Conditionals as representative inferences

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Meaning of conditional sentences

Truth functional: Material Implication

1. Many problems: Irrelevance, Monotonicity, Contraposition, · · ·
2. Solutions: Relevance logic, Conditional Logics, Probability, · · ·
Meaning of conditional sentences

Truth functional: Material Implication

1 Many problems: Irrelevance, Monotonicity, Contraposition, · · ·
2 Solutions: Relevance logic, Conditional Logics, Probability, · · ·

Adams: ‘If A, then C’ is acceptable iff $P(C|A)$ is high

Widely accepted in Cognitive Science
Problems Adam’s thesis: Relevance matters

- High $P(C|A)$ is not sufficient: Dependency $A$ and $C$
- If it is sunny today, $0 \neq 1$
- If it is sunny today, Real Madrid won the Champions League in 2017.

High $P(C|A)$ is not necessary. More than probability

- If you eat these mushrooms, it will kill you Warning
- If you won’t give me your wallet, I’ll kill you! Threat

Issue with conditional threats: credibility

Most probably you won’t kill me if I don’t give you my money. but still ···
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Relevance Logic no way out

- Relevance logics add notion of **aboutness** variable sharing

- And solve
  1. Paradoxes of Mat. Implication \((C \models A \rightarrow C \text{ and } \neg A \models A \rightarrow C)\)
  2. Paradoxes of Strict Implication \((\Box C \models A \Rightarrow C \text{ and } \Box \neg A \models A \Rightarrow C)\)

- But: it is not aboutness, but support that counts
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- What is needed seems **causality**?

- The antecedent helps to cause the consequent
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- But ‘If John smokes, he is nervous’.
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- What is needed seems **causality**?

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- But ‘If John smokes, he is nervous’.

- Evidential, not causal (consequent is **associated** with antecedent)
Association as Distinctiveness

- Pavlov (1920ties): conditioning i.t.o. co-occurrence
Association as Distinctiveness

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- Rescorla (1968): Rats learn a Tone → Shock association so long as the frequency of shocks following the tone is higher than the frequency of shocks experienced otherwise. **Contingency** \( \Delta P_{sh}^{tone} \)

\[ \Delta P_{sh} = P(sh/t) - P(sh/\neg t) \]  

- Gluck & Bower (1988): humans behave similarly. **Contingency** \( \Delta P_C^A \)

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- Is asymptotic result of learning via delta-rule (connectionism)

- Schanks, Cheng (1990ties)

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**Causal learning**
Association as Distinctiveness

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Causal learning

- Gluck & Bower (1988): humans behave similarly

- Contingency: $\Delta P_{A}^{C} = P(C/A) - P(C/\neg A)$ distinctiveness

- Is asymptotic result of learning via delta-rule (connectionism) Schanks, Cheng 1990ties
Prepare for future


- Why? In changing world crucial to track dependencies

- Conditionals express such dependencies
Distinctiveness as Representativeness

- \( \Delta P_A^C = P(C/A) - P(C/\neg A) \)

- is monotone increasing with (and thus has maximal elements in common)

- \( P(C/A) - P(C) \)

- \( \frac{P(C/A)}{P(C/\neg A)} \), and

- \( \frac{P(C/A)}{P(C)} \)
Contingency and Representativeness

- $\Delta P_A^C = P(C/A) - P(C/\neg A)$

- is monotone increasing with
  (and thus has maximal elements in common)

- $P(C/A) - P(C)$ proposed as measure of relevance/support

- $\frac{P(C/A)}{P(C/\neg A)}$, proposed as measure of stereotypicality

- $\frac{P(C/A)}{P(C)}$, proposed as measure of stereotypicality
Representativeness and Causality (Pearl, 2000)

- Lewis: $A$ causes $C$: $A > C$ and $\neg A > \neg C$

- Pearl: Interpret ‘$>$’ in Causal Models i.t.o. intervention

- Probability that $A$ causes $C$ $\equiv P(A > C \land \neg A > \neg C)$
  $\equiv P(C_A \land \neg C_{\neg A})$

