctional aid I.L.S.A. The 22 identified features are a good starting point, yet only a selection from initially almost 300 ideas. They are not described in detail except for their implementation. Studies by Intel [13] do document detailed qualitative results in terms of needs and ideas for appropriate assistance, albeit restricted to cognitive decline. Rogers et al. [14] show functional limitations in healthier elders. Their report is rich in needs, yet interventions are discussed from a human factors point of view, emphasising training and redesign. More knowledge is needed on designing new products.

2.3 Problem Statement

What is needed is a common frame of reference for users and designers that would map aspects of life that old people tend to value to the products that would support them. [3] What are relevant applications, and what strategies make them work? Successful designs for older users need to be documented [18] and presented in a form that both users and designers can understand and use. This paper makes an effort towards this goal by constructing a design space of EAT applications, a structure that collects and interrelates choices that a designer can make.

3. DESIGN SPACE

A number of formal approaches to the exploration of *design rationale* (why is a design chosen?) and the construction of design spaces (what designs *can* be chosen?) have been proposed. We chose to follow an adapted version of the approach of Lane and Asada et al. (in [15]). It allowed us to express design rationales that argue for an artefact or application of EAT because its way of assisting fits the supported user need. Here, we will not argue for a specific application, but instead assess the bigger picture: What applications are possible, and which of these have the potential of benefiting different older people?

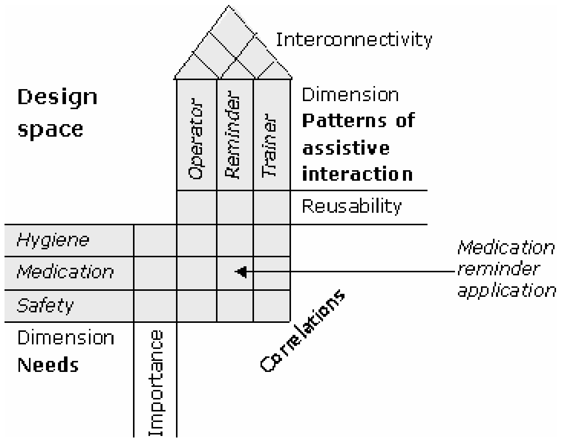

Figure 1: Features of the design space

Figure 1 introduces the general features of our design space notation. *Dimensions* relate to basic questions about a design. Here we have two dimensions. The y-axis explores the question: What *need* of an elderly person does an application support? The x-axis stands for the question: By what means, i.e. by what *pattern of assistive interaction*, does it support a need? Supported needs can be chosen on the basis of their *importance* for older people. Patterns can be chosen on the basis of their *correlation* with the need to be supported (i.e. how well does the pattern fit the need?) and on the basis of their *reusability* (i.e. how many different needs can it support?). A designer aiming for more complex applications may want to connect different patterns. *Interconnectivity* indicates how well two patterns fit together. Not considering such connections, a chosen application design is a pair of one chosen need and one chosen pattern.

3.1 Dimensions

We defined two dimensions for two basic questions that a designer ought to get straight before creating an EAT application: (1) What need does it support? (2) By what means does it assist? These are very basic dimensions to result in a (relatively) small *functional* design space [15]. They should allow for a first 'reality check' when choosing or producing EAT: Are the products that I want available? Are chances good that my product will be of use? Inclusion of further dimensions – e.g. technical details or the user interface – was left for future work. It will require new decision-supporting features, e.g. dependability criteria [10] or usability.

3.1.1 Needs

A need relates to a difficulty or an interest of the user, e.g. an activity of daily living (ADL [8]) such as *hygiene*, an instrumental activity of daily living (IADL [9]) such as handling *medication*, or a more general desire such as *safety*. These are *alternatives* in the needs dimension. They have been entered into Figure 1 as three examples. In creating an EAT application, the designer would choose (at least) one such alternative as the supported need.

3.1.2 Patterns of Assistive Interaction

A pattern of assistive interaction relates to the means by which an application assists. In Figure 1, three examples of patterns have been entered as alternatives: *operator*, *reminder*, and *trainer*. In creating an EAT application, the designer would choose a pattern to support the chosen need (more on patterns in Section 4).

