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Using Elderly as Lead Users for Universal Engineering Design

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Abstract. A design that adheres to all users' needs, can help us generate universally designed products. While nothing is as thorough as active co-design with end users, other less resource intensive approaches are needed as well. We investigate the concept of lead users as a source for ideas on universal design. Specifically we investigate how elderly i.e. people over the age of 65, can act as lead users while designing for the general population. The main idea behind this is that, the elderly may be able to articulate more needs when compared to the general population and the outcome attained by addressing these needs would be preferred by all. We propose a combination of product function and human activity based approach. The elderly survey participants are asked to indicate tasks which they have difficulty completing and universal design rules are derived using those results. We then empirically test the rules by designing set of products based on those rules. The products are then evaluated by both the general population and the elderly. We find that, the products designed by fixing elderly as lead users are either preferred over or equally to the existing products also by the general population.

Keywords. Universal designing, Lead users, Elderly, Hand functions, Activity diagram, ICF

Introduction

"Design for the young and you exclude the old; design for the old and you include the young"

- Bernard Isaacs

Von Hippel introduced the term Lead Users and explained how lead users can be involved in providing ideas for innovative solutions. A lead user can be described as one who experiences a need sooner than the majority of the population even before a product exists. According to von Hippel [1], users who are already adapted to an existing product are unlikely to come up with a novel product concept. In further work he explores users, in particular lead users, as more effective sources for innovation than traditional design teams [2]. With this idea in mind, in this paper, we explore a particular type of potential lead users, persons over the ages of 65 and challenge the above quote by Isaacs.

There are many reasons to why elderly could potentially be used as lead users besides the fact that the products designed by prioritizing the needs of the elderly could

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be of great benefit to the users within that same age group. For instance, delayed muscle response and decrease in dexterity makes the way in which a product is handled by an older person different from that of the younger individuals. This difference gives a different perspective to looking at everyday tasks. Younger individuals tend to be adapted to any kind of products and are usually functionally fixed [3] whereas older users who find it difficult to adapt and therefore they may have needs that can give way to new ideas for innovation. Therefore we assert that older users may be a valuable source of innovation for all during the early stages of design [4].

Involving the elderly while designing has been in existence for quite a long time [5-7]. While there are various research groups who attempt to identify the needs of the elderly in order to design products which can fulfill those needs [8], only a few have focused on the fact that these products could be used by the general population as well. The elderly are likely to generate more new ideas quickly and these new ideas can lead to concepts which even the researchers would not have considered till then [9]. Previous work also finds that involving elderly in product design phase increases the number of eventual end users [10]. Such involvement during the design phase can also result in products that receive better user feedback [8].

As an example, the ergonomic cooking utensils by Oxo were initially designed for persons with difficulties in hand use, such as persons with arthritis, but they are widely popular among all types of users. This has led to many companies copying the more ergonomic thick handles in their lines of cooking utensils. This is a prime example of products designed for elderly, in this case for those with arthritis, being accepted and even preferred by the younger or general population as well [11].

One main problem with universal design is that designers are not really sure about how the principles can be implemented practically. For instance, a device such as a can opener can be automated [12] in order to improve its usability during use. This cannot, however, be an ideal solution in every situation because automated products require a power source and they become useless in the absence of that source. Even if that source is a battery the changing of that can be difficult for many users. Hence, it is important to look at products from also a mechanical (non-powered) standpoint and try to determine design principles for universal design in order to improve product usability.

One necessary aspect for universal design is to understand the needs and functional capabilities of customers in addition to the functional requirements of the product. Designing just to meet the functional requirements of a system will end up in catering to only a part of the population excluding those with physical or other impairments.

The objective of this paper is to investigate if the elderly in deed provide ideas for product innovations that are preferred also by the general population. For this, we propose a step by step approach to answer the following research questions:

RQ1: Will a decrease in human ability (elderly people in this project) help the person being able to articulate unique usability requirements that are not voiced by persons with non-decreased ability?

RQ2: Are designs preferred by persons with a decreased ability also preferred by the general public?

Research Approach

The approach followed for this research can be split into five steps. (1) Model product functions (2) Model corresponding hand functions (3) Interview potential lead users (4) Derive universal design ideas (5) Test if universal products are preferred.

