

# Assistive Technology



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First Edition, 2012

ISBN 978-81-323-2316-7

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*Published by:*

**Library Press**

4735/22 Prakashdeep Bldg,

Ansari Road, Darya Ganj,

Delhi - 110002

Email: [info@wtbooks.com](mailto:info@wtbooks.com)

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WORLD TECHNOLOGIES

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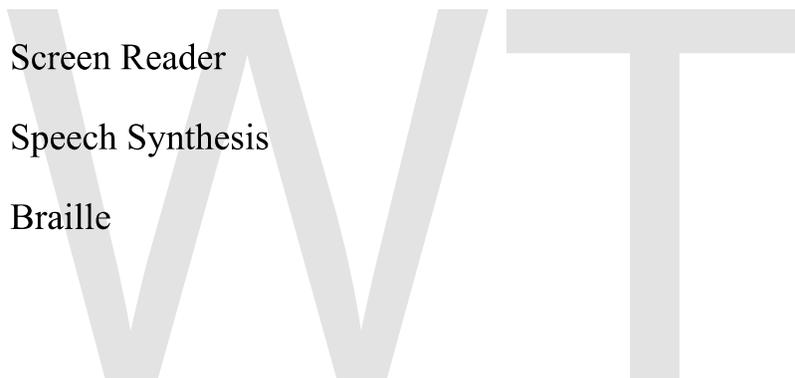
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## Chapter- 1

# Assistive Technology



Hearing aid

**Assistive technology** or **adaptive technology** (AT) is an umbrella term that includes assistive, adaptive, and rehabilitative devices for people with disabilities and also includes the process used in selecting, locating, and using them. AT promotes greater independence by enabling people to perform tasks that they were formerly unable to accomplish, or had great difficulty accomplishing, by providing enhancements to or changed methods of interacting with the technology needed to accomplish such tasks.

Likewise, disability advocates point out that technology is often created without regard to people with disabilities, creating unnecessary barriers to hundreds of millions of people. Even the makers of AT technologies will often still argue that universal design is preferable to the need for AT and that universal design projects and concepts should be continuously expanded.

## ***Assistive technology and universal accessibility***



Universally Accessible Street Cross at Evanston, Illinois

Universal (or broadened) accessibility, or universal design means greater usability, particularly for people with disabilities.

Universally accessible technology yields great rewards to the typical user as well; good accessible design *is* universal design. One example is the "curb cuts" (or dropped curbs) in the sidewalk at street crossings. While these curb cuts enable pedestrians with mobility impairments to cross the street, they also aid parents with carriages and strollers, shoppers with carts, and travelers and workers with pull-type bags.

As an example, the modern telephone is inaccessible to people who are deaf or hard of hearing. Combined with a text telephone (also known as a TDD Telecommunications device for the deaf and in the USA generally called a TeleTYpewriter or TTY), which converts typed characters into tones that may be sent over the telephone line, a deaf person is able to communicate immediately at a distance. Together with "relay" services, in which an operator reads what the deaf person types and types what a hearing person says, the deaf person is then given access to everyone's telephone, not just those of people who possess text telephones. Many telephones now have volume controls, which are primarily intended for the benefit of people who are hard of hearing, but can be useful for all users at times and places where there is significant background noise. Some have larger keys well-spaced to facilitate accurate dialing.

Also, a person with a mobility impairment can have difficulty using calculators. Speech recognition software recognizes short commands and makes use of calculators easier.

People with learning disabilities like dyslexia or dysgraphia are using text-to-speech (TTS) software for reading and spelling programs for assistance in writing texts.

Computers, with their hardware extensibility, editing, spellchecking and speech synthesis software are becoming the cornerstone of assistive technologies, improving quality of life for those with learning disabilities and visual impairments. Spell assist programs and voice-recognition facilities are also bringing the text reading and writing experience to the wider public.

Toys that have been adapted to be used by children with disabilities might have advantages for non-disabled children as well. The Lekotek movement assists parents by lending assistive technology toys and expertise to families.

Many health professionals may be certified by RESNA ([RESNA.org](http://RESNA.org)) to serve assistive technology needs: occupational therapists, physical therapists, speech language pathologists/audiologists, orthotists and prosthetists, educators, and rehabilitation and health professionals.

## ***Assistive technology products***

### **Personal Emergency Response Systems**



This voter with a manual dexterity disability is making choices on a touchscreen with a head dauber.

Personal Emergency Response Systems (PERS), or Telecare (UK term), are a particular sort of assistive technology that use electronic sensors connected to an alarm system to help caregivers manage risk and help vulnerable people stay independent at home longer. An example would be the systems being put in place for senior people such as fall detectors, thermometers (for hypothermia risk), flooding and unlit gas sensors (for people with mild dementia). Notably, these alerts can be customized to the particular person's risks. When the alert is triggered, a message is sent to a caregiver or contact center who can respond appropriately.

Technology similar to PERS can also be used to act within a person's home rather than just to respond to a detected crisis. Using one of the examples above, gas sensors for people with dementia can be used to trigger a device that turns off the gas and tells someone what has happened.

Designing for people with dementia is a good example of how the design of the interface of a piece of AT is critical to its usefulness. People with dementia or any other identified

user group must be involved in the design process to make sure that the design is accessible and usable. In the example above, a voice message could be used to remind the person with dementia to turn off the gas himself, but whose voice should be used, and what should the message say? Questions like these must be answered through user consultation, involvement and evaluation.

### **Accessible computer input**



This is a sip-and-puff device which allows a person with substantial disability to make selections and navigate computerized interfaces by controlling inhalations and exhalations.

Sitting at a desk with a QWERTY keyboard and a mouse remains the dominant way of interacting with a personal computer. Some Assistive Technology reduces the strain of

this way of work through ergonomic accessories with height-adjustable furniture, footrests, wrist rests, and arm supports to ensure correct posture. Key guards fit over the keyboard to help prevent unintentional key presses.

Alternatively, Assistive Technology may attempt to improve the ergonomics of the devices themselves:

- Ergonomic keyboards reduce the discomfort and strain of typing.
- Chorded keyboards have a handful of keys (one per digit per hand) to type by 'chords' which produce different letters and keys.
- Expanded keyboards with larger, more widely spaced keys.
- Compact and miniature keyboards.
- Dvorak and other alternative layouts may offer more ergonomic layouts of the keys. There are also variants of Dvorak in which the most common keys are located at either the left or right side of the keyboard.

Input devices may be modified to make them easier to see and understand:

- Keyboards with lowercase keys
- Keyboards with big keys.
- Keyboards with less and big keys, or multifunctional keys, such as the special keyboard PiTech, with only five big rounded keys, which is used with a special software for writing
- Large print keyboard with high contrast colors (such as white on black, black on white, and black on ivory).
- Large print adhesive keyboard stickers in high contrast colors (such as white on black, black on white, and black on yellow).
- Embossed locator dots help find the 'home' keys, F and J, on the keyboard.
- Scroll wheels on mice remove the need to locate the scrolling interface on the computer screen.
- Footmouse — Foot-operated mouse.

More ambitiously, and quite crucially when keyboard or mouse prove unusable, AT can also replace the keyboard and mouse with alternative devices such as the LOMAK keyboard, trackballs, joysticks, graphics tablets, touchpads, touch screens, foot mice, a microphone with speech recognition software, sip-and-puff input, switch access, and vision-based input devices, such as eye trackers which allow the user to control the mouse with their eyes.

Software can also make input devices easier to use:

- Keyboard shortcuts and MouseKeys allow the user to substitute keyboarding for mouse actions. Macro recorders can greatly extend the range and sophistication of keyboard shortcuts.
- Sticky keys allows characters or commands to be typed without having to hold down a modifier key (Shift, Ctrl, Alt) while pressing a second key. Similarly,

ClickLock is a Microsoft Windows feature that remembers a mouse button is down so that items can be highlighted or dragged without holding the mouse button down throughout.

- Customization of mouse or mouse alternatives' responsiveness to movement, double-clicking, and so forth.
- ToggleKeys is a feature of Microsoft Windows 95 onwards. A high sound is heard when the CAPS LOCK, SCROLL LOCK, or NUM LOCK key is switched on and a low sound is heard when any of those keys are switched off.
- Customization of pointer appearance, such as size, color and shape.
- Predictive text
- Spell checkers and grammar checkers

## **Durable Medical Equipment (DME)**

- Seating products that assist people to sit comfortably and safely (seating systems, cushions, therapeutic seats).
- Standing products to support people with disabilities in the standing position while maintaining/improving their health (standing frame, standing wheelchair, active stander).
- Walking products to aid people with disabilities who are able to walk or stand with assistance (canes, crutches, walkers, gait trainers).
- Advanced technology walking products to aid people with disabilities, such as paraplegia or cerebral palsy, who would not at all be able to walk or stand (exoskeletons).
- Wheeled mobility products that enable people with reduced mobility to move freely indoors and outdoors (wheelchairs/scooters)
- Vehicles modified with Height adjustable suspension, to allow wheelchair entry to the vehicle
- Robot-aided rehabilitation is a sensory-motor rehabilitation technique based on the use of robots and mechatronic devices

## **Learning difficulties**

- Age-appropriate software
- Cause and effect software
- Switch accessible software
- Hand-eye co-ordination skills software
- Diagnostic assessment software
- Mind mapping software
- Study skills software
- Symbol-based software
- Text-to-speech
- Touch typing software

## **Mobility impairment**

- Crutches, including assistive canes
- Walkers
- Wheelchairs

## **Visual impairment**

Choice of appropriate hardware and software will depend on the user's level of functional vision.

- RIAS (Remote Infrared Audible Signage) has the potential to help both low vision and the blind navigate outside and indoors.

## **Hardware**

- White canes
- Large monitors can be used with increased DPI for ease of electronic text reading.
- E-book readers, such as the Amazon Kindle, which offer text-to-speech and adjustable font size features.
- Adjustable task lamp, using a fluorescent bulb, shines directly onto the paper and can be adjusted to suit.
- Bank note reader
- Copyholder holds printed material in near vertical position for easier reading and can be adjusted to suit.
- Closed circuit television (CCTV) or video magnifiers. Printed materials and objects are placed under a camera and the magnified image is displayed onto a screen.
- Modified cassette recorder. To record a lecture, own thoughts, ideas, notes etc.
- Desktop compact cassette dictation system. To allow audio cassette playback with the aid of a foot pedal.
- Fusers produce tactile materials, for example diagrams and maps, by applying heat to special swell paper.
- Scanner. A device used in conjunction with OCR software. The printed document is scanned and converted into electronic text, which can then be displayed on screen as recognizable text.
- Standalone reading aids integrate a scanner, optical character recognition (OCR) software, and speech software in a single machine. These function together without a separate PC.
- Refreshable Braille display. An electronic tactile device which is placed below the computer keyboard. A line of cells which correspond to Braille text move up and down to represent a line of text on the computer screen.
- Electronic Notetaker. A portable computer with a Braille or QWERTY keyboard and synthetic speech. Some models have an integrated Braille display.
- Braille embosser. Embosses Braille output from a computer by punching dots onto paper. It connects to a computer in the same way as a text printer.

- Perkins Braille. To manually emboss Grade 1 or 2 Braille.
- Mountbatten Braille. An electric braille writing machine.

## **Software**

- Customization of graphical user interfaces to alter the colors and size of desktops, short-cut icons, menu bars and scroll bars.
- Screen magnifiers
- Screen readers
- Self-voicing applications
- Optical character recognition. Converts the printed word into text, via a scanner.
- Braille translation. Converts the printed word into Braille, which can then be embossed via a Braille embosser.
- Text-to-speech and Speech-to-text
- Spell checkers and Grammar checkers

## **Augmentative and Alternative Communication (AAC)**

Augmentative and alternative communication is a well defined specialty within Assistive Technology. It involves ways of communication that either enhance or replace verbal language. AAC devices vary widely with respect to their technological sophistication:

- Low-tech systems. Simple paper or object based systems, i.e. do not require a battery (e.g., Talking Mats, Dry Erase Boards, Clipboards, 3-Ring Binders, Manila File Folders, Photo Albums, Laminated PCS/Photographs, Highlight tape).
- Light-tech systems. Typically consisting of a digitized speech recorder with a touch-sensitive display pad and sometimes switch access. Lite-tech systems require a battery (e.g., Tape Recorder, Language Master, Overhead Projector, Timers, Calculators).
- High-tech systems. Computerized VOCAs that vary from single purpose appliance-like systems to multipurpose computer-based communication aids. Typically high-tech systems require training and ongoing support to operate the devices (e.g., Video Cameras, Computers and Adaptive Hardware, Complex Voice Output Devices).

When combined with Applied Behavior Analysis (ABA) teaching methods, AAC has improved communication skills in children with Autism.

## **Deafness and hearing loss**

- Audiometer
- Fire alarm paging system
- Loop system (portable and fixed)
- Radio aids

- Telecommunications device for the deaf
- Teletext
- Video cassette recorders that can read and record subtitles (Closed Captioning).
- Vibrating fire alarm placed under pillow when asleep.
- Door bell lighting system.

## **Others**

- Wakamaru provides companionship, reminds users to take medicine and calls for help if something is wrong.
- Telephone Reassurance: community based program that calls seniors at home ensuring their well-being.
- Cosmobot is part of a play therapy system designed to motivate children to participate in therapy.
- General User Interface for Disorders of Execution (GUIDE) is an interactive verbal prompting system that talks people with cognitive impairment through daily routine tasks.

*Claims* Since children with autism process visual information easier than auditory information, when utilizing assistive technology claims that any time we use these devices with these children, we're giving them information through their strongest processing area (visual). Therefore various types of technology from "low" tech to "high" tech, should be incorporated into every aspect of daily living in order to improve the functional capabilities of children with autism.

*Benefits* Regarding comprehension skills, increasing comprehension of tasks/activities/situations is essential in addressing skill areas such as organization, attending, self help, following directions, following rules and modifying behavior. As a result, the child becomes more independent. The following "low" tech visual support strategies can be created and used to benefit and assist the child in increasing his comprehension skills and thus decreasing the occurrence of challenging behaviors.

Consistent daily use of an individualized visual schedule will increase a child's organization skills and independent functioning throughout all aspects of his life and will ease transition through adulthood. There are numerous ways to present visual schedules for example an object schedule, 3-ring binder schedule, clipboard schedule, manila file folder schedules, and dry erase board schedules are all beneficial to increase a child's organization skills and independent functioning.

The use of a weekly/monthly calendar at both home and school can provide the child with important information regarding up-coming events/activities, rather than relying on auditory information. When the child asks when a particular event will occur, he can easily be referred to the visual calendar. Use of a visual calendar can also be helpful in assisting the child to understand when regularly scheduled events may not occur.

*Outcomes* In a pilot study, Researchers Lacava, Golan, Baron-Cohen, and Myles explored the use of assistive technology to teach emotion recognition to eight children with Autism and the results indicated that after intervention, participants improved on face and voice emotional recognition for basic and complex emotions that were in the software. As well as for complex voice emotional recognition for emotions not included in Mind Reading.

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## Chapter- 2

# Chorded Keyboard



A Microwriter MW4 (circa 1980)

A **keyset** or **chorded keyboard** (also called a chorded keyset, *chord keyboard* or *chording keyboard*) is a computer input device that allows the user to enter characters or commands formed by pressing several keys together, like playing a "chord" on a piano. The large number of combinations available from a small number of keys allows text or commands to be entered with one hand, leaving the other hand free. A secondary advantage is that it can be built into a device (such as a pocket-sized computer or a bicycle handlebar) that is too small to contain a normal-sized keyboard.

A chorded keyboard minus the board, typically designed to be used while held in the hand, is called a **keyer**. Douglas Engelbart introduced the chorded keyset as a computer interface in 1968 at what is often called "The Mother of All Demos".

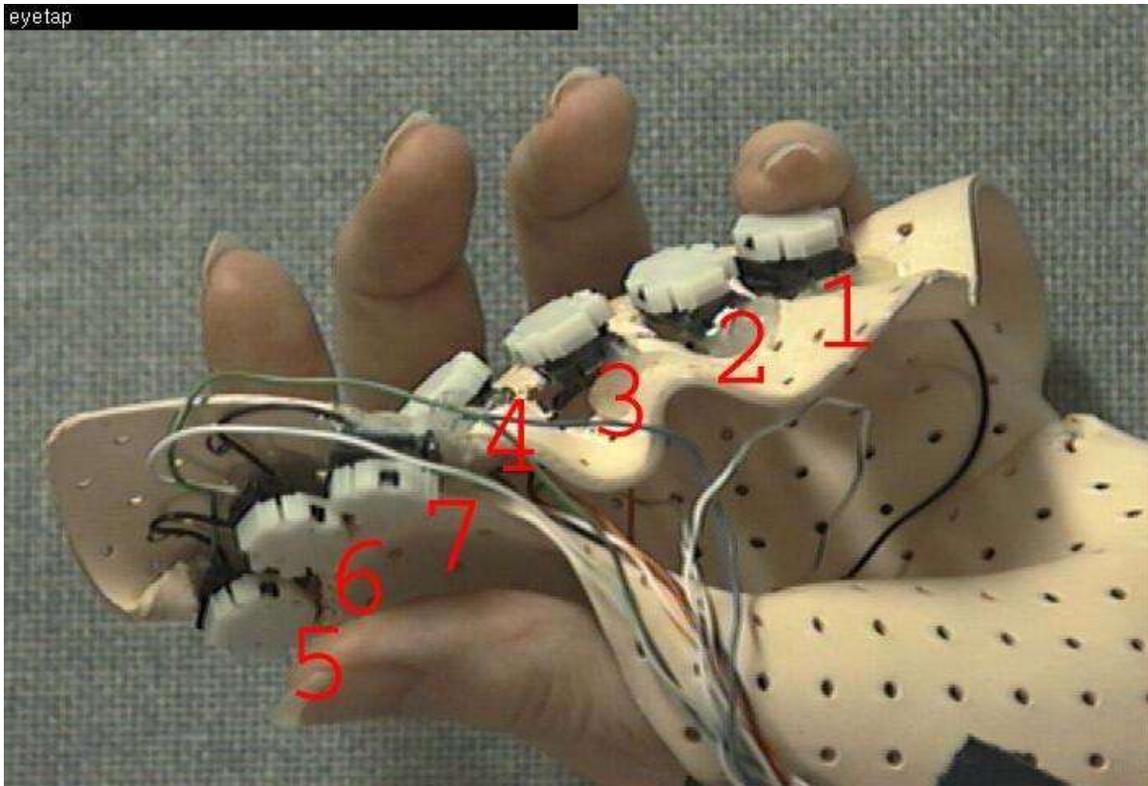
### ***Principles of operation***

Each key is mapped to a number and then can be mapped to a corresponding letter or command. By pressing two or more keys together the user can generate many combinations. In Engelbart's original mapping, he used five keys: 1,2,4,8,16. The keys were mapped as follows: a = 1, b = 2, c = 3, d = 4, and so on. If the user pressed keys  $1 + 2 = 3$  simultaneously the letter "c" appeared. Since Engelbart introduced the keyset, several different designs have been developed based on similar concepts.

As a crude example, each finger might control one key which corresponds to one bit in a byte, so that using seven keys and seven fingers, one could enter any character in the ASCII set—if the user could remember the binary codes. Due to the small number of keys required, chording is easily adapted from a desktop to mobile environment.

Douglas Engelbart recently filed two new patents for mobile chorded keyset devices and TipTap.mobi has released a chorded app for the iPhone with Douglas Engelbart.

Practical devices generally use simpler chords for common characters (*e.g.*, Baudot), or may have ways to make it easier to remember the chords (*e.g.*, Microwriter), but the same principles apply.



An ergonomic chording keyboard without the board is a keyer

These portable devices first became popular with the wearable computer movement in the 1980s.

Thad Starner from Georgia Institute of Technology and others published numerous studies show that two handed chording text entry was faster and yielded fewer errors than on a QWERTY keyboard.

Currently stenotype machines hold the record for fastest word entry. Many stenotype users can reach 300 words per minute. However, stenographers typically train for three years before reaching professional levels of speed and accuracy.



