Tense under Attitudes.
Part I

1. Intensionality in Natural Language.

- To deal with attitudes verbs (e.g. **think**, **hope**) and modal expressions (e.g. **may**, **must, necessarily**), we need to consider not just the extensions of words and phrases, that is, the denotation of a given expression at a fix evaluation world. We also need to consider their so-called intensions: the function mapping each world in D_s (= the set of possible worlds) to the corresponding extension of the expression in that world. The reason for this is the following. For any attitude verb, modal or other intensional operators **O**, and for any formula ϕ, the truth value that $[\![\mathbf{O}\phi]\!]^w$ yields in the current evaluation world w depends not (just) on $[\![\phi]\!]^w$ but on $[\![\phi]\!]^{w'}$ for some other worlds w'. In other words, **O**ϕ involves quantification over possible worlds w' other than w itself, and thus we need to know the extension of the expressions inside ϕ for those possible worlds w'.

(1) John thinks / hopes [Bill is a rock star]
(2) Bill may be a rock star.
LF: may [Bill be a rock star]

- An intensional semantics for NatLg adds two characteristics to our extensional framework

  - It adds intensional operators **O**. Each **O** encodes some quantificational force and some restriction specifying the kind of worlds quantified over, the holder of the attitude, etc.

(3) Quantificational Force:
a. **It is possible that** ϕ: "In *some* world w', $[\![\phi]\!]^{w'}$ =1."
b. **It is necessary that** ϕ: "In *all* worlds w', $[\![\phi]\!]^{w'}$ =1."

(4) Katherine must be very nice.

(5) Restriction specifying the kind of worlds and/or attitude holder:
a. $[\![$**It is obligatory that** ϕ$]\!]^w$: DEONTIC
"In all possible worlds w' *where all our (legal, moral, etc.) obligations from w are fulfilled*, $[\![\phi]\!]^{w'}$ =1."
b. $[\![$**It must be the case that** (as opposed to **perharps, may**, etc.) ϕ$]\!]^w$: EPISTEMIC
"In all possible worlds w' *that conform to our knowledge of w in w*, $[\![\phi]\!]^{w'}$ =1."
c. $[\![$**John believes / thinks that** ϕ$]\!]^w$: DOXASTIC
"In all possible worlds w' *that conform to Johns' beliefs about w in w*, $[\![\phi]\!]^{w'}$ =1."
d. $[\![$**John hopes that** ϕ$]\!]^w$: BOULETIC
"In all possible worlds w' *that conform to Johns' desires about w in w*, $[\![\phi]\!]^{w'}$ =1."

  - It takes worlds as part of the semantic values of the expressions. That is, the semantic value of an expression is now its intension. We will go only as far as implementing Intensional Type Theory for NatLg, where expressions may have types <s, τ>, though s is not a possible type by itself. [The ultimate goal would be Two-Sorted Type Theory, where s is a basic type of its own.]

1.1. Syntax.

(6) Vocabulary:

a. Constants of type <s,e>: **Mary, John, Konstanz**, …

b. Variables of type <s,e> (indices on pronouns and traces): **she_1, she_2, he_1, it_{24}, t_5, t_1**, …

c. Functional constants of different types (each type corresponding to one or more syntactic categories):

<s,<i,et>>	**call**, **run**…
<s, <i,<e,et>>>	**love, buy**, …
<s,i>	**N**
<s, <i, <it,t>>	**P**
etc.	

d. Syncategorematically treated expressions: index n of movement on **that/which$_n$**.

(7) Syntactic Rules: GB and/or Minimalism, yielding LF syntax.

1.2. Semantics.

■ Lexical entries:

(8) Some examples:

a. $[\![\textbf{she}_4]\!]^g = \lambda w_s.\ g(4)$

b. $[\![\textbf{John}]\!]^g = \lambda w_s.$ John

c. $[\![\textbf{call}]\!]^g = \lambda w.\lambda t.\lambda x.$ x calls in w at t

d. $[\![\textbf{love}]\!]^g = \lambda w.\lambda t.\lambda x.\lambda y.$ y loves x in w at t

e. $[\![\textbf{N}]\!]^g = \lambda w.s^*$

f. $[\![\textbf{P}]\!]^g = \lambda w.\lambda t.\lambda P_{<it>}.\ \exists t' < t\ [\ P(t')\ ]$

■ Semantic rules:

(9) Non-Branching Nodes:

If α has the form α | β, then $[\![\alpha]\!]^g = [\![\beta]\!]^g$.

(10) Old Functional Application (OFA):

If α has the form α (with daughters β and γ), then $[\![\alpha]\!]^g = [\![\beta]\!]^g([\![\gamma]\!]^g)$.

