Computational Approaches for Understanding Semantic Constraints on Two-termed Coordination Structures

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Text, Speech and Dialogue 2022

Part 1: Introduction

- Two-termed Coordination
- LCL
- Motivation and Goal

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Coordination groups two or more phrases together:

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Would you like
[NP soup] or [NP salad]?

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Conjuncts

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Conjuncts

Coordinating Conjunction

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Law of Coordination of Likes (LCL)

mandates like conjunct categories

(Prazmowska, 2015; Williams, 1981)

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Law of Coordination of Likes (LCL) mandates like conjunct categories

What about ungrammatical like coordinations…

* John ate with [NP his mother] and [NP good appetite].

(Prazmowska, 2015; Williams, 1981)

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Motivation: computational approaches have revealed syntactic patterns in coordination

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Goal: what can computational approaches tell us about semantics?

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Motivation: computational approaches have revealed syntactic patterns in coordination

Goal: what can computational approaches tell us about semantics? Patterns in conjunction or categories?

Part 2: Background and Related Work

- Basic Types of Coordination
- Computational Methods

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Basic types of coordination, distinguished by conjunction:

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- *and*: links equal elements

(Haspelmath 2007)

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Basic types of coordination, distinguished by conjunction:

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- *or*: mutually-exclusive options

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Basic types of coordination, distinguished by conjunction:

- *and*: links equal elements
- *or*: mutually-exclusive options
- *but*: displays semantic contrast

(Haspelmath 2007)

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***And*-coordinations** have the most general meaning and can take different connotations in context

(Quirk et al. 1985)

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***And*-coordinations** have the most general meaning and can take different connotations in context

Contrastive temporal sequence:

She [VP tried hard] ***but*** [NP failed].

(Quirk et al. 1985)

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***And*-coordinations** have the most general meaning and can take different connotations in context

Contrastive temporal sequence:

She [VP tried hard] ***and*** [NP failed].

(Quirk et al. 1985)

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***Or*-coordinations** are not always disjunctive

Not mutually-exclusive options:

Do you have any
[NP brothers] ***or*** [NP sisters]?

(Quirk et al. 1985)

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Our previous computational approaches focused on **syntax**

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Our previous computational approaches focused on **syntax**

LCL does not account for grammatical, syntactically unlike coordinations...

John is [AP healthy] and
[PP in good shape].

(Prazmowska, 2015; Williams, 1981)

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Our previous findings show anti-symmetry of coordination syntax:

(Kallini & Fellbaum 2021)

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Our previous findings show anti-symmetry of coordination syntax:

- NPs tend to coordinate with subordinate clauses

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Our previous findings show anti-symmetry of coordination syntax:

- NPs tend to coordinate with subordinate clauses

  I agree with [NP the president] and [SBAR what he did].

(Kallini & Fellbaum 2021)

Part 2: Background and Related Work

- Basic Types of Coordination
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Our previous findings show anti-symmetry of coordination syntax:

- The 1st conjunct tends to be shorter than the 2nd conjunct
- Support for theories of grammatical weight

(Kallini & Fellbaum 2021)

Part 3: Approach

- Overview
- UD corpora
- Coordination Extraction
- Semantic Analysis

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Key Idea: process and analyze corpus data to study the *semantic* properties of coordination in English

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- Extracting coordinations from Universal Dependencies corpora

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Key Idea: process and analyze corpus data to study the *semantic* properties of coordination in English

- Extracting coordinations from Universal Dependencies corpora
- Measure relatedness using WordNet and word embeddings

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Universal Dependencies (UD):

(Nivre et al., 2020)

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Universal Dependencies (UD):

- Provides consistent dependency annotation across sources

(Nivre et al., 2020)

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Universal Dependencies (UD):

- Provides consistent dependency annotation across sources
- Enhanced dependencies of UD v2 augment the conjunct relations

(Nivre et al., 2020)

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UD data sources:

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UD data sources:

- English Web Treebank (EWT)

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- English Parallel Universal Dependencies (PWT) treebank

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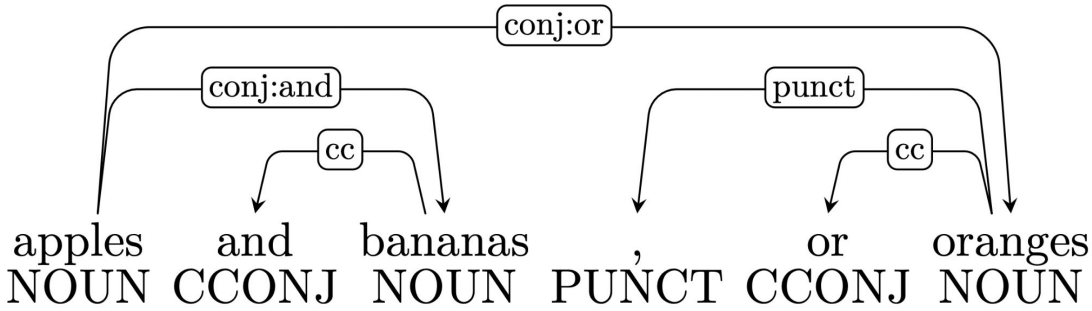
Coordination Extraction:



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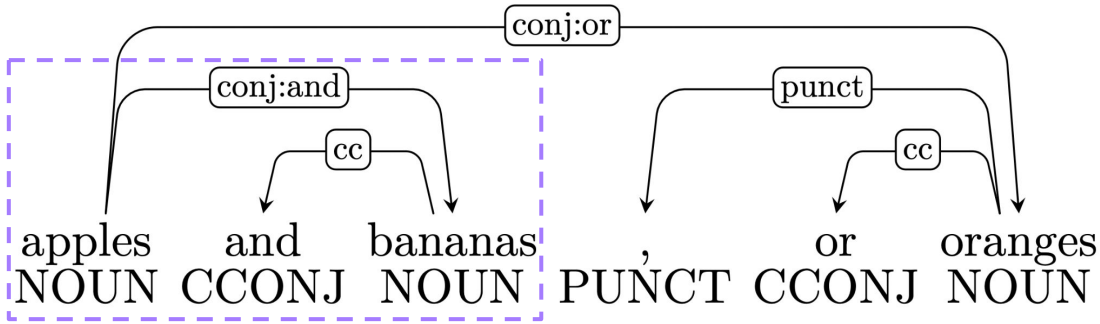

Nested Phrase

(Nivre et al., 2020)

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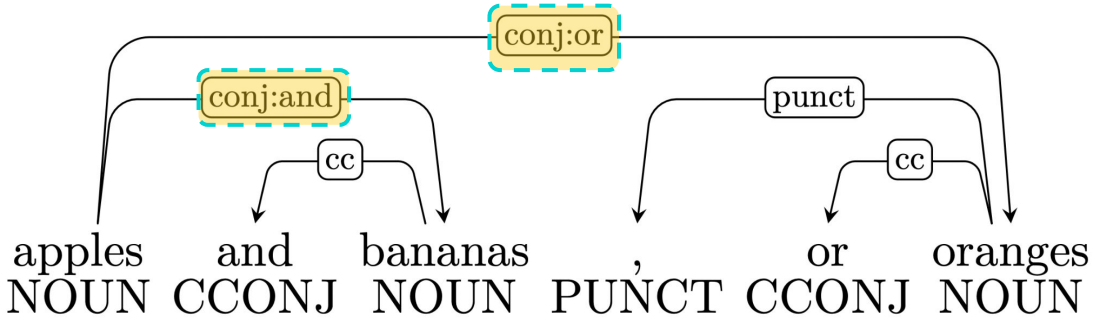

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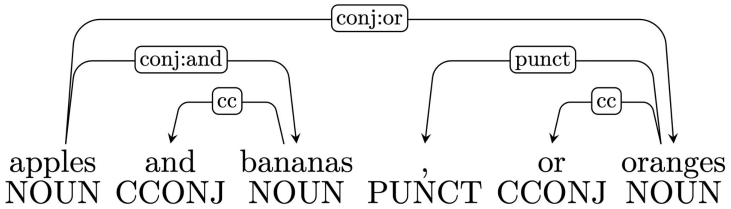

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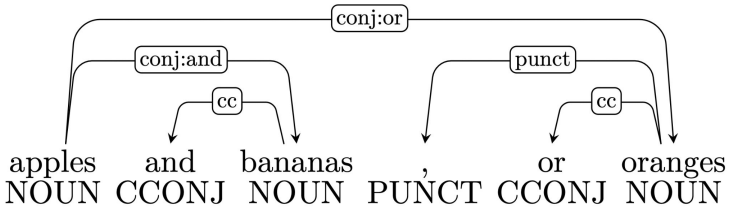

1st Conjunct Category	1st Conjunct Text	2nd Conjunct Category	2nd Conjunct Text	Conjunction

(Nivre et al., 2020)

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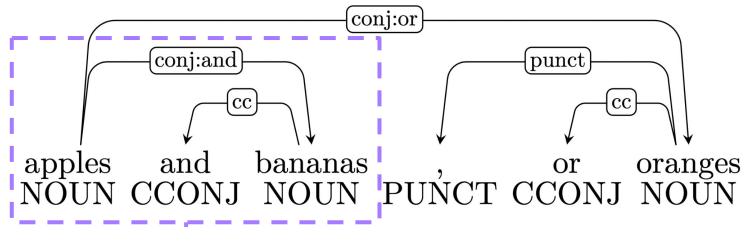

