TEMPORAL VECTORS

1 Some spatial-temporal analogies

(1) *Same modification types*

a. *seven seconds* after the kickoff (*7″* above the line)

b. *very deep* in the past (*very deep* inside Iraq)

c. *right* before Christmas (*right outside* the door)

d. *exactly* between Easter and Whitsuntide (*exactly* between A and B)

(2) *Same words*

a. *between* Dover and Calais a'. *between* 1918 and 1939

b. a *long* spear b'. a *long* battle

c. in the *middle* of the room c'. in the *middle* of the night

d. *right* below the surface d'. *right* after Christmas

(3) *Same notions and distinctions*

a. *proximity*: recently, soon ~ close, near

b. *duration ~ length*: young, old, duration, age ~ short, long, length

c. *ordering*: before, after ~ above, below

(4) *Same constraints (upward monotonicity)*

a. seven seconds after/before kickoff

b. * seven days in January/around Christmas

b' * seven minutes against midnight/between 1 and 2 o'clock

2 The Model

(5) *'Absolute' time*

a. T is a one-dimensional vector space: the moments of time

b. $t_> \in T$ is a unit vector representing the direction of time

c. prospective time: $T_> = \{ st_> : s > 0 \}$, retrospective time: $T_< = -T_> = \{ st_> : s < 0 \}$, zero time: $T_0 = \{ t_0 \}$

(6) *'Relative' time*

a. $\mathbf{T} = T \times T$ is the set of located time vectors

b. $\mathbf{T}_> = T \times T_>$, $\mathbf{T}_< = T \times T_<$, $\mathbf{T_0} = T \times T_0$

c. $\text{start}(\langle t,t' \rangle) = t$, $\text{end}(\langle t,t' \rangle) = t + t'$

d. $|t| = 1$ and $|\langle t',t \rangle| = 1$ mean that t has the same length as $t_>$

(7) a. tim(e): 'eigentime' of an event e (convex, closed set of moments)

b. int(e): the set of closest internal boundary vectors of event e
ext(e): the set of closest external boundary vectors of event e

c. $\text{tim}^{-1}(R)$: the set of events located in the temporal region R

3 Some Lexical Definitions

(8) '*Temporal location'*

a. in: $\lambda A.\lambda \mathbf{t}.\text{int}(\mathbf{t},A)$

b. after: $\lambda A.\lambda \mathbf{t}.\text{ext}(\mathbf{t},A) \wedge \mathbf{t} \in \mathbf{T}_{>}$

c. recent: $\lambda \mathbf{t}.\text{ext}(\mathbf{t},S) \wedge \mathbf{t} \in \mathbf{T}_{<} \wedge |\mathbf{t}| < r$ (S is speech or reference event)

(9) *Temporal axis vector*

The temporal vector of an event pointing from beginning to end

(10) *Temporal size*

a. long: $\lambda e.\exists \mathbf{t}.\text{axis}(e,\mathbf{t}) \wedge |\mathbf{t}| > r$ (e.g. the meeting)

b. young: $\lambda x.\exists \mathbf{t}.\text{axis}(x,\mathbf{t}) \wedge |\mathbf{t}| < r$ (e.g. the child)

(11) *Temporal parts*

a. the beginning of: $\lambda x.x \subseteq y \wedge \exists \mathbf{t}.\text{axis}(y,\mathbf{t}) \wedge \text{place}(x,0\mathbf{t})$

b. the middle of: $\lambda x.x \subseteq y \wedge \exists \mathbf{t}.\text{axis}(y,\text{t}) \wedge \text{place}(x,½\mathbf{t})$

(where place(x,**t**) is short for: '**t** ends in the 'eigentime' of x')

RELATIONAL VECTORS

1 Distance modification across categories

(12) a. Catherine is a *distant* cousin of Cosimo

b. The S node *immediately* dominates the VP node

c. Magritte's style was *closely* akin to surrealism

(13) a. close ally, ancestor, associate, colleague, companion, friend, relative

a'. closely aligned, associated, linked, related

c. close accord, match, resemblance, similarity

c'. closely emulate, identify, imitate, mimic, resemble, similar

(14) *Two interesting features about this kind of modification*

a. The use of spatial terms (*close*, *distant*, *immediate*)

b. The semantic compositionality

1.1 Spatial aspects

(15) *next* of kin, second cousin twice *removed*, *remote* ancestors, collateral *distance*, *ascending* and *descending* generation, one generation *above* or *below* ego, my mother's *side*, bi*lateral* descent

