Conceptual Dependency Theory (CD), Schank 1975

- focuses on concepts instead of syntax.
- focuses on understanding instead of structure.
- assumes inference is fundamental to understanding.
- introduced idea of a **canonical meaning representation.**
    - different words and structures represent the same concept.
    - language-independent meaning representation.

Canonical Meaning Representations

John gave Mary a book.

John gave a book to Mary.

Mary was given a book by John.

Mary took a book from John.

Mary received a book from John.

Tenets of Conceptual Dependency Theory (ICU, Schank & Riesbeck)

- The representation of events is separate from the words used to encode them.
- The task of the understander is to represent the events underlying sentences, rather than the sentences themselves.
- Event representations are governed by a set of rules that involve fitting inputs into a predefined representation scheme.
- The rules for filling the slots of the representation are the basis of language understanding.

Conceptual Primitives

- basic meaning elements that underlie the words that we use.
- can be combined to represent complex meanings.
- an interlingual representation.

Goal: to represent meaning so that general rules can be applied, without duplicating information.

Theory: a small number of primitive actions can represent any sentence.

Conceptual Primitives for Actions

Eleven primitives can account for most actions in the physical world:

ATRANS
ATTEND
INGEST
EXPEL
GRASP
MBUILD
MTRANS
MOVE
PROPEL
PTRANS
SPEAK

Five Primitives for Physical Actions

INGEST: to take something inside an animate object.

EXPEL: to take something from inside an animate object and force it out.

GRASP: to physically grasp an object

MOVE: to move a body part

PROPEL: to apply a force to

Other Primitive Actions

State Changes (physical and abstract transfers)

PTRANS: to change the location of a physical object.

ATRANS: to change an abstract relationship of a physical object.

Mental Acts

MTRANS: to transfer information mentally.

MBUILD: to create or combine thoughts.

Instruments for other ACTs

SPEAK: to produce a sound.

ATTEND: to direct a sense organ or focus an organ towards a stimulus.

Conceptual Categories

PP (picture producer) : physical object.
Actors must be an animate PP, or a natural force.

ACT : One of eleven primitive actions.

LOC : Location.

T : Time.

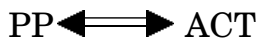
AA (action aider) : modifications of features of an ACT.
e.g., speed factor in PROPEL.

PA : attributes of an object, of the form STATE(VALUE).
e.g., COLOR(red).

Conceptual Roles

- **Conceptualization:** The basic unit of the conceptual level of understanding.
- **Actor:** The performer of an ACT.
- **ACT:** An action done to an object.
- **Object:** A thing that is acted upon.
- **Recipient:** The reciever of an object as the result of an ACT.
- **Direction:** The location that an ACT is directed toward.
- **State:**The state that an object is in.

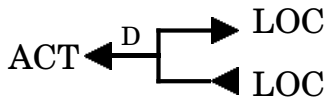
Conceptual Syntax Rules



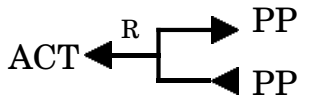
PPs can perform actions.

PPs can be described by an attribute.

ACTs can have objects.

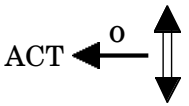


ACTs can have directions.

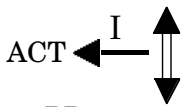


ACTs can have recipients.

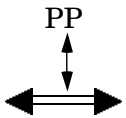
Conceptual Syntax Rules



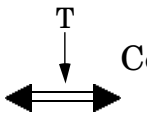
Objects can be conceptualizations.



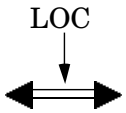
Instruments can be conceptualizations.



PPs can be described by conceptualizations.



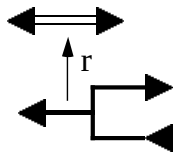
Conceptualizations can have times.

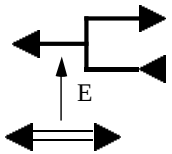


Conceptualizations can have locations.

Conceptual Syntax Rules

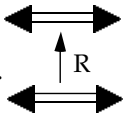
Conceptualizations can result in state changes.





States or state changes can enable conceptualizations to occur.

Mental ACTs can serve as reasons for conceptualizations.



One PP is equivalent to another.

ACTs can be varied along certain dimensions.

Conceptual Tenses

past	p
future	f
negation	/
start of a transition	ts
end of a transition	tf
conditional	c
continuous	k
interrogative	?
timeless	∞
present	nil

States

- states of objects are described by scales with numerical values.