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NOUN	apples	NOUN	bananas	and

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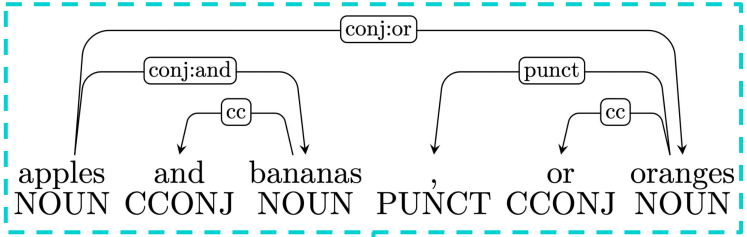

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NOUN	**apples**	**NOUN**	**oranges**	**or**

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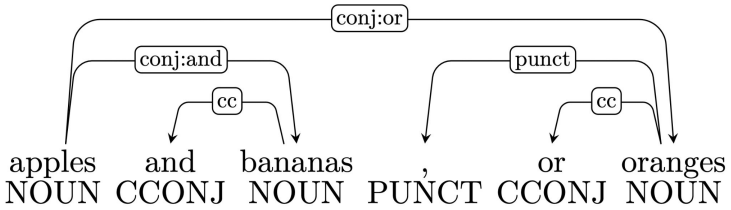

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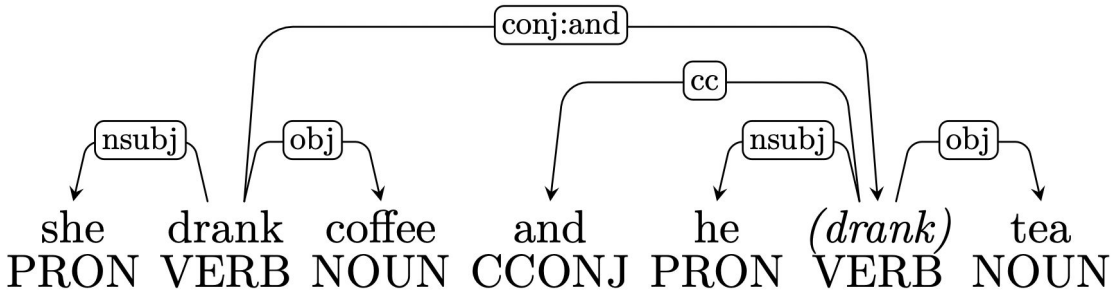
Improved Ellipsis Annotation:



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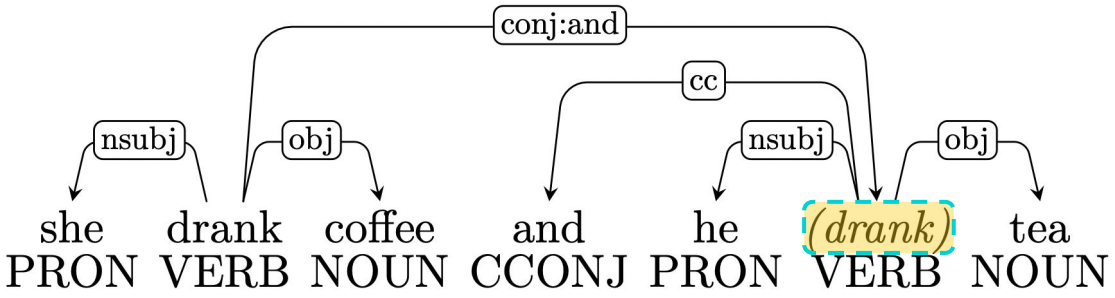

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Employ **two representations of words** for semantic analysis

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Employ **two representations of words** for semantic analysis

- WordNet links words through conceptual relations

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Employ **two representations of words** for semantic analysis

- WordNet links words through conceptual relations
- Word embeddings represent similarity based on the contexts in which two words appear

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WordNet Relations

Relations used in this project:

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WordNet Relations

Relations used in this project:

- Asymmetric relation:
  - Hypernymy/hyponymy

vehicle + car

move + run

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WordNet Relations

Relations used in this project:

- Symmetric relations:
  - Synonymy
  - Antonymy
  - Co-hyponymy

car + automobile

friend + ally

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WordNet Relations

Relations used in this project:

- Symmetric relations:
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small + large

wet + dry

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WordNet Relations

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red + *blue*

apple + *banana*

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Word Embeddings

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Word Embeddings

- Google's Word2Vec embeddings
- Use cosine similarity to test relationship between conjuncts

Part 4: Results and Discussion

- Overview
- WordNet Analysis
- Word Embedding Analysis

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General Results:

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- 6,892 coordinations in total

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- 6,892 coordinations in total
- 6,641 (96.4%) coordinations in WordNet
- 27 coordinations (0.4%) include one elided conjunct

