Language and Computers (Ling 384) Topic 1: Text and Speech Encoding Adriane Boyd* Department of Linguistics, OSU Autumn 2005	Language and Computers Topic 1: Text and Speech Encoding Writing systems Aphateic System Instantion	 Language and Computers – where to start? If we want to do anything with language, we need a way to represent language. We can interact with the computer in several ways: write or read text speak or listen to speech Computer has to have some way to represent text speech 	Language and Computers Topic 1: Text and Speech Encoding Writing systems Aghates: Uagosphic Systems with unsual matization Relation is language Comparison of systems Encoding written Language AGCI Ukicado Tamacrafion Tamacrafion Way speech is hard to represent Acoustics Relating written and spoken language Relating written and spoken language Relating written and spoken language Pom Speech Data Pom Text to Speech	Outline Writing systems Encoding written language Spoken language Relating written and spoken language	Language and Computers Topic 1: Text and Speech Encoding Writing systems System System Computero of system Relation to language Computero of system Encoding written Language Accut Unicolo Transcription Spoken language Accuts Relating written and spoken language Accuts Relating written and spoken language Relating written and spoken language Relating written and spoken language
 Writing systems used for human languages What is writing? "a system of more or less permanent marks used to represent an utterance in such a way that it can be recovered more or less exactly without the intervention of the utterer." (Peter T. Daniels, The World's Writing Systems) "Words that stay." (-Jen (Jim Henson), The Dark Crystal) Different types of writing systems are used: Alphabetic Syllabic Logographic Much of the information on writing systems and the graphics used are taken from the amazing site http://www.omniglot.com. 	<page-header><section-header><section-header><section-header><section-header><section-header><section-header><section-header><text><text><text><text><text></text></text></text></text></text></section-header></section-header></section-header></section-header></section-header></section-header></section-header></page-header>	 Alphabetic systems Alphabets (phonemic alphabets) represent all sounds, i.e., consonants and vowels Examples: Etruscan, Latin, Korean, Cyrillic, Runic, International Phonetic Alphabet Abjads (consonant alphabets) represent consonants only (sometimes plus selected vowels; vowel diacritics generally available) Examples: Arabic, Aramaic, Hebrew 	<page-header><section-header><section-header><section-header><section-header><section-header><section-header><section-header><section-header><section-header></section-header></section-header></section-header></section-header></section-header></section-header></section-header></section-header></section-header></page-header>	Alphabet example: Fraser An alphabet used to write Lisu, a Tibeto-Burman language spoken by about 657,000 people in Myanmar, India, Thailand and in the Chinese provinces of Yunnan and Sichuan. Consonants P d B r W M M T t D S X N L F J [0] [1/2]	<page-header><section-header><section-header><section-header><section-header><section-header><section-header></section-header></section-header></section-header></section-header></section-header></section-header></page-header>
Abjad example: Phoenician An alphabet used to write Phoenician, created between the 18th and 17th centuries BC; assumed to be the forerunner of the Greek and Hebrew alphabet.	Language and Computers Topic 1: Text and Speech Encoding Writing systems Lapgraphic System Comparison of systems Encoding written Language Asci Unicod Typing I in Spoken Language Taracception Why speech is hard to represent Association Accession Relating written and Spoken Language From Speech Is Text From Text to Speech	 A note on the letter-sound correspondence Alphabets use letters to encode sounds (consonants, vowels). But the correspondence between spelling and pronounciation in many languages is quite complex, i.e., not a simple one-to-one correspondence. Example: English same spelling – different sounds: ough: ought, cough, tough, through, though, hiccough silent letters: knee, knight, knife, debt, psychology, mortgage one letter – multiple sounds: exit, use multiple letters – one sound: the, revolution alternate spellings: jail or gaol; but not possible seagh for chef (despite sure, dead, laugh) 	Language and Computers Topic 1: Text and Speech Encoding Writing systems