Lecture 1: Introduction and Encodings

LING-351 Language Technology and LLMs

Instructor: Hakyung Sung

August 26, 2025

*Acknowledgment: These course slides are based on materials by Lelia Glass @ Georgia Tech (Course: Language & Computers)

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Introduction

Course logistics

- Instructor: Dr. Hakyung Sung

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- We'll explore the interaction between language and technology. Topics including:

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- To understand these systems, basic coding skills are helpful
- We will do hands-on exercises during class (Python tutorials)
- No prior coding experience is required—tutorials will start from the very beginning

Updated reading materials

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Final grading components

[a × b] a = number; b = points

- Exercises [4 × 10]: 40%
- Assignments [2 × 10] 20%
- Paper presentations [2 × 5] 10%
- Online exams 30%
  - Midterm [1 × 15] 15%
  - Final [1 × 15]: 15%

Final grading components

- **Exercises [4 × 10]: 40%**
- These are individual assignments, usually based on the work you complete during in-class lab sessions.

Final grading components

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Week	Date	Topic	Readings	Due (Friday, 11:59 pm)
1	8/26	Introduction, Encoding	[LC] Ch.1	
	8/28	Writer's aids: Spelling errors	[LC] Ch.2.1-2.3	
2	9/2	Writer's aids: Grammar errors	[LC] Ch.2.5-2.8	
	9/4	Computer-assisted language learning	[LC] Ch. 3	
3	9/9	Text as data	[LC] Ch. 4.1-4.3	
	9/11	Python tutorial 1		Exercise 1
4	9/16	Python tutorial 2		
	9/18	Python tutorial 3		Exercise 2
5	9/23	Python tutorial 4		
	9/25	Python tutorial 5		Exercise 3
9	10/21	Building a chatbot	[LC] Ch. 8.3	
	10/23	Prompt engineering		Exercise 4

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9	10/21	Building a chatbot	[LC] Ch. 8.3	
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- Please bring your laptop on these days!

Final grading components

- Assignments [2 × 10] 20%
- Paper presentations [2 × 5] 10%
- `https://youtube.com/shorts/Yg7WrDt5I1E?si=12YMKYi_OJRj9c6r`

Final grading components

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- All paper links are on the course website!
- 2 people will be grouped to present papers in each area.

Final grading components

- Weeks 10-13

10	10/28	Prompt engineering		
	10/30	Paper presentation (Papers 1, 2)		
11	11/4	Paper presentation (3, 4)		
	11/6	Paper presentation (5, 6)		
12	11/11	Paper presentation (7, 8)		
	11/13	Paper presentation (9, 10)		Assignment 1
13	11/18	Paper presentation (11, 12)		
	11/20	Paper presentation (13, 14)		
14	11/25	Paper presentation (15, 16)		
	11/27	**Thanksgiving break (No class)**		
15	12/2	Paper presentation (17, 18)		
	12/4	Final wrap-up		Assignment 2

- Week 6

6	9/30	Word vectors	[LC] Ch. 4.4	
	10/2	Text classification	[LC] Ch. 5	Student presentation topics submission

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- Each group presents twice (Rounds 1–9; Rounds 10–18).
- For each round, students will also submit a short assignment summarizing what they learned from (1) the presented studies and (2) other presentations.
- Assignments are released at the start of each round and due at the end of the presentation day.

Final grading components

- **Online exam: 30%**
  - Midterm [1 × 15]: 10%
  - Final [1 × 15]: 10%

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- No extensions will be granted for the **online exam**.

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- You must acknowledge and document how AI tools were used in your work (including individual exercises).

Pause

Any questions?

Lesson plan

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- ~~Course logistics~~

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- What is language

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Key idea: Language $\neq$ writing; multiple writing systems exist.

What is language?

What's language?

