Kamp & Reyle 1993, Ch. 5 (4)
DRS Construction for Sequences of Tensed Sentences

- EVENTS, STATES AND NARRATIVE TIME

(1)	(1) A man entered the White Hart.			$t_1 < n,$	$e_1 \subseteq t_1$
	(2) He was whistling an Irish jig.			$t_2 < n,$	$s_2 \circ t_2,$ $e_1 \subseteq s_2$
	(3) Bill served him a beer.			$t_3 < n,$	$e_3 \subseteq t_3,$ $e_1 < e_3$
(2)	(3) Bill served a customer a beer.			$t_3 < n,$	$e_3 \subseteq t_3$
	(2) The man was whistling an Irish jig.			$t_2 < n,$	$s_2 \circ t_2,$ $e_3 \subseteq s_2$
#	(1) He entered the pub.			$t_1 < n,$	$e_1 \subseteq t_1,$ $e_3 < e_1$
(3)	(1) A man entered the White Hart.			$t_1 < n,$	$e_1 \subseteq t_1$
	(2) He was whistling an Irish jig.			$t_2 < n,$	$s_2 \circ t_2,$ $e_1 \subseteq s_2$
	(3) Bill served him a beer.			$t_3 < n,$	$e_3 \subseteq t_3,$ $e_1 < e_3$
	(4) The man paid.			$t_4 < n,$	$e_4 \subseteq t_4,$ $e_3 < e_4$
	(5) He drank the beer.			$t_5 < n,$	$e_5 \subseteq t_5,$ $e_4 < e_5$
	(6) It tasted good.			$t_6 < n,$	$s_6 \circ t_6,$ $e_5 \subseteq s_6$
	(7) Some of it ran down his chin.			$t_7 < n,$	$e_7 \subseteq t_7,$ $e_4 < e_7$

- PROBLEMS WITH NEGATION, AGAIN

(4)	(1) John looked at Mary.		$t_1 < n,$	$e_1 \subseteq t_1$
	(2) She didn't smile.		$t_2 < n,$	$\neg\exists e_2(e_2 \subseteq t_2,$ $e_1 < e_2)$
(5)	(1) John looked at Mary.		$t_1 < n,$	$e_1 \subseteq t_1$
	(2) She wasn't smiling.		$t_2 < n,$	$\neg\exists s_2(s_2 \circ t_2,$ $e_1 \subseteq s_2)$

- TENSE AS ANAPHOR (Webber 1988 and others)

According to Moens & Steedman (1987), events come with a tripartite structure consisting of three phases:

preparatory activity (*prep*) < event < consequent state (*con*)

Webber (1988) links new location times to phases of salient events. Which phase depends on the RHETORICAL RELATION to prior discourse (see Lascarides & Asher 1993) — roughly,

ELABORATION ~ *event*, CONTINUATION ~ *con.*

In what follows we write **aft**(e) for **loc**(*con*(e)) ('after-time of e').

