Negation and events as truthmakers

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$$[\![A]\!] = (V(A), F(A)) \quad \textit{exactly}$$
$$[\![\neg A]\!] = (F(A), V(A))$$

Davidson 1967

(7) Amundsen flew to the North Pole in May 1926

$\exists x$ Amundsen-flew-to-the-North-Pole$(x) \wedge$ In(May1926, x)

Davidson and $\exists x$

I find entirely persuasive ... Reichenbach's proposal that ordinary action sentences have, in effect, an existential quantifier binding the action variable.
When we were tempted into thinking a sentence like (7) describes a single event we were misled: it does not describe any event at all.
But if (7) is true, then there is an event that makes it true.
This unrecognized element of generality in action sentences is, I think, of the utmost importance in understanding the relation between actions and desires.

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Plan:

$\exists \rightsquigarrow$ *in*exact truthmaking

$x \rightsquigarrow$ *asymmetricalist* negation (Horn)

Agenda

1. Inexact truthmaking $A_{\leq}$ with negation

$$S - V(A_{\leq}) \;\neq\; V((\neg A)_{\leq})$$

2. Negation by forces (mentioned in discourse)

$$\fbox{φ}\fbox{} \;\Rightarrow\; \fbox{}\fbox{φ} + \fbox{$\mathit{force}(\neg\varphi)$}\fbox{$$}$$

3. $\leq$ with non-deterministic fusion

$$\fbox{}\fbox{a}\fbox{} \sqcup \fbox{}\fbox{a'}\fbox{} \;\approx\; \text{Allen}(a, a')$$

Inexact truthmaking and gluts

Fix $\langle S, \leq \rangle$, and $V(A) \subseteq S$ and $F(A) \subseteq S$.

$$V(A_{\leq}) \;:=\; \{s \in S \mid (\exists s' \in V(A))\; s' \leq s\}$$

$$\begin{aligned} A\text{-gluts} \;&:=\; V(A_{\leq}) \cap V((\neg A)_{\leq}) \\ &=\; V(A_{\leq} \wedge (\neg A)_{\leq}) \end{aligned}$$

(A1) $F(A_{\leq}) \;:=\; \{s \in S \mid (\exists s' \in F(A))\; s' \leq s\} \;=\; V((\neg A)_{\leq})$

yielding

$$F(A_{\leq} \wedge \neg A_{\leq}) \;=\; V(A_{\leq}) \cup F(A_{\leq}) \qquad \text{“no } A\text{-gaps”}$$

Classical alternative

(A2) $F(A_{\leq}) \ := \ S - V(A_{\leq}) \ \neq \ V((\neg A)_{\leq})$

yielding

$$F(A_{\leq} \wedge (\neg A)_{\leq}) \ = \ S - (\underbrace{V(A_{\leq}) \cap V((\neg A)_{\leq})}_{A\text{-gluts}})$$

(1) Amundsen did not fly to the North Pole in July 1926.

$$S - V(A_{\leq}) \ = \ \{s \in S \mid (\forall s' \leq s) \ s' \notin V(A)\}$$

$$V((\neg A)_{\leq}) \ = \ \{s \in S \mid (\exists s' \leq s) \ s' \in F(A)\}$$

(2) Amundsen stayed home in 1926.

Temporal extent

Events: *in* as *within* (Pratt-H 2005, Beaver & Condoravdi 2007)

$$t \models A \text{ and } t \sqsubseteq t' \implies t' \models A$$

(3) Amundsen flew to the North Pole and stayed home the same year but not at the same time.

Statives: homogeneous (Taylor 1977, Dowty 1979)

$$t \models A \text{ and } t' \sqsubseteq t \implies t' \models A$$

(4) Amundsen stayed home in July 1926.

Statives $\neq$ Events $\neq$ Forces

stative	event	action/force
φ	s	f
letter	string	automaton

Dowty's Aspect hypothesis (1979)

statives + operators BECOME, DO, CAUSE, ...

