Elements of a Plan-Based Theory of Speech Acts
Cohen & Perrault (1979)

presented by
Martin Schwietzke

Department Linguistik

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Introduction

Plan construction tools

- Formal description of beliefs and goals
- Models of plans
- Form of operators

Speech acts as operator definitions

- Linking to SAs
- Requesting
- Informing

Compositional adequacy

- Planning wh-questions
- Planning yes/no-questions
- Multiparty speech acts (MAS)

References/Discussion/Appendix
"AI researchers formalize SAT on the notions of plans, goals, intentions and beliefs, hoping to derive some of the basic features of speech acts from these primitive notions." (J.S.)
Motivation

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- New areas for application (“computer conversants”, sophisticated dialog systems, dialog analyzer etc.)
Motivation

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- New areas for application ("computer conversants", sophisticated dialog systems, dialog analyzer etc.)
- Show how a plan-based theory provides the basis for adequacy criteria by pointing out how changes in speech act definitions affect the generated plans
- Show which of Searle’s conditions are better regarded as more general aspects of intentional behavior than as particular speech acts
- Provide a more systematic basis for studying real dialogues (tracking of conversants’ beliefs and intentions)
Preliminary remarks on the/a theory of speech acts (SAT)

- SAT must be able to deal with assertions, requests, questions, lies etc.

- SAT concentrates on a person’s beliefs about the world (not what is actually true in the real world)

- “speech acts” usually refers to the illocutionary type of speech acts

- Plan-based SAT: speech acts are operators who have effects on the models that speakers and hearers maintain of each other

Belief

- Belief interpreted as modal operator $A \text{ BELIEVE}(P)$
  - $A =$ believing agent
  - $P =$ believed proposition
  (for axiom schemata see paper p.182)

- Nesting-levels:
  - 2 levels for *disagreement*: $A_{GT1} \text{ BELIEVE}$ and $A_{GT1} \text{ BELIEVE} A_{GT2} \text{ BELIEVE}$
  - 3 levels for $A_{GT1}$ *successfully lied* to $A_{GT2}$: $A_{GT1} \text{ BELIEVE} A_{GT2} \text{ BELIEVE} A_{GT1} \text{ BELIEVE}(\neg P)$

- Even 4 levels if $A_{GT2}$ believes $A_{GT1}$ has lied
- Theoretical no bounds for embedding (mutual belief)
Want(s) = goal(s)

- Requirements:
  - Distinguish information: AGT2’s beliefs vs. AGT1’s beliefs and goals vs. AGT2’s model of someone else’s beliefs and goals
  - Allow different scopes of quantifiers (distinguish “AGT2 wants to take a train” as “There is a specific train that AGT2 wants to take” vs. “AGT2 wants to take any train”)
  - Allow arbitrary embeddings with BELIEVE

- Wants of beliefs: AGT1 WANTS AGT2 BELIEVE P (reason for AGT1’s telling P to AGT2)

- Beliefs of wants: AGT1 BELIEVES AGT1 WANTS P (represent AGT1’s goals P)
Components

- **Operators**: represent real world actions and are organized into plans
- **(quantified) Propositions**: model of a/the world; believed by planner
- **Preconditions**: conditions that make operator *applicable*
- **Effects**: changes in world model made by the operator(s)
- **Bodies**: describe the means by which the effects are achieved; can contain other operators
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**Execution of plans**

Operators are associated to actions and transform planner’s model of the world (i.e. propositions the planner believes) corresponding to the changes in real world. A new world model is obtained by the execution of each operator.
Plan construction inferences

1. S should not introduce in the plan actions whose effects S believes are (or will be) true at the time the action is initiated.
2. If E is a goal, an operator A that achieves E can be inserted into the plan.
3. If an operator is not applicable in the planner’s belief model, all the preconditions of that operator that are not already true can be added to the plan.
4. If the planner needs to know the truth-value of some proposition, and does not, the planner can create a goal that it know whether that proposition is true or false.
5. If the planner needs to know the value of some description before planning can continue, the planner can create a goal that it find out what the value is.
6. Everyone expects everyone else to act this way.

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Planning

“The Process of planning to achieve a goal is essentially a search through this space of inferences to find a temporal sequence of operators such that the first operator in the sequence is applicable in the planner's current world model and the last produces a world model in which the goal is true.”