(1′)	(1) A man entered the White Hart.			$t_1 < n,$	$e_1 \subseteq t_1$
	(2) He was whistling an Irish jig.	[ELA]	$t_2 = \mathbf{loc}(e_1),$	$t_2 < n,$	$s_2 \circ t_2,$ $e_1 \subseteq s_2$
	(3) Bill served him a beer.	[CTD]	$t_3 = \mathbf{aft}(e_1),$	$t_3 < n,$	$e_3 \subseteq t_3$
(2′)	(3) Bill served a customer a beer.			$t_3 < n,$	$e_3 \subseteq t_3$
	(2) The man was whistling an Irish jig.	[ELA]	$t_2 = \mathbf{loc}(e_3),$	$t_2 < n,$	$s_2 \circ t_2,$ $e_3 \subseteq s_3$
#	(1) He entered the pub.	[CTD?]	$t_1 = \mathbf{aft}(e_3),$	$t_1 < n,$	$e_1 \subseteq t_1$
(3′)	(1) A man entered the White Hart.			$t_1 < n,$	$e_1 \subseteq t_1$
	(2) He was whistling an Irish jig.	[ELA]	$t_2 = \mathbf{loc}(e_1),$	$t_2 < n,$	$s_2 \circ t_2,$ $e_1 \subseteq s_2$
	(3) Bill served him a beer.	[CTD]	$t_3 = \mathbf{aft}(e_1),$	$t_3 < n,$	$e_3 \subseteq t_3$
	(4) The man paid.	[CTD]	$t_4 = \mathbf{aft}(e_3),$	$t_4 < n,$	$e_4 \subseteq t_4$
	(5) He drank the beer.	[CTD]	$t_5 = \mathbf{aft}(e_4),$	$t_5 < n,$	$e_5 \subseteq t_5$
	(6) It tasted good.	[ELA]	$t_6 = \mathbf{loc}(e_5),$	$t_6 < n,$	$s_6 \circ t_6,$ $e_5 \subseteq s_6$
	(7) Some of it ran down his chin.	[ELA]	$t_7 = \mathbf{loc}(e_5),$	$t_7 < n,$	$e_7 \subseteq t_7$
(4′)	(1) John looked at Mary.			$t_1 < n,$	$e_1 \subseteq t_1$
	(2) She didn't smile.	[CTD]	$t_2 = \mathbf{aft}(e_1)$	$t_2 < n,$	$\neg\exists e_2(e_2 \subseteq t_2)$
(5′)	(1) John looked at Mary.			$t_1 < n,$	$e_1 \subseteq t_1$
	(2) She wasn't smiling.	[ELA]	$t_2 = \mathbf{loc}(e_1),$	$t_2 < n,$	$\neg\exists s_2(s_2 \circ t_2,$ $e_1 \subseteq s_2)$

- REVISED ANALYSIS OF FRAME ADVERBS

(6)	(1) John came last Friday.			$t_1 < n,\ t_1 \subseteq last\_Fri(n)$	$e_1 \subseteq t_1$	
	(2) It was raining.	[ELA]	$t_2 = \mathbf{loc}(e_1),$	$t_2 < n,$	$s_2 \circ t_2,$	$e_1 \subseteq s_2$
	(3) But *the next day* it was sunny.	[CTD]	$t_3 = \mathbf{aft}(e_1),$	$t_3 < n,\ t_3 \subseteq next\_day(t_2)$	$s_3 \circ t_3$	
(7)	(1) John came last Friday.			$t_1 < n,\ t_1 \subseteq last\_Fri(n)$	$e_1 \subseteq t_1$	
	(2) It was raining.	[ELA]	$t_2 = \mathbf{loc}(e_1),$	$t_2 < n,$	$s_2 \circ t_2,$	$e_1 \subseteq s_2$
#	(3) It was sunny.	[ELA]	$t_3 = \mathbf{loc}(e_1),$	$t_3 < n$	$s_3 \circ t_3,$	$e_1 \subseteq s_2$
(8)	John came *today*.			$t_1 < n,\ t_1 \subseteq today(n)$	$e_1 \subseteq t_1$	
(9)	John will come *today*.			$n < t_1,\ t_1 \subseteq today(n)$	$e_1 \subseteq t_1$	

References

Lascarides, A. and N. Asher. (1993) 'Temporal Interpretation, Discourse Relations and Commonsense Entailment', *Linguistics and Philosophy* **16**:437–93. http://www.cogsci.ed.ac.uk/~alex/papers.html

Moens, M. & M. Steedman (1988) 'Temporal Ontology and Temporal Reference' *Computational Linguistics* **14**:15–28.

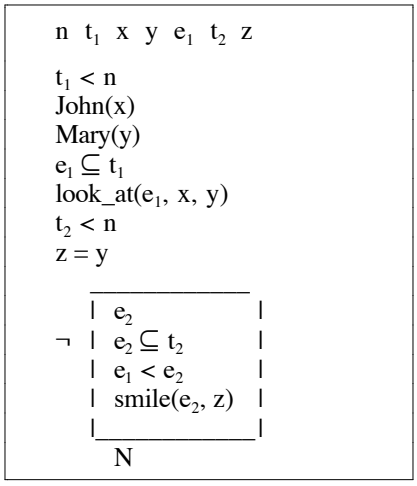
Webber, B. (1988) 'Tense as Discourse Anaphor' *Computational Linguistics* **14**:61–73.