3.2 Choice of Applications

A chosen application can be characterised by a pair of need and pattern. Figure 1 holds 9 empty cells for 9 such pairs, i.e. possible applications. When creating a *medication reminder*, a designer would go for the alternative to support the need *medication*, and for the alternative to do so by means of *reminding*.

What are 'good' choices of applications? The features importance, correlations, reusability, and interconnectivity come to help. For each of these, values based on empirical evidence can be entered. These values may represent qualitative or quantitative statements.

3.2.1 Importance

How important is a certain need for frail older people's quality of life? We can ask such general questions despite the *dynamic diversity* [5] of older adults, since we assess the multitude of possible applications. Of course, for a certain user one would have to ask how important the need is for that particular person. As an example, the designer of the *medication reminder* may have known from evidence about the (supposedly) high importance of the need *medication* for older people's quality of life.

3.2.2 Correlations

What is a good pattern of assistive interaction to support a certain need? Maybe the above designer also knew that a (supposedly) good strategy towards medication adherence is to *remind* the person. This would mean a high positive correlation between *medication* and *reminding*.

3.2.3 Reusability

How many needs can a pattern support? Maybe the *reminder* pattern has a high reusability, and our designer can also use it to support *safety*.

3.2.4 Interconnectivity

Which patterns can be interconnected to form a complex application? One might want to connect a *reminder* with an *operator*. Think of an electronic pillbox that gives off an alarm signal *and* hands out pills automatically when it is time.

4. PATTERNS OF INTERACTION

Before we start instantiating the design space, what are these patterns of interaction, and how do we use them in defining interactive EAT applications?

Patterns of interaction (e.g. [4, 16]) are used to inform analyses of design spaces of human-centred systems with qualitative field study data. They are inspired by pioneer work of Alexander [1] and related to *design patterns*. Yet, patterns of interaction describe real-world social situations rather than prescribing technical solutions. Patterns of interaction can act as a *lingua franca* (common language) among actors in a design process. [4]

Our design space grounds on the assumptions that (1) needs of older people can successfully be supported by applying certain recurring strategies of interacting with an elder, and that (2) these patterns are comparable for the social situation of a human assisting and the usage of an assistive technology device. We further assume that a pattern is generic in the sense that one pattern can support different needs. In addition, a particular pattern will be more suitable to support certain needs than other needs. This idea of generic patterns in care is related to the model of selective optimisation with compensation [2], which identifies three generic strategies towards successful ageing (selection, optimisation, compensation). In our work, we employ a more fine-grained classification. For instance, one of our patterns is 'reminding an elder to do something'. This would be a special form of 'compensation' for a shortcoming in memory. A human caregiver might remind his or her client that it is time to take medicine. There are also traditional assistive technology (AT) artefacts for similar situations, e.g. pillboxes. Then there is EAT, e.g. an electronic pillbox with an alarm signal – a *medication reminder* in Figure 1. A pillbox that hands out pills automatically implements an *operator* pattern. A *medication trainer*, e.g. an interactive video, would assume the role of a doctor or nurse teaching his or her patient a medical procedure.

5. RESEARCH QUESTIONS

In the following sections, we construct a functional design space of EAT applications for elders. Based on the definitions and assumptions above, we empirically identify alternatives, and assess importance, correlations, reusability, and interconnectivity.

In order to instantiate the empty design space (the grey cells in Figure 1), the following questions are to be answered:

1. What are the *needs* of frail older people?
2. Which of these are of high *importance*?
3. How can needs be supported, i.e. what *patterns of assistive interaction* can be employed? (by means of human help, traditional AT, and EAT)
4. Which patterns support which needs, i.e. which pairs have a high positive *correlation*?
5. Which patterns support many needs, i.e. have a high *reusability*?
6. Which patterns support needs together with other patterns, i.e. have a high *interconnectivity*?

Since this is early work aimed at defining basic theoretical concepts, we were mainly looking for qualitative answers to these questions, e.g. in the form of taxonomies or narrative descriptions. Quantitative data was collected for Research Questions 2, 4, 5, and 6, though mainly to back up the qualitative results.

