Designing for Users with Special Needs

Over half of the U.S. population now living will develop some impairment of their perceptual or motor functions during their lifetime. A product design philosophy called universal design promotes the development of products that will accommodate the needs of such users as well as the able population.

Stephen Metz (Honeywell Technology Center)
MN65-2300; HVN 951-7750

Perhaps you have had an experience similar to this. Your retired parents visit your home for a couple of weeks during the summer. When they first arrive, you explain to them how to operate the electronic thermostat and the security system in the house. But your mom has trouble pressing the buttons, and Dad mutters something about "more trouble than it's worth." During their visit, you silently catalog the problems. They have trouble opening the bedroom door because the handle is stiff. The answering machine has cryptically labeled buttons and puzzling features. The space heater has controls that they have to kneel to read. The remote control for the television has too many buttons and features. And there next to the TV, the VCR is blinking "12:00 . . . 12:00 . . . 12:00."

In this article, I examine the state of product design for users with special needs, older and disabled individuals, and argue for a product development philosophy called *universal design*. The essence of a universal design approach is this: A product design that accommodates both the able population as well as older individuals with limitations, so that more people can use the same product. The justification is making products more affordable, avoiding limited production runs of specially adapted products. Moreover, a successful universal design approach that includes individuals with special needs seldom creates a barrier for the majority of users.

Who Are People With Special Needs?

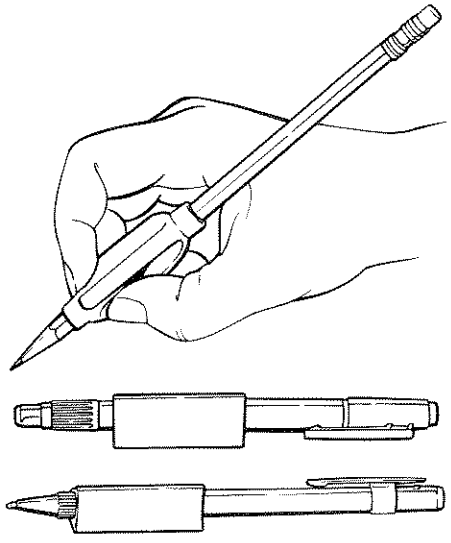
With current trends, over half of the U.S. population can expect to develop a functional limitation of some of their perceptual and motor facilities in older age. Estimates published by Louis Harris and Associates[1] show that the incidence of disability approximately doubles with each decade of life, increasing from 7.5 percent for individuals in their late twenties to 13.4 percent, 23 percent, and a startling 58.5 percent by 55 to 64 years of age. The most common form of disability among both young and older adults is motor impairment, accounting for about 38 percent of all those reporting a function limitation. Sensory impairments, such as vision and hearing, were estimated at 13 percent. Other impairments included cognitive disabilities and serious health impairments, such as heart and respiratory disease, that limited the ability to function at home or in the workplace.

Incorporating the practice of universal design is an extension of good human factors and ergonomics practice, and that begins with anthropometrics. Anthropometry is the study of the dimensions of humans and their functional capabilities. The anthropometric data that is generally available measures young people in the military services, and we need to recognize that the elderly and people with disabilities are not well represented in the design literature.

A critical mistake to avoid in any product design, whether it attempts to serve a special needs population or not, is designing to the statistical average. Designing to the average yields products that are unsuitable for most people. The alternative, and the traditional human factors approach, is to develop a design or a range of designs (as in apparel such as helmets, shoes, etc.) that accommodates about 90 to 95 percent of the population, but this requires that suitable anthropometrics data be available or can be collected. An obvious, though ill-advised, approach for improving accessibility products is to extend the design to a larger group, for example, to 98 percent of the general population, from the first to the ninety-ninth percentile. The fundamental flaw is that this approach, while being more inclusive, does not account for differences in motor movements, sensory capabilities, or perceptual integration. It is not just a matter of degree. For example, reducing torque and making a control easier to turn will not help if the control cannot be grasped at all. A person with vision problems may not be able to find it, or it may be too small for someone with a hand disability.

