## Defining sufficiency in truthmaker semantics

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(1) The light is off because switch A is down.

## The big question

When we interpret causal words, such as *because*, we consider alternatives to reality. How do we decide which ones to consider?

## 1) Sufficiency in because

## Sufficiency via the conditional?

- Evidence for strong centering
- Evidence for conditional excluded middle

## Sufficiency in a situation semantics



(2) The robot took Road B because it took First Street.

- (3) Alice is 20 years old. The legal drinking age is 18.
  - a. Alice can order alcohol because she is over sixteen years old.
  - b. Alice can order alcohol because she is over eighteen years old.
- (4) Priya's mother was born in India. Priya has an Indian passport.
  - a. Priya has an Indian passport because her mother is from Asia.
  - b. Priya has an Indian passport because her mother is from India.
- (5) Let x and y be numbers, where  $x \neq 0$  and y = 0.
  - a. *xy* is 0 because *y* is less than 10.
  - b. xy is 0 because y is 0.

If *E* because *C* is true, then *C* was sufficient for *E* with respect to some set of background conditions.

- A first thought: *C* is sufficient for *E* just in case the conditional *if C*, *E* is true.
- Problem: existing semantics for conditionals validate strong centering
- Strong centering: if A is true then *if* A, C is true if and only if C is.

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(6) Alice: "I bet that if you flip the coin, it will land heads."Bob flips the coin and it lands heads.

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Given that Bob flipped the coin, strong centering correctly predicts that Alice's sentence is true iff the coin **actually** landed heads.

Without strong centering, Bob could reply:

(7) Bob: What Alice said is false since the coin could have landed tails. So she doesn't get her money.

Examples featuring *will/would* conditionals in betting contexts have been previously discussed by Prior (1976, p. 100), Moss (2013), Belnap, Perloff, and Xu (2001, p. 160), Cariani and Santorio (2018) and Cariani (2021, p. 63).

# (8) Alice: "If you flip the coin, it will land heads."What is the probability that what Alice said is true?

(8) Alice: "If you flip the coin, it will land heads."

What is the probability that what Alice said is true?

(9) Bob: Since the coin could have landed tails, what Alice said is false. There is a 0% chance that what Alice said is true.

### Strong centering implies conditional excluded middle:

## $\neg(\mathrm{if}\, p,q) \quad \Leftrightarrow \quad \mathrm{if}\, p, \neg q$

## (10) You will succeed only if you work hard.

## Only if

(10) You will succeed only if you work hard.

Intuitively (5) implies: if you don't work hard you won't succeed.

- only(alt)(p) is true iff  $\forall q \in alt$ , if p does not entail q then  $\neg q$ .
- Conditional alternatives: {*if* p, q, *if*  $\neg p$ , q}.
- *if p, q* does not entail *if*  $\neg p$ , *q*.

 $\Rightarrow$  (10) is true iff  $\neg$ (you will succeed if you don't work hard).

• Strong centering implies conditional excluded middle:

$$\neg(\text{if } p, q) \quad \Leftrightarrow \quad \text{if } p, \neg q$$

giving us the reading of (10) we observe.

• If *will* had a universal meaning, (5) would mean *in some cases where you don't work hard, you succeed*. This is too weak.

- (11) a. Everyone will pass if they work hard.
  - b. No one will fail if they work hard.

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Example from Higginbotham 1986
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(11a) and (11b) are intuitively equivalent.

(12) a.  $\forall x (\text{if } x \text{ works hard, } x \text{ will pass})$ b.  $\neg \exists x (\text{if } x \text{ works hard, } x \text{ will fail})$ 

Assuming *fail*  $\Leftrightarrow$  *not pass*, these are equivalent to:

(13) a.  $\forall x (\text{if } x \text{ works hard, } \neg(x \text{ will pass}))$ b.  $\forall x \neg(\text{if } x \text{ works hard, } x \text{ will fail})$ 

## Conditional excluded middle implies the equivalence of (11a) and (11b).

This puzzle has previously been discussed by von Fintel 1998, Dekker 2001, von Fintel and

Iatridou 2002, Higginbotham 2003, Abbott 2004, Leslie 2008, Huitink 2010, Klinedinst 2011 and

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- (14) Alice is 20 years old. The legal drinking age is 18.
  - a. Alice can order alcohol because she is over sixteen years old.
  - b. Alice can order alcohol because she is over eighteen years old.

As Alice is 20 years old, she is already over sixteen years old.

Strong centering predicts (15) to be true.

(15) If Alice is over sixteen years old, she can order alcohol.

## Sufficiency in because

## Sufficiency via the conditional?

- Evidence for strong centering
- Evidence for conditional excluded middle

## 3 Sufficiency in a situation semantics

#### If x and y are two individuals, then their mereological difference,

x - y

## is the largest individual contained in x which has no part in common with y.

Simons (1987, p. 14), based on a definition by Leśniewski (1927–1931) (for a translation see Sinisi (1983, 29, Definition VII))

Primitive notions (Fine 2017):

- A state space (S, ⊑): a partially ordered set with ⊑ representing parthood, where each state s ∈ S is part of a world (a world is a state that is maximal w.r.t. parthood).
- ② A notion of exact verification, denoted  $\Vdash^e$ , between states and sentences.

Central idea: *s* exactly verifies *A* (denoted  $s \Vdash^e A$ ) just in case *s* is wholly relevant to the truth of *A*.