A 104-key USB keyboard adapted into a chording keyboard. All phonetic keystrokes may be accomplished by one and two-key chords of the home keys (top row)

## ***History***

The earliest known chord keyboard was part of the "five-needle" telegraph operator station, designed by Wheatstone and Cooke in 1836, in which any two of the five needles could point left or right to indicate letters on a grid. It was designed to be used by untrained operators (who would determine which keys to press by looking at the grid), and was not used where trained telegraph operators were available.

The first widespread use of a chord keyboard was in the stenotype machine used by court reporters, which was invented in 1868 and is still in use. But the output of the stenotype is a phonetic code that has to be transcribed later (usually by the same operator who produced the original output), rather than arbitrary text.

In 1874, the five-bit Baudot telegraph code and a matching 5-key chord keyboard was designed to be used with the operator forming the codes manually. The code is optimized for speed and low wear: chords were chosen so that the most common characters used the simplest chords. But telegraph operators were already using typewriters with QWERTY keyboards to "copy" received messages, and at the time it made more sense to build a typewriter that could generate the codes automatically, rather than making them learn to use a new input device.



A braille keyboard

Braille (a writing system for the blind) uses either 6 or 8 tactile 'points' from which all letters and numbers are formed. When Louis Braille invented it, it was produced with a needle holing successively all needed points in a cardboard sheet. In 1892, Frank Hall created the Hall braille writer which was like a typewriter with 6 keys, one for each dot in a braille cell. The Perkins Brailler, first manufactured in 1951, uses a 6-key chord keyboard (plus a spacebar) to produce braille output, and has been very successful as a mass market affordable product. Braille, like Baudot, uses a number symbol and a shift symbol, which may be repeated for shift lock, to fit numbers and upper case into the 31 codes that 6 bits offer.

After World War II, with the arrival of electronics for reading chords and looking in tables of "codes", the postal sorting offices started to research chordic solutions to be able to employ people other than trained and expensive typists. In 1954, an important concept was discovered: chordic production is easier to master when the production is done at the release of the keys instead of when they are pressed.

Researchers at IBM investigated chord keyboards for both typewriters and computer data entry as early as 1959, with the idea that it might be faster than touch-typing if some chords were used to enter whole words or parts of words. One of their designs had 14 keys that were dimpled on the edges as well as the top, so one finger could press two

adjacent keys for additional combinations. Their results were inconclusive, but research continued until at least 1978.

Douglas Engelbart, in the 1968 demo introduced a computer human interface that included the QWERTY keyboard, a three button mouse computer mouse, and a five chord keyset. Engelbart uses the keyset with his left hand and the mouse with his right. He uses the keyset to type both text and specific commands. To type a command Engelbart presses one of the three buttons of the mouse.

Users in Engelbart's Augmentation Research Center at SRI became proficient with the mouse and keyset. In the 1970s the funding Engelbart's group received from the Advance Research Project Agency (ARPA) was cut and many key members of Engelbart's team went to work for Xerox PARC where they continued to experiment with the mouse and keyset. Keychord sets were used at Xerox PARC in the early 1980s, along with mice, GUIs, on the Xerox Star and Alto workstations. A one button version of the mouse was incorporated into the Apple Macintosh but Steve Jobs decided against incorporating the chorded keyset.

In the early 1980s, Philips Research labs at Redhill, Surrey did a brief study into small, cheap keyboards for entering text on a telephone. One solution made use of a grid of hexagonal keys with symbols inscribed into dimples in the keys that were either in the center of a key, across the boundary of two keys, or at the joining of three keys. Pressing down on one of the dimples would cause either one, two or three of the hexagonal buttons to be depressed at the same time, forming a chord that would be unique to that symbol. With this arrangement, a nine button keyboard with three rows of three hexagonal buttons could be fitted onto a telephone and could produce up to 33 different symbols. By choosing widely separated keys, one could employ one dimple as a 'shift' key to allow both letters and numbers to be produced. With eleven keys in a 3/4/4 arrangement, 43 symbols could be arranged allowing for lowercase text, numbers and a modest number of punctuation symbols to be represented along with a 'shift' function for accessing uppercase letters. Whilst this had the advantage of being usable by untrained users via 'hunt and peck' typing and requiring one less key switch than a conventional 12 button keypad, it had the disadvantage that some symbols required three times as much force to depress them as others which made it hard to achieve any speed with the device. That solution is still alive and proposed by Fastap and Unitap among others, and a commercial phone has been produced and promoted in Canada during 2006.

## ***Standards***

Historically, the baudot and braille keyboards were standardized to some extent, but they are unable to replicate the full character set of a modern keyboard. Braille comes closest, as it has been extended to eight bits.

The only proposed modern standard, GKOS (or Global Keyboard Open Standard) can support most characters and functions found on a computer keyboard but has had little

commercial development. There is, however, a GKOS keyboard application available for iPhone since May 8, 2010, and for Android since October 3, 2010.

## ***Open source designs***

Three open source keyer/keyset designs are available: The pickey a ps/2 device based on the PIC microcontroller, the spiffchorder a usb device based on the Atmel AVR family of microcontrollers, and the GKOS keypad driver for Linux as well as the Gkos library for the Atmel/Arduino open source board.

**joy2chord** is a Chorded Keyboard driver for Linux computers. With a configuration file, any joystick or gamepad can be turned into a chorded keyboard. This design philosophy was decided on to lower the cost of building devices, and in turn lower the entry barrier to becoming familiar with chorded keyboards. Macro keys, and multiple modes are also easily implemented with a user space driver.

## ***Commercial devices***

A minimal chordic keyboard is the half qwerty where, to produce the letters of the missing half you just press simultaneously the space bar. It has been academically proven by Mathias and alii that people who can touch type can quickly recover 50 to 70% of their two hands operation. The loss is a solid contribution to the speed discussion above. It is implemented on two popular mobile phones, each provided with software disambiguation, which allows users to avoid using the space-bar.

"Multiambic" keyers for use with wearable computers were invented in Canada in the 1970s. Multiambic keyers are like chording keyboards but without the board, i.e. the keys are grouped in a cluster for being handheld rather than for sitting on a flat surface.

Chording keyboards are also used as portable but two handed input devices for the visually impaired (either combined with a refreshable braille display or vocal synthesis). Such keyboards use a minimum of seven keys, where each key corresponds to an individual braille point, except one key which is used as a spacebar. In some applications, the spacebar is used to produce additional chords which enable the user to issue editing commands, such as moving the cursor, deleting words, etc. Note that the number of points used in braille computing is not 6, but 8, as this allows the user, among other things, to distinguish between small and capital letters, as well as identify the position of the cursor. As a result, most newer chorded keyboards for braille input include at least nine keys.

## **Historical**

The **WriteHander** a 12-key chord keyboard from NewO Company, appeared in 1978 issues of ROM Magazine, an early microcomputer applications magazine.

Another early commercial models was the six-button **Microwriter**, designed by Cy Endfield and Chris Rainey, and first sold in 1980. Microwriting is the system of chord keying and is based on a set of mnemonics. It was designed only for right-handed use.

The **BAT** is a 7-key hand-sized device from Infogrip, and has been sold since 1985. It provides one key for each finger and three for the thumb. It is proposed for the hand which does not hold the mouse, in an exact continuation of Engelbart's vision.

## Modern

Modern examples of chorded keyboards include **TipTapSpeech** (uses Engelbart's original mapping), the **GKOS** keyboard, the **FrogPad**, the **In10did** method, the **EkaPad**, **TextFaster** and **HotTyper**. Some of them are intended for tiny tablet PCs and wireless mobile terminals, many of them are additionally available as apps on Apples iOS devices.

Chris Rainey, the co-inventor of Microwriting, re-introduced Microwriting for PC and Palm PDAs with a standalone miniature chording keyboard called **CyKey** which caters to both left and right-handed users, being 9-keys. CyKey (pronounced sai-ki or "psyche") is named after the Microwriter chord system's co-inventor Cy Endfield, who died in 1995 but the name also reflects its intuitive nature.

The **GKOS** is a 6-key keyboard with a different signs and commands allocation of the 63 different chords in order to provide all PC keyboard functions and to make entering letters and numbers lighter by having to press fewer keys simultaneously. The 6 physical keys are intended to be on the back of the device and to be operated with the 6 free fingers of two hands holding the device. Another option is to have virtual GKOS keys positioned towards the sides of a touch sensitive screen. This so called GKOS Thumbs has additional keys to enable all combos by only one keypress per hand. GKOS iPhone and Android applications are available according to this principle.

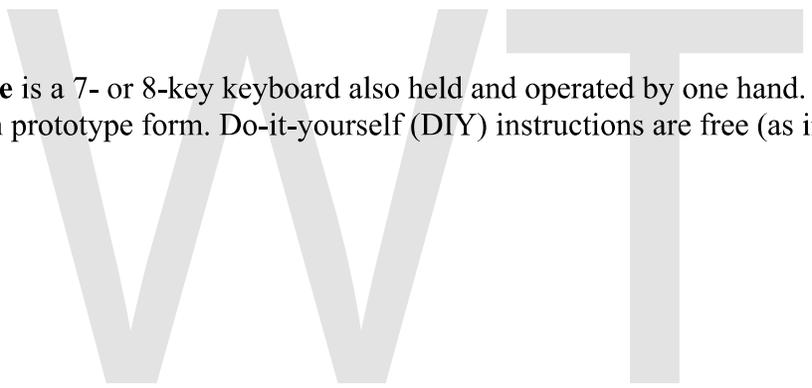
The **EkaPad** is a 12-key chorded keyboard operated with the four fingers of one hand. It is supported on the thumb. With the 9 main keys, (operated by the index, middle, and ring fingers), 2 prefix keys and one delete key, the EkaPad can produce all the inputs of a standard qwerty keyboard with one, two, and a few three finger chords. For some characters one or two prefix chords are required. 9 main keys (3x3 matrix) can produce a total of 511 chords. With each of the three fingers limited to its own row, 229 chords are possible with 3 fingers. EkaPad uses 66 of these accessible chords. One and two finger chords produce about 85% of American English; with an additional prefix chord about 97%. In addition, the EkaPad can store 100 text strings and 100 keyboard shortcuts. Like many other chorded keyboards, this keyboard can be used with one hand.

The **FrogPad** is a 20-key chorded keyboard about the size of a numeric keypad that can be used with one hand, and is optimized by character frequency. 85% of average keystrokes in English text can be typed without chording, and chords are limited to 2 fingers.

The **In10did method** (pronounced "intended") is a ten-key limited chord system that places one key under each finger in order to utilize all of them, however only two are needed for any operations (excluding the "F" keys, which require three key presses). Each key is essentially a shift key so that with ten keys, there are ten single strokes and ninety two-finger keystrokes. The alphabet is produced with a single press or by shifting with a thumb. Changing modes, such as number lock, can make other input provided with a single keystroke. This avoids complex chords while providing enough keystrokes for efficient typing and allows for some unique implementations such as typing with gloves. One other interesting application is on a video game controller and called the X-SKIN which is expected to be commercially available by 2010 and could help make popular MMORPGs possible on console systems. The system can also be applied in a single hand configuration or as one key at a time if needed. Claimed advantages of the IN10DID method are the diversity of devices, limited motion and simple chords.

The **Twiddler** is a 16-key keyboard (plus mouse) keyboard designed to be held and operated in one hand. It was originally introduced in the early 1990s and is currently being produced by TekGear. It was popular among wearable computer researchers and hobbyists.

The **Chordite** is a 7- or 8-key keyboard also held and operated by one hand. It currently exists only in prototype form. Do-it-yourself (DIY) instructions are free (as in 'free beer').



## Chapter- 3

# Wheelchair



Wheelchair seating in a theater (i.e. giving a dedicated, convenient space left free for a user to position his own wheelchair in the cinema).



A typical modern battery powered chair

A **wheelchair** is a chair with wheels, designed to be a replacement for walking. The device comes in variations where it is propelled by motors or by the seated occupant turning the rear wheels by hand. Often there are handles behind the seat for someone else to do the pushing. Wheelchairs are used by people for whom walking is difficult or impossible due to illness (physiological or physical), injury, or disability. People with both sitting and walking disability often need to use a wheelbench.

### ***History***

The earliest record of wheelchairs dates back to the 6th century, as an inscription found on a stone slate in China. Later dates relate to Europeans using this technology during the

German Renaissance. Harry Jennings and his disabled friend Herbert Everest, both mechanical engineers, invented the first lightweight, steel, collapsible wheelchair in 1933. Mr Everest had broken his back in a mining accident. The two saw the business potential of the invention and went on to become the first mass-manufacturers of wheelchairs: Everest and Jennings. Their "x-brace" design is still in common use, albeit with updated materials and other improvements.

## ***Types***

A basic manual wheelchair incorporates a seat, foot rests, handles at the back and four wheels: two castor wheels at the front and two large wheels at the back.

Other varieties of wheelchair are often variations on this basic design, but can be highly customised for the user's needs. Such customisations may encompass the seat dimensions, height, seat angle (also called seat dump or squeeze), footrests, leg rests, front caster outriggers, adjustable backrests and controls.



Wooden wheelchair dating to the early part of the 20th century

**Everyday manual wheelchairs** come in two major designs -- **folding** or **rigid**. The rigid chairs, which are increasingly preferred by active users, have permanently welded joints and many fewer moving parts. This reduces the energy required to push the chair by eliminating many points where the chair would flex as it moves. Welding the joints also reduces the overall weight of the chair. Rigid chairs typically feature instant-release rear wheels and backrests that fold down flat, allowing the user to dismantle the chair quickly for storage in a car.

Many rigid models are now made with **ultralight materials** such as aircraft aluminium and titanium. One major manufacturer, Tilite, builds only ultralights. Another innovation in rigid chair design is the installation of polymer shock absorbers, such as FrogLegs, which cushion the bumps over which the chair rolls. These shock absorbers may be added to the front wheels or to the rear wheels, or both.

Various optional accessories are available, such as anti-tip bars or wheels, safety belts, adjustable backrests, tilt and/or recline features, extra support for limbs or neck, mounts or carrying devices for crutches, walkers or oxygen tanks, drink holders, and clothing protectors.

So-called **transport wheelchairs** are usually light, folding chairs with four small wheels. These chairs are designed to be pushed by a caregiver to provide mobility for patients outside the home or more common medical settings.

Experiments have also been made with unusual variant wheels, like the omniwheel or the mecanum wheel. These allow for a broader spectrum of movement.



Wheelchair fitted with Mecanum wheels, taken at an exhibition in the early 1980s

The **electric wheelchair** shown on the right is fitted with Mecanum wheels (sometimes known as Ilon wheels) which give it complete freedom of movement. It can be driven forwards, backwards, sideways, and diagonally, and also turned round on the spot or turned around while moving, all operated from a simple joystick.

## Manually powered



An antique wheelchair

Manual wheelchairs are those that require human power to move them. Many manual wheelchairs can be folded for storage or placement into a vehicle, although modern wheelchairs are just as likely to be rigid framed.

**Manual or self-propelled wheelchairs** are propelled by the occupant, usually by turning the large rear wheels, from 20-26 inches in average diameter, and resembling bicycle wheels. The user moves the chair by pushing on the handrims, which are made of circular tubing attached to the outside of the large wheels. The handrims have a diameter that is slightly less than that of the rear wheels. Skilled users can control speed and turning and often learn to balance the chair on its rear wheels — do a "wheelie". The wheelie is not just for show — a rider who can control the chair in this manner can climb and descend curbs and move over small obstacles.

One-arm drive enables a user to guide and propel a wheelchair from one side. Two handrims, one smaller than the other, are located on one side of the chair, left or right. On most models the outer, or smaller rim, is connected to the opposite wheel by a folding axle. When both handrims are grasped together, the chair may be propelled forward or backward in a straight line. When either handrim is moved independently, the chair will turn left or right in response to the handrim used. Another alternative is a LeverDrive chair that propels the chair forwards by using a lever that is pumped back and forth.

Some chairs are also configured to allow the occupant to propel using one or both feet instead of using the rims.

**Attendant-propelled chairs** are designed to be propelled by an attendant using the handles, and thus the back wheels are rimless and often smaller. These chairs are often used as 'transfer chairs' to move a patient when a better alternative is unavailable, possibly within a hospital, as a temporary option, or in areas where a user's standard chair is unavailable. These chairs are commonly seen in airports. Special airplane transfer chairs are available on most airlines, designed to fit narrow airplane aisles and transfer wheelchair-using passengers to and from their seats on the plane.

**Wheelbase chairs** are wheeled platforms with specially molded seating systems interfaced with them for users with a more complicated posture. A molded seating system involves taking a cast of a person's best achievable seated position and the either carving the shape from memory foam or forming a plastic mesh around it. This seat is then covered, framed, and attached to a wheelbase.

Light weight and high cost are related in the manual wheelchairs market. At the low-cost end, heavy, tubular steel chairs with sling seats and little adaptability dominate. Users may be temporarily disabled, or using such a chair as a loaner, or simply unable to afford better. Heavy unmodified manual chairs are common as "loaners" at large facilities such as airports, amusement parks and shopping centers. In a higher price range, and more commonly used by persons with long-term disabilities, are major manufacturer lightweight chairs with more options. The high end of the market contains ultra-light models, extensive seating options and accessories, all-terrain features, and so forth. Reclining wheelchairs have handbrake-like controls attached to the push handles or posts supporting the backrest which, when pressed by the caregiver, allow the backrest to recline from its normal upright position (at 90 degrees) to varying angles up to 180 degrees.

## **Electric-powered**

An **electric-powered wheelchair** is a wheelchair that is moved via the means of an electric motor and navigational controls, usually a small joystick mounted on the armrest, rather than manual power. For users who cannot manage a manual joystick, headswitches, chin-operated joysticks, sip-and-puff or other specialist controls may allow independent operation of the wheelchair

## **Other variants**

A Standing wheelchair is one that supports the user in a nearly standing position. They can be used as both a wheelchair and a standing frame, allowing the user to sit or stand in the wheelchair as they wish. They often go from sitting to standing with a hydraulic pump or electric-powered assist.

A mobility scooter is a motorized assist device similar to an EPW, but with a steering 'tiller' or bar instead of the joystick, and fewer medical support options. Mobility scooters are available without a prescription in some markets, and range from large, powerful models to lightweight folding ones intended for travel.

A bariatric wheelchair is one designed to support larger weights; most standard chairs are designed to support no more than 250 lbs. on average.

Pediatric wheelchairs are another available subset of wheelchairs. *Hemi wheelchairs* have lower seats which are designed for easy foot propulsion. The decreased seat height also allows them to be used by children and shorter individuals.

A knee scooter is a related device which may be substituted for a wheelchair when an injury has occurred to only one leg, below the knee. The patient rests the injured leg on the scooter, grasps the handlebars, and pushes with the uninjured leg.

A Power-Assisted wheelchair is a recent development that uses the frame & seating of a typical manual chair while replacing the standard rear wheels with wheels that have small battery-powered motors in the hubs. A floating rim design senses the pressure applied by the users push & activates the motors proportionately. This results in the convenience, small size & light-weight of a manual chair while providing motorised assistance for rough/uneven terrain & steep slopes that would otherwise be difficult or impossible to navigate, especially by those with limited upper-body function.

## Sports variants



A modern racing wheelchair

Disabled athletes use sport wheelchairs for disabled sports that require speed and agility, such as basketball, rugby, tennis and racing. Each wheelchair sport tends to use specific types of wheelchairs, and these no longer look like their everyday cousins. They are usually non-folding (in order to increase rigidity), with a pronounced negative camber for the wheels (which provides stability during a sharp turn), and made of composite, lightweight materials. Sport wheelchairs are not generally for everyday use, and are often a 'second' chair specifically for sport use, although some users prefer the sport options for everyday.



US versus France, FIPFA World Cup, Tokyo, Japan, October 2007.

### **Powerchair Football/Power Soccer**

A new sport has been developed for powerchair users called powerchair football or power soccer. It is the only competitive team sport for powerchair users. The Federation Internationale de Powerchair Football Associations (FIPFA) governs the sport and is located in Paris, France with country affiliates around the world.