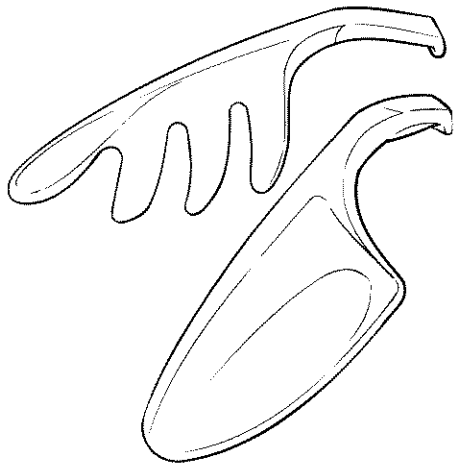
Consider the design of something as simple as a pencil. For decades, the salient

characteristics were a straight wooden shaft of a certain diameter with a graphite core. Some variations were present, such as a round or hexagonal cross-section. It is a one-size-fits-all approach. Everyone uses the same pencil design, though the relative size of the hand to the pencil varies dramatically. If used for a short duration, the design is acceptable, but for longer term use, almost everyone will experience fatigue. Some individuals who have arthritis cannot begin to use a standard pencil because of limited hand mobility and associated joint pain. Modified geometries, available only in alternative mechanical pencils, have appeared that offer shapes that conform better to the dimensions of the fingers and have more compliant surfaces for gripping. These alternative designs are more comfortable for everyone, and individuals with arthritis are much better able to use them.



ADAPTED WRITING INSTRUMENTS are suitable for those with impairments of the hand as well as those who do not have known impairment yet must write for long periods. The principal features are a modified gripping surface that better aligns with the natural grip of the fingers and a compliant surface that spreads the pressure points on the hand.

For example, the development of hand tools with so-called ergonomic grips may seem to be just one more gee-whiz feature to out-tech the competitor. And for those with young, strong hands, there may be no significant benefit for short-term use. But what if hand flexibility and grip strength lessen as we age, or become injured, to 70 percent of what it used to be? Or 50 percent? Then the contoured grip, pliable surface, and correct working angle would allow using all of the grip strength one has to use the tool, rather than wasting hand strength stabilizing the awkward grip or being unable to apply sufficient power to the work. And the person with full capability in their hand is not hindered in any way by the better grip design. In fact, with extended use of the tool, it will be much more comfortable and they will have less cramping and fatigue from overuse.



ADAPTED GARDEN TOOLS are available that permit a straighter wrist during use. This is also a benefit for those without hand impairments because it decreases stress on the associated tendons and nerves of the lower arm and wrist.

In our research with individuals with arthritis at Honeywell, we have seen many with hand geometry that is significantly altered because of their arthritis. This distortion could not be accommodated by extending the original design with another standard deviation of the normal distribution. The fact that many physically challenged individuals are not represented by norms for the general population is obvious for those who have amputated limbs or other injuries that restrict their movement. If we are to include the physically challenged as potential consumers of everyday products, we need to understand their physical and behavioral capabilities in detail. Often, all that is available to designers is personal evidence from individuals or reports based on one or two observations. This is not enough. In most cases, where technical studies have been documented, they have not been collected and disseminated to the larger community of designers. Often this information remains within the medical or rehabilitation specialities, and it is difficult for designers to access and interpret this information. Finding out about actual users is not an easy task and requires hands-on experience as well as research. Educating designers about disabilities can be a very important part of designing accessible products for the physically challenged.

The Role of Standards in Changing Designs

Changes in the design process to implement universal design practices are often straightforward but not necessarily easy. By analogy, we can look at the improvement of access to buildings for those with mobility impairments and the architectural modifications that were necessary. Easy-opening doors, shallow ramps, curb cutouts, and low curb heights are some of the many building access features that both the majority population and those with disabilities appreciate.