HEALTH	(range -10 to 10)
dead	-10
gravely ill	-9
sick	-9 to -1
under the weather	-2
all right	0
tip top	+7
perfect health	+10

More States

FEAR	(range -10 to 0)
terrified	-9
scared	-5
anxious	-2
calm	0

MENTAL STATE	(range -10 to +10)
catatonic	-9
depressed	-5
upset	-3
sad	-2
ok	0
pleased	+2
happy	+5
ecstatic	+10

Combinations of States

CONSCIOUSNESS	(range 0 to +10)
unconscious	0
asleep	5
awake	10
"higher drug consciousness"	>10

Some words can be combinations of scales:

shocked = SURPRISE (6)
DISGUST (-5)

calm = SURPRISE (0)
DISGUST (0)
FEAR (0)
ANGER (0)
CONSCIOUSNESS (> 0)

Some states are not scales ...

... some states take absolute values

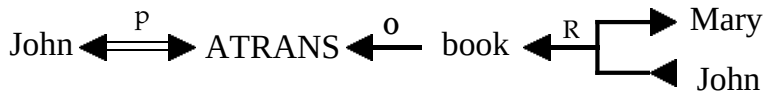
LENGTH
COLOR
MASS
SPEED

... some states are just relationships between objects

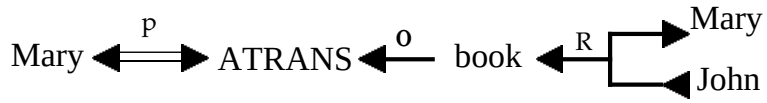
CONTROL
PART (inalienable possession)
POSS (possession)
OWNERSHIP
CONTAIN
PROXIMITY

Examples

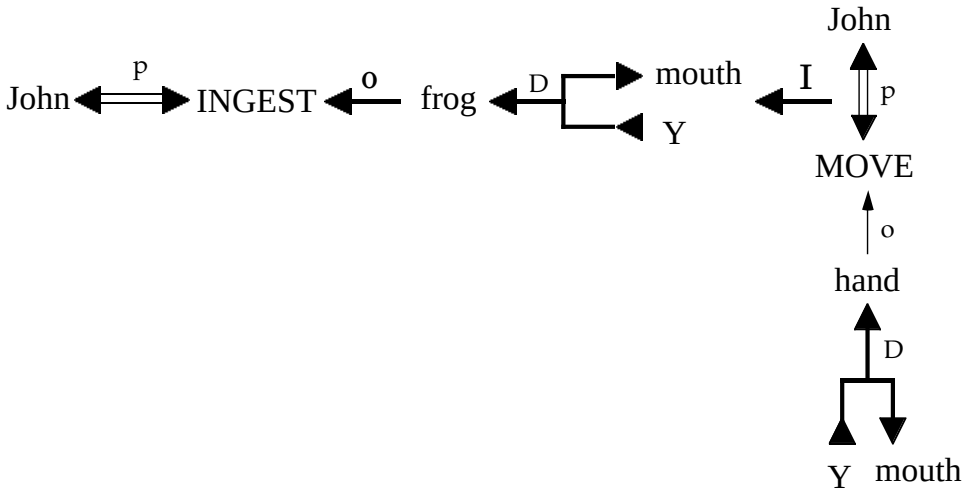
John gave Mary a book.



Mary took a book from John.

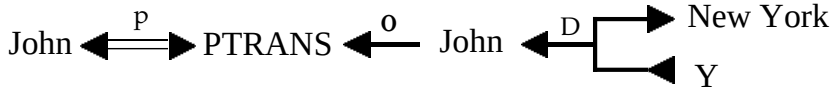


John ate a frog.

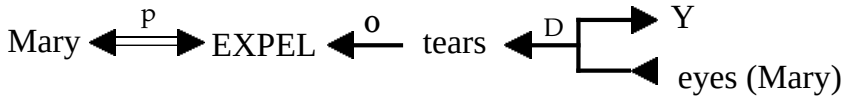


Examples

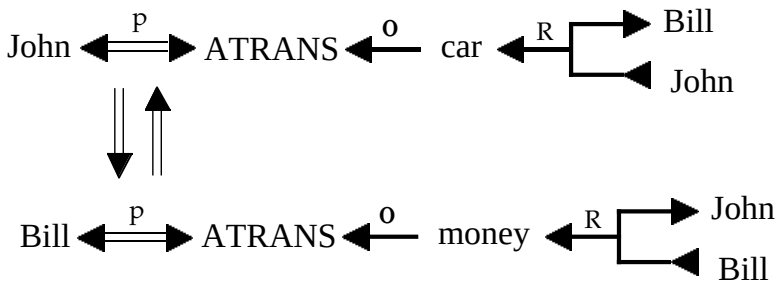
John went to New York.