BECOME(φ) $\rightsquigarrow$ $\boxed{\neg\varphi}\boxed{\varphi}$

DO(f) $\rightsquigarrow$ $\boxed{ap(f)}\boxed{ef(f)}$

$ap(f)$: force f is applied

$ef(f)$: a previous application of f is effectual

Durativity and culmination

s is *durative* if length(s) ≥ 3

	−durative	+durative
−telic	semelfactive $\boxed{ap(f)}\boxed{ef(f)}$	activity $\boxed{ap(f)}\boxed{ap(f), ef(f)}\boxed{ef(f)}$
+telic	achievement $\boxed{\neg\varphi}\boxed{\varphi}$	accomplishment $\boxed{\neg\varphi, ap(f)}\boxed{\neg\varphi, ap(f), ef(f)}\boxed{\varphi, ef(f)}$

s is φ-*telic* if $s \trianglerighteq \boxed{\neg\varphi}^{+}\boxed{\varphi}$

$$\alpha_1 \cdots \alpha_n \trianglerighteq \beta_1 \cdots \beta_m \quad \text{iff} \quad n = m \text{ and } \beta_i \subseteq \alpha_i \text{ for } 1 \leq i \leq n$$

$$s \trianglerighteq L \quad \text{iff} \quad (\exists s' \in L)\ s \trianglerighteq s'$$

Negation and inertia

Inertia: a stative persists unless $\underbrace{\text{something}}_{\text{force}}$ happens to it

$$\mathit{force}(\varphi) \;=\; \mathit{ap}(f) \quad \text{where} \quad \mathit{ef}(f) = \varphi \quad \text{subject to}$$

$$\boxed{\varphi}\boxed{} \;\Rightarrow\; \boxed{}\boxed{\varphi} + \boxed{\mathit{force}(\neg\varphi)}\boxed{}$$

$$\begin{aligned} L \Rightarrow L' \;&:=\; \{s \mid (\forall s' \in \text{factor}(s))\; s' \trianglerighteq L \text{ implies } s' \trianglerighteq L'\} \\ \text{factor}(s) \;&:=\; \{s' \mid s = us'v \text{ for some strings } u, v\} \end{aligned}$$

$$\begin{aligned} \boxed{}\boxed{\varphi} \;&\Rightarrow\; \boxed{\varphi}\boxed{} + \boxed{\mathit{force}(\varphi)}\boxed{} \\ \boxed{\mathit{force}(\varphi)}\boxed{} \;&\Rightarrow\; \boxed{}\boxed{\varphi} + \boxed{\mathit{force}(\neg\varphi)}\boxed{} \end{aligned}$$

Dowty 1986: Semantics or pragmatics?

> *This principle of "inertia" in the interpretation of statives in discourse applies to many kinds of statives but of course not to all of them . . . there must be a graded hierarchy of the likelihood that various statives will have this kind of implicature, depending on the nature of the state, the agent, and our knowledge of which states are long-lasting and which decay or reappear rapidly. Clearly, an enormous amount of real-world knowledge and expectation must be built into any system which mimics the understanding that humans bring to the temporal interpretations of statives in discourse, so no simple non-pragmatic theory of discourse interpretation is going to handle them very effectively.*
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Inertia and force constraints above are non-defeasible.

Left open: forces at play and which win out ... PRAGMATICS

Fusion and Allen relations

$$\boxed{}\boxed{a}\boxed{} \sqcup \boxed{}\boxed{a'}\boxed{} \;=\; \boxed{}\boxed{a,a'}\boxed{} + \boxed{}\textbf{Allen}\boxed{}$$

Allen	$(2^{\{a,a'\}})^+$
a m a'	$\boxed{a}\boxed{a'}$
$a < a'$	$\boxed{a}\boxed{}\boxed{a'}$
a mi a'	$\boxed{a'}\boxed{a}$
$a > a'$	$\boxed{a'}\boxed{}\boxed{a}$