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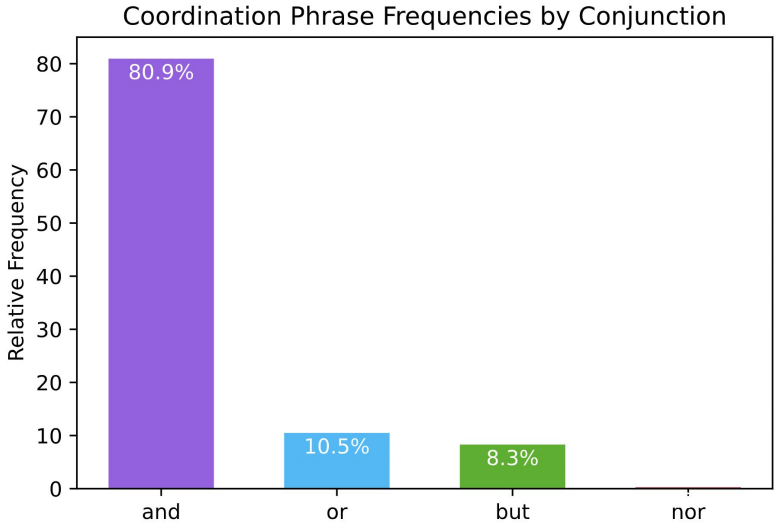
General Results:



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WordNet Analysis by Conjunction:

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WordNet Analysis by Conjunction:

- Examine association between WordNet relations and types of coordinating conjunctions

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WordNet Analysis by Conjunction:

- Examine association between WordNet relations and types of coordinating conjunctions
- Applies to synonymy, antonymy, and co-hyponymy

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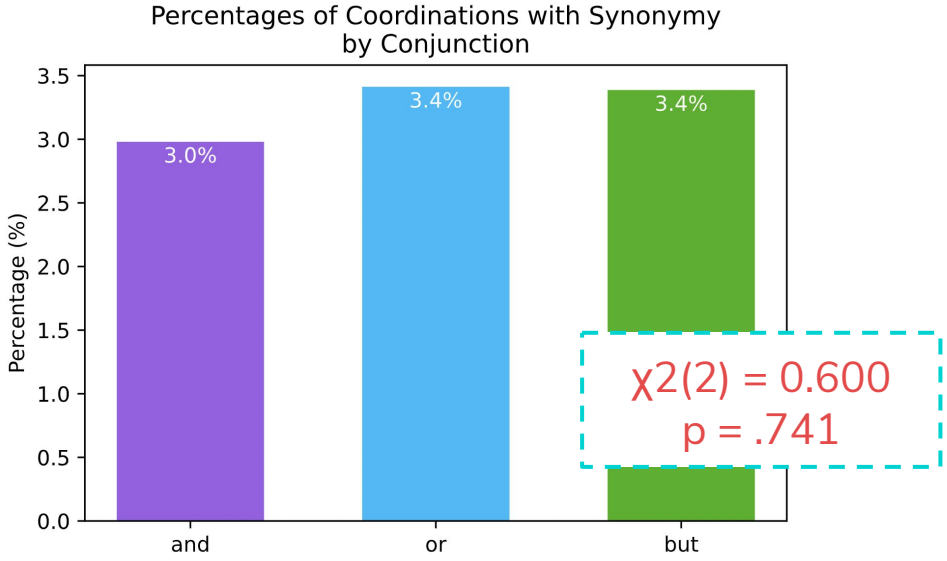
Synonymy by Conjunction



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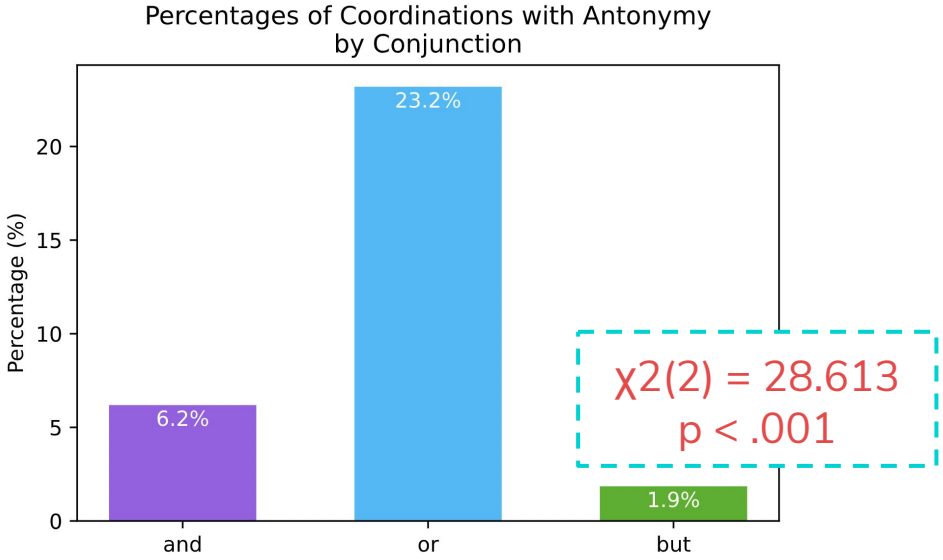
Antonymy by Conjunction