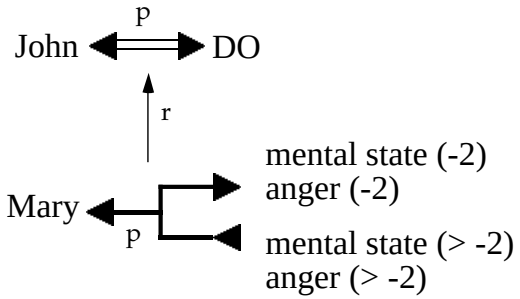
Mary cried.



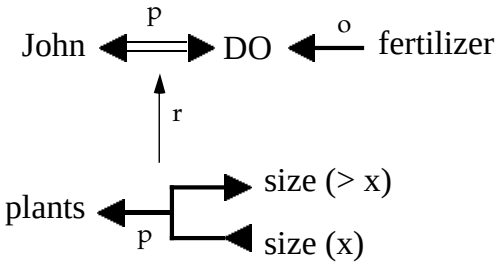
John sold his car to Bill.



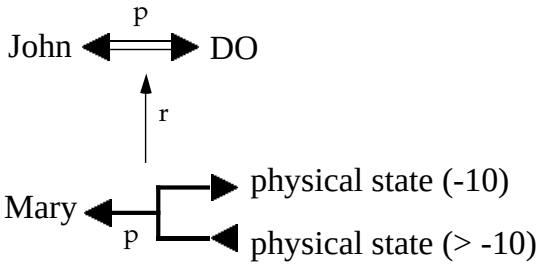
John annoyed Mary.



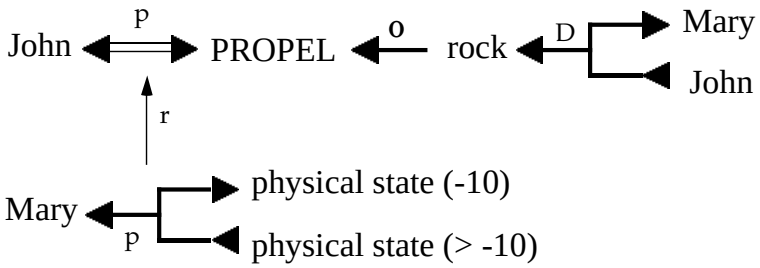
John grew the plants with fertilizer.



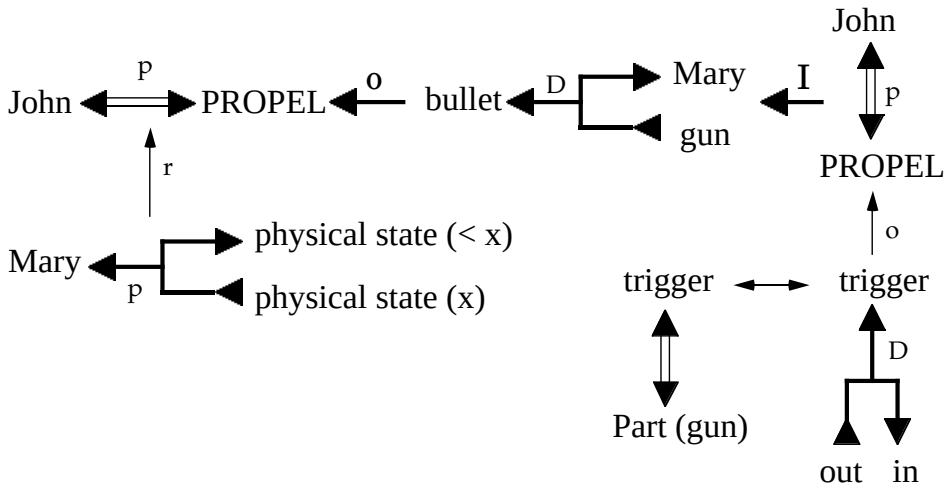
John killed Mary.



