How analogy drives language comprehension: Interpreting novel noun-noun compounds

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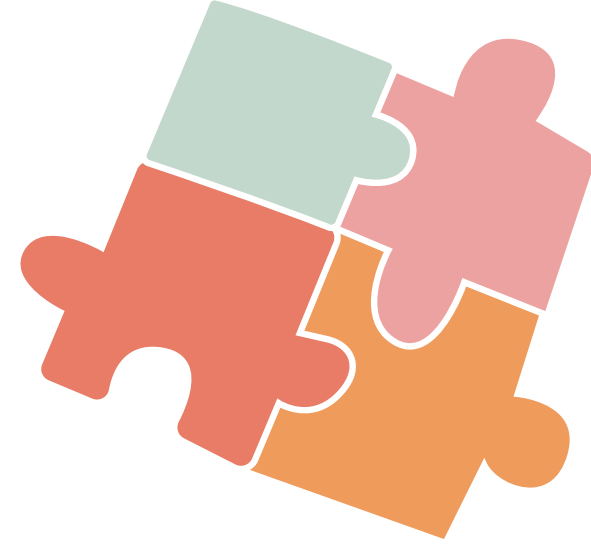
August 29, 2025

How Do We Know
What a Chocolate Knife Is?

- What is the role of analogy in linguistic productivity?

- Can we disentangle analogy from other mechanisms?

- Do LLMs generalize in a way that mirrors humans?

MOTIVATION

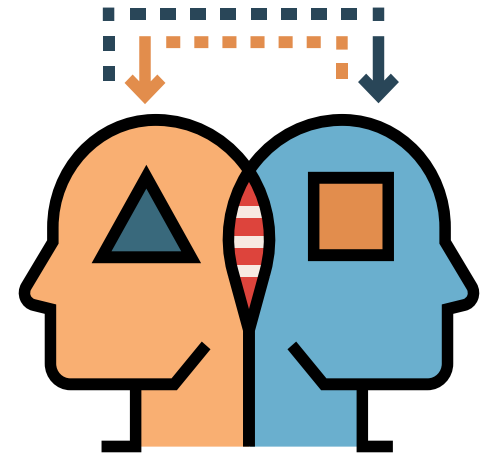Language is **productive**: humans create novel expressions beyond memorized forms.

➢How do people generalize from what they know to what they don't?

 ➢compositions

➢Do Language Models generalize like people do?

PRODUCTIVITY THROUGH ANALOGY

Hypothesis: People use **analogical generalization**—mapping new combinations onto known ones.

- Analogy offers a cognitive mechanism for:
    - Inferring structure from surface forms
    - Extending linguistic knowledge to novel cases

- Foundational in cognitive theories (Gentner & Smith, 2013), yet...
    - Hard to formalize and test in many linguistic phenomena.

Bybee (2010). *Language, usage and cognition*. Cambridge: Cambridge University Press
Ambridge (2020). Against stored abstractions: A radical exemplar model of language acquisition. First Language, 40(5–6)
Rambelli, G. (2024). Constructions and compositionality: Cognitive and computational explorations. Cambridge University Press
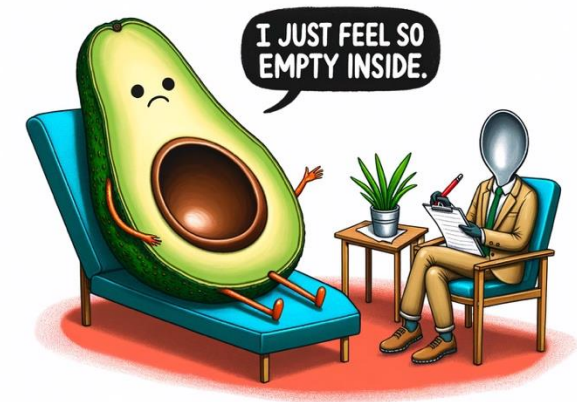
🔍 CASE STUDY: COMPOUNDS

- Interpreting a novel compound involves:
  - accessing the **concepts** denoted by the words
  - selecting a **relation** to form a unified conceptual representation

How is the relation selected?