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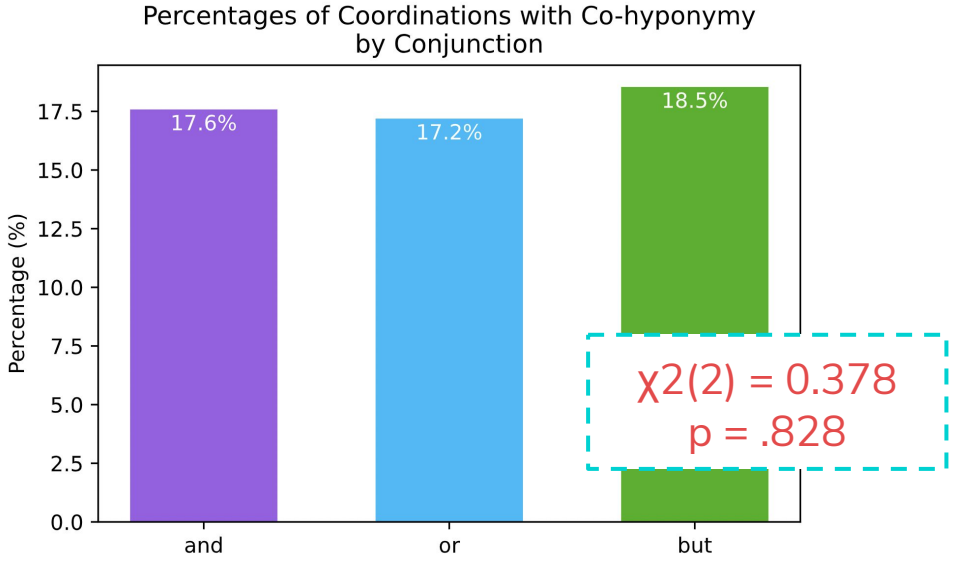
Co-hyponymy by Conjunction



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This **WordNet Analysis by Conjunction** generally shows:

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This **WordNet Analysis by Conjunction** generally shows:

- *or*-coordinations have a distinctive use for contrast

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This **WordNet Analysis by Conjunction** generally shows:

- *or*-coordinations have a distinctive use for contrast
- *and* is more general-purpose in use
- *but*-coordinations do not correlate with relations

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WordNet Analysis by Category:

Part 4: Results and Discussion

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WordNet Analysis by Category:

- Examine association between WordNet relations and the categories of conjuncts

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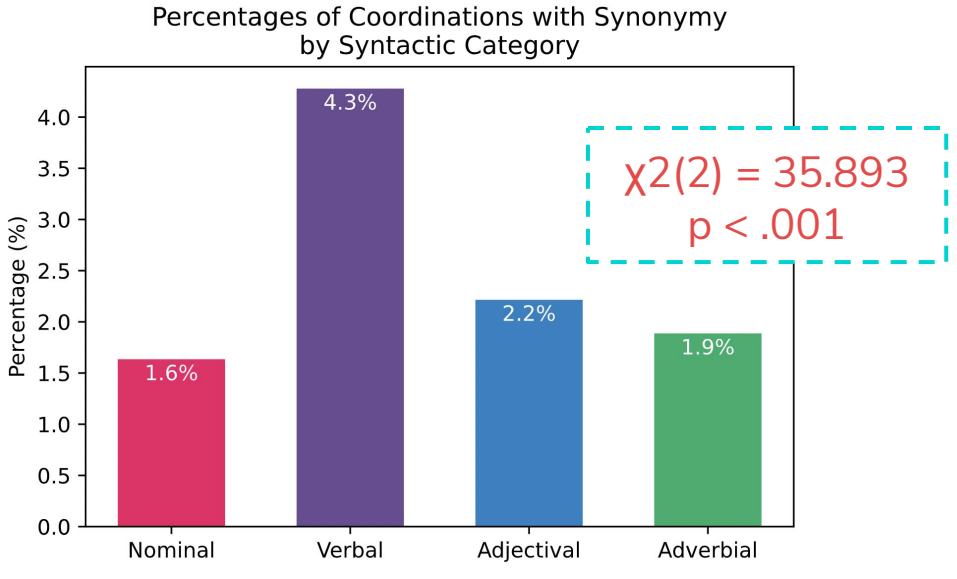
Synonymy by Category