In the development of improved building and facility access, standards were essential. In 1961, ANSI Standard 117.1, "Specification for Making Buildings and Facilities Accessible to, and Usable by, the Physically Handicapped," provided the performance standard along with general recommendations that were referenced in the subsequent legislative action. Its publication was followed by critical legislative mandates and governmental support. Legislative actions such as Public Law 90-480, the Architectural Barriers Act of 1968; Public Law 93-112, the Rehabilitation Act of 1973; and Section 504 of the Rehabilitation Act of 1973 were instrumental in opening buildings to people with disabilities. Other factors, such as the support of the architectural profession and the highly planned and organized nature of large construction projects, also served to promote the adoption of architectural accessibility. The standards that are now in place allow architects and construction firms to create buildings and facilities that accommodate many disabled users. This success arguably would not have happened without either the publication of standards or the legislative pressure. The problem of access to and use of products in the home and office has sim-

ilarities to the problem of access to buildings—after all, for the most part, the people who need assistance are the same.

Yet there are some important differences. People with disabilities generally face a locomotion problem moving within a building. Other tasks, such as seeing obstacles, handles, or doorways, asking for and hearing directions, and remembering or changing routes, are also important, but they are secondary to the act of actually moving within the building. This is in contrast to functioning in the home or office setting. In the home, locomotion is secondary to reading, listening, and manipulating. The dominant tasks involve the hands, eyes, voice, or cognitive capabilities.

Office work or home activities require handling information, not just moving about. Therefore, we need to develop appropriate and useful standards that will help designers implement universal design for consumer products for the home and office. With the support of new federal legislation in this area, the Americans with Disabilities Act, Public Law 101-336, there is impetus for action. However, the standards are not in place as they were with architectural accessibility. Companies and designers need additional direction and guidance to create products that match the varied disabled populations.

General Universal Design Principles

Although standards for universal design are not in place, many of the same general principles that guide a traditional human factors evaluation or design apply to universal design, with some important supplementary principles. Stretching out in design to include people with special needs will require improvements in basic human factors. Fundamental human factors considerations that should be part of any design effort include optimizing the contrast, size, feedback, tactile feel, identification, and differentiation of controls, physical size, brightness, and installation position. Generally, what is required are larger controls, better engineered nonrestrictive movements, larger displays with excellent contrast, larger text, and built-in adjustability, so that the user can fit the product to themselves.

The fact is that many consumer products fall short in these critical areas because of economy, styling, or expediency. When implementing universal design, these basic considerations become all the more important. For example, small controls may not be usable by people with vision and motor disabilities, but larger controls can be used by everyone.

Universal design also benefits from redundancy in information channels. For example, by using both a light and a tone to signal an event, more people will receive the intended feedback. Individuals with hearing disabilities will use the visual feedback of the light. For those with adequate hearing but poor vision, the tone is available. By including both in the design, the range of people who can use the product is dramatically improved.

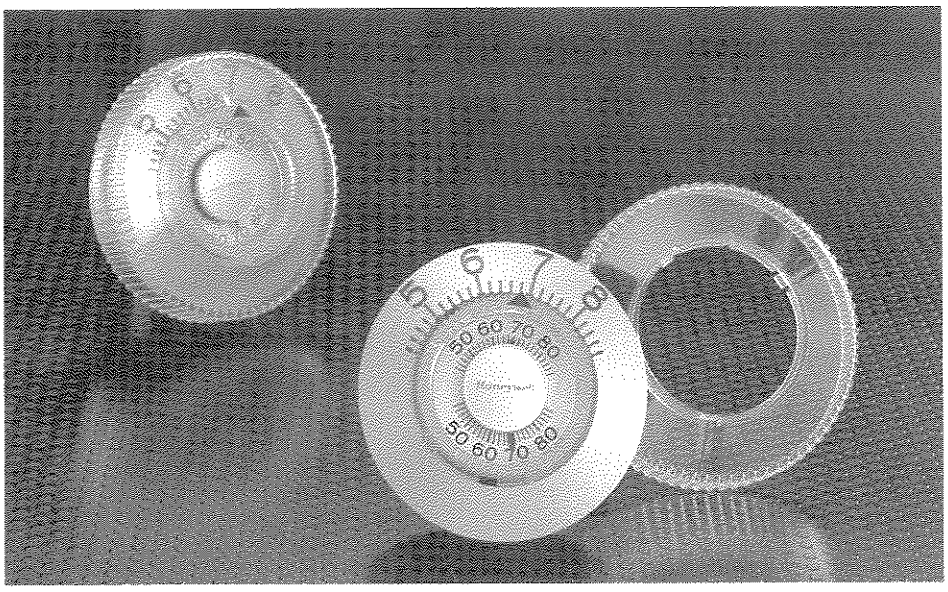
For the foreseeable future, creative design will be an essential element in successful universal design, and creative solutions cannot, by definition, be captured and codified. At this point, we are definitely in an exploratory stage in which new solutions are being tested by designers, and there are more differences than similarities vis-à-vis the universal design approach between otherwise well-designed products. As we gain more experience in universal design, an evolutionary process of success and failure in the marketplace will undoubtedly improve general universal design principles. At first, it may not be clear that a product is suitable for an individual with special needs, because he or she has repeatedly had unsatisfactory experiences with conventional products. The process of standardization will help users learn to look for and recognize features such as adjustability and configuration and make these products more approachable.