(16) *low* rank, the officer *above* me, the servants *below* him, *rise* to a *high* position, *super*ior, *under*dog, the *top*

(17) *Equivalences*

a. Claudius was emperor immediately after Caligula

a'. Claudius was the immediate successor of Caligula

b. William is many generations above/before Alex

b'. William is a remote ancestor of Alex

c. The sergeant is below the captain

c'. The sergeant is a subordinate of the captain

d. Ada is close to Bob

d'. Ada is a close friend of Bob

1.2 Compositionality

(18) a. $[_{PP}$ Modifier $[_{P'}$ P Complement]]

b. $[_{XP}$ Modifier $[_{X'}$ X Complement]] where X is N, A, V, or Adv

(19) a. William is a remote ancestor of Alex

b. [remote [ancestor [of Alex]]

c. ancestor of Alex: $\lambda x.x$ is ancestor of Alex

d. remote: $\lambda X.\lambda x.x \in X$ and x is remote from y

2 Relational vector spaces

(20) Relations of kinship, hierarchy, and similarity are relations in a metaphorical, 'conceptual' space, a 'kinship space', 'hierarchy space', 'similarity space'. (Gärdenfors 2000). These spaces are modeled as vector spaces.

(21) *'Absolute' generations*

a. G is the set of generations, a subset of a one-dimensional vector space V, $G = \{ sg_{>} \in V: s \in Z \}$, where $g_{>} \in V$ is a unit vector representing the direction of descent and the unit of generations and Z is the set of integers.

(22) *'Relative' generations*

a. $\mathbf{G} = G \times G$ is the set of 'located generation vectors', representing the lineal kin relation

b. $\mathbf{G}_{<} = G \times G_{<}$, the set of vectors that point from descendants to ancestors

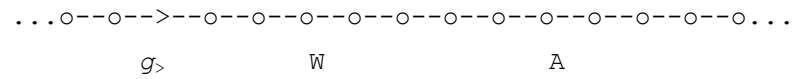
c. $\text{start}(\langle g,g' \rangle) = g$, $\text{end}(\langle g,g' \rangle) = g + g'$

d. $|g| = 1$ and $|\langle g',g \rangle| = 1$ mean that g has the same length as $g_{>}$

(23) a. $\text{gen}(x)$: generation of a person x in G

b. $\text{gen}^{-1}(\mathbf{R}) = \lambda x.\exists \mathbf{g} \in \mathbf{R}.\text{end}(\mathbf{g}) = \text{gen}(x)$

(24) G <-------g-------



(25) a. ancestor: $\lambda x.\lambda \mathbf{g}.\text{start}(\mathbf{g}) = \text{gen}(x) \wedge \mathbf{g} \in \mathbf{G}_<$

b. ancestor of Alex: $\lambda \mathbf{g}.\text{start}(\mathbf{g}) = \text{gen}(\text{alex}) \wedge \mathbf{g} \in \mathbf{G}_<$

c. remote: $\lambda \mathbf{G}.\lambda \mathbf{g}.\mathbf{g} \in \mathbf{G} \wedge |\mathbf{g}| > r$

d. remote ancestor of Alex: $\lambda \mathbf{g}.\text{start}(\mathbf{g}) = \text{gen}(\text{alex}) \wedge \mathbf{g} \in \mathbf{G}_< \wedge |\mathbf{g}| > r$

e. (to be a) remote ancestor of Alex:

$\text{gen}^{-1}(\lambda \mathbf{g}.\text{start}(\mathbf{g}) = \text{gen}(\text{alex}) \wedge \mathbf{g} \in \mathbf{G}_< \wedge |\mathbf{g}| > r) =$

$\lambda x.\exists \mathbf{g}.\text{start}(\mathbf{g}) = \text{gen}(\text{alex}) \wedge \mathbf{g} \in \mathbf{G}_< \wedge |\mathbf{g}| > r \wedge \text{end}(\mathbf{g}) = \text{gen}(x)$

f. William is a remote ancestor of Alex

$\exists \mathbf{g}.\text{start}(\mathbf{g}) = \text{gen}(\text{alex}) \wedge \mathbf{g} \in \mathbf{G}_< \wedge |\mathbf{g}| > r \wedge \text{end}(\mathbf{g}) = \text{gen}(\text{william})$