# Dowty's aspect hypothesis segmented 

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## Where are the events in Dowty's aspect calculus?

# Word Meaning \& Montague Grammar, 1979 statives + DO, BECOME, CAUSE ... 

## A rough approximation from Rothstein 2004

activities
achievements

accomplishments


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$\lambda e .(\mathrm{DO}(\varphi))(e)$
$\lambda e(\operatorname{BFCOMF}(\varphi))(e)$
$\lambda e . \exists e^{\prime}\left[(\mathrm{DO}(\varphi))\left(e^{\prime}\right) \wedge e=e^{\prime} \sqcup_{S} \operatorname{Cul}(e)\right]$

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A rough approximation from Rothstein 2004 $\begin{array}{ll}\text { activities } & \lambda e .(\operatorname{DO}(\varphi))(e) \\ \text { achievements } & \lambda e .(\operatorname{BECOME}(\varphi))(e) \\ \text { accomplishments } & \lambda e . \exists e^{\prime}\left[(\operatorname{DO}(\varphi))\left(e^{\prime}\right) \wedge e=e^{\prime} \sqcup_{S} \operatorname{Cul}(e)\right]\end{array}$

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```

Interval world pairs
For stative $\varphi$,

$$
\langle I, w\rangle \models \varphi \quad \text { iff } \quad(\forall t \in I)\langle\{t\}, w\rangle \mid=\varphi
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contra $\varphi$ for an event

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Idea. Bring out events by segmenting / to track change in stative $\varphi$ 's
A segmentation of $I$ is a sequence $I_{1} 1_{2} \ldots I_{n}$ such that $I=\bigcup_{i=1}^{n} I_{i}$ and for $1 \leq i<n, I_{i} \prec I_{i+1}-$ i.e. $\left(\forall t \in I_{i}\right)\left(\forall t^{\prime} \in I_{i+1}\right) t \prec t^{\prime}$.

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## Tracking $\varphi$

A segmentation $I_{1} \cdots I_{n}$ of $I w$-tracks $\varphi$ if for all subintervals $I^{\prime}$ of $I$,

$$
\left\langle I^{\prime}, w\right\rangle \models \varphi \quad \text { iff } \quad I^{\prime} \subseteq \bigcup\left\{I_{i} \mid 1 \leq i \leq n \text { and }\left\langle I_{i}, w\right\rangle \models \varphi\right\} .
$$

A $(\varphi, w, n)$-alternation in $I$ is a string $t_{1} t_{2} \cdots t_{n} \in I^{n}$ s.t. $t_{i} \prec t_{i+1}$
and $\left\langle\left\{t_{i}\right\}, w\right\rangle \mid=\varphi$ iff $i$ is odd.
$I$ is $(\varphi, w)$-alternation bounded (a.b.) if for some $n>0$, no
$(\varphi, w, n)$-alternation in $I$ exists.
Fact. For stative $\varphi$,
some segmentation of I w-tracks $\varphi$ iff I is $(\varphi, w)$-a.b.

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I is ( $\varphi, w$ )-alternation bounded (a.b.) if for some $n>0$, no $(\varphi, w, n)$-alternation in I exists.

Fact. For stative $\varphi$, some segmentation of I w-tracks $\varphi$ iff I is $(\varphi, w)$-a.b.

From segmentations to strings

$$
I_{1} I_{2}=_{w} \quad \psi \mid \varphi, \psi \quad \text { iff } \quad\left\langle I_{1}, w\right\rangle \models \psi \text { and }\left\langle I_{2}, w\right\rangle \models \varphi \wedge \psi
$$


$\alpha_{1} \cdots \alpha_{n}$ is telic if there is some $\varphi$ in $\alpha_{n}$ such that the negation $\sim \varphi$ of $\varphi$ appears in $\alpha_{i}$ for $1 \leq i<r$

Mary ran to post-office $\quad \varphi=$ at(mary,post-office)

