Criteria of Individuation Determined Compositionally

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Some (relatively) well-known issues of individuation

(1) Michelangelo's David could have been made from a different piece of marble. (Gupta, 1980)

(2) 4000 ships passed through the lock. (Krifka, 1990)
OR There are/were 4000 ships that passed through the lock
ER There have been 4000 occurrences of a ship passing through the lock.

A less well-known issue

> Suppose the library has two copies of Tolstoy's *War and Peace*, Peter takes out one, and John the other. Did Peter and John take out the same book, or different books? If we attend to the material factor of the lexical item, they took out different books; if we focus on its abstract component, they took out the same book. We can attend to both material and abstract factors simultaneously...
>
> (Chomsky, 2000, p. 16)

Copredication

The apparent attribution of incompatible properties to a single object. Some examples:

(3) Lunch was delicious but took forever. (Asher, 2011, p. 11)

(4) The bank was vandalised after calling in Bob's debt.

(5) London is so unhappy, ugly and polluted that it should be destroyed and rebuilt 100 miles away. (Chomsky, 2000, p. 37)

Issues

- What (if anything) do these nouns refer to in these sentences?
- Why are these sentences *not* anomalous?
- How does the counting and individuation work?

Counting and individuation is the topic for today.

Plan for the rest of the talk

1 Individuation in copredication

Examples

(6) Three books are heavy.

(7) Three books are by Dickens.

(8) Three books by Dickens are heavy.

volume 1 | *Oliver Twist*
David Copperfield
Our Mutual Friend

- Physically: 1 book. Informationally: 3 books.
- (7): True, (6),(8): False

(6) Three books are heavy. ×

(7) Three books are by Dickens. ✓

(8) Three books by Dickens are heavy. ×

volume 1	*Oliver Twist*
volume 2	*Oliver Twist*
volume 3	*Oliver Twist*

- Physically: 3 books. Informationally: 1 books.
- (6): True, (7),(8): False

(6) Three books are heavy. ✓

(7) Three books are by Dickens. ×

(8) Three books by Dickens are heavy. ×

The third criterion

Situation 1

v_1	*Oliver Twist* *David Copperfield* *Our Mutual Friend*

Situation 2

v_1	*Oliver Twist*
v_2	*Oliver Twist*
v_3	*Oliver Twist*

(8) Three books by Dickens are heavy. ×

When we 'attend to both material and abstract factors simultaneously', as in **??** and **??**, neither situation 1 nor situation 2 makes the sentence true. For **??** or **??**, the books in question must be *both* physically *and* informationally distinct.

2 Compositional theory

2.1 Preliminaries

Forthcoming in the *Journal of Semantics*

Key points

1. Nouns supporting copredication denote sets of complex objects—in the case of 'book', objects that have a part that is a physical volume and a part that is an informational (abstract) book.
2. Predicates encode criteria of individuation as part of their meaning.
3. Quantifiers access, compose and exploit criteria of individuation.

Complex objects

Suppose that we combine the books in situations 1 and 2 to make situation 3:

v_1	*Oliver Twist* *David Copperfield* *Our Mutual Friend*	v_2	*Oliver Twist*
		v_3	*Oliver Twist*
		v_4	*Oliver Twist*

$[\![book]\!]^{s3}=\{v_1 + OT, v_1 + DC, v_1 + OMF, v_2 + OT, v_3 + OT, v_4 + OT\}$

Problem: In this view, there are 6 books in situation 3.

Solution: This set of 6 is never used in plural quantification because of restrictions imposed by determiners.

v_n: volume n, OT: *Oliver Twist* etc.

Distinctness criteria

- Say that a plurality is 'physically compressible' iff there are two members of it that are physically equivalent.
- E.g. 1 is physically compressible, but 2 isn't.

(1) $v_1 + OT \oplus v_1 + DC \oplus v_2 + OT$

(2) $v_1 + OMF \oplus v_2 + OT \oplus v_3 + OT$

- Both 1 and 2 are informationally compressible.

Composing distinctness criteria

- We can express 'x is physically compressible' as $(\textsc{phys})comp(x)$.
- Compressibilty statements can be complex, e.g.:

  $(\textsc{phys} \sqcup \textsc{info})comp(x)$—$x$ is (physically or informationally) compressible.
- E.g. $(\textsc{phys} \sqcup \textsc{info})comp(a)$, but $\neg(\textsc{phys} \sqcup \textsc{info})comp(b)$

(a) $= v_1 + DC \oplus v_2 + OT \oplus v_3 + OT$

(b) $= v_1 + DC \oplus v_2 + OT$

Formally:

- PHYS is shorthand for $\lambda x_e.\lambda y_e.$phys-equiv$'(x, y)$—the two-place relation of physical equivalence.
- $(R)comp(x)$ is shorthand for $\exists y \exists z(y \neq z \wedge$ i-at$(y) \wedge$ i-at$(z) \wedge y \leq_i x \wedge z \leq_i x \wedge R(y, z))$—the statement that there are two singletons (y and z) that are individual parts of the plurality x and which bear relation R to each other.
- $\sqcup$ is the generalized disjunction operator, familar from e.g. Partee and Rooth (1983).