Kamp & Reyle 1993, Ch. 5 (5)
Problems with Negation in Discourse

- NEGATED EVENT SENTENCE IN CONTEXT

(4) (1) John looked at Mary. (2) She didn't smile

- *DRS* K_4 for (4):



- Intuitively, the discourse of (4) is *false* in the anchored model $\langle M_4, \phi_4 \rangle$ diagramed below:

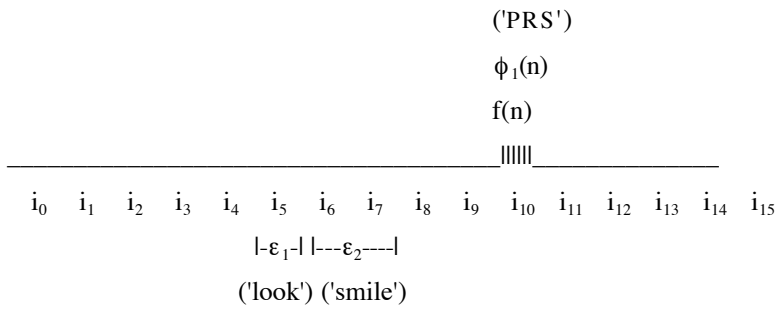
$M_4 = \langle U_{M4}, E_{M4}, S_{M4}, \mathbf{I}_{M4}, \mathbf{T}_{M4}, Loc_{M4}, Name_{M4}, Fun_{M4}, Pred_{M4} \rangle$

$U_{M4} = \{a, b, c\}$ $E_{M4} = \{\varepsilon_0, \varepsilon_1, \ldots\}$ $\mathbf{I}_{M4} = \langle \{i_0, i_1, \ldots\}, < \rangle$, where $i_0 < i_1 < \ldots$

$Loc_{M4}(\varepsilon_1) = \{i_5\}$ $Loc_{M4}(\varepsilon_2) = \{i_6, i_7\}$ $Pred_{M4}(smile) = \{\langle \varepsilon_2, b \rangle\}$

$Name_{M4}(John) = a$ $Name_{M4}(Mary) = b$ $Pred_{M4}(look\_at) = \{\langle \varepsilon_1, a, b \rangle\}$

$\phi_1 = \{\langle n, \{i_{10}\} \rangle\}$



Also, the truth of discourse (4) intuitively depends only on what happens shortly *after* the looking event. The time *before* the looking is irrelevant.

The PROBLEM for Kamp & Reyle's analysis is that, in conflict with these intuitions, their formal semantics predicts that their DRS K_4, which is supposed to represent discourse (4), is *true* in $\langle M_4, \phi_4 \rangle$. Moreover, the following proof of this counterintuitive result crucially relies on a verifying embedding which maps the location time t_2, for smiling, to a time period *before* the looking event, counter to the intuition that this time has no bearing on the truth of discourse (4).

Note: The following proof assumes that clause (i.a) of DRT semantics is extended in the obvious way so that an embedding f verifies '$e_1 < e_2$' in $\langle M, \phi \rangle$ iff $Loc_M(e_1) <_T Loc_M(e_2)$.

- *Proof*:

  To verify the negated condition ¬N of K_4 in $\langle M_4, \phi_4 \rangle$ we just need a ϕ_4-extension f s.t. $f(t_2) <_T f(t_1)$, e.g.:

  $f = \{\langle n, \{i_{10}\}\rangle, \langle t_1, \{i_5\}\rangle, \langle x, a\rangle, \langle y, b\rangle, \langle e_1, \varepsilon_1\rangle, \langle t_2, \{i_2, i_3\}\rangle, \langle z, b\rangle\}$.

