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Design and management features of everyday technology that challenge older adults.

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Introduction

Technology has changed our society and the way we live our lives and perform everyday activities (Emiliani 2006, Nygård 2008, Selwyn 2004). Everyday technology (ET) is a concept that has been defined as the variety of electronic, technical and mechanical equipment that exists in the daily life of a person (Nygård and Starkhammar 2007). Technology has become a self-evident part of everyday activities, however, it has been questioned whether this technological society of ours is able to include all citizens to be active and participating (Emiliani 2006, Selwyn 2004). People with disabilities or older adults with a lack of interest or ability to upgrade their technological possessions and skills are at risk of being excluded. Moreover, studies of people with cognitive impairments due to dementia (Nygård and Starkhammar 2007, Nygård, 2008) or stroke (Lövgreen Engström et al 2010) have shown that these people experience difficulties in managing ETs. The results from these studies highlight the importance of investigating the challenges that people with cognitive impairments may face in their performance of daily activities when using ETs, in order to understand how these difficulties might influence participation.

Difficulties in managing everyday technology

Little is known about what specific features make an ET more or less difficult to handle during its use. Previous research focuses on the difficulties that older adults with and without cognitive impairments encounter when using ETs. These studies have used approaches that investigated the participants' performance by observing the management of an ET during its use in particular activities (Malinowsky et al 2010, Malinowsky et al 2011) or their perceptions of the difficulty of ETs via interviews (Nygård 2008, Rosenberg et al 2009a). However, to our knowledge, research using an innovative approach that seeks to unveil how the situation and activity interact with and influence the difficulty of an ET has not been carried out. Therefore, in this study, the point of departure and frame for the analysis is the actual situation and activity of managing an ET, rather than the self-reported perceptions. A hierarchy of more or less difficult ETs, based on how they were actually managed in everyday life, has been described previously (Malinowsky et al 2011). This hierarchy is herein analyzed within the context of the everyday activities in which the ETs are actually used. This

approach could be called activity-centred, meaning that the artefact, namely, the ET, has to fit into the requirements of the overarching activity (Norman 2005). This activity-centred approach could give us more general and extended knowledge about what challenges users, particularly people with cognitive impairments, may face when using ETs in their everyday activities. This knowledge could be useful for developing new technologies or ET-solutions in activity-centred design processes (Norman 2005). Furthermore, healthcare professionals, for example, occupational therapists, need to understand the difficulties that their clients, such as people with cognitive impairment or dementia, face in carrying out everyday activities in order to be able to provide better ET interventions with the goal of enhancing their participation.

Previous findings have indicated that people with dementia (Nygård and Starkhammar 2007) and stroke (Lövgreen Engström et al 2010) experience difficulties following the sequences of actions an ET may require and there is need for more knowledge of what skills and actions that are required for managing ETs. Research has also shown that, for people with dementia, the performance of everyday activities may be facilitated by the use of their visual, tactile and auditory senses (Nygård 2004). A similar finding was obtained by Lewis et al (2008), who compared the use of two microwave ovens with different interfaces (dial and button interface) and found that the microwave oven with a dial interface that gave more tactile and visual feedback during use was easier for older adults to manage than the microwave with a button interface. It is thus of interest to investigate what perceptual stimuli and feedback of ETs with different levels of difficulty will provide for the user and how the feedback can facilitate the activity performance.

The use of technologies in everyday activities

In this study, the Model of Human Occupation, MoHO (Kielhofner 2008), is used as a frame to comprehend the dynamics of the management of ETs in everyday activities. MoHO describes “the doing” as a dynamic system consisting of several components: the environment we live in, the habits and roles we have, the underlying abilities we possess, and the values, interests and self-images we have (Kielhofner, 2008). The quality of performance is related to the underlying capacities of the person (Kielhofner 2008). Consequently, people with cognitive impairment due to dementia or mild cognitive impairment (MCI) may face more challenges in their management of ETs than older adults with no cognitive impairments (Malinowsky et al 2010, Rosenberg et al 2009a). An ET can be part of the habitual performance of everyday activities, like shaving in the morning or sending information to colleagues using e-mail. A recent study indicated that habits strengthen the ability to manage ETs in old age; the results showed that ETs that were used less than once a week were more difficult to manage than those used more often (Patomella et al 2011). Furthermore, Nygård (2008)