Charles Hockett's Design Features of Language (1960)

- **Modality:**
  Spoken language is produced with the vocal tract and perceived by the auditory system; *Signed* language is produced with the body and perceived visually.
- **Intentionality:**
  Language is produced deliberately for communication.
- **Transitoriness:**
  Language is ephemeral unless recorded.
- **Interchangeability:**
  Anything you can hear, you can also say.
- **Total feedback:**
  Speakers can hear themselves and monitor their speech.
- **Primacy of communication:**
  Language is used primarily for communication—not as a secondary function.
- **Semanticity:**
  Specific words or signs are linked to specific meanings.
- **Arbitrariness:**
  The connection between a sign and its meaning is largely conventional.
- **Discreteness:**
  Continuous variation is categorized into discrete mental units.
- **Displacement:**
  Language allows reference to things not present—past, future, imaginary.
- **Prevarication:**
  Language can be used to lie or deceive.
- More:
  `https://en.wikipedia.org/wiki/Hockett%27s_design_features`

Which are Languages?

Let's test Hockett's design features!

Are the following systems *languages*?

Why or why not?

Is *Music* a Language?

- Can music express specific meanings?

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More discussions + a small break

- How many of Hockett's features does *music* meet?
- Is *Python* a Language?
- Is *Mathematics* a Language?

Language vs. Writing

Language is *technology*

- Tell stories, ask questions, learn, plan, imagine alternate realities

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- Estimated age: 100,000–200,000 years
- Evidence? Archaeological findings (e.g., symbolic beads, tools, burial sites)

Figure 1: Clay tablet inscribed with the earliest known writing system, cuneiform—recording the receipt of barley and malt (around 3000 BCE, left)—and a close-up of cuneiform text on a mudbrick (around 1200 BCE).

Sourced from: `https://en.wikipedia.org/wiki/Cuneiform`

What is *Writing*?

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Writing ≠ Language

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Case 2. Same language, different writing systems:

- Chinese: traditional vs. simplified vs. pinyin (Latinized)

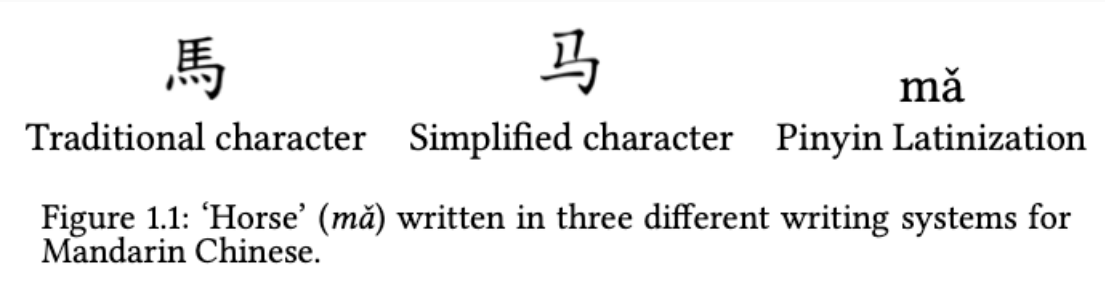

Figure 1.1: 'Horse' (*mǎ*) written in three different writing systems for Mandarin Chinese.

- Turkish: Arabic script (pre-1928) vs. Latin script (modern)

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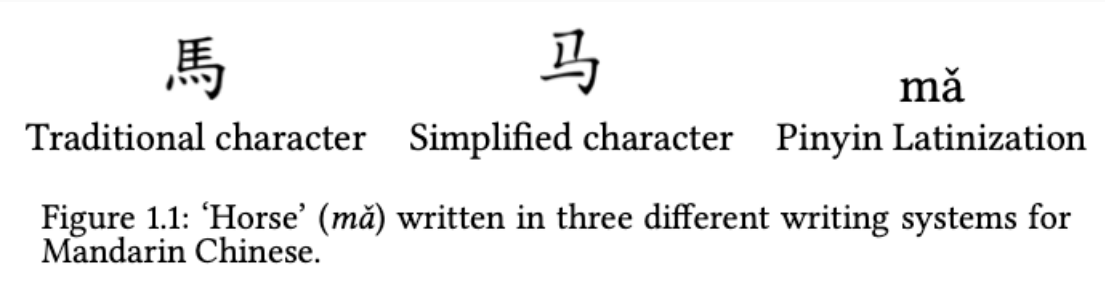

Figure 1.1: 'Horse' (*mǎ*) written in three different writing systems for Mandarin Chinese.

