Memory for cardinality supports a non-relational account of conservativity

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ELM 1 @ UPenn

The conservativity constraint

Three potential explanations

Testing their predictions
Natural language determiners are “conservative”  

\[\text{every circle is green} == \]
\[\text{every circle is a circle that is green} \]
Natural language determiners are “conservative”  

every circle is green ==
every circle is a circle that is green

A determiner DET is conservative iff
(1) \[[\text{DET} N(P)] \text{ PRED}] ==
(2) \[[\text{DET} N(P)] \text{ [be } N(P) \text{ that PRED}]]

We can imagine DETs that are not conservative

equi circles are green
  ≈ the circles are equinumerous with
  the green things
  (TRUE; 8=8)
equi circles are circles that are green
  ≈ the circles are equinumerous with
  the circles that are green
  (FALSE; 8≠4)
We can imagine DETs that are not conservative

**yreve circles are green**

= the circles include all green things
  (FALSE; green non-circles)

=/=  

**yreve circles are circles that are green**

= the circles include all circles that are green
  (TRUE; only circles are green circles)

The conservativity constraint

\[ [[\text{DET } N(P)]] \text{ PRED}] =\]

\[ [[\text{DET } N(P)]] \text{ be } N(P) \text{ that PRED}] \]

\[ every, most, ... \]

\[ \text{yreve} \text{ equi, ...} \]

Three potential explanations

Testing their predictions
Three views of conservativity

Meaning of \([\text{every } N(P)]\) predicate

- **relational**
  - Lexical restriction
    \(P \supseteq N\)
  - Interface filtering
    \(P \cap N \supseteq N\)
    * trivial meanings

- **non-relational**
  - Ordered predication
    \(\forall x [\text{is-P}(x)] \uparrow N\)
    entails conservativity

Proposal 1: Lexical restriction
(Keenan & Stavi 1986)

Determiners express relations between sets
(Barwise & Cooper 1981)

\(\text{every circle is green} \equiv \text{GREEN-THINGS} \supseteq \text{CIRCLES}\)

But only some relations make good DET meanings

\(\supseteq (\text{PRED, NP})\)
\(\text{MOST} (\text{PRED, NP})\)
\(\text{AT-LEAST-FOUR} (\text{PRED, NP})\)
\(\ldots\)
\(\subseteq (\text{PRED, NP}) \leftarrow \text{Meaning of yreve}\)
\(\equiv (\text{PRED, NP})\)
\(\text{EQUAL-IN-NUMBER} (\text{PRED, NP})\)
\(\ldots\)
Proposal 2: Interface filtering
(Romoli 2015; Chierchia 1995; Fox 2002; Sportiche 2005)

$\llbracket \text{Every circle is green} \rrbracket$

$\models LF \llbracket \text{every circle } \llbracket \text{every circle is green} \rrbracket \rrbracket$

\approx \text{GREEN-THINGS } \cap \text{CIRCLES } \supset \text{CIRCLES}$

(QR & Trace conversion)

$\llbracket \text{Equi circles are green} \rrbracket$

\approx |\text{GREEN-THINGS } \cap \text{CIRCLES}| = |\text{CIRCLES}|

$\text{TC } = \text{every!}$

$\llbracket \text{Yreve circle is green} \rrbracket$

\approx \text{GREEN-THINGS } \cap \text{CIRCLES } \subset \text{CIRCLES}$

(always TRUE)

* Trivial meanings

Proposal 3: Ordered predication
(Pietroski, 2005; 2018)

$\llbracket \text{Every circle is green} \rrbracket$

$\models LF \llbracket \text{every circle } \llbracket \text{every circle is green} \rrbracket \rrbracket$

\approx \forall x(\text{is-green}(x)) \uparrow \text{CIRCLES}$

(First argument sets domain)

All conservative determiners stateable in this way, but
non-conservative determiners are not (Westerståhl, 2019)

$\llbracket \text{Equi circle is green} \rrbracket$

\approx ??x(green(x)) \uparrow \text{CIRCLES}$

(intended: |\text{CIRCLES}| = |\text{GREEN-THINGS}|)
The conservativity constraint

\[
[[\text{DET } N(P)] \text{ PRED}] \equiv
[[\text{DET } N(P)] [\text{be } N(P) \text{ that PRED}]]
\]

Three potential explanations

- **Lexical restriction**
  
  \(P \supseteq N\)

- **Interface filtering**
  
  \(P \cap N \supseteq N\)

- **Ordered predication**
  
  \(\forall x [\text{is-P(x)}] \uparrow N\)

Testing their predictions

Testing predictions of the three views

**Linking hypothesis**: in understanding a declarative sentence, people are biased toward verification strategies that directly compute the relations & operations expressed by the semantic representation under evaluation (Lidz et al. 2011)

- **Relational**
  - Lexical restriction
    \(P \supseteq N\)
  - Interface filtering
    \(P \cap N \supseteq N\)
  - Represent and compare two sets

- **Non-relational**
  - Ordered predication
    \(\forall x [\text{is-P(x)}] \uparrow N\)
  - Treat arguments asymmetrically
Which set(s) do participants represent?