found that motivation to use an ET and the need to use it were highly important factors for the ability of individuals with dementia to use an ET. According to the MoHO, the environment can be both enabling and hindering for a person with disability. ETs with a complex design have been found to be more difficult to handle for people with and without cognitive impairments (Malinowsky et al 2011, Patomella et al 2011). However, occupational therapy theory has been criticised for being too dualistic in explaining the person-environment interaction and Cutchin (2004) highlighted the need to move beyond such a reductionistic explanatory approach and place activity in the centre. Therefore, in this study the focus is on exploring the dynamic interactions that occurs in the everyday performance of activities when using ET. So in order to understand what is embedded in the complexity when interacting with ET, we need to know more about what actions are required of an individual to manage such ET: What actions does the person have to take? What is the frequency of these actions? How can the interface of the ET with the surrounding environment facilitate or hinder the activity performance when using an ET?

The main purpose of this study is to identify and describe features that make ETs more or less difficult to manage in a certain activity for older adults with or without cognitive impairment. This is thus an investigation of features that are embedded in the design of the ET and the activity in which it is managed, and that can make the use of the ET more or less difficult. The MoHO (Kielhofner 2008) has been used together with the previous research results described above to formulate five assumptions for investigation.

The specific assumptions explored/tested were as follows:

1. A higher frequency of skill items is required to handle more difficult ETs.
2. More difficult skills will be required more often for more difficult ETs.
3. ETs that provide the user with feedback related to different sensory functions (vision, auditory, tactile) will facilitate the management of ETs.
4. The ET's design will affect the level of difficulty in managing the artefact in an everyday activity.
5. Different environmental characteristics will affect the level of difficulty of an ET.

Methods

Study design

The study used a mixed methods approach (Creswell et al 2011) and had a multi-level perspective on investigating the management of ETs in everyday activities.

Sample

This study was based on an empirical hierarchy of 24 more or less difficult ETs (Figure 1). These ETs were managed by 116 older adults (mean age: 73.4, SD: 9.2) with and without cognitive impairments. Of the 116 participants, 38 had a diagnosis of mild-stage Alzheimer's disease (AD)(American Psychiatric Association 2000, McKhann et al 1984), 33 had mild cognitive impairment (MCI)(Petersen 2004, Winblad et al 2004) and 45 older adults did not have cognitive impairments. The inclusion criteria used was that the participants should be; 55 years or older, active users of ET and motivated to participate in research and adequately compensated with equipment for any visual or hearing impairment. Also participants diagnosed with mild-stage AD should have a Mini-Mental Status Examination (MMSE) score of at least 17 of a maximum of 30, and participants with MCI a MMSE score of at least 24 and older adults with no known cognitive impairment should have a score of at least 27. The recruitment process has been described in more detail by Malinowsky et al (2011). Ethical approval was obtained from the local ethical committee and consent was obtained from the participants.

Procedure

The Management of Everyday Technology Assessment, META (Malinowsky et al 2011, Nygård 2006), was used to assess the participants' ability to manage ET. The data collection started with an open conversation with a set of pre-defined questions about the participant's everyday life in relation to ETs, and resulted in a selection of ETs to be observed and assessed using META. META consists of ten skill actions that assess observable performance actions, for example, to identify and separate objects, to turn a knob or button in the correct direction, and to perform actions in a logical sequence (for a complete presentation of the ten skill items, see Malinowsky et al 2011). Occupational therapists who have received META training observed and scored the skill actions using a three-category rating scale based on the difficulty of managing each ET: 3=no difficulty, 2=minor difficulty and 1=major difficulty (the scoring of the skill items is further described in the detailed manual by Nygård 2006). Each participant was observed and scored on the management of two or more ETs in everyday activities in their own home or neighbourhood. The assessed ETs were chosen by the participants and belonged to them, and were thus relevant to each person.

Data analysis

The META data from the 116 participants were analysed using Rasch statistics and resulted in a hierarchy of ETs from the most to the least difficult for people with or without cognitive impairments to manage and has been presented in previous papers (Malinowsky et al, 2011; Patomella et al,

2011). The present study continues the analysis by investigating a hierarchy of the 24 most used ETs (see Figure 1) from the original hierarchy of 68 ETs. ETs used by less than four people were excluded from the analysis due to the risk of having a hierarchy being associated with large error of estimation potentially influencing the hierarchical order of the ETs. The data analyses of this hierarchy were descriptive, using both qualitative and quantitative analysis, and were implemented in the following three steps:

1) First, research assumptions were formulated. The assumptions were formulated by the research team (consisting of researchers and clinical occupational therapists experienced in working with individuals with cognitive impairments). The clinical experiences of the research team were continually used as a resource for the different steps of the analysis. A visual inspection of the hierarchy (Figure 1) was carried out to attempt to identify any obvious patterns in the rank order of ETs that could influence the level of difficulty of the ETs and this inspection generated input for the assumptions.