- Turkish: Arabic script (pre-1928) vs. Latin script (modern)
- Japanese: 1 language, 3 scripts—hiragana, katakana, kanji

Spot the misconception

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- Both English and French use the **Latin alphabet**, a writing system shared by many languages.
- But! Each language uses it differently:
  - French includes letters with diacritics: *é, è, ê, ç*
  - English doesn’t use those in native words.

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- But! Each language uses it differently:
  - French includes letters with diacritics: *é, è, ê, ç*
  - English doesn’t use those in native words.
- So, it’s not that French borrows “English’s” alphabet— they both adapt a shared system for their own phonology and grammar.

Move on

How language and writing work in language technology?

Writing systems in NLP

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- To process language with computers, NLP requires a way to **encode language** → that's where **writing systems** come in.
- Evolution of writing technologies: **clay → papyrus → printing press → digital text**
- Digital writing allows for new forms of communication and makes language **machine-readable**.

Pause

Any questions?

Encoding

What is encoded in writing?

- Language = (mostly arbitrary) sound-meaning pairs

Three major systems:

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- **Syllabic**: symbol → syllable
- **Logographic**: symbol → meaning

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  - Homophones: *bank (river/finance)*

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  - One sound, multiple letters: *running*, *phone*
  - One letter, multiple sounds: *tax*
  - Homophones: *bank (river/finance)*
- Examples: Latin, Greek, Cyrillic alphabets

1. Alphabetic systems (Example)

Table 1.1: The Cyrillic alphabet used for Russian.

а	б	в	г	д	е	ё	ж	з	и	й
[a]	[b]	[v]	[g]	[d]	[je]	[jo]	[ʒ]	[z]	[i]	[j]
к	**л**	**м**	**н**	**о**	**п**	**р**	**с**	**т**	**у**	**ф**
[k]	[l]	[m]	[n]	[o]	[p]	[r]	[s]	[t]	[u]	[f]
х	**ц**	**ч**	**ш**	**щ**	**ъ**	**ы**	**ь**	**э**	**ю**	**я**
[x]	[ts]	[tɕ]	[ʂ]	[ɕɕ]	[-]	[ɨ]	[ʲ]	[e]	[ju]	[ja]

- The Cyrillic alphabet is used for Russian and other nearby languages.
- Some letters resemble Latin characters, but others are unique.

International Phonetic Alphabet (IPA)

- Each character = exactly one sound

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- Different charts for (1) vowels and (2) consonants