  For if $f(t_2) <_T f(t_1)$ and f verifies '$e_1 \subseteq t_1$', then f cannot be extended to also verify '$e_2 \subseteq t_2$' and '$e_1 < e_2$' in N. So any such embedding will verify ¬N. In particular, for the above f the definition of DRT semantics gives:

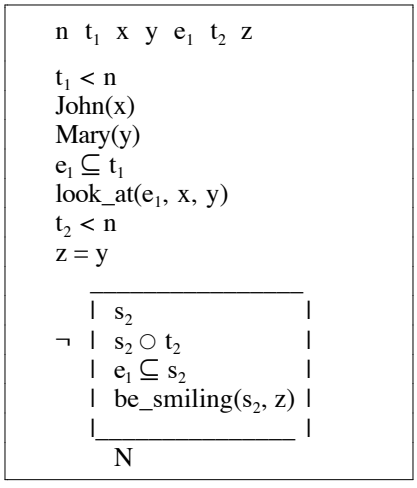
'$t_1 < n$'	is verified, by clause (i.a), because $f(t_1) = \{i_5\} <_T \{i_{10}\} = f(n)$
'John(x)'	is verified, by clause (i.b), because $f(x) = a = Name_{M4}(John)$
'Mary(y)'	is verified, by clause (i.b), because $f(y) = b = Name_{M4}(Mary)$
'$e_1 \subseteq t_1$'	is verified, by clause (i.a), because $Loc_{M4}(f(e_1)) = Loc_{M4}(\varepsilon_1) = \{i_5\} \subseteq \{i_5\} = f(t_1)$
'look_at(e, x, y)'	is verified, by clause (i.e), because $\langle f(e_1), f(x), f(y)\rangle = \langle \varepsilon_1, a, b\rangle \in Pred_{M4}(look\_at)$
'$t_2 < n$'	is verified, by clause (i.a), because $f(t_2) = \{i_2, i_3\} <_T \{i_{10}\} = f(n)$
'$z = y$'	is verified, by clause (i.a), because $f(z) = b = f(y)$
'¬N'	is verified, by clause (i.f), because there is no f-extension which verifies N in $\langle M_4, \phi_4 \rangle$. For suppose there was one, call it g. Then, to verify '$e_1 < e_2$' and '$e_2 \subseteq t_2$' (by clause (i.a)) there would have to be some $\varepsilon \in E_{M4}$ such that (1) and (2): (1) $Loc_{M4}(g(e_1)) = Loc_{M4}(f(e_1)) = \{i_5\} <_T Loc_{M4}(\varepsilon)$ (2) $Loc_{M4}(\varepsilon) \subseteq g(t_2) = f(t_2) = \{i_2, i_3\}$ Consider now any $i \in Loc_{M4}(\varepsilon)$. Then from (1) we infer $i_5 < i$ (by def. $<_T$). Moreover, (2) implies either $i = i_2$ or $i = i_3$. But this cannot be as it contradicts either $i_2 < i_5$ or $i_3 < i_5$.

  So K_4 has a ϕ_4-extending embedding which verifies it in $\langle M_4, \phi_4 \rangle$ (to wit f, by clause (ii)) and so is true in $\langle M_4, \phi_4 \rangle$ (by clause (iii)). u

- NEGATED STATE SENTENCE IN CONTEXT

(5) (1) John looked at Mary. (2) She wasn't smiling.

- *DRS* K_5 for (5):



- *What exactly are the counterintuitive predictions we get in this case*?
  Show just how the DRS K_5 fails to represent the intuitive meaning of (5) in as much detail as shown above for the DRS K_4 as the representation of (4).

- Intuitively, the discourse of (5) is *false* in the anchored model $\langle M_5, \phi_5 \rangle$ diagramed below:

$M_5 = \langle U_{M5}, E_{M5}, S_{M5}, \mathbf{I}_{M5}, \mathbf{T}_{M5}, Loc_{M5}, Name_{M5}, Fun_{M5}, Pred_{M5} \rangle$

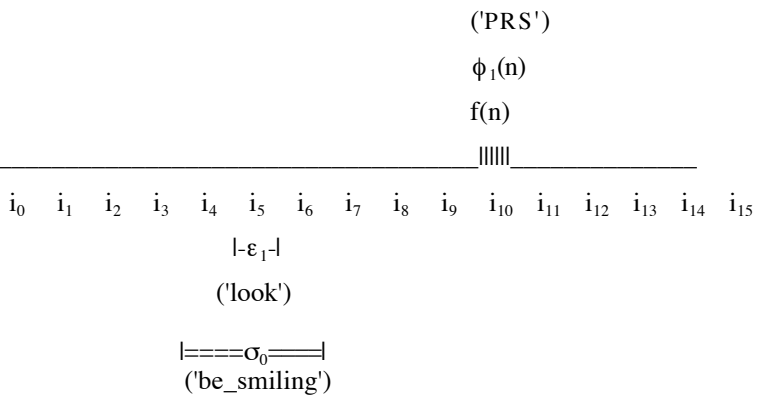
$U_{M5} = \{a, b, c\}$ $E_{M5} = \{\varepsilon_0, \varepsilon_1, \ldots\}$ $S_{M5} = \{\sigma_0, \sigma_1, \ldots\}$

