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chapter 2

Characteristics of Older Adult Users

What is the field of human factors? How can an understanding of the science of human factors and engineering psychology aid people in designing products and in evaluating issues relevant to proper design? This chapter briefly answers these questions and then addresses basic issues in perception, cognition, and control of movements that are important to consider when designing products, environments, systems, and training.

2.1 What Are the Underpinnings of Human Factors?

Too often, we hear people argue that they are human so they know all they need to know about human factors. They believe that issues addressed by human factors specialists can be solved by simple common sense. However, common sense is not sufficient to understand details of human behavior relevant to design. Moreover, common-sense beliefs differ across individuals as a result of their experience, education, and culture. An understanding of perception, cognition, and movement control is critical for the human side of the design process.

The background and underpinnings of the field of human factors and engineering psychology illustrate the relevance of this scientific field to the design process. The discipline of human factors is the study of the characteristics of people and their interactions with products, environments, and equipment when they perform tasks and activities. The basic tenet of the discipline is that human characteristics must be considered in designing and arranging systems and devices that humans use. The field of human factors develops the scientific knowledge base concerning the capabilities and limitations of people and then uses that scientific knowledge about human behavior in specifying the design and use of a human-machine (or human-environment) system. The overarching goal of human factors is to make human-system interaction error-free, productive, safe, comfortable, and enjoyable. The ultimate goal of the science and the practice of human factors is to ensure that human-system and human-environment interactions will be safe, efficient, and effective.

2.2 What Human Characteristics Should Be Considered?

Some reflection on one's own interaction with products, with instructions, work-related tasks, etc. should lead to some sense of the number of movement control, perceptual, and cognitive factors recruited when individuals interact with products. Certainly visual and auditory capability is often a crucial factor. Understanding movement capabilities and cognition are also critical to facilitating proper human-centered design. Indeed, when serious accidents related to products are considered, a majority of accidents are due to informational causes (processing the perceptual cues, understanding that perceptual information, and responding to it appropriately).

Sensation is the awareness of simple properties of stimuli such as color. Perception is the awareness of more complex characteristics of the stimuli. Seeing the color red would be sensation, but seeing and recognizing an apple is perception. Sensation involves the activation of cells such as the retinal cells, whereas perception refers to the interpretation of that information by calling upon stored memory. In this latter sense, the concept of cognition and perception overlap.

Sensation and perception are the first of many complex processes that occur when an individual initiates a behavior. No perception gives complete, direct knowledge of the outside world; rather, cognition takes the products of perception and provides interpretation. Cognition refers to all the processes by which the brain takes sensory input, whether from the eyes, the ears, or other senses, and transforms, reduces, elaborates, stores, recovers, and uses that sensory input. Movement control is the broad term that describes physical responses such as turning a knob, pressing a lever, or selecting keys with different fingers.

The human factors approach involves using scientific knowledge about people's capabilities and limitations to create designs capitalizing on strengths and capabilities while guarding against limitations. Age brings with it many capabilities such as well-maintained verbal ability, increased experience, and a broad knowledge base. However, there are limitations associated with perception, cognition, and the control of movements that increase in prevalence as one ages. It is important to become aware of these limitations.

The focus of the remainder of this chapter will be to review age-related changes that occur in sensing and perceiving information, processing that information, and physically responding to the information (see Table 2.1). This review is not exhaustive; additional information is available in the "Recommended Reading" provided at the end of the chapter.

Table 2.1 Description of Categories Discussed in Chapter 2

Term	Definition	Examples
Sensation	The awareness of simple properties of stimuli such as color; activation of sensation cells (e.g., retinal cells).	Seeing the color red; hearing a high-pitched sound
Perception	The awareness of complex characteristics of things in the environment; the interpretation of information that results from sensation.	Recognizing a red object as an apple or determining that a sound is an alarm
Cognition	Processes by which the brain takes sensory information from the ears, eyes, etc. and transforms, reduces, stores, recovers, and uses that information.	Thinking, problem solving, reasoning, decision making
Movement control	Carrying out an action based on perception or cognition; requires coordination of muscles for control of motion of some type.	Steering a car; double-clicking a mouse button; grabbing an object from a shelf

2.3 Aging and the Sensory Modalities

Sensory processes have received considerable attention in the investigation of the effects of age on capabilities associated with various activities. We focus only briefly on taste, smell, haptics, audition, and vision. Auditory and visual capabilities are perhaps most pertinent because they represent user capabilities and limitations that are directly relevant to design (as discussed in depth in Chapter 4).

2.3.1 Taste and Smell

Taste and smell show age-related decrements that may result in an inability among the very old to distinguish among various foods or odors. The evidence indicates that until age 60 the ability to perceive sweet, sour, bitter, and salt — the four basic tastes — does not change much at all. After age 60, some gradual diminishment is noticed, leading to higher thresholds for the detection of specific tastes. Other things, most notably changes in the sense of smell, often cause the inability to distinguish various tastes or flavors that is sometimes noted by older adults. Anyone who has had a cold knows food may be tasteless when one's nose is stuffy and one's sense of smell is impaired.

Research on age-related declines in the sense of smell suggests that smell declines past the age of 70, possibly due to the loss of nerve endings in the nose. However, throughout life, odor recognition varies greatly among individuals. Thus, if smell is a critical cue in a system (e.g., as a warning), it is important to determine individual thresholds of detection.

2.3.2 Haptics

An emerging area of interest related to design is haptics, which relates generally to the sense of touch. As individuals grow older, there is increasing variability in haptic control and increased thresholds for temperature perception and vibration perception. Chapter 4 discusses the implications of these changes for system design.

Why do older people seem to fall often, or why do they sometimes appear to be less stable in movements compared to younger adults? The answers are linked, in part, to an aspect of haptics, which is kinesthetic sensitivity. Over time, as we age, the automatic integration of movement-related sensation mediated by vestibular cues for maintaining balance does seem to deteriorate.

Some examples may better explain kinesthetic sensitivity. Few young people have any difficulty in recognizing when they are sitting upright or partially prone. Nor do they often make mistakes when called on to locate their feet relative to their knees, such as when climbing on uneven terrain. Usually they are able to make generalized postural adjustments when getting to their feet, compensating for slight misalignments without giving the matter any thought. Some older adults, on the other hand, are not able to control body position or movement unconsciously; the loss of their kinesthetic senses leaves them vulnerable to accidental falls and postural instability. For each of us, the sense of movement, touch, and position depends in part on receptors located in muscles, joints, and the skin. For various reasons, some of which can be traced to sensory impairments and some to a breakdown of the brain's integrative capacities, the dizziness or vertigo reported by some older adults is attributed to dysfunctions in these receptors as well as to the integration of visual cues with the receptor information.

For our purposes, it is important to recognize that the sense of movement, touch, and position is more variable across an older adult population compared with a younger counterpart. Moreover, higher thresholds may make older adults less sensitive to haptic cues.

2.3.3 Audition

The ability to hear may affect one's ability to interact successfully with systems and to function safely and effectively in environments. If auditory information is an important aspect of design, age-related changes in audition must be considered. Various estimates suggest that approximately 10% of all middle-aged adults suffer hearing losses of a magnitude that hinders social interaction. By age 65 or so, the percentage has jumped to over half of all men and 30% of all women. The differences between men's and women's hearing capability may change as more women engage in work and leisure activities as younger adults that are detrimental to hearing.