6. INITIAL ASSUMPTIONS

To obtain a focus for data collection and a preliminary coding scheme for data analysis, a set of initial assumptions was generated for Research Questions 1 and 3, based on a literature analysis. We arrived at lists of 21 categories of needs and 10 patterns of assistive interaction. A slight update after the pilot study (cf. Section 7.1) resulted in

- 20 needs categories: *personal hygiene*, *dressing*, *using the toilet*, *mobility*, *kitchen work/eating & drinking*, *using technology*, *shopping*, *laundry*, *cleaning*, *physical work outside*, *other housekeeping*, *handling medication*, *administrative tasks*, *health*, *safety*, *emotional concerns*, *social contact*, *recreation/creativity/education*, *physical difficulties*, *cognitive difficulties*,
- and 15 patterns of assistive interaction: *monitor*, *locator*, *mediator*, *operator*, *guide*, *recommender*, *informer*, *trainer*, *supplier of activities*, *communicator*, *reminder*, *rememberer*, *listener*, *speaking/writing aid*, and *hearing/reading aid*.

When compiling the results, needs and patterns that would not have become apparent in our investigations would be erased from the lists. Additionally encountered patterns would be added. Due to the complexity of everyday life and the dynamic diversity among older people, we were rather expecting that we would have to extend our lists than to drastically cut them. This would be fine, since we were interested in obtaining and retaining a good design space from which to choose and produce artefacts for a variety of users (and not in finding the next 'killer application').

7. METHOD

In order to answer the research questions and thus to obtain a foundation of the design space to construct, we needed empirical data. This could have been a survey of existing EAT. Yet, our premise was that we are not certain whether the state of the art already provides the needed applications. Thus, we opted for a field study that would take us to settings of older adults' everyday life and to workplaces of caregivers. At home care services, assisted living facilities, retirement and nursing homes, we would encounter needs and patterns in their natural context, i.e. independently of EAT usage. By looking at human assistance first and at human-machine interaction later, we prioritised a process-oriented view of the referent system (older adults' everyday life) over a product-oriented view. This is a suitable approach when designing human-centred systems. [4] Design would be application-driven, rather than technology-driven.

We mapped the research questions to the following list of practical questions to informants.

1. What are typical everyday life interests and difficulties common among frail older people? What are reasons for moving to a care institution?
2. What assistance do carers give? What assistance would they like to give, but lack resources for? What assistance do they not like to give?
3. What traditional assistive technology (AT) is used?
4. How do informants judge relevance and usefulness of existing and potential EAT applications? (Groups 2–5)

7.1 Data Collection

We were interested in the experiences of researchers, caregivers, and last but not least older people themselves. While caregivers were selected from a wide range of institutions to represent various kinds of assistance, we chose elders that received a moderate amount of assistance, but otherwise could actively take part in a conversation and give clear informed consent. (Participation and disclosure of information happened purely on a voluntary basis.) We thus opted for groups of healthier residents of retirement homes. These would also include people that might have been able to remain at their original homes had they been given 'good enough' EAT. Since we had contacts in two countries – Sweden and Germany –, we decided to use them, in order to not restrict results to a specific care system or culture.

The groups of informants were:

1. 19 researchers at 2 Swedish ageing research institutions (considered a pilot study for method validation).

   Questionnaires for Informant Questions 1–3. Presentation of short film clips with care scenes related to 10 patterns (to effect recognition/lively narratives).

2. 15 caregivers at a German home care service. Work tasks included light care, leisure activities, and general everyday services.

   Questionnaires for Informant Questions 1–4. Presentation of short film clips of 15 patterns. For Question 4 presentation of a use-scenario (user with early dementia in a kitchen environment) and the design of a multifunctional computer-based kitchen aid (*safety monitor*, *guide*, *communicator*, *operator*, *trainer*, *reminder*, and *food preparation guide*, *trainer*; this was later implemented [10]).

3. 4 German caregivers of a home care service, 2 retirement homes, and a nursing home. Work tasks: care, leisure activities, administrative work.

   Focus group interview (almost 3 h). Presentation of film scenes as well as use-scenario and design. General discussion of existing and potential EAT applications.

4. 6 caregivers at a German retirement home. Work tasks: care, leisure activities, general everyday services.

