

# DYADIC NEGATION IN NATURAL LANGUAGE

András Kornai

HLT

September 30 2021

SZTAKI Institute of Computer Science



**ARTIFICIAL INTELLIGENCE**  
National Laboratory

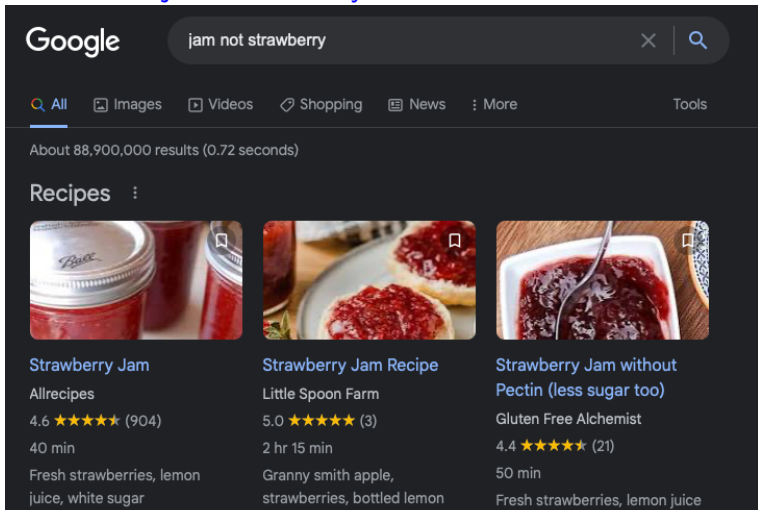
Hungary

# WHY IS NEGATION A PROBLEM FOR LINGUISTS AND LOGICIANS?

*(...) the form and function of negative statements in ordinary language are far from simple and transparent. In particular, the absolute symmetry definable between affirmative and negative propositions in logic is not reflected by a comparable symmetry in language structure and language use. Much of the speculative, theoretical, and empirical work on negation over the last twenty-three centuries has focused on the relatively marked or complex nature of the negative statement vis-a-vis its affirmative counterpart (Horn, 1989)*

# WHY IS NEGATION A PROBLEM FOR NLP?

Well-known Info Retrieval paradox: the most relevant responses to query involving negatives **jam NOT strawberry** tend to be even more relevant for **jam, strawberry**



The screenshot shows a Google search interface with the query "jam not strawberry". The search results are filtered to "Recipes" and show three items:

Recipe Title	Source	Rating	Time	Ingredients
Strawberry Jam	Allrecipes	4.6 ★★★★★ (904)	40 min	Fresh strawberries, lemon juice, white sugar
Strawberry Jam Recipe	Little Spoon Farm	5.0 ★★★★★ (3)	2 hr 15 min	Granny smith apple, strawberries, bottled lemon
Strawberry Jam without Pectin (less sugar too)	Gluten Free Alchemist	4.4 ★★★★★ (21)	50 min	Fresh strawberries, lemon juice

# WHY IS NEGATION A PROBLEM FOR WORD VECTORS

- There is no involution corresponding to antonymy
- Certainly “multiply by  $-1$ ” doesn’t work
- Double negation tends not to exist. Negative imperatives are easy (in English, with *do*-support: from *go!* it is easy to form *don’t go!* with the intended meaning *stay!*)
- Double negatives *???don’t don’t go* are hard to produce, people tend to express the intended meaning by *don’t stay*
- A BNC search reveals 40 examples of *don’t don’t*, all in live conversation (as opposed to writing), and all with the meaning ‘emphatically don’t’ as in *Charlotte please don’t don’t go noisy* or *Don’t don’t you think that there’s a conflict of interest there*. This is from a total of 92,334 *don’ts* in the corpus.
- Consider a grocery store with a sign *no bananas (today)*. Once the shipment arrives, they will not advertise *???no no bananas*

# HEURISTIC EXPLANATION

*'Natural' negation only involves objects or elements a speaker or listener is attending to ... It makes no sense to instruct a listener to suppress a thought he is not considering or an idea he is not having. (De Mey, 1972)*

[In fact it has the opposite effect, cf. **Don't think about the pink elephant**]

This is closely tied to other non-Boolean properties of “natural logic”, e.g. non-commutativity of *and*: compare **I went home and had dinner** to **I had dinner and went home**

# THE REAL DILEMMA

*(...) accounts of truth that treat mathematical and nonmathematical discourse in relevantly similar ways do so at the cost of leaving it unintelligible how we can have any mathematical knowledge whatsoever; whereas those which attribute to mathematical propositions the kinds of truth conditions we can clearly know to obtain, do so at the expense of failing to connect these conditions with any analysis of the sentences which shows how the assigned conditions are conditions of their truth. (Benacerraf, 1973)*