1. Model Product Functions

The first step towards making an existing product as a universal one is to make a functional model of that product. A functional model allows us to visualize the flow of energy, material and information as they change throughout a system. A functional model "provides a basis for organizing the design team, tasks and process" which allows interaction between components and other necessary communications to be available for concurrent engineering [13]. In a functional model energy, material and information flows are displayed with a solid thin arrow, solid thick arrow and dashed arrows respectively. Figure 1 shows an example of a functional model for turning on a simple motor or a rotary actuator which is similar to that.

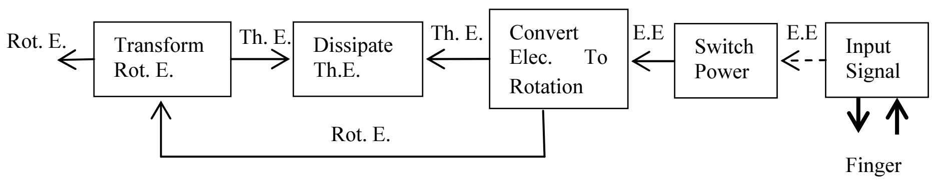

Figure 1. Functional Model for a Simple Motor

Following the functional model, an activity diagram that relates the needs of a customer to the activities of the product should be built. An activity diagram allows parallel and sequential tasks accomplished by the user to be formulated and analyzed [13].

Incorporating functional modeling with product architectural design aids in determining the difference between universally designed structures and typical structures [12]. This allows us to see where the design changes were made from a functional basis and also explains how typical and universal products are related [14, 12].

We build on past work where a typical can opener was compared with an automated one which replaced the human act of turning, a task found difficult in previous work [12], but we take a different approach. Instead of making the difficult tasks automated we investigate if using elderly as lead users helps in creating designs that simplify the tasks, but do not necessarily require automation. The action function diagram allows us to determine which product functions were not directly related to the user [12]. This would save a lot of time for designers while designing.

2. Model Corresponding Hand Functions

The International Classification of Functioning, Disability and Health (ICF) is a system that is used to describe user tasks and activities. The World Health Organization (WHO) established the ICF as a standard language to be used to describe the level of functionality a person has when performing a given task or interacting with a given object [15]. This system can be useful for researchers to establish a relationship between human limitations and product functions.

Figure 2 displays how the ICF is currently organized. Generally speaking, the ICF is an alphanumeric code which can be interpreted as follows: The first part of the code will be either ‘b’ for body functions or ‘s’ for body structures, or ‘d’ for activities and participation or ‘e’ for environmental factors. The first number that follows the alphabetical code will represent the chapter number in which the limitation can be found in the ICF system and the next two digits that come concurrently describe the limitations more accurately. At some instances when further classification is required, a period is placed towards the end of the alphanumeric code and additional digits called qualifiers are added to the right. Such codes are very specific to a particular product that is being used [15].

These ICF codes are used to understand the level of functionality a person has while performing a particular task [16]. This way of applying ICF allows researchers to establish relationships between human limitations as well as product functions and can help designers determine how a product’s design should be altered in order to make it universal.

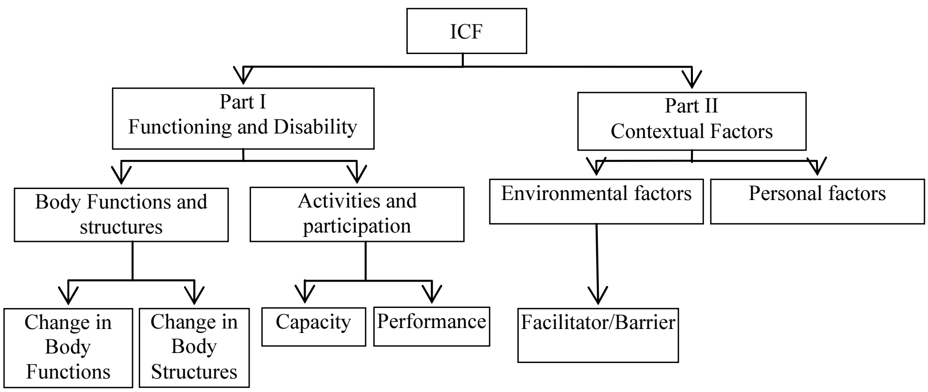

Figure 2.ICF Classification

Action function diagrams links user interactions with the functions and flows in a functional model [11]. The combination of an activity diagram with a functional model allows direct links to be established for user-product interaction. It is a specific approach to task analysis. User tasks or activities can be modeled with the International Classification of Functioning, Disability, and Health [15] while the product functions are modeled using the Functional Basis as described previously. Hence, the ICF was incorporated to ensure consistency while describing user activities.