Cohen & Perrault (1979)
Two kinds of preconditions

- **CANDO.PR**: ensures applicability of operator
- **WANT.PR**: formalizes intentional behaviour (agent has to want to do an action)

**MOVE(AGT, SOURCE, DESTINATION)**

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\text{MOVE}(\text{AGT, SOURCE, DESTINATION})
\]

- **CANDO.PR**: \(\text{LOC}(\text{AGT, SOURCE})\)
- **WANT.PR**: \(\text{AGT BELIEVE AGT WANT move-instance}\)
- **EFFECT**: \(\text{LOC}(\text{AGT, DESTINATION})\)

*move-instance* filled by any instance of MOVE currently being planned, executed or recognized
Schematic of S’s plan to achieve G

S BELIEVE S WANT:

G
Schematic of S’s plan to achieve G

S BELIEVE S WANT:

G

↑
effect

Q do A1

Schematic of S’s plan to achieve G

S believes S wants:

\[
\text{G} \xrightarrow{\text{effect}} \text{Q do A1}
\]

S applies inference type 2: If G is a goal, an operator A1 that achieves G can be inserted into the plan.

Cohen & Perrault (1979)  
Elements of a Plan-Based Theory of Speech Acts
Schematic of S’s plan to achieve G

S BELIEVE S WANT:

G

\[ \text{effect} \]

\[ \text{Q: do A1} \]

S applies inference type 2: If G is a goal an operator A1 that achieves G can be inserted into the plan

agent Q produces effect

---

Schematic of S’s plan to achieve G
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operator A1 is applicable if preconditions Ci and Cj hold and agent Q wants to perform A1

Schematic of S’s plan to achieve G

Inference type 3: If an operator is not applicable in the planner’s belief model, all preconditions of that operator that are not already true can be added to the plan allows Ci to be achieved by other actions/agents.
Schematic of S’s plan to achieve G

S BELIEVE Q BELIEVE Q WANT Q do A1

truth or falsity of preconditions is evaluated with respect to S's beliefs

Linking Searle’s conditions to plan tools

**point-of-view principle (POVP):**
- preconditions → “speaker believe”
- effects → “hearer believe”

- **preparatory condition:** “is able to do A” → CANDO(Q,ACT) = true, if CANDO.PR of ACT are true

- **essential condition:** “get H to do A” → EFFECT of REQUEST

- for **sincerity condition, propositional content,**
  “non-obviousness” condition see plan of REQUEST
REQUEST (1st version)

- formalizes illocutionary act

\[
\text{REQUEST}(S, H, \text{ACT})
\]

\[
\text{CANDO.PR: } S \text{ BELIEVE } H \text{ CANDO ACT}
\]

\[
\text{AND}
\]

\[
S \text{ BELIEVE}
\]

\[
H \text{ BELIEVE } H \text{ CANDO ACT}
\]

\[
\text{WANT.PR: } S \text{ BELIEVE } S \text{ WANT request-instance}
\]

\[
\text{EFFECT: } H \text{ BELIEVE}
\]

\[
S \text{ BELIEVE } S \text{ WANT ACT}
\]
Intermediate act CAUSE-TO-WANT

- formalizes perlocutionary effect
- “get person to know that you want him/her to do it”

CAUSE-TO-WANT(AGT, AGT1, ACT)
CANDO.PR: AGT BELIEVE
   AGT1 BELIEVE AGT1 WANT ACT
EFFECT: AGT BELIEVE AGT WANT ACT
REQUEST plan

REQUEST plan

"non-obviousness" condition if system already believed goal is true no REQUEST would happen.

REQUEST plan

"sincerity" condition
Speaker’s wanting hearer to move is the reason for planning REQUEST.
“propositional content” (= future act to be performed by hearer) determined by a combination of these prior planning steps.
INFORM (1st version)

- “Speaker states a proposition to a hearer to get him to believe that the speaker believes that proposition to be true.”
- planned on basis of wanting hearer to believe that proposition

INFORM(S,H,PROP)

CANDO.PR: S BELIEVE PROP

WANT.PR: S BELIEVE S WANT inform-instance

EFFECT: H BELIEVE
S BELIEVE PROP

Intermediate act CONVINCE

- “for AGT1 to convince AGT of truth of PROP AGT need only believe that AGT1 thinks PROP is true”
- Problem: one can be convinced of one’s own lie

CONVINCE(AGT1,AGT,PROP)