Allen	$(2^{\{a,a'\}})^+$
a s a'	$\boxed{a,a'}\boxed{a'}$
a si a'	$\boxed{a,a'}\boxed{a}$
a f a'	$\boxed{a'}\boxed{a,a'}$
a fi a'	$\boxed{a}\boxed{a,a'}$

Allen	$(2^{\{a,a'\}})^+$
a d a'	$\boxed{a'}\boxed{a,a'}\boxed{a'}$
a di a'	$\boxed{a}\boxed{a,a'}\boxed{a}$
a o a'	$\boxed{a}\boxed{a,a'}\boxed{a'}$
a oi a'	$\boxed{a'}\boxed{a,a'}\boxed{a}$

$\cup$ componentwise

$$\boxed{}\boxed{a,a'}\boxed{a'}\boxed{} = \boxed{}\boxed{a}\boxed{}\boxed{} \;\&\; \boxed{}\boxed{a'}\boxed{a'}\boxed{}$$

$$\downarrow bc \qquad\qquad \downarrow bc$$

$$\boxed{}\boxed{a}\boxed{} \qquad\qquad \boxed{}\boxed{a'}\boxed{}$$

Superposition with stutters

$$\alpha_1 \cdots \alpha_n \;\&\; \beta_1 \cdots \beta_n \;:=\; (\alpha_1 \cup \beta_1) \cdots (\alpha_n \cup \beta_n)$$

$$L \& L' \;:=\; \{s \& s' \mid (s, s') \in L \times L' \text{ and } \mathrm{length}(s) = \mathrm{length}(s')\}$$

$\alpha_1 \cdots \alpha_n$ is *stutter-free* if $\alpha_i \neq \alpha_{i+1}$ for $1 \leq i < n$

s is stutter-free iff $s = bc(s)$

$$L^{bc} \;:=\; \{s \mid (\exists s' \in L)\; bc(s) = bc(s')\}$$

$$L \,\&_{bc}\, L' \;:=\; \{bc(s) \mid s \in L^{bc} \& \, L'^{bc}\}$$

$$\boxed{}\boxed{a}\boxed{} \,\&_{bc}\, \boxed{}\boxed{a'}\boxed{} \;=\; \mathrm{Allen}(a, a')$$

$\leq$ with non-deterministic fusion

$$s' \leq s \quad \text{iff} \quad (\exists s_1 \in \mathsf{factor}(s))(\exists s_2 \in s'^{bc})\ s_1 \trianglerighteq s_2$$

$\leq$ is a partial order on stutter-free strings

$$s' \leq s \quad \text{iff} \quad s \in s \ \&_{bc}\ (\square + \epsilon) s' (\square + \epsilon) \quad \text{for stutter-free } s$$

$$\begin{aligned} V(A \wedge A') &:= \bigcup \{ s \ \&_{bc}\ s' \mid (s, s') \in V(A) \times V(A') \} \\ F(A \vee A') &:= \bigcup \{ s \ \&_{bc}\ s' \mid (s, s') \in F(A) \times F(A') \} \end{aligned}$$

$$L' \leq L \quad \text{iff} \quad L \subseteq L \ \&_{bc}\ (\square + \epsilon) L' (\square + \epsilon)$$

Back to negation

What to negate

stative	event	action/force
φ	s	f
letter	string	automaton

Fine *state space* $(S, \leq)$ with $V(A) \subseteq S$

$$\begin{aligned} V(A_{\leq}) &:= \{ s \in S \mid (\exists s' \in V(A))\ s' \leq s \} \\ F(A_{\leq}) &:= S - V(A_{\leq}) \end{aligned}$$

Fine *modalized state space* $(S, S^{\diamond}, \leq)$ with $S^{\diamond} \subseteq S$

$$\boxed{\varphi}\boxed{} \quad \Rightarrow \quad \boxed{}\boxed{\varphi} + \boxed{force(\neg\varphi)}\boxed{}$$

Are there finite automata that accept $S^{\diamond}$, $V(A)$, …?

Finite-state truthmaking (ESSLLI 2015: `tinyurl.com/fsm4sas`)