INTRO: INTENSIONALITY

Topics & Goals

- Basic facts about intensionality (referential opacity, propositional attitudes)
- Modeling intensionality
- Review of some formal techniques (λ-calculus, composition interpretation)
- Initial evidence for object language worlds/situation variables

1. INTENSIONALITY

The intensional contexts that will be of interest are environments that violate *Leibniz*' *Law* (aka 'Principle of Substitution *salva veritate*' or 'Principle of Indiscernibility of Identicals'):

(1) *Leibniz' Law* [Gottfried Leibniz, quote from around 1686]
Substitution of coextensional expressions preserves truth.
(*Eadem vel Coincidentia sunt quae sibi ubique substitutui possunt salva veritate*)

Extensionally, (2)a and (2)b are synonymous. Still, they do not mean the same: (2)a is a tautology while (2)b is cognitively significant.

(2) a. The Morning Star is the Morning Star.
b. The Morning Star is the Evening Star.

I. Intensional operators. Embedding under intensional operators exposes truth conditional difference. Substituting co-extensive terms under *modals* affects meaning:

(3) a. It is *possible* that the Morning Star is *not* the Evening Star. (true)
b. $\nRightarrow$ It is *possible* that the Morning Star is *not* the Morning Star. (false)

(4) *Opaque context*
For any syntactic environment ε and ε' and expressions α and β such that ε contains α and ε' is just like ε except that α has been substituted by β:
a. ε is *opaque* iff $[\![\varepsilon]\!] \neq [\![\varepsilon']\!]$
b. ε is *transparent* otherwise

II. Intensional Transitive Verbs. Object position of ITV-verbs (*want*, *need*, *seek*, *desire*, *lack*, *admire*, *own*, *offer*, *buy*, *paint*, *imagine*,...) is opaque. Suppose the speaker knows that Clark Kent is Superman.

(5) a. Lois Lane killed Clark Kent.
b. $\Rightarrow$ Lois Lane killed Superman.

(6) a. Lois Lane is *looking* for Clark Kent.
b. $\nRightarrow$ Lois Lane is *looking* for Superman.

III. Propositional Attitudes. Propositional attitudes express relations between sentient individuals and propositions. Embedding under *propositional attitude* predicates leads to opacity.

(7) *Supposition*: Dimitris is a Russian athlete who won a stage of the Tour the France. John has been watching the race, but mistakenly believes that Dimitris is Greek because all Dimitrides he knows are Greek. No other Russian took part in the race.

(8) a. Dimitris won the race.
b. ⇒ The Russian athlete won the race.

(9) a. John *believes* that Dimitris won the race.
b. ⇏ John *believes* that the Russian athlete won the race.

(10) *Supposition*: All and only those animals that have a heart (*cordates*) also have a liver. John is not aware of this fact, though. Also, for religious reasons, he does not eat animals with a liver.

(11) a. John has eaten an animal with a heart.
b. ⇒ John has eaten an animal with a liver.

(12) a. John does not *want* to eat animals with a liver. (true)
b. ⇏ John does not *want* to eat animals with a heart. (false)

All fours statements in (13) can be simultaneously true (from SEP entry on *Propositional Attitude Reports*):

(13) a. Superman is Clark Kent.
b. John *believes* that Superman is invincible.
c. John does not *believe* that Clark Kent is invincible. (*Neg-raising*: (13)c ⇒ (13)d)
d. John *believes* that Clark Kent is not invincible.

IV. Intensional adverbs. Some adverbs fail to preserve meaning.

(14) *Supposition*: All and only those who ate at a fish restaurant X on 15th Nov 1999 had food poisoning. [Robin Cooper 2005, lecture notes]

(15) a. John ate a fish in restaurant X on 15th Nov 1999.
b. ⇔ John had food poisoning on 15th Nov 1999.

(16) a. John *voluntarily* ate a fish in restaurant X on 15th Nov 1999.
b. ⇏ John *voluntarily* had a food poisoning X on 15th Nov 1999.

(17) *Supposition*: The doctors are the violinists.

(18) a. John *allegedly* is a doctor.
b. ⇏ John *allegedly* is a violinist.

V. Intensional adjectives. non-intersective (*skillful*, *good*, *typical*,...) and intensional non-subsective APs (*former*, *alleged*, *fake,...*) create opaque contexts (Siegel 1976; Larson 2000, among many others).

(19) *Supposition*: Mr. Perry murdered both Smith and Jones.

(20) a. Sam met the murderer of Smith.
b. ⇒ Sam met the murderer of Jones.

(21) a. Sam met the *alleged* murderer of Smith.
b. ⇏ Sam met the *alleged* murderer of Jones.

(22) *Supposition*: The doctors are the violinists.

(23) a. Sam knows the doctors.
b. ⇒ Sam knows the violinists.

(24) a. Sam knows the *skillful* doctors.
b. ⇏ Sam knows the *skillful* violinists.

VI. Conditionals. Antecedent of conditionals is opaque.

(25) a. *If* Lois Lane starts dating Clark Kent, she will be dating an office mate.
b. $\nRightarrow$ *If* Lois Lane starts dating Superman, she will be dating an office mate.

VII. Quotation. Quotations are opaque. Additional indicator of opacity is indexical shift inside quotations from speaker in context to 'quoting authority'.

(26) a. Lois Lane *said*: "I like Clark Kent".
b. $\nLeftarrow$ Lois Lane *said*: "I like Superman".

(27) a. Lois Lane *said*, that I liked Clark Kent. (*I* denotes in context c speaker in c)
b. $\nLeftarrow$ Lois Lane *said*: "I like Clark Kent". (*I* denotes in context c Lois Lane)

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2. INTENSIONAL SEMANTICS

2.1. LAMBDA CALCULUS

(28) a. *Syntax*
If φ is an expression of type δ, and α is a variable of type ε,
then λα.φ is an expression of type <ε,δ>.

b. *Semantics* [Heim and Kratzer 1998]
i. λα.φ $=_{Def}$ the smallest function which maps α to φ
ii. λα.φ $=_{Def}$ the function which maps α to 1 if φ, and to 0 otherwise

(29) a. f(x) = x+2
b. λx.x+2 'the smallest function which maps arbitrary x to x+2'
c. λx.Prime(x) 'the smallest function which returns 1 (T) if arbitrary x is a prime'

(30) a. λx.love(x)(John) 'the individuals John loves'
b. λx.love(John)(x) 'the individuals loved by John'
c. λx.λy.love(x)(y) 'diadic relation between lovers and loved ones' = ⟦love⟧

2.2. MODELING INTENSIONALITY

Standard analysis of failed inferences (Frege 1882):

- Natural language expressions have two different denotations: an *extension* and an *intension* (Carnap 1947; ≈ *reference* and *sense* in Frege 1882)
- Leibniz' Law applies to extensions only.
- Intensional contexts combine with intensions.

