NPFL123 Dialogue Systems

3. What happens in a dialogue?

https://ufal.cz/npfl123

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How do you “define” dialogue?

- Spoken/written conversational (interactive, collaborative) communication between two or more people
- **verbal** + (possibly) non-verbal
  - can be multimodal (language + gestures, pitch, expressions…)
- **collaborative**, social
  - participants aim at communicative goal(s)
  - involves inference about intended meanings
- **practical**, related to actions
- **interactive**, incremental, messy!

Dialogue systems – simpler than that

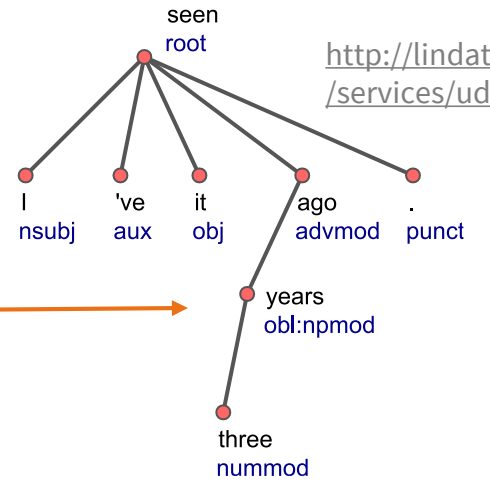
Describing a dialogue

- Levels of linguistic description
  - **phonetics / phonology** – sounds
  - **morphology** – word forms
  - **syntax** – sentence structure
  - **semantics** – sentence (propositional) meaning
  - **pragmatics** – meaning in context, communication goal

[ə] [oʊ] [ð] [iː] [n]

ag**o** **th**r**ee** see**n**

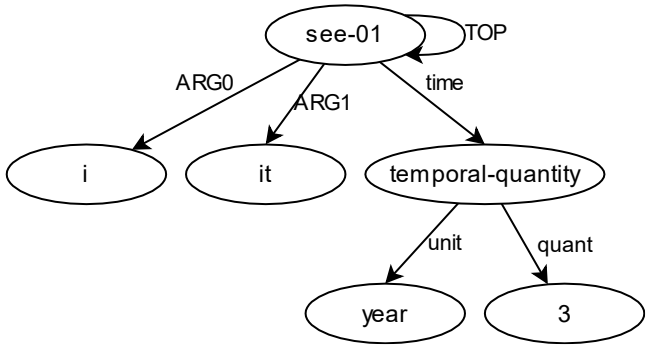
adverb *numeral* *verb-past*



http://lindat.mff.cuni.cz/services/udpipe/

- This lecture is (a lot) about **pragmatics**

(I don't remember it well)



http://cohort.inf.ed.ac.uk/amreager.html

Turn-taking (interactivity)

- Speakers **take turns** in a dialogue
  - **turn** = continuous utterance from one speaker
- Normal dialogue – very fluent, fast
  - minimizing **overlaps** & **gaps**
    - little silence (usually <250ms), little overlap (~5%)
    - (fuzzy) rules, anticipation
  - cues/markers for turn boundaries:
    - linguistic (e.g. finished sentence), voice pitch
    - timing (gaps)
    - eye gaze, gestures (…)
- overlaps happen naturally
  - ambiguity in turn-taking rules (e.g. two start speaking at the same time)
  - **barge-in** = speaker starts during another one's turn

Turn-taking (example)