AVOCADO CHAIR

Connell & Lynott (2012). Flexible shortcuts: Linguistic distributional information affects both shallow and deep conceptual processing. In Proc. of CogSci.
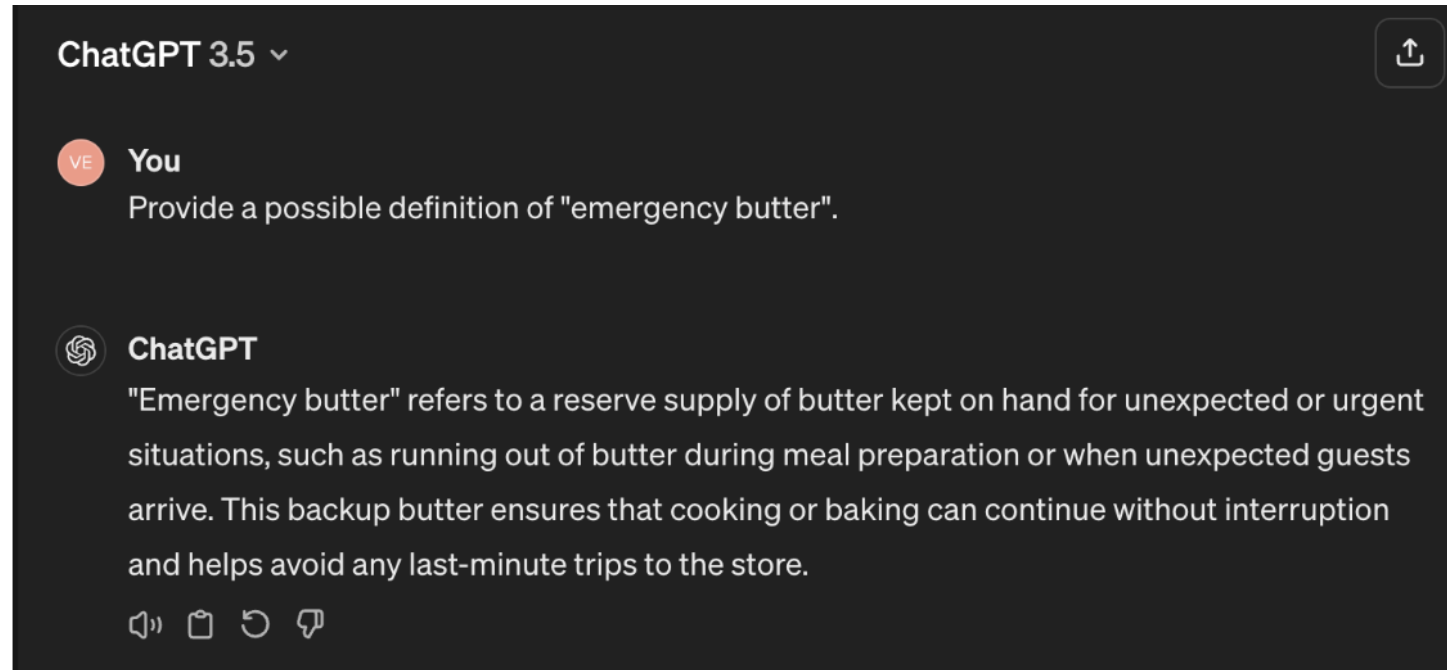
🔍 COMPOUNDS & ANALOGY

- Gagné & colleagues: Interpreting novel nominal compounds depends on **analogous lexicalized ones**.

Gagné & Shoben (2002). Priming Relations in Ambiguous Noun-noun Combinations. *Memory & Cognition*.
Gagné & Spalding (2006). Conceptual Combination: Implications for the Mental Lexicon. *The Representation and Processing of Compound Words*.