Interpretation relative to a *possible world* or *situation*:

(31) *Intension* of *α relative to an assignment g (world/situation independent denotation of α)*
a. $=_{def}$ the function f from possible worlds w to denotations of type α which assigns to each w the extension of ⟦α⟧ in w.
b. $=_{def}$ $\lambda w.[\![\alpha]\!]^{w,g}$

(32) *Extension of α relative to an assignment g and a world w (denotation evaluated in w)*
a. $=_{def}$ the result of evaluating at w the function f from possible worlds w to denotations of type α which assigns to each w the extension of ⟦α⟧ in w
b. $=_{def}$ $[\![\alpha]\!]^{w,g}$

The terms ‘situation’ and ‘world’ will be used as if they were interchangeable *salva veritate*. Strictly speaking, this is not true - worlds are more like maximal situations (Kratzer 2011).

Natural language semantics specifies recursive definitions of values for each expression relative to a model, an assignment function for variables/pronouns and a world/situation.

(33) A *Model* is a structure $\langle D, I\rangle$ in which
 a. D is the domain of entities (aka *universe* or *ontology*)
 b. I is the interpretation function from constants of type τ to elements of D_τ

(34) *Interpretation relative to model, assignment and world (index)*
 $[\![\alpha]\!]^{M, g, w}$ = denotation of α relative to M, assignment g and world w

(35) g is an *assignment function* from variables of type τ to entities of D_τ

(36) *Semantic values of simple expressions (terms*)
 a. If α is a constant, $[\![\alpha]\!]^{M,g} = I(\alpha)$
 b. If α is a variable, $[\![\alpha_1]\!]^{M,g} = g(\alpha_1) = g(1)$ [the latter convention]

(37) *Notational convention*: superscripts for M and g will be ommitted unless ambiguity arises.

(38) *Intensional Model*
☞ a. Set of possible worlds/situations
☞ b. Domains of individuals in each world
 c. Interpretation function (for constants, i.e. lexical items) ≈ the Lexicon
 d. Assignment function (for variables)
☞ e. Accessibility relation

Extensional vs. intensional systems: In intensional system, natural language is interpreted relative to a world/situation parameter. This the world/situation, can be bound and manipulated by metalanguage operators (e.g. IFA below). In extensional system, world/situations are part of object language.

(39) *Intensional* language: interpretation relative to worlds as atoms of logical meta language.
 $[\![\text{dog}]\!]^{w, g}$ = $\lambda x.x$ is a dog in w $[\![\text{dog}]\!]$ is of type $\langle e,t\rangle$

(40) *Extensional* language: worlds are part of object language. [Gallin 1975 Ty2; Cresswell 1990]
 a. $[\![\text{dog}]\!]^{g}$ = $\lambda w.\lambda x.x$ is a dog in w $[\![\text{dog}]\!]$ is of type $\langle s,\langle e,t\rangle\rangle$
 b. $[\![\text{dog}]\!]^{g}$ = $\lambda x\lambda w.x$ is a dog in w $[\![\text{dog}]\!]$ is of type $\langle e,\langle s,t\rangle\rangle$

2.2.1. Definitions

1. Types: Recursive definition of semantic types of object language expressions that correspond to the syntactic categories of the metalanguage:

(41) *Intensional:* the set of *types* T is the smallest set such that
 a. $e \in T$
 b. $t \in T$
 c. If $\tau \in T$ and $\upsilon \in T$, then $\langle\tau,\upsilon\rangle \in T$
☞ d. If $\tau \in T$, then $\langle s, \tau\rangle \in T$ (s *is not* an atomic type)

(42) *Extensional* (Ty2; Gallin 1975)
 a. $e \in T$
 b. $t \in T$
☞ c. $s \in T$ (s *is* an atomic type)
 d. If $\tau \in T$ and $\upsilon \in T$, then $\langle\tau,\upsilon\rangle \in T$

2. Domain: recursive definition of possible denotations for each type τ.

(43) *Domain*s

a. D_e = D (the set of all possible individuals)

b. D_t = {0,1}

c. D_s = domain of situations (mereological structure)

d. $D_{<\tau,\upsilon>}$ = set of all functions from D_τ to D_υ ($\{f \mid f: D_\tau \to D_\upsilon\}$, for any type τ, υ

☞ e. $D_{<s,\tau>}$ = $\{f \mid f: D_s \to D_\tau\}$, for any type τ

3. *Typed vocabulary* (aka *signature*): logical and non-logical symbols in lexicon.

A. Non-logical vocabulary

(44) $[\![\text{Perry}]\!]^{w,g}$ = Perry $\in D_e$

(45) a. $[\![\text{dog}]\!]^{w,g}$ = $\lambda x.x$ is a dog in w $\in D_{<e,t>}$ (intensional)

b. $[\![\text{dog}]\!]^{g}$ = $\lambda w.\lambda x.x$ is a dog in w $\in D_{<s,<e,t>>}$ (extensional Ty2)

B. Logical vocabulary: Logical constants are extensional (their meaning is invariant under all permutations). Some authors have suggested higher types ((47)), e.g. to account for e-type anaphora:

(46) a. $[\![\text{every}]\!]^{w,g}$ = $\lambda P_{<et>}.\lambda Q_{<et>}.\forall x[P(x) \to Q(x)]$ (intensional)

b. $[\![\text{and}]\!]^{w,g}$ = $\lambda p.\lambda q.p = q = 1$

(47) a. $[\![\text{every}]\!]^{g}$ = $\lambda P_{<s,et>}.\lambda Q_{<s,et>}.\lambda s.\forall x[P(w)(x) \to Q(w)(x)]$ (extensional, Ty2)

b. $[\![\text{every}]\!]^{g}$ = $\lambda P_{<e,st>}.\lambda Q_{<e,st>}.\lambda s.\forall x[P(x)(w) \to Q(x)(w)]$

(48) Variables, indexed for every possible type: $x_{e,1}$, $x_{e,2}$, ..., $y_{e,1}$, $y_{e,2}$,..., $x_{<et>,1}$, ...