Comparison of systems Encoding writien Language Comparison of systems Encoding writien Language Accus Tamscription Spoken Language Tamscription Way geach is hard to systems Accus Way geach is hard to systems Accus Accus Tamscription Way geach is hard to systems Accus Comparison Way geach is hard to systems Accus Accus Comparison Way geach is hard to systems Accus Accus Comparison Way geach is hard to systems Accus Accus Comparison Way geach is hard to systems Accus Comparison Way geach is hard to systems Accus Comparison Compa	More examples for non-transparent letter-sound correspondences French (1) a. tailles → [taj] b. étais, était, étaient → [etε] Irish (2) a. Baile A'tha Cliath (Dublin) → [bl'a: kli uh] b. samhradh (summer) → [sauruh] c. scri'obhaim (I write) → [ʃgri:m] What is the notation used within the []?	Language and Computers Topic 1: Text and Speech Encoding Writing systems System Bythe Computing Ration is important Ration is important Ration is important Encoding written Ianguage Accut Isono Speech Istrato My geech Istrato I mension My geech Istrato I mension Relations Relations Transcription Research Internation Relation in Speech Istrato Peer Speech Istrato Peer Speech Istrato Peer Speech Istrato Peer Speech Istrato

 The International Phonetic Alphabet (IPA) Several special alphabets for representing sounds have been developed, the best known being the International Phonetic Alphabet (IPA). The phonetic symbols are unambiguous: designed so that each speech sound gets its own symbol, eliminating the need for multiple symbols used to represent simple sounds one symbol being used for multiple sounds. Interactive example chart: http://web.uvic.ca/ling/resources/ipa/charts/IPAlab/IPAlab.htm 	Language and Computers Topic 1: Text and Speech Encoding Writing systems Language Systems Relation to longuage Comparison of systems Encoding written Language ASCII Unicod Typing II in Spoken Language Thanscription Way speech is hard to represent Accustor Relating written and spoken Language From Speech to Text From Text to Speech	 Syllabic systems Syllabic alphabets (Alphasyllabaries) writing systems with symbols that represent a consonant with a vowel, but the vowel can be changed by adding a diacritic (= a symbol added to the letter). Examples: Balinese, Javanese, Tibetan, Tamil, Thai, Tagalog* (cf. also: http://www.omniglet.com/writing/syllabic.htm) Syllabaries writing systems with separate symbols for each syllable of a language Examples: Cherokee, Ethiopic*, Cypriot, Ojibwe, Hiragana (Japanese) (cf. also: http://www.omniglet.com/writing/syllabaries.htm#syll) 	Language and Computers Topic 1: Text and Speech Encoding Writing systems Aphatein Systems Relation to surgest Comparison of systems Encoding written Ianguage Comparison of systems Encoding written Ianguage Tamaraphia Vision Spoken language Pamagesch is hard to represent Acoustics Relating written and spoken language Pom Speech to Text Pom Text to Speech	Syllabary example: Cypriot* The Cypriot syllabary or Cypro-Minoan writing is thought to have developed from the Linear A, or possibly the Linear B script of Crete, though its exact origins are not known. It was used from about 800 to 200 BC. $\begin{array}{cccccccccccccccccccccccccccccccccccc$	Language and Computers Topic 1: Text at Speech Encodit Writing systems Aphatet Strategy and the systems Comparison of systems Encoding written language Ascil Unicod Transcription Way geneth is final to apresent in and to appear in the system Spoken language Transcription Way geneth is final to approximate the system Accuston Accuston Accuston Relating written approximation Relating written approximation Spoken language From Speech to Text From Text to Speech
 Logographic writing systems Logographs (also called Logograms): Pictographs (Pictograms): originally pictures of things, now stylized and simplified. Example: development of Chinese character horse: 	10/99 Anguage and Anguage and Anguage and Anguage and Anguage	Logograph writing system example: Chinese Pictographs 女子口日月山川豕目心雨田木龜 woman child mouth sun moon mountain river pig eye heart rain field tree burtle Ideographs <u></u>	11/59 Language and Longuitter Spicit 1: Text and Speech Encoding Witting systems Ashates Spital Barrow Relating written and Speech Ianguage Marcia Disoben Ianguage Marcia Speech Ianguage Marcia Marcia Barrow Marcia Marc	Semantic-phonetic compoundsphonetic componentphonetic component \underline{b} <td>12/ Language and Speech Encodi Writing systems Apataes Partial Partia</td>	12/ Language and Speech Encodi Writing systems Apataes Partial Partia