2) The next step was to conduct activity analyses for all 24 ETs. An activity analysis can be used to create a general understanding of an activity, like its potential demands, identifying the multiple skills typically required and the potential cultural meaning that the activity may have (Blesedell Crepeau and Boyt Schell 2009). The activity analysis is based on the idea that activity is an abstract, general and culturally shared idea of actions, offering flexibility of expectations about the environment (Pierce, 2001). The analyses in the present study were based on a table of ten analysis areas (Blesedell Crepeau and Boyt Schell 2009), here focusing on the management of ET (for an example of an activity analysis, see Table 1: Using an electric stove to boil water). The activity analyses were also reviewed by skilled researchers and experienced occupational therapists in order to increase the reliability of the analyses.

3) In the final step, the activity analyses were analysed to investigate the assumptions. For the first and second assumptions, the fifth and sixth steps from the activity analysis (see Table 1) were used as the basis to count the repeated use of skill actions (i.e. the META skill actions) required to perform an everyday activity using the ET under investigation. For example, when counting the number of times the META skill actions would have been observable for boiling water on a stove, 11 skill actions were counted (out of a range of 7 different skill actions, with some being used repeatedly).

Descriptive statistics using Spearman's Rho were used to compare and correlate different frequencies of skill actions performed to the hierarchy of the ETs. Cohen (1988) suggests that the correlation coefficient could be interpreted as insubstantial/trivial when it is below 0.1, small when it is between 0.1 and 0.3, medium when it is between 0.3 and 0.5 and large when it is above 0.5.

For the third, fourth and fifth assumptions, content analyses were used for qualitative comparison of the different ETs. For the third assumption, concerning feedback, the tenth step in the activity analysis (see Table 1) was extended and a theoretical description was written for each ET, describing what kind of feedback was given to the user during the performance of everyday activities using the ET. These descriptions were compared and categorized in the analysis and resulted in a categorization of the feedback that was provided when managing the ET during the process of performing a specific activity. In the analysis, the feedback and interaction from managing more or less difficult ET were compared to seek possible patterns.

Furthermore, for the third, fourth and fifth assumptions, concerning the design and environmental features, the results of the activity analyses of all the ETs were qualitatively compared regarding the second, third and fourth steps in the activity analyses (those concerning the context, artefact and environment). This comparison resulted in a categorization of features related to the environmental characteristics and features that could have affected the difficulty of the ET when performing an activity.

Findings

The findings will be presented and commented upon using the following assumptions as headings.

1. A higher frequency of skill actions is required to handle more difficult ETs.

When investigating the relationship between the frequency of skill actions used and the level of difficulty for the ETs (as rank ordered, see Figure 1), the analysis showed a large ($r_s=0.57$) and significant correlation between the level of difficulty and the frequency of skill actions that were used for each ET (see Table 2). The frequency of skill actions required when managing each of the 24 ETs is visualized in a graph showing the distribution from the most difficult to the least difficult ET (see Table 3a).

This result supports the first assumption and indicates that a higher frequency of total skill actions was required for managing more difficult ETs.

2. More difficult skills will be required more often for more difficult ETs.

When correlating the frequency of skill actions required with the level of difficulty for the ETs (as rank ordered, see Figure 1), the analysis also showed a large and significant correlation between the ET's level of difficulty and the frequency of use of the three most difficult skill actions from META: "Choose correct button or command" ($r_s=0.54$), "Identify services and functions" ($r_s=0.56$) and "Perform actions in a logical sequence" ($r_s=0.56$, see Table 2). The frequency of these skill actions

required when managing each of the 24 ETs is visualized in graphs showing the distribution from the most difficult to the least difficult ET (see Tables 3 b-d). The tables indicate that, overall, more difficult ETs in the hierarchy require a higher frequency of skill actions than less difficult ones. However, when inspecting individual item there are exceptions like use of a washing machine, calling using a press-button telephone and some of the computer items like internet banking. These less difficult ETs require a higher frequency of repeated use of skill actions than anticipated. Although with some exceptions the overall results support the assumption and verify that a higher frequency of more difficult skill actions was required for managing the more difficult ETs.

3. ETs that provide the user with feedback related to different sensory functions (vision, auditory, tactile) will facilitate the management of ETs.