C. Sentential operators (epistemic modals, raising verbs, maybe some root modals) apply to propositions. Flavors of modality are distinguished by different *accessibility relations*, which characterize sets of alternative worlds compatible with the knowledge/belief/desire/... of an individual (typically the *attitude holder*; for other intensional operators see 2.2 below).

(49) a. *Accessibility relation for epistemic alternatives (speaker oriented version)*

For any world w:

$Epi_w =_{Def}$ {w'|w' is compatible with the evidence available to the speaker in w}

b. *Accessibility relation for deontic alternatives*

For any world w:

$Deon_w =_{Def}$ {w'|w' is compatible with the laws in w}

(50) a. $[\![\text{must}_{epi}]\!]^{g}$ = $\lambda p_{<st>}.\lambda w.\forall w' \in Epi_w \to p(w')$ ≡

≡ $\lambda p_{<st>}.\lambda w.\forall w'[Epi_w(w') \to p(w')]$ (notational convention)

b. $[\![\text{could}_{epi}]\!]^{g}$ = $\lambda p_{<st>}.\lambda w.\exists w'[Epi_w(w') \wedge p(w')]$

c. $[\![\text{must}_{deon}]\!]^{g}$ = $\lambda p_{<st>}.\lambda w.\forall w'[Deon_w(w') \to p(w')]$

(51) a. John *must*$_{epi}$ be home. His car is parked outside.

b. John *must*$_{deon}$ be home by eight. Otherwise, he'll miss *The Simpsons*.

4. Semantic rules of composition assign *semantic values* to simple and complex expression, relative to model, assignment g and relative to a world.

(52) *Rules for simple expressions (terms)*
a. If α is a constant, $[\![\alpha]\!]^{w,g} = I(\alpha)$
b. If α is a variable, $[\![\alpha_1]\!]^{w,g} = g(\alpha_1) = g(1)$

(53) *Rules for complex expressions (extensional)* [Heim & Kratzer 1998]
For any nodes α that immediately dominate β and γ, for any assignment g and any world w:

a. *FA. Functional Application*
If $[\![\gamma]\!]^g$ is in the domain of $[\![\beta]\!]^g$, then $[\![\alpha]\!]^g = [\![\beta]\!]^g([\![\gamma]\!]^g)$

b. *PM. Predicate Modification*
If $\beta \in D_{<s,et>}$ and $\gamma \in D_{<s,et>}$, then $[\![\alpha]\!]^g = \lambda w.\lambda x.[\![\beta]\!]^g(w)(x) \wedge [\![\gamma]\!]^g(w)(x)$

(54) *Rules for complex expressions (intensional)* [von Fintel & Heim 2011]
For any nodes α immediately dominating β and γ, for any assignment function g and world w:

a. *FA. Functional Application*
If $[\![\gamma]\!]^{w,g}$ is in the domain of $[\![\beta]\!]^{w,g}$, then $[\![\alpha]\!]^{w,g} = [\![\beta]\!]^{w,g}([\![\gamma]\!]^{w,g})$.

☞ b. *IFA. Intensional Functional Application*
If $\lambda w.[\![\gamma]\!]^{w,g}$ is in the domain of $[\![\beta]\!]^{w,g}$, then $[\![\alpha]\!]^{w,g} = [\![\beta]\!]^{w,g}(\lambda w.[\![\gamma]\!]^{w,g})$

c. *PM. Predicate Modification*
If $\beta \in D_{<s,et>}$ and $\gamma \in D_{<s,et>}$, then $[\![\alpha]\!]^{w,g} = \lambda x.[\![\beta]\!]^{w,g}(x) \wedge [\![\gamma]\!]^{w,g}(x)$

d. UP. 'up' operator: $[\![{}^\wedge\alpha]\!]^{w,g} = \lambda w.[\![\alpha]\!]^{w,g}$ [Montague's 1973; PTQ][1]

Following von Stechow (1993) and Heim & Kratzer (1998), I adopt (55):

(55) a. λ-operators subscripted with indices (λ_1) are part of object language LF representations.
b. Movement results in λ-abstraction

(56) a. *λ-abstraction (standard version, semantics)*
If x is a variable of type σ and α an expression of type τ, then $[\![\lambda x.\alpha]\!]^{M,g}$ is the function from arbitrary $a \in D_\sigma$ to $[\![\alpha]\!]^{M,g[x \to a]}$

b. *Modified assignment*
$g^{[a \to x]}$ is the *modified assignment function* of g, which is like g except possibly in the value it assigns to x. (Hence, $g(x) = g^{[a \to x]}$ whenever $a \neq x$)

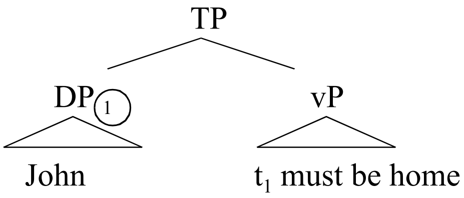
(57) *Á la Heim & Kratzer*
a. *Syntax of index re-analysis (movement results in abstraction)*
If α immediately dominates β and γ and
β has been moved and
β bears index i
then merge i with γ and
combine the result with α

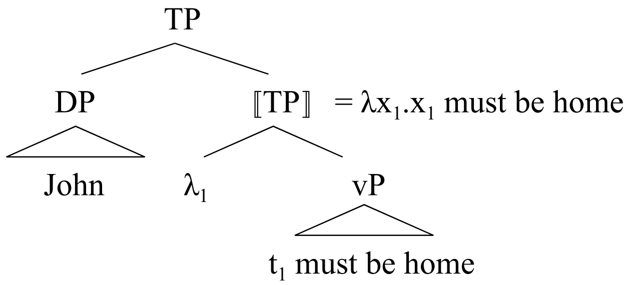
b. *ABS. Abstraction*
For any index $i \in \mathbb{N}$, any node α and any type σ
$[\![\lambda_i\ \alpha]\!]^{w,g} = \lambda x_{i,\sigma}.[\![\alpha]\!]^{w,g[i \to x_{i,\sigma}]}$

NB: The index is also called the *λ-binder* of the trace left by the moved element and is prefixed by λ.