 Two writing systems with unusual realization Tactile Braille is a writing system that makes it possible to read and write through touch; primarily used by the (partially) blind. It uses patterns of raised dots arranged in cells of up to six dots in a 3 x 2 configuration. Each pattern represents a character, but some frequent words and letter combinations have their own pattern. Chromatographic The Benin and Edo people in southern Nigeria have developed a system of writing based on different color combinations and symbols. 	Language and Computers Topic 1: Text and Speech Encoding Whiting systems Values Bystem without and the system Comparison of systems Comparison of systems Encoding written Encoding written Encoding written Spoken Language Naccas Spoken Language Naccas Naccas Spoken Language Naccas Naccas Naccas Reserves Associas	Braille alphabet	Language and Computers Aphaetic Syntais Syntais Logopaphic Systems witrausual matching Comparison of systems Comparison of Systems C	Chromatographic system $ \begin{array}{ccccccccccccccccccccccccccccccccccc$	Language and Computers Topic 1: Text ar Speech Encodin Systems Systems Comparison Computers System Number Comparison Comp

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Relating writing systems to languages	Language and Computers Topic 1: Text and Speech Encoding	Japanese	Language and Computers Topic 1: Text and Speech Encoding	Japanese example	Language ar Computers Topic 1: Text a Speech Encod
 There is not a simple correspondence between a writing system and a language. For example, English uses the Roman alphabet, but Arabic numerals (e.g., 2 instead of the Roman II). We'll look at three other examples: Japanese Korean Azeri 	Aphabatic Systems Systems Systems Tealization Relation to Isopage Comparison of systems Encoding written Ianguage ASCII Ukucod Typing It in Spoken Ianguage Tanscoption Why speech is faird to represent Actuation Actuation Relating written and Spoken Ianguage Fom Speech to Teat Pom Speech to Teat Pom Speech to Teat	 Japanese: logographic system kanji, syllabary katakana, syllabary hiragana kanji: 5,000-10,000 borrowed Chinese characters katakana Used mainly for non-Chinese loan words, onomatopoeic words, foreign names, and for emphasis hiragana Originally used only by women (10th century), but codified in 1946 with 48 syllables used mainly for word endings, kids' books, and for words with obscure kanji symbols Romaji: Roman characters 	Writing systems Aphabatic Comparison Systems Comparison Relations to leave Comparison Co	<mark>カプセルホテル</mark> 各室がカプセル形の簡易ホテル。終電に乗り遅れたサラリーマンなどが高いタクシ 一代を払って帰宅するより安く済むことから、手軽に利用している。 kanji (red), hiragana (black), katakana (blue) Translation: Capsule Hotel A simple hotel where each room is capsule-shaped. When businessmen miss the last train home, they can stay overnight very cheaply instead of paying a lot of money to go home by taxi. (from: http://www.omniglot.com/writing/japanese.htm#origin)	Writing system: Aphabatic System System Transaction Mathematican Comparison of system Encoding Written Encoding Written Tanacorption Way speech is hard to represent Articultury Accountion Relating Written Spoken Languag From Speech to Text From Text to Speech
Korean	Language and Computers Topic 1: Text and Speech Encoding	Azeri	Language and Computers Topic 1: Text and Speech Encoding	Comparison of writing systems	Language ar Computers Topic 1: Text a Speech Encod
 "Korean writing is an alphabet, a syllabary and logographs all at once." (http://home.vicnet.net.au/⁻ozideas/writkor.htm) The <i>hangul</i> system was developed in 1444 during King Sejong's reign. There are 24 letters: 14 consonants and 10 vowels But the letters are grouped into syllables, i.e. the letters in a syllable are not written separately as in the English system, but together form a single character. E.g., "Hangeut" (tron: http://www.onniglot.com/writing/korean.htm):	Writing systems Aphabetic Systems Loopopspit Comparison of systems Comparison of systems Comparison of systems Comparison of systems Comparison of systems Comparison of Systems Comparison of Systems Comparison	 A Turkish language with speakers in Azerbaijan, northwest Iran, and (former Soviet) Georgia 7th century until 1920s: Arabic scripts. Three different Arabic scripts used 1929: Latin alphabet enforced by Soviets to reduce Islamic influence. 