   Individual interviews (30–45 min). Presentation of a patterns poster (to help recall their recent work shift), use-scenario and design. General EAT discussion.

5. 7 elders at the same retirement home, 1 at a German assisted living facility. Mean age: 85, all female.

   Individual interviews (30–90 min) about interests, difficulties, and a 'typical' day. Presentation of use-scenario and design. Discussion of existing EAT that might suit the informant's needs (interests/difficulties).

6. 14 elders (70–95 years old, mostly female) and various carers at a Swedish retirement home.

   Participatory observation (using a method of 'quick and dirty' ethnography [4]) during 3 days. Complementary interviews.

7.2 Data Analysis

Analysis of questionnaires and transcripts was a two-phase process. Since data ranged from large amounts of short, general comments (questionnaires) to fewer, but rich individual narratives (interviews) and rather detailed observations, we first gathered results for each of Informant Groups 1–6, then integrated these.

To answer Research Question 1, we collected all needs that were indicated for all informant questions over all groups. Our initial assumptions proved to be good, but it was soon clear that they were only high-level concepts. It was more appropriate to structure needs in a hierarchy of super- and sub-categories. By doing so, we obtained many new alternatives in the needs dimension of the design space.

To answer Research Question 2, we determined which needs had been identified as most important by each group when answering Informant Question 1. There was no point in calculating an overall ranking, since we received very different answers, depending on informants' backgrounds. We grouped these needs by qualitative categories instead.

For Research Questions 3–6, we coded all data regarding Informant Questions 2–4 as pairs of one need and one pattern. Sometimes, two or three patterns were included, namely when patterns appeared in combination (a sign of interconnectivity). Initially assumed patterns would have been deleted from the design space if they had appeared only rarely. There were no such rare patterns, though. Instead, new patterns had to be introduced where no assumed pattern fit, thus adding new alternatives to the patterns dimension of the design space.

Since this initial study was not extensive enough to make confident and representative quantitative statements, we determined correlations and interconnectivity in qualitative terms. '●' stands for a high positive correlation (cf. [15]) or high interconnectivity. For a certain pattern, we looked through all coded need/pattern pairs, and considered the needs. If a need was among the more frequent needs (high quantity) or among the more comprehensively described needs (high quality) or had a medium quantity and quality for that pattern, the respective need/pattern correlation became '●'. If neither of these was true, but the need had occurred at least once, the need/pattern correlation became

'O' – a low positive correlation. For needs not encountered with the pattern, no correlation was noted. An analogous procedure was applied to pattern/pattern combinations to find high and low interconnectivity. Reusability of a pattern became the number of top-level needs categories with which the pattern has some positive correlation. Both correlation and interconnectivity results were entered into the design space.

Each found pattern was further assigned a *validity ranking*. [1] We identified for each of the six informant groups (1) which patterns had the highest positive correlations, and (2) which patterns had the highest reusability (using intermediate results from the process above). A high validity (2 asterisks) was then assigned to the patterns that excelled in this way 8–10 times. A medium validity (1 asterisk) was assigned to the patterns that excelled 3–5 times. A low validity (no asterisk) was assigned to those that excelled less often.

Finally, we conceived a simple pattern language that would make the results accessible to users and designers. It includes examples from the field study for human assistance (a quote), AT usage (all mentioned devices), as well as promising EAT (all discussed designs and applications that received positive comments). Note that the selection of EAT is biased, since our presented design covered only certain needs and patterns. Plus, discussion of existing and potential EAT was based on ad-hoc assessment of informant needs and the interviewer's knowledge of applications.

8. RESULTS

As a whole, the design space is too large to be printed here. Figure 2 shows a subset for the 3 needs and 3 patterns of Figure 1.

