Semantics

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Review

Expressions denote in boolean domains

t, *et*, *eet*, ... and *e*?

Semantic Combination via Function Application

$$\left[\!\!\left[\begin{array}{ccc} & \bullet & \\ \alpha & & \beta \end{array}\right]\!\!\right] = \begin{cases} [\![\alpha]\!]\,([\![\beta]\!]) & \text{if } \alpha : ab \text{ and } \beta : a \\ [\![\beta]\!]\,([\![\alpha]\!]) & \text{if } \alpha : a \text{ and } \beta : ab \end{cases}$$

I will write $\alpha \otimes \beta$ to mean $\alpha(\beta)$ or $\beta(\alpha)$, which ever is appropriate

Conjoining NPs

NP Coordination

Logical operators

- denote boolean operations
- can combine with *any* element in a boolean domain

Problem:
e (the type of entities) is not a boolean domain

but we can still coordinate NPs

- John and Mary
- every teacher or some student
- Greg and some student

NPs and (non-)entities

John laughs
true iff the individual *john* is a laugher i.e. iff
$[\![laugh]\!] ([\![John]\!]) = 1$

everyone laughs
true iff the individual *everyone* is a laugher???

no one laughs
true iff the individual *noone* is a laugher???

someone laughs
true iff the individual *someone* is a laugher???

Inference patterns with quantifiers

everyone laughs
entails

1. *John laughs*
2. *Mary laughs*

⋮

no one laughs
entails

1. *John doesn't laugh*
2. *Mary doesn't laugh*

⋮

someone laughs
entails that for some name *Name*,

1. *Name laughs*

Inferences with individuals

everyone laughs
entails

1. *John laughs*
2. *Mary laughs*

$\vdots$

there must be some individual $e \in E$
such that if $e \in A$ then every other individual is also in A

- except for the individual $[\![noone]\!]$

Inferences with individuals (II)

no one laughs
entails

1. *John doesn't laugh*
2. *Mary doesn't laugh*

$\vdots$

there must be some individual $n \in E$
such that if $n \in A$ then no other individual is also in A

- and nothing is true of nothing, but rather of n

Inferences with individuals (II)

someone laughs
entails that for some name *Name*,

1. *Name laughs*

there must be some individual $s \in E$
such that if $s \in A$ then at least one other individual is also in A

- but not just $[\![$*everyone*$]\!]$
- and not $[\![$*noone*$]\!]$

This is a little weird

Who *are* these mysterious individuals?

- ⟦*everyone*⟧
- ⟦*someone*⟧
- ⟦*noone*⟧

They don't act like normal individuals:

- We are three. All of us were at the party. Therefore, five people went to the party:
  - the three of us, Someone, and Everyone
- No one went to the party. Therefore, exactly one person went to the party:
  - No one

Rethinking types

$$NP_e \oplus VP_{et} = S_t$$

Rethinking types

$$NP_{\square} \oplus VP_{et} = S_t$$

Rethinking types

$$NP_{\square} \oplus VP_{et} = S_t$$

Possible choices for $\square$

- e
- $(et)t$

The type $(et)t$

an object of type $(et)t$

- looks at a property
- and says **yes** or **no**

This is called a generalized quantifier

John
is true of a property P iff

someone
is true of a property P iff

everyone
is true of a property P iff

no one
is true of a property P iff

The type $(et)t$

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- looks at a property
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John
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is true of a property P iff something is in P

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no one
is true of a property P iff nothing is in P

A boolean reformulation

- $[\![\textit{someone}]\!](P) = 1$ iff $P \neq 0$
- $[\![\textit{everyone}]\!](P) = 1$ iff $P = 1$
- $[\![\textit{noone}]\!](P) = 1$ iff $P = 0$

More GQs

- *the boy*
- *at least 3 students*
- *most doctors*
- *more doctors than lawyers*
- *between 3 and 12 professors*
- *at least 3 adults but not more than 15 students*

Booleanity

Now NPs denote in boolean algebras

- type *(et)t*
- so we can interpret logical operations on NPs too!

⟦*some boy and every girl laughed*⟧

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$$[\![\textit{some boy and every girl laughed}]\!] = [\![\textit{some boy and every girl}]\!]([\![\textit{laughed}]\!])$$

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$$[\![\textit{some boy and every girl laughed}]\!]$$
$$= [\![\textit{some boy and every girl}]\!]\,([\![\textit{laughed}]\!])$$
$$= ([\![\textit{some boy}]\!] \wedge [\![\textit{every girl}]\!])([\![\textit{laughed}]\!])$$

Booleanity

Now NPs denote in boolean algebras

- type *(et)t*
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$$
\begin{aligned}
&[\![\textit{some boy and every girl laughed}]\!] \\
&\qquad = [\![\textit{some boy and every girl}]\!]\,([\![\textit{laughed}]\!]) \\
&\qquad = ([\![\textit{some boy}]\!] \wedge [\![\textit{every girl}]\!])([\![\textit{laughed}]\!]) \\
&\qquad = [\![\textit{some boy}]\!]\,([\![\textit{laughed}]\!]) \wedge [\![\textit{every girl}]\!]\,([\![\textit{laughed}]\!])
\end{aligned}
$$

When do GQs distribute over boolean operations?