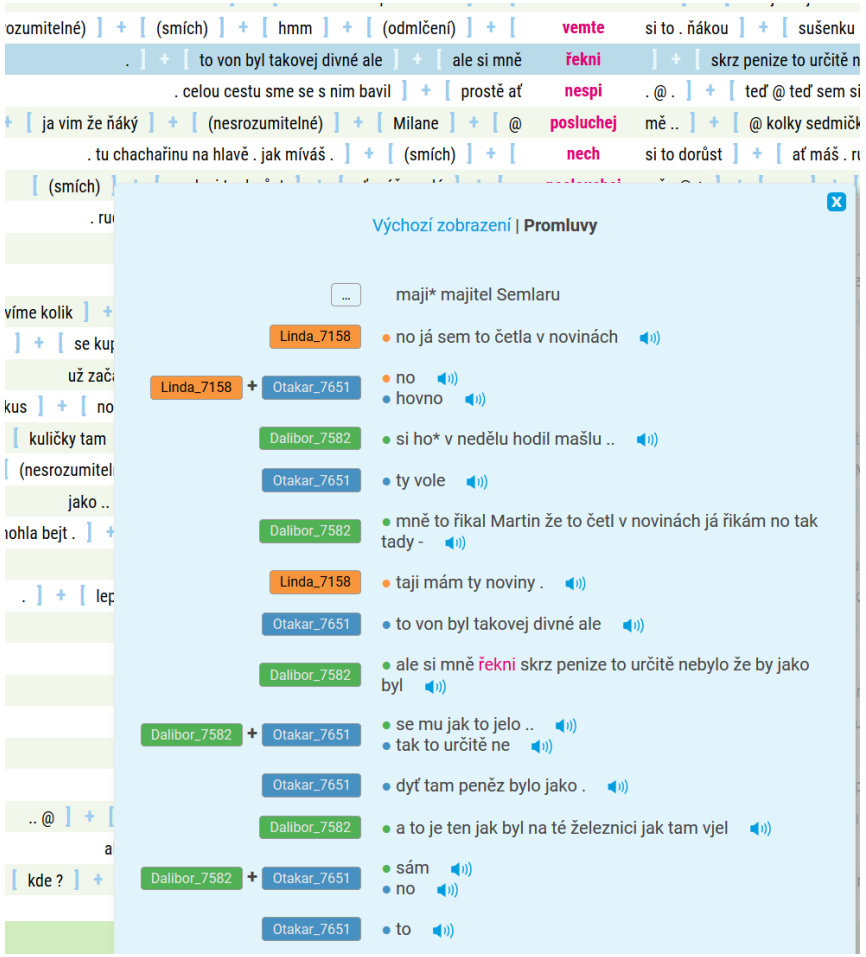
https://youtu.be/BZF9eg35IXI?t=91

20 seconds of a semi-formal dialogue (talk show):

S: um uh , you're about to start season [six ,]
J: [yes]
S: you probably already started but [it launches]
J: [yes thank you]
A: *(cheering)*
J: we're about to start thank you yeah .. we're starting , we- on Sunday yeah , we've been eh- we've been prepping some [things]
S: [confidence] is high . feel good ?
J: *(scoffs)*
S: think you're gonna
[squeeze out the shows this time ? think you're gonna do it ?]
J: *(laughing)* [you're talking to me like I'm an a-]
confidence high ? no !
S: [no]
J: [my confidence] is never high .
S: okay
J: self loathing high . concern astronomic .

Speech vs. text

- Natural speech is **very different from written text**
  - ungrammatical
  - restarts, hesitations, corrections
  - overlaps
  - pitch, stress
  - accents, dialect
- See more examples in speech corpora
  - https://kontext.korpus.cz/ (Czech)
  - select the “oral” corpus and search for a random word



Turn taking in dialogue systems

- consecutive turns are typically assumed
  - system waits for user to finish their turn (~250ms non-speech)
- **voice activity detection**
  - binary classification problem – "is it user's speech that I'm hearing?"[Y/N]
  - segments the incoming audio (checking every *X* ms)
  - actually a hard problem
    - nothing ever works in noisy environments
- **wake words** – making VAD easier
  - listen for a specific phrase, only start listening after it
- some systems allow user's barge-in
  - may be tied to the wake word

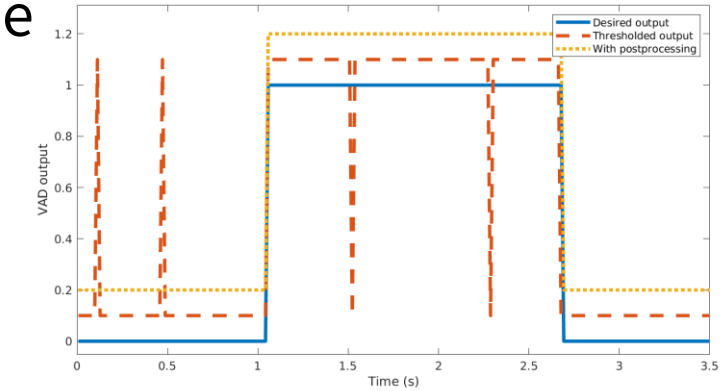
hey Siri
okay Google
Alexa

Voice activity detection

- **Overlapping windows of ~30ms + binary classifier**
- Features – actually similar to speech recognition itself
  - energy (loudness)
  - autocorrelation
  - checking for fundamental voice frequency
  - MFCCs (mel frequency spectrum)
  - deltas (trends over time)

https://wiki.aalto.fi/pages/viewpage.action?pageId=151500905

- **Onset is easier to detect** than end of speech
  - they're louder, more pronounced
  - hard to detect speech towards the system vs. someone else
    - that's why wake words are used
  - how long can pauses/hesitations be?
- Postprocessing
  - smoothing out short-term errors