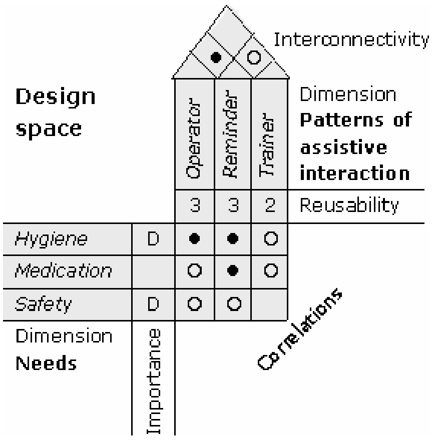

Figure 2: Instantiated design space

The resulting needs dimension (y-axis) is given in Table 1 in the form of a hierarchical taxonomy. The deeper in the hierarchy, the more specific a need category is. Classifying a certain need as a *medication times* need would mean to classify it as a *handling medication* need as well. Notice that *laundry* became a two-dimensional category, and *administrative tasks* became a three-dimensional category. A need 'understanding the mail from the health insurance' can thus be specified as ⟨*cognitive*, *home-based*, *authorities*⟩. One could wonder whether further data would have resulted in dimensions like physical/cognitive over all needs. In fact, the Canadian Model of Occupational Performance [17] is a three-dimensional needs model with a physical/cognitive/affective dimension – however not in relation to a concrete taxonomy.

Table 1: Needs taxonomy

Personal hygiene: Washing/bathing; Brushing teeth; Hairdressing; Shave

Dressing

Using the toilet: Physical toileting; Cognitive toileting

Mobility:

- Physical: Walking & walking aids; Walking environment; Transferring
- Cognitive: Public transportation; Navigation

Kitchen work/eating & drinking:

- Eating & drinking: Physical eating; Times; Nutrition; Menu
- Kitchen work: Food preparation – Physical; Doing dishes
- Kitchen environment: Food storage & consumption; Kitchen locations

Using technology:

- Telephone: Number length; Key size; Physical telephoning; Costs
- Other: Computer; Electronics; Clock; Assistive technology; Kitchen appliances; Bathroom appliances; Credit card

Shopping: Grocery; Pharmacy; Clothes; Gifts

Laundry: {Physical; Cognitive} × {Washing machine; Drying; Tumble-drier; Ironing; Clothes management}

Housekeeping: Cleaning; Tidying; Physical work outside; Sewing; Curtains; Light bulbs; Bed; Garbage

Handling medication: Medication times; Pillbox; Procedures; Effects

Administrative tasks: {Physical; Cognitive} × {Home-based; Offices; Visits; General knowledge} × {Bank; Post; Authorities; Care services; Finances}

Health:

- Vital signs • Diseases & wellbeing: Diseases in general; Own diseases
- Medical staff: Medical contact; Medical appointments; Emergencies

Safety:

- Safe environment: Safe static environment; Safe dynamic environment
- Falls • Crime

Emotional concerns: Encouragement; Identity; Comfort; Feeling at home; Deaths

Social contact: Communicate; Visits; Group activity; Birthdays; Friends

Recreation/creativity/education: Walks; Excursions; Cemetery; Nature; Games; Puzzles; Sports; Making music; Dancing; Painting; Handicrafts; Reading; Creative writing; History; Radio; TV; Video; Theatre; Religion; Reminiscence; Discussions; News; Courses

Physical difficulties:

- Sensory: Seeing – Near, Far; Hearing
- Motor: Writing; Reaching; Bending; Lifting; Carrying; Moving things; Using ladder; Opening & closing – Containers, Letters, Doors, Windows
- Exercise

Cognitive difficulties:

- Memory: Prospective memory; Remembering
- Talking; Problem solving; Declarative knowledge; Orientation
- Routines: Waking up; Daily routine
- Deviating and dangerous behaviour: 'Wandering'; Other behaviours
- Living environment: Static living environment; Dynamic living env.
- Losing things: Money; Glasses; Handkerchiefs; Alarm; Tools

The ‘D’ in the importance cell of two needs in Figure 2 stands for an importance group. Considering the focus group’s summary of Informant Question 1 and the needs that were mentioned the most by informants with certain backgrounds, we found strong relations between our data and Maslow’s classic hierarchy of needs [12]. We thus grouped those high-level taxonomy needs indicated to us as most important accordingly: see the bold-faced pyramid contents in Figure 3 (headlines such as ‘meaningful activities’ are labels for such groups that are frequently used in literature).