International Phonetic Alphabet (IPA)-Vowels

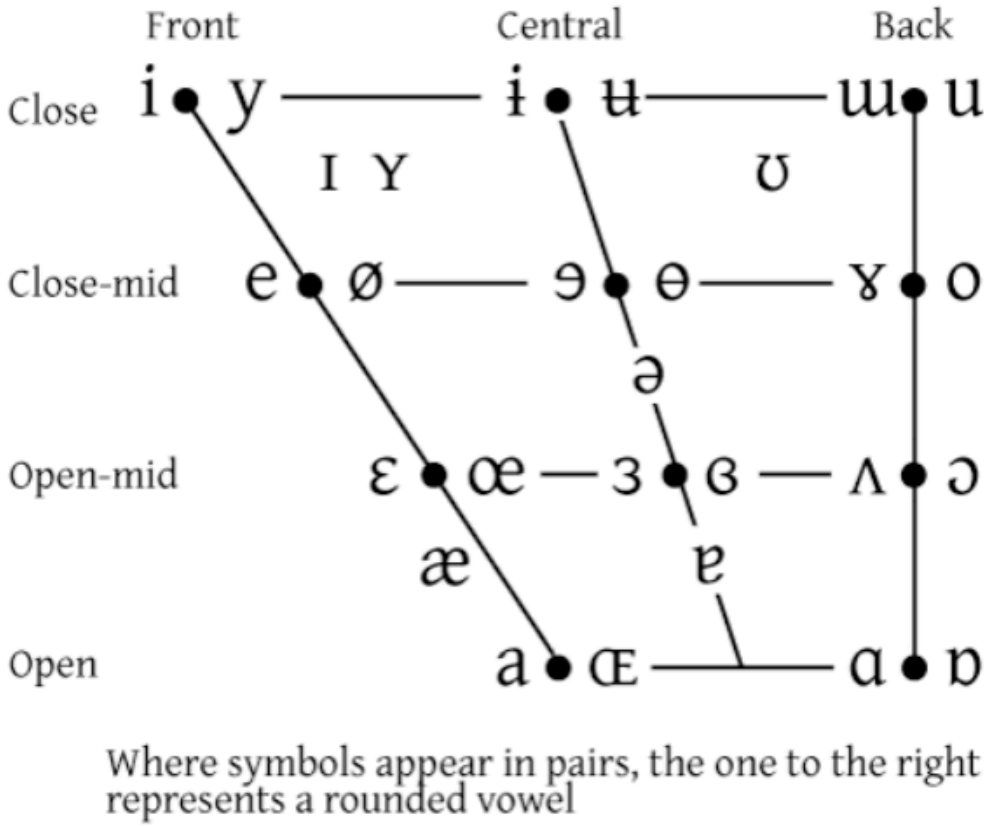
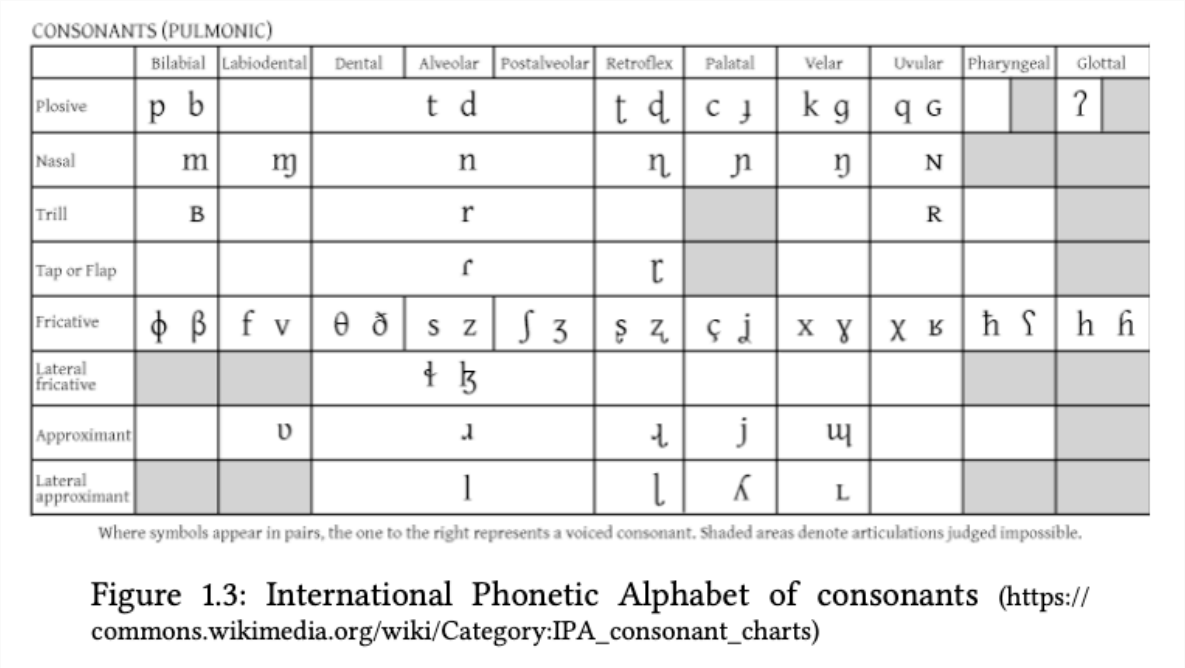


