THE USABILITY OF WATER FAUCETS FOR OLDER ADULTS WITH AND WITHOUT DEMENTIA: HOW IMPORTANT IS FAMILIAIRTY?

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INTRODUCTION

Among Americans 65 years and older, approximately 6–10% have dementia, with Alzheimer's disease (AD) accounting for two-thirds of these cases (Hendrie, 1998). While older adults with dementia generally have impairments in short-term and explicit memory, long-term and implicit memory are often relatively spared (Son, Therrien & Whall, 2002). It is believed that products designed for this population should focus on making use of functional abilities while supporting diminished ones by incorporating features that would be recognizable or familiar to users based on their previous experiences. The concept of familiarity and its impact on helping older adults with dementia preserve independent functioning has been extensively explored in architectural and environmental design (e.g. Küller, 1991), but has not received much attention within the field of product design.

The study proposed in this paper aims to provide insights into the impact of familiarity with the design of everyday products for older adults with a cognitive impairment. In particular, this study will examine the impact of familiarity and other design aspects, e.g. intuitiveness, on the use of different styles of water faucets by older adults, both with and without a dementia, through the comparison of various usability measures collected through the representative task of hand washing. Information collected from this study will be used to develop preliminary design guidelines for water faucets and other related hardware and controls, as well as to gain insight of how to design everyday products so that they take into account older adults with a cognitive impairment.

IMPORTANCE OF FAMILIARITY FOR PEOPLE WITH DEMENTIA

Dementia broadly describes a group of symptoms that can include a progressive loss of intellectual functioning and memory, confusion, personality change, and impaired judgment and reasoning capabilities (Alzheimer's Association, 2007). A hallmark of people with dementia is that they find learning new tasks very difficult. When presented with a new device that requires some learning to be used, people with dementia are likely to become very anxious, be unable to operate the device, and are very likely to reject it. Therefore, products designed for dementia should have a simple and familiar appearance and require simple, logical and familiar actions by users (Orpwood et al., 2005).

The concept of focusing on familiarity is based on the theory that long-term memory is generally more intact than short-term, recent memories for people with dementia. This means that ingrained and well-learnt skills from earlier in life can be retrieved when opportunities within the environment promote their use (e.g., an analog clock instead of a digital one, a sink of soapy water instead of a dishwasher, a rotary phone instead of a touch-tone model, etc.). Therefore, to maximize ease of use for people with dementia, it is important to maintain as much as familiarity and consistency as possible in the environment. The more familiar an environment is, the more supportive it will be. Familiarity is arguably the most important design principle for users with dementia, as it underlies many of the other guidelines and directly addresses the use of environments and products (Calkins, Sanford & Proffitt, 2001).

This study focuses on the use of water faucets – a common object which most of us take for granted. This simple implement for providing water for washing one's hands can become a nightmare for people with dementia (Stewart, 1999). Any new and unfamiliar water faucet design may be too difficult to learn to use for someone with dementia, even when the elements are consistent with how one would expect them to work. For example, caregivers have reported that some people with dementia have a difficult time regulating the temperature of water when using a single-lever faucet (Olsen et al., 1993). Although the single-lever faucet requires less strength and precision to operate than separate hot and cold handles, which is a highly desirable for frail older individuals, for people with dementia the lack of familiarity with this type of faucet makes it more difficult to understand and use than familiar ones that require greater effort.

PRODUCT USABILITY

Usability can be seen as an operational measurement of interaction, which has multiple components and is traditionally associated with the following three scales, as seen in Figure 1 (Nielsen, 1993):

Effectiveness: The accuracy and completeness (i.e. quality and quantity of the output of the interaction) with which users achieved the specified goals. It may be evaluated by *number of errors* and *completion rate*.

Efficiency: The resources expended in relation to the accuracy and completeness with which users achieve goals. It may be measured in terms of time (e.g. task completion time, learning and relearning time) and effort (e.g. physical and cognitive workload)

Satisfaction: The comfort and acceptability of use. It can be measured subjectively by *questionnaires* or objectively by *observation* of the verbal or non-verbal behavior of users during an extended period of use.

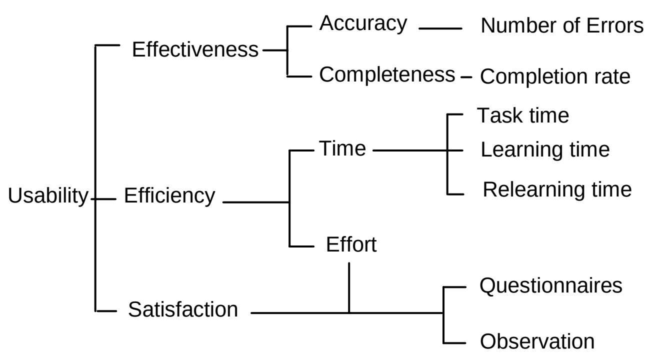

Figure 1: The relationship between aspects and measurements of usability

DESIGN OF WATER FAUCET

The *function* of a faucet is to release a flow of water at the appropriate speed and temperature when turned on. Turing a faucet on and off requires manual dexterity as well as cognitive awareness and judgment to determine how to operate the faucet for the speed and temperature desired. The *anatomy* of a faucet includes: 1) the mechanism for activating the flow, which may be a crosshead, knob, lever, or an electronic eye; 2) a spout for the water; 3) identification mark or color code for hot and cold (except for infrared/automatic faucets).