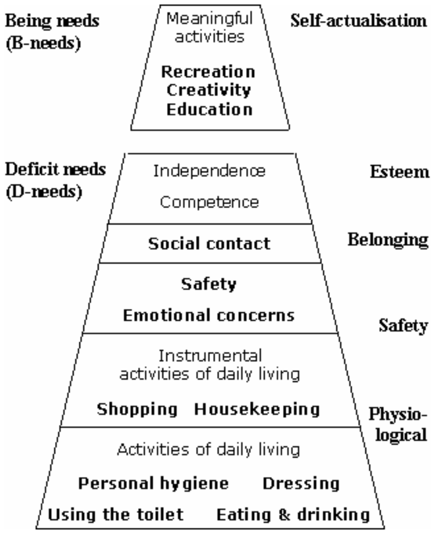

Figure 3: Importance of needs

A main idea in Maslow’s theory is that needs exist on different levels. In striving for quality of life, lower-level needs must be fulfilled before a higher-level need can be fulfilled. In particular, certain *deficit needs* (‘D’) must be satisfied before one can strive for a *being need* (‘B’). While this view can be criticised – e.g. all elders we met had an interest in recreation and creativity –, an important realisation is that certain needs are more *immediate* (the lower ones), while others are more *meaningful* (the higher ones). Which needs should EAT support? It depends. Which needs can your user(s) still care for on their own? Which needs are assisted by human help? For instance in Group 6, (I)ADLs were well cared for, but elders desired more support of higher-level needs.

Our study was not meant to give the definite answer to the importance question. Figure 3 includes those high-level taxonomy elements described to us most often or as most important. This need not mean that a need without a ‘D’ or ‘B’ in the importance column (Figure 2) is of no importance. *Health* and *mobility* were almost included. Had we asked physicians, *health* would certainly have appeared in Figure 3. In fact, Haigh et al. [7] identified *health*, *mobility*, and *handling medication* as the top needs. Thus, no need was dropped; just the importance cell was left empty.

The resulting pattern alternatives (x-axis in Figure 2) are the 15 initially assumed ones plus 3 new patterns: *reinforcer* (praising a person), *participator in activities*, and *supplier of objects*.

In Table 2, we present those eight patterns of interaction that were most valid (they excelled in correlations or reusability in a group at least twice) in our simple pattern language. For each pattern, we included the highest correlation and interconnectivity values (i.e. normally all ‘●’ values) as well as the reusability value. Due to space limitations, we had to exclude diagrams that define the patterns (see Figure 4, left, in Section 9.2 for the *operator*).

9. DISCUSSION

It was obvious in our field study that there are shortcomings in care. Some of the worst stories we heard in interviews involved residents being drugged or immobilised just because there is not enough staff for keeping an eye on them. Then there are cases of elders who, due to a lack of time, are cared for, e.g. washed, while sitting on the toilet. On the other hand, we talked to an old woman who did not believe in ageing in place (which EAT promises to enable). She moved to a home voluntarily for the social contact.

Promising EAT that might help overcome problems exists or is being developed. When discussing applications with elders and caregivers, certain trends in attitudes towards such technology became visible. *Operator* (having the carer do a task) is the dominating pattern in human care, often due to a lack of time – it is faster. Carers criticise this, and would rather allow elders to do more themselves. Interestingly though, in EAT (at least for *safety* needs) a majority prefer a high-automation *operator* application over a low-automation *guide*. Many carers imagined interactive guidance as too demanding for users. They would mostly want it for mentally fit people or in addition to human guidance. Several carers described a general *telecare* model where the user could contact a human assistant via video as a desirable alternative.

Our design space can help identify needed EAT. Yet, in its current form it contains 142+ applications (out of 18 high-level needs × 18 patterns = 324), and is not very handy. Fortunately, there exists a more compact form of this structure: the set of all needs and patterns alternatives together with their correlations. A set of 18 + 18 = 36 alternatives is more manageable. This is where the instrument becomes useful for choosing and (co-) producing EAT.

