Intensional Semantics

1 Why extensional semantics is not sufficient

- In Extensional Semantics, every expression is of type e, or t, or a derived type based on e and t.
  - Sentence:
  - Common noun:
  - Intransitive verb:
  - Transitive verb:
  - *the*+NP
- So far, we've been using extensional semantics: the meaning of a complex expression is composed from the <u>extensions</u> of the components of a complex expression.

  (1) $[\![\text{Andy met Betty}]\!]^w = [\![\text{met}]\!]^w([\![\text{Andy}]\!]^w, [\![\text{Betty}]\!]^w) = [\![\text{met}]\!]^w(a, b)$

  Here, *met* is a relation between entities.
- Nevertheless, extensional semantics is insufficient.

  In the actual world w, Gennaro smokes and likes Belgian chocolate. Thus:

  (2) $[\![\text{Gennaro smokes}]\!]^w = [\![\text{Gennaro likes Belgian chocolate}]\!]^w = 1$

  If *believe* expresses a relation between the extension of the belief holder and the the extension of the embedded sentence, we have:

  (3) $[\![\text{Kate believes S}]\!]^w = [\![\text{believe}]\!]^w([\![\text{Kate}]\!]^w, [\![\text{S}]\!]^w)$

  Due to the equation in (2), we expect the following equation to hold in the actual world:

  (4) $[\![\text{Kate believes Gennaro smokes}]\!]^w = [\![\text{Kate believes Gennaro likes Belgian chocolate}]\!]^w$
  a. $[\![\text{believe}]\!]^w([\![\text{Kate}]\!]^w, [\![\text{Gennaro smokes}]\!]^w) = [\![\text{believe}]\!]^w(k, 1)$
  b. $[\![\text{believe}]\!]^w([\![\text{Kate}]\!]^w, [\![\text{Gennaro likes Belgian chocolate}]\!]^w) = [\![\text{believe}]\!]^w(k, 1)$

  However, equation (4) doesn't hold. In fact, Kate knows Gennaro smokes, but she doesn't know that he likes Belgian chocolate.

  The fact that equation (2) doesn't ensure equation (4) shows that the meaning of *believe* cannot be defined purely based on the extension of its embedded clause. In other words, *believe* is not type of type $\langle t, \langle e, t\rangle\rangle$. It does not express a relation between an entity (Kate) and a truth value (the extension of "Gennaro smokes").
- We call predicates like *believe* as **intensional verbs**. More examples of intensional verbs:

  know, wish, doubt, hope, fear, think, discover, want, demand, expect.

- **Extensional expressions versus Intensional expressions** (Modified from Winter 2016: chap. 5)[1]

– Example 1: *talk to* versus *look for*

Assume that every pianist is a composer, and that every composer is a pianist. Then:

(5) $[\![\text{composer}]\!] = [\![\text{pianist}]\!]$

This equation extends to:

(6) a. John is talking to a pianist.
b. John is talking to a composer.

But doesn't extend to the following, since John may be looking for a pianist without being aware that the pianists are the composers:

(7) a. John is looking for a pianist.
b. John is looking for a composer.

– Example 2: *in Tina's room* versus *in Tina's dream*

Assume that every pianist is a composer, and that every composer is a pianist. Then:

(8) $[\![\text{composer}]\!] = [\![\text{pianist}]\!]$

This equation extends to:

(9) a. In Tina's room, some composer is playing.
b. In Tina's room, some pianist is playing.

But doesn't extend to the following, since John may be looking for a pianist without being aware that the pianists are the composers:

(10) a. In Tina's dream, some composer is playing.
b. In Tina's dream, some pianist is playing.

– Hence:

Extensional expressions: *talk to*, *in Tina's room*
Intensional expressions: *look for*, *in Tina's dream*

Discussion: Can you think of more extensional expressions and intensional expressions?

[1] Winter, Yoad, 2016. *Elements of Formal Semantics*, Edinburgh University Press.