### **Transfer, stretcher, or mechanical**

Stretcher (or transfer) chairs are mobile chairs that can be adjusted to lay flat like a stretcher to help in the lateral (or supine) transfer of a patient from a bed to the chair. Once transferred, the stretcher can be adjusted to allow the patient to assume a sitting position. Transfer chairs often use sliding sheets or inflatable sliding mats with air

bearings to facilitate the movement of the patient from the bed to the chair. The patient in bed is rolled onto the transfer sheet or mat, and the sheet slides between the bed and the chair (configured as a flat stretcher), carrying the patient with it. Transfer chairs sometimes have separate manual cranks or electric winches which attach to the sliding sheet and pull (or drag) the patient off the bed and onto the chair. Such devices can also be used to transfer patients to standard gurneys. Alternately nurses can lift or slide the transfer sheet and patient manually. Transfer chairs are usually much more expensive than common wheelchairs. This is because of the complex engineering required to be able of change the chair's configuration from a stretcher to a mobile chair. This kind of lateral patient transfer requires a stable platform to prevent injury (i.e., avoid patient falls). This stability requirement makes transfer chairs larger, heavier, and less mobile than standard wheelchairs.

### **All terrain variants**

This wheelchair allow users to enter the water and provide a better mobility in the sand and on uneven terrain. There are lots of different models available both manual and battery driven. In many countries in Europe where the Accessible Tourism is well set, many beaches are wheelchair accessible and provide this kind of wheelchairs to clients free of charge.

### **Recent developments**

Recent technological advances are slowly improving wheelchair and EPW technology. Some wheelchairs, such as the iBOT, incorporate gyroscopic technology and other advances, enabling the chair to balance and run on only two of its four wheels on some surfaces, thus raising the user to a height comparable to a standing person. They can also incorporate stair-climbing and four-wheel-drive feature motorized assists for hand-powered chairs are becoming more available and advanced. The popular Segway Personal Transporter is a mobility device that was a direct outgrowth of the development of the iBOT wheelchair. The Segway, which is basically an iBOT with two wheels removed, was developed explicitly to increase the number of units produced and take advantage of the economies of scale to make the iBOT affordable to wheelchair users. The \$25,000 iBot, which was developed as a joint venture between Johnson and Johnson's Independence Technology and Dean Kamen's DEKA Research, was discontinued in January 2009.

The addition of geared, all-mechanical wheels for manual wheelchairs is a new development incorporating a hypocycloidal reduction gear into the wheel design. The 2-gear wheels can be added to a manual wheelchair. The geared wheels provide a user with additional assistance by providing leverage through gearing (like a bicycle, not a motor). The two-gear wheels offer two speed ratios- 1:1 (no help, no extra friction) and 2:1, providing 100% more hill climbing force. The low gear incorporates an automatic "hill hold" function which holds the wheelchair in place on a hill between pushes, but will allow the user to override the hill hold to roll the wheels backwards if needed. The low gear also provides downhill control when descending.

A recent development related to wheelchairs is the handcycle. They come in a variety of forms, from road and track racing models to off-road types modelled after mountain bikes.

There have been significant efforts over the past 20 years to develop stationary wheelchair trainer platforms that could enable wheelchair users to exercise as one would on a treadmill or bicycle trainer. Some devices have been created that could be used in conjunction with virtual travel and interactive gaming similar to an omnidirectional treadmill.

### ***Mobility and access***



A wheelchair-swing on a playground in New Zealand



Wheelchair ramp and disabled parking space



A gate for wheelchairs in Hiroshima

## Buildings

Adapting the built environment to make it more accessible to wheelchair users is one of the key campaigns of disability rights movements and the Americans with Disabilities Act of 1990 (ADA). The most important principle is Universal design - that all people regardless of disability are entitled to equal access to all parts of society like public transportation and buildings. A wheelchair user is less disabled in an environment without stairs.



Wheelchair elevator located outdoors

Sometimes it is necessary to add structures like ramps or elevators in order to permit people in wheelchairs (and those using crutches, canes, walkers and so forth, or those with unsupported walking disabilities) to use a particular building. Other important adaptations are powered doors, lowered fixtures such as sinks and water fountains, and toilets with adequate space and grab bars to allow the person to maneuver himself or herself out of the wheelchair onto the fixture. In the United States, most new construction for public use must be built to ADA standards of accessibility.

With the aging of the population, architects are seeking to design wheelchair ramps for private homes that are less obtrusive and harmonize better with the overall design of the home's structure. Other important adaptations to private homes are larger bathroom doors

that can accommodate wheelchairs, and showers and bathtubs that are designed for accessibility. These designs can permit the use of mobile shower chairs or shower benches to facilitate bathing for people with disabilities.

The construction of low floor trams and buses is being encouraged, whereas the use of paternosters in public buildings without any alternative method of transportation has been criticized due to the lack of access for wheelchair users. Modern urban architecture now incorporates better accessibility for people with disabilities.

In many countries, such as UK, the owners of inaccessible buildings are advised to keep a lightweight portable wheelchair or scooter access ramp on hand to make premises disabled-friendly.

## **Vehicles**

Public transit accessible vehicles are public transportation revenue vehicles which do not restrict access, are useable and provide allocated space and/or priority seating for people who use wheelchairs.

In Los Angeles there is a program to remove a small amount of seating on some trains to make more room for bicycles and wheel chairs.

New York City's entire bus system is wheelchair-accessible, and a multi-million-dollar renovation program is underway to provide elevator access to many of the city's 485 subway stations.

In Adelaide, Australia, all public transport has provision for at least two wheelchairs per bus, tram or train. In addition all trains have space available for bicycles.

The Washington, DC Metro system features complete accessibility on all its subways and buses.

A wheelchair that has been designed and tested for use as a seat in motor vehicles are often referred to as a "WC19 Wheelchair" or a "transit wheelchair". ANSI-RESNA WC19 (officially, SECTION 19 ANSI/RESNA WC/VOL. 1 Wheelchairs for use in Motor Vehicles) is a voluntary standard for wheelchairs designed for use when traveling facing forward in a motor vehicle. ISO 7176/19 is an international transit wheelchair standard that specifies similar design and performance requirements as ANSI/RESNA WC19. Thus, a WC19 Wheelchair is a crash-tested wheelchair with four clearly identified securement points that meets the design and performance requirements of ANSI-RESNA WC19 Wheelchairs Used as Seats in Motor Vehicles, and is sometimes called a transit wheelchair.

## ***User organizations***

Several organizations exist that help to give and receive wheelchair equipment. Organizations that accept wheelchair equipment donations typically attempt to identify recipients and match them with the donated equipment they have received. Organizations that accept donations in the form of money for wheelchairs typically have the wheelchairs manufactured and distributed in large numbers, often in developing countries. Organizations focusing on wheelchairs include Direct Relief International, the Free Wheelchair Mission, Hope Haven, Personal Energy Transportation, and the Wheelchair Foundation.

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## Chapter- 4

# Mobility Impairment

## Crutch



A typical forearm crutch



Using underarm crutches

**Crutches** are mobility aids used to counter a mobility impairment or an injury that limits walking ability.

## **Types**

There are several different types of crutches:

### Forearm

**Forearm crutches** are crutches with a cuff at the top to go around the forearm, and are also known as the **Lofstrand crutch**. They have been the type most commonly used in Europe; in the United States and Canada, they have been almost exclusively used by people with permanent or lifelong disabilities. However, American orthopaedic surgeons are now beginning to prescribe forearm crutches for patients with shorter-term needs. Forearm crutches are used by slipping the arm into a cuff and holding the grip. The cuff, typically made of plastic or metal, can be a half-circle or a full circle with a V-type opening in the front allowing the forearm to slip out in case of a fall.

### Underarm

In the United States **underarm** crutches are used most often by people with temporary disability or injury. These are used by placing the pads against the ribcage beneath the armpits and holding the grip, which is below and parallel to the pad. These are sometimes known as **axillary crutches**.

### Strutters

These are a variation on underarm crutches, incorporating large soles which remain flat on the floor or ground while the user walks. They allow for an improved walking gait, and distribute body weight to reduce the risk of nerve damage caused by underarm crutches.

### Platform

These are less common and used by those with poor hand grip due to arthritis, cerebral palsy, or other condition. The arm rests on a horizontal platform and is

strapped in place. The hand rests on a grip which, if properly designed, can be angled appropriately depending on the user's disability.

### Leg Support

These non-traditional crutches are useful for users with an injury or disability affecting one lower leg only. They function by strapping the affected leg into a support frame that simultaneously holds the lower leg clear of the ground while transferring the load from the ground to the user's knee or thigh. This style of crutch has the advantage of not using the hands or arms while walking. A claimed benefit is that upper thigh atrophy is also reduced because the affected leg remains in use. Unlike other crutch designs these designs are unusable for pelvic, hip or thigh injuries and in some cases for knee injuries also.

### Walking sticks (canes)

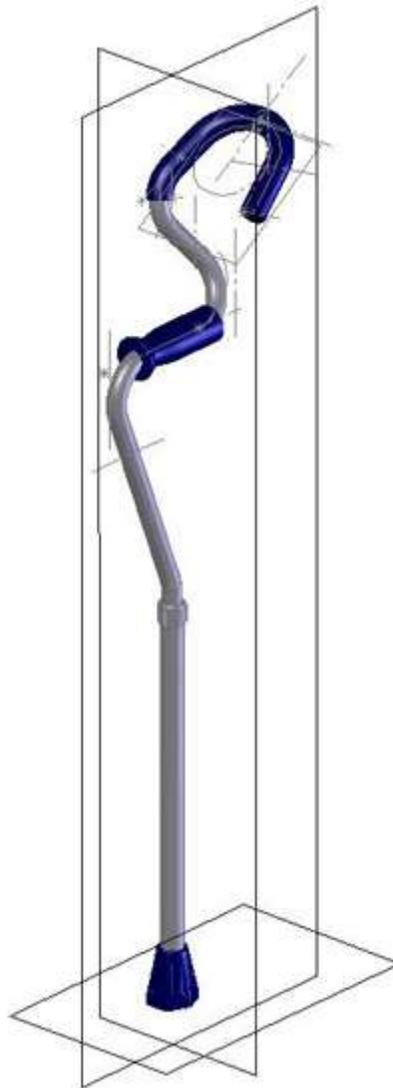
Walking sticks or canes serve an identical purpose to crutches, but are held only in the hand and have a limited load bearing capability because of this.

### Information on use

Several different gait patterns are possible, and the user chooses which one to use depending on the reason the crutches are needed. For example, a person with a non-weight bearing injury generally performs a "swing-to" gait: lifting the affected leg, the user places both crutches in front of himself, and then swings his uninjured leg to meet the crutches. Other gaits are used when both legs are equally affected by some disability, or when the injured leg is partially weight bearing.

With underarm crutches, sometimes a towel or some kind of soft cover is needed to prevent or reduce under arm injury. A condition known as *crutch paralysis*, or *crutch palsy* can arise from pressure on nerves in the armpit, or axilla. Specifically, "the brachial plexus in the axilla is often damaged from the pressure of a crutch...In these cases the radial is the nerve most frequently implicated; the ulnar nerve suffers next in frequency".

## ***Alternative devices***



Innovative Crutch

The knee scooter and the wheelchair are possible alternatives for patients who cannot use or do not like crutches. These wheeled devices introduce an additional limitation, however, since they cannot negotiate stairs.

## ***Materials***

1. Wood
2. Metal alloys (most often Steel, Aluminium alloys, Titanium alloys)
3. Carbon or glass fiber reinforced composites
4. thermoplastic
5. carbon fiber reinforced polymer

## ***Patents and inventions***

Emile Schlick, a French mechanical engineer, patented a walking stick (US patent number 1244249, filed Oct. 23, 1917) that provided an oblique support at the upper end for resting the forearm. This invention was first patented in France on May 7, 1915. Philipp Cederstom patented a similar-looking cane crutch (US Patent 2192766). Finally, the invention of A. R. Lofstrand, Jr., who filed a patent in 1945, consists of an adjustable-length crutch. In the US, forearm crutches are also sometimes referred to as *Lofstrands*, *Canadian crutches* (since they are commonly used in Canada), *elbow crutches* or even *Walk Easies* (Walk Easy is a brand name).

Different variations of walking and mobility devices have appeared on the market, notably one called the Strongarm Forearm Crutch, which is a combination between a traditional walking cane and forearm crutch. The inventor of the Strongarm Forearm Crutch, Michael E. Adams of Chicago, Illinois patented this device (US patent number 7,610,926)

## **Assistive cane**



Wooden Cane

An **assistive cane** is a walking stick used as a crutch, a mobility aid.

Like all crutches, it is used as a mobility aid by an injured or disabled person. It can serve several different functions as appropriate to the needs of the individual user; it can aid balance, it can support a weakened or painful limb or joint, and it can aid in sensing the environment. Users may use either a single cane, usually in the hand opposite the affected limb, or may use one in each hand where greater support is needed or both legs are affected.

In contrast to other crutches, canes are generally lighter, but, because they transfer the load through the user's unsupported wrist, are unable to offload equal loads from the legs.

Another type of crutch is the walker, a frame held in front of the user and which the user leans on during movement. Walkers are more stable due to their greater area of ground contact, but are larger and less wieldy and, like canes, pass the full load through the user's wrists in most cases.

### ***Parts of medical canes***



Bottom of a quad cane showing ferrules

The basic cane has four parts. These parts vary depending on the design of the cane and the needs of the user.

- **Handle** The handle of a cane is extremely important to the user. Many different styles exist, the most common traditional designs are the Tourist, or crook handle, the Fritz Handle and the Derby Handle. Ergonomically shaped handles have become increasingly common for canes intended for medical use, both increasing the comfort of the grip for the user (particularly important for those users with disabilities which also affect their hands or wrists), and better transmitting the load from the user's hand and arm into the shaft.
- **Collar** The collar of a cane may be only a decorative addition made for stylistic reasons, or may form the structural interface between shaft and handle.
- **Shaft** The shaft of the cane transmits the load from the handle to the ferrule and may be constructed from carbon fiber polymer, metal, composites, or traditional wood.
- **Ferrule** The tip of a cane provides traction and added support when the cane is used at an angle. Many kinds of ferrules exist, but most common is a simple, ridged rubber stopper. Users can easily replace a ferrule with one that better suits their individual needs.

Modern canes may differ from the traditional fixed structure. For instance, a quad cane has a base attached to the shaft that provides added stability by having four ferrules, and an adjustable cane may have two shaft segments telescoping one inside the other to allow adjustment for multiple sizes.

All cane users who need a walking cane for medical reasons should consult a medical professional before choosing the style that is right for them. It is particularly important that the cane is the appropriate height for the individual user

***Types of canes***



White Cane



Forearm crutch/cane

- **White canes:** specially for assisting the visually impaired, these are longer and thinner and allow the user to "feel" the path ahead. They also alert others, such as motorists, to know the user is blind and therefore use caution. In the UK, red banding on a white cane indicates a deaf-blind user.
- **Folding canes:** have several joints, generally linked by an internal elastic cord, allowing them to be folded into a shorter length when not in use.
- **Forearm canes:** are either regular canes or offset canes with additional forearm support, allowing increased stability and load shifted from the wrist to the forearm.
- **Quad canes:** have four ferrules at the base, allowing them to stand freely, and offering a more stable base for standing.
- **Tripod canes:** open in tripod fashion. Often available with an attached seat.

- **Adjustable canes:** feature two or more shaft pieces for a telescoping effect that allows the user to lengthen or shorten their walking cane to fit to size. This feature can be combined with other variations.

## ***Accessories***

- The most common accessory is a hand strap, to prevent loss of the stick should the hand release its grip. These are often threaded through a hole drilled into the stick rather than tied around.
- A clip-on frame or similar device can be used to stand a stick against the top of a table.
- In cold climates, a metallic cleat may be added to the foot of the cane. This dramatically increases traction on ice. The device is usually designed so it can be easily flipped to the side to prevent damage to indoor flooring.
- Different handles are available to better match the size of the user's hands and their medical needs.
- Rubber ferrules give extra traction on most surfaces.

## ***Handedness***

Canes are generally used in the hand *opposite* the injury or weakness. This may appear counter-intuitive, but this allows the cane to be used for stability in a way that lets the user shift much of their weight onto the cane and away from their weaker side as they walk. It also allows for fluid movement that better matches walking, as the hand opposite the leg generally sways forward in normal human locomotion. Personal preference, or a need to hold the cane in their dominant hand means some cane users choose to hold the cane on the same side as the affected leg.

# Walker



Modern-day walker

A **walker** or **walking frame** is a tool for disabled or elderly people who need additional support to maintain balance or stability while walking. The British English common equivalent term for a walker is **Zimmer frame** - from Zimmer Holdings, a major manufacturer of such devices and joint replacement parts.

A type of walker was patented on 10 May 1988 by Andrejs Muiza who immigrated to the United States (Nashville, TN) from Latvia following World War II. The basic design consists of a frame that is about waist high, approximately twelve inches deep and

slightly wider than the user. Walkers are also available in other sizes such as Pediatric (for children) or Bariatric (for overweight or obese persons). Modern walkers are height adjustable and should be set at a height that is comfortable for the user, but will allow the user to maintain a slight bend in their arms. This bend is needed to allow for proper blood circulation through the arms as the walker is used. The front two legs of the walker may or may not have wheels attached depending on the strength and abilities of the person using it. It is also common to see caster wheels or glides on the back legs of a walker with wheels on the front.

## ***Use***

The person walks with the frame surrounding their front and sides and their hands provide additional support by holding on to the top of the sides of the frame. Traditionally, a walker is picked up and placed a short distance ahead of the user. The user then walks to it and repeats the process. With the use of wheels and glides, the user may push the walker ahead as opposed to picking it up. This makes for easier use of the walker, as it does not require the user to use their arms to lift the walker. This is beneficial for those with little arm strength.

A walker is a good tool for those who are recuperating from leg or back injuries. It is also commonly used by persons having problems with walking or with mild balance problems.

Also related is a hemi-walker, a walker about half the size of a traditional walker which is intended for use by persons whose dexterity is limited or non-existent in one hand or arm. These walkers are more stable than a quad cane (a cane with four points that touch the ground, as opposed to one), but are not recommended as highly as a traditional walker for those who can use it.

## ***Wheeled walkers***



A European style rollator with hand-brakes and a 'shopping cart', the lid of which can be used as a seat



Rollator with hand brakes

A variant of the walker is the wheeled walker, also commonly called a **rollator**. It is a walking frame with wheels. Rollators are typically more sophisticated than conventional walkers with wheels. They are adjustable in height and are equipped with a seat and sometimes with a basket; with the use of modern materials, they are light-weight yet sturdier. Modern wheeled walkers may also provide a back against which a person can lean. A particularly important part of a rollator is hand brakes mounted on the top of the frame that can be lifted or pushed downward to stop the wheeled walker at once. The brakes can also be used in maneuvering the rollator; when turning, the user can brake on the side being turned towards in order to achieve a tighter turning radius.

Modern rollators with wheels at least seven inches in diameter ensure better reliability. Also, to the advantage of safety, convenience, and durability of a wheeled walking aid and its parts, modern rollators use tubular seats, back seats and baskets with spacers and cushions, and rather than using simple hooks as in early models, are equipped with latches and release buttons.

### ***The Zimmers***

In May 2007, a group of elderly people in the United Kingdom formed a rock group to highlight the plight and difficulties associated with old age. They called themselves The Zimmers in recognition of this generic term.

WWT

## Chapter- 5

# Telecommunications Device for the Deaf



Miniprint 425 TDD. The acoustic coupler on the top is for use with telephone handsets. The printer records the conversation. The specific GA and SK keys allow for speedier use of common abbreviations.

A **telecommunications device for the deaf (TDD)** is an electronic device for text communication via a telephone line, used when one or more of the parties has hearing or speech difficulties. Other names include **teletypewriter (TTY)** (TTY is also a term used for teletypes in general), **textphone** (Common in Europe and the UK), and **minicom** (United Kingdom).

The typical TTY is a device about the size of a typewriter or laptop computer with a QWERTY keyboard and small screen that uses LEDs or an LCD screen to display typed text electronically. In addition, TTYs commonly have a small spool of paper on which text is also printed — old versions of the device had only a printer and no screen. The text is transmitted live, via a telephone line, to a compatible device, i.e. one that uses a similar communication protocol. In certain countries there are systems in place so that a deaf person can communicate with a hearing person on an ordinary voice phone using a human relay operator. There are also "carry-over" services, enabling people who can hear but cannot speak ("hearing carry-over," a.k.a. "HCO"), or people who cannot hear but are able to speak ("voice carry-over," a.k.a. "VCO") to use the telephone.