🔍 COMPOUNDS & LARGE LANGUAGE MODELS

- LLMs are somewhat able to generalize to new examples that are conceptually similar to training examples.

ChatGPT 3.5 ⌄

You
Provide a possible definition of "emergency butter".

ChatGPT
"Emergency butter" refers to a reserve supply of butter kept on hand for unexpected or urgent situations, such as running out of butter during meal preparation or when unexpected guests arrive. This backup butter ensures that cooking or baking can continue without interruption and helps avoid any last-minute trips to the store.

- ...But past models <u>still</u> over-relied on similar training examples and were brittle when these examples are manipulated.

Coil, J. & Shwartz, V. (2023). From chocolate bunny to chocolate crocodile: Do Language Models Understand Noun Compounds? Findings of ACL 2023.
Shapira, N. et al. (2023). Clever hans or neural theory of mind? stress testing social reasoning in large language models. *arXiv preprint*.

EXPERIMENTS

1. Examinate how native English speakers (**L1**) and **L2** English learners interpret the semantic relationships implicit in noun compounds.

2. Examinate how **LLMs**' choices resemble L1 English speakers or L2 learners of English.

- Understand how prior knowledge of the language influences the acquisition of new linguistic combinations

  - **H1**: L2 learners encounter greater difficulties than L1
  - **H2**: Competition between different semantic interpretations cause difficulties in interpretation

- 7 semantic relations
    - Hatcher-Bourque classes

- Lexicalized compounds (**LC**) from previous datasets.

- Novel compounds (**NC**) are built by substituting the modifier with a more general word

TOPIC	Background information → Information ABOUT background
LOCATION	Prostate cancer → A cancer LOCATED AT/NEAR/IN a prostate
COMPOSITION	Crystal ball → A ball COMPOSED OF crystal
CONTAIN	Garbage bin → A bin that CONTAINS garbage
USAGE	Voice mail → A mail that USES a voice
PURPOSE	Measuring cup → A cup INTENDED FOR measuring
PRODUCTION	Grape vine → A vine that PRODUCES grapes

rice bowl → <u>nutrient</u> bowl

18 LC + 18 NC 18 for 7 classes (= 252 compounds)

Pepper, S. (2022). Hatcher-Bourque: Towards a reusable classification of semantic relations. *Empirical Approaches to Language Typology [EALT]*.

Participants:

- 24 L1 English speakers +
- 34 L2 (Italian high school students)

Task:

- Multiple choice task

The compound noun "candy bar" can be interpreted as:

○ a bar about candy

○ a bar located at/near/in candy

○ a bar composed of candy

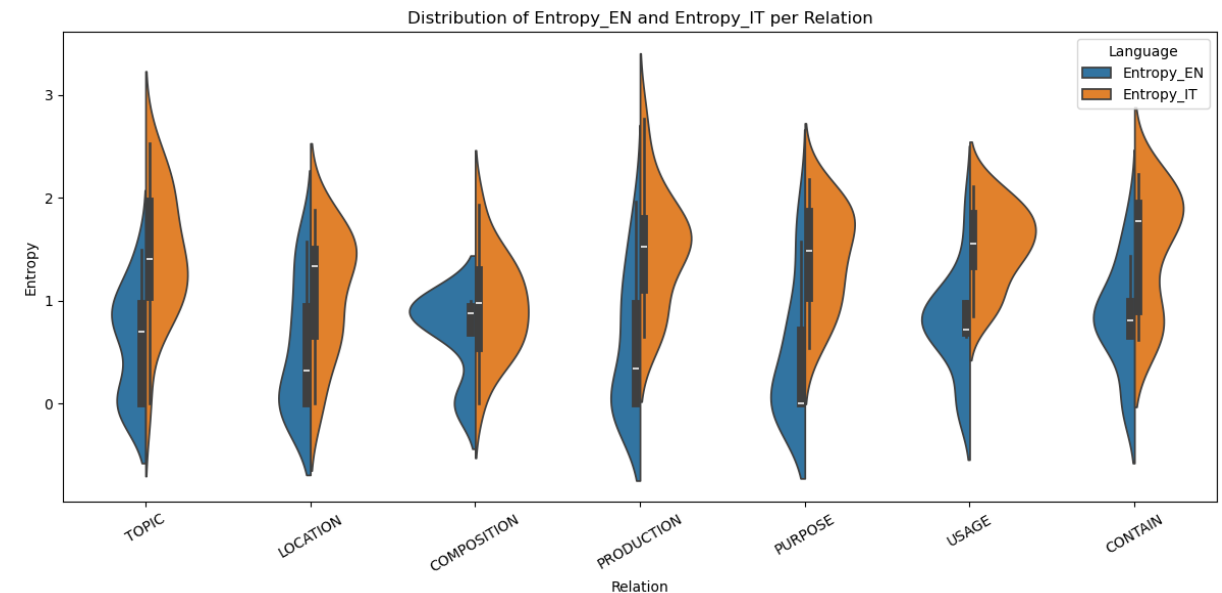○ a bar that contains candy

○ a bar that uses candy

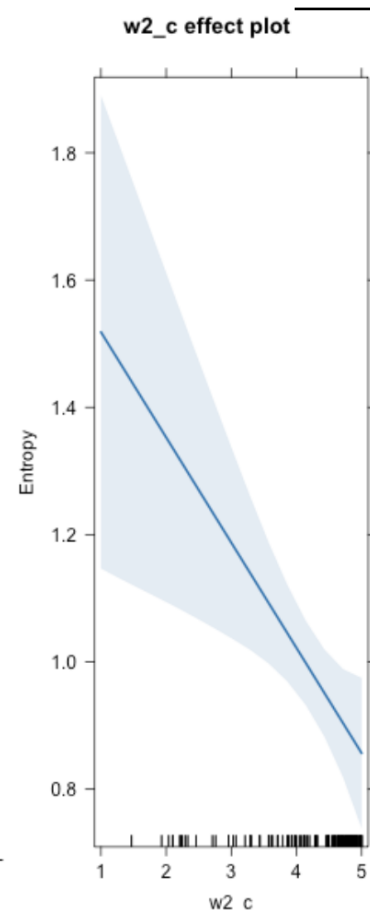○ a bar intended for candy

○ a bar that produces candy

Hamada, M. (2024). Multiword Expressions: Understanding the Meanings of Noun-Noun Compounds in L2. *English Teaching & Learning*, 1-19.
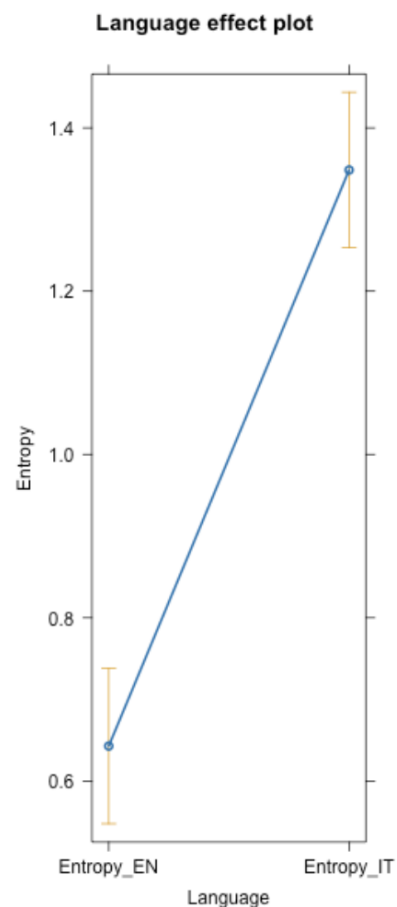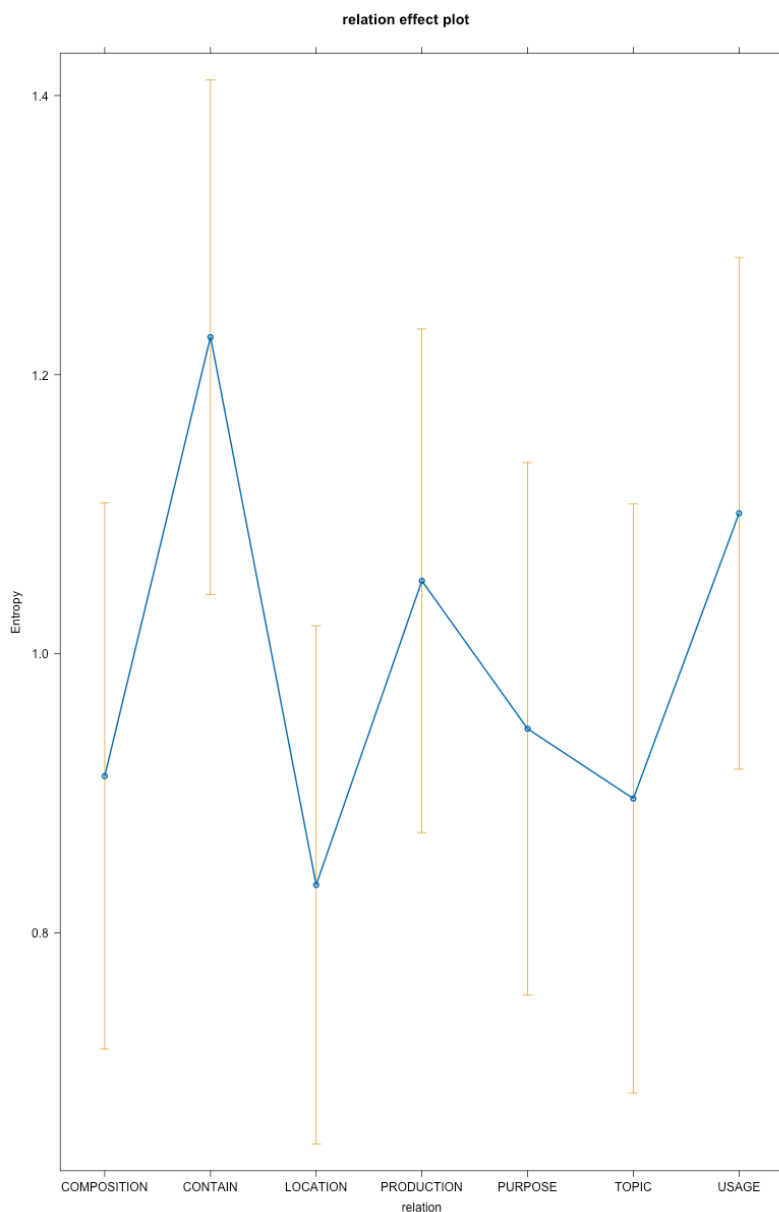
Entropy

$$H = -\Sigma p_i \log_2 p_i$$

- Relational competition
  - how consistently participants converge on a specific interpretation

- L1 converge towards the same interpretation, while L2's anwers vary.

- Certain semantic relations are easier than others

Distribution of Entropy_EN and Entropy_IT per Relation

Schmidtke, , Kuperman, Gagné & Spalding (2016). Competition between conceptual relations affects compound recognition: The role of entropy. *Psychonomic bulletin & review, 23*(2).