Honeywell's Human Factors Guidelines and Research Efforts

At the Honeywell Technology Center in Minneapolis, we have directed a project on Technologies for the Disabled for several years. A volunteer group since our inception, we have worked to bring technology solutions to individuals with handicaps. During the first year, we undertook two goals: a set of human factors design guidelines for products for people with disabilities and a communication protocol that would allow remote control of home devices. These projects were selected because they had the potential for helping the largest number of individuals and were not targeted at a single group. We completed the guidelines and demonstrated the protocol after the first year of work, and have continued to edit and supplement the guideline document since then.

Our purpose in writing and distributing the human factors design guidelines was education: information for designers about the capabilities of individuals with physical challenges and potential design solutions to accommodate both their disabilities and capabilities. The areas the guidelines cover are display selection and performance, labeling, and control selection. Additional sections on integrating these components are still pending; however, we have added capsule descriptions of disabilities that affect product use as well as research data describing the capabilities of the special needs population. In the long term, we intend to continue revising the guidelines document as more information becomes available.

Our modest research program to support guideline development specialized in the capabilities of groups of individuals who are challenged by arthritis, spinal cord injury, and multiple sclerosis that decreases their hand flexibility and strength. We have done basic research on rotary control design, looking at the effects of knob shape, size, and surface texture. Generally, we found a relationship between turning ability (torque) and pinch strength and the relative efficacy of larger rotary knobs. The data documented the decrease in functional ability with arthritis—individuals with arthritis had as little as half the ability to turn a knob as individuals of the same age in the control group. Interestingly, individuals with arthritis had an especially difficult time with the small rotary controls commonly used for adjustments in some home electronics, such as televisions. Larger knobs with serrated edges narrowed the gap between the experimental and control group, but knobs with a stiff action will always be difficult for those with arthritis. Later research in our lab showed the efficacy of broader knobs with flattened surfaces for people with limited hand strength that could serve well on appliances and other home products. This area requires more testing with a wider range of control types. We are especially interested in launching a new series of tests with membrane key-



EASY-TO-SEE AND EASY-TO-USE thermostats are modifications of the Honeywell "Round" manual thermostat. The Easy-to-See thermostat has larger lettering and raised features so that it can be adjusted by those with visual impairments. The recently introduced Easy-to-Use accessory accommodates individuals with difficulties in gripping the adjustment ring and is designed so that the user can manipulate the thermostat with the palm or the side of the hand.

boards and related control technologies that are generally believed to cause problems for individuals with both hand and vision problems because of inadequate feedback.

The communication protocol, Public Access Protocol, was a success in testing, although we have not implemented it in a real-world setting. Parallel developments in other home communication networks may provide the same functionality and allow us to test one of the original concepts: control of all devices in the home environment from a single universal remote control.

Honeywell Home Products for People with Special Needs

About five years ago, Honeywell developed a thermostat for those with visual impairments. It was, a custom modification of a standard manual thermostat, the T87. The standard bezel was replaced by a cover with large numerals to indicate the setting. The numerals are raised so that they can be felt with the fingertips. The thermostat also has detents that allow one to count up or down to the desired setting. There is an aspect of universal design in the product, because it doesn't restrict users without visual impairments. It is currently marketed as the Easy-to-See T87F manual thermostat.