- Assume Monotonicity: $\equiv P(C_A) - P(C_{\neg A})$

- Assume Exogeneity: $\equiv P(C|A) - P(C|\neg A)$ $\equiv$ Contingency (no common cause)
Proposal 1

- If $A$, then $C'$ is appropriate only if $P(C|A) - P(C|\neg A) = \Delta P^C_A \gg 0$
Proposal 1

- If $A$, then $C'$ is appropriate only if $P(C|A) - P(C|\neg A) = \Delta P_A^C \gg 0$

- This explains

  1. * If it is sunny today, $0 \neq 1$
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- Other good consequences
  
  1. Proposal 1 $\implies$ If $\leadsto$ iff Conditional Perfection
     
     **Affirming consequent:** $A \rightarrow C, C \leadsto A$
     **Denying antecedent:** $A \rightarrow C, \neg A \leadsto \neg C$


But this is controversial

What about other cases?

1. (Ir)Relevance conditionals: If you are hungry, there is food in the fridge

2. Utility conditionals: If you won't give me your wallet, I'll kill you
Proposal 1

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  1. * If it is sunny today, $0 \neq 1$
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- Other good consequences
  1. Proposal 1  \(\Rightarrow\) If \(\sim\) iff Conditional Perfection
     - Affirming consequent: $A \rightarrow C$, $C \sim A$
     - Denying antecedent: $A \rightarrow C$, $\neg A \sim \neg C$
  2. Excluded Middle effect: $\neg (\text{If } A \text{ then } C) \approx \text{if } A, \text{ then } \neg C$
Proposal 1

- If $A$, then $C'$ is appropriate only if $P(C|A) - P(C|\neg A) = \Delta P^C_A \gg 0$

- This explains
  1. * If it is sunny today, $0 \neq 1$
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- Other good consequences
  1. Proposal 1 $\Rightarrow$ If $\rightsquigarrow$ iff Conditional Perfection
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     Denying antecedent: $A \rightarrow C$, $\neg A \rightsquigarrow \neg C$
  2. Excluded Middle effect: $\neg (\text{If } A \text{ then } C) \approx \text{if } A, \text{ then } \neg C$
  3. Chater & Oaksford (1999): Wasow selection task $\rightsquigarrow \approx \Delta P^C_A$
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Proposal 1

- If \( A \), then \( C' \) is appropriate only if \( P(C|A) - P(C|\neg A) = \Delta P_A^C \gg 0 \)

- This explains
  1. * If it is sunny today, \( 0 \neq 1 \)
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- Other good consequences
  1. Proposal 1 \( \Rightarrow \) If \( \sim \) iff Conditional Perfection
  2. **Affirming consequent**: \( A \rightarrow C, C \mid \sim A \)
  3. **Denying antecedent**: \( A \rightarrow C, \neg A \mid \sim \neg C \)
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- What about other cases?
  1. (Ir)Relevance conditionals: If you are hungry, there is **food** in the fridge
  2. Utility conditionals: If you won’t give me your wallet, I’ll **kill** you
Experimental tests + Amendment


- Result: \( \Delta P^C_A = P(C|A) - P(C|\neg A) \) isn’t quite right:

\[ \Delta^* P^C_A = \Delta P^C_A - P(C|\neg A) \] (Proposal 1*) Cheng

Effects

1. Mostly similar to \( \Delta P^C_A \)
2. Distinctiveness
3. But \( \Delta^* P^C_A \) increases, if \( P(C|\neg A) \) increases e.g. if \( P(C|\neg A) = 0 \), \( \Delta^* P^C_A = 10 \times \Delta P^C_A \); \( P(C|A) \) counts for more than \( P(C|\neg A) \)