A faucet may seem very simple but is not always so. In terms of usability, the design of a water faucet should be 1) ergonomically sound, e.g. easy to grip and turn on or off, and 2) cognitively usable, e.g. operation is visible and intuitive at a glance. Figure 2 shows some examples of typical water faucets grouped in terms of their user interaction (operation mode) similarities. Apart from minor differences in handle shapes, movement directions and resistance, there are four main variations:

Crosshead/Knob: The user turns the water on and off by twisting two separate actuators (one for hot water and one for cold). This was the most common design of faucet for many years, including the time period when older adults were in their childhood and mid-adulthood.

Lever: To overcome the necessity for gripping the crossheads and knobs, lever faucets were introduced. Simple lever taps are often the best solution for people with restricted movement in their hands. Although lever taps have been used successfully by some people with dementia, some may not recognize or be able to use a lever tap.

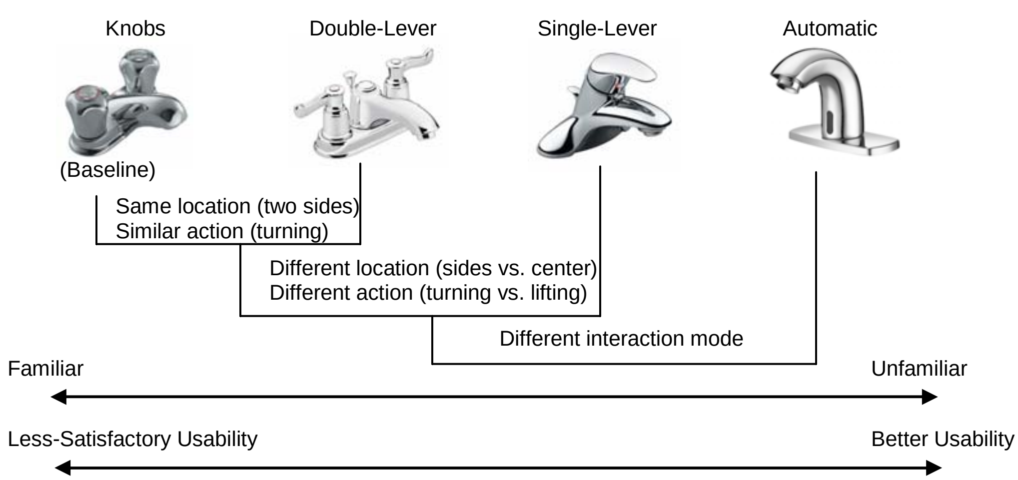

Figure 2: Different types of water faucet designs grouped in terms of user interaction similarities

Single Lever: Sophisticated internal mechanisms have led to the design of the single lever tap by which a simple flick of the wrist can raise the lever to the desired water flow speed and a second action rotates the lever to the desired temperature. For people with impaired hand functions, single lever faucets are usually much more convenient than round knobs or two-handled faucets. However, this single lever design is a big leap from the conventional dual-knob or dual-lever design in terms of operating location (e.g. two sides vs. center), operating action (e.g. turning vs. lifting), operational mode (e.g. rotating to regulate water temperature) and appearance (e.g. the single lever and spout are parallel to each other and look similar, which may cause confusion).

Automatic. An electronic, "touch-free" water faucet allows water to flow and to stop when an infrared beam emanating from a sensor is broken, without the person having to turn a knob or lift a lever. This can enhance independence and compensate for a disability. The electronic beam might be the answer for people with physical disabilities, such as arthritis, but these faucets have very different, "hands off" interaction mode which could easily confuse someone with dementia.

Although conventional water faucet design (e.g. dual-knob or dual-lever) is the easiest for people with dementia to use due to its familiarity, there is the need and potential for new designs to compensate dementia patients' physical declines (e.g. less manual dexterity) and cognitive impairments (e.g. forgetfulness and confusion). One example is a commercially available automatic faucet control device (Figure 3) designed especially for people with dementia (Automatic Faucet Control, 2006). This device screws onto the end of the spout and has a small white plastic wand that projects downwards. Any contact with the wand will turn the water on. Moving the hands away releases pressure on the wand and shuts off the water, ensuring that the water cannot accidentally be left on. This design is also appropriate for anyone who has difficulty grasping and turning the hot and cold water knobs, due to arthritis or any other condition. A potentially superior aspect of this design over the automatic electronic eye lies in the presence of a natural cue, the small white plastic wand.