$\therefore$ (PHYS $\sqcup$ INFO)$comp(x) \equiv$
$\exists y \exists z(y \neq z \wedge$ i-at$(y) \wedge$ i-at$(z) \wedge y \leq_i x \wedge z \leq_i x$
$\wedge$ (phys-equiv$'(y, z) \vee$ info-equiv$'(y, z)))$

2.2 Lexical entries

Compositional theory

Novel lexical entries:

- $[\![book]\!] = \lambda x_e.\, \langle \text{book}'(x)\ ,\ \text{PHYS} \sqcap \text{INFO} \rangle$
- $[\![books]\!] = \lambda x_e.\, \langle {}^*\text{book}'(x)\ ,\ \text{PHYS} \sqcap \text{INFO} \rangle$
- $[\![be\ heavy_{PL}]\!] = \lambda y_e.\, \langle {}^*\text{heavy}'(y)\ ,\ \text{PHYS} \rangle$

In the full system things are a bit more complex, e.g. we really have

$$[\![books]\!] = \lambda y_e\, \langle {}^*\text{book}'(y)\ ,\ \lambda f_{e\to\mathcal{R}}.f(y) \sqsubseteq (\text{PHYS} \sqcap \text{INFO}) \rangle$$

, Lexical entries for higher-arity verbs can be set up accordingly, e.g.

$[\![mastered]\!] = \lambda y_e.\lambda z_e\, \langle \text{master}'(z, y)\ ,\ \lambda g_{e\to\mathcal{R}}\big(g(y) \sqsubseteq \text{INFO} \wedge g(z) \sqsubseteq \text{ANI}\big) \rangle$

Quantification

(Where $\mathcal{R}$ abbreviates $e \to (e \to t)$) $\pi_1(\langle a, b\rangle) = a \qquad \pi_2(\langle a, b\rangle) = b$

$$[\![three]\!] = \lambda P_{e\to(t\times\mathcal{R})}.\lambda Q_{e\to(t\times\mathcal{R})}.\ \Big\langle \exists x\big(|x| \geq 3 \wedge \pi_1(Px) \wedge \pi_1(Qx) \wedge \neg(\pi_2(Px) \sqcup \pi_2(Qx))comp(x)\big),\ \pi_2(Px) \sqcap \pi_2(Qx) \Big\rangle$$

$$\therefore [\![three\ books]\!] = \lambda Q_{e\to(t\times\mathcal{R})}.\ \Big\langle \exists x\big(|x| \geq 3 \wedge {}^*\text{book}'(x) \wedge \pi_1(Qx) \wedge \neg((\text{PHYS} \sqcap \text{INFO}) \sqcup \pi_2(Qx))comp(x)\big),\ (\text{PHYS} \sqcap \text{INFO}) \sqcap \pi_2(Qx) \Big\rangle$$

- $\mathcal{R}$ is shorthand for $e \to (e \to t)$.
- π_1 and π_2 are projection functions from tuples to their inhabitants, i.e. $\pi_1(\langle a, b\rangle) = a$ and $\pi_2(\langle a, b\rangle) = b$.

Again the reality is more complex: we have

$$[\![three]\!] = \lambda A.\lambda B\Big\langle \exists x\big(|x| \geq 3 \wedge \pi_1(Ax) \wedge \pi_1(Bx) \wedge \neg(\Omega(\lambda v.\pi_2(Av)) \sqcup \Omega(\lambda v.\pi_2(Bv)))comp(x)\big),\ \lambda h.\exists v\big(\pi_1(Av) \wedge \pi_2(Av)(h) \wedge \pi_2(Bv)(h)\big)\Big\rangle$$

Where the Ω function is defined as follows:

$$\Omega_{(e\to((e\to\mathcal{R})\to t))\to\mathcal{R}}(A) \stackrel{\text{def}}{=} \bigvee \{R : \exists x_e \exists f_{e\to\mathcal{R}}(A(x)(f) \wedge f(x) = R)\}$$