When analysing and comparing the feedback that is given from the ETs during use, five different categories describing different kinds of feedback received were revealed. These categories are presented in Table 4. This shows that the more challenging ETs provided the user with multiple visual stimuli consisting of technocratic language, symbols or concepts (for example, PLAY on a video recorder or a computer screen with several visual stimuli that have to be considered before taking any action), while the less difficult ETs provided the user with singular visual stimuli consisting of universal commands (for example, I/O or green light/red light). The analysis also indicated that the less difficult ETs provided direct feedback on an action just taken, while the feedback from more difficult ETs was less direct and clear (for example, when using a video recorder to watch a VHS film, there are many steps and actions before finishing and there is no direct feedback if the user makes an incorrect action). Auditory feedback could be provided to the user either during the process of using the ET or at the end point when reaching the goal of the activity. The findings of the analysis showed that auditory feedback during the process was more frequent for the less difficult ETs (for example, water in an electric kettle produces sound when the water starts boiling and the fan in a microwave oven makes a sound when the machine is on). The interaction between the user and the ET could be either complex or simple, complex interaction required the user to take many actions before finishing, while simple interaction required fewer actions (as an example, when heating prefabricated food in a microwave, most of the process is about waiting for the heating to finish). Complex interactions were more frequently present for the more difficult ETs than for the less difficult ones. Tactile and olfactory feedback (sensing heat and smelling food/drink) was only given when using the four ETs that heated up food or drinks, that is, ETs that were also less difficult to manage (coffeemaker, microwave, electric kettle and stove).

In summary, the results from the content analysis confirm the assumption that feedback from different modes of stimuli facilitates the use of ETs, but also indicate that too much visual feedback does not necessarily support the user in managing an ET competently. The results also indicate that auditory feedback during the process could facilitate the use of an ET. The complexity of the interaction between the user and the ET was positively related to the level of difficulty of the ET. The results generally indicate that a variety of different modes of feedback were given in the management of less difficult ETs.

4. The ET's design will affect the level of difficulty to manage the artefact in an everyday activity

The analysis showed that more difficult ETs required the user to handle more complex language, consisting of commands and words that presented several choices for the user. This was most evident among the more difficult ETs in the hierarchy (i.e. those above radio without a remote control, see Figure 1), with the exception of TV: using a remote control, which also required the management of the complex language on the remote control. Furthermore, the analysis showed that more difficult ETs more often consisted of two or more components, for example, computer: print, which consisted of a screen, computer, keyboard, mouse and printer. However, there were exceptions: a cell phone only consists of one component, but it is a more difficult ET according to the hierarchy, although the different menus that are presented in the interface on the cell phone's screen could be seen as several components. Another exception was the coffeemaker, which is a less difficult ET in the hierarchy, but consists of several components (can, filter-holder and different lids), although these components are not electrical, in contrast to the ETs in the upper range of the hierarchy. Furthermore, the analysis showed that the more difficult ETs required the user to have some experience before being able to use them (for example, using a TV with a video or DVD player), while the less difficult ETs had a design that was more intuitive, the design guided the user and fewer errors could be made. These results partly confirmed the assumption above, namely, that features of the design (language, number of components and previous experience required for handling) of the artefact affect the difficulty of the ET.

5. Different environmental characteristics will affect the ET's level of difficulty

The content analysis across the activity analyses of the ETs in the hierarchy showed no difference in environmental or contextual settings between more or less difficult ETs, all ETs were used in a home setting that was facilitating and culturally typical, with the exception of the cell phone, which could also have been used outside the home. The cultural environment for the ETs in this study was similar, a Western culture with a wide range of different ETs that most people take for granted and that most people can manage (for example, a stove and a cell phone). The analysis of the social environment

showed that most of the ETs could be managed without direct interaction with other people, except in those activities that involved communication, such as making calls with a cell phone or e-mailing with a computer. The analysis showed no specific environmental characteristic that would contribute to explain the level of difficulty of different ETs.

Discussion

The main purpose of this study was to identify and describe features that make ETs more or less difficult to use in everyday life. One of the main findings is that more difficult ETs require repeated actions by the user, and that the actions that are required more often for difficult ETs are “Choose correct button or command”, “Identify services and functioning” and “Perform actions in a logical sequence”. These findings support previous research that older adults with cognitive impairments experience challenges in following a sequence required for the management of an ET (Lövgreen Engström et al 2010, Nygård and Starkhammar 2007). Consequently, the findings suggest that there is a need for a redesign of ETs so that they require the user to take fewer actions in sequence, as this could facilitate their use among older people with and without cognitive impairments. The four ETs that were least difficult to manage (see Figure 1) placed limited demands with respect to performing actions in a logical sequence. On the basis of this finding, we suggest that occupational therapists may adapt ETs like the cell phone with applications that would guide the user directly through the activity that he or she needs to perform, for example, calling a health service provider or searching for information on the internet. Norman (2005) argues that ETs need to be designed from an understanding of the activity that is to be performed. As occupational therapists have extensive knowledge about the everyday activities that their clients need and want to perform, this could be the basis for designing new ETs or applications.