1. $g(P \wedge Q) \stackrel{?}{\equiv} g(P) \wedge g(Q)$
2. $g(P \vee Q) \stackrel{?}{\equiv} g(P) \vee g(Q)$
3. $g(\neg P) \stackrel{?}{\equiv} \neg g(P)$

Distributivity over Disjunction

1. everyone (either) laughed or praised Mary
2. (either) everyone laughed or everyone praised Mary
3. someone (either) laughed or praised Mary
4. (either) someone laughed or someone praised Mary
5. no one (either) laughed or praised Mary
6. (either) no one laughed or no one praised Mary
7. John (either) laughed or praised Mary
8. (either) John laughed or John praised Mary

Distributivity over Disjunction

1. everyone (either) laughed or praised Mary
2. $\neq$ (either) everyone laughed or everyone praised Mary
3. someone (either) laughed or praised Mary
4. $=$ (either) someone laughed or someone praised Mary
5. no one (either) laughed or praised Mary
6. $\neq$ (either) no one laughed or no one praised Mary
7. John (either) laughed or praised Mary
8. $=$ (either) John laughed or John praised Mary

Distributivity over Conjunction

1. everyone (both) laughed and praised Mary
2. everyone laughed and everyone praised Mary
3. someone (both) laughed and praised Mary
4. someone laughed and someone praised Mary
5. no one (both) laughed and praised Mary
6. no one laughed and no one praised Mary
7. John (both) laughed and praised Mary
8. John laughed and John praised Mary

Distributivity over Conjunction

1. everyone (both) laughed and praised Mary
2. $=$ everyone laughed and everyone praised Mary
3. someone (both) laughed and praised Mary
4. $\neq$ someone laughed and someone praised Mary
5. no one (both) laughed and praised Mary
6. $\neq$ no one laughed and no one praised Mary
7. John (both) laughed and praised Mary
8. $=$ John laughed and John praised Mary

Distributivity over Negation

1. everyone didn't laugh
2. It is not the case that everyone laughed
3. someone didn't laugh
4. It is not the case that someone laughed
5. no one didn't laugh
6. It is not the case that no one laughed
7. John didn't laugh
8. It is not the case that John laughed

Distributivity over Negation

1. everyone didn't laugh
2. $\neq$ It is not the case that everyone laughed
3. someone didn't laugh
4. $\neq$ It is not the case that someone laughed
5. no one didn't laugh
6. $\neq$ It is not the case that no one laughed
7. John didn't laugh
8. $=$ It is not the case that John laughed

Distributivity Summary

everyone
distributes only over $\wedge$

someone
distributes only over $\vee$

no one
never distributes

john
always distributes

Proper names

Proper names always distribute
how special is this?

In other words:

What is the relation between proper names and distributivity?

Boolean Homomorphisms

g is a boolean homomorphism if

1. it distributes over

$$\begin{aligned} \textbf{complement} \quad & g(\neg a) = \neg(g(a)) \\ \textbf{meet} \quad & g(a \wedge b) = g(a) \wedge g(b) \\ \textbf{join} \quad & g(a \vee b) = g(a) \vee g(b) \end{aligned}$$

2. it maps extrema to extrema

$$\begin{aligned} \textbf{top} \quad & g(1) = 1 \\ \textbf{bottom} \quad & g(0) = 0 \end{aligned}$$

Individuals are Homomorphisms

$I_j(P) = 1$ **iff** $j \in P$

in words: you are the sum of your properties

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Extrema

$$I_j(E) \leftrightarrow j \in E \qquad \text{(top)}$$
$$\leftrightarrow \texttt{True}$$
$$= 1$$

$$I_j(0) \leftrightarrow j \in \emptyset \qquad \text{(bottom)}$$
$$\leftrightarrow \texttt{False}$$
$$= 0$$

Homomorphisms are Individuals

$E = \{a, b, c\}$

g is a homomorphism

$$g(\emptyset) = 0$$
$$g(E) = 1$$

$$\begin{aligned} g(E) &= g(\{a\} \vee \{b\} \vee \{c\}) \\ &= \underbrace{g(\{a\}) \vee g(\{b\}) \vee g(\{c\})}_{\text{exactly one must be true}} \end{aligned}$$

Proper names revisited

We have shown:

1. all individuals are homomorphisms
2. all homomorphisms are individuals

’Entities’
are exactly those GQs which

- distribute over logical operations
- map extrema to extrema

A purely semantic characterization of proper name denotations

Summary

NPs denote in $(et)t$

Individuals are homomorphisms

There are many more things than individuals

- *more male than female students* is not a thing
- it is a function that
  - looks at a property, and says
  - whether or not more male than female students have that property

Are there semantic characterizations of other things?