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\begin{array}{rll}
I_{1} I_{2} \models_{w} \psi \mid \varphi, \psi & \text { iff } & \left\langle I_{1}, w\right\rangle \models \psi \text { and }\left\langle l_{2}, w\right\rangle \models \varphi \wedge \psi \\
I_{1} \cdots I_{n} \models_{w} \alpha_{1} \cdots \alpha_{m} & \text { iff } \quad n=m \text { and for } 1 \leq i \leq n \text { and } \varphi \in \alpha_{i},
\end{array}
$$

$$
\left\langle I_{i}, w\right\rangle \models \varphi
$$

|  | non-durative | durative (length $\geq 3$ ) |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| telic | achieve $\sim \sim \varphi \mid$ | accomplish $\sim \varphi$ | $\sim \varphi, \psi \mid$ | $\sim \varphi, \psi{ }^{+}$ | $\varphi$ |
| -tel | semelfactive $\psi$ | activity |  |  |  |

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$$
\left\langle l_{i}, w\right\rangle \models \varphi
$$

|  | non-durative |  | durative (length $\geq 3$ ) |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| telic | achieve $\sim \sim$ | $\varphi$ | accomplish | $\sim \varphi$ | $\sim \varphi, \psi$ | $\sim \varphi, \psi$ | $\varphi$ |
| -tel | semelfactive | $\psi$ | ac | tivity | 㥩 $\psi$ |  |  |

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| telic | achieve $\sim \varphi$ | $\varphi$ | accomplish | $\sim \varphi$ | $\sim \varphi, \psi$ | $\sim \varphi, \psi$ | $\varphi$ |
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Mary ran to post-office $\quad \varphi=$ at(mary,post-office) not quantized (Krifka) ... "arrow of time" (Landman \& R 2012)

Moens \& Steedman 1988 in strings


(2) $s \beta$; $\alpha s^{\prime}:=$ $s(\beta \cup \alpha) s^{\prime}$
(3) $L ; L^{\prime}:=\left\{s ; s^{\prime} \mid s \in L-\{\epsilon\}\right.$ and $\left.s^{\prime} \in L^{\prime}-\{\epsilon\}\right\}$
(4) iterate $(L):=($ least $Z \supseteq L ; L) Z ; L \subseteq Z$


Moens \& Steedman 1988 in strings

(1) iterate $\left(\begin{array}{|}\mid \psi\end{array}\right)=\square_{|\psi| \psi}{ }^{+}$
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## Comrie 1976

With a state, unless something happens to change that state, then the state will continue... With a dynamic situation, on the other hand, the situation will only continue if it is continually subject to a new input of energy.
 $:=\varphi \wedge \operatorname{Prev}(\sim \varphi)$ no segmentation w-satisfies any string in


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For $\psi:=\varphi \wedge \operatorname{Prev}(\sim \varphi)$, no segmentation $w$-satisfies any string in


Incremental change and grain

$$
\langle I, w\rangle \models d<\varphi \text {-deg } \quad \text { if } \quad(\forall t \in I) d<\operatorname{deg}_{\varphi, w}^{D}(t)
$$

$$
\langle I, w\rangle \models \varphi-\operatorname{deg} \leq d \quad \text { ff } \quad(\forall t \in I) \operatorname{deg}_{\varphi, w}^{D}(t) \leq d
$$



Grain is fixed by the set of propositions we can box.

Incremental change and grain

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\end{array}
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$\left(\forall t \in I_{i-1}\right)\left(\forall t^{\prime} \in I_{i}\right)$

$\square$


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For $\psi:=(\exists d \in D)(d<\varphi-\operatorname{deg} \wedge \operatorname{Prev}(\varphi-\operatorname{deg} \leq d))$,


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$$
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I_{0} I_{1} \cdots I_{n} \models_{w}|\psi|^{n} \quad \text { iff } \quad & \left(\exists d_{1}, \ldots, d_{n} \in D\right)(\forall i \in[1, n]) \\
& \left(\forall t \in I_{i-1}\right)\left(\forall t^{\prime} \in I_{i}\right) \\
& \operatorname{deg}_{\varphi, w}^{D}(t) \leq d_{i}<\operatorname{deg}_{\varphi, w}^{D}\left(t^{\prime}\right)
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\end{aligned}
$$

$$
\begin{array}{|l|l|}
\hline \varphi \text {-deg } \leq d_{1} & d_{1}<\varphi \text {-deg, } \varphi \text {-deg } \leq d_{2} \\
\cdots \cdots & d_{n-1}<\varphi \text {-deg, } \varphi \text {-deg } \leq d_{n} \\
& d_{n}<\varphi \text {-deg } \\
\hline
\end{array}
$$

Grain is fixed by the set of propositions we can box.