Figure 3: A commercially available automatic water faucet designed for people with dementia

TASK ANALYSIS OF USE OF WATER FAUCET IN HAND WASHING

Figure 4 is a flow chart depicting the hierarchical task analysis (HTA) for the use of a water faucet during hand washing. The task the user must perform is decomposed hierarchically into goals, the plans for meeting these goals, and the operations for carrying out these plans (Kirwan & Ainsworth, 1992). In addition, potential errors associated with each step are identified and defined as follows:

Wrong goal: try to manipulate faucet as another object instead of using it for hand washing.

No goal: no response; do not know what the faucet is or what to do with it.

Missing step(s): forgetting to execute necessary step(s), e.g. failing to turn off the water after washing

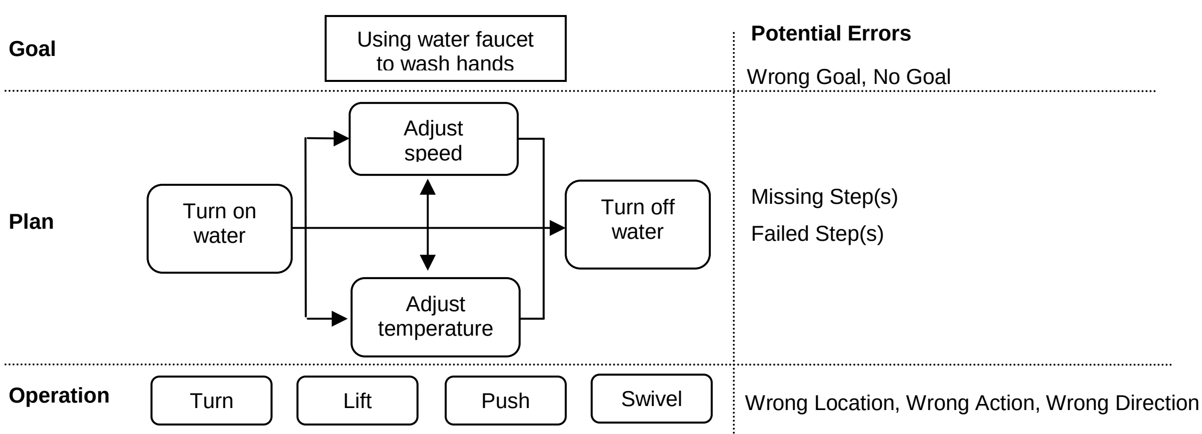

Figure 4: Flow chart of hierarchical task analysis for the use of the water faucet in the hand washing task with potential errors associated with each step indicated.

hands.

Failed step(s): failing to execute intended step(s), e.g. forgetting how to regulate water speed or temperature.

Wrong Location: attempting to operate at a wrong location, e.g. trying to manipulate the spout to turn on or off the water, trying to find knobs/levers on the two sides of the spout when it is a single-lever faucet.

Wrong Action: attempting to operate by a wrong action, e.g. trying to lift a knob instead of turning, trying to turn a lever instead of lifting.

Wrong Direction: attempting to operate in a wrong direction, e.g. trying to push down lever to turn on the water.

RESEARCH DESIGN

Subjects

A total of sixty older adults will be recruited to participate in this study: twenty with no cognitive impairments (MMSE score of 25 or greater), twenty with mild cognitive impairment (MMSE between 20 and 24) and twenty with moderate cognitive impairment (MMSE between 15 and 19). The MMSE (Mini-Mental State Examination) is a standardized tool developed to assist in estimating the cognitive abilities of an older adult (Folstein, et al., 1975).

Apparatus

The study will be completed in specially designed test washrooms. These washrooms will be equipped with a changeable sink unit that will allow the faucet type to be easily switched between trials. The washroom will also be equipped with a video camera and microphone to record trials, so that detailed post-trial data could be extracted in terms of usability of the faucets, which in itself is a multivariate measure as defined in Figure 1.

Task

Subjects will be asked to wash their hands using the water faucet. The following steps will be the focus of testing and observation in terms of whether and how the subjects can successfully conduct them: 1) turning on the water; 2) turning off the water; 3) adjusting water flow, if possible with design; 4) adjusting water temperature, if possible with the design.

Procedure

A within-subjects design approach will be used, with each subject completing one trial per day. This will involve the subject using different water faucet designs in a test washroom to complete the task of hand washing. The designs that will be tested (shown in Figure 2) are a baseline of a traditional dual knob faucet with single spout, and four interventions which will be 1) a dual-lever handled design, 2) a single-lever handled design, 3) an electronic “no-hands” faucet, and 4) the commercially available design intended for people with dementia (Figure 3). Each subject will be tested on each type of faucet design for twenty consecutive days (i.e. there will be 20 trials on each design for each subject and a total of 100 trials per subject). This will allow observations to be made over longer period of time in order to observe how subjects interact with familiar faucet designs and how they use and adapt to new faucet designs that will be introduced. The order of the faucet designs presented to each subject will be balanced and randomized in order to minimize ordering effects.

ACKNOWLEDGEMENTS

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