	F value	Pr(>F)	
relation	2.6725	0.015757	*
w1_conc	1.2069	0.273051	
w2_conc	10.1120	0.001667	**
compound_conc	0.2175	0.641380	
language	106.7	< 2.2e-16	***
relfreq	0.1363	0.712304	

relation effect plot

Language effect plot

w2_c effect plot

- Entropy depends on
  - the **language**
  - the **concreteness** of the head
  - the type of semantic **relation**.

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Native English Speakers

L2 English learners

- Abstract relation PURPOSE for opaque compounds.

- Concrete, decompositional, literal.

"product jug"

jug INTENDED for   jug COMPOSED of..

- Preference for metaphorical, functional uses

- Literal/material relations

"peanut butter"

butter that CONTAINS p.   butter that is COMPOSED of p.

- Understand the linguistic knowledge of LLMs.

    1. Do LLMs Grasp Semantic Relations in Lexicalized Noun Compounds?
    2. Are LLMs able to generalize semantic relations over novel compounds?

  ➢ **Do they resemble more as L1 speakers or learners of English?**

Rambelli, G., Chersoni, E., Collacciani, C., & Bolognesi, M. (2024). Can Large Language Models Interpret Noun-Noun Compounds? A Linguistically-Motivated Study on Lexicalized and Novel Compounds. ACL 2024)

ACL 2024
Bangkok, Thailand

- Model: qwen3-30b-a3b
  - Same istructions as humans
  - 3 runs for internal consistency: 74.2%

- For LC, Qwen is more similar to L1 (memorization effect)

- For NC, Qwen is more similar to L2 (compositional)

Similarity of Column 1 with Column 2 and 3 by Relation

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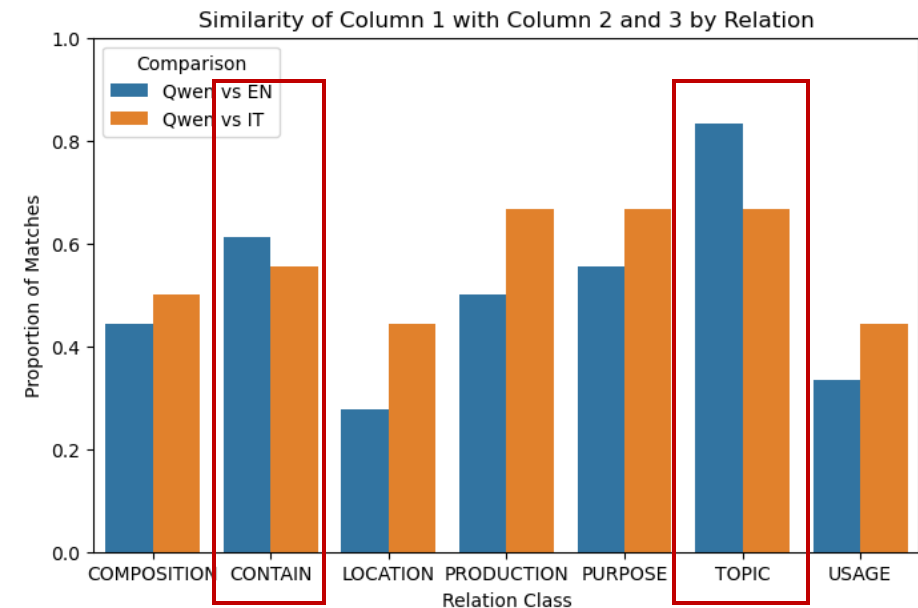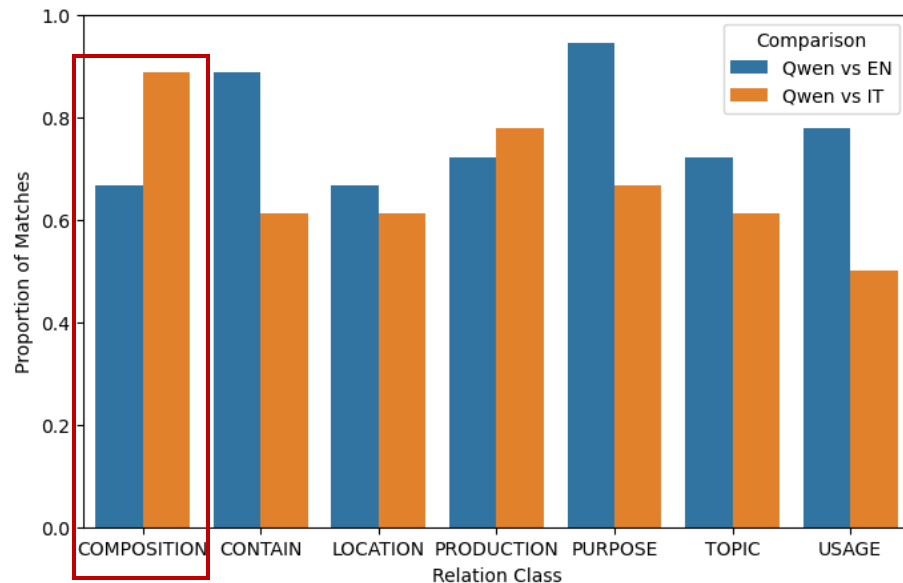
- Reasoning is working for LC