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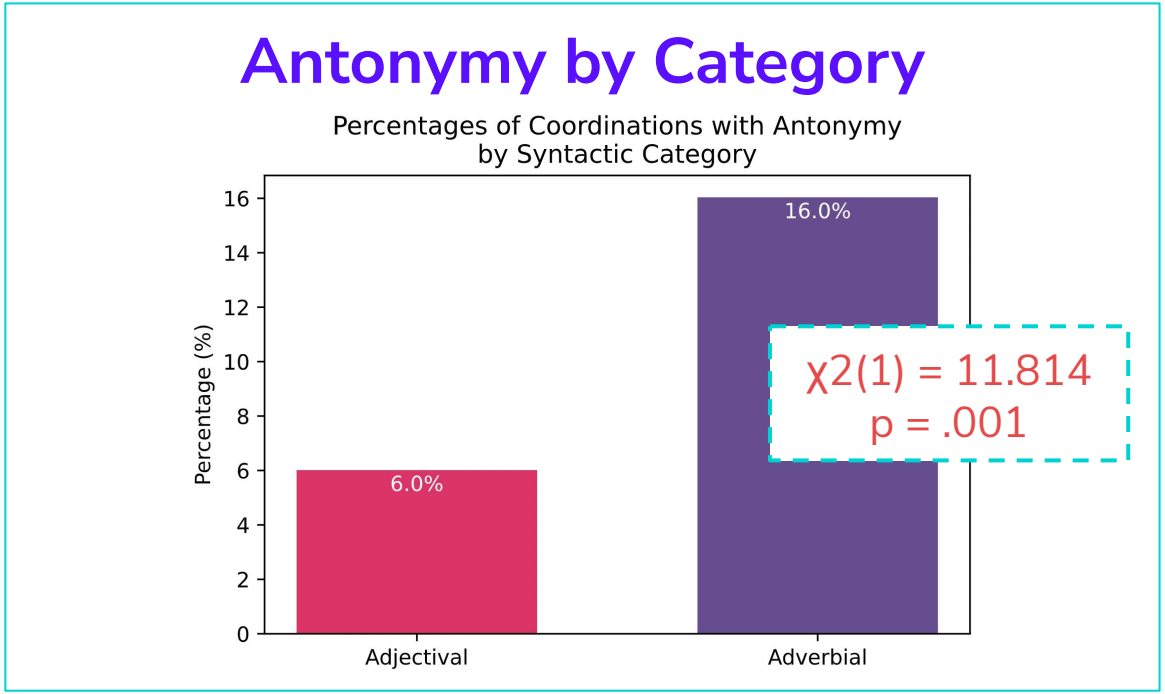

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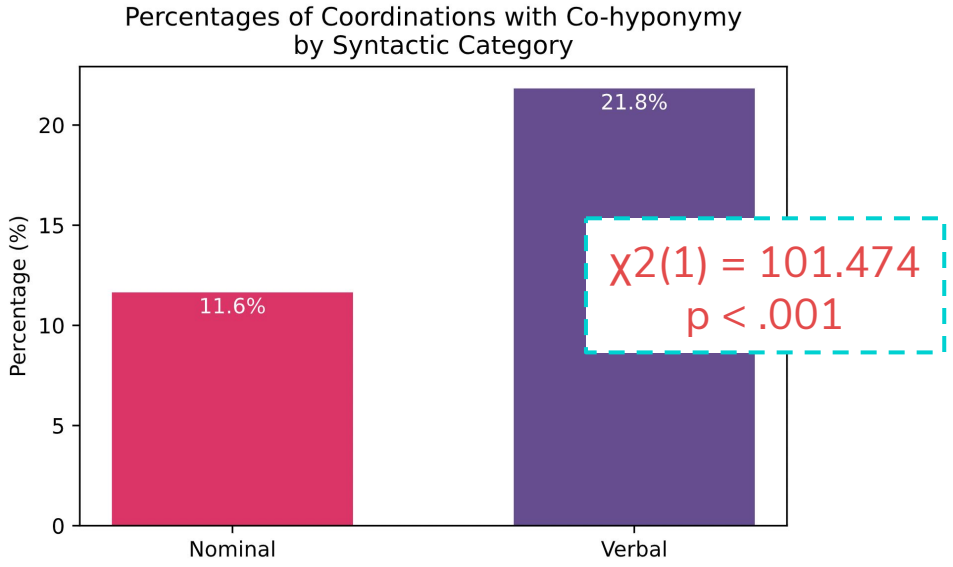
Co-hyponymy by Category



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This **WordNet Analysis by Category** generally shows:

- Verbal categories correlate with synonymy and co-hyponymy

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This **WordNet Analysis by Category** generally shows:

- Verbal categories correlate with synonymy and co-hyponymy

  Trust me, and most especially, [v trust] and [v believe] yourself.