β: $<\sigma,\tau>$ γ: σ

(11) Intensional Functional Application (IFA):

If α has the form α (with daughters β and γ), then $[\![\alpha]\!]^g = \lambda w_s.\ [\![\beta]\!]^g(w)([\![\gamma]\!]^g)$

β: $<s, <\sigma,\tau>$ γ: σ

(12) (New) Functional Application (FA):
If α has the form α, then $[\![\alpha]\!]^g = \lambda w_s.\ [\![\beta]\!]^g(w)\ ([\![\gamma]\!]^g(w))$

$$\begin{array}{ccc} & \alpha & \\ \beta & & \gamma \\ <s, <\sigma,\tau> & & <s,\sigma> \end{array}$$

(13) Predicate Modification (PM):
If α has the form α, and β and γ are both in $D_{<s,et>}$,

$$\begin{array}{ccc} & \alpha & \\ \beta & & \gamma \end{array}$$

then $[\![\alpha]\!]^g = \lambda w_s.\lambda x_e.\ [\![\beta]\!]^g(w)(x) \wedge [\![\gamma]\!]^g(w)(x)$

(14) Predicate Abstraction (PA):
If α has the form α, where $i \in |N$ and the type of i's trace is $<s,\sigma>$,

$$\begin{array}{ccc} & \alpha & \\ i & & \gamma \end{array}$$

then $[\![\alpha]\!]^g = \lambda w_s.\lambda x \in D_\sigma.\ [\![\gamma]\!]^{gx/i}(w)$

QUESTION 1: Do the semantic computation of (15) and (16), specifying which semantic rule is used in each step.

(15) **John loves Mary**.
LF: **N λt_2 John loves(t_2) Mary**

(16) **John loved Mary**.
LF: **P N λt_2 John loves(t_2) Mary**

■ Modal auxiliaries / adverbs / paraphrases as intensional operators:

(17) $[\![\mathbf{must_{Deo}}]\!]^g = \lambda w_s \lambda p_{<st>}.\ \forall s'\ [\ s' \in Deo(s) \rightarrow p(s')=1\ ]$

(18) $[\![\mathbf{can_{Deo}}]\!]^g = \lambda w_s \lambda p_{<st>}.\ \exists s'\ [\ s' \in Deo(s) \wedge p(s')=1\ ]$

(19) $[\![\mathbf{must_{Epi}}]\!]^g = [\![\mathbf{necessarily_{Epi}}]\!]^g = [\![\mathbf{it\ must\ be\ the\ case\ that_{Epi}}]\!]^g$
$= \lambda w_s \lambda p_{<st>}.\ \forall s'\ [\ s' \in Epi(s) \rightarrow p(s')=1\ ]$

(20) $[\![\mathbf{can_{Epi}}]\!]^g = [\![\mathbf{possibly_{Epi}}]\!]^g = [\![\mathbf{it\ may\ be\ the\ case\ that_{Epi}}]\!]^g$
$= \lambda w_s \lambda p_{<st>}.\ \exists s'\ [\ s' \in Epi(s) \wedge p(s')=1\ ]$

QUESTION 2: Complete the computation for (21)-(22).

(21) **Necessarily, John loves Mary.**
(22) **Necessarily, John loved Mary.**

2. Tense under attitudes.

■ Standard analysis of complements of attitudes.

The standard way of defining complements of predicates of attitudes is to say that they are simply propositions, i.e. sets of worlds. For instance, the sentence **John loves Mary** would mean [λw.John loves Mary in w at s*]. A straight forward semantics of attitudes in the style of (Hintikka, 1969) would be this:

(23) **believe**, type <s,<st,<i,et>>>
$[\![\textbf{believe}]\!]^g = \lambda w.\lambda p_{st}.\lambda t.\lambda x.(\forall w')[w'$ is compatible with everything x believes of w in w at time t → $p(w')]$

■ DEICTIC APPROACH: Embedded temporal ordering with respect to the speech time s*

Once we have (23), we have to decide what we do with the embedded temporal ordering. If the embedded temporal ordering is calculated wrt the speech time, then the sentence **Peter believes John loves Mary** would be analysed as in (24) and the sentence **Peter believes John left Mary** would be analysed as (25):

(24) **N λt_1 Peter believes(t_1) [N λt_2 John loves(t_2) Mary]** (to be revised)
$= \lambda w.\ (\forall w')[w'$ is compatible with everything John believes of w in w at time s* → John loves Mary in w' at s*]

(25) **N λt_1 Peter believes(t_1) [P N λt_2 John left(t_2) Mary]** (to be revised)
$= \lambda w.\ (\forall w')[w'$ is compatible with everything John believes of w in w at time s* → $\exists t' < s^*$ [John leaves Mary in w' at t']]

QUESTION 1: Consider the following sentences. A deictic analysis of the embedded temporal ordering like the one we just sketched makes the wrong predictions. For (26), it derives a reading that the sentence does not have. Which one? For (27), it fails to derive a reading that the sentence has. Which one?