- ..but it hallucinate for NC

The compound 'peanut butter' refers to a **type of butter made from peanuts**. The semantic relation is that the butter is **composed of peanuts**, similar to 'crystal ball' (a ball composed of crystal). **While 'contains' (option 5) might seem plausible, 'composed of' more accurately reflects the material basis of the compound**, as peanut butter is primarily made from ground peanuts, not just containing them as an ingredient

The compound 'container phone' can be interpreted **as a phone that uses a container**. This follows the pattern of 'voice mail' (a mail that uses a voice) and 'measuring cup' (a cup intended for measuring), where the second noun describes the function or purpose of the first. Here, 'container' likely refers to the phone's use of a container, such as for data storage or a specific operational context.
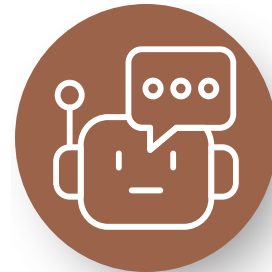
DISCUSSION

- Analogy is a theoretical construct, but lacks a concrete operationalization.
    - Can we adapt experimental paradigms from cognitive science?
    - Can we use LLMs as cognitive tools to test how analogy works?
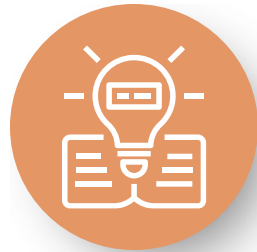
Theory

Formalization of analogy as a core principle in productivity

LMs linguistic abilities

How LMs reflects cognitive-like representations and where they diverge from human learners.

Analogy-Angle II

A second edition of an interdisciplinary workshop co-located with ACL 2025. Analogy-Angle II will occur in Vienna, Austria on August 1, 2025.

The Second Workshop on Analogical Abstraction in Cognition, Perception, and Language (Analogy-Angle II)

Explore, model, and understand analogical reasoning in cognition, language, and computational models from an interdisciplinary perspective

Analogy-Angle II is a multidisciplinary workshop to advance research on analogical abstraction by bridging the fields of computational linguistics, artificial intelligence, and cognitive psychology. This workshop seeks to foster collaboration among researchers by providing a platform for sharing novel insights, benchmarks, methodologies, and analogy applications across disciplines. **Analogy-Angle II** welcomes diverse contributions, including original research, reviews, and previously accepted papers from leading conferences. Analogy-Angle I was co-located with IJCAI 2024.

Keynote Speakers

Melanie Mitchell

Ekaterina Shutova

Proceedings of Analogy-Angle II @ ACL 2025

Giulia Rambelli
Filip Ilievski
Marianna Bolognesi,
Pia Sommerauer