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This **WordNet Analysis by Category** generally shows:

- Antonymous adverbs stem from common phrases

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This **WordNet Analysis by Category** generally shows:

- Antonymous adverbs stem from common phrases
  - “Up and down,” “here or there,” “more or less”

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Hypernymy

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Hypernymy

- We consider the two possible directions of the relation

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Hypernymy

- We consider the two possible directions of the relation
- The second conjunct is more often a hypernym of the first conjunct

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Hypernymy

- We consider the two possible directions of the relation
- The second conjunct is more often a hypernym of the first conjunct
- No significant difference, $\chi 2(1) = 2.045$, $p = 0.153$

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Hypernymy

- Hypothesized that hypernymy would apply in certain contexts

  I bought [strawberries] and [other fruit].

- Asymmetry is not prominent

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Word Embedding Analysis:

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Word Embedding Analysis:

- Compare the effect of conjunctions and categories on the cosine similarity of conjuncts

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Word Embedding Analysis:

- Compare the effect of conjunctions and categories on the cosine similarity of conjuncts
- Include post-hoc tests

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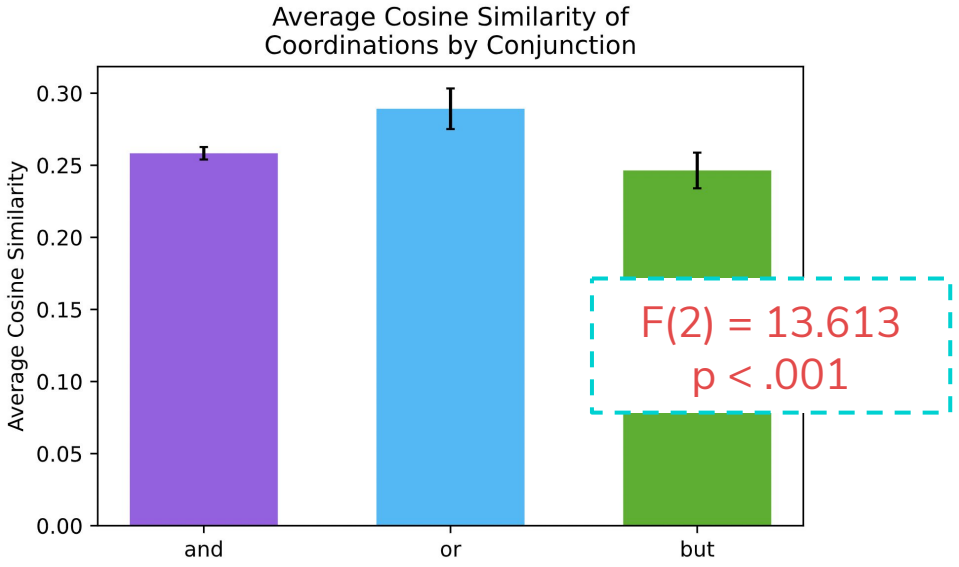
Cosine Similarity by Conjunction



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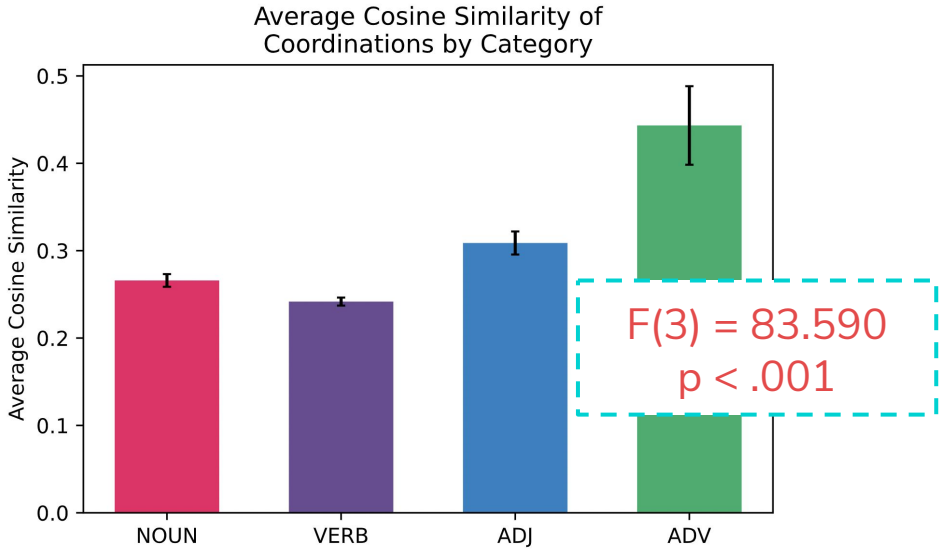
Cosine Similarity by Category



Part 5: Conclusion

- We use a **computational corpus analysis** to understand semantic patterns in the use of two-termed coordination
- Differences in coordination semantics depend on the **conjunction** and **categories** of the conjuncts
- This work is a step toward a fuller understanding of speakers' **real-world usage** of coordination phrases to better inform linguistic theories

Thank you!