Normally, young adults can hear pure tones in frequencies up to 15,000 vibrations per second. After age 65 or 70, sounds above 4000 vibrations per second may be inaudible. Conversely, low-range tones (below 1000 cycles) are not affected appreciably by age. This age-related change in hearing is called presbycusis; the specific causes are debated but the prevalence is well established.

Volume, or loudness measured in decibels, is a more common measure of hearing. Humans can hear sounds well below the level of a whisper, which averages about 8 decibels, to those in excess of 130 decibels, although pain and nausea are associated with the latter. The range of normal conversation is around 60 decibels and severe hearing impairments occur when an individual's threshold exceeds 35 decibels.

Age-related declines in the hearing of high-frequency sounds can be traced to a deterioration of receptor hair cells, neurons, and vascular changes in the inner ear or membranes within the inner ear. Depending on which decline is most prominent, the ability to hear different types of sound will be affected. To summarize, the best evidence at this time supports the contention that the association between age and hearing loss of all types is strong. Designers of products and environments must be cognizant of changes in hearing capability that influence older adults' ability to detect tones and other sounds, as well as the ability to comprehend speech.

2.3.4 Vision

Visual impairments affect many people, regardless of age. However, like so many other chronic conditions, the prevalence of visual impairments increases with age. In fact, age is the single best predictor of visual limitations or blindness. If we live long enough, nearly all of us will have vision problems.

Visual acuity is the measure most often used when speaking of vision. It is a summary index of efficiency most often reported in the ability to discriminate test objects at a distance of 20 feet. Individuals with 20/20 vision can read an eye chart as well as normal people at that distance; larger denominators (e.g., 20/20 versus 20/50) indicate progressively poorer eyesight. For example, vision rated as 20/70 means objects distinguishable at 20 feet with impaired eyesight can be discriminated at 70 feet by the normally sighted. Most declines become noticeable by late in the fourth decade, if not earlier, resulting from changes in the eye. Hence, seven out of ten people over age 45 find it necessary to wear glasses, compared to three out of ten younger than 45. Vision correction to 20/40 is successful for more than 80% of adults over age 65, which is more than adequate for normal activities. However, even while correcting vision, the use of bifocals or progressive lenses may make certain tasks more demanding.

The old person squinting at a newspaper held out at arm's length has been a source of humor for many years. But presbyopia, or the inability to change the eye's focal length, is so common during the last half of life that most people over age 40 have experienced it. A similar decline in the eyes' ability to adapt to darkness tends to inhibit reading and driving at night among older adults. Nonetheless, carefully controlled illumination can minimize a large share of the problems that might otherwise interfere with a person's daily routine.

Changes in vision also affect sensitivity to glare, breadth of field, and speed of processing. The ability to adapt to large changes in illumination (e.g., moving from dark to bright environments) is more difficult for older than for younger adults. Some deterioration in breadth of field has also been observed. For example, age-related changes in peripheral vision lead to a reduction in functional field of view (the physical area that can be processed in a single glance). Finally, research has indicated an apparent slowing in the speed with which visual information is processed that increases with age. Consequently, perceptual flexibility in visual sensation undergoes a gradual decline with age.

2.4 Cognition

Interactions with products may be analyzed in terms of various cognitive processing components required for successful performance. For our purposes, we discuss the cognitive components in the framework of human information processing. Age-related changes in cognition can be important to consider when designing for older adults. As with the review of sensory and perceptual changes, we highlight aspects of cognition that designers should consider. Citations to further reference materials are provided at the end of the chapter. Table 2.2 provides a glossary of the scientific constructs discussed in this section.

Table 2.2 Definitions of Cognitive Constructs

Working memory	Active memory of what has just been perceived and what is currently being thought about. It consists of new information and information that has recently been retrieved from long-term memory. Only a few bits of information can be active in working memory at any one time (think of holding three names in memory versus ten names). Information held in working memory decays quite rapidly unless it is rehearsed to keep it there.
Semantic memory	Long-term memory for acquired knowledge; includes such concepts as vocabulary words, historical facts, cultural norms, rules of language, art and music information, and more.
Prospective memory	Remembering to perform an action in the future. Time-based prospective memory tasks are those in which the person must remember to do something at a certain time (e.g., at 2:00 p.m.) or after a particular amount of time has passed (e.g., in 2 hours). Event-based prospective memory tasks are those in which something must be done in response to an event (e.g., when the buzzer goes off, turn off the oven).
Procedural memory	Procedural memory is knowledge about how to perform activities. Procedural memory varies along the dimension of automaticity, from knowledge that is executed almost without thought (e.g., shifting gears or steering a car) to explicit but well-practiced routines (e.g., following a recipe).
Attention	The process that controls awareness of events in the environment; attention determines the events to which we become conscious. Attention is limited — it operates selectively on stimuli in the environment. A person in the midst of multiple conversations can only "pay attention" to one particular conversation. Attention capture is a response to salient cues (e.g., if someone calls your name). Attention can be divided across sources of information or switched between tasks.
Spatial cognition	The ability to manipulate images or patterns mentally; the ability to represent information and transform it (e.g., mentally rotate an image) or to accurately represent spatial relationships among components.
Language comprehension	The ability to interpret verbal information, whether written or spoken. Includes the ability to understand individual words, to understand sentences and paragraphs, and to draw logical inferences that are implied in a text or discourse.

2.4.1 Memory

A common belief is that memory gets worse as we get older. However, whether and how much memory capability declines with age depends on what kind of memory is involved in any given activity. Age-related decline in *working memory* (sometimes called short-term memory) is well documented. Working memory refers to the capability to temporarily keep information active while we "work on it" or until we use it. Using a telephone menu system requires working memory as the user of that system needs to remember the goal of the call, listen to each option, match the option to the goal, and make a selection. Designing to guard against the limits of working memory is an important recommendation.

Working memory capacity affects performance of everyday tasks to varying degrees. Age-related differences in a variety of domains (speech and language comprehension, reasoning, problem solving) have been attributed to age-related differences in working memory. These conclusions have been reached through both within-context and out-of-context assessments of working memory. Within-context assessments involve inferring working-memory capacity from task performance. For example, redundant questions asked by a person might be indicative of a working memory deficit. An out-of-context assessment of working memory involves measuring performance on tasks specifically designed to assess memory (e.g., span tasks, keeping-track tasks). Regardless of the measurement method, working memory declines for older adults are typically found (and the impact on performance is a recurrent theme throughout this book).

There is another kind of memory often referred to as long-term memory. Long-term memory can be thought of as a more permanent storage of knowledge (including learned movements and skilled behaviors). A type of long-term memory, *semantic memory* shows minimal decline with normal aging. Semantic memory is defined as the store of factual information that accrues through a lifetime of learning. Remembering the meaning of a word is semantic memory, as is remembering historical facts, memory for art and music, and general knowledge — basically, information acquired throughout one's lifetime. Older adults may be slower to access stored information and sometimes experience retrieval difficulties (e.g., the "tip-of-the-tongue" phenomenon). However, the information stored in semantic memory is generally not lost entirely. Therefore, designing to make use of such semantic memory can be important. Population stereotypes (such as "up" indicating "on" for a light switch in North America but "off" in Europe) are a form of semantic memory shared by groups of people. Making use of population stereotypes in design can facilitate ease of use. Design that is contrary to population stereotypes can lead to disastrous consequences.