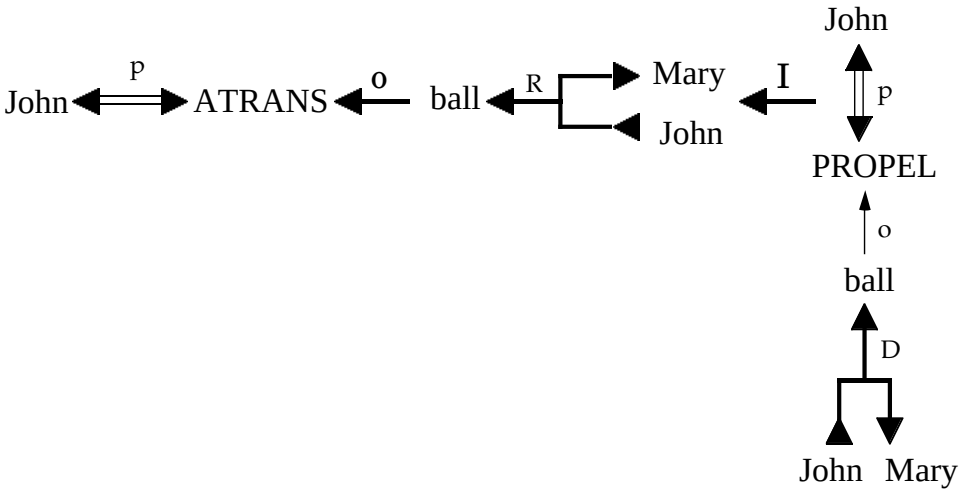
John killed Mary by throwing a rock at her.



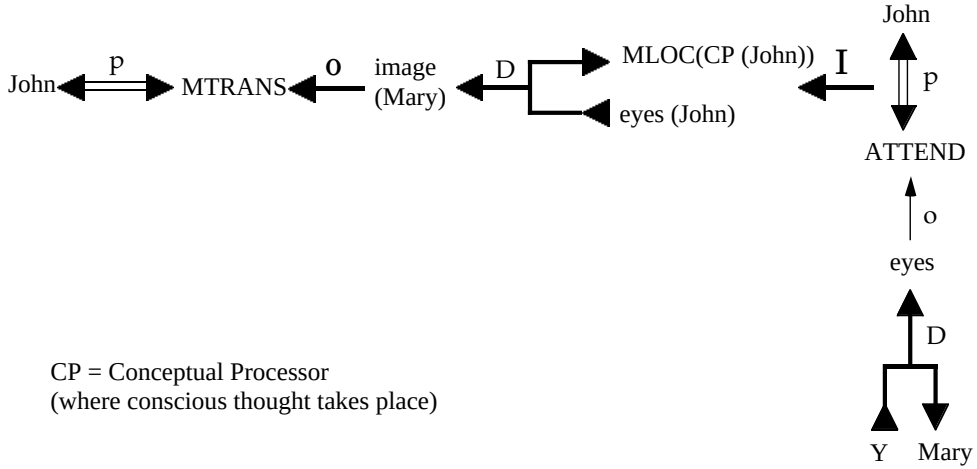
John shot Mary.



John threw a ball to Mary.

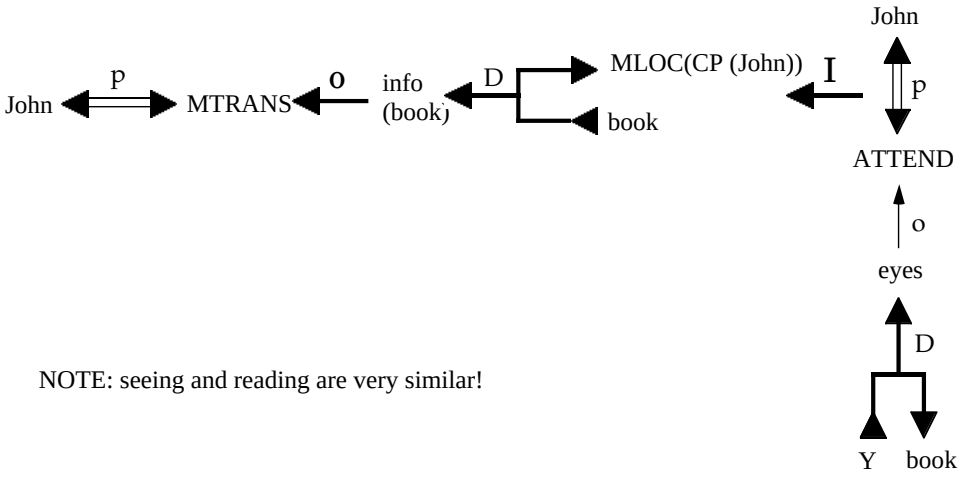


John saw Mary.