Speech acts (by John L. Austin & John Searle)

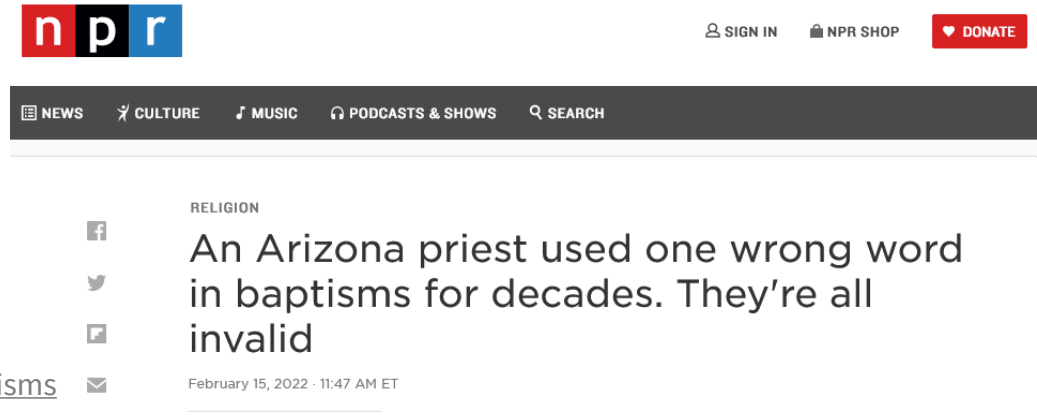
- each utterance is an **act**
  - intentional
  - changing the state of the world
    - changing the knowledge/mood of the listener (at least)
    - influencing the listener's behavior
- speech acts consist of:
  - **a) utterance** act = the actual uttering of the words
  - **b) propositional** act = semantics / "surface" meaning
  - **c) illocutionary** act = "pragmatic" meaning
    - e.g. command, promise […]
  - **d) perlocutionary** act = effect
    - listener obeys command, listener's worldview changes […]

X to Y: *You're boring!*
a) [jʊr 'bɔrɪŋ]
b) boring(Y)
c) statement
d) Y is cross

X to Y: *Can I have a sandwich?*
a) [kæn aɪ hæv ə 'sændwɪʧ]
b) can_have(X, sandwich)
c) request
d) Y gives X a sandwich

Speech acts

- Types of speech acts:
  - **assertive**: speaker commits to the truth of a proposition — *It's raining outside.*
    - statements, declarations, beliefs, reports […]
  - **directive**: speaker wants the listener to do something — *Stop it!*
    - commands, requests, invitations, encouragements
  - **commissive**: speaker commits to do something themselves — *I'll come by later.*
    - promises, swears, threats, agreements
  - **expressive**: speaker expresses their psychological state — *Thank you!*
    - thanks, congratulations, apologies, welcomes
  - **declarative**: performing actions ("performative verbs") — *You're fired!*
    - sentencing, baptizing, dismissing



https://www.npr.org/2022/02/15/1080829813/priest-resigns-baptisms

Speech acts

- Explicit vs. implicit
  - explicit – using a verb directly corresponding to the act
  - implicit – without the verb

explicit: *I **promise** to come by later.*
implicit: *I'll come by later.*

explicit: *I'm **inviting** you for a dinner.*
implicit: *Come with me for a dinner!*

- Direct vs. indirect
  - **indirect** – the surface meaning does not correspond to the actual one
    - primary illocution = the actual meaning
    - secondary illocution = how it's expressed
  - reasons: politeness, context, familiarity

direct: *Please close the window.*
indirect: *Could you close the window?*
even more indirect: *I'm cold.*

direct: *What is the time?*
indirect: *Have you got a watch?*

Conversational Maxims (by Paul Grice)