3. Interview Potential Lead Users

The next step after modeling the corresponding hand functions according to the tasks is interviewing potential lead users. Viewing the product function and human function simultaneously has the potential to highlight how products should be redesigned to be more universal, usable by all. In order to understand what should be redesigned, we explore the use of elderly as lead users.

For this research, two phases of interviews were conducted among 17 people over the age of 65. First phase was the pilot study and the second phase was the main survey which was conducted to determine which everyday task became more difficult with age. Seven males and ten females at an average age of 72 took part in the study. They were given questionnaires with a list of common tasks such as opening a water bottle, releasing a seatbelt receptacle, undoing the buttons on a shirt and using a manual can opener. In the questionnaire, they were asked to indicate the tasks which they found to be difficult while performing.

From these interviews, the difficulties experienced while performing these common tasks were determined. Once these difficulties were determined, the respective tasks were broken down into different parts in order to understand the hand functions that were necessary to complete that particular task. This analysis was done using the ICF system which was discussed earlier.

Apart from the elderly participants who were above the age of 65, 17 more participants between the age group of 18-50 were also included in the survey in order to gauge how well the elderly might act as lead users, i.e. express the needs that others might also have. Only 7% of the younger group reported difficulty in completing the tasks whereas 25% of people over the age of 65 reported difficulty in completing the same tasks. This difference in perceived difficulty indicates that the older population is able to express more needs when compared to the younger population. Further research into how they can be used effectively will be explained in the following sections.

4. Deriving Universal Ideas

After surveying the lead users on the difficulty they face while performing their everyday tasks, the hand motions corresponding to those tasks were analyzed. Table 1 shows the hand motions required to complete a particular task along with the percentage of users who find it difficult to complete those tasks. Opening large jars was claimed as the most difficult task among people over the age of 65 (71% of the users reported it to be difficult).

Even though it is evident that the tasks which require more force are reported as more difficult, there is another interesting trend which was observed. By analyzing Table 1 we notice that the tasks that demand three hand motions are deemed to be more difficult than tasks that involve two hand motions. This result in a potential design principle of reducing the number of simultaneous hand motions needed to accomplish a particular task. In Table 1 the outcome for pumping the gas (35% difficulty) alone is exceptional due to the fact that most participants have never executed that task.

Table 1. Task Difficulty and Related Hand Motion Required

Action/ Function	Grab motion	Twist motion	Press-ure motion	Pinch motion	Users Reporting Difficulty (%)
Open Large Jars					71
Operate Manual Can Opener					53
Open Water Bottles					53
Buttoning a Shirt					53
Pump Gas					35
Hold Key					24
Close Ziploc					18
Undo Seatbelts					12

In order to understand where in the product a potential change can be made with regards to the difficulties faced by the user, we link the above difficulties to the product function by applying the action function diagram as discussed earlier. Figure 3 illustrates the action function diagram of a gas pump as an example. From the action function diagram, it is clear that the actions required to accomplish this particular task are reaching for the pump, grasping it and then manipulating it.

Table 2. ICF Codes For Gas Pump[11]

ICF Code	ICF Term	ICF Definition
D4401	Grasping	Using one or both hands to seize and hold something, such as when grasping a tool or a door knob.
D4402	Manipulating	Using fingers and hands to exert control over, direct or guide something
D4452	Reaching	Using the hands and arms to extend outwards and touch and grasp something

Table 2 shows the definition provided by ICF for these particular hand motions [12]. The action function diagram highlights grasping as one possible human activity that could be redesigned. The idea gained from the action function diagram and the definition provided by ICF were implemented together to redesign the gas pump. The action diagram of the remodeled gas pump is as follows.

From Figure 4 it can be observed that the need for users to manipulate their fingers while pumping the gas has been omitted and replaced by grasping motion so that the task can be accomplished with just two hand motions. In this case, we chose to redesign the product by aiming to achieve multiple functions with a single action. Another potential alternative could have been sequencing the actions (grasp & manipulate in Figure 3) thereby reducing the number of simultaneous hand motions required.

