Do people make spontaneous logical inferences while reading?

Maksymilian Dąbkowski '19.5, Logic (AB)
faculty sponsor: Prof. Roman Feiman

Logic in thought

$$p \rightarrow q$$
$$\neg q$$
$$\therefore \neg p$$

John Stuart Mill: the necessary truths of logic are simply those things that we find it impossible to doubt.

Gottlob Frege: logic is a normative law that states how thinkers ought to judge, not a description of how they do in fact judge.

What is the relation of logic to human thought?

Task #1

Sarah is 12 years of age. She is very talkative and sociable. She goes to drama classes and is learning to play the guitar. She wants to be a pop singer or an actress.

Which of the following statements is more likely?

1. Sarah likes to cook.
2. Sarah likes to cook and she collects pop magazines.

Task #1

Sarah is 12 years of age. She is very talkative and sociable. She goes to drama classes and is learning to play the guitar. She wants to be a pop singer or an actress.

Which of the following statements is more likely?

1. Sarah likes to cook.
2. Sarah likes to cook and she collects pop magazines.

Thought is not logical.

Task #2

All living things need water.
All roses need water.

Would you conclude that, therefore, all roses are living things?

1. Yes.
2. No.

Task #2

All living things need water.
All roses need water.

Would you conclude that, therefore, all roses are living things?

1. Yes.
2. No.

Thought is not logical.

any-licencing

1. He did not see any movie.
2. He saw *any movie.
3. Someone with (*any) talent auditioned.
4. No one with (any) talent auditioned.
5. Everyone with (any) talent auditioned.
6. If you saw any movie, let me know.

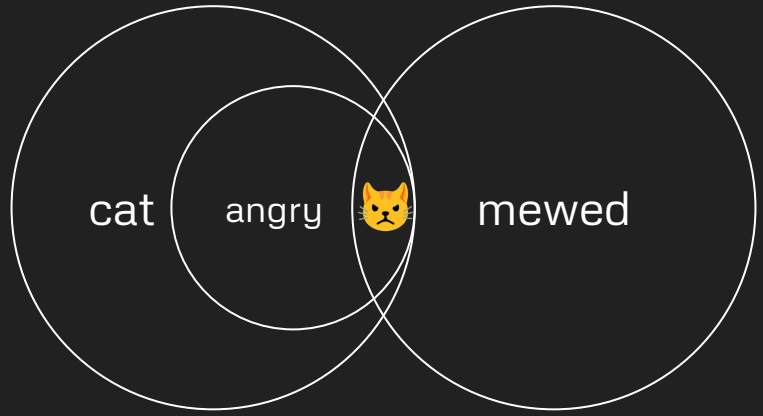
The solution has to do with entailment.

entailment = one sentence is always true when the other one is true

Entailments with *a*

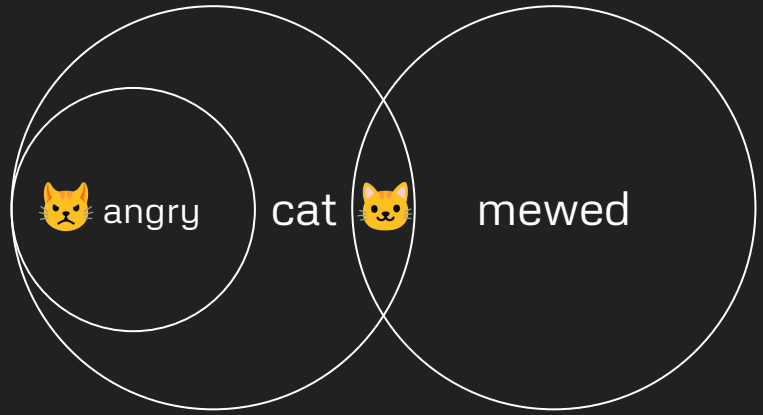
An angry cat mewed. ⊨ A cat mewed.

subset ⊨ superset



A cat mewed. ⊭ An angry cat mewed.