(26) **Gordon said that Josephine <u>was</u> pregnant.**

(27) **(Tomorrow when he arrives late) John will say that he <u>fell</u> asleep on the bus.**

■ ANAPHORIC APPROACH: Embedded temporal ordering wrt the "subjective now"

Now it has been known at least since (Prior, 1967) that (at least some) tenses under attitudes do not have a deictic interpretation. That is, an embedded tense expresses simultaneity, anteriority or posteriority with respect to the "subjective now" of the attitude holder, not with respect to the actual now. For example, the sentence **Peter believed that John loved Mary** can be used to report a belief of Peter that he would have worded as "John loves Mary", where the loving is simultaneous to the believing

time, not to the actual now. Similarly, **Peter believed that John left Mary** can be used to report a belief of Peter that he would have worded as "John left Mary", where the leaving is ordered as anterior with respect to the believing time, not to the actual now. In other words, regardless of what the embedded temporal ordering is, the ordering is done with respect to the "subjective now" of the attitude holder. In order to express this, the embedded Tense has to be bound. Using the strategy we know from the interpretation of relative clauses, we may assume a **Tpro** in the embedded clause and bind it to the matrix tense:

(28) **Peter believed that John loved Mary** (to be revised)
P N λ_1 Peter believed(t_1) Tpro$_1$ λt_2 John loves(t_2) Mary
= λw.($\exists t_1 < s^*$) Peter believes in w at t_1 λw'.John loves Mary in w' at t_1

(29) **Peter believed that John left Mary** (to be revised)
P N λ_1 Peter believed(t_1) P(Tpro$_1$) λt_2 John left(t_2) Mary
= λw.($\exists t_1 < s^*$) Peter believes in w at t_1 λw'.($\exists t_2 < t_1$) John leaves Mary in w' at t_2

■ Problem in temporal de se scenarios

It has been known for a long time that this cannot be the whole story ((von Stechow, 1984), (Abusch, 1994), (Heim, 1994), (von Stechow, 1995) among others). The analysis so far assumes that the subject knows precisely the time at which he is, but we can certainly be wrong about what time it is. Consider the following case:

(30) Scenario: (Kusumoto 1999: 62)
Josephine was pregnant on December 1998, and expected to give birth to her baby on January 6th, 1999 . On the morning of December 31st, Gordon and Josephine were involved in a car accident. Josephine and her baby were not injured, but Gordon was and was carried to a hospital. He was in a coma. Four months later at 11:00 AM, on May 1st, Gordon suddenly woke up and remembered everything including the accident, but not his losing consciousness. He did not know that he was located on May 1st but believed it was still Dec 31. He was worried about his wife and said, "Where's Josephine? She is pregnant."

In this scenario, one can truthfully report what Gordon said using the following sentence:

(31) **Gordon said that Josephine was pregnant**.
P N λ_1 Gordon said(t_1) Tpro$_1$ λ_2 was(t_2) λ_3 Josephine pregnant(t_3)
= λw.($\exists t_1 < s^*$) Gordon says in w at t_1 λw'. Josephine is pregnant in w' at t_1

But the anaphoric approach derives the wrong reading: that Gordon thinks on May 1 1999 that Josephine is pregnant on May 1 1999. But of course he knows that Josephine cannot be (still) pregnant on May 1 1999, given the nature of human pregnancies.

The same happens when we want to express that someone located themselves wrongly in the time line:

(32) **At 5 o' clock Mary thought it was 6 o'clock**.
P N λ_1 t_1 at 5 o' clock Mary thought(t_1) Tpro$_1$ λ_2 was(t_2) λ_3 t_3 at 6 o'clock
$= \lambda w.(\exists t_1 < s^*)\ t_1 = 5$ o'clock & Mary thinks in w at t_1 $\lambda w'.t_1 = 6$ o'clock.

According to the anaphoric analysis, the content of Mary's belief is the proposition that 5 o'clock is 6 o' clock, a blatant contradiction. Intuitively, however, there is nothing wrong with Mary's belief, she simply believes that the time at which she located is 6 o' clock.