Physical individuation

$$[\![three\ books\ are\ heavy]\!] = \Big\langle \exists x\big(|x| \geq 3 \wedge {}^*\text{book}'(x) \wedge {}^*\text{heavy}'(x) \wedge \neg((\text{PHYS} \sqcap \text{INFO}) \sqcup \text{PHYS})comp(x)\big),\ (\text{PHYS} \sqcap \text{INFO}) \sqcap \text{PHYS} \Big\rangle$$

$$= \Big\langle \exists x\big(|x| \geq 3 \wedge {}^*\text{book}'(x) \wedge {}^*\text{heavy}'(x) \wedge \neg(\text{PHYS})comp(x)\big),\ \text{PHYS} \sqcap \text{INFO} \Big\rangle \tag{3}$$

The truth conditions shown in 3 require that there be a plurality of three books that are heavy, a group that is not physically compressible.

2.3 Composition

More pieces of the puzzle

$$[\![\textit{by Dickens}]\!] = \lambda P_{e\to(t\times\mathcal{R})}.\lambda y_e.\,\langle(\text{by}'(d',y)\wedge\pi_1(Py))\ ,\ \pi_2(Py)\sqcup\text{INFO}\rangle$$

$$\begin{aligned}\therefore [\![\textit{books by Dickens}]\!] &= \lambda y_e.\langle\text{by}'(d',y)\wedge{*}\text{book}'(y)\ ,\\ &\qquad (\text{PHYS}\sqcap\text{INFO})\sqcup\text{INFO}\rangle\\ &= \lambda y_e.\,\langle\text{by}'(d',y)\wedge{*}\text{book}'(y)\ ,\ \text{INFO}\rangle\end{aligned}$$

Copredication

$\therefore [\![\textit{three books by Dickens}]\!] =$

$\lambda Q_{e\to(t\times\mathcal{R})}\cdot$

$\Big\langle\exists x\big(|x|\geq 3\wedge{*}\text{book}'(x)\wedge\text{by}'(d',x)\wedge\pi_1(Qx)\wedge\neg(\text{INFO}\sqcup\pi_2(Qx))\mathit{comp}(x)\big),$

$\text{INFO}\sqcap\pi_2(Qx)\Big\rangle$

$\therefore [\![\textit{three books by Dickens are heavy}]\!] =$

$\Big\langle\exists x\big(|x|\geq 3\wedge{*}\text{book}'(x)\wedge\text{by}'(d',x)\wedge{*}\text{heavy}'(x)\wedge\neg(\text{INFO}\sqcup\text{PHYS})\mathit{comp}(x)\big),$

$\text{INFO}\sqcap\text{PHYS}\Big\rangle$

These truth conditions require that there be a group of three books that are heavy and that Fred mastered, a group that is not (physically or informationally) compressible.

3 Relation to other issues of individuation

(2) 4000 ships passed through the lock.

The event-reading of (2) according to Doetjes and Honcoop (1997):

(4) $4000\langle e,x\rangle : \text{ship}'(x)\wedge\text{passed-through-the-lock}'(e,x)$

According to Barker (1999, p. 688):

> The one-to-many [event-related] reading arises when context favors [...] considering two stages of the same ship as distinct entities. In both cases there must be 4,000 ship entities present in the model—but several of those discourse entities (stages, if you prefer) may correspond to the same ship in the world of experience.

Mapping from (traditional) individuals to stages not straightforward. Suggestion:

- Take stages as basic entities
- Model a stage as an individual-at-a-time (however you incorporate times in the model)
- Model identity through time by means of an equivalence relation

$\text{ent-equiv}'(\text{pinafore}'@t_1,\text{pinafore}'@t_2)$

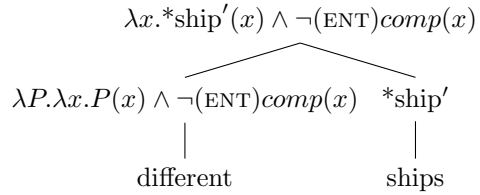
$\therefore(\text{ENT})\mathit{comp}(\text{pinafore}'@t_1\oplus\text{pinafore}'@t_2)$

Derive the (usual) object-related reading using a compressibility statement.

$\text{ER}:\exists x\big(|x|=4000\wedge{*}\text{ship}'(x)\wedge{*}\text{pass-through}'(x)\big)$

$\text{OR}:\exists x\big(|x|=4000\wedge{*}\text{ship}'(x)\wedge{*}\text{pass-through}'(x)\wedge\neg(\text{ENT})\mathit{comp}(x)\big)$

(9) 4000 different ships passed through the lock.



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