[1](54)d is built into the composition rule IFA in von Fintel & Heim (ibid); cf. also Keshet (2011), i.a.

(58) a. John $[_{vP}\ t_1$ must be home$]$ b.





(59) *Sample derivation: computing (58)b*

For any g and w:

a.	$\llbracket [_{TP} \text{ John } \lambda_1 [\text{must}_{epi}\ [_{vP}\ t_1 \text{ be home}]]] \rrbracket^g$	= 1 iff	
b.	$\llbracket \lambda_1 [\text{must}_{epi} [_{vP}\ t_1 \text{ be home}]] \rrbracket^g (\llbracket \text{John} \rrbracket^g)$	= 1 iff	(FA)
c.	$\llbracket \lambda_1 [\text{must}_{epi} [_{vP}\ t_1 \text{ be home}]] \rrbracket^{g]}) (\text{John})$	= 1 iff	(Lexicon)
d.	$\lambda_1.\llbracket \text{must}_{epi} [_{vP}\ t_1 \text{ be home}] \rrbracket^{g[1\to x1]}) (\llbracket \text{John} \rrbracket^g)$	= 1 iff	(ABS)
e.	$\lambda_1.\llbracket \text{must}_{epi} \rrbracket^{g[1\to x1]}(\llbracket \text{be home} \rrbracket^{g[1\to x1]} (\llbracket t_1 \rrbracket^{g[1\to x1]}))(\text{John})$	= 1 iff	(FA)
f.	$\lambda_1.\llbracket \text{must}_{epi} \rrbracket^{g[1\to x1]}(\llbracket \text{be home} \rrbracket^{g[1\to x1]} (g^{[1\to x1]}(1))(\text{John})$	= 1 iff	(Assignment; (36)b))
g.	$\lambda_1.\llbracket \text{must}_{epi} \rrbracket^{g[1\to x1]}(\llbracket \text{be home} \rrbracket^{g[1\to x1]} (x_1))(\text{John})$	= 1 iff	(Assignment; (36)b)
h.	$\lambda_1.\llbracket \text{must}_{epi} \rrbracket^{g} (\lambda x.\lambda w.\boldsymbol{x} \text{ is home in } w\ (\boldsymbol{x_1}))\ (\text{John})$	= 1 iff	(Lexicon)
i.	$\lambda_1.\llbracket \text{must}_{epi} \rrbracket^{g} (\lambda w.x_1 \text{ is home in } w)\ (\text{John})$	= 1 iff	(β-conversion)
j.	$\lambda_1.\lambda p.\lambda w.\forall w'[\text{Epi}_w(w') \to \boldsymbol{p}(w')]\ (\boldsymbol{\lambda w.x_1 \text{ is home in } w})\ (\text{John})$	= 1 iff	(Lexicon)
k.	$\lambda_1.\lambda w.\forall w'[\text{Epi}_w(w') \to \lambda w.x_1 \text{ is home in } \boldsymbol{w}\ (\boldsymbol{w'})]\ (\text{John})$	= 1 iff	(β-conversion)
l.	$\lambda_1.\lambda w.\forall w'[\text{Epi}_w(w') \to \boldsymbol{x_1} \text{ is home in } w']\ (\boldsymbol{\text{John}})$	= 1 iff	(β-conversion)
m.	$\lambda w.\forall w'[\text{Epi}_w(w') \to \text{John is home in } w']$		

2.2.2. The relation between syntax and semantics

The choice between an intensional vs. extensional (Ty2) meta language ((39) vs. (40)) is orthogonal to assumptions about the ontology of natural language. In intensional systems, predicates are of type <e,t> and are interpreted relative to a world/situation parameter. The world/situation parameter can be bound by operators (IFA). By contrast, there are *two* ways to design an extensional system. Either, worlds/situations are syntactically represented in the object language (LF; (60)b). Alternatively, worlds/situations are introduced by the lexical translation rule for the verb but are not assigned object language status ((60)c). On this view, w/s-variables cannot be bound by object language binders (they can be bound my metalanguage operators, though). In both cases, monadic individual predicate denotations belong to the domain <s,et>.

(60) a. $\llbracket \text{sleep} \rrbracket^g \quad = \quad \lambda x.\lambda w.x \text{ is asleep in } w$

b. *<u>world variable</u> syntactically represented at LF - syntactically derived relation*

$$\llbracket [\lambda_2 [\lambda_1 [\underline{\underline{\boldsymbol{w_1}}} [_{vP}\ t_2 [_{VP} \text{ sleep}]]]]] \rrbracket^g = \lambda_2.\lambda_1.[_{VP}\ \lambda x.\lambda w.\boldsymbol{x} \text{ is asleep in } w](\boldsymbol{t_2})(w_1) =$$
$$= \lambda_2.\lambda_1.[\lambda w.t_2 \text{ is asleep in } \boldsymbol{w}](\boldsymbol{w_1}) =$$
$$= \lambda_2.\lambda_1.t_2 \text{ is asleep in } w_1 =$$
$$= \lambda x.\lambda w.x \text{ is asleep in } w \quad \text{(alphabetic variance)}$$

c. *world variable not syntactically represented at LF*

$$\llbracket [\lambda_2 [_{vP}\ t_2 [_{VP} \text{ sleep}]]] \rrbracket^g = \lambda_2.[\lambda x.\lambda w.x \text{ is asleep in } w](t_2) =$$
$$= \lambda_2.\lambda w.\ t_2 \text{ is asleep in } w =$$
$$= \lambda x.\lambda w.x \text{ is asleep in } w$$

3. PROPOSITIONAL ATTITUDES AND REFERENTIAL TRANSPARENCY

Three classic diagnostics for intensional contexts (Cooper 1983: 7):

(61) *Three standard tests for referential opacity*
 a. Lack of existential import
 b. Lack of specific reference: indefinites can receice non-specific interpretation
 c. Failure of substitution *salva veritate*

(62) *Transparent contexts*
 a. John met (the god) Jupiter. (false)
 b. John met a doctor. (specific only)
 c. John met Jupiter $\Leftrightarrow$ John met Zeus

(63) *Opaque contexts*
 a. John *believes* that he met Jupiter. (possibly true)
 b. John *offered* Mary a glass of wine (before opening the bottle). [Moltmann 2009, (6)c]
 c. John *hopes* to meet Jupiter. $\nLeftarrow$ John *hopes* to meet Zeus.