## ***History***

The TTY concept was developed by James C. Marsters (1924–2009), a dentist and private airplane pilot who became deaf as an infant because of scarlet fever, and Robert Weitbrecht, a Deaf physicist. In 1964, Marsters, Weitbrecht and Andrew Saks, an electrical engineer and grandson of the founder of the Saks Fifth Avenue department store chain, founded APCOM (Applied Communications Corp.), located in the San Francisco Bay area, to develop the acoustic coupler, or modem; their first product was named the PhoneType. APCOM collected old teletype machines from the Department of Defense and junkyards. Couplers were cabled to TTYs enabling the Bell Telephone company standard "500 handset" to couple, or fit, into the rubber cups on the coupler, thus transmitting and receiving a unique set of tones generated by the different corresponding TTY keys. The entire configuration of teletype machine, acoustic coupler, and telephone set became known as the TTY. Weitbrecht invented the acoustic coupler modem in 1964. The actual mechanism for TTY communications was accomplished electromechanically through frequency shift keying (FSK) allowing only one-way (simplex) communication.

During the late 1960s, Paul Taylor combined Western Union teletype machines with modems to create the first teletypewriters, known as TTYs or (TDDs as they later became known). He distributed these early, non-portable devices to the homes of many in the Deaf community in St. Louis, Missouri. He worked with others to establish a local telephone wake-up service. In the early 1970s, these small successes in St. Louis evolved into the nation's first local telephone relay system for the deaf.

In 1973 the MCM (Manual Communications Module), which was the world's first electronic portable TTY allowing two-way telecommunications, premiered at the CAD (California Association of the Deaf) convention in Sacramento, California. The battery-powered MCM was invented and designed by Michael Cannon in conjunction with physicist Art Ogawa and Deaf interpreter Kit Patrick Corson. It was manufactured by Michael Cannon's company, Micon Industries, and initially marketed by Kit Corson's company, Silent Communications. In order to be compatible with the existing TTY network, the MCM was designed around the five-bit Baudot code established by the older TTY machines instead of the ASCII code used by computers. The MCM was an instant success with the Deaf community despite the drawback of a \$599 cost. Within six months

there were more MCMs in use by the Deaf and Hard of Hearing than TTY machines. After a year Micon took over the marketing of the MCM and subsequently concluded a deal with Pacific Bell (who coined the term "TDD") to purchase MCMs and rent them to Deaf telephone subscribers for \$30 per month. After Micon formed an alliance with APCOM, Michael Cannon, Paul Conover (Micon), and Andrea Saks (APCOM) successfully petitioned the California Public Utilities Commission (CPUC) resulting in a tariff that paid for TTY devices to be distributed free of cost to Deaf persons. Micon produced over 1,000 MCMs per month resulting in approximately 50,000 MCMs being disseminated into the Deaf community. Before he left Micon in 1980, Michael Cannon developed several computer compatible variations of the MCM and a portable, battery operated printing TTY, but they were never as popular as the original MCM. Newer model TTYs could communicate with selectable codes that allow communications at a higher bit rate on those models similarly equipped. However, the lack of true computer interface functionality spelled the demise of the original TTY and its clones. During the mid-1970s other so-called portable telephone devices were being cloned by other companies, and this was the time period when the term "TDD" began being used largely by those outside the Deaf community. It is to be noted that the Deaf community prefers the term "TTY" both because it best describes the device and because the term "TDD" was invented by Pacific Bell, a company founded by A.G. Bell, who is one of the major historical oppressors of the Deaf Community.

## **Marsters Award**

In 2009, AT&T received the James C. Marsters Promotion Award from TDI, (formerly Telecommunications for the Deaf, Inc.) for its efforts to increase accessibility to communication for people with disabilities. The award holds some irony; it was AT&T that, in the 1960s, resisted efforts to implement TTY technology, claiming it would damage its communication equipment. In 1968, The Federal Communications Commission struck down AT&T's policy and forced it to offer TTY access to its network.

## **Protocols**

There are many different textphone standards. The original standard used by TTYs is the Baudot code implemented asynchronously at either 45.5 or 50 baud, 1 start bit, 5 data bits, and 1.5 stop bits. Baudot is a common protocol in the US. In Europe, different states use different protocols. For example, V.21 is found in the UK and several Scandinavian countries. Other protocols used for text telephony are EDT, DTMF, V.23, etc.

The TDD/TTY protocols are generally incompatible with standard Hayes-compatible modems. In 1994 the ITU approved the V.18 standard. V.18 is a dual standard. It is both an umbrella protocol that allows recognition and interoperability of some of the most commonly used textphone protocols, as well as offering a native V.18 mode, which is an ASCII full- or half-duplex modulation method.

Computers can, with appropriate software and modem, emulate a V.18 TTY. Some voice modems, coupled with appropriate software, can now be converted to TTY modems by using a software-based decoder for TTY tones. Same can be done with such software using a computer's soundcard, when coupled to the telephone line.

In the UK, a virtual V.18 network, called TextDirect, exists as part of the Public Switched Telephone Network, thereby offering interoperability between textphones using different protocols. The platform also offers additional functionality like call progress and status information in text and automatic invocation of a relay service for speech-to-text calls.

In addition to regular Baudot, the UltraTec company implements another protocol known as Enhanced TTY, which it calls "Turbo Code," in its products. Turbo Code has some advantages over Baudot protocols, such as a higher data rate, full ASCII compliance, and full-duplex capability. However, Turbo Code is proprietary, and UltraTec only gives its specifications to parties who are willing to license it.

## **Devices**



AT&T TDD 2700

In addition to TDD, there are a number of pieces of additional equipment that can be coupled to telephones to improve their utility. For those with hearing difficulties the

telephone ring and conversation sound level can be amplified or pitch adjusted, ambient noise can also be filtered. The amplifier can be a simple addition or through an inductive coupler to interact with suitable hearing aids. The ring can also be supplemented with extension bells or a visual call indicator.

## ***Etiquette***

There are some etiquette rules that users of TTYs must be aware of. Because of the inability to detect when a person has finished speaking, the term "Go Ahead" (GA) is used to denote the end of a thought.

### **Commonly used abbreviations**

#### **Acronym**

BRB	Be Right Back
CA	Communications assistant (another term for a relay operator)
CU	See You (be seeing you)
GA	Go Ahead
SK	Stop Keying (not an imperative to the other person but rather a description of what the keyer is doing, A. preventing the subsequent dead air from confusing the recipient by letting the recipient know not to expect any more messages but also B. letting the recipient know that the keyer remains "listening" for any "goodbye"-type message)
SKSK	Now hanging up (used in reply to SK as confirmation that the replying keyer has nothing left to say and that both ends of the conversation [and, therefore, the conversation as a whole] are terminated)
GA OR SK, SKGA	Goodbye
Q, QQ, QM	Question Mark (?)
PLS	Please
RO	Relay Operator
OIC	Oh, I See
OPR	Operator
NBR	Number
TMW	Tomorrow
THX	Thanks
WRU	Who are You? (or Where are You?)
XXXX	Xs are often used to indicate a typing error instead of backspacing

## Sample conversation

**Caller A:** HELLO JOHN, WHAT TIME WILL YOU BE COMING AROUND TODAY  
Q GA

**Caller B:** HI FRED, I WILL BE AROUND NOON GA

**Caller A:** OK, NO PROBLEM, DON'T FORGET TO BRING THE BOOKS AND THE  
WORK SO FAR GA

**Caller B:** WILL DO SK

**Caller A:** BYE BYE SKSK

SK is used to allow the users to say their farewells, while SKSK indicates an immediate call hang-up.

## Sample conversation 2

**Caller A** HI, THIS IS JOHN, CAN I ASK WHO IS CALLING? GA

**Caller B** HI JOHN, ITS ME FRED, I AM WONDERING WHERE YOU ARE, ITS  
GETTING LATE TO GO OUT TO THE PUB GA

**Caller A** HI FRED, SORRY I DONT THINK I CAN GO GA

**Caller B** WHY CANT YOU GO? GA

**Caller A** MY WIFE IS NOT FEELING WELL AND I HAVE NO BABYSITTER FOR  
MY KIDS! GA

**Caller B** AWWWW DARN. I WANTED YOU THERE. OH WELL WHAT CAN YOU  
DO ? GA

**Caller A** I KNOW.. I GOTTA GO. THE KIDS NEED ME. SEE YOU AROUND! BYE  
FOR NOW SK

**Caller B** OK NO WORRIES SEE YOU SOON! BYE BYE SK GA

**Caller A** SKSK (THE PARTY HAS HUNG UP)

## Sample Text Relay call

**Caller A** TXD DIALING.. TXD RING... TXD OPERATOR CONNECTED..  
EXPLAINING TEXT RELAY SERVICE. PLEASE WAIT.... HI THIS IS JOHN GA

**Caller B** HI JOHN ITS ME FRED. I AM WONDERING WHAT YOU ARE DOING  
TONIGHT? GA

**Caller A** HI FRED. I AM THINKING OF HAVING A POKER NIGHT AT MINE,  
WHAT DO YOU THINK? GA

**Caller B** GOOD IDEA, I'LL CALL A FEW MATES TO COME ROUND AND HAVE  
A GOOD GAME GA

**Caller A** OK SEE YOU AT 7PM. BYE BYE SK GA

**Caller B** OK SEE YOU AT 7PM BYE BYE SKSKSKSK GA

**Caller A** THANK YOU FOR USING TEXT RELAY SERVICE. GOODBYE

*Note: TTYs use only capital letters.*

*Note: Text relay service used to be called typetalk (RNID) but have merged with the*

*phone line using the dialling prefix 18001 (TTY) or the 18002 (voice relay) the emergency line is 18000 (TTY)*

## **Relay**

One of the most common uses for a TTY is to place calls to a Telecommunications Relay Service (TRS), which makes it possible for the Deaf to successfully make phone calls to regular phone users.

The use of voice recognition systems is in limited use due to technical difficulties. A new development called the captioned telephone now utilizes voice recognition to assist the human operators. Newer text based communication methods, such as short message service (SMS), Internet Relay Chat (IRC), and instant messaging have also been adopted by the Deaf as an alternative or adjunct to TTY.

WWT

## Chapter- 6

# Hearing Aid



Behind-the-ear aid

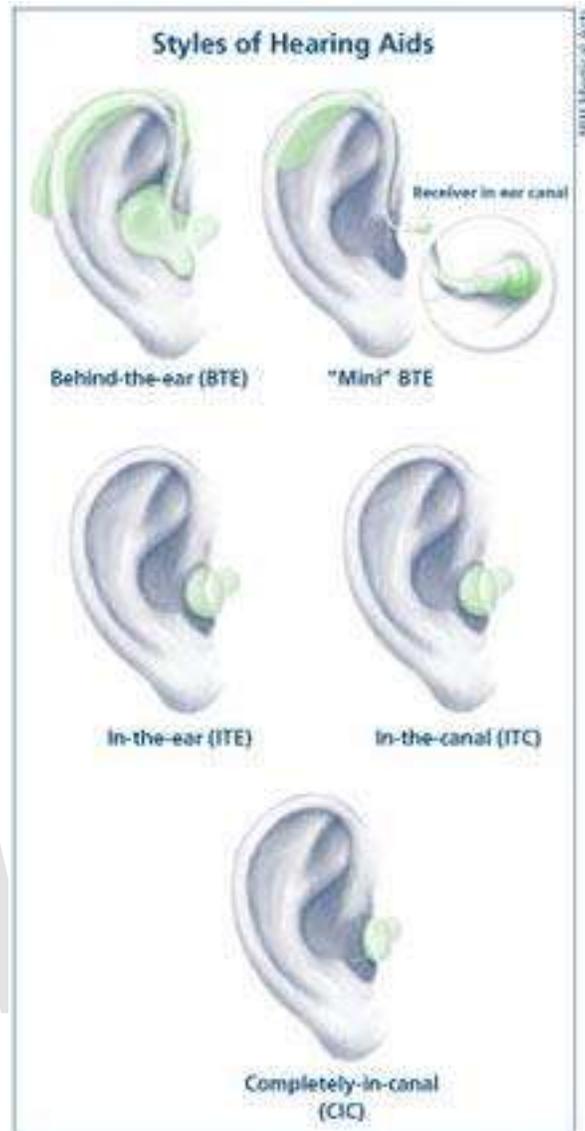


In-the-ear aid

A **hearing aid** is an electroacoustic device which typically fits in or behind the wearer's ear, and is designed to amplify and modulate sound for the wearer. Earlier devices, known as an "ear trumpet" or "ear horn", were passive funnel-like amplification cones designed to gather sound energy and direct it into the ear canal. Similar devices include the bone anchored hearing aid, and cochlear implant.

### ***Types of hearing aids***

There are many types of hearing aids (also known as hearing instruments), which vary in size, power and circuitry. Among the different sizes and models are:



NIH illustration of different hearing aid types

### Body worn aids

This was the first type of hearing aid invented by Harvey Fletcher while working at Bell Laboratories. Thanks to developments in technology they are now rarely used. These aids consist of a case, an earmold, and a cord. The case contains the amplifier components. The case is about the size of a pack of playing cards and is worn in the pocket or on a belt. The ear mold is connected to the case via a cord. Because of use of vacuum tubes, body worn aids can provide loud amplification. This made them the first appropriate hearing aid for profound hearing losses. Today, body aids have largely been replaced by **Behind-The-Ear (BTE)** instruments.

## **Behind the ear aids (BTE)**

BTE aids consist of a case, a tube and an earmold. The case is small and made of plastic. Generally, the case sits behind the pinna (ear) with the tube coming down the front into the earmold. The case contains the amplification system. The sound is routed from the hearing aid case to the earmold via the tube. The sound can be routed acoustically or electrically. If the sound is routed electrically, the speaker (receiver) is located in the earmold, rather than in the case. The earmold is created from an impression taken of the individual's outer ear. This usually ensures a comfortable fit and reduces the possibility of feedback. Earmolds are made from a variety of hard (firm) and soft (pliable) materials. The color of the case and earmold of a BTE aid can be modified and optional decorations can be added.

BTEs can be used for mild to profound hearing loss. Due to the electrical components being located outside the ear, the chance of moisture and earwax damaging the components is reduced. This increases the durability of a BTE aid and with proper care it can last for a number of years. BTEs can be connected to assistive listening devices, such as FM systems. An important aspect of the BTE aid is that the case and earmold are separate which makes it easier to replace the earmold. BTE aids are commonly worn by children who need a durable type of hearing aid. As children get older, they will require new earmolds on a regular basis; for example, babies may need earmolds replacing as often as every two weeks.

Recent innovations in BTEs include miniature BTEs with thin hair-like sound tubes. These are often less visible than In-The-Ear aids (ITEs). They use a larger vent than other hearing aid types. This keeps the ear canal more open, which allows sound to enter the ear without being amplified. This is helpful for listeners with normal hearing in the lower frequencies. Miniature BTEs are generally used for mild to moderate high frequency losses.

## **In the ear aids (ITE)**

These devices fit in the outer ear bowl (called the concha); they are sometimes visible when standing face to face with someone. ITE hearing aids are custom made to fit each individual's ear. They can be used in mild to some severe hearing losses. Feedback, a squealing/whistling caused by sound (particularly high frequency sound) leaking and being amplified again, may be a problem for severe hearing losses. Some modern circuits are able to provide feedback regulation or cancellation to assist with this. Another way to deal with feedback is venting. The vent is a tube primarily placed to offer pressure equalization. However, different vent styles and sizes can be used to influence and prevent feedback. Traditionally, ITEs have not been recommended for young children because their fit could not be as easily modified as the earmold for a BTE, and thus the aid had to be replaced frequently as the child grew. However, there are new ITEs made from a silicone type material that mitigates the need for costly replacements.

## **Receiver In the Canal/Ear (RIC/RITE)**

At a first glance, these devices are similar to the BTE aid. There is however one crucial difference: The speaker ('receiver') of the hearing aid is placed inside the ear canal of the user and thin electrical wires replace the acoustic tube of the BTE aid. There are some advantages with this approach: Firstly, the sound of the hearing aid is arguably smoother than that of a traditional BTE hearing aid. With a traditional BTE hearing aid, the amplified signal is emitted by the speaker (receiver) which is located within the body of the hearing aid (behind the ear). The amplified signal is then directed to the ear canal through an acoustic tube, which creates a peaky frequency response. With a RITE hearing aid, the speaker (receiver) is right in the ear canal and the amplified output of the hearing aid does not need to be pushed through an acoustic tube to get there, and is therefore free of this distortion. Secondly, RITE hearing aids can typically be made with a very small part behind-the-ear and the wire connecting the hearing aid and the speaker (receiver) is extremely inconspicuous. For the majority of people this is one of the most cosmetically acceptable hearing device types. Thirdly, RITE devices are suited to "open fit" technology (see below) so they can be fitted without plugging up the ear, offering relief from occlusion.

## **In the canal (ITC), mini canal (MIC) and completely in the canal aids (CIC)**

ITC aids are smaller, filling only the bottom half of the external ear. You usually cannot see very much of this hearing aid when you are face to face with someone. MIC and CIC aids are often not visible unless you look directly into the wearer's ear. These aids are intended for mild to moderately-severe losses. CICs are usually not recommended for people with good low frequency hearing, as the occlusion effect is much more perceivable.

In-the-ear hearing aids are typically much more expensive than their behind-the-ear counterparts with equal functionality. The reason is the fact that all in-the-ear aids are custom made to fit comfortably into the patient's ear. At first, an audiologist takes a physical impression of the ear. The ear mold is scanned, resulting in a 3D model of the outer ear. This model is modeled using a special CAD system like ShellDesigner (3Shape, Copenhagen) or Rapid Shell Modelling (Materialise, Leuven). During the modeling also the above mentioned venting tube is inserted. The digitally modeled *shell* is printed using a Rapid Prototyping technique like stereolithography. Finally, the aid is assembled and shipped to the audiologist after a quality check.

## **Invisible In canal hearing aids (IIC)**

This type of hearing aid fitting is not visible when worn. This is because it fits deeper in the canal than other types, so that it is out of view even when looking directly in to the ear bowl (concha). A comfortable fit is achieved because the shell of the aid is custom-made to an individual ear canal after taking a mould of the patient's ear. Invisible hearing aid types use venting and their deep placement in the ear canal to give a more natural

experience of hearing. Unlike other hearing aid types, with the IIC aid the majority of the ear is not blocked (occluded) by a large plastic shell. This means that sound can be collected more naturally by the shape of the ear, and can travel down in to the ear canal as it would with unassisted hearing. Instead of taking out the IIC to change memory or volume settings, some allow the wearer to use their mobile phone as a remote control to alter settings. IIC types are most suitable for users up to middle age, but are not suitable for more elderly people.

## **Extended wear hearing aids**

Extended wear hearing aids are hearing devices that are non-surgically placed in the ear canal by a hearing professional. The extended wear hearing aid represents the first "invisible" hearing device. The concept was invented by Adnan Shennib. These devices are worn for 1–3 months at a time without removal. They are made of soft material designed to contour to each user and can be used by people with mild to moderately severe hearing loss. They work by directing sound into the ear canal from the outer ear (the pinna). Their close proximity to the ear drum results in improved sound directionality and localization, reduced feedback, and improved high frequency gain. While traditional BTE or ITC hearing aids require daily insertion and removal, extended wear hearing aids are worn continuously and then replaced with a new device. Users can change volume and settings without the aid of a hearing professional. The devices are very useful for active individuals because their design protects against moisture and earwax and can be worn while exercising, showering, etc. Because the device's placement within the ear canal makes them invisible to observers, extended wear hearing aids are popular with those who are self-conscious about the aesthetics of BTE or ITC hearing aid models. As with other hearing devices, compatibility is based on an individual's hearing loss, ear size and shape, medical conditions, and lifestyle. The disadvantages include regular removal and reinsertion of the device when the battery dies, inability to go underwater, earplugs when showering, and for some discomfort with the fit since it is inserted deeply in the ear canal in the only part of the body where skin rests directly on top of bone.