Figure

#### Definition

For any state *s* and sentence *A*, let s - A be the fusion (least upper bound) of the parts of *s* disjoint from every exact verifier and falsifier of *A*:

$$s - A := s - \bigsqcup \{ v : v \Vdash^e A \text{ or } v \Vdash^e \neg A \}$$

Define that *t* is an *A*-variant of *s* just in case if s - A exists, then  $s - A \subseteq t$ .

(16) **Proposal.** For any sentences *A* and *C*, *A* is *sufficient for C* in a world *w* just in case for every *A*-variant of *w* where *A* is true, *C* is also true.

## Defining remainders







A technician is testing whether a printer is calibrated correctly. They want it to print a circle that is a particular shade of blue – baby blue – on a blue piece of paper. In prints this:



Consider:

(17) The machine passed the test because the circle is blue.

- (18) Alice is 20 years old. The legal drinking age is 18.
  - a. Alice can order alcohol because she is over sixteen years old.
  - b. Alice can order alcohol because she is over eighteen years old.
- (19) Priya's mother was born in India. Priya has an Indian passport.
  - a. Priya has an Indian passport because her mother is from Asia.
  - b. Priya has an Indian passport because her mother is from India.
- (20) Let x and y be numbers, where  $x \neq 0$  and y = 0.
  - a. *xy* is 0 because *y* is less than 10.
  - b. *xy* is 0 because *y* is 0.

- Sufficiency cannot be defined using conditionals, since they validate strong centering.
- Sufficiency can be defined using the notion of *A*-variants, given in terms of truthmaker semantics.

## **References I**

Abbott, Barbara (2004). Some remarks on indicative conditionals. Semantics and Linguistic Theory. Vol. 14, pp. 1–19. DOI: 10.3765/salt.v14i0.2914.

- Belnap, Nuel, Michael Perloff, and Ming Xu (2001). Facing the future: agents and choices in our indeterminist world. Oxford University Press.
- Cariani, Fabrizio (2021). The Modal Future: A Theory of Future-Directed Thought and Talk. Cambridge University Press.
- Cariani, Fabrizio and Paolo Santorio (2018). Will done better: Selection semantics, future credence, and indeterminacy. *Mind* 127.505, pp. 129–165. DOI: 10.1093/mind/fzw004.
- Dekker, Paul (2001). On 'if' and 'only'. Semantics and Linguistic Theory. Vol. 11, pp. 114–133. DOI: 10.3765/salt.v11i0.3097.

## References II

- Fine, Kit (2017). Truthmaker Semantics. A Companion to the *Philosophy of Language*. Wiley-Blackwell. Chap. 22, pp. 556–577. DOI: 10.1002/9781118972090.ch22.
- von Fintel, Kai (1998). Quantifiers and 'If'-Clauses. *The Philosophical Quarterly* 48.191, pp. 209–214. DOI: 10.1111/1467-9213.00095.
- von Fintel, Kai and Sabine Iatridou (2002). If and When *If*-Clauses Can Restrict Quantifiers. *Workshop in Philosophy and Linguistics at the University of Michigan*, pp. 1–14. URL: http:
  - //web.mit.edu/fintel/fintel-iatridou-2002-ifwhen.pdf.
- Higginbotham, James (1986). Linguistic theory and Davidson's program in semantics. *Truth and interpretation: Perspectives on the philosophy of Donald Davidson*. Ed. by E. Lepore. Blackwell Oxford, pp. 29–48.

## **References III**

- Higginbotham, James (2003). Conditionals and compositionality. *Philosophical perspectives* 17, pp. 181–194. DOI: 10.1111/j.1520-8583.2003.00008.x.
- Huitink, Janneke (2010). Quantified conditionals and compositionality. *Language and Linguistics Compass* 4.1, pp. 42–53. DOI: 10.1111/j.1749-818X.2009.00175.x.
- Klinedinst, Nathan (2011). Quantified conditionals and conditional excluded middle. *Journal of Semantics* 28.1, pp. 149–170. DOI: 10.1093/jos/ffq015.
- Kratzer, Angelika (2021). Chasing hook: Quantified indicative conditionals. Conditionals, Probability, and Paradox: Themes from the Philosophy of Dorothy Edgington. Ed. by Lee Walters and John Hawthorne. Oxford University Press. DOI: 10.1093/0s0/9780198712732.003.0004.

## **References IV**

- Leslie, Sarah-Jane (2008). 'If', 'unless', and quantification. Compositionality, context and semantic values: essays in honour of Ernie Lepore. Ed. by Robert J Stainton and Christopher Viger. Springer, pp. 3–30.
- Leśniewski, Stanisław (1927–1931). O podstawach matematyki [On the Foundations of Mathematics], I–V. *Przeglad Filozoficzny*. Volume 30 (1927), 164–206; 31 (1928), 261–291; 32 (1929), 60–101; 33 (1930), 77–105; 34 (1931), 142–170. Abridged English translation by Vito Sinisi 1983.
- Moss, Sarah (2013). Subjunctive credences and semantic humility. *Philosophy and Phenomenological Research* 87.2, pp. 251–278.
- Prior, Arthur Norman (1976). It was to be. Papers in semantics and ethics. Ed. by Peter Geach Anthony . Duckworth, pp. 97–108.
- Simons, Peter (1987). *Parts: A study in ontology*. Oxford University Press.

## Sinisi, Vito (1983). Leśniewski's foundations of mathematics. *Topoi* 3.1, pp. 3–52. DOI: 10.1007/BF00139700.