CANDO.PR: AGT BELIEVE
AGT1 BELIEVE PROP

EFFECT: AGT BELIEVE PROP
The diagram represents a plan for information sharing, based on the work of Cohen & Perrault (1979). The structure involves a series of belief and want states, with actions such as informing and convincing, leading to the desired belief in the proposition.
Wh- and yes/no-questions

- Questioner REQUESTs hearer to INFORM
- REQUEST satisfies INFORM’s WANT.PR
- only “what”, “when” and “where” generable (not “which”, “why”, “how”)

Wh-question: find out value of some expression planned on basis of believing that hearer knows that value

Yes/no-question: find out whether some proposition is true planned on basis believing that hearer knows whether proposition is true; speaker does not know what hearer believes
Quantified propositions and quantified beliefs

Belief of a quantified proposition:

AGT believes the train354 has a departure time.

AGT BELIEVE
\[ \exists x \ (\text{the } y : \text{DEPARTURE-TIME}(	ext{TRAIN354}, y)) = x) \]

Quantified belief:

AGT knows what the departure time for the train354 is.

\[ \exists x \ \text{AGT BELIEVE} \ (\text{the } y : \text{DEPARTURE-TIME}(	ext{TRAIN354}, y)) = x) \]

“the \ y :P(y)” \rightarrow “the \ y \ which \ is \ P” \rightarrow “there \ is \ something \ which \ AGT \ believes \ to \ be \ the \ departure \ time \ for \ the \ train354”
New operator INFORMREF

- generates “what”-, “when”- and “where”-questions
- $\lambda x D x$ means “D is a predicate of one argument”

<table>
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<td><strong>CANDO.PR:</strong> $\exists y \ S \ \text{BELIEVE} \ (i x D x) = y$</td>
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<td><strong>WANT.PR:</strong> $S \ \text{BELIEVE} \ S \ \text{WANT} \ \text{informref-instance}$</td>
</tr>
<tr>
<td><strong>EFFECT:</strong> $\exists y \ H \ \text{BELIEVE} \ S \ \text{BELIEVE} \ (i x D x) = y$</td>
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“There must be some individual that the speaker believes is the value, and speaker must want to say what it is.”
$\rightarrow$ “then there is some individual that the hearer thinks the speaker believes to be the value”

Mediating act CONVINCEREF

- modeling “hearer now believes that individual to be the value of the description”

\[
\text{CONVINCEREF}(\text{AGT1, AGT, } \lambda x D_x)
\]

CANDO.PR: \( \exists y \ \text{AGT BELIEVE AGT1 BELIEVE} (\text{iD}_x) = y \)

EFFECT: \( \exists y \ \text{AGT BELIEVE} (\text{iD}_x) = y \)

Wh-question plan

S BELIEVE S WANT:

3 x S BELIEVE (iLOC(MARY, y) = x)

CONVINCEREF (JOE, S, λy LOC(MARY, y))

cando.pr

3 x S BELIEVE JOE BELIEVE (iLOC(MARY, y) = x)

INFORMREF (JOE, S, λy LOC(MARY, y))

want.pr

JOE BELIEVE

JOE WANT INFORMREF (JOE, S, λy LOC(MARY, y))

effect

CAUSE-TO-WANT (S, JOE, INFORMREF (JOE, S, λy LOC(MARY, y)))

cando.pr

JOE BELIEVE

S BELIEVE

S WANT INFORMREF (JOE, S, λy LOC(MARY, y))

effect

REQUEST (S, JOE, INFORMREF (JOE, S, λy LOC(MARY, y)))

cando.pr

JOE BELIEVE

3 x JOE BELIEVE

(iLOC(MARY, y) = x)

S BELIEVE

3 x JOE BELIEVE

(iLOC(MARY, y) = x)
INFORMIF and CONVINCEIF

- plan y/n-question about some Proposition P requires that hearer knows whether P is true or false

**INFORMIF(S, H, P)**
- CANDO.PR: OR(S BELIEVE P, S BELIEVE ¬P)
- WANT.PR: S BELIEVE S WANT informif-instance
- EFFECT: OR(H BELIEVE S BELIEVE P, H BELIEVE S BELIEVE ¬P)

**CONVINCEIF(AGT, AGT1, P)**
- CANDO.PR: OR(AGT BELIEVE AGT1 BELIEVE P, AGT BELIEVE AGT1 BELIEVE ¬P)
- EFFECT: OR(AGT BELIEVE P, AGT BELIEVE ¬P)
MAS lead to reformulation