- based on Grice's **cooperative principle** ("dialogue is cooperative")
  - speaker & listener cooperate w. r. t. communication goal
  - speaker wants to inform, listener wants to understand
- 4 Maxims (basic premises/principles/ideals)
  - M. of **quantity** – don't give too little/too much information
  - M. of **quality** – be truthful
  - M. of **relation** – be relevant
  - M. of **manner** – be clear

https://youtu.be/IJEaMtNN_dM

- By default, speakers are assumed to adhere to maxims
  - apparently breaking a maxim suggests a different/additional meaning

Conversational Implicatures

- **implicatures** = implied meanings
  - standard – based on the assumption that maxims are obeyed
  - maxim flouting (obvious violation) – additional meanings (sarcasm, irony)

John ate some of the cookies → [otherwise too little/low-quality information] not all of them

A: *I've run out of gas.*
B: *There's a gas station around the corner.* → [otherwise irrelevant] the gas station is open

A: *Will you come to lunch with us?*
B: *I have class.* → [otherwise irrelevant] B is not coming to lunch

A: *How's John doing in his new job?*
B: *Good. He didn't end up in prison so far.* → [too much information] John is dishonest / the job is shady

Speech acts & maxims & implicatures in dialogue systems

- Learned from data / hand-coded
- **Understanding**
  - tested on real users → usually knows indirect speech acts
  - **implicatures limited** – there's no common sense
    - (other than what's hand-coded or found in training data)

      system: *The first train from Edinburgh to London leaves at 5:30 from Waverley Station.*
      user: *I don't want to get up so early.* → [fails]

- **Responses**
  - mostly strive for clarity – user doesn't really need to imply

Grounding

- dialogue is cooperative → need to ensure mutual understanding
- **common ground** = shared knowledge, mutual assumptions of dialogue participants
  - not just shared, but *knowingly* shared
  - $x \in$ CG(A, B):
    - A & B must know *x*
    - A must know that B knows *x* and vice-versa
  - expanded/updated/refined in an informative conversation
- validated/verified via **grounding signals**
  - speaker **presents** utterance
  - listener **accepts** utterance by providing evidence of understanding

Grounding signals / feedback

- used to notify speaker of (mis)understanding
- positive – understanding/acceptance signals:
  - **visual** – eye gaze, facial expressions, smile […]
  - **backchannels** – particles signalling understanding — *uh-uh, hmm, yeah*
  - **explicit feedback** – explicitly stating understanding — *I know, Yes I understand*
  - **implicit feedback** – showing understanding implicitly in the next utterance

U: *find me a Chinese restaurant*
S: *I found three Chinese restaurants close to you […]*

A: *Do you know where John is?*
B: *John? Haven't seen him today.*

- negative – misunderstanding:
  - **visual** – stunned/puzzled silence
  - **clarification requests** – demonstrating ambiguity & asking for additional information

A: *Do you know where John is?*
B: *Do you mean John Smith or John Doe?*

  - **repair requests** – showing non-understanding & asking for correction

Oh, so you're not flying to London? Where are you going then?

Grounding (example)

T: [...] And the ideology is also very against mixed-race couples. So that was also a target. Whenever we saw mixed-race couples, we attacked them.

E: Was there ever a moment back there where you felt a tiny bit bad about it?

T: No.

E: **No? So you were** absolutely convinced that you're doing the right thing…

T: Yeah, for quite some time **(nods)**, **yeah**.

E: … for the sake of the white race and et cetera?

E: No doubt at all?

T: Well I got **doubt** eventually, roughly a year before I left the movement [...]

https://video.aktualne.cz/dvtv/cernoch-mi-miril-pistoli-na-hlavu-nevim-proc-me-nezabil-rika/r~d87679def2fd11e8a7f60cc47ab5f122/ (2:45 and onwards)

