Chapter 2

Understanding the Spectrum of Human Abilities

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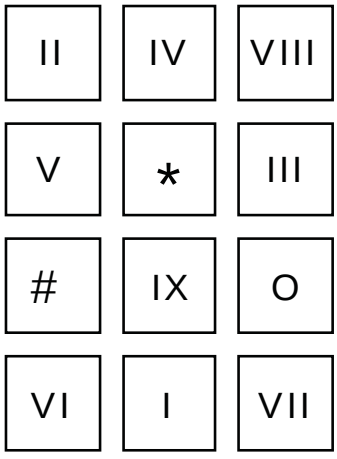
Each of us is unique in age, size, abilities, talents, and preferences. Any human characteristic that can be measured spans a broad range in any population. An understanding of human diversity is critical to designing effectively. Successful application of universal design principles requires an understanding of how abilities vary with age, disability, the environment, or the circumstances.

Human abilities can be grouped into the following categories: cognition, vision, hearing and speech, body function, arm function, hand function, and mobility. The following sections describe how variations in each of these areas may affect design usability, the types of people who may use a design, and ways to test a product or environment to assess its broad usability.

Universal Design and Cognition

1. How cognition affects design usability...

Imagine if your telephone's keypad were arranged as shown at right:



Roman numerals are foreign to the keypad design, as is the jumbled layout. Most people could probably still place a call, but it would put more demand on their thought processes. Everyone would require more time to use this keypad, and probably make more mistakes

because of the cognitive "mapping" each of us has internalized from making countless phone calls with conventional keypads.

Obviously, using this design is even more difficult for individuals who do not understand Roman numerals, or who have cognitive limitations and difficulty doing things in a non-standard way.

2. **Universal design for cognition means considering the variety of human abilities in receiving, comprehending, interpreting, remembering, or acting on information. This includes:**

   - self-starting; initiating tasks without prompting
   - reacting to stimuli; response time
   - paying attention; concentration
   - comprehending visual information
   - comprehending auditory information
   - understanding or expressing language
   - sequencing; doing things in proper order
   - keeping things organized
   - remembering things, either short- or long-term
   - problem-solving; decision-making
   - creative thinking; doing things in a new way
   - learning new things

3. **Cognition can vary widely according to age, disability, the environment, or the particular situation. This variability should be considered when the design population may include:**

   - very young children, with limited vocabulary, grammar, and reasoning skills
   - individuals with limited literacy
   - individuals using foreign languages or having different cultural backgrounds
   - older adults with diminished memory and reasoning skills
   - individuals who are fatigued or distracted

- individuals with limited comprehension, memory, concentration, or reasoning due to:
  - retardation
  - Down's syndrome
  - learning disabilities
  - head injuries
  - stroke
  - Alzheimer's disease

4. **Assess the effectiveness of a design for cognition by answering the following questions. Is the design still as usable and safe if you…**
   - are using it for the first time without help or instructions?
   - cannot read?
   - perform steps out of order?
   - try to use it much faster or slower than intended?
   - make a mistake and want to correct it or start over?
   - are distracted or interrupted while using it?

Universal Design and Vision

1. **How vision affects design usability…**

   If you do not have a vision impairment, consider the following circumstances.

   Try reading a book at the beach without sunglasses, finding your way after walking out of a movie theater into bright daylight, or driving toward the sun. You will experience the limiting effects of glare. Try getting a key into your front door in the dark, reading a detailed road map in your car at night, or finding the light switch in a dark room. You will appreciate the limitations caused by inadequate light.

   When you're lost and struggling to find a specific road sign, all signs may seem small and hard to locate. How much more difficult would this be if your glasses or windshield were badly smudged?

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How difficult would it be to find the sign if you could not move your neck, used only one eye, or viewed the world through a cardboard tube?

The scenarios described above may cause anyone to make mistakes, slow down, get help, or avoid even simple tasks because the demand on visual capabilities is too great, whether temporarily or permanently.