superset ⊭ subset



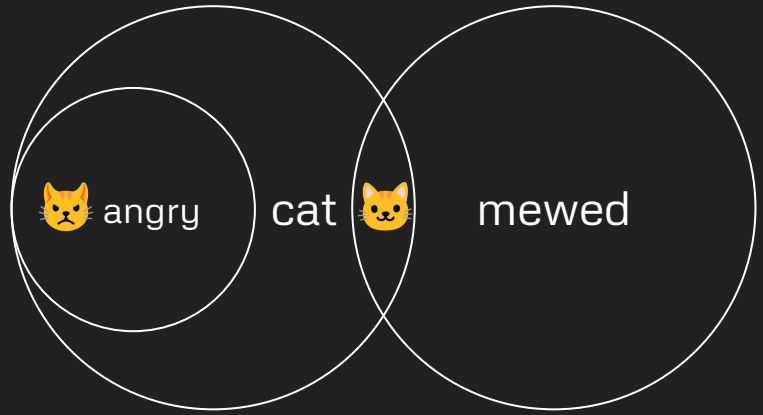
Entailments with *no*

No cat mewed. ⊨ No angry cat mewed.

superset ⊨ subset

No angry cat mewed. ⊭ No cat mewed.

subset ⊭ superset



Entailment direction

upward entailment = you can go from a subset (angry cat) to a superset (cat)
downward entailment = you can go from a superset (cat) to a subset (angry cat)

upward entailing environments: *a*, *some*
downward entailing environments: *every*, *all, no*, *none, if*

any is licenced in a downward entailing environments.

Thought is very logical.

any-licencing, revisited

1. He did not see any movie. ⊨ He did not see any good movie.
2. He saw *any movie. ⊭ He saw *any good movie.
3. Someone with (*any) talent auditioned.
   ⊭ Someone with (*any) vocal talent auditioned.
4. No one with (any) talent auditioned.
   ⊨ No one with (any) vocal talent auditioned.
5. Everyone with (any) talent auditioned.
   ⊨ Everyone with (any) vocal talent auditioned.
6. If you saw any movie, let me know.
   ⊨ If you saw any good movie, let me know.

Our hypotheses

Do people make **spontaneous logical inferences** while reading?

Do people process **downward** and **upward** entailing environments differently?

Study design

self-paced reading task

short narratives which include quantified sentences

reading time measured

feedback welcome!

An example narrative

John works at the SPCA, where there are different kinds of lost pets: mostly stray pitbulls, some other dogs, and a few cats. He always locks up for the night, but last night he must have forgotten! He came in this morning and found that some of the pets escaped. Since some of the dogs escaped, he'll include that in his report about last night.

An example narrative

John works at the SPCA, where there are different kinds of lost pets: mostly stray pitbulls, some other dogs, and a few cats. He always locks up for the night, but last night he must have forgotten! He came in this morning and found that some of the pets escaped. Since some of the dogs escaped, he'll include that in his report about last night.

some of the pets escaped $\not\models$ some of the dogs escaped

An example narrative, ver. 2

John works at the SPCA, where there are different kinds of lost pets: mostly stray pitbulls, some other dogs, and a few cats. He always locks up for the night, but last night he must have forgotten! He came in this morning and found that none of the pets escaped. Since none of the dogs escaped, he'll include that in his report about last night.

none of the pets escaped $\models$ none of the dogs escaped

An example narrative, ver. 3

John works at the SPCA, where there are different kinds of lost pets: mostly stray pitbulls, some other dogs, and a few cats. He always locks up for the night, but last night he must have forgotten! He came in this morning and found that some of the pitbulls escaped. Since some of the dogs escaped, he'll include that in his report about last night.

some of the pitbulls escaped $\vDash$ some of the dogs escaped

Study design, cntd.

18 narratives

In 9 versions:

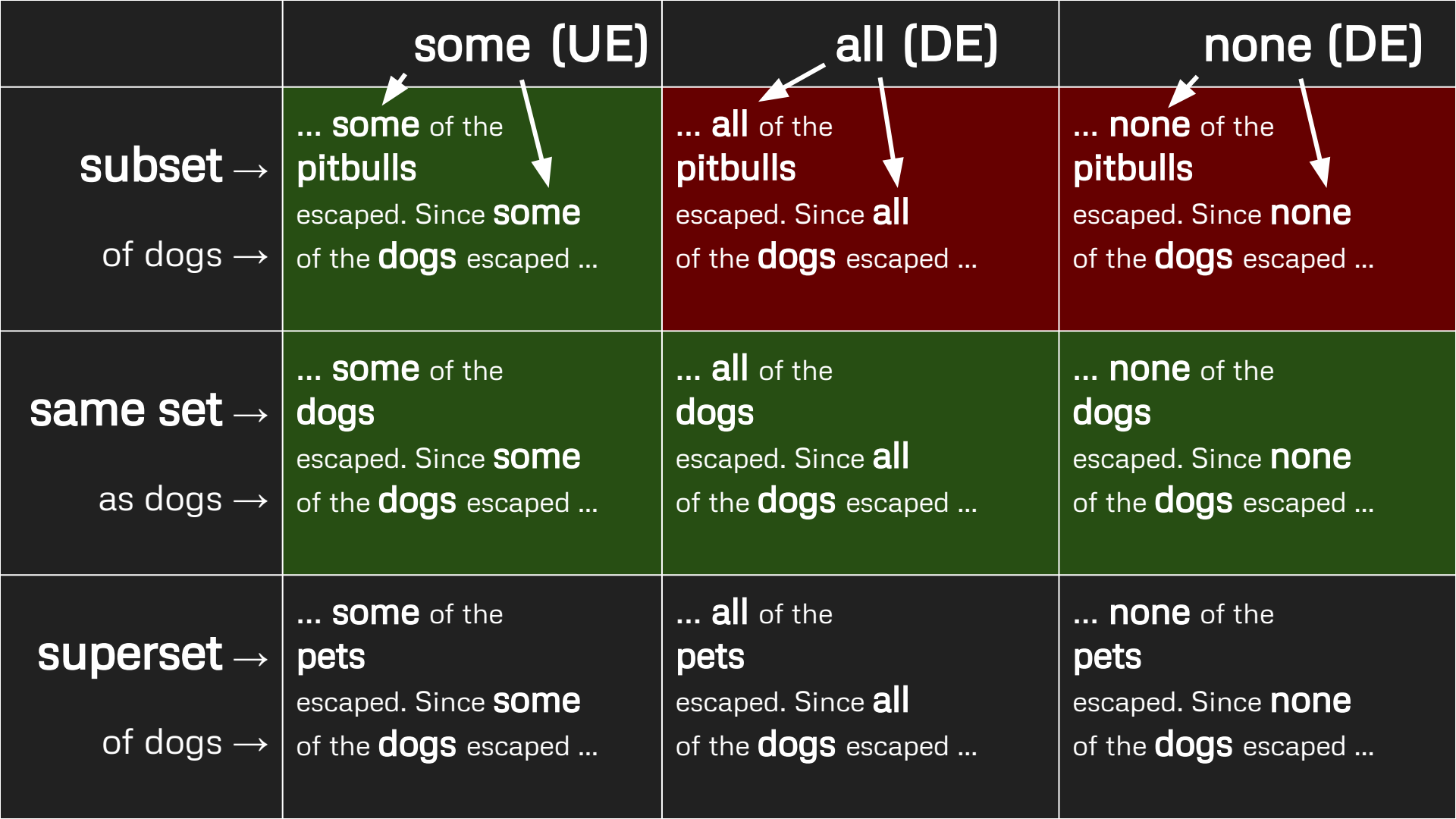
3 set containment relations × 3 quantifiers

	some (UE)	all (DE)	none (DE)
subset → of dogs →	… **some** of the **pitbulls** escaped. Since **some** of the **dogs** escaped …	… **all** of the **pitbulls** escaped. Since **all** of the **dogs** escaped …	… **none** of the **pitbulls** escaped. Since **none** of the **dogs** escaped …
same set → as dogs →	… **some** of the **dogs** escaped. Since **some** of the **dogs** escaped …	… **all** of the **dogs** escaped. Since **all** of the **dogs** escaped …	… **none** of the **dogs** escaped. Since **none** of the **dogs** escaped …
superset → of dogs →	… **some** of the **pets** escaped. Since **some** of the **dogs** escaped …	… **all** of the **pets** escaped. Since **all** of the **dogs** escaped …	… **none** of the **pets** escaped. Since **none** of the **dogs** escaped …