## **Open-fit devices**

"Open-fit" or "Over-the-Ear" OTE hearing aids are small behind-the-ear type devices. This type is characterized by a small plastic case behind the ear, and a very fine clear tube running into the ear canal. Inside the ear canal, a small soft silicone dome or a molded, highly vented acrylic tip holds the tube in place. This design is intended to reduce the occlusion effect. Conversely, because of the increased possibility of feedback, and because an open fit allows low frequency sounds to leak out of the ear canal, they are limited to moderately severe high frequency losses. Whilst the design approach is attractive to a general hearing aid user where they fall into the category to be considered fitted with one of these types of hearing instruments it has to be taken into account that Open-fit devices can by their design have problems when connected to Assistive Listening Devices (ALD's). This is due to the open-ear effect and that the user would hear Low Frequency sounds normally via no Occlusion whilst the hearing aid filters and

provides the high frequencies. When a ALD's such as a Wireless FM system are provided to help a hearing aid user to hear over a distance in some cases only the high frequencies are provided to the user and the Low frequencies are lost over distance. This can easily be verified by taking different open ear hearing aids and measuring their Output Frequency Response using a hearing aid Analyzer and then comparing the output when connected to ALD device and observing if any considered Gain in Low Frequency has been provided.

## **Personal, User, Self, or Consumer Programmable**

The personal programmable, consumer programmable, consumer adjustable, or self programmable hearing aid allows the consumer to adjust their own hearing aid settings to their own preference using their own PC. Personal programmable hearing aid manufacturers or dealers can also remotely adjust these types of hearing aids for the customer. Available in all hearing aid styles, these hearing aids differ from traditional hearing aids only in that they are adjustable by the consumer.

## **Disposable hearing aids**

Disposable hearing aids are hearing aids that have a non-replaceable battery. These aids are designed to use power sparingly, so that the battery lasts longer than batteries used in traditional hearing aids. Disposable hearing aids are meant to remove the task of battery replacement and other maintenance chores (adjustment or cleanings). To date, two companies have brought disposable hearing aids to market: Songbird Hearing and Lyric. Both are digital, but are used in very different ways by the consumer. Songbird is a BTE hearing aid that is bought online and worn like any other BTE device. When it runs out, the user replaces it with a new one. Lyric is implanted deep in the ear canal by a professional. When it runs out, it must be removed and replaced with a new one by a professional.

## **Bone Anchored Hearing Aids (BAHA)**

The BAHA is an auditory prosthetic which can be surgically implanted. The BAHA uses the skull as a pathway for sound to travel to the inner ear. For people with conductive hearing loss, the BAHA bypasses the external auditory canal and middle ear, stimulating the functioning cochlea. For people with unilateral hearing loss, the BAHA uses the skull to conduct the sound from the deaf side to the side with the functioning cochlea.

Individuals under the age of 5 typically wear the BAHA device on a headband. Over age 5, a titanium "post" can be surgically embedded into the skull with a small abutment exposed outside the skin. The BAHA sound processor sits on this abutment and transmits sound vibrations to the external abutment of the titanium implant. The implant vibrates the skull and inner ear, which stimulate the nerve fibers of the inner ear, allowing hearing.

## **Eyeglass aids**

During the late 1950s through 1970s, before in-the-ear aids became common (and in an era when thick-rimmed eyeglasses were popular), people who wore both glasses and hearing aids frequently chose a type of hearing aid that was built into the temple pieces of the spectacles. However, the combination of glasses and hearing aids was inflexible: the range of frame styles was limited, and the user had to wear both hearing aids and glasses at once or wear neither. Today, people who use both glasses and hearing aids can use in-the-ear types, or rest a BTE neatly alongside the arm of the glasses. There still are some specialized situations where hearing aids built into the frame of eyeglasses can be useful, such as when a person has hearing loss mainly in one ear: sound from a microphone on the "bad" side can be sent through the frame to the side with better hearing.

This can also be achieved by using CROS or bi-CROS style hearing aids, which are now wireless in sending sound to the better side.

Recently, a new type of eyeglass aid was introduced. These 'hearing glasses' feature directional sensitivity: four microphones on each side of the frame effectively work as two directional microphones, which are able to discern between sound coming from the front and sound coming from the sides or back of the user. This improves the Signal-to-noise ratio by allowing for amplification of the sound coming from the front, the direction in which the user is looking, and active noise control for sounds coming from the sides or back. Only very recently has the technology required become small enough, in size, to be put in the frame of the glasses. As a recent addition to the market, this new hearing aid is currently available only in the Netherlands and Belgium.

## ***Hearing aid technology***

### **Wireless hearing aids**

Recent hearing aids include wireless hearing aids. One hearing aid can transmit to the other side so that pressing one aid's program button simultaneously changes the other aid and both aids change background settings simultaneously. FM listening systems are now emerging with wireless receivers integrated with the use of hearing aids. A separate wireless microphone can be given to a partner to wear in a restaurant, in the car, during leisure time, in the shopping mall, at lectures, or during religious services. The voice is transmitted wirelessly to the hearing aids eliminating the effects of distance and background noise. FM systems have shown to give the best speech understanding in noise of all available technologies. FM systems can also be hooked up to a TV or a stereo.



Phonak wireless FM system



ReSound Alera Hearing Aid



ReSound Alera Unite Wireless Accessories

In developed countries FM systems are considered a cornerstone in the treatment of hearing loss in children. More and more adults discover the benefits of wireless FM systems as well, especially since transmitters with different microphone settings and Bluetooth for wireless cell phone communication have become available.

Many theatres and lecture halls are now equipped with assistive listening systems that transmit the sound directly from the stage; audience members can borrow suitable receivers and hear the program without background noise. In some theatres and churches FM transmitters are available that work with the personal FM receivers of hearing instruments.

## **Directional microphones**

Most older hearing aids have only an omnidirectional microphone. An omnidirectional microphone amplifies sounds equally from all directions. In contrast, a directional microphone amplifies sounds from in front more than sounds from other directions. This means that sounds originating from the direction the listener is facing are amplified more than sounds from behind or in other directions. If the speech is in front of the listener and the noise is from a different direction, then compared to an omnidirectional microphone, a directional microphone provides a better signal to noise ratio. Improving the signal to noise ratio improves speech understanding in noise. Directional microphones are the second best method to improve the signal to noise ratio (the best method is an FM system).

Many hearing aids now have both an omnidirectional and a directional microphone. This is because speech often comes from directions other than in front of the listener. Usually, the omnidirectional microphone mode is used in quiet listening situations (e.g. living room) whereas the directional microphone is used in noisy listening situations (e.g. restaurant). The microphone mode is typically selected by using a switch. Some hearing aids automatically switch the microphone mode.

Adaptive directional microphones vary the direction of maximum amplification. The direction of amplification is varied by the hearing aid processor. The processor attempts to provide maximum amplification in the direction of the speech signal. Unless the user manually temporarily switches to a "restaurant program, forward only mode" adaptive directional microphones have a disadvantage of amplifying speech of other talkers in a restaurant. This makes it difficult for the processor to select the desired speech signal. Another disadvantage is that noise often mimics speech characteristics, making it difficult to separate the speech from the noise. Despite the disadvantages, adaptive directional microphones can provide improved speech recognition in noise

Directional microphones work best when the distance to the talker is small. In contrast, an FM system continues to provide a better signal to noise ratio even at larger speaker to talker distances.

## **Telecoil**

Telecoils (T-coils), sometimes referred to as "Telephone Coils", allow audio sources to be directly connected to a hearing aid, which is intended to help the wearer filter out background noise. They can be used with telephones, FM systems (with neck loops), and induction loop systems (also called "hearing loops") that transmit sound to hearing aids from public address systems and TVs. In the UK and the Nordic countries, hearing loops are widely used in churches, shops, railway stations, and other public places. In the U.S.A., telecoils and hearing loops are gradually becoming more common. According to a Hearing Review 2008 survey of hearing professionals: "Respondents said that 62% of their fittings included a telecoil, [an] increase . . . from 37% in 2001."

A T-coil consists of a metal core (or rod) around which ultra-fine wire is coiled. T-coils are also called induction coils because when the coil is placed in a magnetic field, an alternating electrical current is induced in the wire (Ross, 2002b; Ross, 2004). The T-coil detects magnetic energy and transduces(or converts) it to electrical energy.

Although T-coils are effectively a wide-band receiver, interference is unusual in most hearing loop situations. Interference can manifest as a buzzing sound, which varies in volume depending on the distance the wearer is from the source. Sources are electromagnetic fields, such as CRT computer monitors, older fluorescent lighting, some dimmer switchers, and airplanes.

The states of Florida and Arizona have passed legislation that requires hearing professionals to inform patients about the usefulness of telecoils.

### **Legislation affecting use**

In the United States, the Hearing Aid Compatibility Act of 1988 (HAC Act) requires that the Federal Communications Commission (FCC) ensure that all telephones manufactured or imported for use in the United States after August 1989, and all "essential" telephones, are hearing aid-compatible (through the use of a telecoil).

"Essential" phones are defined as "coin-operated telephones, telephones provided for emergency use, and other telephones frequently needed for use by persons using such hearing aids." These might include workplace telephones, telephones in confined settings (like hospitals and nursing homes), and telephones in hotel and motel rooms. Secure telephones, as well as telephones used with public mobile and private radio services, are exempt from the HAC Act. "Secure" phones are defined as "telephones that are approved by the U.S. Government for the transmission of classified or sensitive voice communications."

In 2003, the FCC adopted rules to make digital wireless telephones compatible with hearing aids and cochlear implants. Although analog wireless phones do not usually cause interference with hearing aids or cochlear implants, digital wireless phones often do because of electromagnetic energy emitted by the phone's antenna, backlight, or other components. The FCC has set a timetable for the development and sale of digital wireless telephones that are compatible with hearing aids. This effort promises to increase the number of digital wireless telephones that are hearing aid-compatible.

## DAI



A DAI plug on the end of a cable

Direct Audio Input (DAI) allows the hearing aid to be directly connected to an external audio source like a CD player or an assistive listening device (ALD). By its very nature, DAI is susceptible to far less electromagnetic interference, and yields a better quality audio signal as opposed to using a T-coil with standard headphones.

## Processing

Every electronic hearing aid has at minimum a microphone, a loudspeaker (commonly called a receiver), a battery, and electronic circuitry. The electronic circuitry varies among devices, even if they are the same style. The circuitry falls into three categories based on the type of audio processing (Analog or Digital) and the type of control circuitry (Adjustable or Programmable).

- **Analog audio/Adjustable control:** The audio circuit is analog with electronic components that can be adjusted. The hearing professional determines the gain and other specifications required for the wearer, and then adjusts the analog components either with small controls on the hearing aid itself or by having a laboratory build the hearing aid to meet those specifications. After the adjustment the resulting the audio does not change any further, other than overall loudness

- that the wearer adjusts with a volume control. This type of circuitry is generally the least flexible. The first practical electronic hearing aid with adjustable analog audio circuitry was based on US Patent 2,017,358, "Hearing Aid Apparatus and Amplifier" by Samuel Gordon Taylor, filed in 1932.
- Analog audio/Programmable control: The audio circuit is analog but with additional electronic control circuitry that can be programmed, sometimes with more than one program. The electronic control circuitry can be fixed during manufacturing or in some cases, the hearing professional can use an external computer temporarily connected to the hearing aid to program the additional control circuitry. The wearer can change the program for different listening environments by pressing buttons either on the device itself or on a remote control or in some cases the additional control circuitry operates automatically. This type of circuitry is generally more flexible than simple adjustable controls. The first hearing aid with analog audio circuitry and automatic digital electronic control circuitry was based on US Patent 4,025,721, "Method of and means for adaptively filtering near-stationary noise from speech" by D Graupe, GD Causey, filed in 1975. This digital electronic control circuitry was used to identify and automatically reduce noise in individual frequency channels of the analog audio circuits and was known as the Zeta Noise Blocker.
  - Digital audio/Programmable control: Both the audio circuit and the additional control circuits are fully digital. The hearing professional programs the hearing aid with an external computer temporarily connected to the device and can adjust all processing characteristics on an individual basis. Fully digital circuitry allows implementation of many additional features not possible with analog circuitry, can be used in all styles of hearing aids and is the most flexible. Fully digital hearing aids can be programmed with multiple programs that can be invoked by the wearer, or that operate automatically and adaptively. These programs reduce acoustic feedback (whistling), reduce background noise, detect and automatically accommodate different listening environments (loud vs soft, speech vs music, quiet vs noisy, etc.), control additional components such as multiple microphones to improve spatial hearing, transpose frequencies (shift high frequencies that a wearer may not hear to lower frequency regions where hearing may be better), and implement many other features. Fully digital circuitry also allows control over wireless transmission capability for both the audio and the control circuitry. Control signals in a hearing aid on one ear can be sent wirelessly to the control circuitry in the hearing aid on the opposite ear to ensure that the audio in both ears is either matched directly or that the audio contains intentional differences that mimic the differences in normal binaural hearing to preserve spatial hearing ability. Audio signals can be sent wirelessly to and from external devices through a separate module, often a small device worn like a pendant and commonly called a "streamer", that allows wireless connection to yet other external devices. This capability allows optimal use of mobile telephones, personal music players, remote microphones and other devices. With the addition of speech recognition and internet capability in the mobile phone, the wearer has optimal communication ability in many more situations than with hearing aids alone. This growing list includes voice activated dialing, voice activated software applications

either on the phone or on the internet, receipt of audio signals from databases on the phone or on internet, or audio signals from television sets or from global positioning systems. The first practical, wearable, fully digital hearing aid was invented by Maynard Egebretson, Robert E Morley, Jr. and Gerald R Popelka. Their work resulted in US Patent 4,548,082, "Hearing aids, signal supplying apparatus, systems for compensating hearing deficiencies, and methods" by A Maynard Egebretson, Robert E Morley, Jr. and Gerald R Popelka, filed in 1984. This patent formed the basis of all subsequent fully digital hearing aids from all manufacturers, including those produced currently.

## ***Indications***

Hearing aids are incapable of truly correcting a hearing loss; they are an *aid* to make sounds more accessible. Two primary issues minimize the effectiveness of hearing aids:

- When the primary auditory cortex does not receive regular stimulation, this part of the brain loses cells which process sound. Cell loss increases as the degree of hearing loss increases.
- Damage to the hair cells of the inner ear results in sensorineural hearing loss, which affects the ability to discriminate between sounds. This often manifests as a decreased ability to understand speech, and simply amplifying speech (as a hearing aid does) is often insufficient to improve speech perception.

## ***Adjustment to hearing aids***

- The occlusion effect is a common complaint, especially for new users. Though if the aids are worn regularly, most people will become acclimated after a few months. If the effect persists, an audiologist can sometimes further tune the hearing aid(s).
- The initial fitting appointment is rarely sufficient, and multiple follow-up visits are often necessary. Most audiologists will recommend an up to date audiogram at the time of purchase and at subsequent fittings.

## ***Regulation***

### **Ireland**

Like much of the Irish health care system, hearing aid provision is a hodge-podge of public and private.

Hearing aids are provided by the State to children, OAPs and to people whose income is at or below that of the State Pension. The Irish State hearing aid provision is extremely poor; people often have to wait for two years for an appointment.

It is estimated, that the total cost to the State, of supplying one hearing aid, exceeds €2,000.

Hearing aids are also available privately, and there is grant assistance available for insured workers.

Irish taxpayers can also claim tax relief, at the standard rate, as hearing aids are recognised as a medical device.

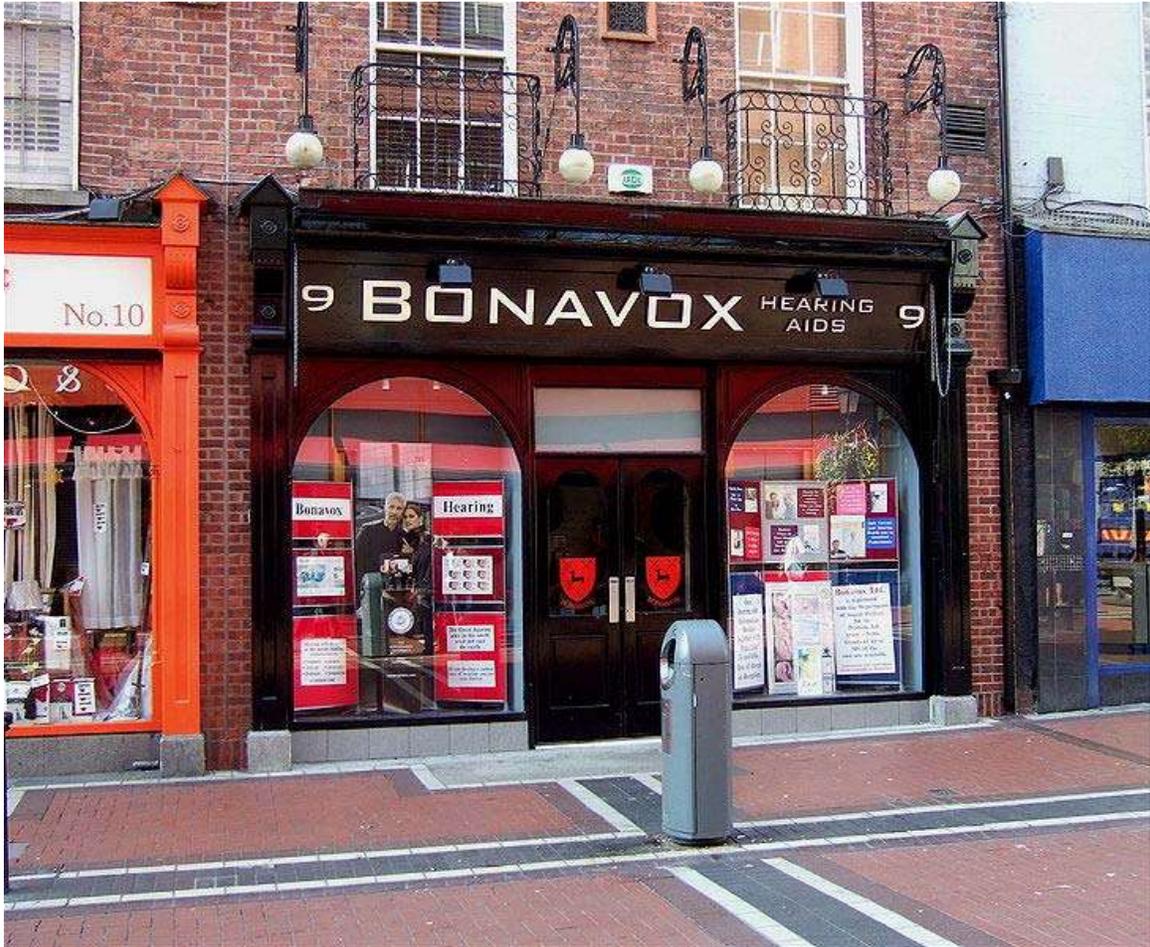
Hearing aids in the Republic of Ireland are exempt from VAT.

Hearing aid providers in Ireland, mostly belong to the Irish Society of Hearing Aid Audiologists.

## **United States**

Ordinary hearing aids are Class I regulated medical devices under Federal Food and Drug Administration (FDA) rules. A 1976 statute explicitly prohibits any state requirement that is "different from, or in addition to, any requirement applicable" to regulated medical devices (which includes hearing aids) which relates "to the safety and effectiveness of the device." Inconsistent state regulation is preempted under the federal law. In the late 1970s, the FDA established federal rules governing hearing aid sales, and addressed various requests by state authorities for exemptions from federal preemption, granting some and denying others.

## **Purchase costs**



Bonavox hearing aid shop, Dublin, Ireland

Several industrialized countries supply free or heavily-discounted hearing aids through their publicly funded health care system.

### **Australia**

The Australian Department of Health and Ageing provides eligible Australian citizens and residents with a basic hearing aid free-of-charge, though recipients can pay a "top up" charge if they wish to upgrade to a hearing aid with more or better features. Maintenance of these hearing aids and a regular supply of batteries is also provided, on payment of a small annual maintenance fee.