Figure 1.2: International Phonetic Alphabet of vowels (https://commons.wikimedia.org/wiki/File:Ipa-chart-vowels.png)

International Phonetic Alphabet (IPA)-Consonants



CONSONANTS (PULMONIC)

	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Retroflex	Palatal	Velar	Uvular	Pharyngeal	Glottal
Plosive	p b			t d		ʈ ɖ	c ɟ	k g	q ɢ		ʔ
Nasal	m	ɱ		n		ɳ	ɲ	ŋ	ɴ		
Trill	ʙ			r					ʀ		
Tap or Flap				ɾ		ɽ					
Fricative	ɸ β	f v	θ ð	s z	ʃ ʒ	ʂ ʐ	ç ʝ	x ɣ	χ ʁ	ħ ʕ	h ɦ
Lateral fricative				ɬ ɮ							
Approximant		ʋ		ɹ		ɻ	j	ɰ			
Lateral approximant				l		ɭ	ʎ	ʟ			

Where symbols appear in pairs, the one to the right represents a voiced consonant. Shaded areas denote articulations judged impossible.

Figure 1.3: International Phonetic Alphabet of consonants (https://commons.wikimedia.org/wiki/Category:IPA_consonant_charts)

Figure 2: Textbook, p. 8

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- **English**: allows complex clusters (e.g., *spark*) → many possible syllables → syllabaries become impractical.

3. Logographic systems

- Symbol is a meaning (not sound)

Figure 1.8: U.S. National Park Service symbols (pictographs).
(http://commons.wikimedia.org/wiki/File:National_Park_Service_sample_pictographs.svg)

Figure 3: p. 14

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Figure 3: p. 14

Chinese Characters

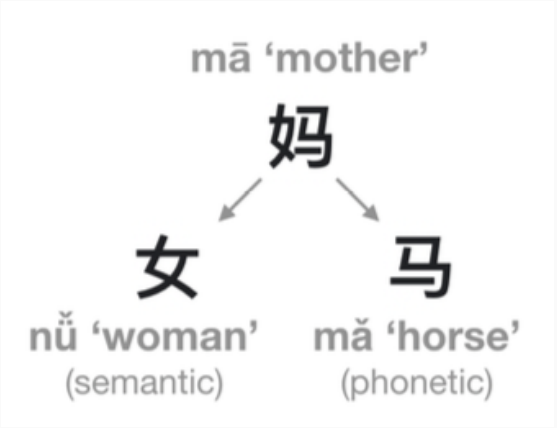
- Represent syllables
- Combine logographic and phonetic elements: “semantic-phonetic compounds”
- Over time: symbols become more abstract

Figure 1.9: The Chinese character for “horse.”
(http://commons.wikimedia.org/wiki/Category:Ancient_Chinese_characters)

Figure 4: p. 14

Logographic Writing: Semantic-Phonetic Compounds

- Chinese characters often combine:



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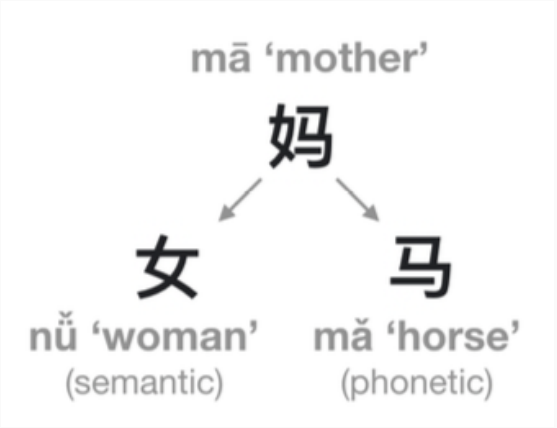