2. **Universal design for vision means considering the variety of human abilities in perceiving visual stimuli. This includes:**
    - perceiving visual detail clearly
    - focusing on objects up close and far away
    - separating objects from a background
    - perceiving objects in the center, as well as at the edges of the field of vision
    - perceiving contrasts in color and brightness
    - adapting to high and low lighting levels
    - tracking moving objects
    - judging distances

3. **Vision can vary widely according to age, disability, the environment, or the particular situation. This variability should be considered when the design population may include:**
    - individuals distracted by a "busy" visual environment
    - individuals fatigued from excessive visual tasks
    - individuals functioning under colored lighting or very high or very low lighting conditions
    - individuals functioning in adverse weather conditions
    - older adults and others with:
        - blindness
        - hereditary loss of vision
        - cataracts
        - glaucoma
        - retinitis
        - presbyopia (farsightedness after middle age)
        - macular degeneration
        - eye injuries

4. **Assess the effectiveness of a design for vision by answering the following questions. Is the design still as usable and safe if you…**
    - view it in very low light?
    - view it in very bright light?
    - view it much closer or further away than intended?
    - could see it only in black and white?
    - view it through a tube?
    - view it with one eye closed?
    - view it using only peripheral vision?

Universal Design and Hearing and Speech

1. **How hearing and speech affect design usability…**

    If you do not have a hearing impairment, consider the following circumstances.

    Have you ever struggled to determine where a siren was coming from while driving with the radio on? Has the congestion from a head cold, especially if you did any airline traveling, ever left you temporarily impaired in hearing, speech, or even balance?

    Try giving directions to someone across a busy street. Try following verbal instructions while listening to music through headphones. Much of the message may get lost or confused in the ambient sound.

    If you have ever used a cordless or cellular phone in a car, a shopping mall, or the airport, you have had the experience of trying to hold a conversation amid background noise and other distractions. In addition, the variable quality of transmission often causes lapses in communication or even interference from other conversations.

    The situations described above can cause anyone to miss important information, repeat messages, rely on other sensory input, or just give up because the demands on auditory capabilities are too great, whether temporarily or permanently.

2. **Universal design for hearing and speech means considering the variety of human abilities in perceiving auditory stimuli. This includes:**
    - localizing the source of sound
    - separating auditory information from background sound
    - perceiving both high- and low-pitched sounds
    - carrying on a conversation

3. **Hearing and speech can vary widely according to age, disability, the environment, or the particular situation. This variability should be considered when the design population may include:**
    - individuals whose attention is divided among several auditory sources
    - individuals functioning in very noisy environments
    - individuals using headphones
    - older adults and others with:
        - deafness
        - hereditary loss of hearing
        - blockages in the route to the inner ear
        - damage from prolonged exposure to excessive noise
        - diseases
        - presbycusis (reduction of hearing in older age)
        - head injuries or stroke

4. **Assess the effectiveness of a design for hearing by answering the following questions. Is the design still as usable and safe if you…**
    - use it in a noisy environment?
    - use it with one ear plugged?
    - use it with both ears plugged?
    - eliminate the sounds of the letters c, ch, s, sh, f, and z?

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Universal Design and Body Functions

1. How body function affects design usability…

If your body is non-disabled, consider the following circumstances.

Imagine working in a chair with one missing caster. With every change in posture, you might lose your balance. This would affect your concentration and productivity and might cause you to avoid changing body position.

Try doing your job from a straight-back chair with your spine firmly against the seat back and your feet on the floor. Retain that position without twisting or bending as you try to retrieve materials from your desk, use the telephone, and perform other simple everyday tasks. Limitations to your reach, field of vision, and mobility make simple tasks more difficult and eventually cause fatigue and pain from the lack of range of motion.

Perhaps you have carried a bulky object up or down a flight of stairs. The added weight made balance more difficult and the object may have prevented you from using the railings for support or even seeing the steps in front of you.

Remember the last time you had the flu. Even the simplest tasks were exhausting, and it was difficult to concentrate on anything for very long. Getting up from the bed or a chair required a few extra seconds for you to clear your head and keep your balance. If you took any medication, these effects may have been more pronounced and prevented you from even attempting other tasks, such as driving.

Consider the difficulty of strenuous exercise on a very hot summer day.

In each of the situations described above, the demands of the tasks may exceed human capabilities to some extent, making the task inconvenient, frustrating, exhausting, dangerous, or impossible.