■ DE SE APPROACH: 'Subjective now' as temporal de se

A solution of the problem following (Lewis, 1979) is this: despite the morphological appearance, the complement of the attitude predicate is not a temporally independent proposition of type <st> but a temporally dependent proposition of type <s,it>, i.e. a property of times. In other words, the clausal complement of the sentence in (27) is not the proposition that the time t_1 is 6 o' clock, but the property of being at 6 o'clock. We obtain this property by abstracting **Tpro$_1$** away. The semantics of the verb of attitudes has to be revised accordingly.

(33) **believe**, type <s,<s,it>,<i,et>> (style of (Lewis, 1979))
$[\![\textbf{believe}]\!]^g = \lambda w.\lambda P_{s(it.)}\lambda t.\lambda y.(\forall w')(\forall t')[(w',t')$ is compatible with everything y believes of (w,t) in w at time t $\rightarrow P(w')(t')]$

(w,t) may be thought as that part of the world history w that is at time t. The antecedent of the conditional is abbreviated as $(w',t') \in Dox_y(w,t)$.) The revised LF for the sentence in (27) is the following:

(34) **P N λ_1 t_1 at 5 o' clock Mary thought(t_1) ~~PRO~~ λ_4 t_4 λ_2 was(t_2) λ_3 t_3 at 6 o'clock**
$= \lambda w.(\exists t_1 < s^*)[t_1 = 5$ o'clock & $((\forall w',t') \in Dox_{Mary}(w,t_1))\ t' = 6$ o'clock$]$

In other words, Mary locates her time at 6 o'clock, and she does that at 5 o'clock.

The LF for the complement is created by starting with a temporal PRO at the Tense position. Since PRO is semantically void, it has to be moved for type reasons and creates a complement of the correct type. This is precisely the analysis proposed by (Kratzer, 1998).

3. Data on Sequence-of-Tense (SOT) and non-Sequence-of-Tense (non-SOT) languages

- Two main differences have been discussed in the literature between SOT languages (English, Spanish) and non-SOT languages (Japanese, Russian, Polish): the semantics of embedded past tense and that of embedded present (and future) tense:

(35) Behaviour of SOT- and non-SOT languages under matrix past tense:

	SOT lgs	Non-SOT lgs
Embedded past tense	Ambiguous: PAST-wrt-t or vacuous	Unambiguous: PAST-wrt-t
Embedded present (and future) tense	Indexical, i.e. necessarily anchored to speech s* (double access reading): PRES-wrt-s*	Not indexical, but bound by matrix t: PRES-wrt-t

- English

(36) Embedded past:
a. Bernhard said that Junko was sick
b. Mariko believed that Mako went to school by bus every day

(37) Embedded present:
a. Bernhard said that Junko is sick
b. Mariko believed that Mako goes to school by bus every day

- Spanish: Here I ignore inflectional aspect.

(38) Embedded past:
Juan dijo que María estaba enferma
John say/past/perf that Mary be/**past**/imp sick
'John said that Mary was sick'

(39) Embedded present:
Juan dijo que María está enferma
John say/past/perf that Mary be/**pres** sick
'John said that Mary is sick'

- Japanese

(40) Embedded past:
a. Bernhard-wa Junko-ga byooki-dat-ta to it-ta
B-top J-nom sick-be-**past** comp say-past
'Bernhard said that Junko had been sick'
b. Mariko-wa Mako-ga mainiti basu-de gakkoo-ni kayotteita to sinziteita
M-top M-nom every-day bus-by school-dat go-teiru-**past** comp believe-teiru-past
'Mariko believed that Mako used to go to school by bus every day'

(41) Embedded present:

a. Bernhard-wa Junko-ga byooki-da to it-ta
B-top J-nom sick-be-**pres** comp say-past
'Bernhard said that Junko was sick (at the time of saying)'

b. Mariko-wa Mako-ga mainiti basu-de gakkoo-ni kayotteiru to sinziteita
M-top M-nom every day bus-by school-dat go-teiru-**pres** comp believe-teiru-past
'Mariko believed that Mako went to school by bus every day (during the relevant period including the belief time)'

■ Russian

(42) Embedded past:
Ma_a skazala, _to Vova spal
M say/past/perf that V sleep/**past**/imp
'Masha said that Vova had been sleeping'

(43) Embedded present:
Ma_a skazala, _to Vova spit
M say/past/perf that V sleep/**pres**
'Masha said that Vova was sleeping (at the time of the saying)'

4. Analysis of non-SOT languages: Japanese and Russian.

■ Summary of the data:

(44) Embedded past:
John <u>said</u> that Mary <u>was</u> sick. (shifted)
'John said that Mary had been sick'

(45) Embedded present:
John <u>said</u> that Mary <u>is</u> sick. (simultaneous)
'John said that Mary was sick'

■ Analysis of tense in complement clauses

(46) Assumptions about Japanese and Russian complement clauses:
i. Tense in complement clauses always involves at least **PRO**. **PRO** has to be moved for type reasons and thus creates a temporal abstract.
ii. Embedded present tense morphology results in **PRES(PRO).** See **PRES** in (47).
iii. Embedded past tense morphology results in **P(PRO)**. **P** is as in (8f).