Modus Tollens less acceptable than Modus Ponens.
Experimental tests + Amendment


- Result: \( \Delta P^C_A = P(C|A) - P(C|\neg A) \) isn’t quite right:
  1. \( \Delta P^C_A \) must be > 0 for acceptance
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- Result: \( \Delta P_A^C = P(C|A) - P(C|\neg A) \) isn’t quite right:
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- New measure: $\Delta^* P^C_A = \frac{\Delta P^C_A}{1 - P(C|\neg A)}$ (Proposal 1*) Cheng
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- Effects
  1. Mostly similar to $\Delta^C_A$
  2. But $\Delta^* P^C_A$ increases, if $P(C|\neg A)$ increases
    e.g. if $P(C|\neg A) = 0.9$, $\Delta^* P^C_A = 10 \times \Delta P^C_A$

Distinctiveness
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- Effects
  1. Mostly similar to \( \Delta^C_A \) (Distinctiveness)
  2. But \( \Delta^* P^C_A \) increases, if \( P(C|\neg A) \) increases
     e.g if \( P(C|\neg A) = 0.9 \), \( \Delta^* P^C_A = 10 \times \Delta P^C_A \)
     \( \leadsto P(C|A) \) counts for more than \( P(C|\neg A) \)
  3. Modus Tollens less acceptable than Modus Ponens.
Utility conditionals

Examples

1. I’ll kill you, if you don’t give me your wallet
2. I give you €10, if you mow my lawn.

Problem of conditional threats: credibility

\[ P(\text{kill} | \neg \text{give wallet}) \text{ is not high} \]

\[ \iff \text{Adam’s thesis} \]
Utility conditionals

- **Examples**
  1. I’ll kill you, if you don’t give me your wallet  
     Threat
  2. I give you €10, if you mow my lawn.  
     Promise

- **Problem of conditional threats: credibility**
  \[ P(\text{kill} \mid \neg \text{give wallet}) \text{ is not high} \]
  \[ \Leftrightarrow \text{Adam’s thesis} \]

- But \[ P(\text{kill} \mid \neg \text{give wallet}) - P(\text{kill} \mid \text{give wallet}) > 0, \]
  because \[ P(\text{kill} \mid \text{give wallet}) \approx 0 \]
Utility conditionals

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- **But** \[ P(\text{kill} | \neg \text{give wallet}) - P(\text{kill} | \text{give wallet}) > 0 \]
  
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- **Distinctiveness counts**

  **Contingency**
Utility conditionals

- **Examples**
  1. I’ll kill you, if you don’t give me your wallet
     - Threat
  2. I give you €10, if you mow my lawn.
     - Promise

- **Problem of conditional threats: credibility**
  - $P(kill|\neg \text{give wallet})$ is not high
  - $\Leftrightarrow$ Adam’s thesis

- But $P(kill|\neg \text{give wallet}) - P(kill|\text{give wallet}) > 0$, because $P(kill|\text{give wallet}) \approx 0$

- Distinctiveness counts

- but it is not enough....
From Contingency to Representativeness

Contingency: $\Delta P_{OC} = P(O/C) - P(O/\neg C)$

Fear Conditioning (see also Slovic on emotion and representation)

High Impact Outcomes are better learned and remembered.

How representative is $O$ for $C$:

$\nabla P_{OC} = \Delta \left(\ast\right) P_{OC} \times \text{Impact}(O)$

$= \text{distinctiveness} \times \text{Impact}(f)$
Contingency: $\Delta P_C^O = P(O/C) - P(O/\neg C)$

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From Contingency to Representativeness

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- Fear Conditioning (see also Slovic on emotion and representation)
  High Impact Outcomes are better learned and remembered.