	some (UE)	all (DE)	none (DE)
subset → of dogs →	… **some** of the **pitbulls** escaped. Since **some** of the **dogs** escaped …	… **all** of the **pitbulls** escaped. Since **all** of the **dogs** escaped …	… **none** of the **pitbulls** escaped. Since **none** of the **dogs** escaped …
same set → as dogs →	… **some** of the **dogs** escaped. Since **some** of the **dogs** escaped …	… **all** of the **dogs** escaped. Since **all** of the **dogs** escaped …	… **none** of the **dogs** escaped. Since **none** of the **dogs** escaped …
superset → of dogs →	… **some** of the **pets** escaped. Since **some** of the **dogs** escaped …	… **all** of the **pets** escaped. Since **all** of the **dogs** escaped …	… **none** of the **pets** escaped. Since **none** of the **dogs** escaped …

	some (UE)	all (DE)	none (DE)
subset → of dogs →	… **some** of the **pitbulls** escaped. Since **some** of the **dogs** escaped …	… **all** of the **pitbulls** escaped. Since **all** of the **dogs** escaped …	… **none** of the **pitbulls** escaped. Since **none** of the **dogs** escaped …
same set → as dogs →	… **some** of the **dogs** escaped. Since **some** of the **dogs** escaped …	… **all** of the **dogs** escaped. Since **all** of the **dogs** escaped …	… **none** of the **dogs** escaped. Since **none** of the **dogs** escaped …
superset → of dogs →	… **some** of the **pets** escaped. Since **some** of the **dogs** escaped …	… **all** of the **pets** escaped. Since **all** of the **dogs** escaped …	… **none** of the **pets** escaped. Since **none** of the **dogs** escaped …

	some (UE)	all (DE)	none (DE)
subset → of dogs →	... **some** of the **pitbulls** escaped. Since **some** of the **dogs** escaped ...	... **all** of the **pitbulls** escaped. Since **all** of the **dogs** escaped ...	... **none** of the **pitbulls** escaped. Since **none** of the **dogs** escaped ...
same set → as dogs →	... **some** of the **dogs** escaped. Since **some** of the **dogs** escaped ...	... **all** of the **dogs** escaped. Since **all** of the **dogs** escaped ...	... **none** of the **dogs** escaped. Since **none** of the **dogs** escaped ...
superset → of dogs →	... **some** of the **pets** escaped. Since **some** of the **dogs** escaped ...	... **all** of the **pets** escaped. Since **all** of the **dogs** escaped ...	... **none** of the **pets** escaped. Since **none** of the **dogs** escaped ...


some (UE)
all (DE)
none (DE)
subset →
of dogs →
... some of the pitbulls escaped. Since some of the dogs escaped ...
... all of the pitbulls escaped. Since all of the dogs escaped ...
... none of the pitbulls escaped. Since none of the dogs escaped ...
same set →
as dogs →
... some of the dogs escaped. Since some of the dogs escaped ...
... all of the dogs escaped. Since all of the dogs escaped ...
... none of the dogs escaped. Since none of the dogs escaped ...
superset →
of dogs →
... some of the pets escaped. Since some of the dogs escaped ...
... all of the pets escaped. Since all of the dogs escaped ...
... none of the pets escaped. Since none of the dogs escaped ...

	some (UE)	all (DE)	none (DE)
subset → of dogs →	… **some** of the **pitbulls** escaped. Since **some** of the **dogs** escaped …	… **all** of the **pitbulls** escaped. Since **all** of the **dogs** escaped …	… **none** of the **pitbulls** escaped. Since **none** of the **dogs** escaped …
same set → as dogs →	… **some** of the **dogs** escaped. Since **some** of the **dogs** escaped …	… **all** of the **dogs** escaped. Since **all** of the **dogs** escaped …	… **none** of the **dogs** escaped. Since **none** of the **dogs** escaped …
superset → of dogs →	… **some** of the **pets** escaped. Since **some** of the **dogs** escaped …	… **all** of the **pets** escaped. Since **all** of the **dogs** escaped …	… **none** of the **pets** escaped. Since **none** of the **dogs** escaped …