MAS add intermediaries: “Ask Tom to tell you where the key is.”
- Certain preconditions lead to other unnecessary preconditions in third party REQUESTs

- Solution: reformulate REQUEST’s preconditions making them independent of speaker’s belief (depend only on planner’s beliefs) → “neutral”

- neutral precond. eliminate prior knowledge requirements

- “speaker based” vs. “neutral” leads to reformulation of REQUEST and INFORM

Side Effects

- On identifying a certain speech act a hearer learns that a speaker believed various preconditions

- *Side Effect* = hearer’s acquisition of beliefs

- Side effects cannot be specified in advance

- Minimal s.e.: H BELIEVE S BELIEVE H CANDO ACT
REQUEST with side effects

![Diagram](image_url)
The "Cando" preconditions and effects of speech acts should be defined in a way that does not depend on who the speaker of that speech act is. That is, no CANDO.PR or EFFECT should be stated as a proposition beginning with "SPEAKER BELIEVE". (PROP or HEARER BELIEVE instead)

- Makes EFFECTs independent of the use of intermediaries
- New POVP cannot be used for INFORMREF and INFORMIF (∃ and OR highest elements)
New POVP applied:

REQUEST(S, H, ACT)
CANDO.PR: H CANDO ACT
WANT.PR: S BELIEVE S WANT request-instance
EFFECT: H BELIEVE S BELIEVE S WANT ACT

CANDO.PR stated as PROP instead of S BELIEVE PROP:

INFORM(S, H, PROP)
CANDO.PR: PROP
WANT.PR: S BELIEVE S WANT inform-instance
EFFECT: H BELIEVE S BELIEVE PROP


 URLs

“Searle does not supply justifications for the adequacy of his definitions”

But does a plan-based theory really provide these adequacy criteria in terms of philosophy of language (like Searle treated SATs)? Justify issues of philosophy of language with AI-plans?

Some operators not fully developed (e.g. CONVINCE)
Conditions for successful performance

**Normal Input/Output Conditions.** These include such conditions as: H is not deaf and S is not mute, joking, or acting.

**Propositional Content Conditions.** Literal speech acts only use propositions of certain forms. The restrictions on these forms are stated in the *propo- positional content conditions*. For a request, the proposition must predicate a future act of H.

**Preparatory Condition.** A preparatory condition states what must be true in the world for a speaker to felicitously issue the speech act. For a request, the preparatory conditions include:

- H is able to do A.
- S believes H is able to do A.
- It is not obvious to S and H that H will do A in the normal course of events (the "non-obviousness" condition).

Searle claims the non-obviousness condition is not peculiar to illocutionary acts. This paper will support his claim by showing how the condition can be applied more generally to rational, intentional behavior.

**Sincerity Condition.** A *sincerity condition* distinguishes a sincere performance of the speech act from an insincere one. In the case of a request, S must want H to do A; for a promise, S must intend to do the promised action; for an assertion, S must believe what he is asserting.

**Essential Condition.** An *essential condition* specifies what S was trying to do. For a request, the act is an attempt to get H to do A.
Plan third party request

Plan 3rd party request (neutral preconditions)

\[ S \text{ BELIEVE} S \text{ WANT:} \]

(P1) \( P \) \( \text{cando.pr} \) \( \text{ACT}(T) \)
\( \text{want.pr} \)
\( T \text{ BELIEVE} T \text{ WANT}(\text{ACT}(T)) \)
\( \text{effect} \)
\( \text{CAUSE-TO-WANT}(I, T, \text{ACT}(T)) \)
\( \text{cando.pr} \)

(P2) \( T \text{ BELIEVE} (P) \)

(P3) \( T \text{ CANDO} \text{ACT}(T) \)
\( \text{P} \)
\( \text{cando.pr} \)

(P4) \( J \text{ BELIEVE} J \text{ CANDO REQUEST}(I, T, \text{ACT}(T)) \)
\( \text{J BELIEVE} \)
\( J \text{ WANT REQUEST}(I, T, \text{ACT}(T)) \)
\( \text{effect} \)
\( \text{CAUSE-TO-WANT}(I, J, \text{REQUEST}(I, T, \text{ACT}(T))) \)
\( \text{cando.pr} \)

(P5) \( J \text{ CANDO REQUEST}(I, T, \text{ACT}(T)) \)
\( \text{P} \)
\( \text{cando.pr} \)

References/Discussion/Appendix

REQUEST with neutral preconditions + side effects