9.1 The Use for the User

For users, we can generate a catalogue of existing and potential EAT from the design space. The language of needs and patterns would act as a lingua franca ‘spoken’ at the ‘interface’ between user and designer. When choosing products, a user would – together with an expert in assessment and intervention – pick a number of needs plus a number of positively correlated patterns, and thus describe on a high level what kind of assistance he or she wants. This will further work when involving users in design. Of course, such a catalogue must be very usable, and include clear guidelines and clear definitions of the design alternatives. It must further be easy to extend. In our own Virtual Companion project [10], we define an *instantiation process* for multifunctional EAT that allows users, carers, and experts to describe personalised EAT by needs, patterns, and personal data. Needs and patterns correspond to reusable *software components*, which can be assembled by designers. Our long-term vision is to support users’ descriptions by a software toolkit that would automatically generate the code of personal ‘companions’ from their selections.

9.2 The Use for the Designer

The designer obtains guidelines for making informed decisions when planning a new product. For a start, he or she would choose an important need of the respective user group, and create an artefact that assists in the spirit of a positively correlated pattern. With time, designers would gain experience, and update or refine

Table 2: Patterns of assistive interaction

(1) **OPERATOR** ** Caregiver does a difficult task him- or herself. **Sample:** 'Shopping is done by my daughter, and by the institution on shopping day. I give them a list, and they go shopping.' **Correlations:** Personal hygiene, Transferring, Kitchen work/eating & drinking, Shopping, Laundry, Housekeeping, Administrative tasks, Motor (all ●, **Reusability:** 15) **Interconnectivity:** MONITOR, REMINDER (both ●) **Used AT:** Microwave, dishwasher, person lifter, automatic door **Promising EAT:** Home automation for safety (e.g. turning off tap or cooker, regulating temperature), washing/bathing robot	(2) **MEDIATOR** ** Caregiver makes a difficult task easier to do. **Sample:** 'When I walk alone, I am insecure. I'm afraid I could fall. During winter, I only go out with my daughter. The carers take me to the hairdresser. If there were more staff, I would go out more.' **Correlations:** Dressing, Physical toileting, Walking & walking aids, Transferring, Physical eating, Telephone, Housekeeping (all ●, **Reusability:** 12) **Interconnectivity:** OPERATOR, RECOMMENDER (both ○) **Used AT:** Cane, walker, wheelchair, lift, letter opener, book holder, stocking puller, forceps, handhold, trapeze bar, basic magnifying devices, 'feeding cup'; Automatic bed, chair; Simplified toilet, scales, toothbrush, scissors, shoehorn, plate, telephone, games **Promising EAT:** Simple phone, magnifying devices (near and far)
(3) **SUPPLIER OF ACTIVITIES** * Caregiver offers an activity. Elder and caregiver engage in the activity. **Sample:** 'We have bowling for the demented. It is not that difficult. We use soft balls (…) and – amazingly – people who otherwise can't move a finger (…) somehow they're all capable of bowling.' **Correlations:** Kitchen work, Shopping, Group activities, Recreation/creativity/education, Exercise, Memory (all ●, **Reusability:** 8) **Interconnectivity:** RECOMMENDER (○) **Used AT:** Guitar, games, jigsaw puzzles, gymnastics apparatuses, books **Promising EAT:** Electronic crossword puzzles, mental exercise games, and the like	(4) **COMMUNICATOR** * The elder needs to talk to somebody. The caregiver identifies the person, and contacts him or her. **Sample:** 'A blind and weak woman had two daughters in the States, with whom she talked regularly. Dialling was difficult, so we did this for her. We checked every 15 min if she was still telephoning.' **Correlations:** Using technology, Administrative tasks, Medical staff, Communication (all ●, **Reusability:** 11) **Interconnectivity:** MONITOR (●) **Used AT:** Internal calling system, mobile phone, external alarm **Promising EAT:** Reachable alarms with quick response times, urgency indication for staff, and possibility of voice input; Videophones and chat for social contact; Telecare by video contact
(5) **LISTENER** * The elder tells something about his or her life, and the caregiver listens. **Sample:** 'They talk about their children, the garden, their husband, war experiences, Christmas, … – so far I haven't experienced anyone who would not want to talk.' **Correlations:** Emotional concerns, Communication, Reminiscence (all ●, **Reusability:** 5) **Interconnectivity:** None (but helps caregiver in general) **Used AT:** Institution newspaper **Promising EAT:** Virtual community for sharing life stories and producing oral history	(6) **MONITOR** * Caregiver watches over elder or the environment. When something unusual is noticed, the caregiver reacts. **Sample:** 'Since you know people's behaviour, you look what Mr X is doing, is he all right? But it cannot be preventive. You look into a room, 3 sec later someone can fall. Or he's been lying there for 2 h.' **Correlations:** Health, Safety, Deviating and dangerous behaviour (all ●, **Reusability:** 11) **Interconnectivity:** OPERATOR, COMMUNICATOR, GUIDE (●) **Used AT:** Blood pressure, smoke detector, external alarm **Promising EAT:** Detector for food boiling over or scorching, monitoring of kitchen appliances with text/sound warnings to prevent accidents (divided opinion about relevance and cognitive demand), fall detector, warnings in traffic, warnings about intruders
(7) **REMINDER** Caregiver notices that a time has come or a situation has occurred, and reminds elder of something to be done. **Sample:** 'I leave a note "Tomorrow you'll be showered" on the night table for 24 h. Otherwise they'd already be finished then.' **Correlations:** Personal hygiene, Eating & drinking, Medication times, Administrative tasks, Medical appointments, Recreation/ creativity/education, Cognitive difficulties (all ●, **Reusability:** 12) **Interconnectivity:** OPERATOR (●) **Used AT:** Calendar, notes, pillboxes **Promising EAT:** Electronic cues that remind of safety precautions (e.g. 'Turn off the cooker' after cooking food)	(8) **GUIDE** Caregiver explains how to do a difficult task. **Sample:** 'And then of course the classic case of the remote control, which, even if it's for the hundredth time, is explained. Where to turn on and off the TV.' **Correlations:** Mobility, Kitchen work, Using technology, Administrative tasks, Cognitive difficulties (all ●, **Reusability:** 14) **Interconnectivity:** MONITOR (●) **Used AT:** Written instructions, map, signpost **Promising EAT:** Interactive assistance in food preparation (like a radio or TV cook) and maybe emergencies (but divided opinion about relevance and cognitive demand)

