Memory for cardinality supports a non-relational account of conservativity

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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”  

\[ \text{every circle is green} \] == \\
\[ \text{every circle is a circle that is green} \]

A determiner \textit{DET} is conservative iff

1. \[[\text{DET N(P)}] \text{ PRED}] ==
2. \[[\text{DET N(P)}] \text{ [be N(P) that PRED}]\]

We can imagine \textit{DET}s that are not conservative

\[ \text{equi circles are green} \] == \\
\[ =/\] \\
\[ \text{equi circles are circles that are green} \] == \\
\[ \text{the circles are equinumerous with} \] \\
\[ \text{the green things} \] \\
\[ \text{the circles that are green} \] \\
\[ \text{(TRUE; 8=8)} \] \\
\[ \text{(FALSE; 8\#4)} \]
We can imagine **DET**s that are not conservative

**yreve circles are green**

= the circles include all green things

(\text{FALSE}; green non-circles)

/==

**yreve circles are circles that are green**

= the circles include all circles that are green

(\text{TRUE}; only circles are green circles)

The conservativity constraint

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

\text{every, most, …} \quad \text{yreve \ X \ equi, …}

Three potential explanations

Testing their predictions
Three views of conservativity

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

- **Relational**
  - **Lexical restriction**
    - \(P \supseteq N\)
    - \(\supseteq\) and \(\subseteq\)
  - **Interface filtering**
    - \(P \cap N \supseteq N\)
    - *trivial meanings*

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

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Proposal 1: Lexical restriction

(Keenan & Stavi, 1986)

Determiners express relations between sets

(Barwise & Cooper, 1981)

*every circle is green* \(\equiv\) **GREEN-THINGS** \(\supseteq\) **CIRCLES**

But only some relations make good DET meanings

\(\supseteq(PRED, NP)\) \n\(\subseteq(PRED, NP)\) \n\(\supseteq(PRED, NP)\) \n\(\subseteq(PRED, NP)\) \n\(\supseteq(PRED, NP)\) \n\(\subseteq(PRED, NP)\)

\(\supseteq(PRED, NP)\) \n\(\subseteq(PRED, NP)\) \n\(\supseteq(PRED, NP)\) \n\(\subseteq(PRED, NP)\) \n\(\supseteq(PRED, NP)\) \n\(\subseteq(PRED, NP)\)
Proposal 2: Interface filtering
(Romoli 2015; Chierchia 1995; Fox 2002; Sportiche 2005)

\[
(Every\ \text{circle is green}) =_{LF} \text{[every circle [every circle is green]]} \approx \text{GREEN-THINGS} \cap \text{CIRCLES} \supseteq \text{CIRCLES}
\]

\[
(Equide\ \text{circles are green}) \approx | \text{GREEN-THINGS} \cap \text{CIRCLES} | = | \text{CIRCLES} | \quad \text{TC} = \text{every!}
\]

\[
(Yreve\ \text{circle is green}) \approx \text{GREEN-THINGS} \cap \text{CIRCLES} \subseteq \text{CIRCLES}
\]

(always TRUE)

* Trivial meanings

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

\[
(Every\ \text{circle is green}) =_{LF} \text{[every circle [every circle is green]]} \approx \forall x [\text{is-green}(x)] \uparrow \text{CIRCLES}
\]

(First argument sets domain)

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

\[
(Equide\ \text{circle is green}) \approx ??x [\text{green}(x)] \uparrow \text{CIRCLES}
\]

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

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

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?

Every big circle was blue

How many big circles were there?

How many big circles were there?

(Marsh et al. 2005; Odic et al. 2016)

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

Measuring #-knowledge

response=number

Average numerical response

Number of dots presented

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

Every big circle is blue

Below baseline
Lexical restriction

\[ P \supseteq N \]

Represent and compare two sets

Interface filtering

\[ P \cap N \supseteq N \]

Represent and compare two sets

Every big circle is blue

Below baseline

Size
1st argument

Color
2nd argument

Size & Color
Intersection

19

20
Lexical restriction
\( P \supseteq N \)
Represent and compare two sets

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

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

---

Every big circle is blue

Below baseline

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

---

Every big circle is blue

Below baseline

Size 1st argument  Color 2nd argument  Size & Color Intersection
Lexical restriction
\[ P \supseteq N \]

Represent and compare two sets

Interface filtering
\[ P \cap N \supseteq N \]

Represent and compare two sets

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

Treat arguments asymmetrically

Is there something special about size?

Every big circle is blue

Below baseline
n.s.

n = 48
Is there something special about size?

No: swap arguments, same result!

Is the extension of the NP always mentally grouped?

n = 48
Is the extension of the NP always mentally grouped?

No: not with only!

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 signal of the effect?
Yes: let participants opt not to answer

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

**Average % pressing IDK button**

**Baseline task**

n = 48

Is there another signal of the effect?
Yes: let participants opt not to answer

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

**Average % pressing IDK button**

**T/F task (every)**

**Baseline task**

n = 48
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!

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

\(n = 48\)
Three views of conservativity

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

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**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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