2 Defining extension and intension

- The **extension** of an expression is dependent on the evaluation world. We add an *evaluation world parameter* $[\![\bullet]\!]^w$ to the notations of extensions:

  (11) General notation: $[\![X]\!]^w$ ('the extension of X in w')

  Examples:

  (12) a. $[\![\text{Gennaro smokes}]\!]^w = 1$ iff Gennaro smokes in w.
  b. $[\![\text{composer}]\!]^w = \lambda x_e.\ x$ is a composer in w.
  $= \lambda x_e[\mathsf{composer}_w(x) = 1]$
  $= \lambda x_e[\mathsf{composer}_w(x)]$

- The **intension** of an expression X is a function which (i) takes a possible world as an argument, and (ii) returns the extension of X in that world.

  (13) General notation: $\lambda w_s.[\![X]\!]^w$ ('the intension of X')

  - The intension of a sentence is a function from worlds to truth values, called *proposition*.
  - The intension of a one-place predicate (IV/VP/NP/Pred Adj/..) of type $\langle e, t\rangle$ is a function from worlds to $\langle e, t\rangle$ functions, called *property*.
  - The intension of a definite NP is a function from worlds to entities, called *individual concept*.

  Examples: (the descriptions of each example are all equivalent)

  (14) The intension of "Gennaro smokes" :
  a. λw_s. Gennaro smokes in w
  b. $\lambda w_s[\mathsf{smokes}_w(g) = 1]$
  c. $\lambda w_s.\mathsf{smokes}_w(g)$

  (15) The intension of "composer":
  a. $\lambda w_s \lambda x_e.x$ is a composer in w
  b. $\lambda w_s \lambda x_e[\mathsf{composer}_w(x) = 1]$
  c. $\lambda w_s \lambda x_e.\mathsf{composer}_w(x)$

  Exercise: Can you define the extension and intension of the definite expression *the instructor of 106*?

  Discussion: The semantic type of a possible word is s, then what is the semantic type of a proposition, a property, and an individual concept?

- Using set-theoretical notations, a proposition can also be viewed as the set of possible worlds where this proposition is true.

(16) The intension of "Gennaro smokes":
$\{w : [\![\text{Gennaro smokes}]\!]^w = 1\}$

(17) Consider the following four worlds:
a. In $w1$, Gennaro smokes, and he like Belgian chocolate.
b. In $w2$, Gennaro smokes, but he doesn't like Belgian chocolate.
c. In $w3$, Gennaro doesn't smoke, but he likes Belgian chocolate.
d. In $w4$, Gennaro doesn't smoke, and he doesn't like Belgian chocolate.

(18) Then:
a. The intension of "Gennaro smokes": $\{w1, w2\}$
b. The intension of "Gennaro likes Belgian chocolate": $\{w1, w3\}$

While "Gennaro smokes" and "Gennaro likes Belgian chocolate" have the same extension in the actual world, they have different intensions.

3 Defining *believe* (won't be tested)

- The meaning of the clausal object of *believe* must be intensional.

(19) $[\![\text{Kate believes S}]\!]^w = [\![\text{believe}]\!]([\![\text{Kate}]\!]^w, \lambda w.[\![\text{S}]\!]^w)$

- "x believes S" is true in w iff S is true in every world that is compatible with x's belief in w.

Assume that in the actual world w, Kate believes that Gennaro smokes, and she has no idea whether he likes Belgian chocolate. Then the worlds that are compatible with Kate's belief in w are $\{w1, w2\}$. Then "Kate believes S" is true in w iff S is true in both $w1$ and $w2$.

- Now compute the extension of the two *believe*-sentences:

(20) a. $[\![\text{Kate believes Gennaro smokes}]\!]^w$
$= [\![\text{believe}]\!]^w([\![\text{Kate}]\!]^w, \lambda w.[\![\text{Gennaro smokes}]\!]^w)$
$= 1$
(because for every world in $\{w1, w2\}$, Gennaro smokes is true.)
b. $[\![\text{Kate believes Gennaro likes Belgian chocolate}]\!]^w$
$= [\![\text{believe}]\!]^w([\![\text{Kate}]\!]^w, \lambda w.[\![\text{Gennaro likes Belgian chocolate}]\!]^w)$
$= 0$
(because there is a world in $\{w1, w2\}$ where Gennaro likes Belgian chocolate isn't true.)

4 You need to know ...

- Why extensional semantics is insufficient?
- Some typical intensional expressions.
- Formally, what is extension and what is intension?