- How representative is \( O \) for \( C \): \( \nabla P^O_C = \Delta^{(\ast)} P^O_C \times \text{Impact}(O) \)
  \( = \text{distinctiveness} \times \text{Impact}(f) \)
Role of impact: proposal 2

Problems

1. \( P(\text{kill} | \neg \text{give wallet}) \succ P(\text{kill} | \text{give wallet}) \)  
   Thus \( \Delta^C_A \succ 0 \)

2. Why threat/promise better (more credible), if more at stake?
Role of impact: proposal 2

- Problems
  1. \( P(\text{kill} | \neg \text{give wallet}) \gg P(\text{kill} | \text{give wallet}) \)
  2. Why threat/promise better (more credible), if more at stake?

- What counts:
  \( P(\text{kill} | \neg \text{give wallet}) \times \text{Impact(kill)} \gg P(\text{kill} | \text{give wallet}) \times \text{Imp(kill)} \)
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P(\text{kill}|\neg \text{give wallet}) \times \text{Impact}(\text{kill}) \gg P(\text{kill}|\text{give wallet}) \times \text{Imp}(\text{kill})
  \]

- \( P(C|A) \times \text{Impact}(C) \gg P(C|\neg A) \times \text{Impact}(C) \) iff
  Distinctiveness of \( A \) versus \( \neg A \) on \( C \times \text{Impact}(C) \gg 0 \)
Role of impact: proposal 2

- Problems
  1. \( P(\text{kill} | \neg \text{give wallet}) \gg P(\text{kill} | \text{give wallet}) \)  
     Thus \( \Delta^C_A \gg 0 \)
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- \[
  P(C | A) \times \text{Impact}(C) \gg P(C | \neg A) \times \text{Impact}(C) \text{ iff }
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- Proposal 2: ‘If \( A \), then \( C \)’ is appropriate iff \( \Delta^{(*)} P_A^C \times \text{Impact}(C) \gg 0 \)
Problems

1. \( P(\text{kill}|\neg \text{give wallet}) \gg P(\text{kill}|\text{give wallet}) \)

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What counts:

\[ P(\text{kill}|\neg \text{give wallet}) \times \text{Impact(kill)} \gg P(\text{kill}|\text{give wallet}) \times \text{Imp(kill)} \]

\[ P(C|A) \times \text{Impact}(C) \gg P(C|\neg A) \times \text{Impact}(C) \text{ iff} \]

Distinctiveness of \( A \) versus \( \neg A \) on \( C \times \text{Impact}(C) \gg 0 \)

Proposal 2: ‘If \( A \), then \( C \)’ is appropriate iff \( \Delta^{(*)} P_{A}^{C} \times \text{Impact}(C) \gg 0 \)

iff \( C \) is representative for \( A \)
Utility and Causality

- Conditionals
  1. Causal: If the patient is infected, then she has a fever
  2. Diagnostic: If the patient has a fever, then she is infected.

- For conditional threats/promises it is crucial that conditional reflects causal structure

Generalization to Relevance/Biscuit Conditionals

Data

1. If you are hungry, there is food in the fridge
2. * If you are hungry, there is beer in the fridge
Generalization to Relevance/Biscuit Conditionals

- **Data**
  1. If you are hungry, there is food in the fridge
  2. *If you are hungry, there is beer in the fridge

- Notice: now $P(C|A) = P(C|\neg A)$, and thus $\Delta P_A^C = 0$

- Thus $\Delta P_A^C \times Impact(C) = 0$
Generalization to Relevance/Biscuit Conditionals

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- Assertion of consequent only relevant /of impact, if antecedent true
Generalization to Relevance/Biscuit Conditionals

- **Data**
  1. If you are hungry, there is **food** in the fridge
  2. * If you are hungry, there is **beer** in the fridge

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- Thus \( \Delta P_A^C \times Impact(C) = 0 \)

- Assertion of consequent only relevant /of impact, if antecedent true

\( \Rightarrow \quad Impact(C|A) - Impact(C|\neg A) \) is high.
Generalization to Relevance/Biscuit Conditionals

Data
1. If you are hungry, there is food in the fridge
2. * If you are hungry, there is beer in the fridge

Notice: now \( P(C|A) = P(C|\neg A) \), and thus \( \Delta P^C_A = 0 \)

Thus \( \Delta P^C_A \times \text{Impact}(C) = 0 \)

Assertion of consequent only relevant /of impact, if antecedent true

\( \Rightarrow \quad \text{Impact}(C|A) - \text{Impact}(C|\neg A) \) is high.