1939: Cyrillic alphabet enforced by Stalin 1991: Back to Latin alphabet, but slightly different than before. → Latin typewriters and computer fonts were in great demand in 1991 	Writing systems Aphabatic dystas (approprint) (approprint	 What are the pros and cons of each type of system? accuracy: Can every word be written down accurately? learnability: How long does it take to learn the system? cognitive ability: Are some systems unnatural? (e.g. Does dyslexia show that alphabets are unnatural?) language-particular differences: English has thousands of possible syllables; Japanese has very few in comparison connection to history/culture: Will changing a writing system have social consequences? 	Writing systems Aphabatic Systems Lapoprefit Systems Relation to transage Comparison of system Encoding Written Language ASCI Unicod Typing it in Spoken Language Transcription Way speech is hard to represent Articulation Accessito Prom Speech to Teat From Teat to Speech
 Encoding written language Information on a computer is stored in bits. A bit is either on (= 1, yes) or off (= 0, no). A list of 8 bits makes up a byte, e.g., 01001010 Just like with the base 10 numbers we're used to, the order of the bits in a byte matters: Big Endian: most important bit is leftmost (the standard way of doing things) The positions in a byte thus encode: 128 64 32 16 8 42 1 "There are 10 kinds of people in the world; those who know binary and those who don't" (torm: http://www.wlg.org.nzl.titleEndian: Little Endian: most important bit is rightmost (only used on Intel machines) The positions in a byte thus encode: 12 4 8 16 32 64 128 	22/59 Language and Computers Description Activation Computers Activation Computers Activation Computers Activation Computers Activation Computers Activation Computers Activation Activation Computers Activation Activ	Converting binary numbers to decimals The first 3 bits on a Big Endian machine: $\frac{2^2 \ 2^1 \ 2^0 = 4 \ 2 \ 1}{0 \ 0 \ 0 = 0 + 0 + 0 = 0}$ $0 \ 0 \ 1 = 0 + 0 + 1 = 1$ $0 \ 1 \ 0 = 0 + 2 + 0 = 2$ $0 \ 1 \ 1 = 0 + 2 + 1 = 3$ $1 \ 0 \ 0 = 4 + 0 + 0 = 4$ For all 8 bits in a byte: $\frac{2^7 \ 2^6 \ 2^5 \ 2^4 \ 2^3 \ 2^2 \ 2^1 \ 2^0 = \frac{128 \ 64 \ 32 \ 16 \ 8 \ 4 \ 2 \ 1}{1 \ 0 \ 1 \ 1 \ 1 \ 0 \ 0 \ 1 \ 1 = 1}$ $\frac{2^7 \ 2^6 \ 2^5 \ 2^4 \ 2^3 \ 2^2 \ 2^1 \ 2^0 = \frac{128 \ 64 \ 32 \ 16 \ 8 \ 4 \ 2 \ 1}{1 \ 0 \ 1 \ 1 \ 1 \ 0 \ 0 \ 1 \ 1 = 1}$	23/58 Language and Topis 1: Tota and Speach Encoding Writing systems Aspeader: Logografic Systems with unsue Relations bringuage Comparison of systems Brancing Speach Inguage Speach Inguage Asculation With Speach Inguage Asculation Speach Inguage Asculation Speach Inguage Association	Converting decimal numbers to binary - Tabular Method Using the first 4 bits, we want to know how to write 10 in bit (or binary) notation. $\frac{8 4 2 1}{? ? ? 2}$ $8 < 10 ? ? ? 2$ $1 8 + 4 = 12 > 10 ? 2$ $1 0 8 + 2 = 10 = 10 ?$ $1 0 1 0$	244
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Converting decimal numbers to binary - Division Method	Language and Computers Topic 1: Text and Speech Encoding	Using bytes to store characters	Language and Computers Topic 1: Text and Speech Encoding	An encoding standard: ASCII	Language and Computers Topic 1: Text ar Speech Encodir
DecimalRemainder?Binary $10/2 = 5$ no0 $5/2 = 2$ yes10 $2/2 = 1$ no010 $1/2 = 0$ yes1010	Writing systems Aphaten: Dylan: Logographic Characteristics Anti- anti-	 With 8 bits (a single byte), you can represent 256 different characters. Why would we want so many? If you look at a keyboard, you will find lots of non-English characters. With 256 possible characters, we can store every single letter used in English, plus all the things like commas, periods, space bar, percent sign (%), back space, and so on. 	Writing systems Aphabete: Systac Lapoprapie Present with unusual relations Readen to language Comparison of systems Control of the system Control of the s	 ASCII = the American Standard Code for Information Interchange 7-bit code for storing English text 7 bits = 128 possible characters. The numeric order reflects alphabetic ordering. 	Writing systems Aphabetic System Lapoprapie Systems with unusual relations Comparison to signing Comparison of systems Encoding written Language Net Vision Tancorigon Way speach is hard to represent Accutation Accutation Accutation Represent Encologues to Text From Text to Speech Text From Text to Speech
The ASCII chart	28/59 Language and Computers	E-mail issues	29/59 Language and Computers	Multipurpose Internet Mail Extensions (MIME)	Language and Computers