Another form of long-term memory is *prospective memory*; that is, remembering to do something in the future. If our prospective memory is based on doing something at a later time (such as remembering to take medication in 4 hours), this is time-based prospective memory. Another kind of prospective memory depends on performing some action after some event occurs (such as remembering to take medication after eating or after a timer bell sounds). This latter kind of prospective memory is referred to as event-based prospective memory. Age-related declines in prospective memory are usually much greater for time-based than event-based tasks. From a design perspective, it is important to guard against time-based prospective memory demands and to ensure that event-based prospective memory demands are coupled with an event that will provide the appropriate reminder to cue memory. Salient cues about when an activity needs to be performed can support prospective memory quite well for adults of all ages.

Another aspect of long-term memory is *procedural memory* — knowledge about *how* to perform activities. Procedural memory varies along the dimension of automaticity, from knowledge that is executed almost without thought (e.g., balancing on a bicycle) to explicit but well-practiced routines (e.g., doing long division or following a recipe). Older adults have difficulty developing new automatic processes (conceptually like developing new habits) in some domains. However, for tasks and activities "automatized" prior to senescence, evidence suggests that these automatic behaviors remain intact. Some procedural tasks are not performed automatically but represent overlearned procedures that are executed under conscious control (e.g., using an algorithm to solve a problem). Such application has been shown to be age-insensitive if sufficient practice is provided.

From a design perspective, it is important to make the same actions (e.g., starting a computer browser) consistent across different systems and tasks to support procedural memory. In addition, when designing training or instruction, it is critical to examine the to-be-trained activity for consistent elements of the task. These consistent elements can then become important training or learning modules. It is important to also keep in mind that older adults seem to have more difficulty compared with younger adults when required to inhibit previously well-learned procedures. Therefore, when designing something new, it is important to guard against the requirement to inhibit well-learned procedures; if that is not possible, ensure extra learning time for older adults to unlearn the previous procedures and learn the new procedures. Finally, it is important to note that previously well-learned procedures may reappear in behavior when individuals are under stress or faced with multiple task demands. This is another reason to guard against designs that are inconsistent with past procedural knowledge.

2.4.2 Attention

Attention refers to our limited capacity to process information. Through selective attention we can choose information to process in more depth; we are also able to divide attention between sources of information or switch back and forth between tasks.

Interacting with products often involves visual search. Detecting and categorizing warning information or finding which buttons to press on an automatic teller machine are search-detection tasks. Searching for things requires selective attention. As the demands on attention increase, age-related performance problems also increase.

Dynamic visual attention is another aspect of cognition that can be related to successful interaction with products or environments. Dynamic visual attention is how we scan the environment and involves focusing attention in one location and then another location. However, the ability of the person to focus attention and then reorient that focus is limited by the availability of a finite amount of attention-related resources. It can take almost a second to reorient attention from one item of interest to another even under ideal, controlled laboratory situations. Generally, older adults require more time to orient attention from one location to another.

Attention is captured by highly salient events in the environment and other stimuli will not be processed during this capture of attention. Older adults tend to be more affected by salient events such as flashing, high-intensity lights as well as stimuli that appear to pose an immediate "threat." Clearly, when designing for older adults, it is critical to require as small a number of things to search through to perform a task. It is also critical to remove extraneous information that might capture attention (such as blinking display elements on a web page). However, older adults can successfully take advantage of cues that are specifically designed to capture attention.

In many situations, older adults must coordinate multiple tasks, which involves dividing attention across multiple sources of information or switching attention between tasks. Issues of task control include speed demands and multitasking. Research results generally demonstrate a slowing of response as a function of age. Moreover, as the complexity of the task increases, the degree of slowing increases as well. Although this generalization may not be strictly true, older adults are proportionately slower, from an average sense, on more complex tasks. This is true primarily for tasks that take several seconds or minutes to complete.

Virtually all complex tasks can be logically divided into subtasks. Whether individuals divide tasks down into subtasks, psychologically, probably depends on the extent to which the different subtasks can be performed in sequence. In many tasks, the different components are

inextricably linked. When younger and older adults are required to perform more than one task at a time (such as driving and looking for street signs), older adults generally perform more poorly compared to their younger counterparts. Older adults perform less well than younger adults in dual-task conditions, and the magnitude of the age difference increases with task difficulty. When a design requires older adults to perform novel activities, it is critical not to require the combined performance of tasks or components of tasks.

2.4.3 Spatial Cognition

Some tasks require the performer to develop and reason about visual images, using external cues that do not directly develop that "image in the mind." An example is translating directions and information abstracted from a two-dimensional map into an image of three-dimensional space through which one can traverse. The maintenance and manipulation of visual images involves spatial cognition. For example, in a configural learning task, people are required to combine spatial and temporal information into a representation that they can compare to a new perspective of a scene. Young adults outperform older adults on this task, especially when an unfamiliar location is tested. Age differences are also observed in tasks that require memory for object locations and the development of a sequence or route. In addition, age differences have been observed in the segmentation, integration, and transformation of spatial information. A decline in spatial ability has been shown to be predictive of proficiency in performing computer-based tasks.

2.4.4 Understanding Written and Spoken Language

Linguistic representations are those based largely on verbal descriptions of situations. For example, when reading a story, individuals often develop a linguistic representation of the events in the story. An analysis of word-by-word reading times suggests that young and older adults may develop different linguistic representations during reading comprehension. Research suggests that older adults are storing smaller "chunks" and must do more frequent integration. Working memory limitations have been implicated as the source of age differences in various linguistic tasks such as understanding natural language and processing and producing syntactically complex speech.

Older adults also have more difficulty comprehending language when inferences are required. That is, if connections between ideas are not made explicit, an inference must be made; such inference generation may be reliant on working memory, which is perhaps why older adults have more difficulties. If older adults can rely on their semantic memory base, language comprehension improves. From a design perspective, familiar terms and labels should be used and connections between concepts should be made explicit.

2.5 Control of Movements and Movement Speed

There is a large body of literature that shows that as people age, their movement control performance gets worse. Generally, older adults take longer than younger adults to make similar movements and the movement is less precise. Such difficulties occur across a wide range of activities, from difficulty in using a mouse to positioning a cursor on a computer to movements related to driving an automobile. This age-related difference in performance can be a major impediment to activities performed by older adults and must be considered by designers.

Why are older adults slower and more error-prone when it comes to movement control? Laboratory research has established the source of age-related performance decline as a combination of (1) poorer perceptual feedback, (2) increased "noise" in the motor pathway, and (3) strategy differences in approaching the task. A rule of thumb to estimate movement times (and performance of novel tasks in general) is that, on average, older adults will be about 1.5 to 2 times slower than their younger counterparts.