Another assumption that was confirmed in the analysis was the third one, indicating that different kinds of feedback facilitate the use of ETs, but also that too high a frequency of visual feedback could hinder their management, when many visual commands are presented to the user, this might be confusing and the user could have difficulty in selecting and responding to commands that are required in order to continue the performance of the activity. People with cognitive impairments may struggle to perform everyday activities due to a lack of attention, memory deficits and other functional deficits, therefore, they can struggle to use ETs (Lövgreen Engström et al 2010, Nygård and Starkhammar 2007). Hence, plurality of visual feedback would not help people with cognitive impairments to manage ETs.

The final assumption concerning the environmental characteristics was not confirmed in the present study, the analysis showed no specific environmental characteristic that would explain the level of

difficulty of use of different ETs. This result is contradicting the results from a previous study (Malinowsky et al 2010) and this assumption needs further investigation. The reason for the present result may be that the activity analysis was undertaken on a general idea of performing an activity (Pierce 2001) and therefore did not account for all the variation that could be observed in an empirical situation. Furthermore, most of the ETs included in the present study were artefacts used within the home environment, future studies should investigate the challenge of using ETs in different environments. These contradictory findings also indicate that occupational therapy as a discipline needs to continuously question the underlying assumptions about person-environment interactions and place activity in the centre joining the place and the individual in order to define an integrated theory- and evidence-based approach within our practice (Cutchin, 2004).

In the MoHO (Kielhofner 2008), the technical objects in our environment are defined as the things that we interact with and whose properties influence what we do with them. The present results also reveal what properties could make these objects more or less difficult to manage. However, ETs are not only a means for performing an activity, for many activities, it is the ET that defines the activity (Norman 2005). Occupational therapists need to consider the difficulty of use of the ETs that older adults need and want to manage in their performance of everyday activities, in addition, the difficulty of use of ETs' needs to be considered when planning an intervention. This study provides new insight on ETs and on what features pose a challenge in managing these artefacts within an activity situation.

Limitations of the study

The method used to collect data was an activity analysis that was carried out theoretically. The findings from the activity analyses are dependent on the creativity of the researchers, however, the activity analysis was based on empirical results and the extensive experiences of a research team. The results are not straightforward and there could be other factors affecting the challenge of managing ETs. We also chose to analyse the assumptions one at a time, it would have been interesting to analyse these assumptions in a regression analysis to examine to what extent a combination of different interacting factors can explain the level of difficulty in ETs, however, the data we had did not allow this to be done in a reliable manner.

Another limitation of the present study is that it was conducted within a Swedish urban environment and the results may not be transferable to other contexts. The Swedish culture is also atypical in Western culture in terms of the general high density of technological artefacts in homes. It also has one of the highest levels of household internet access in Europe (LO 2006). However, as the technological landscape is continually changing at a rapid pace, although Sweden is currently at the

forefront of this change, this might not be the case in just a few years. Therefore, the present results need to be seen as dependent on temporal and cultural factors.

Conclusion

The present study indicated the features that make ETs more or less difficult to manage in everyday activities. The results indicated that, in order for an ET to be less difficult for the user, it should:

- require the user to take fewer actions, especially if the actions must be performed in a particular sequence,
- provide the user with different modes of feedback that are distinct and not overwhelming during the whole process of managing the ET,
- consist of a design that only requires the user to handle simple and universal commands,
- consist of a design that only requires management of a few components,
- consist of a design that is within the experience of most people, that is, recognisable and intuitive.

This knowledge could be used to design ETs that are manageable for a broader range of people, including those with cognitive impairments. It could also be used by occupational therapists to plan and adapt interventions in rehabilitation following cognitive impairment.

Key findings:

- Features in the design of an ET will affect how difficult the technology is to use.
- Feedback from an ET could both hinder and facilitate performance of an activity.

What the study has added:

Insight into features that make ETs less difficult to manage in everyday activities.

Knowledge useful for designing ETs; for adapting activities using ET and teaching clients how to use ETs

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