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AN EMPIRICAL ANALYSIS OF THE CORRELATION OF SYNTAX AND PROSODY

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MAIN IDEA

Are words spoken differently depending on their syntactic function?

E.g., **do subjects prosodically differ from objects?** (significantly and all other aspects being equal).

We examine **pitch**, **power**, **duration** of a word, and the length of the **pause** after it. → low-level and objective

We model the acoustic properties using textual features, **with/without syntactic function**.
Significantly better model → significant correlation

			det↗	attr↗				aux↗…		
		subj~obja	…↗(subj~obja)		s~neb	s~rel	s~aux	(s~neb)	(s~rel)	(s~aux)
pitch	p-value	***	ns	**	ns	***	ns	ns	***	***
	effect in Cent	19.38	—	25.14	—	39.38	—	—	22.81	53.77
power	p-value	***	0.06	*	*	***	ns	ns	ns	ns
	effect in dB	-0.01	0.005	0.01	0.01	0.02	—	—	—	—
duration	p-value	***	***	ns	***	***	***	0.12	***	*
	effect in ms	35.42	-14.62	—	-17.8	-23.03	-29.32	15.88	19.03	30.04
pause	p-value	*	**	ns	ns	*	***	ns	***	ns
	effect in ms	3.81	6.14	—	—	-5.52	-10.17	—	10.73	—

STATISTICAL APPROACH

likelihood ratio test: basic and extended model to fit property, check merit of extension

basic:
property ~ 1 + *textual features* + *speaker normalization*

extended:
property ~ *basic* + *syntactic function*

We then

- Compare goodness of fit of *basic* vs. *extended*
- fit(*extended*) ≫ fit(*basic*) → significance
- coefficient of syntactic function → effect size

Textual features for estimation:

- **predicted word duration**: "expected" word length as per MaryTTS (*tpred*)
- Word **position** in sentence and **sentence length**: "late" words spoken differently from "early" ones (*wpos* and *slength*)

Normalization to account for speaker variation:

- z-normalized pitch (in semitones)
- condition *tpred* on article to normalize for tempo

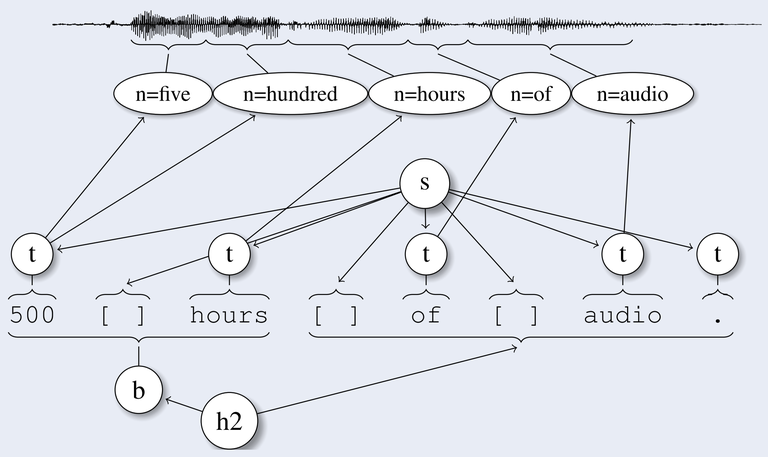
E.g. *duration* ~ 1 + *tpred* ∗ *wpos* ∗ *slength* + (*tpred*|*article*)

DATA SOURCE

Spoken Wikipedia Corpus for German:

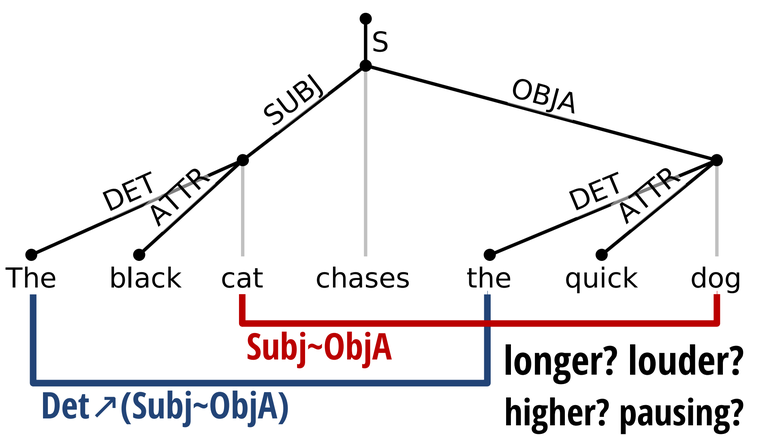
- 46 h of segmentally aligned speech
- 31,803 sentences
- 348,062 word tokens

(out of 386 h of total audio in >1000 spoken articles).



Parsed with TurboParser trained on the **Hamburg Dependency Treebank**. Audio features extracted with `SNACK`.

EXAMPLE



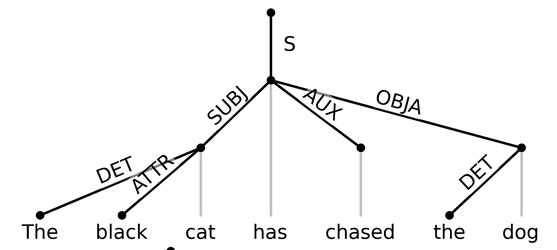
We compare words that can occur in two syntactic funtions (e.g., **Subj~Obj**).

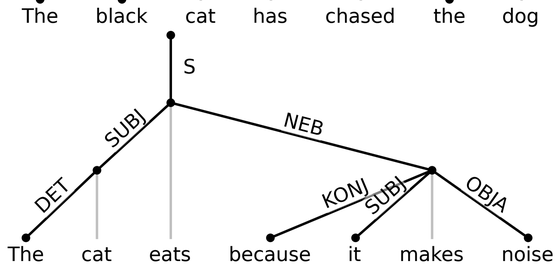
We also compare words with the same function but attached to words with different functions (e.g., **Det↗(Subj~ObjA)**).

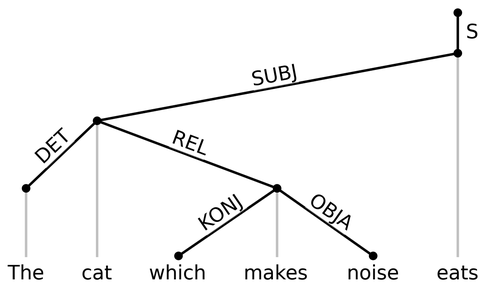
We aggregate over all sentences, i.e., different syntactic functions need not occur in the same sentence (as in the example).

Examples for **verb function**:

s: verb or auxiliary that is the head of a sentence
aux: full verb attached to an auxiliary
neb: verb that heads a subordinate phrase
rel: verb that heads a relative clause







ANALYSIS AND DISCUSSION

Highly significant effects!

Effect sizes often well above *just noticeable difference* for pitch and tempo; other effects might subconciously help in disambiguation.

Regarding nouns and words modifying nouns:

Subjects are longer and higher pitched than objects (accusative objects).

Signal power is slightly lower for subjects – maybe because energy is spread out further (longer duration)?

Determiners of subjects are significantly shorter – partially making up for the longer subjects?

Attributive adjectives of subjects are higher pitched, even more than the subject itself.

Regarding verbs:

All of *neb*, *rel*, and *aux* are spoken substantially longer than main verbs.

Verbs heading **subordinate phrases are most similar to full sentences**; the structural similarity is mirrored in prosody.

Relative clauses are **interjected phrases** that modify nouns. Their verbs are spoken with **lower pitch, less power and lengthened**, i.e., less pronounced, possibly to distinguish the additional information from the main content of the sentence.

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