This information is relevant to design. For example, knowing that movement control is less precise and slower, a straightforward approach to making a computer mouse interface easier to use for older adults includes simply implementing software changes in the gain and acceleration profiles that translate mouse movement into cursor movement. All current computer systems have software that allows a user to adjust the gain ratio to customize cursor-positioning performance. This is a cost-effective way to compensate, at least partially, for age-related differences in movement control.

2.6 Summary of Review

The present chapter was intended to provide a brief overview of perceptual, cognitive, and movement control factors that should be understood when designing for older adults. Capabilities do not all decline with age nor do all older adults show age-related declines. However, in general, some factors show age-related declines whereas others remain intact. Designers must compensate for declines and capitalize on abilities. Assistance for such design decisions comes from mathematical models developed based on the cognitive aging literature. Such models predict performance differences in system interactions due to age-related changes in perception and cognition (see Chapter 15 for an example). Below is a summary of the key findings discussed in this chapter.

- **Sensation and perception:**
  - — Taste and smell show age-related declines.
  - — Changes in haptics result in increased perceptual thresholds for temperature and vibration and may make older adults more susceptible to falls.
  - — Auditory declines are common, especially for older men, and especially for high-frequency sounds.
  - — Vision declines for many older adults; visual acuity declines begin to be noticeable around age 40.
  - — Glare is more problematic for older, relative to younger, adults.
  - — Other aspects of vision also show age-related declines: dark adaptation slows, breadth of visual field decreases, visual processing speed slows, and perceptual flexibility declines.
- **Cognition:**
  - — Memory is a multifaceted construct; only some aspects show age-related declines:
    - Working memory (i.e., the ability to hold and manipulate information) declines with age.
    - Semantic memory (i.e., acquired knowledge) shows minimal decline with age although the ability to access information may be slower and less reliable.
    - Prospective memory is remembering to do something in the future. Age-related declines are less evident if people have strong cues available as reminders (e.g., take medication with dinner).
    - Procedural memory is knowledge about how to do something. Well-learned procedures are maintained into old age and, in fact, are difficult to inhibit. Older adults are slower and less successful at acquiring new procedures, relative to younger adults.
  - — Attention is a multifaceted construct; only some aspects show age-related declines:
    - Selective attention (i.e., searching a visual display) and dynamic attention (reorientation of attentional focus) both show age-related declines.
    - Older adults can benefit from cues to orient and capture their attention.
    - Age-related differences in rate of information processing increase with task complexity (i.e., attentional demands).
    - Older adults perform less well than younger adults when required to coordinate multiple tasks, either by dividing attention or switching attention.

— Spatial cognition (i.e., maintenance and manipulation of visual images) declines with age.
— Language comprehension remains intact if older adults can capitalize on their semantic memory; impairments are observed when inferences are required and working memory is overloaded.

- **Movement control:**
  — Older adults respond more slowly than younger adults. In general, an older adult will take between 1.5 and 2 times longer to respond than a younger adult.
  — Movements made by older adults tend to be less precise and more variable than those made by younger adults.

2.7 Guidance for Design

There are several themes evident in our review that point to the sources of age differences in performance at a variety of levels. First, working memory often appears to be the limiting factor in performance (e.g., speech comprehension, task coordination). Pragmatically, such working memory limitations are sometimes reduced with practice (e.g., consistent practice on memory search tasks), through the training of strategies (e.g., using external memory aids for planning purposes), or through the provision of environmental support to reduce working memory demands. Environmental support (putting required knowledge into the world rather than requiring memory retrieval) has been suggested as a means of minimizing age-related differences in a number of contexts. In an attentional search task, the provision of cues directing attention to a spatial location in a display is a form of environmental support.

Our review identified processes that are important for task performance, psychological sources of overall performance and learning decrements, and provided prescriptions for designing systems that overcome general or age-specific information processing problems that hinder maximal task performance. Hence, we have outlined the foundation for principled task decomposition. The task decomposition identifies the psychological components necessary for novice and skilled performance, and provides the principled approach to possible age-dependent remediation. In essence, it forms the foundation for the principled approach to age-specific design. Chapter 3 discusses the process of task analysis and using that analysis in product design; task analysis is also detailed in Chapter 16 in the context of predicting when and where older adults might make errors.

The review of age-related effects on cognition leads to fundamental design guidelines. These design guidelines are emphasized in the chapters that follow. For example, it is important that the design limits demand on working memory and attention. One should also design to make use of previous experience. Generally, people perceive and respond rapidly to things that they expect on the basis of past experience. People generally respond much more slowly to those things that are unexpected compared to things that are expected. One of the roles of the designer is to understand, predict, and capitalize on what people will expect. Another role of the designer is to understand that when people are faced with using a novel product or experiencing a new environment, they will try to make their task manageable by relating what is new to what they already know. If design does not capitalize on relevant semantic memory, problems can and often do arise.

When experience cannot guide action, it is perhaps easy to see why it is critical to guard against information overload and to guard against inappropriate actions because people thought they knew what to do based on past experience. Indeed, this discussion should point out that it truly can be difficult to interact with new products.

Recommended Reading

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chapter 3

Guiding the Design Process

Many people have difficulty operating consumer products or interacting with systems, and more often than not the root of the problem lies in the design process rather than with the user. The incorporation by designers, often unknowingly, of complexity, ambiguity, and inconsistency into devices, interfaces, and instructions can create imbalances between the demands imposed by these products and the mental and physical resources at the disposal of the user (see Chapter 2). In addition, the information provided about important features may be insufficient, inappropriate, or omitted altogether.

To minimize the problems people encounter in using products, it is necessary to apply a systematic procedure to the design process. Such a procedure hinges on the timely application of various methods at different stages in the design process. The procedure currently advocated is generally referred to as "user-centered design" (UCD), which is discussed in more detail further on.

The design of complex systems, such as a software application, often requires the consideration of user groups that may include trainers, installers, the people who maintain these systems, and salespeople. The focus in this chapter is on design for the end user, and specifically individual older adult users who do not collectively comprise a work group.

3.1 Principles of Design

The user-centered design process adheres to four principles of design:

1. Early focus on the user and the tasks the user will be performing, which often requires the application of a method called task analysis.
2. Empirical measurement using questionnaires and surveys as well as usability testing studies that rely on observations and quantitative or qualitative performance data.
3. Iterative design and testing, which often requires the development of prototypes of products or system interfaces to support rapid development cycles and performing cost-benefit analyses to support trade-off decisions.
4. Integrated design, wherein all aspects of the usability design process evolve in parallel and are generally under the coordination of a single person.

These four principles roughly correspond to the following four phases of the design process: (1) the gearing-up or front-end analysis phase, (2) the initial design or usability testing phase, (3) the iterative design and development phase, and (4) the final test and evaluation phase.

Despite the fact that UCD has been promoted by human factors professionals for over 20 years, designer-centered design is still commonplace. One reason is that designers are often under pressure from management to produce products with shorter development times while being allocated insufficient resources for addressing the requirements entailed by UCD. However, the considerable shortening in recent years of product development times is even more reason why users must be integrated into the design process — to produce the most usable product feasible as rapidly as possible.