We will investigate non-mathematical discourse, considering the standard (Boole) account quite satisfactory for math/logic

# PLAN OF THE TALK

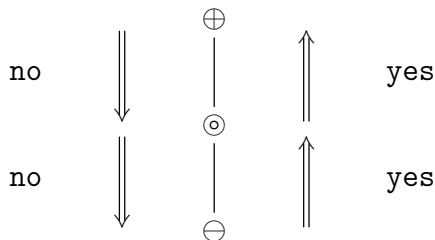
- We begin with an (exhaustive) study of negation in the lexicon
- Turns out that classical negation plays no role! Only a (dyadic) predicate LACK will be needed
- Simple force dynamic account
- Syntactic (compositional) negation will fall out as quantifying over the first argument using our only primitive quantifier *gen*
- This accounts for the actually observed cases of double negation: ‘a not unfriendly letter, a not unhappy person’ where we have one lexical negation negated compositionally
- Compositional quantification, scope ambiguities
- Disjunction



# LEXICAL NEGATION

- Exhaustive survey of elements with any kind of negative aspect in 4lang V1.0 (144 entries), e.g. *accept* 'to decide that there is nothing you can do to change a difficult and unpleasant situation or fact and continue with your normal life'
- In the final analysis many of them receive a purely positive definition `accept elfogad accipio akceptowac1 615 u V receive, =agt think[=pat[right/1191] for =agt]` 'John accepted the prison sentence'
- Classic antonym pairs like *clean* 'not dirty' and *dirty* 'not clean' or *blind/sighted* can be easily broken up: one member of the pair can be defined in purely positive terms. This member represents the default state: things are (somewhat) dirty, people are normally sighted
- **The negation of the default is given by LACK** *blind* 'LACK sight'; *clean* 'LACK dirty(ness)'; ...
- No cases left! The lexical item *no* receives the analysis `gen LACK`

# FORCES IN NEGATION AND AFFIRMATION



antidisestablishmentarianism, close v. open, move up!

## gen

- Quantifiers are nominals (rather than nominals being generalized quantifiers)
- gen is just the vector  $(\frac{1}{n}, \frac{1}{n}, \dots, \frac{1}{n})$
- We are interested in lexicalized quantifiers either in their base form *some, any, no, ...* or in a subtyped form *someone, somebody, something, somewhere, somehow, anyone, anybody, anything, anywhere, anyhow, noone/no-one, nobody, nothing, ...*
- These (incl. interrogatives) will be treated on a par with pronouns, as members of a new lexical category *proquant*, whose crosslinguistic coherence (but not the name *proquant*) is argued for by (Szabolcsi, 2015).
- Compositional quantifiers *at least seven, no more than 10* are over-analyzed in standard treatments
- The analysis would extend to cases that people have problems with, like *no more than -3* yet fails to cover mathematically routine cases like “less than *i*”

# PROQUANTS

- *any-* <one>, =agt is\_a
- *anyone, anything, anywhere, ...*
- Not fully compositional (this is the lexicon after all), but still reasonable, with *anyone* as person, =agt is\_a, *anywhere* as place, =agt is\_a, etc.
- Recall that *no* is gen LACK, so *noone/nobody* is person LACK, *nothing* is thing LACK etc, (everything unifies with gen)
- Episodic readings require special effort as in Database Logic (Doherty, Lukaszewicz, and Szalas, 2000), see also critique of MG's episodic readings in (Kornai, 2010)
- *Thou shalt not kill* after(gen LACK kill)

# DOUBLE NEGATION = 1+1 NEGATION

- Not really the same negation twice: both syntactic and lexical negation are involved. People are not happy, and letters are not friendly by default
- Two possible analyses: *(not unhappy) person* versus *not (unhappy person)*
- They lead to the same conclusion person HAS happy(ness)

# THE MAIN PIECES

- *unhappy* LACK *happy*
- Syntactic *no(t)* negates the main predicate *John eats fish* versus *No, John doesn't eat fish* (do-support parochial to English)
- The negation of LACK is HAS, the negation of both HAS and IS\_A is LACK
- *person* unifies with *gen* to yield *person*
- LACK unifies with IS\_A to yield LACK

# THE DERIVATIONS

- *unhappy person* person IS\_A unhappy ordinary adjectival predication, see earlier MILAB talk  
<http://nessie.ilab.sztaki.hu/~kornai/MILAB/hltsem.pdf>
- Substitution s.v. gives person IS\_A LACK happy
- IS\_A and LACK unify to yield LACK: person LACK happy
- *no(t)* negates the main predicate, to yield person  $\neg$ LACK happy i.e. person HAS happy
- On the other path, *not unhappy* gen LACK unhappy
- *(not unhappy) person* person LACK unhappy
- Notice this covers both unhappy and 'neither unhappy nor happy'
- Small victory: explains lack of double syntactic negation, with the right exceptions *Don't you ever NOT clean up after yourself!*