(47) $[\![\mathbf{PRES}]\!]^g = \lambda w.\lambda t.\lambda P_{<it>}.\ \exists t' = t\ [\ P(t')\ ]$

(48) John <u>said</u> that Mary <u>was</u> sick. (shifted)
$\mathbf{N\ \lambda_1\ P(t_1)\ \lambda_2\ John\ say(t_2)\ \cancel{PRO}\ \lambda_3\ P(t_3)\ \lambda_4\ was(t_4)\ \lambda_5\ Mary\ sick(t_5)}$

(49) John <u>said</u> that Mary <u>is</u> sick. (simultaneous)
$\mathbf{N\ \lambda_1\ P(t_1)\ \lambda_2\ John\ say(t_2)\ \cancel{PRO}\ \lambda_3\ PRES(t_3)\ \lambda_4\ is(t_4)\ \lambda_5\ Mary\ sick(t_5)}$

5. Analysis of past embedded under past for SOT languages: English

■ Assumptions about English complement clauses:

(50) i. Tense in complement clauses always involves at least **PRO**. **PRO** has to be moved for type reasons and thus creates a temporal abstract.

ii. The semantic tense of a complement with past tense morphology is either just **PRO** (leaving the embedded past tense uninterpreted) or **P**(**PRO**) (interpreting the embedded past tense). We can leave past tense uninterpreted only if we can form a binding chain from some interpreted past tense to the uninterpreted embedded past tense.

■ Embedded past tense as **PRO**:

(51) **P N λ_1 t_1 at 5 o' clock Mary thought(t_1) ~~PRO~~ λ_4 t_4 λ_2 was(t_2) λ_3 t_3 at 6 o'clock**

iP uP uP uP

$= \lambda w.(\exists t_1 < s^*)[t_1 = 5 \text{ o'clock } \& ((\forall w',t') \in Dox_{Mary}(w,t_1))\ t' = 6 \text{ o'clock}]$

■ Embedded past tense as **P(PRO)**:

(52) Mary thought Bill left. (shifted)

P N λ_1 Mary thought(t_1) ~~PRO~~ λ_2 P(t_2) λ_3 Bill left(t_3)

$= \lambda w.\ (\exists t_1 < s^*)\ ((\forall w',t_2) \in Dox_{Mary}(w,t_1))\ \ (\exists t_3 < t_2)$ Bill leaves in w' at t_3

■ Ogihara's example:

In (53), the embedded past tense morphology on **was** does not express past in any sense: not wrt the speech time s*, not wrt the thinking time t_0, not even wrt the de se subjective now t_1. This past tense is simply left uninterpreted.

(53) **John thought that he would buy a fish that <u>was</u> still alive.**

P N λ_0 J. thought(t_0) ~~PRO~~ λ_1 t_1 λ_2 would(t_2) λ_3 he buy(t_3) a fish WH_4 $Tpro_3$ λ_5

iP uP uP uP uP

<u>was</u>(t_5) λ_6 x_4 alive(t_6)

uP

$= \lambda w.(\exists t_0 < s^*)\ ((\forall w',t_1) \in Dox_{John}(w,t_0))\ (\exists t_3 > t_1)(\exists x)[fish(x,w')\ \&\ alive(x,w',t_3)\ \&\ buy(J.,x,w',t_3)]$

Note that the **$Tpro_3$** in the relative clause is bound buy the future **would**, the past form of **will**. This accounts for the fact that the temporal variable **t_5** of **was** denotes a time after the subjective now of John.

■ Abusch' example (based on Kamp and Rohrer 1984):

(54) **John decided a week ago that in ten days he would say to this mother that they <u>were</u> having their last meal together**.

QUESTION 2: Derive the LF and truth conditions corresponding to the intended reading of (54).

QUESTION 3: Consider (55), with **would** as the past form of **will**. In principle, the current approach predicts that (55) has an LF where **P** has not been deleted. What reading is derived from this LF? Is this a possible reading of the sentence?

(55) **Jen said that Cecilia would move to Amherst**. (Kusumoto 1999:71)
P N λ_0 Jen said(t_0) ~~PRO~~ λ_1 P(t_1) λ_2 would(t_2) λ_3 Cecilia move(t_3) to Amherst