Designer-centered design can also result from designers who are overconfident in their designs. These designers believe that their work on previous versions of the product (almost all new products or systems are actually follow-ons to a previous product) and knowledge of existing problems with the product, often based on anecdotal evidence, are sufficient for producing a new design. Management pressure and overconfidence can combine to lay the foundation for rationalizations by designers on why continual user involvement in the design process is unnecessary. For example, designers may convince themselves that instruction manuals, online help systems, and telephone hot lines will take care of any design shortcomings, or that the product should be fine given that various standards and guidelines were followed. Such attitudes will generally have disastrous implications for older users. Some designers may also be apt to believe that iteration results in degrees of fine-tuning that are not cost effective when in reality there is ample evidence that the opposite is true.

3.2 *Universal Design*

A further extension of the idea of UCD is universal (or inclusive) design, whereby products or environments are designed that are flexible enough to be usable by people with no limitations as well as by people with functional limitations related to disabilities or due to circumstances. In principle, good universal design benefits everyone and thus would benefit many more people without disabilities than those with disabilities (e.g., those who are blind, cannot speak, cannot hear, or have learning disabilities) or those whose limitations are due to other reasons (e.g., those whose hands are temporarily occupied, those who cannot hear due to a noisy environment, or those who are very young or very old). Designing for older people, similar to designs intended for accommodating people with functional limitations, can also provide insights into designs that benefit all users. However, the focus in this chapter is on design for the

population of older people with normal age-related declines in abilities rather than those with serious functional limitations.

3.3 *What Makes a Product Usable?*

The usefulness of a product can be considered from two standpoints: (1) its "utility" and its (2) "usability." A device's utility concerns whether the functionality provides what is needed, whereas usability relates to how well users can access that functionality. From this perspective, the perceived utility of a device is fundamental to the concept of usability — a very usable product may in fact not be used if its perceived utility is insignificant.

The following are five important attributes of usability

1. *Learnability* concerns how easy it is to learn to use the device.
2. *Efficiency* implies that the product should allow users to achieve their intended objectives — that is, produce acceptable product performance — within a reasonable amount of time without inducing frustration, fatigue, or dissatisfaction.
3. *Memorability* relates to how easy it is to remember how to use a device, which implies that the effort in relearning following periods of nonuse should be minimal.
4. *Errors* can be broadly construed as user actions that are performed or omitted that result in the user not accomplishing the desired goal. Feedback to the user concerning errors may or may not be signaled by the product's interface. In any case, errors resulting from interacting with the product should be minimal; and if they do occur, the user should be able to easily recover from them.
5. *Satisfaction* addresses the pleasantness of the experience the user has in interacting with the product.

The consideration by designers of the perceived utility of the device and each of these five attributes of usability requires increased emphasis when designing with older users in mind. In particular, older users may have difficulty learning to use the device, especially if the instructions overload the user's working memory and thus make it difficult to integrate information effectively (Chapter 2). In general, memory-related problems common among many older people make it more imperative that product procedures are easy to remember following periods of nonuse. Frustrating experiences associated with repeatedly relearning to use a product are likely to adversely affect the adoption of new technologies in the future, creating a downward spiraling effect that is a lose-lose situation for both designers and users.

Similarly, designing products that make it easy for errors to be made and difficult to recover from can lead to older users becoming disillusioned with technological products. Providing error messages that are not easily interpretable can further intensify the level of frustration. Thus, it is essential that products are easily learnable and not conducive to errors; otherwise, product attributes of memorability, efficiency, and satisfaction may never become realizable.

3.4 Measuring Usability Components

Measuring usability will require some understanding of the methods that constitute the UCD process. These methods are discussed in the ensuing sections, and form the core set of tools and knowledge that the designer should be aware of and preferably familiar with.

Measures of learnability attempt to capture indications of the initial ease of learning. A basic measure is the time it takes users who are unfamiliar with the product to reach a specified level of proficiency in using it. The measure can be chosen to reflect the degree to which a specified task is completed successfully or the extent to which a task (or set of tasks) is completed by a specified time. To measure efficiency, it is necessary to obtain a representative sample of users who are reasonably experienced with the device. One can then measure the time it takes for them to perform various tasks that are typically performed on that device.

Measuring memorability should be confined to users who do not intend to use the device frequently. One approach is to have a test participant return to the testing environment at some future time following learning of the device and then measure the time needed to complete a set of tasks previously learned. Alternatively, users can be asked to recall various procedures regarding device use following a test session with the device; depending on the product, users may be able to rely on visual cues from the device to recall such features or procedures.

There are many ways to characterize errors. When assessing usability, these different types of errors are usually described and counted. Errors that the user immediately detects and corrects are generally differentiated from errors that are more troublesome for the user to diagnose or catastrophic in the sense that they stop the device from functioning. A mode error, another important category of error, occurs when the user cannot achieve the task objective due to the inability to recognize that the product is in a different mode from the one necessary for the product to function as intended. Other error categories include the omission of critical steps, the substitution of incorrect steps, and the execution of task steps in an incorrect sequence. Distinctions between "slips" (e.g., an inadvertent activation of a control) and "mistakes" (e.g., an intended but inappropriate action) are also useful.

Satisfaction with a device is usually measured subjectively by short questionnaires or sometimes by exit interviews following a testing session. A questionnaire might ask users to rate their degree of agreement

with a statement about the device on a scale from 1 to 5 (where 1 = strongly disagree, 2 = somewhat disagree, 3 = neither agree nor disagree, 4 = somewhat agree, and 5 = strongly agree). To mitigate the problem of people tending to be polite in their responses in such instruments, it is recommended that some questions be included with "reverse polarity," whereby agreement corresponds to a negative rating. Generally, ratings are more meaningful when compared to ratings of different versions of the product, or when comparing different populations of users such as younger and older persons on the same product. This enables ratings to be interpreted on a relativistic rather than absolute basis. Ratings can also be generated from questions posed during exit interviews. An advantage of exit interviews is that they can promote spontaneous dialogue regarding the user's experiences in interacting with the product, and thus provide potentially valuable information that might otherwise have been missed.

3.5 User-Centered Design (UCD)

As implied above, UCD is a broad concept that encompasses a host of methods. Although all of the UCD methods draw attention to the need for designing products from the perspective of the user, they go about accomplishing this objective in different ways. Generally, the design team needs to decide which subset of methods to utilize.

The most fundamental method in UCD, and one that almost all other methods directly or indirectly rely on, is task analysis. The application of this method is illustrated in Chapter 15.

3.5.1 Task Analysis

Task analysis is a method that decomposes the tasks the user performs when interacting with a product or system into steps that ultimately provide information concerning the requirements for accomplishing the task objectives. Many different approaches to task analysis exist. A particular type of task analysis method useful in product design is hierarchical task analysis (HTA). In using HTA, the task the user needs to perform is considered in terms of its goals, which are then decomposed hierarchically into the plans for meeting these goals and the operations for carrying out these plans. For example, consider the goal of taking a black-and-white picture with a digital camera under low lighting conditions. The plan for meeting this goal may consist of turning on the camera; setting the camera to black-and-white picture taking mode; and adjusting the flash and speed to compensate for low lighting conditions. For each goal considered in the HTA, the order in which the plan is carried out is specified; likewise, for each step of the plan, the required operations would be specified in the order that they should be performed.