Grounding in dialogue systems

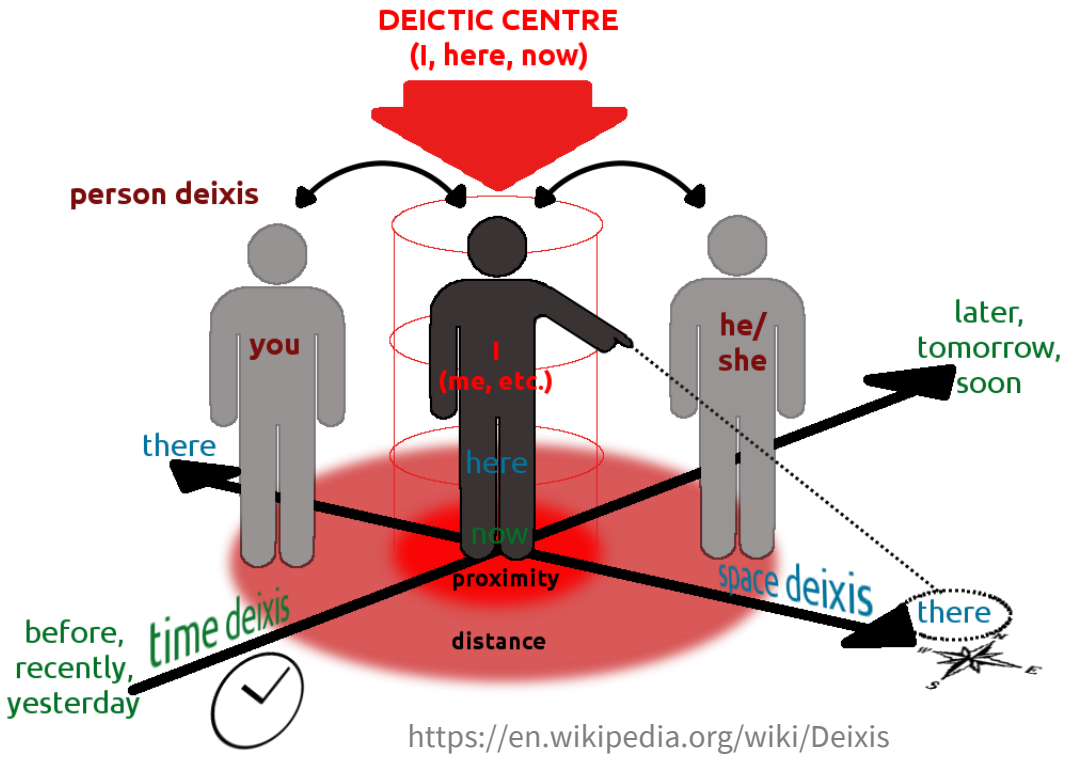
- Crucial for successful dialogue
  - e.g. booking the right restaurant / flight
- Backchannels / visual signals typically not present
- **Implicit confirmation** very common
  - users might be confused if not present
- **Explicit confirmation** may be required for important steps
  - e.g. confirming a reservation / bank transfer
- **Clarification & repair requests** very common
  - when input is ambiguous or conflicts with previously said
- Part of dialogue management
  - uses NLU confidence in deciding to use the signals

Deixis

- **deixis** = “pointing” – relating between language & context/world
  - this is very important in dialogue
  - dialogue is typically set/situated in a specific context
- **deictic expressions** = words/grammar expressing deixis
  - their meaning depends on the context
    - who is talking, when, where
  - pronouns — *I, you, him, this*
  - verbs: tense & person markers — *goes* [3rd ps. sg.], *went* [past]
  - adverbs — *here, now, yesterday*
  - other (lexical meaning) — *come / go* [=here/away],
  - non-verbal (gestures, gaze…)

Deixis

- (typically) **egocentric**:
  I – here – now is the center (**origo**)
- main types of deixis:
  - **personal** – *I/me/you/she…*
  - **temporal** (time) – *now, yesterday, later, on Monday…*
  - **local** (space) – *here, there…*
- other:
  - **social** (politeness)
    - formal/informal address (Cz. *ty/vy*, Ger. *du/Sie*), honorifics in Asian languages
  - **discourse/textual**
    - referring to words/portions of texts – *next chapter, how do you spell that?*



https://en.wikipedia.org/wiki/Deixis

https://glossary.sil.org/term/discourse-deixis

Anaphora/Coreference

- expression referring to something mentioned in context
  - **anaphora** = referring back
  - **cataphora** = referring forward
- avoiding repetition, faster expression
- can refer to basically anything
  - objects/persons/events
  - qualities
  - actions/full sentences/portions of text
- used frequently in dialogue
- may be ambiguous

*Susan dropped the plate. **It** shattered.*

***His** friends describe John as smart and hard-working.*

*I don't like it as much as he **does**.*

*Her dress is green. **So** is mine.*

*– Shall I book a room for you? – Sure, I'd like **that**.*

*Bill stands next to John. **He** is tall.*
*Bill tickled John. **He** squirmed.*