Proposal 3: 'If \( A \), then \( C \)' appropriate
iff \( P(C|A) \times \text{Imp}(C|A) \gg P(C|\neg A) \times \text{Imp}(C|\neg A) \)
Special cases

- **Proposal 3:** 'If $A$, then $C$’ appropriate

  iff $P(C|A) \times \text{Imp}(C|A) \gg P(C|\neg A) \times \text{Imp}(C|\neg A)$
Special cases

- **Proposal 3:** 'If $A$, then $C$' appropriate
  
  iff $P(C|A) \times \text{Imp}(C|A) \gg P(C|\neg A) \times \text{Imp}(C|\neg A)$

- if $\text{Imp}(C|A) = \text{Imp}(C|\neg A) = \text{Imp}(C)$, $\sim \Delta P_A^C \times \text{Imp}(C) \gg 0$
  
  (Proposal 2)
Special cases

- **Proposal 3**: 'If $A$, then $C$' appropriate
  \[ \text{iff } P(C|A) \times \text{Imp}(C|A) \gg P(C|\neg A) \times \text{Imp}(C|\neg A) \]

- if $\text{Imp}(C|A) = \text{Imp}(C|\neg A) = \text{Imp}(C)$, $\sim \Delta P_{A}^{C} \times \text{Imp}(C) \gg 0$ (Proposal 2)

- If also $\text{Impact}(C) = 1$, $\sim P(C|A) - P(C|\neg A) = \Delta_{A}^{C} \gg 0$ (Proposal 1)
How general?

- Swanson (2013). Biscuit conditionals can also be subjunctive.

- I want to vacation in a posh hotel in London. We would have tea every afternoon, and there would be biscuits on the sideboard, if you’re into that sort of thing.

- Iatridou (1991). Biscuit conditionals special in three ways:
  1. obligatory absence of conditional ‘then’; (but see J. Zakkou)
  2. consequent cannot c-comment antecedent;
  3. inability antecedents to serve as first constituents in V2 languages

- Swanson: all this holds also for subjunctive biscuits.
Conditionals and Generics

- Conditionals (with when-clauses)
  - About specific events (episodic)
    - Mary left, when George came back.
    - When I entered the room, Anna was knitting
Conditionals and Generics

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2. Generic conditionals
   - John smokes, if/when he is nervous
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- **Generic conditionals**
  1. Counterfactual: If he were nervous, John would have smoked
  2. Non-causal: If John smoked, he was nervous.
  3. Future-oriented: John will smoke, if he will be nervous
Semantics for Generics

- Analyze generic conditionals like \( \cdots \) generics
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- Conditional analysis: Birds fly \( \sim \) if it is a Bird, then it flies

\[ P(F/B) \] high or if \( x \) normal bird, then \( x \) flies

But: for generic \( G \)'s are \( f \) to be true, this is not sufficient: *Germans are right-handed* not necessary: Birds lay eggs, Sharks attack, Mary murders children

It is about distinctiveness \( \Delta_f G \) and impact 'G's are \( f \)' true iff \( \approx \Delta^*(P_f G \times \text{Impact}(f)) \) high if \( f \) is a representative feature for \( G \)

March 7, 2018 20 / 21
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- ‘Gs are \( f \)’ true \( \iff \approx \Delta(\ast) P^f_G \times \text{Impact}(f) \) high
  \( \iff \) \( f \) is a representative feature for \( G \)
Conclusion

- Same analysis in terms of **representativeness** for
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