the design space, adding concepts and applications. In actual design work however, one should not have to interpret the design space over and over again. This is why in our own work we map patterns of assistive interaction to EAT design patterns (i.e. typical EAT behaviours), and then needs and design patterns to reusable and connectable software components. Figure 4 shows this mapping for the *operator* pattern in a UML notation.

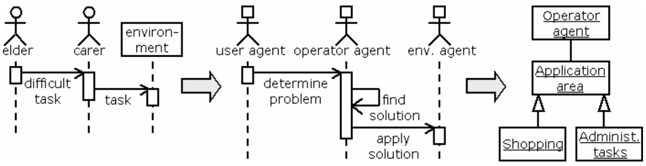

Figure 4: From patterns to software components

The mapping works since in the project we design EAT as systems of *interactive software agents* whose behaviour is – to a certain degree – inspired by the human interaction. Components relate to needs (*application areas*) and patterns (*functions*, i.e. the agents, e.g. an *operator* agent). From these, a designer can e.g. build both, a *shopping operator* (e.g. an online shopping application) and an *administrative tasks operator* (due to the high reusability of the *operator*). We further exploit interconnectivity of patterns by defining multi-agent design patterns (applications that combine functions), such as *reminder-operator*. Thus, one can also build an *administrative tasks reminder-operator* (relying on the high interconnectivity of these patterns). For more details of our *generic multi-agent architecture* see [10]. It is intended as a foundation for a toolkit for users, caregivers, and experts (cf. Section 9.1), which would reduce the workload of designers, and make user involvement in design feasible on a larger scale.

10. CONCLUSIONS AND FUTURE WORK

In order to provide users and designers with a common frame of reference, we have constructed a functional design space of EAT applications. We described the field study that led to the instrument, and gave advice and ideas on how it can be used.

As this was early work defining basic concepts, we will be refining the content and extending the dimensionality of the design space in the future. Already from the collected narratives and observations, we can learn more about human-human patterns of assistive interaction and their implications for human-machine interaction. Further data will be collected in experiments with realistic applications built and personalised for users on the basis of the design space. If the instrument indicates to scale to a variety of older adults, we can attend to the vision of a toolkit based on it.

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