### **Canada**

In Canada, health care is a responsibility of the provinces. In the province of Ontario, the price of hearing aids is partially reimbursed through the Assistive Devices Program of the Ministry of Health and Long-Term Care, up to \$500 for each hearing aid, every three

years. Like eye appointments, audiological appointments are no longer covered through the provincial public health plan. Audiometric testing can still easily be obtained, often free of charge, in private sector hearing aid clinics and some ear, nose and throat doctors offices. Hearing aids are often covered to some extent by private insurance or in some cases through government programs such as Department of Veteran Affairs or Workplace Safety & Insurance Board.

## **Iceland**

Social Insurance pays a one time fee of ISK 30,000 for any kind of hearing aid. However, the rules are complicated and require that both ears have a significant hearing loss in order to qualify for reimbursement. BTE hearing aids range from ISK 60,000 ISK to 300,000 ISK.

## **UK**

Within the UK, the NHS provides BTE hearing aids to NHS patients, on long-term loan, free of charge. BTEs are often the only style available, and private purchases may be necessary if a user desires a different style. Batteries are free. Private purchases can cost between £600 to £3,500.

## **US**

Most private US health care providers do not provide coverage for hearing aids, so all costs are usually borne by the recipient. The cost for a single hearing aid can vary between \$500 to \$6,000 or more, depending on the level of technology and whether the clinician bundles fitting fees into the cost of the hearing aid. Though if an adult has a hearing loss which substantially limits major life activities, some state-run vocational rehabilitation programs can provide upwards of full financial assistance. Severe and profound hearing loss often falls within the "substantially limiting" category. Less expensive hearing aids can be found on the internet or mail order catalogs but many of these are poorly made sound amplifiers that do not amplify sounds associated with the human voice.

The cost of hearing aids is a tax-deductible medical expense for those who itemize medical deductions.

### ***Hearing aid batteries***

While there are some rare instances that a hearing aid uses a rechargeable battery or a long-life disposable battery, the majority of modern hearing aids use one of five standard Button Cell Zinc-air batteries. (Older hearing aids often used mercury battery cells, but these cells have become banned in most countries today.) Modern hearing aid button cell types are typically referred to by their common number name or the color of their packaging.

They are typically loaded into the hearing aid via a rotating battery door, with the flat side (case) as the positive terminal (cathode) and the rounded side as the negative terminal (anode).

These batteries all operate at 1.35 up to 1.45Volts.

The type of battery a specific hearing aid utilizes depends on the physical size allowable and the desired lifetime of the battery, which is in turn determined by the power draw of the hearing aid device. Typical battery lifetimes run between 1 and 14 days (assuming 16 hour days).

WWT

## Chapter- 7

# Screen Reader

A **screen reader** is a software application that attempts to identify and interpret what is being displayed on the screen (or, more accurately, sent to standard output, whether a video monitor is present or not). This interpretation is then re-presented to the user with text-to-speech, sound icons, or a Braille output device. Screen readers are a form of assistive technology (AT) potentially useful to people who are blind, visually impaired, illiterate or learning disabled, often in combination with other AT, such as screen magnifiers.

A person's choice of screen reader is dictated by many factors, including platform, cost (even to upgrade a screen reader can cost hundreds of U.S. dollars), and the role of organizations like charities, schools, and employers. Screen reader choice is contentious: differing priorities and strong preferences are common.

Microsoft Windows operating systems have included the Microsoft Narrator light-duty screen reader since Windows 2000. Apple Inc. Mac OS X includes VoiceOver, a feature-rich screen reader. The console-based Orinux Linux distribution ships with three screen-reading environments: Emacspeak, Yasr and Speakup. The open source GNOME desktop environment long included Gnopernicus and now includes Orca.

There are also open source screen readers, such as the Linux Screen Reader for GNOME and NonVisual Desktop Access for Windows.

The most widely used screen readers are separate commercial products: JAWS from Freedom Scientific, Window-Eyes from GW Micro, System Access from Serotek, and ZoomText Magnifier/Reader from Ai Squared are prominent examples in the English-speaking market.

### ***Types of screen reader***

#### **CLI (text) screen readers**

In early operating systems, such as MS-DOS, which employed command line interfaces (CLIs), the screen display consisted of characters mapping directly to a screen buffer in memory and a cursor position. Input was by keyboard. All this information could therefore all be obtained from the system either by hooking the flow of information

around the system and reading the screen buffer or by using a standard hardware output socket and communicating the results to the user. This was relatively easy to engineer.

In the 1980s, the Research Centre for the Education of the Visually Handicapped (RCEVH) at the University of Birmingham developed Screen Reader for the BBC Micro and NEC Portable.

## **GUI screen readers**

### **Off-screen models**

With the arrival of graphical user interfaces (GUIs), the situation became more complicated. A GUI has characters and graphics drawn on the screen at particular positions, and as such there is no purely textual representation of the graphical contents of the display. Screen readers were therefore forced to employ new low-level techniques, gathering messages from the operating system and using these to build up an "off-screen model", a representation of the display in which the required text content is stored.

For example, the operating system might send messages to draw a command button and its caption. These messages are intercepted and used to construct the off-screen model. The user can switch between controls (such as buttons) available on the screen and the captions and control contents will be read aloud and/or shown on refreshable Braille display.

Screen readers can also communicate information on menus, controls, and other visual constructs to permit blind users to interact with these constructs. However, maintaining an off-screen model is a significant technical challenge: hooking the low-level messages and maintaining an accurate model are both difficult tasks.

### **Accessibility APIs**

Operating system and application designers have attempted to address these problems by providing ways for screen readers to access the display contents without having to maintain an off-screen model. These involve the provision of alternative and accessible representations of what is being displayed on the screen accessed through an API.

Existing APIs include:

- Apple Accessibility API
- AT-SPI
- IAccessible2,
- Microsoft Active Accessibility (MSAA)
- Microsoft UI Automation
- Java Access Bridge

Screen readers can query the operating system or application for what is currently being displayed and receive updates when the display changes. For example, a screen reader

can be told that the current focus is on a button and the button caption to be communicated to the user. This approach is considerably easier for screen readers, but fails when applications do not comply with the accessibility API: for example, Microsoft Word does not comply with the MSAA API, so screen readers must still maintain an off-screen model for Word or find another way to access its contents. One approach is to use available operating system messages and application object models to supplement accessibility APIs: the Thunder screenreader operates without an off-screen model in this way. (Note: the latest version of Thunder also includes an off-screen model but has one that does not involve installing a device driver. Consequently it can be used on a memory stick without any files needing to be installed.)

Screen readers can be assumed to be able to access all display content that is not intrinsically inaccessible. Web browsers, word processors, icons and windows and email programs are just some of the applications used successfully by screen reader users. However, using a screen reader is, according to some users, considerably more difficult than using a GUI and many applications have specific problems resulting from the nature of the application (e.g. animations in Macromedia Flash) or failure to comply with accessibility standards for the platform (e.g. Microsoft Word and Active Accessibility).

### **Self-voicing applications**

Some programs speak or make other sounds so that they can be used by blind people or people who cannot see the screen. These programs are termed self-voicing and can be a form of assistive technology if they are designed to remove the need to use a screen reader.

### **Web-based screen readers**

A relatively new development in the field is web-based applications like Spoken-Web that is web portal, managing content like news updates, weather, science and business articles for visually impaired or blind computer users. Or BrowseAloud that adds text-to-speech functionality to web content. The primary audience for such applications is those who have difficulty reading because of learning disabilities or language barriers. Although functionality remains limited compared to equivalent desktop applications, the major benefit is to increase the accessibility of said websites when viewed on public machines where users do not have permission to install custom software, giving people greater 'freedom to roam'.

### ***Screen reader customization***

Not only do screen readers differ widely from each other, but most are highly configurable. For example, most screen readers allow the user to select whether most punctuation is announced or silently ignored. Some screen readers can be tailored to a particular application through scripting. One advantage of scripting is that it allows customizations to be shared among users, increasing accessibility for all. JAWS enjoys an active script-sharing community, for example.

## **Emulators**

- Fangs screen reader emulator - An open source Mozilla Firefox extension that simulates how a web page would look in JAWS.

## **Verbosity**

Verbosity is a term used to describe a feature of screen reading software that support vision-impaired computer users. **Speech verbosity** controls enable users to choose how much speech feedback they wish to hear. Specifically, verbosity settings allow users to construct a mental model of web pages displayed on their computer screen. Based on verbosity settings, a screen-reading program informs users of certain formatting changes, such as when a frame or table begins and ends, where graphics have been inserted into the text, or when a list appears in the document.

Some screen reading programs also include **language verbosity**, which automatically detects verbosity settings related to speech output language. For example, if a user navigated to a website based in the United Kingdom, the text would be read with a British accent.

## **Language**

Some screen readers can read text in more than one language, providing that the language of the material is encoded in its metadata. Some screen reading programs also include language verbosity, which automatically detects verbosity settings related to speech output language. For example, if a user navigated to a website based in the United Kingdom, the text would be read with an English accent.

## **Screen magnifier**

A **screen magnifier** is software that interfaces with a computer's graphical output to present enlarged screen content. It is a type of assistive technology suitable for visually impaired people with some functional vision; visually impaired people with little or no functional vision usually use a screen reader.

The simplest form of magnification presents an enlarged portion of the original screen content, the **focus**, so that it covers some or all of the full screen. This enlarged portion should include the content of interest to the user and the pointer or cursor, also suitably enlarged. As the user moves the pointer or cursor the screen magnifier should track with it and show the new enlarged portion. If this tracking is jerky or flickers it is likely to disturb the user. Also, the pointer or cursor may not be the content of interest: for example, if the user presses a keyboard shortcut that opens a menu, the magnified portion should jump to that menu. Pop-up windows and changes in system status can also trigger this rapid shifting.

Screen magnifier can be especially helpful for people suffering from low vision, for example, many elderly users. However, Hanson points out that people with low vision often also suffer from additional disabilities such as tremors. Pramudianto et al. compared different magnification techniques to use a Wii controller as a magnifier for distant displays. They determined that users have a lower error rate for selecting small targets if using one of the tested magnification techniques.

## ***Features***

Ranges of 1- to 16-times magnification are common. The greater the magnification the smaller the proportion of the original screen content that can be viewed, so users will tend to use the lowest magnification they can manage.

Screen magnifiers commonly provide several other features for people with particular sight difficulties:

- **Color Inversion.** Many people with visual impairments prefer to invert the colors, typically turning text from black-on-white to white-on-black. This can reduce screen glare and is useful for elderly people suffering from age-related macular degeneration.
- **Smoothing** Text can become blocky and harder to recognise when enlarged. Some screen magnifiers anti-alias or smooth text to compensate.
- **Cursor customisation.** The mouse and text cursors can often be modified in several ways, such as circling it to help the user locate it on the screen.
- **Different Magnification Modes** Screen magnifiers can alter how they present the enlarged portion: covering the full screen, providing a lens that is moved around the un-magnified screen, or using a fixed magnified portion.
- **Screen reader.** Some magnifiers come packaged with a basic screen reader, allowing whatever the user is pointing at to be read out.

## ***Screen magnifiers bundled with the OS***

- A basic Magnifier application has been included within the Microsoft Windows operating system since Windows 98.
- On Mac OS X, the built-in screen magnification feature can be used at any time holding the Control key and scrolling the mouse wheel to zoom in or zoom out.
- Many Linux Operating systems utilize a program called Compiz-Fusion which has a highly configurable plugin named "Enhanced Zoom Desktop"
- Haiku includes an application called Magnify

## Chapter- 8

# Speech Synthesis



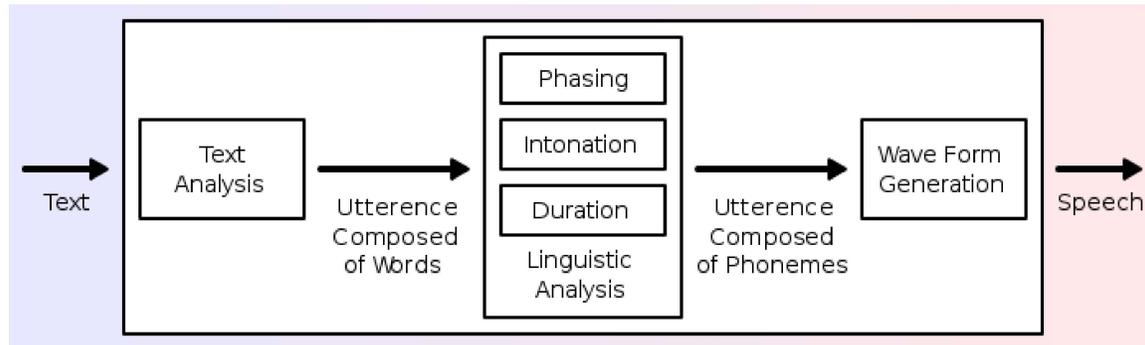
Stephen Hawking is one of the most famous people using speech synthesis to communicate

**Speech synthesis** is the artificial production of human speech. A computer system used for this purpose is called a **speech synthesizer**, and can be implemented in software or hardware. A **text-to-speech (TTS)** system converts normal language text into speech; other systems render symbolic linguistic representations like phonetic transcriptions into speech.

Synthesized speech can be created by concatenating pieces of recorded speech that are stored in a database. Systems differ in the size of the stored speech units; a system that stores phones or diphones provides the largest output range, but may lack clarity. For specific usage domains, the storage of entire words or sentences allows for high-quality output. Alternatively, a synthesizer can incorporate a model of the vocal tract and other human voice characteristics to create a completely "synthetic" voice output.

The quality of a speech synthesizer is judged by its similarity to the human voice and by its ability to be understood. An intelligible text-to-speech program allows people with visual impairments or reading disabilities to listen to written works on a home computer. Many computer operating systems have included speech synthesizers since the early 1980s.

### Overview of text processing



Overview of a typical TTS system

A text-to-speech system (or "engine") is composed of two parts: a front-end and a back-end. The front-end has two major tasks. First, it converts raw text containing symbols like numbers and abbreviations into the equivalent of written-out words. This process is often called *text normalization*, *pre-processing*, or *tokenization*. The front-end then assigns phonetic transcriptions to each word, and divides and marks the text into prosodic units, like phrases, clauses, and sentences. The process of assigning phonetic transcriptions to words is called *text-to-phoneme* or *grapheme-to-phoneme* conversion. Phonetic transcriptions and prosody information together make up the symbolic linguistic representation that is output by the front-end. The back-end—often referred to as the *synthesizer*—then converts the symbolic linguistic representation into sound. In certain systems, this part includes the computation of the *target prosody* (pitch contour, phoneme durations), which is then imposed on the output speech.

### History

Long before electronic signal processing was invented, there were those who tried to build machines to create human speech. Some early legends of the existence of "speaking heads" involved Gerbert of Aurillac (d. 1003 AD), Albertus Magnus (1198–1280), and Roger Bacon (1214–1294).

In 1779, the Danish scientist Christian Kratzenstein, working at the Russian Academy of Sciences, built models of the human vocal tract that could produce the five long vowel sounds (in International Phonetic Alphabet notation, they are [a], [e], [i], [o] and [u]). This was followed by the bellows-operated "acoustic-mechanical speech machine" by Wolfgang von Kempelen of Vienna, Austria, described in a 1791 paper. This machine added models of the tongue and lips, enabling it to produce consonants as well as vowels.

In 1837, Charles Wheatstone produced a "speaking machine" based on von Kempelen's design, and in 1857, M. Faber built the "Euphonia". Wheatstone's design was resurrected in 1923 by Paget.

In the 1930s, Bell Labs developed the VOCODER, a keyboard-operated electronic speech analyzer and synthesizer that was said to be clearly intelligible. Homer Dudley refined this device into the VODER, which he exhibited at the 1939 New York World's Fair.

The Pattern playback was built by Dr. Franklin S. Cooper and his colleagues at Haskins Laboratories in the late 1940s and completed in 1950. There were several different versions of this hardware device but only one currently survives. The machine converts pictures of the acoustic patterns of speech in the form of a spectrogram back into sound. Using this device, Alvin Liberman and colleagues were able to discover acoustic cues for the perception of phonetic segments (consonants and vowels).

Dominant systems in the 1980s and 1990s were the MITalk system, based largely on the work of Dennis Klatt at MIT, and the Bell Labs system; the latter was one of the first multilingual language-independent systems, making extensive use of Natural Language Processing methods.

Early electronic speech synthesizers sounded robotic and were often barely intelligible. The quality of synthesized speech has steadily improved, but output from contemporary speech synthesis systems is still clearly distinguishable from actual human speech.

As the cost-performance ratio causes speech synthesizers to become cheaper and more accessible to the people, more people will benefit from the use of text-to-speech programs.

## **Electronic devices**

The first computer-based speech synthesis systems were created in the late 1950s, and the first complete text-to-speech system was completed in 1968. In 1961, physicist John Larry Kelly, Jr and colleague Louis Gerstman used an IBM 704 computer to synthesize speech, an event among the most prominent in the history of Bell Labs. Kelly's voice recorder synthesizer (vocoder) recreated the song "Daisy Bell", with musical accompaniment from Max Mathews. Coincidentally, Arthur C. Clarke was visiting his friend and colleague John Pierce at the Bell Labs Murray Hill facility. Clarke was so impressed by the demonstration that he used it in the climactic scene of his screenplay for his novel *2001: A Space Odyssey*, where the HAL 9000 computer sings the same song as it is being put to sleep by astronaut Dave Bowman. Despite the success of purely electronic speech synthesis, research is still being conducted into mechanical speech synthesizers.

Handheld electronics featuring speech synthesis began emerging in the 1970s. One of the first was the Telesensory Systems Inc. (TSI) *Speech+* portable calculator for the blind in

1976. Other devices were produced primarily for educational purposes, such as Speak & Spell, produced by Texas Instruments in 1978. The first video game to feature speech synthesis was the 1980 shoot 'em up arcade game, *Stratovox*, from Sun Electronics. The first multi-player game using voice synthesis was *Milton* from Milton Bradley Company, which produced the device in 1980.

## ***Synthesizer technologies***

The most important qualities of a speech synthesis system are *naturalness* and *intelligibility*. Naturalness describes how closely the output sounds like human speech, while intelligibility is the ease with which the output is understood. The ideal speech synthesizer is both natural and intelligible. Speech synthesis systems usually try to maximize both characteristics.

The two primary technologies for generating synthetic speech waveforms are *concatenative synthesis* and *formant synthesis*. Each technology has strengths and weaknesses, and the intended uses of a synthesis system will typically determine which approach is used.

### **Concatenative synthesis**

Concatenative synthesis is based on the concatenation (or stringing together) of segments of recorded speech. Generally, concatenative synthesis produces the most natural-sounding synthesized speech. However, differences between natural variations in speech and the nature of the automated techniques for segmenting the waveforms sometimes result in audible glitches in the output. There are three main sub-types of concatenative synthesis.

#### **Unit selection synthesis**

Unit selection synthesis uses large databases of recorded speech. During database creation, each recorded utterance is segmented into some or all of the following: individual phones, diphones, half-phones, syllables, morphemes, words, phrases, and sentences. Typically, the division into segments is done using a specially modified speech recognizer set to a "forced alignment" mode with some manual correction afterward, using visual representations such as the waveform and spectrogram. An index of the units in the speech database is then created based on the segmentation and acoustic parameters like the fundamental frequency (pitch), duration, position in the syllable, and neighboring phones. At runtime, the desired target utterance is created by determining the best chain of candidate units from the database (unit selection). This process is typically achieved using a specially weighted decision tree.

Unit selection provides the greatest naturalness, because it applies only a small amount of digital signal processing (DSP) to the recorded speech. DSP often makes recorded speech sound less natural, although some systems use a small amount of signal processing at the point of concatenation to smooth the waveform. The output from the best unit-selection

systems is often indistinguishable from real human voices, especially in contexts for which the TTS system has been tuned. However, maximum naturalness typically require unit-selection speech databases to be very large, in some systems ranging into the gigabytes of recorded data, representing dozens of hours of speech. Also, unit selection algorithms have been known to select segments from a place that results in less than ideal synthesis (e.g. minor words become unclear) even when a better choice exists in the database.