#-knowledge on T/F task
#-knowledge on baseline task

Every big circle is blue
How many big circles are there?

Every big circle was blue
How many big circles were there?

How many big circles were there?

How many big circles are there?

Which set(s) do participants represent?

Measuring #-knowledge on T/F task
Measuring #-knowledge on baseline task

(response=number$^9$

(Stevens 1964; Krueger 1984; Odic et al. 2016)
Which set(s) do participants represent?

Every big circle is blue

#-knowledge on T/F task

#-knowledge on baseline task

How many big circles are there?

Below baseline

Every big circle is blue

Size 1st argument

Color 2nd argument

Size & Color Intersection

Measuring #-knowledge

response=number

(Stevens 1964; Krueger 1984; Odic et al. 2016)
Lexical restriction

\[ P \supseteq N \]

Represent and compare two sets

Below baseline

Every big circle is blue

\[ P \cap N \supseteq N \]

Represent and compare two sets

Interface filtering

Below baseline

Every big circle is blue

Size 1st argument

Color 2nd argument

Size & Color Intersection
Lexical restriction
\( \mathcal{P} \supseteq \mathcal{N} \)
Represent and compare two sets

Interface filtering
\( \mathcal{P} \cap \mathcal{N} \supseteq \mathcal{N} \)
Represent and compare two sets

Ordered pred.
\( \forall x \left[ \text{is-P}(x) \right] \uparrow \mathcal{N} \)
Treat arguments asymmetrically

Every big circle is blue

Below baseline

Size
1st argument
Color
2nd argument
Size & Color
Intersection

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**Lexical restriction**

\[ P \supseteq N \]

**Represent and compare two sets**

**Interface filtering**

\[ P \cap N \supseteq N \]

**Represent and compare two sets**

**Ordered pred.**

\[ \forall x[is-P(x)] \uparrow N \]

**Treat arguments asymmetrically**

---

**Every big circle is blue**

![Graph showing statistical analysis](image)

- **Below baseline**
  - **n.s.**

- **Size**
  - 1st argument
  - 2nd argument

- **Color**
  - 2nd argument

- **Size & Color Intersection**

**n = 48**

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**Is there something special about size?**

![Graph showing statistical analysis](image)

- **Below baseline**
  - **n.s.**

- **Size**
  - 1st argument

- **Color**
  - 2nd argument

- **Size & Color Intersection**

**n = 48**
Is there something special about size?

No: swap arguments, same result!

Is the extension of the NP always mentally grouped?

Below baseline

n.s.

n = 48

Every blue circle is big

25

26
Is the extension of the NP always mentally grouped?

No: not with *only*!

Below baseline

n = 48

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Is the extension of the NP always mentally grouped?

No: not with *only*!

Below baseline

n = 48
Are they failing to represent color b/c of wm limit (3)?

No: they still fail when color named first!
Is there another signature of the asymmetry?

Yes:
rate of opting not to answer

How many (big/blue) circles were there?
I don't know!

**Average % pressing IDK button**

Baseline task

$\text{Size}$
1st argument

$\text{Color}$
2nd argument

$\text{Size & Color}$
Intersection $n = 48$

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**Average % pressing IDK button**

T/F task (every)
Baseline task

$\text{Size}$
1st argument

$\text{Color}$
2nd argument

$\text{Size & Color}$
Intersection $n = 48$

32
Are participants fully conscious of not knowing #?

No: same result when they did respond

How many (big/blue) circles were there?
I don’t know!

Below baseline

n = 48

33

Three views of conservativity

Meaning of \([\text{every } N(P)]\) predicate

\begin{align*}
\text{relational} & \quad \text{non-relational} \\
\text{Lexical restriction} & \quad \text{Interface filtering} \\
\exists P \supseteq N & \quad \exists P \cap N \supseteq N \\
* \text{trivial meanings} & \quad \forall x [\text{is-P(x)}] \supseteq N \\
\end{align*}

entails conservativity
Three views of conservativity

**Meaning of** \([\text{every } N(P)]\) predicate

**Takeaway:**
Participants only mentally group the extension of *every*'s first argument
→ *every*'s meaning does not express a relation b/t sets, in line with ordered predication

**Ordered predication**
\[ \forall x [\text{is-} P(x)] \uparrow N \]
entails conservativity

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Thanks!

**Special thanks to:**
Simon Chervenak       Valentine Hacquard
Zoe Ovans             Nico Arlotti
The members of UMD’s Language Acquisition Lab
& Cognitive Neuroscience of Language Lab

**And audiences at:**
UPenn's ILST seminar   UMD's LSLT series
CUNY 2020 @ UMass     SALT 30 @ Cornell