	some (UE)	all (DE)	none (DE)
subset → of dogs →	… **some** of the **pitbulls** escaped. Since **some** of the **dogs** escaped …	… **all** of the **pitbulls** escaped. Since **all** of the **dogs** escaped …	… **none** of the **pitbulls** escaped. Since **none** of the **dogs** escaped …
same set → as dogs →	… **some** of the **dogs** escaped. Since **some** of the **dogs** escaped …	… **all** of the **dogs** escaped. Since **all** of the **dogs** escaped …	… **none** of the **dogs** escaped. Since **none** of the **dogs** escaped …
superset → of dogs →	… **some** of the **pets** escaped. Since **some** of the **dogs** escaped …	… **all** of the **pets** escaped. Since **all** of the **dogs** escaped …	… **none** of the **pets** escaped. Since **none** of the **dogs** escaped …

	some (UE)	all (DE)	none (DE)
subset → of dogs →	… **some** of the **pitbulls** escaped. Since **some** of the **dogs** escaped …	… **all** of the **pitbulls** escaped. Since **all** of the **dogs** escaped …	… **none** of the **pitbulls** escaped. Since **none** of the **dogs** escaped …
same set → as dogs →	… **some** of the **dogs** escaped. Since **some** of the **dogs** escaped …	… **all** of the **dogs** escaped. Since **all** of the **dogs** escaped …	… **none** of the **dogs** escaped. Since **none** of the **dogs** escaped …
superset → of dogs →	… **some** of the **pets** escaped. Since **some** of the **dogs** escaped …	… **all** of the **pets** escaped. Since **all** of the **dogs** escaped …	… **none** of the **pets** escaped. Since **none** of the **dogs** escaped …

Pilot study

20 participants

significant effect of entailment direction *above* the effect of quantifier

marginally significant effect of validity

very underpowered

Thank you!

special thanks to
Prof. Roman Feiman
Prof. Joshua Schechter

Dean Peggy Chang

Prof. Uriel Cohen Priva
Prof. Scott AnderBois
Prof. Pauline Jacobson

Conversational implicature

implicature = enriched meaning, not openly conveyed

John had an apple or a pear.

+> John did not have both an apple and a pear.

A or B = A, B, or A and B

1. The speaker said “John had an apple or a pear.”
2. “John had an apple and a pear” would have been more informative.
3. The speaker tries to be as informative as possible, but not more.
4. It is not the case that “John had an apple and a pear.”

Thought is logical.

Hoeksema (2012)

1. negation
2. *yes*/*no* questions
3. *wh*-questions
4. comparatives of inequality
5. conditional clauses
6. restriction of universals
7. restriction of *the only*
8. restriction of superlatives
9. scope of *only*

	1	2	3	4	5	6	7	8	9
Any	+	+	+	+	+	+	+	+	+
Ever	+	+	+	+	+	+	+	+	+
Ook maar	+	+	+	+	+	+	+	+	+
Minimizer	+	+	+	+	+	+	+	-	-
Remotely	+	+	+	+	+	+	+	-	+
At all	+	+	+	+	+	+	+	-	+
Adv. Any	+	+	+	+	+	+	+	-	+
Yet	+	+	-	+	+	-/+	+	+	+
Either	+	+	-	+	-	-	-	-	-
In X	+	-	-	+	-	-	+	+	-
Can help	+	+	+	+	+	-/+	-	-	-
Can blame	+	+	+	-	-	-	+	-	-
Kwaad kunnen	+	+	+	-	-	-	+	-	+
Need, etc.	+	+	+	+	-	-/+	+	-	+
Anymore (US)	+	-	-	-	-	-	+	-	-
Squat	+	-	-	-	-	-	+	-	-
Exactly	+	-	-	-	-	-	-	-	-
Meer/mehr	+	-	-	-	-	-	-	-	-

Predictors in our model

quantifier:

- *some*,
- *all*,
- *none*

validity of entailment:

- *valid* (green),
- *invalid* (red)

entailment direction:

- *upward* (some),
- *downward* (all, none)

set containment relation:

- *subset* > *superset* (pitbull > dog),
- *same set* (dog > dog),
- *superset* > *subset* (pet > dog)

Our goals

Better understand the role logic plays in language processing.

Find a psychological correlates of language patterns (such *any*-licencing).