Although graphical flowchart formats are often used to depict an HTA, tabular formats are sometimes recommended to enable the designer to include additional columns that can contain useful information related to operational steps (see Chapter 15). Examples of such information include the type of action or behavior required by the user, the potential for errors associated with these actions, opportunities that exist for recovery from these errors, excessive cognitive demands imposed by that operation, and the potential for injury or the creation of hazardous conditions.

Task analysis performed early in the design process is referred to as preliminary task analysis, and should be differentiated from task analysis performed when a prototype of the device exists. Task analysis is extremely important for early input into the design process, especially when designing for older adults. Such analysis identifies information needs, visual and auditory requirements, demands for focused attention and for retaining information in memory, the time necessary to react to signals, and physical requirements such as digit manipulation and required forces. This information provides a starting point for identifying problems that older users potentially face. At the later stages of product development, users can be observed interacting with the product and asked questions concerning why they did a certain action or how they went about accomplishing a particular step of a plan (see Chapter 12). Generally, the later design stages enable greater insight into dependencies between task steps and difficulties accomplishing objectives.

Task analysis is a powerful method that can also be applied to instructional manuals or any other "tool" the user requires for performing the task. For example, when applied to older users, task analysis may determine that the instructional manual contains textual information that is difficult to read as well as comprehend, and lacks diagrams or pictures that would allow the user to identify important functional elements associated with the device.

A very useful role of task analysis involves analysis of safety issues. Some products are potentially hazardous in ways not foreseeable by designers. For such products, older users may not detect or interpret warnings as readily as younger users, or may have physical limitations that could decrease the likelihood of adequately responding to hazardous conditions. Task analysis — and in particular one that addresses cognitive demands such as the need for discriminating between warning indicators, interpreting messages, or requirements for focused or divided attention — is essential for predicting the possibility of overloading or confusing the user.

HTA is particularly well suited for this purpose. For each step of the analysis, the possibility of different types of errors or problems is assessed. Using a tabular format, the analyst can also include a column that addresses the consequences of the error, the possibility for the user to recover from the error, and design interventions for eliminating or reducing the negative consequences of the error or problem (see Chapter 15). An environmental analysis can provide a more detailed analysis of the contexts within which the user interacts with the device or system, and thus help the designer determine whether a hazardous condition or human error might propagate to an adverse outcome for the user.

3.5.2 *Usability Testing*

Usability testing is a very important UCD method. In a usability test, one or more participants perform specified tasks with the product in regulated test environments while being watched by one or more observers. It is not uncommon for usability testing to be coupled with other UCD methods (discussed below), which provides the design team with a more comprehensive appraisal of design issues.

3.5.2.1 *Two Perspectives to Usability Testing*

There are two broad perspectives to usability testing. One focuses primarily on the discovery of problems the user confronts and ways to resolve those problems, whereas the other focuses on task performance measurement related to the accomplishment of well-defined task goals, although some emphasis is also usually given to documenting usability problems. The first perspective lends itself to more informal approaches to usability testing and a greater variety of methods. For example, the analyst may sit next to the participant to encourage verbal indications of frustration or points of confusion in task performance, taking notes of these occurrences, or may rely on the participant to "think aloud" (see below) while performing each step of the task. Generally, the analyst collects data on steps or sequences of steps that are problematic for the user, the frequency with which the different types of problems are encountered, the contexts in which they occur, and the effects that encountering these types of problems have on the participants. With older users, it is probably not advisable to interrupt their task activities by asking them questions as this could disrupt their momentum and make it more difficult for them to reorient themselves to the task.

Although there are no restrictions on how participants may be observed with either approach to usability testing (sitting in close proximity to the participant, observing through a one-way mirror, or watching a video broadcast of the participant performing the task), there is generally a greater degree of interaction between participants and practitioners in problem-discovery studies. In contrast, usability testing that emphasizes precise measurements generally requires less interaction between the practitioner and the participant. However, this approach usually dictates a more formal usability test, as might be the case when the design goal is to produce an interactive voice menu system that results in 5% or fewer errors in making menu selections. In these studies, the analyst must identify the appropriate variables to measure, establish usability goals, and collect data to determine if the usability goals have been met.

The measurements in usability testing will generally fall into four classes: (1) indices of goal achievement such as success rate or accuracy, (2) measures of speed and efficiency, (3) error rates and indicators of function usage, and (4) measures of learning. Usability goals can be based on previous usability studies of predecessor or competitive products that have used similar user populations. However, in the absence of such information, the analyst will need to recommend a set of goals, perhaps through discussion with other design team members. A general guideline in setting usability testing measurement goals is to refer to an average rather than to a percentile of a measurement. For example, it is better to set a goal in terms of statements such as "The average time to find and successfully execute function X will be less than 30 seconds" rather than "90% of all participants will be able to find and successfully execute function X in less than 45 seconds." Finally, the analyst should consider conducting statistical tests to determine the appropriate number of participants needed for achieving a particular usability test goal or, in the case where the test was already conducted, to be able to assess the evidence regarding whether the test goal was achieved. A separate tutorial (see Chapter 14) is devoted to the topic of statistical considerations in usability testing.

3.5.2.2 *Usability Test Plan*

Irrespective of the usability testing method chosen, the analyst should employ a "usability test plan" to ensure that the methods used have been clearly documented and that proper caution has been exercised in interpreting the results. The initial item that a usability test plan should include is a clear statement of the goals of the test. Examples of such goals are determining if the user can find certain functions without the use of an instruction manual, recover from certain types of mistakes, or input a sequence of characters without an error. The goals for older users may be different than those for younger users. For example, in usability testing of a new cell phone, it may not be important to subject older users to the array of functions that younger users are likely to use but rather limit the functions to those that are deemed most critical to the tasks older adults are likely to perform. The identification of relevant functions and contexts of operation can come from other supporting UCD methods, such as interviews, questionnaires, and focus groups, as discussed below.

Finally, as usability testing usually involves an iteration of test and design/updating cycles whereby testing is initiated early on in the product development cycle and reoccurs throughout this cycle, the usability test plan should also specify "stopping rules" with respect to testing.

For example, decisions need to be made as to whether usability testing should terminate with an earlier version of the product or following completion of product development.

3.5.2.3 *Think-Aloud Verbal Protocols*

The verbal protocol or "think-aloud" method is often used in usability testing studies. It is especially useful in studies that emphasize problem discovery as some of the concerns in using this method — in particular, that it could cause the test participant to perform slower and thus render measured data as inaccurate — are not as relevant. The reliability of such verbalizations hinges on whether producing the verbalization exacts additional cognitive processing over and beyond the cognitive processing required to perform the task. If so, then it is likely that the effort required in formulating the verbalization is taking cognitive processing resources away from performance of the task.

In using this method, a test participant continuously thinks aloud while interacting with the product, with the emphasis being on what the users are doing and why they are doing it rather than detailed rationalizations of their activities. This method circumvents reliance on explanations that are offered afterward concerning problems the user encountered, and provides excellent qualitative data that can be integrated into reports by designers for supporting arguments for redesign or product embellishment. Within the usability testing community, it has been recommended when using this method that the practitioner running the test use interrogative "acknowledgment tokens" such as "uh-huh?" or "And now …?" to encourage the participant to keep talking.