$\begin{array}{c cccc} \begin{tabular}{ c c c c c c c c c c c c c c c c c c c$	Speech Encoding Writing systems Apartes Upparte Upparte Anatoria Anatoria Speech Encoding writien Anatoria Speech Encoding writien Anatoria Spoken Inguerste Anatoria	 Have you ever had something like the following at the top of an e-mail sent to you? [The following text is in the ''ISO-8859-1'' character set.] [Your display is set for the ''US-ASCII'' character set.] [Some characters may be displayed incorrectly.] Mail sent on the internet used to only be able to transfer the 7-bit ASCII messages. But now we can detect the incoming character set and adjust the input. Note that this is an example of meta-information = information which is printed as part of the regular message, but tells us something about that message. 	<section-header><section-header><section-header><section-header><text><text><text><text></text></text></text></text></section-header></section-header></section-header></section-header>	 MIME provides meta-information on the text, which tells us: which version of MIME is being used what the charcter set is if that character set was altered, how it was altered Mime-Version: 1.0 Content-Type: text/plain; charset=US-ASCII Content-Transfer-Encoding: 7bit 	Rypech Checodin Speech Checodin Writing systems Appendie Writing Writing Writing Writing Comparison of systems Comparison of systems Checoding Writing Checoding Writing Checo
Different coding systems	Language and Computers Topic 1: Text and	Unicode	Language and Computers Topic 1: Text and	How big is Unicode?	Language and Computers Topic 1: Text an
 But wait, didn't we want to be able to encode <i>all</i> languages? There are ways Extend the ASCII system with various other systems, for example: ISO 8859-1: includes extra letters needed for French, German, Spanish, etc. ISO 8859-7: Greek alphabet ISO 8859-8: Hebrew alphabet JIS X 0208: Japanese characters Have one system for everything → Unicode 	speech Encoding Writing systems Aphatic Upgente System: Without Matance Ungage Comparison of patients Encoding written Language Asce Ubcode Typing it in Spoken Language Taxaction Why speech tam's of Arbituation Accuston Relating written and Spoken Language From Speech to Test From Test's Speech	 Problems with having multiple encoding systems: Conflicts: two encodings can use the same number for two different characters and use different numbers for the same character. Hassle: have to install many, many systems if you want to be able to deal with various languages Unicode tries to fix that by having a single representation for every possible character. "Unicode provides a unique number for every character, no matter what the platform, no matter what the program, no matter what the language." (www.unicode.org) 	Speech Encoding Writing systems Aphabetic Systems Systems Lopographic Ratence longuage Comparison of systems Encoding written Language Asco Uncode Typing in Spoken language Transcription Accustics Relating written and Spoken language Pom Speech lo Test Pom Test to Speech	 Version 3.2 has codes for 95,221 characters from alphabets, syllabaries and logographic systems. Uses 32 bits - meaning we can store 2³² = 4,294,967,296 characters. 4 billion possibilities for each character? That takes a lot of space on the computer! 	Speech Encoding Writing systems Aphabatic Systems with unusual real-action Relation to support Relation to support Relation to support Transcription Way speech is hard to represent Arisolation Association Relating written a Spoken language Fiom Speech Is Test Fiom Speech Is Test

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Compact encoding of Unicode characters	Language and Computers Topic 1: Text and Speech Encoding	How do we type everything in?	Language and Computers Topic 1: Text and Speech Encoding	Unwritten languages	Language and Computers Topic 1: Text and Speech Encoding
 Unicode has three versions UTF-32 (32 bits): direct representation UTF-16 (16 bits): 2¹⁶ = 65536 UTF-8 (8 bits): 2⁸ = 256 How is it possible to encode 2³² possibilities in 8 bits (UTF-8)? Several bytes are used to represent one character. Use the highest bit as flag: highest bit 0: single character highest bit 1: part of a multi byte character Nice consequence: ASCII text is in a valid UTF-8 encoding. 	Writing systems Aphabetic Systems with unusual realization Relation to language Comparison of systems Encoding written Ianguage XSCII Unucode Tanacoption Way opens is hard to Accustics Accustics Relating written and Spoken Ianguage From Speech to Test Prom Speech to Test Prom Test to Speech	 Use a keyboard tailored to your specific language e.g. Highly noticeable how much slower your English typing is when using a Danish-designed keyboard. Use a processor that allows you to switch between different character systems. e.g. Type in Cyrillic characters on your English keyboard. Use combinations of characters. An <i>e</i> followed by an ' might result in an <i>é</i> Pick and choose from a table of characters. So, now we can encode every language, as long as it's written. 	