$\mathbf{I}_{M5} = \langle \{i_0, i_1, \ldots\}, < \rangle$, where $i_0 < i_1 < \ldots$

$Loc_{M5}(\varepsilon_1) = \{i_5\}$ $Loc_{M5}(\sigma_0) = \{i_4, i_5, i_6\}$ $Pred_{M5}(be\_smiling) = \{\langle \sigma_0, b \rangle\}$

$Name_{M5}(John) = a$ $Name_{M5}(Mary) = b$ $Pred_{M5}(look\_at) = \{\langle \varepsilon_1, a, b \rangle\}$

$\phi_1 = \{\langle n, \{i_{10}\} \rangle\}$



The truth of discourse (5) depends only on what happens *at the time of* the looking event. If there is a state of Mary smiling that holds at that time then discourse (5) is *false*. It does not matter what goes on at any past time outside of that smiling state.

The PROBLEM for Kamp & Reyle's analysis is that it is precisely such an intuitively irrelevant time that can be used to show that their DRS K_5 — the putative representation of discourse (5) — is *true* in $\langle M_5, \phi_5 \rangle$.

- *Proof*:

The DRS K_5 is verified in $\langle M_5, \phi_5 \rangle$, e.g., by the following ϕ_5-extension:

$f = \{\langle n, \{i_{10}\} \rangle, \langle t_1, \{i_5\} \rangle, \langle x, a \rangle, \langle y, b \rangle, \langle e_1, \varepsilon_1 \rangle, \langle t_2, \{i_8\} \rangle, \langle z, b \rangle\}$.

For by the definition of DRT semantics we get:

'$t_1 < n$'	is verified, by clause (i.a), because $f(t_1) = \{i_5\} <_T \{i_{10}\} = f(n)$
'John(x)'	is verified, by clause (i.b), because $f(x) = a = Name_{M5}(John)$
'Mary(y)'	is verified, by clause (i.b), because $f(y) = b = Name_{M5}(Mary)$
'$e_1 \subseteq t_1$'	is verified, by clause (i.a), because $Loc_{M5}(f(e_1)) = Loc_{M5}(\varepsilon_1) = \{i_5\} \subseteq \{i_5\} = f(t_1)$
'look_at(e, x, y)'	is verified, by clause (i.e), because $\langle f(e_1), f(x), f(y) \rangle = \langle \varepsilon_1, a, b \rangle \in Pred_{M5}(look\_at)$
'$t_2 < n$'	is verified, by clause (i.a), because $f(t_2) = \{i_8\} <_T \{i_{10}\} = f(n)$
'$z = y$'	is verified, by clause (i.a), because $f(z) = b = f(y)$
'¬N'	is verified, by clause (i.f), because there is no f-extension which verifies N in $\langle M_5, \phi_5 \rangle$.
	For suppose there was one, call it g. Then, to verify 's_2 s t_2' (by clause (i.a)) and 'be_smiling(s_2, z)' (by clause (i.d)) there would have to be some $\sigma \in S_{M5}$ such that (1) $Loc_{M5}(\sigma) \circ_T g(t_2) = Loc_{M5}(\sigma) \circ_T \{i_8\}$ (2) $\langle \sigma, b \rangle \in Pred_{M5}(be\_smiling)$ But (1) and (2) imply $i_8 \in Loc_{M5}(\sigma)$ and $\sigma = \sigma_0$, whereas from the definition of M_5 we get $i_8 \notin Loc_{M5}(\sigma_0) = \{i_4, i_5, i_6\}$. A contradiction.

So K_5 has a ϕ_5-extending embedding which verifies it in $\langle M_5, \phi_5 \rangle$ (to wit f, by clause (ii)) and so is true in $\langle M_5, \phi_5 \rangle$ (by clause (iii)). □