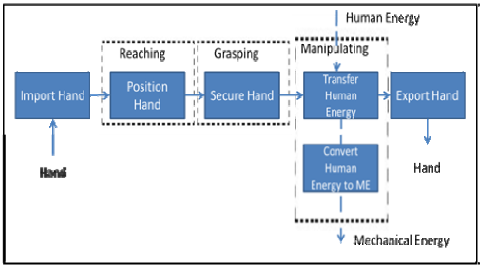

Figure 3.Action Function Diagram-Gas Pump

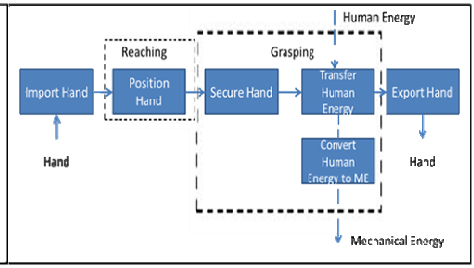

Figure 4.Action Function Diagram-Redesigned Gas Pump

5. Test If Universal Products Are Preferred

The fact that people above the age of 65 were able to articulate more difficulties with their everyday tasks (Table 1) shows that a decrease in human ability (aging in this case) can results in the people being able to articulate needs that are less likely to be voiced by an average user.

Table 3.Required Hand Motions for the Redesigned Products

Action/Function	Grab motion	Twist motion	Pressure motion	Pinch motion
Pump Gas				
Open Water Bottles				
Undo Seatbelts				
Operate Manual Can openers				

In order to test if the designs preferred by the elderly are equally preferred by the general public, we designed a total of four sets of products following the approach which was used to redesign the gas pump. The products were redesigned in a way that they utilized less simultaneous hand motions and larger muscles were to be targeted. Table 3 displays different actions required to complete a particular task using redesigned products. All the redesigned products demand less hand motions when compared to the products that are currently available in the market.

To ensure that the redesigned products were preferred both by the lead users as well as the general population, a survey was conducted among 24 people. This 24 included 17 from older age group (above the age of 65) and 7 from younger age group (between 18 and 50). Participants of age 50-64 were excluded from the study in order to obtain a clear cut difference in age between what we label “young” and “old”.

During the survey, the subjects were provided with three different designs of water bottle caps, seatbelt receptacles, gas pumps and manual can openers. They were asked to choose one design from each product, one model which they felt was easy to use. Among the three designs, one was similar to the typical design available at the market, another was a design that was modeled according to the needs of the lead users and the final one was a decoy design that was designed such that its action function diagram and the hand motions it demanded were similar to that of the design currently available at the market except that it has a different appearance. This was done in order to avoid the new design being too obvious to the participants. The order of the products in a set was random.

Figure 5 shows the three different water bottle cap designs that were provided to the participants. With the redesigned water bottle cap (middle in Figure 5) which is lip shaped, the user will no longer do the lateral pinching motion. The lip shaped cap would allow the user to keep their fingers more extended and therefore utilize more muscles in the fingers to open the bottle. The decoy cap has a smaller diameter than the typical cap and is much taller but anyway the user would still be required to do all three tasks similar to that of a typical design except that it looks different than an existing cap.

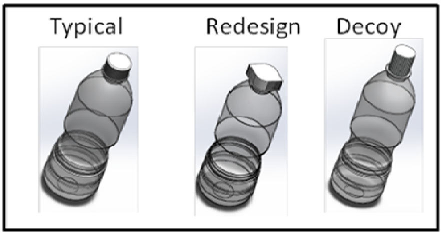

Figure 5. Water Bottle Cap Designs

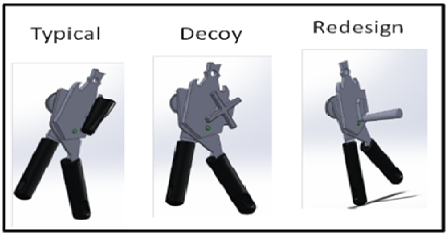

Figure 6. Manual Can Opener Designs

The redesigned can opener (right in Figure 6) contains an extended handle due which the user just needs to grab the handle and rotate it with their arm. This will eliminate the need to twist and apply pressure while opening a can. Though the decoy can opener appears to look different from a typical can opener, it still requires the user to twist and apply pressure while grabbing the other handle to open a can.