Writing systems Aphatetic Systems with unusual matrication Relation to language Comparison of systems Accil Language ACCI Theoret in Spectra Inguage Theoret Inguage Theoret Inguage Accil Lincode Theoret Inguage Theoret Inguage Accusition Relating written and Accusition Relating written and Spoken Language Pom Speech to Text Pom Text to Speech	 Many languages have never been written down. Of the 6700 spoken, 3000 have never been written down. Salar, a Turkic language in China. Gugu Badhun, a language in Australia. Southeastern Pomo, a language in California 	Writing systems Aphaber Syntae Lagopaphie Syntae Relation to Insurgation Composition of systems Encoding writite and Uncode Typing & In Specific Systems Transcription Way gray in Is hard to Account Relating writiten and Spocken Ianguage From Speach to Text Prom Speach to Text Prom Speach to Text Prom Speach to Text
The need for speech	37/59 Language and Computers Topic 1: Text and	What does speech look like?	38/59 Language and Computers Topic 1: Text and	What makes representing speech hard?	39/59 Language and Computers Topic 1: Text and
 What if we want to work with an unwritten language? What if we want to examine the way someone talks and don't have time to write it down? Many applications for encoding speech: Building spoken dialogue systems, i.e. speak with a computer (and have it speak back). Helping people sound like native speakers of a foreign language. Helping speech pathologists diagnose problems 	Speech Encoding Writing systems Aphatenic Elagographic Systems with nucusal relatation Relation to lunguage Comparison of systems Encoding written language Ascu Uncode Spoten Language Marcolos Way speech is hard to respect Aroustion Relating written and spoken language Pron Speech to Test Pron Test to Speech	 We can transcribe (write down) the speech into a phonetic alphabet. It is very expensive and time-consuming to have humans do all the transcription. To automatically transcribe, we need to know how to relate the audio file to the individual sounds that we hear. ⇒ We need to know: some properties of speech how to measure these speech properties how these measurements correspond to sounds we hear 	Speech Ericouring Writing systems Autheter System Lapoyaphic System Relation binguage Comparison of system Relation binguage Addition Relation binguage Addit Unicod System Spocken language Relation language Rel	 Difficulties: People have different dialects and different size vocal tracts and thus say things differently Sounds run together, and it's hard to tell where one sound ends and another begins. What we think of as one sound is not always (usually) said the same: coarticulation = sounds affecting the way neighboring sounds are said e.g. <i>k</i> is said differently depending on if it is followed by <i>ee</i> or by <i>oo</i>. What we think of as two sounds are not always all that different. e.g. The <i>s see</i> is very acoustically similar to the <i>sh</i> in <i>shoe</i> 	Speech Enclosing Writing systems Aphabate Splate Lapopaptic International Relation Systems Encoding writine Language Addi Unixoda Tamostom Spoken language Tamostom Myseesh sharts on Spoken language Pressent Status Relation Splate Relation Splate Relation Splate Relation Splate Press Speech Status Press Speech Status
Articulatory properties: How it's produced	40/59 Language and Computers Topic 1: Text and	Acoustic properties: What it sounds like	41/59 Language and Computers Topic 1: Text and	Oscillogram (Waveform)	42/59 Language and Computers Topic 1: Text and