# SCOPE AMBIGUITIES

- Everyone on Cormorant Island speaks two languages
- Two languages are spoken by everyone on Cormorant Island
- (Katz and Postal, 1964) assumed that both readings are available for both sentences
- Quantifiers appear in *by*-phrases only in 1.5% of the BNC quantifier data
- Active: person IN Cormorant, person speak language(two)
- Passive: language(two) is\_spoken\_by person IN Cormorant Island
- It's not enough to say active/passive is a lexical relation (Genabith and Crouch, 1999)



# NOONE ON CORMORANT ISLAND

- Phenomenon even more marginal: only 8 instances within a *by*-phrase among over 10m sentences
- Active: Cormorant\_Islander LACK speak language(two)
- Both active and passive come with smart Alec downward entailment *but Joe here speaks seven!*
- LACK negates a non-default proposition (as in 1+1 negation)

# EVIDENTIAL BASIS

- Shifted from made-up examples to corpus
- “E” passives lg(two) `is_spoken_by` LACK  
`Cormorant_Islander`
- ‘among the people who speak two languages we don’t find  
`Cormorant_Islanders`’
- Same downward entailment problem as for the active
- The phenomenon is truly marginal: *by noone/nobody* phrases are just 0.1% of the total occurrences of *noone/nobody* in the BNC, for a total of 8 sentences among over ten million.
- One would really have to be superbly confident about having already captured 99.9999% of English grammar before seeing these as a descriptive challenge.

# DISJUNCTION

- Signifies choice (XOR) rather than OR
- In conjunction a higher *collective* node is formed (Scha, 1981)
- In disjunction both alternatives are kept open
- Can introduce counterfactual alternatives: *It can wait, or they would have called us by now*
- Deontic paradox: *No food and drink*, see also Ross' Paradox
- De Morgan laws don't work

# CONCLUSIONS

- Simple, robust theory of negation (also of temporal logic, presuppositions, and a host of other classic topics of semantics)
- Well aligned with commonsense reasoning
- Smoothly extends from lexicon to compositional syntax
- Reasonably well interfaced to word vectors (lot of work remains)
- Also reasonably well interfaced to Aristotle (far better than to Boole)
- More solid evidential basis (goes against the grain of Chomsky's anti-stats crusade) (Kornai, 2019)
- **It's the word meaning, stupid**

Thank you!

Benacerraf, Paul (1973). “Mathematical Truth”. In: *The Journal of Philosophy* 70.19, pp. 661–679.

De Mey, M. (1972). “The Psychology of Negation and Attention”. In: *Logique et Analyse* 15, pp. 137–153.

Doherty, Patrick, Witold Lukaszewicz, and Andrzej Szalas (2000). “Efficient reasoning using the local closed world assumption”. In: *Proc 9th International Conference on AI: Methodology, Systems, Applications (AIMSA 2000)*.

Genabith, Josef Van and Richard Crouch (1999). In: *Semantics and syntax in Lexical Functional Grammar: The resource logic approach*. Ed. by Mary Dalrymple. MIT Press, pp. 209–260.

Horn, Larry (1989). *The Natural History of Negation*. Chicago: University of Chicago Press.

Katz, Jerrold J. and Paul M. Postal (1964). *An Integrated Theory of Linguistic Descriptions*. Cambridge: MIT Press.

Kornai, András (2010). “The treatment of ordinary quantification in English proper”. In: *Hungarian Review of Philosophy* 54.4, pp. 150–162.

- (2019). *The counterrevolutionary*. URL:  
<http://kornai.com/Papers/chomsky90.pdf>.
- Ross, Alf (1941). “Imperatives and Logic”. In: *Theoria* 7, pp. 53–71.
- Scha, R. (1981). “Distributive, Collective and Cumulative Quantification”. In: *Formal Methods in the Study of Language, Part 2*. Ed. by J. A. G. Groenendijk, T. M. V. Janssen, and M. B. J. Stokhof. Mathematisch Centrum, pp. 483–512.
- Szabolcsi, Anna (2015). “What do quantifier particles do?” In: *Linguistics and Philosophy* 38.2, pp. 159–204. ISSN: 1573-0549. DOI: [10.1007/s10988-015-9166-z](https://doi.org/10.1007/s10988-015-9166-z). URL:  
<https://doi.org/10.1007/s10988-015-9166-z>.