When using the think-aloud method, the analyst should be aware that not all people are comfortable verbalizing their thoughts while occupied in some activity. Providing a warm-up thinking-aloud exercise is recommended to minimize the possible discomfort associated with thinking aloud as well as the tendency to not verbalize. For example, the user can be asked to think aloud while searching for the number of an airline using the telephone book.

In the case of some older adults who are relatively unfamiliar with the product and may have diminished cognitive capacities, their interaction with the product may be so consuming that they continuously forget, or do not have the spare capacity, to verbalize. For these people, the process of verbalizing their activities may create a dual-task situation — that is, the thinking-aloud activity takes on the role of another task that must be performed, which may cause them to perform more poorly than they would if they had not been asked to think aloud. If the purpose of usability testing is primarily problem discovery, this issue may be addressed by allowing the person to perform the task first, without thinking aloud, and then to perform the task a second time while thinking aloud.

3.5.2.4 Equipment

Many large organizations have usability laboratories characterized by sound-proofed rooms; one-way glass separating observer and participant areas; video cameras to capture the user's interactions, often from multiple viewing angles; and microphones to capture verbalizations or other relevant sounds. However, it is often the case that formal laboratories are not needed, and that converting existing spaces into usability testing areas is sufficient. In fact, less formalized settings are often more realistic, and may actually be better suited for older adults who are more likely to experience anxiety in unfamiliar environments. The emphasis on elaborate recording equipment is also sometimes overstated, and simple observations and manual note-taking may be all that is needed to conduct many usability tests.

3.5.2.5 Participants

The determination of who will participate in a usability test will usually depend on who the expected end users of the product are. Profiles of these users can often be derived from marketing groups. Most importantly, the test participants need to be representative of the population of end users, which requires that the characteristics of the end users be clearly specified and differentiated from people who are not members of the end-user population. Once the target population is identified, the analyst should attempt to capture as much variability (i.e., heterogeneity) in this sample as possible so that the results of usability testing can apply (i.e., generalize) to as much of the target population as possible.

Suppose the target population is older adults and the product is a medical device that will come with a small instruction booklet. One could achieve heterogeneity in the sample of test participants by considering how much previous experience the participant has had with similar products, previous models of this product, or any healthcare products, and then attempt to recruit individuals with no, some, and moderate degrees of experience in each of these categories. Although it is important to test potential end users who are currently unfamiliar with the product, it is also essential that users who have experience with similar products be tested. This allows a "boundary of expectations" to be established — if people very familiar with the basic product are having difficulty, then it is unreasonable to expect novice older users to have much success. Other individual attributes that can serve as a basis for promoting heterogeneity in the test sample are age (e.g., by differentiating between different older age groups such as 60–69, 70–79, and 80–89 years of age); gender; education level (which may be critical with respect to comprehension of instructions); and health status (which could point to physical problems that could undermine usability of the product).

Achieving generalizability of test results also requires that the test scenarios be representative of the types of tasks actual users will perform with the product. Often, the goal in usability testing is to subject the participant to a variety of scenarios of product or system use, with each scenario requiring the performance of particular tasks.

A very important consideration is the need for ethical treatment of participants who will be subjected to usability testing. This means that they must give their informed consent to participate in the study. Signed informed consent usually follows oral and written statements by the practitioner concerning the motivation for the test, what the test will entail, the ability to leave the test at any time without the need to provide an explanation, assurance that the risks associated with participation are no different than those encountered in normal everyday situations, that the data being collected is confidential, and the nature of any compensation that will be given for participation in the study. It is especially critical when briefing older participants about the study that they are informed that the goals of the study are to improve the usability of the product and not to determine how well they perform on the test.

The participants also need to be informed about additional instruments such as checklists or questionnaires that may be administered to them following their performance on the test scenarios, which raises the issue of fatigue with older participants. If the test scenarios are too long, the participant may elect to leave before completing the testing, resulting in important missing data about preferences and other subjective responses. Thus, the analyst needs to consider carefully the time demands imposed by the tests and, if deemed necessary, ensure that the participants are given adequate breaks. This can be determined during pilot testing, as discussed below.

3.5.2.6 Pilot Testing and Training

Prior to formally testing users, "pilot tests" should be performed on a small group of users. If the user's age is a consideration for the designer, then at least one participant from each target age group should be pilot tested. The purpose of pilot testing is to identify and ultimately remove any problems that would undermine formal user testing, such as incomprehensible instructions or questionnaires, unreasonable amounts of time allocated for testing, inability to collect certain measures, or the discovery that certain measures are incorrectly defined.

Another important consideration in usability testing is the extent and form of training that will be needed on the tasks. Some products such as telephone voice menu systems should probably be tested with minimal instructions, if any, to be consistent with the fact that users will typically encounter these systems without any instructions on their use.

Training can be imparted through written manuals, computer-based programs, or face-to-face communication. For some types of testing, the interest may lie in determining if the user can learn to solve new functions given a basic understanding or overview of the product. In other cases, the interest may lie in determining how a user acquires this basic knowledge. These objectives should dictate the strategy used for imparting knowledge to the user about the product. Finally, because many participants, especially older users, are likely to ask questions as they confront various types of difficulty or uncertainty during their interaction with the product, a protocol should be established governing the rules associated with the kind of help the analyst could offer. This provides a degree of standardization that helps to ensure that the participants all receive the same kind of information.

3.5.3 Field Observations

Whereas observations that are taken by the practitioner in a usability study are in response to controlled task scenarios, field observations are generally undertaken to identify problems that users have when interacting with products or systems under actual conditions. For example, suppose there is an interest in determining if an airline's airport kiosk for issuing boarding passes is problematic for older passengers. Assuming consent has been granted to perform the study (e.g., by the airline), an obvious way of becoming informed about potential problems the user may encounter is to observe the user interacting with the device and recording the observations.

During field observations, the observer should try to be as unobtrusive as possible to foster realistic user interactions with the product. There may be times when interrupting a user to clarify an action is warranted, but these instances should be carefully chosen (you would not want the user to miss a flight because of your prodding). Also, for ethical reasons, the individual would need to be informed about the purpose of the study. Observer bias is also a concern; for example, the practitioner may focus on activities expected to be problematic for older users. To counter this tendency, practitioners should attempt to direct their attention also to actions by the user that are not necessarily consistent with what they expect the user to do.

To better manage the tremendous variability in the types and amount of data collected from an observational study performed in the field, prior to performing observations the observer should attempt to become familiar with the product or system by interacting with it. The knowledge gained from this experience could then be used to perform a task analysis that would enable the practitioner to anticipate possible points of difficulty or areas of concern for users.

3.5.4 Interviews

There are different approaches to interviews that can be taken, ranging from highly unstructured methods that elicit free-form discussions to highly structured methods whereby a predetermined sequence of questions is posed. When interviewing product users, an approach somewhere in between these extremes is recommended. The interview should be sufficiently focused to capture important situational contexts, but also flexible enough to allow for tangential exploration of design issues and more in-depth comments that can serve as useful anecdotal evidence to justify design decisions.