References

Behzad, S., Zeldes, A.: A cross-genre ensemble approach to robust Reddit part of speech tagging. In: Proceedings of the 12th Web as Corpus Workshop (WAC-XII). pp. 50–56 (2020)

Fellbaum, C.: Co-occurrence and antonymy. International journal of lexicography 8(4), 281–303 (1995)

Fellbaum, C.: WordNet: An Electronic Lexical Database. MIT Press, Cambridge, MA (1998)

Haspelmath, M.: Coordinating constructions: an overview. In: Coordinating constructions. pp. 3–39. Typological Studies in Language, 58, John Benjamins Publishing Company (2004). https://doi.org/10.1075/tsl.58.03has

References

Haspelmath, M.: Coordination. In: Shopen, T. (ed.) Language Typology and Syntactic Description, vol. 2, chap. 1. Cambridge University Press, 2 edn. (2007). https://doi.org/10.1017/CBO9780511619434

Justeson, J.S., Katz, S.M.: Co-occurrences of antonymous adjectives and their contexts. Computational Linguistics 17(1), 1–19 (1991)

Kallini, J., Fellbaum,C.: A corpus-based syntactic analysis of two-termed unlike coordination. In: Findings of the Association for Computational Linguistics: EMNLP 2021. pp. 3998–4008. Association for Computational Linguistics, Punta Cana, Dominican Republic (Nov 2021). https://doi.org/10.18653/v1/2021.findings-emnlp.335, https://aclanthology.org/2021.findings-emnlp.335

References

Mikolov, T., Chen, K., Corrado, G.S., Dean, J.: Efficient estimation of word representations in vector space (2013), http://arxiv.org/abs/1301.3781

Mikolov, T., Sutskever, I., Chen, K., Corrado, G., Dean, J.: Distributed representa- tions of words and phrases and their compositionality. In: Neural Information Pro- cessing Systems (NeurIPS) (2013), https://papers.nips.cc/paper/5021-distributed-representations-of-words-and-phrases-and-their-compositionality.pdf

Miller, G.A.: Wordnet: A lexical database for english. Commun. ACM 38(11), 39–41 (Nov 1995). https://doi.org/10.1145/219717.219748, https://doi.org/10.1145/219717.219748

Nivre, J., et al.: Universal Dependencies v2: An evergrowing multilingual treebank collection. In: Proceedings of the 12th Language Resources and Evaluation Confer- ence. pp. 4034–4043. European Language Resources Association, Marseille, France (May 2020), https://aclanthology.org/2020.lrec-1.497

References

Prażmowska, A.: Is unlike coordination against the law (of the coordination of likes)? (2015)

Quirk, R., Greenbaum, S., Leech, G., Svartvik, J.: A Comprehensive Grammar of the English Language. Longman, London (1985)

Sag, I.A., Gazdar, G., Wasow, T., Weisler, S.: Coordination and how to distinguish categories. Natural Language and Linguistic Theory 3(2), 117–171 (1985), http://www.jstor.org/stable/4047644

Silveira, N., Dozat, T., de Marneffe, M.C., Bowman, S., Connor, M., Bauer, J., Manning, C.: A gold standard dependency corpus for English. In: Proceedings of the Ninth International Conference on Language Re- sources and Evaluation (LREC'14). pp. 2897–2904. European Language Re- sources Association (ELRA), Reykjavik, Iceland (May 2014), http://www.lrec-conf.org/proceedings/lrec2014/pdf/1089paper.pdf

References

Stenström, E.: CoNLL-U parser. https://github.com/EmilStenstrom/conllu/ (2021)

Williams, E. S.: Transformationless grammar. In: Linguistic Inquiry 12. pp. 645–653 (1981)

Zeldes, A.: The GUM corpus: Creating multilayer resources in the classroom. Language Resources and Evaluation 51(3), 581–612 (2017). https://doi.org/http://dx.doi.org/10.1007/s10579-016-9343-x

Zeman, D., et al.: CoNLL 2017 shared task: Multilingual parsing from raw text to Universal Dependencies. In: Proceedings of the CoNLL 2017 Shared Task: Multilingual Parsing from Raw Text to Universal Dependencies. pp. 1– 19. Association for Computational Linguistics, Vancouver, Canada (Aug 2017). https://doi.org/10.18653/v1/K17-3001, https://aclanthology.org/K17-3001