(Smaby, 1978)
https://link.springer.com/chapter/10.1007/978-94-009-9775-2_2

Deixis & anaphora in dialogue systems

- systems typically assume a **single user**
  - this makes personal deixis much easier
- most systems are aware of time, location is more complicated
  - pronouns are often avoided – clearer, although less natural
- coreference resolution – separate problem
  - a whole area of research, specific resolution systems developed
  - some dialogue systems don’t include it, some do, sophistication varies

Prediction

- Dialogue is a **social interaction**
  - people view dialogue partners as goal-directed, intentional agents
  - they analyze their partners' goals/agenda
- Brain does not listen passively
  - projects hypotheses/interpretations on-the-fly
- **prediction** is crucial for human cognition
  - people predict what their partner will (or possibly can) say/do
  - continuously, incrementally
  - unconsciously, very rapidly
  - guides the cognition
- this is (part of) why we understand in adverse conditions
  - noisy environment, distance

Entropy (Claude Shannon)

- Information theory: dialogue is information transfer
  - **communication channel** – speaker to listener (in the given situation)
  - **entropy** – expected value of information conveyed (in bits)

$$H(\text{text}) = -\sum_{\text{word} \in \text{text}} \frac{\text{freq}(\text{word})}{\text{len}(\text{text})} \log_2 \left(\frac{\text{freq}(\text{word})}{\text{len}(\text{text})} \right)$$

over vocabulary

X X X X : entropy = 0
W X Y Z : entropy = 2

- Plays well with the social interaction perspective
  - people tend to **use all available channel capacity**
    - limiting factors: noise, listener's hearing ability, mental capacity
  - people tend to **spread information evenly**
    - words carrying more information are emphasized

Conditional entropy

- how hard it is to guess the next word in the sentence?
  - given preceding context (n-gram)
  - related to Shannon entropy, but may differ
    - typically much lower than Shannon entropy
  - better estimate of prediction difficulty
    - although humans work with “unlimited” preceding context and reevaluate using following context

<s> The cat sat on the mat .
P(cat | <s> The)
P(sat | the cat)
P(on | the cat sat)
P(the | the cat sat on)

$$H_{\text{cond}}(\text{text}) = -\sum_{(c,w)\in\text{text}} \frac{\text{freq}(c,w)}{\text{len}(\text{text})} \log_2 \left(\frac{\text{freq}(c,w)}{\text{freq}(c)} \right)$$

# of times word w occurs after context c

means # of n-grams here (not just words)

context (preceding n-gram)

word

total # of times context c occurs, with or without word w

Prediction in dialogue systems

- Used a lot in speech recognition
  - **language models** – based on information theory
    - statistical, trained on a text corpus (bunch of texts)
  - predicting likely next word given context
  - weighted against acoustic information
- Not as good as humans
  - may not reflect current situation (noise etc.)
  - (often) does not adapt to the speaker
- Less use in other DS components

Alignment/entrainment

- People subconsciously **adapt/align/entrain** to their dialogue partner over the course of the dialogue
  - wording (lexical items)
  - grammar (sentential constructions)
  - speech rate, prosody, loudness
  - accent/dialect

pram → stroller [BrE speaker
lorry → truck talking to AmE speaker]

S: *[…] Confidence is high, feel good?*
[…]
J: ***Confidence high**? No!*
S: *No.*
J: *My **confidence is** never **high**.*
S: *Okay.*
J: ***Self loathing high**, concern astronomic.*

- This helps a successful dialogue
  - also helps social bonding, feels natural

(Oppenheim & Jones, 2018)
http://oppenheim-lab.bangor.ac.uk/pubs/OppenheimJones_2018_COM_Americanisms_poster.pdf

Alignment in dialogue systems

- Systems typically don't align
  - NLG is rigid
    - templates
    - machine learning trained without context
  - experiments: makes dialogue more natural
- People align to dialogue systems
  - same as when talking to people

(Dušek & Jurčíček, 2016)
http://www.aclweb.org/anthology/W16-3622

context	*is there a later option*
response DA	implicit_confirm(alternative=next)
base NLG	Next connection.
+ alignment	You want a later option.

context	*I need to find a bus connection*
response DA	inform_no_match(vehicle=bus)
base NLG	No bus found, sorry.
+ alignment	I'm sorry, I cannot find a bus connection.