Checklist and guideline items (discussed below) can often serve as the basis for structuring interviews — for example, items that address the organization, visual clarity, and functionality of the controls and displays of an advanced audio system in an automobile. One outcome of such an interview might be that older adults in particular may benefit from less clutter on the digital audio display, and from a larger rotating volume control button, which would afford easier control while driving. Overall, interviews not only provide the opportunity for exploring issues in particular contexts, such as the inadequacy of a control while driving in traffic, but also for exposing problems in other areas, such as instruction manuals.

Interviews should be administered as soon as possible following user interaction with the product to minimize possible distortions or forgetting of opinions. In conducting the interview, it is important that the interviewer remain neutral by avoiding any tendency to agree or disagree with the user. Questions that evoke yes or no responses should be avoided as these responses have limited diagnostic value. Ideally, interviews should capture best- and worst-case experiences with the product.

3.5.5 Questionnaires

Questionnaires allow for quantification, using various scales, of the user's feelings about the product or system. A typical example would be a five-point scale that allows the user's response to questions to range from "strongly agree" to "strongly disagree." Once a particular rating scale is chosen, its use should be consistent throughout the questionnaire. In the example above, this implies that there should not be any questions that range from "strongly disagree" to "strongly agree."

The items on questionnaires can be grouped to handle different aspects of the product assessment. They can also address general feelings about the device through items such as, "I felt very confident when I used this product" or "I felt that the displayed information was too cluttered." As with interviews, questionnaires should capture best- and worst-case experiences, and should be administered as soon as possible following user interaction with the product. However, it is essential that questionnaires be subjected to pilot testing and considerable scrutiny before they are administered. Careful consideration must be given to the language to ensure correct interpretation, to the content to ensure that it is capturing the intended issues, to the format to ensure that it is not frustrating or confusing to negotiate, and to the length to ensure that it is not too taxing. These considerations are especially important for older users.

The After-Scenario Questionnaire (ASQ), which consists of three 7-point items, is an example of a standardized usability questionnaire (i.e., it has been subjected to rigorous scientific scrutiny to ensure its objectivity, reliability, and validity) that can address the user's satisfaction with any product or system. Its three questions focus on the ease with which the task could be completed, the time needed to complete the task, and the adequacy of support information (such as online help, messages, or documentation) during the execution of the tasks (see Lewis, 2006, for more details on standardized usability questionnaires). The conciseness of the ASQ makes it especially suitable for usability studies involving older adults.

The advantage to the designer of having responses quantified, which questionnaires enable, is that it can provide a basis for drawing conclusions. Through analysis of questionnaires, it may be inferred, for example, that older people have more problems than do younger people in finding information, or that most users are confused about how to shut off the device. It may also be of interest to determine if there are inconsistencies between user preferences (as determined from questionnaires) and user performance with the product. In such cases, the designer should consider why the design that is preferred is not proving to be the most effective one to use.

3.5.6 Focus Groups

Focus groups are essentially discussion groups comprised of about six to twelve users or potential users of a device or system who are brought together to discuss user needs, feelings, experiences, and opinions, and to generate ideas and recommendations. Chapter 13 discusses this important UCD method in detail.

3.6 Design Methods That Do Not Involve the User

There are a number of design methods that, strictly speaking, are not user-centered. Although these methods can be used in isolation, they are generally viewed as complementary tools that enhance the overall UCD methodology. Some of these methods are discussed below.

3.6.1 Checklists and Guidelines

Checklists and guidelines are intended to ensure that a number of issues have been considered. The problem with these methods is that the degree of coverage will depend on whoever constructs the list. Likewise, the assessment of whether a product's design feature violates a checklist item or guideline may depend on the assessor. This method is usually confined to tracking very fundamental design issues, such as determining if a product feature is too small to be detected or activated. When designing for older populations, it is critical that these lists reflect cognitive and physical limitations associated with older users (see Chapter 2).

3.6.2 Heuristic Evaluation

A heuristic evaluation of a design uses one or more evaluators to examine the characteristics of the product, prototype, or the system to determine whether they meet various criteria such as safety and comfort, or the usability criteria discussed previously. Heuristic evaluations usually require multiple evaluators (at least three) who examine the product or system independently of one another. It is important that at least one evaluator has expertise in usability and one has expertise in the application domain. For products and systems that are not too complex, the evaluators often require nothing more than checklists to aid them in their assessments. The evaluators are expected to discuss their findings as a group, and also to share their results with other design team members as part of a larger group brainstorming session intended for arriving at design solutions.

3.6.3 Layout Analysis

Layout analysis concerns the application of various principles of display design for determining how to group or locate the functional elements of a device. Most human factors texts (such as Wickens et al., 2004) provide a listing and discussion of these principles. Three commonly used principles are (1) frequency of use, (2) sequence of use, and (3) importance of the functional element. The frequency-of-use principle states that functional elements that are frequently used should be grouped together. Similarly, the sequence-of-use principle states that the functional elements used in sequence should be grouped together. The importance principle addresses the need for making important elements easily detectable and accessible and the need for grouping certain elements together — for example, when the inadvertent activation of one element makes it imperative that a deactivation switch be located near that element.

Although these principles are relevant to all users, they may be applied differently to different user populations. For example, older users may seldom use an element that is frequently used by younger users, or they may attribute different degrees of importance to the functional elements of the device. Consequently, when applying principles of design to older adults, it is important to consider the objectives, tendencies, and preferences of the older user. Much of this information can be obtained from interviews, focus groups, questionnaires, and observations.

3.7 The Product Design Lifecycle

Table 3.1 presents six general design stages in the product design lifecycle. Some of the design methods (such as interviews, questionnaires, focus groups, and heuristic evaluations) are potentially applicable across all stages of the product's lifecycle, whereas other methods (such as field observations, think aloud verbal protocols, and layout analysis) are generally not applicable until the prototype stage of design. Depending on the extent to which preliminary analyses are conducted, methods such as task analysis (including safety and environmental analysis) and checklists could be used throughout the lifecycle as these methods can be refined and adapted, depending on the stage of design. The projected use of design methods across the design lifecycle will, however, depend on a number of considerations, including the type of product, the resources

Table 3.1 General Design Stages of Product Design Lifecycle

	Design Stage	Description
1.	Conceptual design	The idea for the device is considered, and many implementations of the design remain viable.
2.	Formalization	The idea becomes more formalized and there is a corresponding reduction in the number of feasible design solutions.
3.	Design	A design solution is derived and the plan for developing the product is devised.
4.	Prototyping	A prototype of the product is developed for analysis.
5.	Commissioning	The final design solution is implemented and the product enters the marketplace.
6.	Operation and maintenance	The focus is on supporting the use of the product in the marketplace.

(*Source:* Adapted from Stanton, N. (1997). *Human Factors in Consumer Products*. London, England: Taylor & Francis.)

and time constraints associated with product development, the estimated costs of producing an unsatisfactory product, and the level of competition that will exist from other products.

3.8 Conclusion

This chapter discussed a number of methods and issues involving design for users. Depending on the product, some of these methods will be more useful than others in designing for older users. Familiarity with these techniques can provide the designer with the knowledge necessary for deciding which methods to select when older adults are a target user group. It can also provide the insight necessary for determining how to tailor these tools toward identifying problems older users may face in interacting with devices, and to the potential solutions to those problems. Informal examples were provided throughout the chapter to help orient the designer toward achieving these goals.

Recommended Reading

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