We could talk about how sounds are produced in the vocal tract, i.e. articulatory phonetics place of articulation (where): [t] vs. [k] manner of articulation (how): [t] vs. [s] voicing (vocal cord vibration): [t] vs. [d] But unless the computer is modeling a vocal tract, we need to know acoustic properties of speech which we can quantify.	Speech Encoding Writing systems Aphabetic Systems Upperprint Ratento Is Ungage Comparison Ratento Is Ungage Comparison of systems Encoding written language ASCII Uncode Typing It in Spoken language Paracoptoin Way speech is lawd to represent Associatio Reclaring written and spoken language Para Para Para Para Para Para Para Para	 Sound waves = "small variations in air pressure that occur very rapidly one after another" (Ladefoged, A Course in Phonetics) ⇒ Akin to ripples in a pond speech flow = rate of speaking, number and length of pauses (seconds) loudness (amplitude) = amount of energy (decibels) frequencies = how fast the sound waves are repeating (cycles per second, i.e. Hertz) pitch = how high or low a sound is In speech, there is a fundamental frequency, or pitch, along with higher-frequency overtones. intonation = rise and fall in pitch 	Speech Encoding Writing systems Aphatence Systems Systems Uspagnable Systems Relation to Improve Relation Rela	(Check out the Speech Analysis Tutorial, of the Deptartment of Linguistics at Lund University, Sweden at http://www.ling.lu.se/research/speechtutorial/tutorial.html, from which the illustrations on this and the following slides are taken.)	Speech Encoding Writing systems Aphabaic Systems Writing Readors is any application with the systems and the systems and the systems and the systems and the system and the

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Fundamental frequency (F0, pitch)	Language and Computers Topic 1: Text and Speech Encoding	Spectrograms	Language and Computers Topic 1: Text and Speech Encoding	How measurements correspond to sounds we hear	Language and Computers Topic 1: Text and Speech Encoding
	Writing systems Aphabetic Syltabic Syltabic Deproprint Restation to Linguage Comparison of systems Encoding written Anguage ASCII Luncode Typing It in Syltabic I and Syltabic Typing I and Syltabic Typing I and Syltabic Syltabic I and Syltabic Syltabic I and Syltabic Syltabic I and Syltabic Syltabic I and Syltabic Form Systech I and Form Sy	Spectrogram = a graph to represent (the frequencies of) speech over time.	Writing systems Ajshateric Systems with runsual realization Ratiano to Isingang Comparison of systems Encoding written Language AdCII Linacola Typeng II n Systems All Typeng II n Compared Systems Typeng II n Compared Sy	 How dark is the picture? → How loud is the sound? We can measure this in decibels. Where are the lines the darkest? → Which frequencies are the loudest and most important? We can measure this in terms of Hertz, and it tells us what the vowels are. How do these dark lines change? → How are the frequencies changing over time? Which consonants are we transitioning into? 	Writing systems Aphabaric Systems Systems Relation to insugate Comparison of systems Encoding writine and Language Asicil Usinoode Tying in Spoken Inguage Negotate Relating writine and Spoken Inguage Press baset in Test Press Speech in Test
How did we get these measurements?	Language and Computers Topic 1: Text and Speech Encoding	Sampling rate	Language and Computers Topic 1: Text and Speech Encoding	Applications of speech encoding	Language and Computers Topic 1: Text and Speech Encoding
sampling rate = how many times in a given second we extract a moment of sound; measured in samples per second Sound is continuous, but we have to store data in a discrete manner. CONTINUOUS DISCRETE • We store data at each discrete point, in order to capture the general pattern of the sound	Writing systems Advance: System Lopoparation Comparison of systems Encoding written Language AsCit Unicode Tanacoption Tanacoption Way speech is hard to represent Relating written and Spoken Language Form Speech to Text Form Text to Speech	 The sampling rate is often 8000 or 16,000 samples per second. The rate for CDs is 44,100 samples/second (or Hertz (Hz)) The higher the sampling rate, the better quality the recording but the more space it takes. Speech needs at least 8000 samples/second, but most likely 16,000 or 22,050 Hz will be used nowadays. 	Writing systems Aphaten: System Loopoppid: Usopoppid: Usopoppid: Systems in Innovation Comparison of hystems Relation to Innovation Comparison of hystems Accil Unicode Tamacription Way speech in Brand to Approp I in Spoken Language Paracription Way speech in Brand to Spoken Language Paracription Management in Speech I Seat Point Spoken Language Point Spoken Language Point Spoken Language	Mapping sounds to symbols (alphabet), and vice versa, isn't all that easy. • Automatic Speech Recognition (ASR): sounds to text • Text-to-Speech Synthesis (TTS): texts to sounds	Writing systems Aphabatic Upperformer Systems Augustation Relation to temporate Comparison of systems Encoding writing and Uncode Uncode Transcription Way speech is that to Annotation Relation to systems Accounts Background and and and Relation of the system Accounts Relation of the system Point System of the system Point System of the system Point System of the system Point System Test to Speech
