Contributions of Propositional Content and Syntactic Categories in Sentence Processing

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Background

Expectation-based theories of sentence processing

- Processing difficulty is determined by predictability in context
- Can be quantified via *surprisal* (Shannon, 1948)

This work: A left-corner parser that incorporates both information about *propositional content* and *syntactic category labels* in generating surprisal estimates

Why propositional content?

- Comprehension entails building a coherent mental representation of propositional content (Kintsch, 1988)
- Propositional content rather than surface form stored during processing (Bransford & Franks, 1971; Jarvella, 1971)
- Parsing decisions are informed by semantic interpretation (Brown-Schmidt et al., 2002; Tanenhaus et al., 1995)

Left-corner Parser with Propositional Content

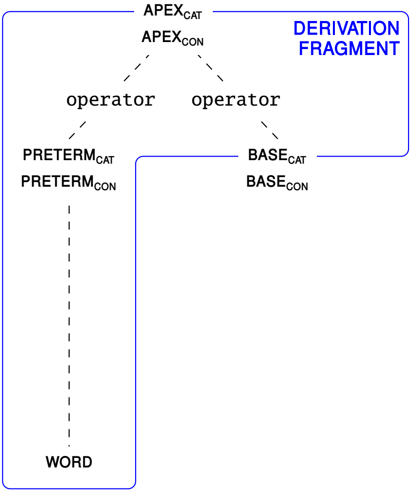
Each node in the parse tree has a *predicate context vector*

(Levy & Goldberg, 2014)

- Each element has the form of $predicate_{role}$, representing argument structure (e.g. $pour_2$)
- Argument structure derived from generalized categorial grammar reannotation (Bach, 1981; Nguyen et al., 2012)

The left-corner parser generates a predicate context vector for each word and propagates it along the parse tree

Full Model Overview



APEX_{CAT}
APEX_{CON}
DERIVATION FRAGMENT
operator
operator
$\text{PRETERM}_{\text{CAT}}$
$\text{PRETERM}_{\text{CON}}$
BASE_{CAT}
BASE_{CON}
WORD

Lexical phase

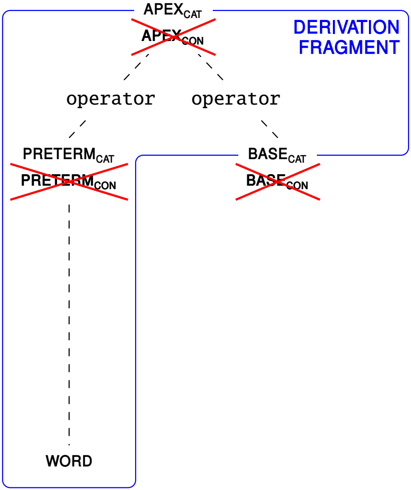
- Attach?
- Preterminal?
- Word?

Grammatical phase

- Attach?
- Operators?
- Apex?
- Base?

- Parsing decisions condition on both CONTENT and CATEGORY information
- For surprisal estimation, beam search is utilized to calculate prefix probabilities of a given word sequence (*FullSurp*)

Ablated Model 1: Content-ablated Model



Lexical phase

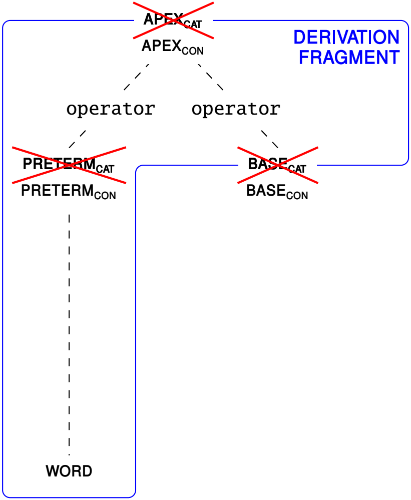
- Attach?
- Preterminal?
- Word?

Grammatical phase

- Attach?
- Operators?
- Apex?
- Base?

- Parsing decisions do not condition on CONTENT information
- Used to generate *NoConSurp* estimates

Ablated Model 2: Category-ablated Model



~~APEX$_{\text{CAT}}$~~

APEX$_{\text{CON}}$

DERIVATION FRAGMENT

operator operator

~~PRETERM$_{\text{CAT}}$~~

PRETERM$_{\text{CON}}$

~~BASE$_{\text{CAT}}$~~

BASE$_{\text{CON}}$

WORD

Lexical phase

- Attach?
- Preterminal?
- Word?

Grammatical phase

- Attach?
- Operators?
- Apex?
- Base?

- Parsing decisions do not condition on CATEGORY information
- Used to generate *NoCatSurp* estimates

Training Setup

Full, content-ablated, category-ablated models trained on WSJ02-21 (Marcus et al., 1993)

- 39,832 sentences
- 950,028 words
- Reannotated to generalized categorial grammar (Nguyen et al., 2012)
- Each variant trained with three random seeds for initialization

FullSurp, *NoConSurp*, and *NoCatSurp* estimated using beam search

Psycholinguistic Evaluation

Does propositional content or syntactic category information contribute to predicting human behavioral responses?

Evaluation on Natural Stories Corpus (Futrell et al., 2018)

- Self-paced reading times from 181 participants
- 485 sentences
- 10,245 words

Series of likelihood ratio tests based on linear mixed-effects models

- Full LME model: *NoConSurp* or *NoCatSurp* + *FullSurp*
- Base LME model: *NoConSurp* or *NoCatSurp* only

LRT Results

NoConSurp only vs. *NoConSurp* + *FullSurp*

	FullSurp		
NoConSurp	1	2	3
1	*ConvFail*	0.035^{*}	0.018^{*}
2	0.004^{**}	*ConvFail*	0.047^{*}
3	0.003^{**}	0.058	0.036^{*}

NoCatSurp only vs. *NoCatSurp* + *FullSurp*

	FullSurp		
NoCatSurp	1	2	3
1	*ConvFail*	$<0.001^{***}$	*ConvFail*
2	$<0.001^{***}$	$<0.001^{***}$	$<0.001^{***}$
3	*ConvFail*	$<0.001^{***}$	$<0.001^{***}$

- Suggests a differential role of propositional content and syntactic category information in broad-coverage sentence processing
- Future work could aim to localize the influence of these information

Thank you for listening!

Source code:
`https://github.com/modelblocks/modelblocks-release`

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