## The projections $b c_{A}(s):=b c\left(\rho_{A}(s)\right)$

days in a year $\sim$ months in a year

$$
\begin{array}{|l|l|l|}
\hline \text { Jan,d1 } & \text { Jan, d2 } & \cdots \\
\hline
\end{array}
$$


$\rho_{A}$ "see only $A$ "
$b c$ "no time without change" : compress $\alpha^{+}$to $\alpha$
For infinite $\Phi$, let Fin $(\Phi)$ be the set of finite subsets of $\Phi$.
A $\Phi$-system is a function $f: \operatorname{Fin}(\Phi) \rightarrow\left(2^{\phi}\right)^{*}$ such that

$$
(\forall B \subset \operatorname{Fin}(\phi))(\forall A \subseteq B) \quad f(A)=b c_{A}(f(B))
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Fact. The set of $\Phi$-systems is the inverse limit $\mathbb{I L}(\Phi)$ of

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days in a year $\sim$ months in a year

| Jan, d1 | Jan, d2 | $\cdots$ Dec, d31 |
| :--- | :--- | :--- |



$$
\begin{array}{|l|l|}
\hline \text { Jan } & \text { Feb }
\end{array} \cdots \begin{array}{|l|}
\hline \text { Dec } \\
\hline
\end{array}
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\hline \text { Jan, d1 } & \text { Jan, d2 } & \cdots \text { Dec, d31 } \\
\hline
\end{array} \\
& \rho_{\text {months }}^{\sim} \\
& \mathrm{Jan}^{31} \mathrm{Feb}^{28} \cdots \mathrm{Dec}^{31} \\
& \begin{array}{|l|l|l|}
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\hline
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\begin{array}{|l|l|ll|l|l|}
\hline \text { Jan, d1 } & \text { Jan, d2 } & \cdots \text { Dec, d31 } & \stackrel{\rho_{\text {moonths }}}{\sim} & \mathrm{Jan}^{31} \mathrm{Feb}^{28} \cdots \mathrm{Dec}^{31} \\
& \stackrel{b c}{\sim} & \mathrm{Jan} & \mathrm{Feb} & \cdots & \text { Dec } \\
\end{array}
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$$
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$$

$\mathbb{I L}(\Phi)$ branches

For $f, f^{\prime} \in \mathbb{I L}(\Phi)$,
$f \prec_{\phi} f^{\prime} \quad$ iff $f \neq f^{\prime}$ and $(\forall A \in \operatorname{Fin}(\phi)) f(A)$ is a prefix of $f^{\prime}(A)$
where

$$
s \text { is a prefix of } s^{\prime} \text { iff }\left(\exists s^{\prime \prime}\right) s^{\prime}=s s^{\prime \prime}
$$

Fact. $\prec_{\Phi}$ is transitive and left linear: for all $f \in \mathbb{L}(\Phi)$, and $f_{1}, f_{2} \prec_{\Phi} f$,

$$
f_{1} \prec_{\Phi} f_{2} \text { or } f_{2} \prec_{\Phi} f_{1} \text { or } f_{1}=f_{2} .
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From intensions to truthmaking \& finite-state methods

An interval world pair $\langle I, w\rangle$ is $\Phi$-approximable if every $\varphi \in \Phi$ is homogeneous and alternation-bounded in $\langle I, w\rangle$.

Fact. Every $\Phi$-approximable $\langle I, w\rangle$ is representable in $\mathbb{L}(\Phi)$ by a unique system $\{f(A)\}_{A \in \operatorname{Fin}(\Phi)}$ of approximations of $\langle I, w\rangle$ as $f(A) \in\left(2^{A}\right)^{*}$ at granularity $A$.
$\mathrm{DAH}_{s}$ : At granularity $A$, events within $\langle I, W\rangle$ are representable as substrings of $f(A)$
an E-event occurs in $\langle l, w\rangle$ iff $\left(\exists s \in L_{E}\right) s \sqsubseteq f(A)$ relational intension: $s^{\prime} \sqsupseteq_{E} s$ iff $s \in L_{E}$ and $s \sqsubseteq s^{\prime}$

Construe strings as models/segmentations (for completeness) a poor man's IL amenable to finite-state methods

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