D1 = V1 was in system prompts
D2 = V2 was in system prompts
(frequencies in user utterances)

Words	D1 Freq. (% rel. Freq)	D2 freq (% rel. Freq)
V1: next	13204 (99.9%)	492 (82.9%)
V2: following	3 (0.1%)	101 (17.1%)
V1: previous	3066 (100%)	78 (44.8%)
V2: preceding	0 (0%)	96 (55.2%)
V1: now	6241 (99.8%)	237 (80.1%)
V2: immediately	10 (0.2%)	59 (19.9%)
V1:leaving	4843 (98.4%)	165 (70.8%)
V2: departing	81 (1.6%)	68 (29.2%)
V1: route/schedule	2189 (99.9%)	174 (94.5%)
V2: itinerary	2 (0.1%)	10 (5.5%)
V1: okay/correct	1371 (49.3%)	48 (27.7%)
V2: right	1409 (50.7%)	125 (72.3%)
V1: help	2189 (99.9%)	17 (65.3%)
V2: assistance	1 (0.1%)	9 (34.7%)
V1: query	6256 (99.9%)	70 (20.4%)
V2: request	3 (0.1%)	272 (79.6%)

(Parent & Eskenazi, 2010)
https://www.isca-speech.org/archive/interspeech_2010/i10_3018.html

Politeness

- Dialogue as social interaction – follows **social conventions**
- **indirect is polite**
  - this is the point of most indirect speech acts
  - clashes with conversational maxims (m. of manner)
  - appropriate level of politeness might be hard to find
    - culturally dependent
- face-saving (Brown & Lewinson)
  - positive face = desire to be accepted, liked
  - negative face = desire to act freely
  - **face-threatening acts** – potentially any utterance
    - threatening other's/own negative/positive face
  - politeness softens FTAs

Open the window.
Can you open the window?
Would you be so kind as
to open the window?
Would you mind closing the window?

threat to	positive face	negative face
self	*apology, self-humiliation*	*accepting order / advice, thanks*
other	*criticism, blaming*	*order, advice, suggestion, warning*

Politeness in dialogue systems

- Typically **handcrafted** by system design
  - does not adapt to situation very much
  - typically not much indirect speech, but trying to stay polite
- Learning from data can be tricky
  - **check your data** for offensive speech!
  - not just swearwords – problems can be hard to find

Microsoft Tay Twitter chatbot
(learning from users)
https://en.wikipedia.org/wiki/Tay_(bot)

I already have a woman to sleep with.

(Experimental chatbot we trained
at Heriot-Watt using Reddit data)

Summary

- Dialogue is messy
  - **turn** overlaps, **barge-ins**, weird grammar […]
- Dialogue utterances are acts
  - **illocution** = pragmatic meaning
- Dialogue needs understanding
  - **grounding** = mutual understanding management
    - **backchannels**, **confirmations**, **clarification**, **repairs**
- Dialogue takes place in context
  - lot of pointing – **deixis**
- Dialogue is cooperative, social process
  - **conversational maxims** ~ “play nice”
  - all while following **social conventions** (politeness)
  - people **predict & adapt** to each other
- Next week: language understanding

Thanks

Contact us:

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Skype/Meet/Zoom (by agreement)

Labs in 10 mins

Get the slides here:

https://ufal.cz/npfl123

References/Inspiration/Further:

Apart from materials referred directly, these slides are based on:

- Pierre Lison's slides (Oslo University): https://www.uio.no/studier/emner/matnat/ifi/INF5820/h14/timeplan/index.html
- Ralf Klabunde's lectures and slides (Ruhr-Universität Bochum): https://www.linguistics.ruhr-uni-bochum.de/~klabunde/lehre.htm
- Filip Jurčíček's slides (Charles University): https://ufal.mff.cuni.cz/~jurcicek/NPFL123-SDS-2014LS/
- Arash Eshghi & Oliver Lemon's slides (Heriot-Watt University): https://sites.google.com/site/olemon/conversational-agents
- Gina-Anne Levow's slides (University of Washington): https://courses.washington.edu/ling575/
- Eika Razi's slides: https://www.slideshare.net/eikarazi/anaphora-and-deixis
- Wikipedia: Anaphora_(linguistics) Conversation Cooperative_principle Coreference Deixis Grounding_in_communication Implicature Speech_act Sprechakttheorie