Some expressions (predicates, names) are ambiguous between transparent and opaque construals once embedded in opaque environments. This is the source of the *de dicto* vs. *de re* ambiguity.

3.1. THE *DE DICTO/DE RE* DISTINCTION

There are two *modes* of ascribing a property to an expression α:[2]

(64) a. Transparent *de re* reading of α (≈speaker's perspective)
 α is used according to the way the ***speaker*** is ascribing the property expressed by α.
 b. Opaque *de dicto* reading of α (≈ attitude holder's perspective)
 α is used according to the way the ***attitude holder*** is ascribing the property expressed by α.

Examples for *de dicto* - *de re* ambiguities from DP-interpretation.

3.1.1. Definite descriptions

The model below attests to the fact that *de dicto* - *de re* ambiguities are logically independent:

(65) *Scenario*$_{before\ 2006}$: There are nine planets (i.e. Pluto still qualifies as one). John believes in some strange law of physics according to which all planetary systems are made up of an even number of planets. So for John, the denotation of *number of planets* only includes even number. Otherwise, he is an entirely sane and consistent person.

(66) John believes *the number of planets* is even.
 a. *de dicto*: True, because of John's non-standard views of cosmology.
 b. *de re:* False, because John does not believes that the number 9 is even.

(67) John believes *the number of planets* is odd.
 a. *de dicto*: False, because of John non-standard views of cosmology.
 b. *de re*: True, because John believes that the number 9 is odd.

Question: Could the ambiguity be a consequence of different scope options for the definite?

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[2]The term *de re* was first used by Peter Abelard (12c), while *de dicto* seems to come from a comment by Thomas Aquinas (13c) on Aristotle's *De Interpretatione* (Kneale and Kneale 1967). The distinction was imported into into modal logic by von Wright (1951), and into tense logic by Prior (1952) and later Hintikka.

3.1.2. Bare plurals and indefinites
Bare plurals always take narrow scope. Hence, ambiguity cannot be due to scope.

(68) *Supposition throughout:* John systematically mistakes violas for violins, and violins for violas.

(69) *Scenario*: The instruments John is interested in collecting are in fact violas.

(70) John wants to collect *violins.*
a. *de dicto*: True, because for John, violas go by the name *violins*.
b. *de re*: False, because we do not call violas *violins*.

(71) *Scenario*: The instruments John is interested in collecting are *violins*.

(72) John wants to collect *violins.*
a. *de dicto*: False, because for John, the predicate *violin* applies to what we call *violas.*
b. *de re*: True, because the objects John wants to collect are in reality violins.

Analysis: Modelling *de dicto*/*de re* in terms of scope of binder of world/situation variable.

(73) a. $[\![\text{violin}]\!] = \lambda x.\lambda w.x \text{ is a violin in } w$

b. $[\![\text{want}]\!] = \lambda p_{<st>}.\lambda x.\lambda w.\forall w'[Boul_{x,\,w}(w') \rightarrow p(w')]$

c. *Bouletic alternatives* $Boul_{x,w}$
$Boul_{x,w} =_{Def} \{w'|w' \text{ is compatible with x's wishes in w}\}$

(74) John wants to collect *violins.*

a. *de dicto*: $\lambda w.\underline{\underline{\forall w'}}[Boul_{John,\,w}(w') \rightarrow \text{John collects}[\textbf{\textit{violins in}}\ \underline{\underline{\textbf{\textit{w'}}}}] \text{ in } w']$
'violins in John's bouletiv alterntaives'

b. *de re*: $\underline{\underline{\lambda w}}.\forall w'[Boul_{John,\,w}(w') \rightarrow \text{John collects } [\textbf{\textit{violins in}}\ \underline{\underline{\textbf{\textit{w}}}}] \text{ in } w']$
'violins according to the speaker's perspectiv'

Indefinites pattern along with bare plurals:

(75) *Scenario*: The instrument John has in mind is in actuality a *viola*.

(76) John wants to buy *a violin.*
a. *de dicto*: True, because for John, violas goes by the name *violins*.
b. *de re*: False, because we do not call violas violins.

(77) *Scenario*: The instrument John has in mind is actually a *violin.*

(78) John wants to buy *a violin.*
a. *de dicto*: False, because for John, the predicate *violin* describes violas.
b. *de re*: True, because for us, these instruments are violins.

A test for de re readings: de dicto readings only admit 'special' anaphor (*that*, *the same thing*; see Moltmann 2009 for discussion; ex. her (5)b):

(79) a. John needs a good secretary$_{\text{de dicto}}$. Bill needs *that*, too. [Moltmann 2009, ex. (5)b]
b. *John needs a good secretary$_{\text{de dicto}}$. Bill needs *her*, too.

3.1.3. Names, guises and aquaintance
Conjecture: All of the above cases involved (possibly embedded) common nouns. Thus, the ambiguity might be related to different binding options for a world/situation variables of nominal predicates ((74)).

Problem: It is possible to entertain two inconsitent beliefs about *one and the same individual* (*res*).

(80) *Scenario*: A new neighbor, Perry has moved in next door. John mistakenly believes that his new neighbor is called Smith, because the name tag has not been changed yet. Also, John has independently always hoped to get to know Perry (a famous philosopher) but has no strong urge to meet his neigbor Smith again.

(81) John wants to invite *the new neighbor of his* for dinner.
a. *de dicto*: False, because for John, *the new neighbor of his* refers to Smith, who he does not specifically care about.
b. *de re* : True, because in reality, *the new neighbor of his* refers to Perry, who John would like to get to know.