### **Diphone synthesis**

Diphone synthesis uses a minimal speech database containing all the diphones (sound-to-sound transitions) occurring in a language. The number of diphones depends on the phonotactics of the language: for example, Spanish has about 800 diphones, and German about 2500. In diphone synthesis, only one example of each diphone is contained in the speech database. At runtime, the target prosody of a sentence is superimposed on these minimal units by means of digital signal processing techniques such as linear predictive coding, PSOLA or MBROLA. The quality of the resulting speech is generally worse than that of unit-selection systems, but more natural-sounding than the output of formant synthesizers. Diphone synthesis suffers from the sonic glitches of concatenative synthesis and the robotic-sounding nature of formant synthesis, and has few of the advantages of either approach other than small size. As such, its use in commercial applications is declining, although it continues to be used in research because there are a number of freely available software implementations.

### **Domain-specific synthesis**

Domain-specific synthesis concatenates prerecorded words and phrases to create complete utterances. It is used in applications where the variety of texts the system will output is limited to a particular domain, like transit schedule announcements or weather reports. The technology is very simple to implement, and has been in commercial use for a long time, in devices like talking clocks and calculators. The level of naturalness of these systems can be very high because the variety of sentence types is limited, and they closely match the prosody and intonation of the original recordings.

Because these systems are limited by the words and phrases in their databases, they are not general-purpose and can only synthesize the combinations of words and phrases with which they have been preprogrammed. The blending of words within naturally spoken language however can still cause problems unless the many variations are taken into account. For example, in non-rhotic dialects of English the "r" in words like "clear" is usually only pronounced when the following word has a vowel as its first letter. Likewise in French, many final consonants become no longer silent if followed by a word that begins with a vowel, an effect called liaison. This alternation cannot be reproduced by a simple word-concatenation system, which would require additional complexity to be context-sensitive.

## Formant synthesis

Formant synthesis does not use human speech samples at runtime. Instead, the synthesized speech output is created using additive synthesis and an acoustic model (physical modelling synthesis). Parameters such as fundamental frequency, voicing, and noise levels are varied over time to create a waveform of artificial speech. This method is sometimes called *rules-based synthesis*; however, many concatenative systems also have rules-based components. Many systems based on formant synthesis technology generate artificial, robotic-sounding speech that would never be mistaken for human speech. However, maximum naturalness is not always the goal of a speech synthesis system, and formant synthesis systems have advantages over concatenative systems. Formant-synthesized speech can be reliably intelligible, even at very high speeds, avoiding the acoustic glitches that commonly plague concatenative systems. High-speed synthesized speech is used by the visually impaired to quickly navigate computers using a screen reader. Formant synthesizers are usually smaller programs than concatenative systems because they do not have a database of speech samples. They can therefore be used in embedded systems, where memory and microprocessor power are especially limited. Because formant-based systems have complete control of all aspects of the output speech, a wide variety of prosodies and intonations can be output, conveying not just questions and statements, but a variety of emotions and tones of voice.

Examples of non-real-time but highly accurate intonation control in formant synthesis include the work done in the late 1970s for the Texas Instruments toy Speak & Spell, and in the early 1980s Sega arcade machines, and in many Atari, Inc. arcade games using the TMS5220 LPC Chips. Creating proper intonation for these projects was painstaking, and the results have yet to be matched by real-time text-to-speech interfaces.

## Articulatory synthesis

Articulatory synthesis refers to computational techniques for synthesizing speech based on models of the human vocal tract and the articulation processes occurring there. The first articulatory synthesizer regularly used for laboratory experiments was developed at Haskins Laboratories in the mid-1970s by Philip Rubin, Tom Baer, and Paul Mermelstein. This synthesizer, known as ASY, was based on vocal tract models developed at Bell Laboratories in the 1960s and 1970s by Paul Mermelstein, Cecil Coker, and colleagues.

Until recently, articulatory synthesis models have not been incorporated into commercial speech synthesis systems. A notable exception is the NeXT-based system originally developed and marketed by Trillium Sound Research, a spin-off company of the University of Calgary, where much of the original research was conducted. Following the demise of the various incarnations of NeXT (started by Steve Jobs in the late 1980s and merged with Apple Computer in 1997), the Trillium software was published under the GNU General Public License, with work continuing as gnuspeech. The system, first marketed in 1994, provides full articulatory-based text-to-speech conversion using a

waveguide or transmission-line analog of the human oral and nasal tracts controlled by Carré's "distinctive region model".

## **HMM-based synthesis**

HMM-based synthesis is a synthesis method based on hidden Markov models, also called Statistical Parametric Synthesis. In this system, the frequency spectrum (vocal tract), fundamental frequency (vocal source), and duration (prosody) of speech are modeled simultaneously by HMMs. Speech waveforms are generated from HMMs themselves based on the maximum likelihood criterion.

## **Sinewave synthesis**

Sinewave synthesis is a technique for synthesizing speech by replacing the formants (main bands of energy) with pure tone whistles.

## **Challenges**

### **Text normalization challenges**

The process of normalizing text is rarely straightforward. Texts are full of heteronyms, numbers, and abbreviations that all require expansion into a phonetic representation. There are many spellings in English which are pronounced differently based on context. For example, "My latest project is to learn how to better project my voice" contains two pronunciations of "project".

Most text-to-speech (TTS) systems do not generate semantic representations of their input texts, as processes for doing so are not reliable, well understood, or computationally effective. As a result, various heuristic techniques are used to guess the proper way to disambiguate homographs, like examining neighboring words and using statistics about frequency of occurrence.

Recently TTS systems have begun to use HMMs (discussed above) to generate "parts of speech" to aid in disambiguating homographs. This technique is quite successful for many cases such as whether "read" should be pronounced as "red" implying past tense, or as "reed" implying present tense. Typical error rates when using HMMs in this fashion are usually below five percent. These techniques also work well for most European languages, although access to required training corpora is frequently difficult in these languages.

Deciding how to convert numbers is another problem that TTS systems have to address. It is a simple programming challenge to convert a number into words (at least in English), like "1325" becoming "one thousand three hundred twenty-five." However, numbers occur in many different contexts; "1325" may also be read as "one three two five", "thirteen twenty-five" or "thirteen hundred and twenty five". A TTS system can often infer how to expand a number based on surrounding words, numbers, and punctuation,

and sometimes the system provides a way to specify the context if it is ambiguous. Roman numerals can also be read differently depending on context. For example "Henry VIII" reads as "Henry the Eighth", while "Chapter VIII" reads as "Chapter Eight".

Similarly, abbreviations can be ambiguous. For example, the abbreviation "in" for "inches" must be differentiated from the word "in", and the address "12 St John St." uses the same abbreviation for both "Saint" and "Street". TTS systems with intelligent front ends can make educated guesses about ambiguous abbreviations, while others provide the same result in all cases, resulting in nonsensical (and sometimes comical) outputs.

## **Text-to-phoneme challenges**

Speech synthesis systems use two basic approaches to determine the pronunciation of a word based on its spelling, a process which is often called text-to-phoneme or grapheme-to-phoneme conversion (phoneme is the term used by linguists to describe distinctive sounds in a language). The simplest approach to text-to-phoneme conversion is the dictionary-based approach, where a large dictionary containing all the words of a language and their correct pronunciations is stored by the program. Determining the correct pronunciation of each word is a matter of looking up each word in the dictionary and replacing the spelling with the pronunciation specified in the dictionary. The other approach is rule-based, in which pronunciation rules are applied to words to determine their pronunciations based on their spellings. This is similar to the "sounding out", or synthetic phonics, approach to learning reading.

Each approach has advantages and drawbacks. The dictionary-based approach is quick and accurate, but completely fails if it is given a word which is not in its dictionary. As dictionary size grows, so too does the memory space requirements of the synthesis system. On the other hand, the rule-based approach works on any input, but the complexity of the rules grows substantially as the system takes into account irregular spellings or pronunciations. (Consider that the word "of" is very common in English, yet is the only word in which the letter "f" is pronounced [v].) As a result, nearly all speech synthesis systems use a combination of these approaches.

Languages with a phonemic orthography have a very regular writing system, and the prediction of the pronunciation of words based on their spellings is quite successful. Speech synthesis systems for such languages often use the rule-based method extensively, resorting to dictionaries only for those few words, like foreign names and borrowings, whose pronunciations are not obvious from their spellings. On the other hand, speech synthesis systems for languages like English, which have extremely irregular spelling systems, are more likely to rely on dictionaries, and to use rule-based methods only for unusual words, or words that aren't in their dictionaries.

## **Evaluation challenges**

The consistent evaluation of speech synthesis systems may be difficult because of a lack of universally agreed objective evaluation criteria. Different organizations often use

different speech data. The quality of speech synthesis systems also depends to a large degree on the quality of the production technique (which may involve analogue or digital recording) and on the facilities used to replay the speech. Evaluating speech synthesis systems has therefore often been compromised by differences between production techniques and replay facilities.

Recently, however, some researchers have started to evaluate speech synthesis systems using a common speech dataset.

## **Prosodics and emotional content**

A recent study reported in the journal "**Speech Communication**" by Amy Drahota and colleagues at the University of Portsmouth, UK, reported that listeners to voice recordings could determine, at better than chance levels, whether or not the speaker was smiling. It was suggested that identification of the vocal features which signal emotional content may be used to help make synthesized speech sound more natural.

## **Dedicated hardware**

- Votrax
  - SC-01A (analog formant)
  - SC-02 / SSI-263 / "Artic 263"
- General Instruments SP0256-AL2 (CTS256A-AL2, MEA8000)
- Magnevation SpeakJet
- Savage Innovations SoundGin
- National Semiconductor DT1050 Digitaltalker (Mozer)
- Silicon Systems SSI 263 (analog formant)
- Texas Instruments LPC Speech Chips
  - TMS5110A
  - TMS5200
- Oki Semiconductor
  - ML22825 (ADPCM)
  - ML22573 (HQADPCM)
- Toshiba T6721A
- Philips PCF8200
- TextSpeak Embedded TTS Modules

## **Computer operating systems or outlets with speech synthesis**

### **Atari**

Arguably, the first speech system integrated into an operating system was the 1400XL/1450XL personal computers designed by Atari, Inc. using the Votrax SC01 chip in 1983. The 1400XL/1450XL computers used a Finite State Machine to enable World English Spelling text-to-speech synthesis. Unfortunately, the 1400XL/1450XL personal computers never shipped in quantity.

The Atari ST computers were sold with "stspeech.tos" on floppy disk.

## **Apple**

The first speech system integrated into an operating system that shipped in quantity was Apple Computer's MacInTalk in 1984. Since the 1980s Macintosh Computers offered text to speech capabilities through The MacinTalk software. In the early 1990s Apple expanded its capabilities offering system wide text-to-speech support. With the introduction of faster PowerPC-based computers they included higher quality voice sampling. Apple also introduced speech recognition into its systems which provided a fluid command set. More recently, Apple has added sample-based voices. Starting as a curiosity, the speech system of Apple Macintosh has evolved into a fully-supported program, PlainTalk, for people with vision problems. VoiceOver was for the first time featured in Mac OS X Tiger (10.4). During 10.4 (Tiger) & first releases of 10.5 (Leopard) there was only one standard voice shipping with Mac OS X. Starting with 10.6 (Snow Leopard), the user can choose out of a wide range list of multiple voices. VoiceOver voices feature the taking of realistic-sounding breaths between sentences, as well as improved clarity at high read rates over PlainTalk. Mac OS X also includes say, a command-line based application that converts text to audible speech. The AppleScript Standard Additions includes a say verb that allows a script to use any of the installed voices and to control the pitch, speaking rate and modulation of the spoken text.

## **AmigaOS**

The second operating system with advanced speech synthesis capabilities was AmigaOS, introduced in 1985. The voice synthesis was licensed by Commodore International from a third-party software house (Don't Ask Software, now Softvoice, Inc.) and it featured a complete system of voice emulation, with both male and female voices and "stress" indicator markers, made possible by advanced features of the Amiga hardware audio chipset. It was divided into a narrator device and a translator library. Amiga Speak Handler featured a text-to-speech translator. AmigaOS considered speech synthesis a virtual hardware device, so the user could even redirect console output to it. Some Amiga programs, such as word processors, made extensive use of the speech system.

## **Microsoft Windows**

Modern Windows systems use SAPI4- and SAPI5-based speech systems that include a speech recognition engine (SRE). SAPI 4.0 was available on Microsoft-based operating systems as a third-party add-on for systems like Windows 95 and Windows 98. Windows 2000 added a speech synthesis program called Narrator, directly available to users. All Windows-compatible programs could make use of speech synthesis features, available through menus once installed on the system. Microsoft Speech Server is a complete package for voice synthesis and recognition, for commercial applications such as call centers.

**Text-to-Speech** (TTS) capabilities for a computer refers to the ability to play back text in a spoken voice. TTS is the ability of the operating system to play back printed text as spoken words.

An internal (installed with the operating system) driver (called a TTS engine): recognizes the text and using a synthesized voice (chosen from several pre-generated voices) speaks the written text. Additional engines (often use a certain jargon or vocabulary) are also available through third-party manufacturers.

## **Android**

Version 1.6 of Android added support for speech synthesis (TTS).

## **Internet**

The most recent TTS development in the web browser, is the JavaScript Text to Speech work of Yury Delendik, which ports the Flite C engine to pure JavaScript. This allows web pages to convert text to audio using HTML5 technology. The ability to use Yury's TTS port currently requires a custom browser build that uses Mozilla's Audio-Data-API. However, much work is being done in the context of the W3C to move this technology into the mainstream browser market through the W3C Audio Incubator Group with the involvement of The BBC and Google Inc.

Currently, there are a number of applications, plugins and gadgets that can read messages directly from an e-mail client and web pages from a web browser or Google Toolbar such as Text-to-voice which is an add-on to Firefox. Some specialized software can narrate RSS-feeds. On one hand, online RSS-narrators simplify information delivery by allowing users to listen to their favourite news sources and to convert them to podcasts. On the other hand, on-line RSS-readers are available on almost any PC connected to the Internet. Users can download generated audio files to portable devices, e.g. with a help of podcast receiver, and listen to them while walking, jogging or commuting to work.

A growing field in internet based TTS is web-based assistive technology, e.g. 'Browsealoud' from a UK company and Readspeaker. It can deliver TTS functionality to anyone (for reasons of accessibility, convenience, entertainment or information) with access to a web browser. Additionally SPEAK.TO.ME from Oxford Information Laboratories is capable of delivering text to speech through any browser without the need to download any special applications, and includes smart delivery technology to ensure only what is seen is spoken and the content is logically pathed.

## **Others**

- Some e-book readers, such as the Amazon Kindle.
- Some models of Texas Instruments home computers produced in 1979 and 1981 (Texas Instruments TI-99/4 and TI-99/4A) were capable of text-to-phoneme synthesis or reciting complete words and phrases (text-to-dictionary), using a very

- popular Speech Synthesizer peripheral. TI used a proprietary codec to embed complete spoken phrases into applications, primarily video games.
- IBM's OS/2 Warp 4 included VoiceType, a precursor to IBM ViaVoice.
  - Systems that operate on free and open source software systems including Linux are various, and include open-source programs such as the Festival Speech Synthesis System which uses diphone-based synthesis (and can use a limited number of MBROLA voices), and gnspeech which uses articulatory synthesis from the Free Software Foundation.
  - Companies which developed speech synthesis systems but which are no longer in this business include BeST Speech (bought by L&H), Eloquent Technology (bought by SpeechWorks), Lernout & Hauspie (bought by Nuance), SpeechWorks (bought by Nuance), Rhetorical Systems (bought by Nuance).

## ***Speech synthesis markup languages***

A number of markup languages have been established for the rendition of text as speech in an XML-compliant format. The most recent is Speech Synthesis Markup Language (SSML), which became a W3C recommendation in 2004. Older speech synthesis markup languages include Java Speech Markup Language (JSML) and SABLE. Although each of these was proposed as a standard, none of them has been widely adopted.

Speech synthesis markup languages are distinguished from dialogue markup languages. VoiceXML, for example, includes tags related to speech recognition, dialogue management and touchtone dialing, in addition to text-to-speech markup.

## ***Applications***

Speech synthesis has long been a vital assistive technology tool and its application in this area is significant and widespread. It allows environmental barriers to be removed for people with a wide range of disabilities. The longest application has been in the use of screen readers for people with visual impairment, but text-to-speech systems are now commonly used by people with dyslexia and other reading difficulties as well as by pre-literate children. They are also frequently employed to aid those with severe speech impairment usually through a dedicated voice output communication aid.

Sites such as Ananova and YAKiToMe! have used speech synthesis to convert written news to audio content, which can be used for mobile applications.

Speech synthesis techniques are used as well in the entertainment productions such as games, animation and similar. In 2007, Animo Limited announced the development of a software application package based on its speech synthesis software FineSpeech, explicitly geared towards customers in the entertainment industries, able to generate narration and lines of dialogue according to user specifications. The application reached maturity in 2008, when NEC Biglobe announced a web service that allows users to create phrases from the voices of Code Geass: Lelouch of the Rebellion R2 characters.

TTS applications such as YAKiToMe! and Speakonia are often used to add synthetic voices to YouTube videos for comedic effect, as in Barney Bunch videos. YAKiToMe! is also used to convert entire books for personal podcasting purposes, RSS feeds and web pages for news stories, and educational texts for enhanced learning.

Software such as Vocaloid can generate singing voices via lyrics and melody. This is also the aim of the Singing Computer project (which uses GNU LilyPond and Festival) to help blind people check their lyric input.

Next to these applications is the use of text to speech software also popular in Interactive Voice Response systems, often in combination with speech recognition.

The image shows the letters 'WWT' in a large, bold, sans-serif font. The letters are light gray and are centered horizontally. The 'W' is composed of three vertical strokes, and the 'T' is a single vertical stroke with a horizontal top bar.

## Chapter- 9

# Braille

Braille	
Type	Alphabet (non-linear writing)
Spoken languages	Several
Creator	Louis Braille
Time period	1821 to the present Night writing
Parent systems	Braille
Unicode range	U+2800 to U+28FF



Braille code

The **Braille** system is a method that is widely used by blind people to read and write, and was the first digital form of writing.

Braille was devised in 1821 by Louis Braille, a blind Frenchman. Each Braille character, or *cell*, is made up of six dot positions, arranged in a rectangle containing two columns of three dots each. A dot may be raised at any of the six positions to form sixty-four ( $2^6$ ) possible subsets, including the arrangement in which no dots are raised. For reference purposes, a particular permutation may be described by naming the positions where dots are raised, the positions being universally numbered 1 to 3, from top to bottom, on the left, and 4 to 6, from top to bottom, on the right. For example, dots 1-3-4 (□) would describe a cell with three dots raised, at the top and bottom in the left column and on top of the right column, i.e., the letter *m*. The lines of horizontal Braille text are separated by a space, much like visible printed text, so that the dots of one line can be differentiated from the Braille text above and below. Punctuation is represented by its own unique set of characters.

## History

The Braille system was based on a method of communication originally developed by Charles Barbier in response to Napoleon's demand for a code that soldiers could use to communicate silently and without light at night called night writing. Barbier's system of sets of 12 embossed dots encoding each letter was too difficult for soldiers to perceive by touch, and was rejected by the military. In 1821 he visited the National Institute for the Blind in Paris, France, where he met Louis Braille. Braille identified the major failing of the code, which was that the human finger could not encompass the whole symbol without moving, and so could not move rapidly from one symbol to another. His modification was to use a 6 dot cell — the Braille system — which revolutionized written communication for the blind.

At first the system was a one-to-one transliteration of French, but soon various abbreviations and contractions were developed, creating a system much more like shorthand.

## Derivation

Braille is derived from the Latin alphabet, albeit indirectly. In Braille's original system, the points were assigned according to the position of the letter within the alphabetic order of the French alphabet, with diacritic letters sorted at the end.

The first ten letters of the alphabet, *A–J*, use the upper four dot positions, 1, 2, 4, 5. These also stand for the numerals *1–0* in a system parallel to Hebrew gematria and Greek isopsephy. (Though the dots are assigned in no obvious order, the first three letters and lowest numerals, *ABC ~ 123*, and the vowels, *AEI* have the fewest dots, whereas the even numerals *4680* are corners.)