2. **Universal design for body function means considering the variety of human abilities in performing common tasks. These tasks include cardiovascular, musculoskeletal, and central nervous system functions such as:**
    - physical exertion
    - achieving, maintaining, and changing posture
    - maintaining equilibrium
    - breathing

3. **Body function can vary widely according to age, disability, the environment, or the particular situation. This variability should be considered when the design population may include:**
    - very young children, with limited physical development
    - older adults with diminished stamina, balance, or other body functions
    - individuals of extreme body size or weight
    - women in later stages of pregnancy, whose balance is affected by the weight of the baby
    - individuals with pain or limited range of motion due to temporary or minor injuries or illness
    - individuals under adverse environmental conditions (e.g., bad weather, extremes of temperature, poor air supply, unstable footing)
    - individuals who are fatigued or ill
    - individuals with chronic limitations due to:
        - epilepsy or other seizure disorders
        - allergies
        - multiple chemical sensitivities
        - asthma
        - diabetes
        - arthritis
        - musculoskeletal injuries or illness
        - hernia
        - stroke

4. **Assess the effectiveness of a design for body function by answering the following questions. Is the design still as usable and safe if you…**
   - have shortness of breath?
   - stop frequently to rest?
   - need to lean on something for support while using it?
   - cannot bend, stoop, or twist at the waist?
   - use it only in a seated position?
   - cannot turn your head?
   - are sensitive to dust, fumes, smoke, or chemicals?

Universal Design and Arm Function

1. **How arm function affects design usability…**

If your arms are unimpaired, consider the following circumstances.

Think of objects you regularly reach for, lift, and carry. Some ordinary household products weigh more than you might guess. A six-pack of 12-oz. cans and a ream of paper each weigh over 5 lbs. One-gallon containers of milk or juice weigh about 8 lbs. each, and cartons of detergent up to 20 lbs. each. Could you move these products using only one arm? How would you reach them if you could not straighten your arms to reach forward, up, or down?

What about other ordinary tasks like driving, cooking, eating, drinking a cup of coffee, or opening a window? Think about the last time you experienced pain in a shoulder or elbow. How did it affect the way you performed these everyday tasks? How would your strength and movements be limited if you constantly wore a 3-lb. weight on each wrist?

In each of the situations described above, the demands of the tasks may exceed human capabilities to some extent, making the task inconvenient, frustrating, exhausting, dangerous, or impossible.

2. **Universal design for arm function means considering the variety of human abilities in upper extremity range of motion, coordination, and strength. This includes:**
    - reaching up, down, forward, or behind
    - pushing
    - pulling
    - lifting
    - lowering
    - carrying

3. **Arm function can vary widely according to age, disability, the environment, or the particular situation. This variability should be considered when the design population may include:**
    - very young children, with limited physical development
    - older adults with diminished joint range of motion or strength
    - individuals with pain or limited range of motion due to temporary or minor injuries or illness
    - individuals who are fatigued
    - individuals with only one free arm due to carrying things or performing another task
    - individuals wearing thick clothing
    - individuals with chronic limitations due to:
        - congenital loss or deformation of an arm
        - cerebral palsy
        - post-poliomyelitis
        - muscular dystrophy
        - multiple sclerosis
        - Lou Gehrig's disease (amyotrophic lateral sclerosis, or ALS)
        - Parkinson's disease
        - spinal cord injuries
        - amputations
        - arthritis
        - bursitis
        - tendonitis
        - stroke

4. **Assess the effectiveness of a design for arm function by answering the following questions. Is the design as usable and safe if you…**
   - wear 3-lb. weights on each wrist?
   - hold your elbows against your body?
   - use only your non-dominant arm?

Universal Design and Hand Function

1. **How hand function affects design usability…**

   If your hands are unimpaired, consider the following circumstances.

   Consider how much you depend on use of both hands. Using only one hand, try hammering a nail, tying a shoe, or placing a telephone call. Try dialing a mobile phone while driving.

   Try turning a door knob with oily or wet hands, or when carrying packages.

   Try using only your non-dominant hand for precision tasks such as using scissors, cutting food, or shaving. Try doing these tasks while wearing mittens.

   Perhaps you have experienced a minor cut or burn that temporarily limited your ability to open a jar, squeeze a tube of toothpaste, operate a faucet, or hold a cup of coffee.

   In each of these situations, the demands of the tasks may exceed human capabilities to some extent, making the task inconvenient, frustrating, exhausting, dangerous, or impossible.