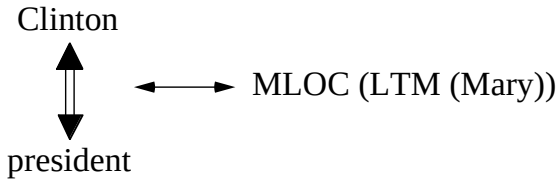
CP = Conceptual Processor
(where conscious thought takes place)

John read a book.



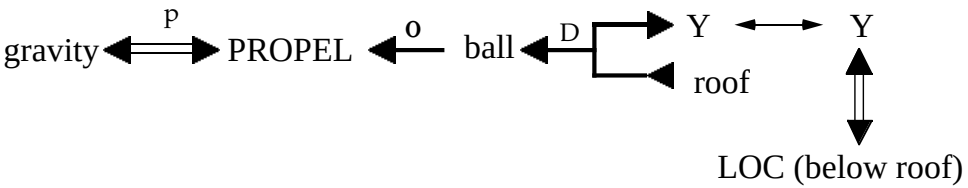
NOTE: seeing and reading are very similar!

Mary knows that Clinton is president.

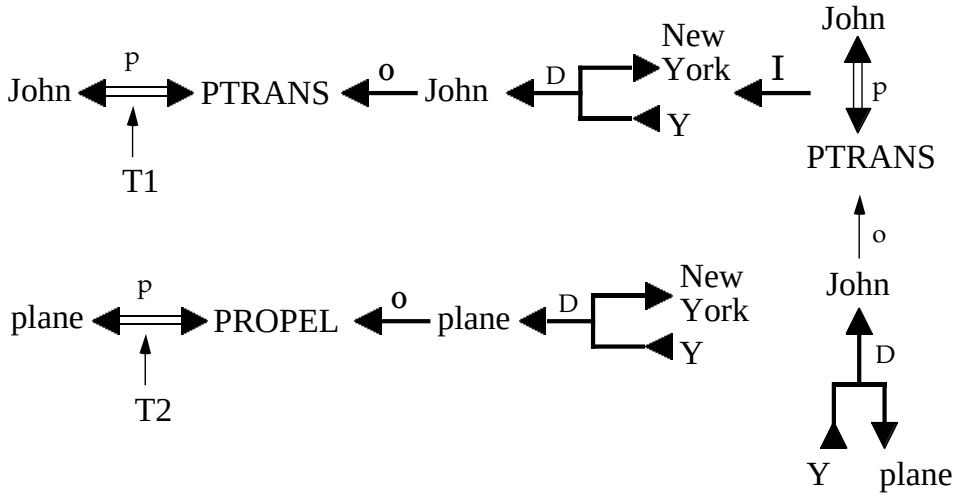


LTM = Long Term Memory

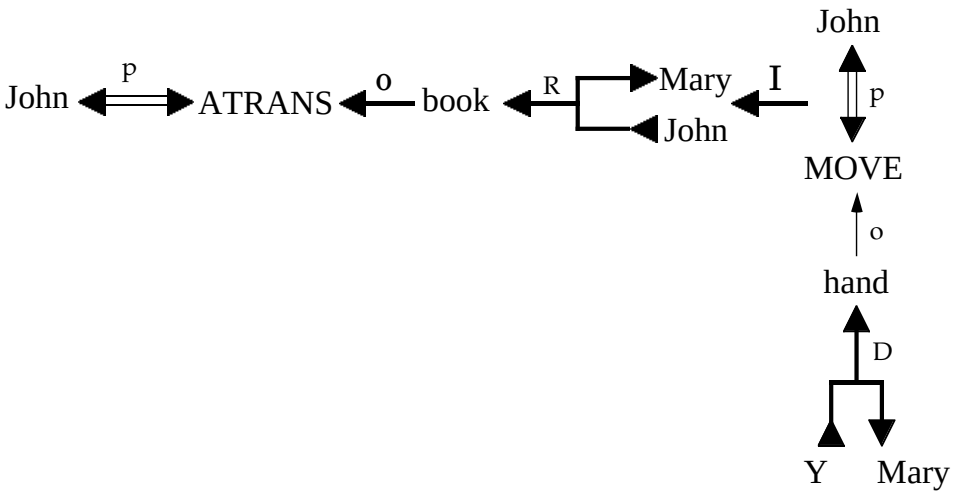
The ball fell from the roof.