The next ten letters, *K–T*, are identical to *A–J*, respectively, apart from the addition of a dot at position 3. The next ten letters are the same again, but with dots at both 3 and 6. Here *W* was left out as not being part of the basic alphabet; the order is *U V X Y Z Ç É À È Û*. The next ten, ending in *W*, are the same again, except that for this series only position 6 is used. These are *Â Ê Î Ò Û Ë Ì Ï Ö W*. The *A–J* series lowered in dot space become punctuation: comma, semicolon, colon, period, (not used), exclamation point, parentheses, question mark, (not used), quotation marks. *A* and *C*, which only use the top row, were lowered two spaces for the apostrophe and hyphen. In addition, a few letters used upper-space patterns which are not letters by themselves: 4 (by itself the acute accent for letters other than *É*) with 3, 3-6, and 6 makes *Ì, Ò*, decimal point; 4-5 with the same makes *Ä*, numeral sign, ellipsis

## Form

Braille can be seen as the world's first binary encoding scheme for representing the characters of a writing system. The system as originally invented by Braille consists of two parts:

1. A character encoding for mapping characters of the French language to tuples of six bits or *dots*.
2. A way of representing six-bit characters as raised dots in a Braille cell.

Today different Braille codes (or code pages) are used to map character sets of different languages to the six bit cells. Different Braille codes are also used for different uses like mathematics and music. However, because the six-dot Braille cell only offers 63 possible combinations ( $2^6 - 1 = 63$ ), of which some are omitted because they feel the same (having the same dots pattern in a different position, many Braille characters have different meanings based on their context. Therefore, character mapping is not one-to-one.

In addition to simple encoding, modern Braille transcription uses contractions to increase reading speed.

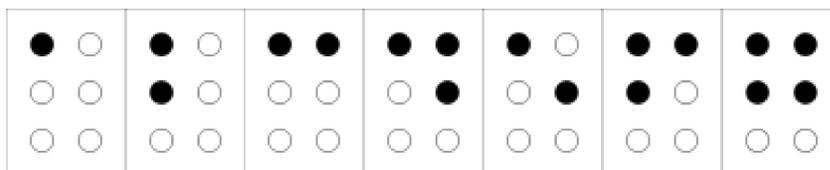
## Writing Braille

Braille may be produced using a *slate and stylus* in which each dot is created from the back of the page, writing in mirror image, by hand, or it may be produced on a Braille typewriter or *Perkins Brailier*, or produced by a Braille embosser attached to a computer. It may also be rendered using a refreshable Braille display.

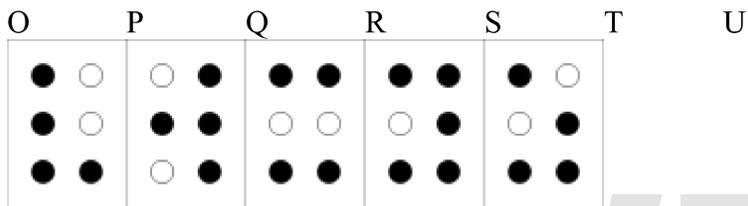
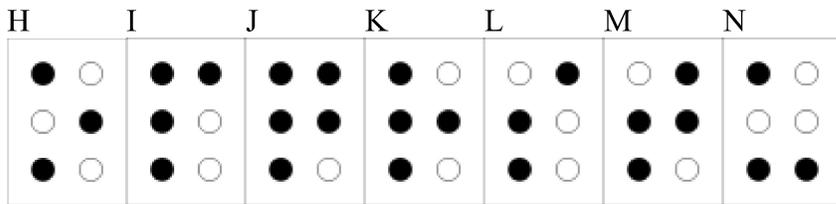
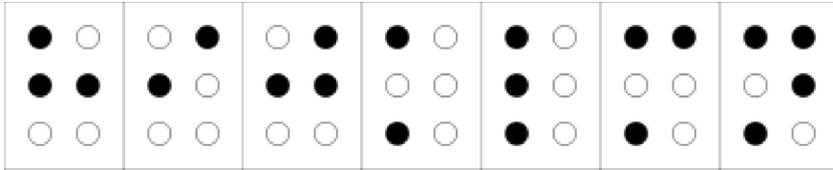
Braille has been extended to an 8-dot code, particularly for use with Braille embossers and refreshable Braille displays. In 8-dot Braille the additional dots are added at the bottom of the cell, giving a matrix 4 dots high by 2 dots wide. The additional dots are given the numbers 7 (for the lower-left dot) and 8 (for the lower-right dot). Eight-dot Braille has the advantages that the case of an individual letter is directly coded in the cell containing the letter and that all the printable ASCII characters can be represented in a single cell. All 256 ( $2^8$ ) possible combinations of 8 dots are encoded by the Unicode standard. Braille with six dots is frequently stored as Braille ASCII.

The first ten letters of the alphabet are formed using only the top four dots (1, 2, 4, and 5). Reminiscent of Greek numerals, these symbols also represent the digits 1 through 9 and 0 (preceded by the symbol [number follows]; [number follows]j also stands for 10, within context). Adding dot 3 forms the next ten letters, and adding dot 6 forms the last six letters (except w) and the words *and*, *for*, *of*, *the*, and *with*. Omitting dot 3 from the letters U-Z and the five word symbols form nine digraphs (ch, gh, sh, th, wh, ed, er, ou, and ow) and the letter w.

### Letters and numbers

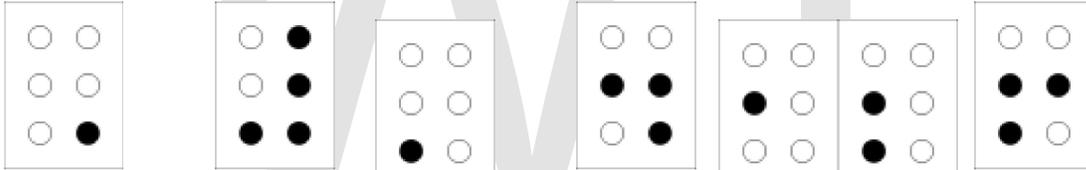


A      B      C      D      E      F      G

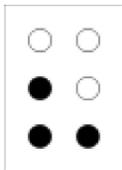


V W X Y Z

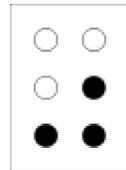
**Other symbols**



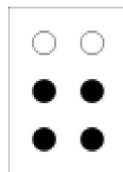
Capital letter follows



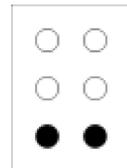
Number follows



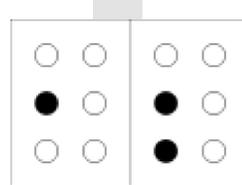
Apostrophe



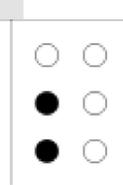
Full stop (Period)



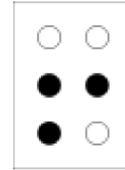
Comma



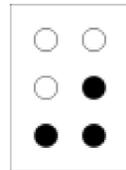
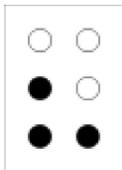
Semicolon



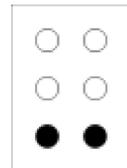
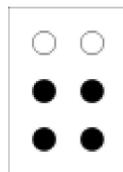
Exclamation point



Opening quotation mark, question mark \* Closing quotation mark \* mark



Bracket (Parentheses) \* Hyphen

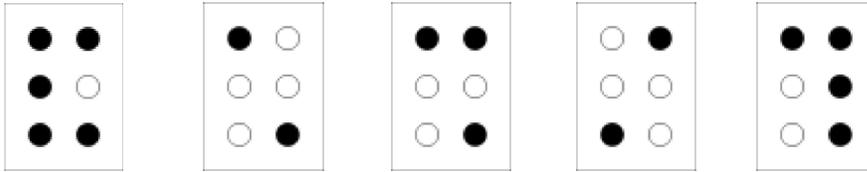


Note:

\* The question mark is represented by dots 2-3-6—the same as the opening quotation mark. Therefore the placement of the dots—before a word or after a word—will determine which symbol it is.

\* Opening and closing parentheses are shown with the same symbol. Therefore, the placement context will determine whether the parentheses is opening or closing.

## Grade 2 Braille contractions



The word ANDThe letters CHThe letters SHThe letters STThe letters TH

This is just a small sample of some of the contractions that are used in Grade 2 Braille. More information about Grade 2 Braille is below in the section on Braille transcription.

Braille also includes a number of whole word contractions, for example the word Braille becomes a three cell word brl.

## Unicode rendering table

The Unicode standard encodes 8-dot Braille glyphs according to their binary appearance, rather than following the alphabetic order of any particular convention. Unicode defines the "Braille Patterns" character block in the hex codepoint range from 2800 to 28FF. Dot 1 corresponds to the least significant bit of the low byte of the Unicode scalar value, and dot 8 to the high bit of that byte.

## Literacy

A sighted child who is reading at a basic level should be able to understand common words and answer simple questions about the information presented. He should also have enough fluency to get through the material in a timely manner. Over the course of a child's education, these foundations are built upon in order to teach higher levels of math, science, and comprehension skills. Children who are blind not only have the educational disadvantage of not being able to see, but they also miss out on the very fundamental parts of early and advanced education if not provided with the necessary tools.

## Braille literacy statistics

In 1960, 50% of legally blind, school-age children were able to read Braille in the U.S. According to the 2007 *Annual Report* from the American Printing House for the Blind, there are approximately 57,696 legally blind children in the U.S. Out of those school-age children, only 10% use Braille as their primary reading medium.

There are numerous causes for the decline in Braille usage, including school budget constraints, technology advancement, and different philosophical views over how blind children should be educated.

A key turning point for Braille literacy was the passage of the Rehabilitation Act of 1973, an act of Congress that moved thousands of children from specialized schools for the blind into mainstream public schools. Because only a small percentage of public schools could afford to train and hire Braille-qualified teachers, Braille literacy has declined since the law took effect. Braille literacy rates have improved slightly since the bill was passed, in part because of pressure from consumers and advocacy groups that has led 27 states to pass legislation mandating that children who are legally blind be given the opportunity to learn Braille.

In 1998-99 there were approximately 55,200 legally blind children, but only 5,500 of them used Braille as their primary reading medium. Early Braille education is crucial to literacy for a visually impaired child. A study conducted in the state of Washington found that people who learned Braille at an early age did just as well, if not better, than their sighted peers in several areas, including vocabulary and comprehension. In the preliminary adult study, while evaluating the correlation between adult literacy skills and employment, it was found that 44% of the participants who had learned to read in Braille were unemployed, compared to the 77% unemployment rate of those who had learned to read using print. Currently, among the estimated 85,000 blind adults in the United States, 90% of those who are Braille literate are employed. Among adults who do not know Braille, only 33% are employed. Statistically, history has proven that Braille reading proficiency provides an essential skill set that allows visually impaired children not only to compete with their sighted peers in a school environment, but also later in life as they enter the workforce.

Though Braille is thought to be the main way blind people read and write, in Britain (for example) out of the reported 2 million visually impaired population, it is estimated that only around 15-20 thousand people use Braille. Younger people are turning to electronic text on computers with screen reader software instead, a more portable communication method that they can also use with their friends. A debate has started on how to make Braille more attractive and for more teachers to be available to teach it.

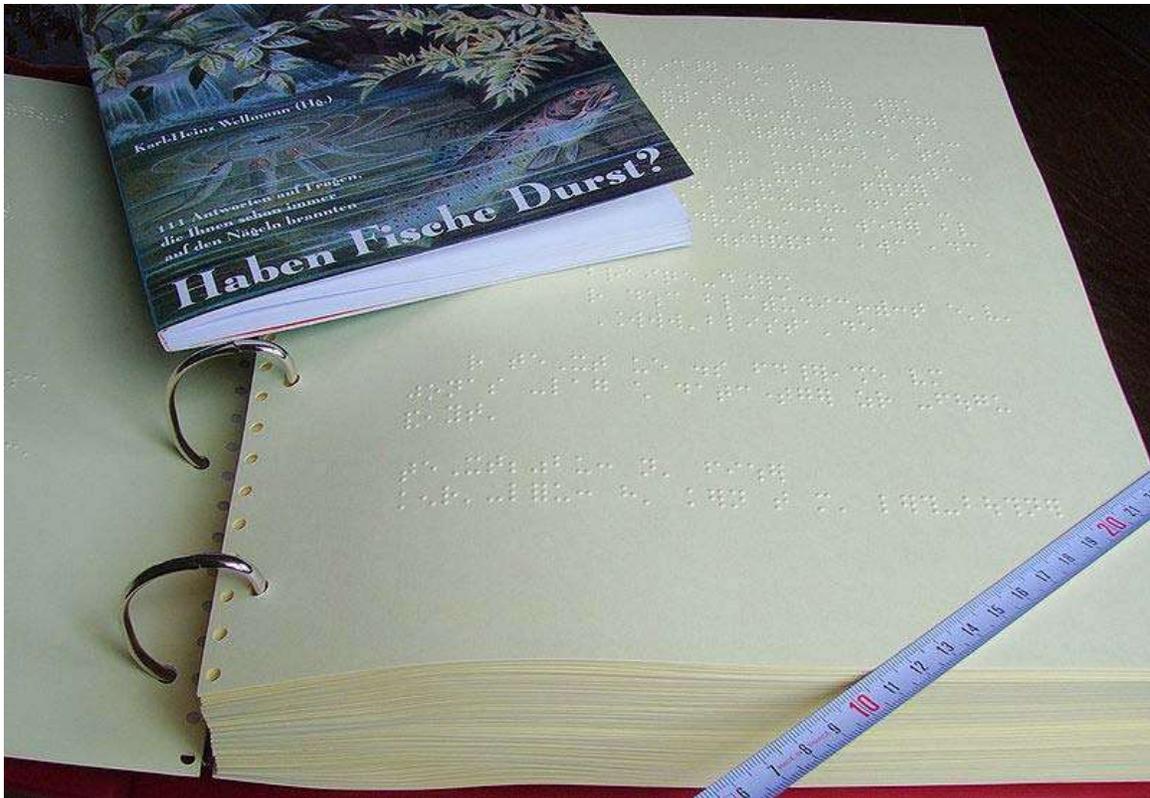
***Braille transcription***



Braille Writer



Braille on a box of tablets



Braille book and the same book in common letters

Although it is possible to transcribe Braille by simply substituting the equivalent Braille character for its printed equivalent, such a character-by-character transcription (known as *Grade 1 Braille*) is used only by beginners.

Braille characters are much larger than their printed equivalents, and the standard 11" by 11.5" (28 cm × 30 cm) page has room for only 25 lines of 43 characters. To reduce space and increase reading speed, virtually all Braille books are transcribed in what is known as *Grade 2 Braille*, which uses a system of contractions to reduce space and speed the process of reading. As with most human linguistic activities, Grade 2 Braille embodies a complex system of customs, styles, and practices. The Library of Congress's *Instruction Manual for Braille Transcribing* runs to nearly 200 pages. Braille transcription is skilled work, and Braille transcribers need to pass certification tests.

In English, the system of Grade 2 Braille contractions begins with a set of 23 words which are contracted to single characters. Thus the word *but* is contracted to the single letter *b*, *can* to *c*, *do* to *d*, and so on. Even this simple rule creates issues requiring special cases; for example, *d* is, specifically, an abbreviation of the verb *do*; the noun *do* representing the note of the musical scale is a different word, and must be spelled out.

Portions of words may be contracted, and many rules govern this process. For example, the character with dots 2-3-5 (the letter "f" lowered in the Braille cell) stands for "ff" when used in the middle of a word. At the beginning of a word, this same character

stands for the word "to" although the character is written in Braille with no space following it; this contraction was removed in the Unified English Braille Code. At the end of a word, the same character represents an exclamation point.

One problem that can occur when reading Grade 2 Braille is that some contractions are closely similar, even when the words are not. One example compares the contractions "ll", meaning little, and "lr", meaning letter from Barry Hampshire's "Working with Braille". The Braille notation for the letter "r" differs only by adding one dot to the letter "l". This causes greater confusion between words that are not as similar in normal print and can hinder the learning process of Grade 2 Braille.

The contraction rules take into account the linguistic structure of the word; thus, contractions are not to be used when their use would alter the usual Braille form of a base word to which a prefix or suffix has been added. And some portions of the transcription rules are not fully codified and rely on the judgment of the transcriber. Thus, when the contraction rules permit the same word in more than one way, preference is given to "the contraction that more nearly approximates correct pronunciation."

*Grade 3 Braille* is a system that includes many additional contractions, almost a shorthand; it is not used for publication, but is used mostly for individuals for their personal convenience.

### ***Braille reading techniques***

Since Braille is one of the few writing systems where tactile perception is used, as opposed to visual perception, a Braille reader must develop new skills. One skill important for Braille readers is the ability to create smooth and even pressures when running one's fingers along the words. There are many different styles and techniques used for the understanding and development of Braille, even though a study by B. F. Holland suggests that there is no specific technique that is superior to any other.

Another study by Lowenfield & Abel shows that Braille could be read "the fastest and best... by students who read using the index fingers of both hands." Another important reading skill emphasized in this study is to finish reading the end of a line with the right hand and to find the beginning of the next line with the left hand simultaneously. One final conclusion drawn by both Lowenfield and Abel is that children have difficulty using both hands independently where the right hand is the dominant hand. But this hand preference does not correlate to other activities.

## Braille for other scripts



Braille plate in *Duftrosengarten* in Rapperswil, Switzerland

There are many extensions of Braille for additional letters with diacritics, such as *ç, ô, é*.

When Braille is adapted to languages that do not use the Latin alphabet, the blocks are generally assigned to the new alphabet according to how it is transliterated into the Latin alphabet. The alphabetic order of the national script (and therefore the natural order of Latin Braille) is disregarded. Such is the case with Russian, Greek, Hebrew, Arabic, and Chinese. Greek, for example, *gamma* is written as Latin *g*, despite the fact that it has the alphabetic position of *c*; Hebrew *bet*, the second letter of the alphabet and cognate with the Latin letter *b*, is sometimes pronounced /b/ and sometimes /v/, and is written *b* or *v* accordingly; Russian *ts* is written as *c*, which is the usual letter for /ts/ in those Slavic languages that use the Latin alphabet; and Arabic *f* is written as *f*, despite being historically *p*, and occurring in that part of the Arabic alphabet (between historic *o* and *q*). Esperanto letters with circumflexes, *ĉ, ĝ, ĥ, ĵ* and *ŝ*, are written as those letters without circumflexes with a filled sixth dot. Therefore the letter *ĵ* has the same representation as the English *w*, to write a *w* in Esperanto dot 3 is filled. The *ŭ*, used in Esperanto also, is as the *u*, but the first dot is moved to the fourth place.

Greater differences occur in Chinese Braille. In the case of Mandarin Braille, which is based on Zhuyin rather than the Latin Pinyin alphabet, the traditional Latin Braille values

are used for initial consonants and the simple vowels. However, on Latin Braille for many of the initial consonants and simple vowels (based on romanizations of a century ago), but the blocks pull double duty, with different values depending on whether they're placed in syllable-initial or syllable-final position. For instance, the block for Latin *k* represents old-style Cantonese *k* (*g* in Yale and other modern romanizations) when initial, but *aak* when final, while Latin *j* represents Cantonese initial *j* but final *oei*.

At least three adaptations of Braille have completely reassigned the Latin sound values of the blocks: Japanese Braille, Korean Braille, and Tibetan Braille. In Japanese Braille, alphabetic signs for a consonant and vowel are combined into a single syllabic block; in Korean Braille, the consonants have different syllable-initial and syllable-final forms. These modifications made Braille much more compatible with Japanese kana and Korean hangul but meant that the Latin sound values could not be maintained.

## **Uses**

The current series of Canadian banknotes has a tactile feature consisting of raised dots that indicate the denomination, allowing bills to be easily identified by visually impaired people. It does not use standard Braille; rather, the feature uses a system developed in consultation with blind and visually impaired Canadians after research indicated that not all potential users read Braille.

Mexican bank notes and Indian Rupee notes also have special raised symbols to make them identifiable by the visually impaired.

In India there are instances where the parliament acts have been published in Braille, such as 'The Right to Information Act'.