Automatic Speech Recognition (ASR)	49/59 Language and Computers Topic 1: Text and Speech Encoding Writing systems	Kinds of ASR systems	50/59 Language and Computers Topic 1: Text and Speech Encoding Writing systems	Kinds of ASR systems	Language and Computers Topic 1: Text and Speech Encoding Writing systems
 Automatic speech recognition = process by which the computer maps a speech signal to text. Uses/Applications: Dictation Telephone conversations People with disabilities – e.g. a person hard of hearing could use an ASR system to get the text 	Aphabetic System Lapopapito Systems and unusual Comparison of systems Encoding written Language AsCII Unicod Typing It in Spoken Language Teanscription Way speech is hard to represent Accusition Accusition Reliating written and spoken language Pers Speech Teat	 Different kinds of systems: Speaker dependent = work for a single speaker Speaker independent = work for any speaker of a given variety of a language, e.g. American English Speaker adaptive = start as independent but begin to adapt to a single speaker to improve accuracy 	Aphaletic System Logographic Logographic Systems and unusual Comparison of systems Encoding written Language Accil Ulucod Typing it in Spoken Language Transcription Way speach is hard to represent Accusation Accusation Accusation Relating written and spoken language Peem Speech Iswit	 Differing sizes of vocabularies, from tens of words to tens of thousands of words continuous speech vs. isolated-word systems: continuous speech systems = words connected together and not separated by pauses isolated-word systems = single words recognized at a time, requiring pauses to be inserted between words → easier to find the endpoints of words 	Apparator System Lapproprint Lapproprint Lapproprint Systems of the usual Apparation of systems Encoding written Language Again Unicode Transcription Way speech is hard to present Attachation Acousties Relating written and spoken Language Free Test is Speech
	52/59		53/59		54/59

Steps in an ASR system	Language and Computers Topic 1: Text and Speech Encoding	Text-to-Speech Synthesis (TTS)	Language and Computers Topic 1: Text and Speech Encoding	It's hard to be natural	Language and Computers Topic 1: Text and Speech Encoding
 Digital sampling of speech Acoustic signal processing = converting the speech samples into particular measurable units Recognition of sounds, groups of sounds, and words May or may not use more sophisticated analysis of the utterance to help. 	Writing systems Appears By and By and By and By and appears Comparison of systems Comparison of systems Comparison of systems Comparison of Systems Comparison Compar	 Could just record a voice saying phrases or words and then play back those words in the appropriate order. Or can break the text down into smaller units 1. Convert input text into phonetic alphabet 2. Synthesize phonetic characters into speech To synthesize characters into speech, people have tried: using formulas which adjust the values of the frequencies, the loudness, etc. using a model of the vocal tract and trying to produce sounds based on how a human would speak 	Writing systems Apates Writing Opages Comparison of systems	 When trying to make synthesized speech sound <i>natural</i>, we encounter the same problems as what makes speech encoding in general hard: The same sound is said differently in different contexts. Different sounds are sometimes said nearly the same. Different sentences have different intonation patterns. Lengths of words vary depending on where in the sentence they are spoken. The car crashed into the tree. It's my car. Cars, trucks, and bikes are vehicles. 	Writing systems Agenes Systems Systems Corport
Speech to Text to Speech	Language and Computers Topic 1: Text and	Demos	Language and Computers Topic 1: Text and		37739
 If we convert speech to text and then back to speech, it should sound the same, right? But at the conversion stages, there is information loss. To avoid this loss would require a lot of memory and knowledge about what exact information to store. The process is thus irreversible. 	Speech Encoding Writing systems Applies Upper Systems Partial	 Text-to-Speech AT&T mulitilingual TTS system: http://www.research.att.com/projects/tts/demo.html various systems and languages: http://www.ims.uni-stuttgart.de/~moehler/synthspeech/ 	Speech Encoding Writing systems Apatentic System System System System Congregation System Second Speech Spe		