(82) John wants to invite *Smith* for dinner.
a. *de dicto*: False, because John does not like Smith.
b. *de re* : True, *Smith* actually refers to Perry, and John would like to get to know Perry.

(83) John wants to invite *Perry* for dinner.
a. *de dicto*: True, as John likes Perry.
b. *de re*: False, because we know that Perry is in actuality Smith.

Double vision (Quine 1956). The fact that in the classic scenario (84), both (85)a and (85)b can be true shows that attitude holders can have apparently conflicting beliefs about one and the same individual.

(84) *Quine's (1956) Double Vision scenario:* Ralph encountered Ortcutt in a dark alleyway close to the ambassy of a hostile country wearing a brown hat, and forms the belief that Ortcutt is a spy. At another occasion, Ralph sees Ortcutt on TV being officially honored at a reception. Ralph deduces that Ortcutt must be a pillar of society.

(85) a. Ralph believes that $\text{Ortcutt}_{\text{Alleyway/brown hat guise}}$ is a spy.
b. Ralph does not believe that $\text{Ortcutt}_{\text{TV guise}}$ is a spy.

Acquaintance relations. An individual can be known under one and the same name but different 'guises' (Quine 1956). The meanings are distringuished by the *acquaintance relation* which links the believe holder to the individual (Kaplan 1968; Lewis 1979; Charlow & Sharvit 2014, i.a.):[3]

(86) Ralph believes that Ortcutt is a spy.
a. ∃R.R is an acquaintance relation that Ralph bears uniquely to Ortcutt at s, and
R = glimpsing in the alleyway
b. ∃R.R is an acquantance relation that Ralph bears uniquely to Ortcutt at s, and
R = seeing on TV

Another famous example:

(87) a. George IV wished to know whether Scott was the author of Waverley. [Russell 1905]
b. George IV wished to know whether Scott was Scott.

(88) *Interim conclusion*
a. If two coextensional NPs are interpreted *de re*, they can be substituted *salva veritate* (this is a simplication; see Zimmermann 2005)
b. Not all names can be substituted *salva veritate*.

[3]Quine (1956) calls *de dicto* beliefs 'notional beliefs', because they are about notions/concepts.

3.2. Towards an analsysis of double vision

Diadic propositional attitudes. Accessibility relation relativized to an *attitude holder*. It characterizes sets of alternative compatible with the attitude holder's beliefs, hopes, fears, etc... (Hintikka 1969).

(89) a. $[\![\text{believe}_2]\!] \quad = \quad \lambda p_{<s,t>}.\underline{\underline{\lambda att}}.\lambda w.\forall w'[Dox_{att,w}(w') \rightarrow p(w')]$

b. *Doxastic alternatives* $Dox_{x,w}$

$Dox_{x,w} \quad =_{Def} \quad \{w'|w' \text{ is compatible with x's beliefs in w}\}$

Triadic 'relational theory' of de re (Quine 1956). believe is a three place relation between a property, the *res* and and attitude holder. The *res* argument can (but does not have to) be syntactically projected:

(90) a. $John_1$ believes that *he* will win. (covert *res* argument, can co-vary with *he*)

b. $John_1$ believes (of $Bill_2$) that $he_{*1/2}$ will win. (overt *res* argument binds lower subject)

(91) $[\![\text{believe}_3]\!] \quad = \quad \lambda P_{<e,st>}.\underline{\underline{\lambda res}}.\lambda att.\lambda w.\forall w'[Dox_{att,w}(w') \rightarrow P(res)(w')]$

Analysis of double vision. acquaintance relation is part of the assertion of the propositioal attitude predicate. Quantification over individual-world pairs generates *centered propositions.*

(92) a. $[\![\text{believe}_{3'}]\!] \quad = \quad \lambda P_{<e,st>}.\lambda res.\lambda att.\lambda w.\exists Acq[Acq(res)(att)(w) \wedge$ [Moulton 2009]

$\forall\underline{\underline{<att',w'>}} \in Dox_{att,w} \rightarrow P(\iota z.(Acq(z)(att')(w'))(w')]$

b. Acq $=_{Def}$ suitable and vivid acquaintance relation [Lewis 1979; Aloni 2005]

(93) $\lambda w.\exists Acq[Acq(Ortcutt)(Ralph)(w) \wedge \forall<x',w'> \in Dox_{Ralph,w} \rightarrow spy(\iota z.(Acq(z)(x')(w'))(w')]$

a. There is an acquaintance relation Acq that Ralph uniquely bears to Ortcutt in w

b. All doxastic alternatives x' of Ralph in w are such that the unique individual z related to x' by Acq in w' is a spy in w'

c. $Acq_1 = \lambda x.\lambda y.\lambda w.$y encountered x wearing a brown hat in w

d. $Acq_2 = \lambda x.\lambda y.\lambda w.$y has seen x on TV in w

A third reading - de se beliefs: *de se* readings can be modeled as a particular manifestations of *de re* interpretations in which Acq is witnessed by the identiy relation (Lewis 1979; there are other alternatives theories on the market).

(94) a. John believes that he_1 will win. (g(1) = John) *'coreferential' de se*

b. $\lambda w.\exists Acq[Acq(j)(g(1))(w) \wedge \forall<x',w'> \in Dox_{j,w} \rightarrow spy(\iota z.(Acq(z)(x')(w'))(w')]$

c. $Acq = \lambda x.\lambda y.\lambda w.x = y$ in w (Acq is identity)

d. $\lambda x.\lambda w.\exists Acq[Acq(\underline{x})(\underline{x})(w) \wedge \forall<x',w'> \in Dox_{j,w} \rightarrow spy(\iota z.(Acq(z)(x')(w'))(w')](j)$

Identical results are obtained by letting *res* and *att* being captured by the binder:

(95) a. John λ_1 t_1 believes that he_1 will win. *'bound' de se*

b. $\lambda w.\lambda x.\exists Acq[Acq(\underline{x})(\underline{x})(w) \wedge \forall<x',w'> \in Dox_{x,w} \rightarrow spy(\iota z.(Acq(z)(x')(w'))(w')](j)$

In (94), covaluation is obtained by selecting reflexive Acq in meta language, in (95) it comes about by binding in the object language. The two options can be teased apart in ellipsis contexts, where (94) underlies strict readings for the pronoun.