2. Universal design for hand function means considering the variety of human abilities required to perform common tasks. These tasks include:

- grasping
- squeezing
- rotating
- twisting
- pinching
- pulling
- pushing

3. Abilities of hand function can vary widely according to age, disability, the environment, or the particular situation. This variability should be considered when the design population may include:

- very young children, with small hands and weak fingers
- older adults with diminished joint range of motion or strength
- individuals with pain or limited range of motion due to temporary or minor injuries or illness
- individuals whose hands are fatigued from repetitive tasks
- individuals wearing gloves
- individuals with wet or oily hands
- individuals with only one free hand due to simultaneously performing another task
- individuals with chronic limitations due to:
  - congenital loss or deformation of a hand
  - cerebral palsy
  - post-poliomyelitis
  - muscular dystrophy
  - multiple sclerosis
  - Lou Gehrig's disease (amyotrophic lateral sclerosis, or ALS)
  - Parkinson's disease
  - spinal cord injuries
  - amputations
  - carpal tunnel syndrome
  - arthritis
  - stroke

4. **Assess the effectiveness of a design for hand function by answering the following questions. Is the design as usable and safe if you…**
    - •wear mittens?
    - •repeat no motion more than three times per minute?
    - •do not bend or rotate your wrists?
    - •use only one hand?
    - •use only the fist of your non-dominant hand?
    - •exert no more force than the strength in your little finger?

Universal Design and Mobility

1. **How mobility affects design usability…**

    If your legs are unimpaired, consider the following circumstances.

    Consider driving your car without using your legs. Without walking, how could you get to work? Could you do your job without leaving a seated position? What if there are stairs along the way?

    Consider the difficulty of maintaining your balance while walking or standing in an airplane, subway car, or bus. Imagine having this difficulty even on stable ground.

    Remember the last time you walked a long distance or ascended a long flight of stairs and how the fatigue affected your stability. Did you tend to use the railings more toward the end? Consider how carefully you use stairs that are slippery with water or ice, and how dangerous it is when you lose your balance on stairs.

    Notice the different ways people walk on different surfaces. Grass, sidewalks, loose gravel, carpeting, and tile floors each require a different gait to maintain balance and avoid tripping or slipping. When surfaces change unexpectedly, falls can result.

    If you've ever injured a leg and used crutches, you realize the additional time and effort required to cover distances, especially if stairs, revolving doors, or slippery floors were in your way.

You may have also learned the importance of space to elevate or straighten your leg or maneuver a wheelchair. As you recovered, you learned the value of grab bars and sturdy surfaces to lean on.

In each of the situations described above, the demands of the tasks may exceed human capabilities to some extent, making the task inconvenient, frustrating, exhausting, dangerous, or impossible.

2. Universal design for mobility means considering the variety of human abilities in performing common tasks. These tasks include:

- rising from a seated position
- standing upright
- walking
- running
- jumping
- climbing
- kneeling
- balancing on one foot
- operating foot controls

3. Mobility can vary widely according to age, disability, the environment, or the particular situation. This variability should be considered when the design population may include:

- very young children, with limited physical development
- older adults with diminished strength, stamina, balance, range of motion in spine and lower extremities, or proprioception (sensing the positions of body parts and the motions of the muscles and joints)
- individuals of extreme body size or weight
- individuals with pain or limited range of motion due to temporary or minor injuries or illness
- individuals who are fatigued
- individuals under adverse environmental conditions (e.g., bad weather, uneven or unstable terrain)

- individuals with chronic limitations due to:
  - congenital loss or deformity of a leg
  - cerebral palsy
  - post-poliomyelitis
  - muscular dystrophy
  - multiple sclerosis
  - cerebral vascular disease
  - diabetes
  - Lou Gehrig's disease (amyotrophic lateral sclerosis, or ALS)
  - Parkinson's disease
  - amputations
  - spinal cord injury
  - arthritis
  - stroke
  - asthma, emphysema, or other respiratory complications

4. **Assess the effectiveness of a design for mobility by answering the following questions. Is the design as usable and safe if you…**
   - cannot see the floor surface?
   - cannot lift either foot?
   - wear two different shoes (different heel heights and sole friction)?
   - use a cane?
   - use crutches?
   - use a wheelchair?
   - cannot rise from a seated position?