One special case we took into consideration was the seatbelt receptacle. Though this task was reported to be the least difficult among the participants, it was for redesigned in response to observing the difficulty faced by people affected by arthritis while using it. The redesigned seatbelt receptacle (middle in Figure 7) would require the user to reach down and grab the receptacle with their whole hand instead of using the tip of their thumb to release it. This modification is done because tip of the fingers are one of the first regions to get affected in people with arthritis [17]. Hence, a grabbing motion would release the receptacle thereby enabling them to use their entire hand.

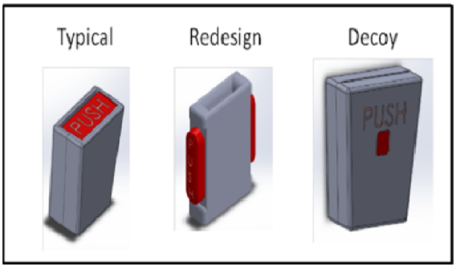

Figure 7. Seat Belt Receptacle Designs

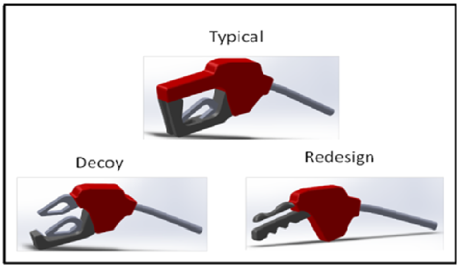

Figure 8.Gas Pump Designs

As described previously, a typical gas pump handle will require the user to apply pressure, grab the unit and then do the lateral pinching to release the gas. Whereas, the redesigned gas pump handle (lower right corner in Figure 8) would just require the user to grab the handle along with the lever and then apply pressure with their forearm to release the gas. Even here the decoy design looks different from that of a typical one but then the hand motions required to complete the tasks are similar.

6. Results

Figure 9 displays the outcome of the survey conducted among the elderly, i.e. potential lead users and the younger users. It can be seen that the products that were universally designed based on the concept of using less simultaneous hand motions to complete a task are well preferred by the elderly participants. The younger participants also almost always preferred the universally designed products when compared to the existing products. Therefore, these products were at least equally preferred by the majority of the younger individuals when compared to the existing designs. These products were preferred even more by the elderly. This indicates that most of the redesigned products can be considered to be universally designed products.

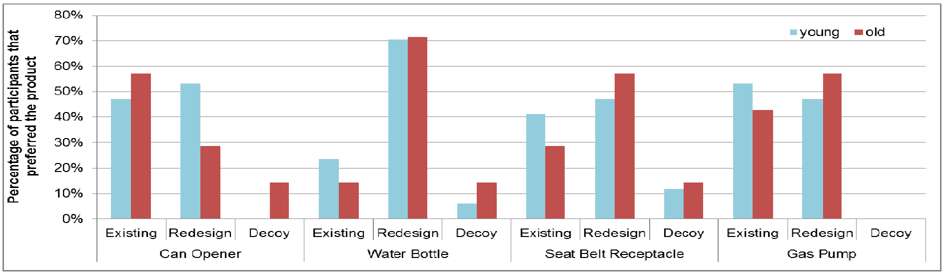

Figure 9. Preference Of Universally Redesigned Product Option Over Existing And A Decoy (Non-Universal) Product Option

Can opener was the only exception which did not receive as much acceptance as expected. The number of participants who took part in this research is too low to determine if the difference in acceptance level between both the can openers are really significant or if they are equally preferred.

7. Conclusion and Future Work

By empirically testing the use of elderly as lead users, we were able to design universally acceptable, i.e. universally designed products. The needs that the elderly participants expressed seems to correspond to possible latent needs in the rest of the population. Hence, analyzing these needs not only gives us ideas for assistive solutions but more importantly triggers more innovative ideas. A step by step methodology was proposed to analyze and implement those needs in order to design universally designed products. The survey conducted among the participants over the products that were designed based on the needs of the elderly proves that the products that were universally designed by using elderly as the lead users are equally preferred by the younger population of users in addition to being preferred by older users themselves. Future work could include testing the hypothesis with a larger sample size to get a better analysis of the approach. Other work could include involving lead users in providing design solutions to products.

8. Acknowledgement

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