3.3. Specificity vs. *de dicto/de re*

de dicto/de re ambiguity cross-cuts with the specific vs. non-specific interpretation of indefinite. This has been taken to indicate that there must be a device for binding s-variables at a distance. Hence, s-variables must be part of object language.[4]

Fodor's third reading: Fodor (1970: 227ff) observed that specificity and referential opacity are independent dimensions of DP-interpretation. Suppose John is still systematically mixing up violas and violins.

(96) John wants to buy a violin.

a. narrow scope *de dicto* (aka non-specific/non-referential/attributive *de dicto*)
John wants to buy any instrument which, according to John's terminolgy is called a violin. In actuality, what he desires is a viola.

b. wide scope *de re* (aka specific transparent, referential *de re, ...*)
John wants to buy a particular violin, according to the speaker's/our way of naming things. For John, it would be called a viola.

☞ c. narrow scope *de re* (aka non-specific/non-referential *de re*) (*Fodor's 3rd reading*)
John wants to buy any instrument known to him as violin and to us as viola. He does not care which specific instrument he is acquiring.

d. *wide scope *de dicto* (aka specific opaque, referential *de dicto*)
John wants a particular viola - we would call it a violin.

Fodor's 3rd reading poses a problem for scope/QR theory of *de re* readings, on which *de re* readings are produced by scoping the transparent expression out of the opaque context (May 1977).

Bäuerle (1983): In (97), Georg might be entirely uninformed as to the profession of the soccer players, hence *jeden VfB-Spieler*/'member of the VfB team' is understood *de re*. At the same time, universal is in scope of indefinite *a woman from Stuttgart:*

(97) Georg glaubt, dass eine Stuttgarterin *jeden VfB-Spieler* liebt.
Georg believes that a woman from Stuttgart loves every member of the VfB team.
(*believe* $\succ$ *a woman* $\succ$ *every member*$_{\text{de re}}$)

(98) "Die Identifizierung dieser Herren als die Gesamtheit der VfB-Spieler stammt also von dem, der den Satz äußert, ist damit nicht selber Gegenstand des Glaubens und somit transparent"

"Identifying these gentlemen as the totality of VfB-players (VfB = a soccer club) originates from the person who utters the sentence; thereby, it is not part of the belief and is therefore transparent." [Bäuerle 1983; quoted from Sternefeld 2009]

Analysis: The standard analysis assumes that world/situation variable can be freely linked to higher predicates (see e.g. von Fintel and Heim 2011).

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[4]Semantically, a system with modal operators has been proven to be equivalent to a system with explicit quantification over worlds/situations (Cresswell 1990). So the argument for s-variables in the object language comes from *syntactic* conditions on these variables.

(99) John wants PRO to buy a violin.

a. *narrow scope de dicto*
LF: [λw.John wants [λw'.PRO to buy **[$_{DP}$ *a violin w'*]** in w']]
$\lambda w.\underline{\underline{\forall w'}}[\text{Boul}_{John,\, w}(w') \rightarrow \exists x[x \text{ is a violin in } \underline{\underline{w'}} \wedge \text{John buys x in } w']]$
(true if unbeknownst to John, x turns out to be a viola)

b. *wide scope de re*
LF: [λw.**[$_{DP}$ *a violin w*]** λ_1 [John wants [λw'.PRO to buy t_1 in w']]]
$\underline{\underline{\lambda w}}.\exists x[x \text{ is a violin in } \underline{\underline{w}} \wedge \forall w'[\text{Boul}_{John,\, w} \rightarrow \text{John buys x in } w']]$

c. *narrow scope de re (Fodors 3rd reading)*
LF: [λw.John wants [λw'. PRO to buy **[$_{DP}$ *a violin w*]** in w']]
$\underline{\underline{\lambda w}}.\forall w'[\text{Boul}_{John,\, w}(w') \rightarrow \exists x[x \text{ is a violin in } \underline{\underline{w}} \wedge \text{John buys x in } w']]$
(true if John has no specific x in mind, belives x to be viola, but x is in fact a violin)

d. **wide scope de dicto*
LF: [λw.**[$_{DP}$ *a violin* ☛*w'*]** λ_1 [John wants [λw'.PRO to buy t_1 in w']]] (w' is unbound)
$\lambda w.\exists x[x \text{ is a violins in } \underline{\underline{w'}} \wedge \underline{\underline{\forall s'}}[\text{Boul}_{John,\, w}(w') \rightarrow \text{John buys x in } w']]$
(cannot be produced in system that assumes restrictive quantification)

NB: Sternefeld (2009) observes that Ty2 representation (99)c is too weak, because it entails that the speaker knows the extension of the predicate/name. But this could presumably be made to follow from proper definition of acquaintance relation. For relevant discussion see Schwager (2009, 2011).

Is there are forth reading? Fodor originally argued for the existenc a fourth reading ((96)d, (99)d). Consensus has it, though, that such a reading is missing. Keshet (2011: fn4) provides an empirical argument to this end. Pronominal anaphor forces specific readings. (100)a is odd, indicating that (96)d is indeed absent. (100)b shows that proposition (100)a *can* be expressed by different means.

(100) a. Mary wants to buy an inexpensive coat. #But really, *it* is quite expensive.
b. There's a coat that Mary wants to buy. She thinks it is inexpensive. But really, it is quite expensive.

3.4. COMPARATIVES AND DOUBLE INDEXING

Another indication that natural language has the expressive power of explicit quantification over worlds and that world variables are part of the object language comes from *double indexing* or *double access* phenomena (Cresswell 1990, Percus 2000; for tense see Abusch 1994; typed logic see Gallin 1975).