More recently, designers at Home and Building Control developed several accessories for a manual thermostat that helped individuals with manual dexterity problems. We completed a usability test of these prototypes with people with arthritis and multiple sclerosis, some in wheelchairs. Both thermostats were easy to use, as judged by many of our testers. But a prototype with a handle to turn the knob was judged to be unattractive and "adapted," while another prototype with good functionality but even better appearance was judged to be more neutral in appearance, because it didn't look as if it was built for those with disabilities. This experience helped direct our own thinking toward universal design. The soon-to-be available thermostat accessory, dubbed "Easy-to-Use," is attractive, functional, and broadens the population of people who can use the product.

Security Panels

Honeywell has also developed modifications to home security control panels for individuals with special needs. These modified panels have enhanced graphics, larger buttons, and touch feedback, with added visual and enhanced sound feedback. They are designed to help people with limitations of the hand, vision, or hearing use the security system. While the appearance of the product is not dramatically changed, the feedback to date is that the panels would be suitable for any home and are another example of how relatively small improvements can yield a more universal design.

Future Technologies

New technologies may help Honeywell serve individuals with special needs and promote universal design. Speech recognition technology has significantly improved during the last decade, and machine speech can have very good intelligibility. We know that individuals with impaired vision could use products that can be controlled by voice. For those with adequate vision, speech can still be useful to access information when outside the house, while do ing other tasks. It also can remove some of the apparent complexity, because the number of buttons could be reduced. Another improvement would be a talking manual that could never be lost and takes up no space on the product. This would serve

A MODIFIED TOTALHOME™ security panel uses larger keys, larger lettering, louder auditory tones, and color-coded function buttons to enhance the usability of this home system.

both those with impaired vision and normal vision. We must recognize, however, that we cannot reduce the visual component without impairing the use by the deaf and those with significant hearing loss.

Individuals who cannot use a universal design solution because of severe motor disabilities could use their existing communication devices, often a computer with a customized user interface, to operate products in the home, such as the telephone, thermostat, lights, and security. The key technology is communication and standardization of the communication protocols to allow this. A standard remote control device could also be developed that allowed individuals in wheelchairs with good hand control to operate the same devices.

Conclusion

Technology can be the solution as well as the problem in the design of useful and usable consumer products. With today's technology in our kitchens, bathrooms, bedrooms, automobiles, and offices, it is difficult to imagine our lives without electronic controls and advanced communication. Yet when technology was simpler, it was easier, in many cases, to adapt to the limitations of age or disability, sticky faucets notwithstanding. While modern devices such as the telephone make it easier for those with mobility limitations to communicate, they also impose barriers for those with vision, hearing, and hand limitations. Innovations like the telefax offer new possibilities for those with speech problems, but one still has to manipulate the complex controls on the fax machine, let alone write down something to send. While technology can offer help for those with special needs, it often tends to narrow the information bandwidth by selecting only one communication modality (speech or text) and thereby reduces the redundancy in information coding.

Universal design solutions can help by restoring redundancy and broadening the population of users for standard products. Yet universal design concepts are in a transitional phase, and moving from customized designs toward universal design for special needs populations will be slow at first. Universal design is the best long-term solution, but this approach needs either success in the marketplace or legislative mandate, and the science is not in place to support legislative action. As the population demographics shift and the number of older consumers increases, the economics of universal design may be very straightforward. Products that are hard to use by older consumers will not sell, and products that help us bridge their functional limitations will take their place. A transition to universal design in this manner has the potential for being more permanent and beneficial than through legislation. Yet companies need to begin now to anticipate new consumers with special needs, or they will be caught short as the baby boomer generation meets with the joys and difficulties of life after 40.

Acknowledgments

Special thanks to the Honeywell Foundation for their support for the Technologies for the Disabled project, to team members Brian Isle, Sandra Denno, and Li Wang, and to Mary Nelson and Sandi Peterson at Honeywell Home and Building Control. TotalHome is trademark of Honeywell Inc.

Reference

1. Louis Associates, Inc. (1986). *The ICD Survey of Disabled Americans into the Mainstream*. New York, New York, March.