John flew to New York.



John gave Mary a book by handing it to her.



Inference

- Inference is fundamental to language understanding.
- Inferences aren't always right, but they are common assumptions that often *are* right.
- Even wrong assumptions form the basis of conversations:

A: John hit Mary yesterday.
B: What did Mary do to upset him?
A: Nothing, they were practicing judo and his hand slipped.
B: Was she badly hurt?
A: No, he barely grazed her.
B: I'll bet she was mad though.
A: No, she thought it was pretty funny.

Primitive ACTs facilitate inference

- Reduces the number of inferences that need to be stored explicitly.
- A lot of information is true for many verbs; we don't need to have an exhaustive list of information associated with each verb.
- It is unlikely that people associate general information with each verb separately.
- A system of primitives is only as good as the inferences that it generates.
- The name of a concept (e.g., ATRANS) is meaningless; the meaning of the concept consists of the inferences that it makes.

What is an inference?

A conceptualization that can be derived from another conceptualization with probability less than 1.

The "but not" test:

- If it makes sense to say "X but not Y" then Y is a valid inference.
- If it is absurd to say "X but not Y" then Y is part of the basic conceptualization.

John went to New York, but he didn't get there.
vs.
** John arrived in New York, but he didn't get there.*

Inferences associated with PTRANS

1. The object is located at the destination.
2. The object is no longer at the source.
3. If a human actor requested the action, then they will probably do whatever is normally done with the object.
4. Doing this will cause the person to be pleased.

John went to New York from Texas.

1. John is in New York.
2. John is no longer in Texas.
3. John wanted to do something in New York.
4. John thought he would enjoy being in New York.

Inferences associated with INGEST

1. PTRANS is inferred.
2. The object ceases to exist in its usual form.
3. If the object is edible, then the actor is nourished.
4. If the object is inedible, then the actor becomes sick.
5. If the actor thinks the object tastes good, then the actor is pleased.

John ate an apple.

1. An apple was put into John's mouth.
2. The apple ceased to exist.
3. John was nourished.
5. John liked eating the apple.

John ate poison.

4. John became sick.

Inferences associated with PROPEL

1. PTRANS is inferred.
2. The destination might be negatively affected (physically).
3. If the destination is human, the actor might have been mad at him/her.
4. If the object is brittle then it will become in a negative state.

John threw an egg at Mary.

1. The egg came in contact with Mary.
2. Mary was hurt.
3. John was angry at Mary.
4. The egg was broken.

Object-based inferences

Additional inferences can be made depending upon the representation of the objects.

1. If the object is liquor, then the actor may become drunk.
2. If the object is candy, then the actor may get bad teeth.
3. If the object is medicine, then the actor may feel better.

But these inferences represent information about the objects, and are therefore stored with the object and not the ACT.

Backward inference

- Forward inferences represent things that result from an ACT.
- Backward inferences represent things that might have caused an ACT or state.

John has a book -> something cause him to have the book
(e.g., someone PTRANSed the book to him).

Mary knows what Fred did -> someone told her what Fred did
(e.g., someone MTRANSed the information to her).

Strengths of CD

- Decomposed words into primitives so that language processing focuses on general concepts instead of individual words.
- Canonical representation captures commonality across different words and structures.
  - "John went to San Francisco by BART."
  - "John took BART to San Francisco."
- Interlingual representation facilitates machine translation.
- Words trigger CD frames that provide predictions about what will come next. Identifies conceptual roles and helps disambiguation. (Also suggests how we can finish other people's sentences.)
- Facilitates inference. We can infer properties of unknown words. Inferences are attached to general concepts so inference rules are not overwhelming.

Weaknesses of CD

- Incompleteness
  - no ontology (e.g., no ISA hierarchy)
  - missing entire conceptual areas (e.g., objects)
  - no method for handling quantification
- The Primitives
  - are the primitives really atomic? (e.g., MOVE to a doctor involves may smaller actions)
  - primitives can be composed of other primitives (e.g., a PTRANS may consist of many smaller PTRANS's).
  - these are the wrong set of primitives.
- No higher level concepts
- Many inferences not organized around primitives.
  - "John bought a book" => at the store
  - "John kissed Lynn" => John likes Lynn
  - "John got a gun" => to threaten or shoot someone'
  - "O.J. said he was innocent" => of the murder charges