Russell's yacht sentences: comparatives embedded under propositional attitude verbs are ambiguous (Heim 1985; Hellan 1981; Postal 1974; von Stechow 1984; Larson 1987):

(101) I thought that your yacht was larger than it is. [Russell 1905]

a. *Sensible de re reading*
"The size that I thought your yacht was is greater than the size your yacht is."
In all worlds/situations w' that are compatible with my beliefs in w, the size of the yacht in $\underline{\underline{w'}}$ exceeds its height in $\underline{\underline{w}}$**.**

b. *Contradictory de dicto*
"I though that the size of your yacht was greater than the size of your yacht."
In all worlds/situations w' that are compatible with my beliefs in w, the size of the yacht in $\underline{\underline{w}}$ exceeds its height in $\underline{\underline{w}}$**.**

There are at least two competing accounts of these facts:

Scope: Comparative clause escapes scope of intensional operator by QR of the comparative complement (Russell 1905; cf. von Stechow 1984).

☞ *Double indexing*: World/situation variable of embedded predicate is anchored to evaluation world (Heim 1985, von Stechow's interpretation of Postal 1974).

In support of double indexing: QR-theories cannot explain consistent readings in which the comparative complement contains a variable bound from outside (Hoeksema 1984; Heim 1985; Rullmann 1995).

(102) a. We expect that *no boy*$_3$ thinks he$_3$ is brighter than *he*$_3$ is [Hoeksema 1984]

b. $\lambda w.\neg\exists x[x \text{ is a boy in } w \wedge \forall w'[\text{Dox}_{x,w}(w') \rightarrow \iota d.x \text{ is d-bright } \underline{\underline{\text{in } w'}} \succ \iota d.x \text{ is d-bright } \underline{\underline{\text{in } w}}]]$

c. LF1: $[_{than\text{-}XP}$ than he$_3$ is] [λ_1 [no boy thinks he$_3$ is brighter t_1]

d. LF2: [no boy λ_3 [than he$_3$ is] [λ_1 t_3 thinks he$_3$ is brighter t_1]]]]

(103) ⟦MORE⟧ = $\lambda d.\lambda AP.\lambda x.\lambda w.\iota d[AP(w)(x)(d) \succ d]$ [von Stechow 1984]

Problem: Intermediate landing site in (102)d satisfies all binding requirements. Binder must be located above propositional attitude verb. Heim (1985)'s example avoids this complication:

(104) We believed that *every problem*$_3$ was harder than *it*$_3$ was.

Question: Can *problem* be evaluated inside the scope of *believe* and still bind individual variable?

(105) *Scenario*: We consistently mistake Armenians for Azerbaidjani and v.v.

(106) We believed that *every Armenian*$_{de\ dicto}$ was taller than *he*$_3$ was.

Sentence (106) appears to have a consistent *de dicto* reading. If correct, subject must remain inside scope of *believe* at LF. This is independent support for double indexing analysis.

SUMMARY

(107)
- ☐ Intensional contexts can be modeled by extensional languages (Ty2)
- ☐ Interpretation of DPs (descriptions, nominal predicate, names) is dependent on the evaluation world/situation. The meaning differences are truth conditional (as opposed to due to vagueness, imprecision, ...) ☞ reconstruction
- ☐ Conjecture: the object language includes world/situation variables (Percus 2000, i.a.). ☞ head movement, reconstruction
- ☐ Opacity is accounted for by different binding options for these world/situation variables ☞ reconstruction
- ☐ Binding by situation variables is also implicated in comparatives ☞ reconstruction, reflexivization
- ☐ Certain pronominal contexts admit a third reading apart from the *de dicto* - *de re* distinction: *de se* readings. ☞ reflexivization

(☞ marks topics that will re-appear in course of the discussion over the next two weeks.)

APPENDIX A. LIMITS OF POSSIBLE WORLD SEMANTICS (EXPRESSIVE POWER)

Problem I: Logical omniscience

If a believes proposition p, then a should also believe every proposition p' logically entailed by p. In standard possible world semantics, the set of beliefs is closed under logical consequence.

(108) a. John knows that Amsterdam is in the Netherlands.
b. $\not\Rightarrow$ John knows that Amsterdam is in the Netherlands and that 33 x 33 x 33 = 35,937.

(109) a. John knows the rules of chess.
b. $\not\Rightarrow$ John knows whether White has a winning strategy. (ex. by Mikaël Cozic)

Response: Impossible worlds, alternative epistemic logics, ...

Problem II: Hyperintensionality

In possible world semantics, co-intensional expressions can be substituted *salva veritate.* Incorrect:

(110) a. John knows that that 3 x 3 = 9.
b. $\not\Leftrightarrow$ John knows that 33 x 33 x 33 = 35,937.

Response: structured propositions (Lewis 1972; Cresswell 1985; Soames 1985; Cresswell & von Stechow 1990). For overview and discussion of many issues see Aloni (2001).

APPENDIX II: NON-INTENSIONAL SUBSTITUTION FAILURES

Relationality: Larson (2000) and McConnell Ginet (1982) note that not all substitution failures are due to intensionality. The proper analysis of invalid inferences (111)c is *not* (112)a, but (112)b, which is based on 1st order properties and the fact that *eat* and *cook* are relational.

(111) a. Supposition: $\{x|x \text{ eats}\} = \{x|x \text{ cooks}\}$ (those who eat are those who cook)
b. Olga eats $\Leftrightarrow$ Olga cooks
c. Olga eats fish $\not\Leftrightarrow$ Olga cooks fish

(112) a. fish(λw.Olga eats in w) $\not\Leftrightarrow$ fish(λw.Olga cooks in w) (incorrect analysis)
b. $\forall x\exists y[eat(y)(x) \Leftrightarrow cook(y)(x)]$ $\not\Rightarrow$ $\exists y\forall x[eat(y)(x) \Leftrightarrow cook(y)(x)]$ (correct)

In extensional systems that posit hidden world/situation arguments, failed inferences are also explained as a result of hidden relationality (Larson 2000: fn 18). The same rationale underlies switch from Davidsonian to Neo-Davidsonian semantics. Including agent in denotation of verb triggers false entailments ((113)a). Recognizing these false inferences due to hidden relationality lead Castandeda to suggest Neo-Davidsonian approach.

(113) John is writing on the blackboard.
a. $\exists e[write(e)(blackboard)(John)]$ (Davidsonian)
$\Rightarrow$ John is on blackboard.
b. $\exists e[write(e) \wedge Agent(e)(John) \wedge Location(e)(blackboard)]$ (Neo-Davidsonian)
$\not\Rightarrow$ John is on blackboard.

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