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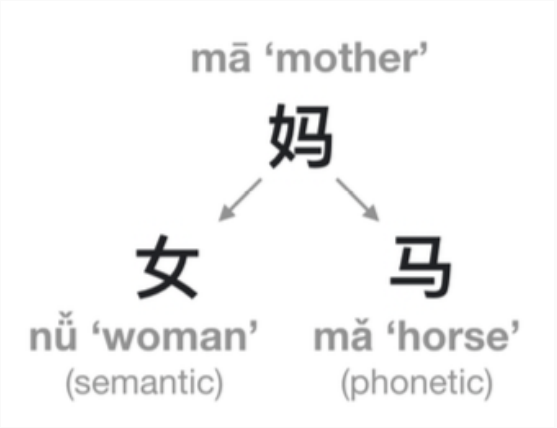

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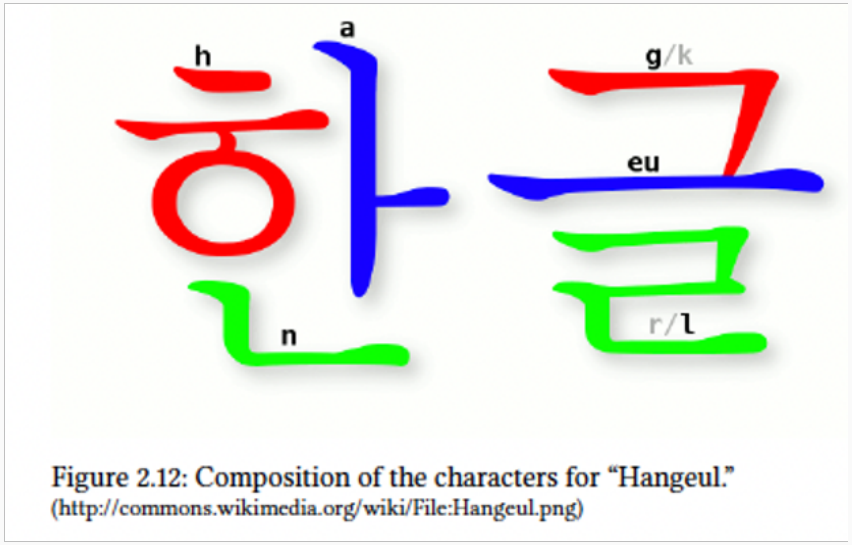

Figure 2.12: Composition of the characters for "Hangeul."
(http://commons.wikimedia.org/wiki/File:Hangeul.png)

Writing system design choices

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Digital encoding of writing

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- UTF-8: variable-length encoding using 8-bit blocks

How is speech encoded on a computer?

Waveform

Representation of sound amplitude over time.

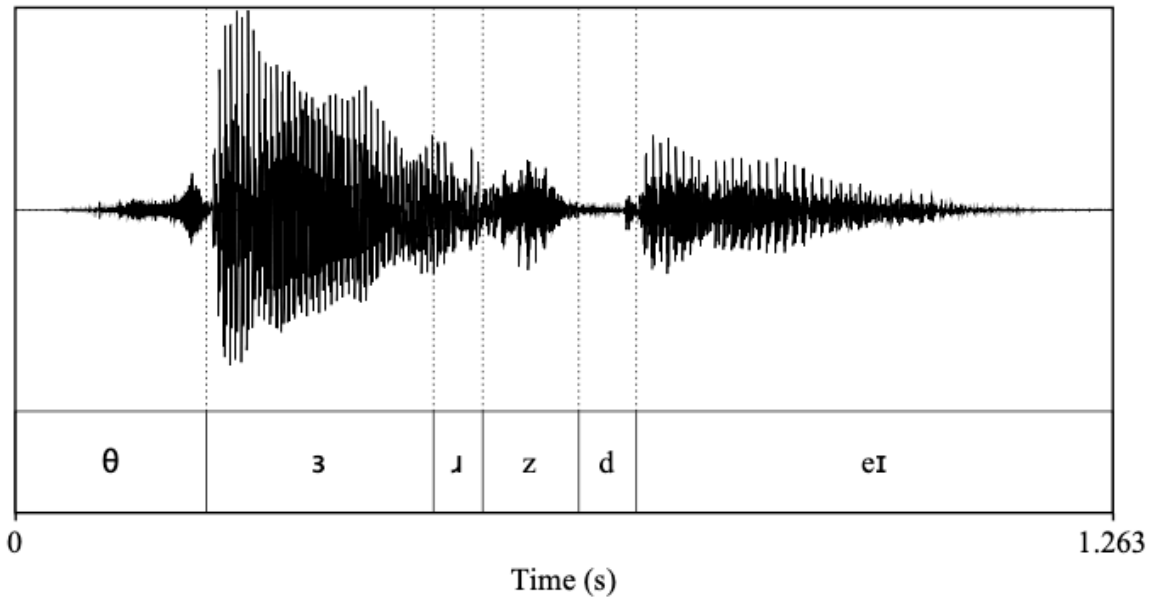

Figure 1.15: A waveform for *Thursday*.

How is speech encoded on a computer?

Spectrogram

Representation of frequency components over time (color/brightness = intensity).

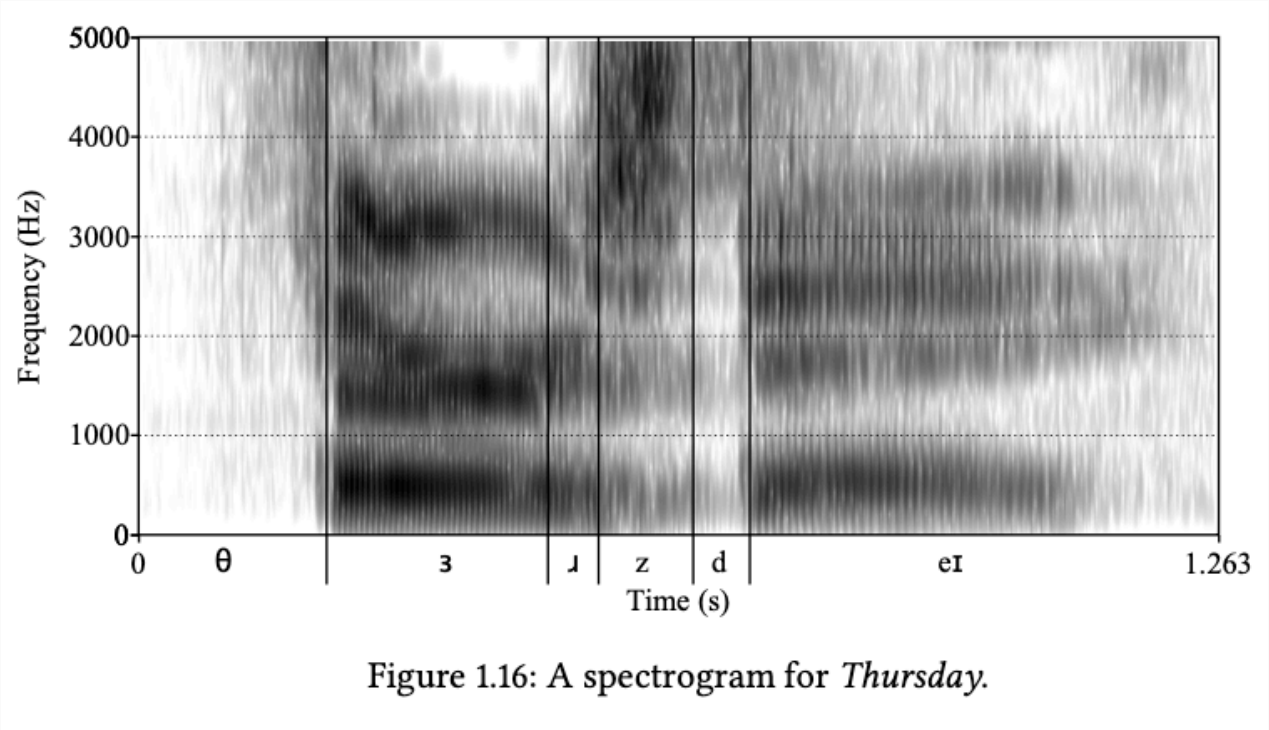

Figure 1.16: A spectrogram for *Thursday*.

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- We'll come back to this topic when learning about the **word vectors**.

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