Introduction to Semantic Role Labelling

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One Last Item, Word Senses

We reviewed and defined many linguistic terms in our last session; we need one more: Word Senses.

Similar to **1-to-n**, **n-to-1** relations between syntactic forms and semantic structures; we have a **1-to-n** and **n-to-1** relationships (which consequently turns into many n-to-n relationships) between lexical-forms and lexical-meanings.

One Last Item, Word Senses (contd.)

The idea is well-known to you, one lexical form can have different meanings:

I joined the demonstration (to take part; to participate).

I joined the army (to become a member).

...

We call each of the meanings listed above a word sense (see a dictionary for many more).

Since **join** has several meanings, or equivalently **senses**, it is polysemous (i.e., we have a 1-to-n relationship between the lexical-form *join* and the set of all possible meanings). Similarly, *join* and *participate* are named synonyms when they refer to the same sense *take part*.

One Last Item, Word Senses (contd.)

Synonymy is one of the many well-established lexical semantics relations (antonymy, hyponymy, hypernymy, etc.).

Polysemous words are also called ambiguous words. Disambiguation of a word's meaning is not an easy job (for both human and computers).

In computational linguistics, selecting the appropriate sense of a word in a given context is called word sense disambiguation. For word sense disambiguation (WSD), we have an inventory of meanings and hand-annotated examples for it (i.e., a so-called supervised framework).

But, the task can be done in an unsupervised fashion (i.e., without any labelled data), too. This is called word sense induction (WSI).

One Last Item, Word Senses (contd.)

Apart from technical matters, defining an inventory of senses, a discrete set in which meanings have clear-cut boundaries, is problematic (especially applicable to WSD).

WSD and WSI, as you will witness later, can be helpful (even crucial) for semantic role labeling.

If interested in this topic as a project, let me know!

Semantic Role Labeling: Linguistic Background

As mentioned briefly in our first session, Charles Fillmore is often considered as the most influential linguist in topics related to Semantic Role Labeling (semantic analysis, syntax–semantics interface, Linking Theory).

Semantic Role Labeling: Linguistic Background

In 1968, Fillmore proposed his Case Grammar including the idea of deep cases which shook up the linguists' world Fillmore (1968).

As described by himself, in Case Grammar, Fillmore considered

> *a set of quite general (presumed universal) semantic-role categories that could stand for how the dependent elements of a verb-headed sentence related to the type of situation introduced by the verb, beginning with such traditional notions as Agent (the enactor of some controlled event) and Patient (the undergoer of a change designated by the verb).*

Semantic Role Labeling: Linguistic Background (contd.)

Borrowing the word case from the tradition of studies of the uses of the categories found in such "case languages" as Latin, Greek, Sanskrit or Russian, but using it to refer to semantic functions rather than categories of grammatical form, I defined case frames as **the configurations of semantic cases that could constitute the argument structures of particular classes of lexical items**, *most saliently verbs.*

Semantic Role Labeling: Linguistic Background (contd.)

The full combinatory description of a verb [verb alternation patterns/subcategorization frames/valency?!] would consist, then, of a pairing of a case frame with the manner in which the phrases representing the individual cases are realized in the syntax. (For example, for a simple transitive verb, we can have the pairing {agent-as-subject, patient-as-object}.)

Semantic Role Labeling: Linguistic Background (contd.)

Simply put, Fillmore points to syntactic cases (*Dative*, *Accusative*, etc.) and suggests that they initially take place at the deep structure (the deep-structure case).

You can consider "deep-structure case" as what is hidden behind the syntactic form of sentences; and that syntactic cases are signalling them (the deep cases).

Assume something like an overhead projector: Source=deep-case, what-is-seen=syntactic-cases, lamp=our-cognitive-faculties

The list of cases discussed in the Fillmore's 1968 paper are Agentive, Instrumental, Dative, Factitive, Locative and Objective.

Semantic Role Labeling: Linguistic Background (contd.)

Fillmore proposed the notion of associating different *types of nouns* with different *types of cases* such as the fillers of Agentive and Dative roles (i.e., words that occupy these roles) are most likely to be of type +ANIMATE (research topic up until now).

* Fillmore proposed that the semantics of a verb determines the number of roles and their types for the verb, e.g.:

to blush has only on Dative role;

to give has three obligatory roles of the giver (Agentive), the thing given of Objective role, and the recipient with Dative role;

open takes 3 roles Agentive, Objective, and an Instrument, but in contrast to give, Agentive and Instrument are optional.

Semantic Role Labeling: Linguistic Background (contd.)

A few important points regarding Case Grammar

As mentioned before (several times), Fillmore's Case Grammar was one of the first serious attempts on, later known as, *Linking Theory*.

Fillmore proposed several tests for identifying semantic role fillers of the same or different types, e.g., conjunction test:

> *Only fillers of the same case can be conjoined: John and Alex broke a window is ok but John and Hammer broke a window is not ok!*
> *Is guitar and football ok?!*

Semantic Role Labeling: Linguistic Background (contd.)

Additionally, one outcome of analysis was that it could potentially be used to reduce the number of entries in lexical databases (e.g., by distinguishing word senses and their alternative role assignments; by the same token, consolidating different words of similar meaning into one entry, e.g., resent and dislike are more-or-less the same (synonyms) and both license a Dative-Objective pattern) .

Why should we care about reduced lexicon size? According to Palmer et al. (2010):

> *Inference rules could be written with respect to a finite set of cases rather than thousands of individual lexical items.*

In other words, a systematic generalization!

Semantic Role Labeling: Linguistic Background (contd.)

Above all, Fillmore's Case Grammar initiated research and discussions regarding the existence of semantic roles, and their nature: how many of them exists, etc. which have been continued up until now.

Maybe we could rephrase this as: Fillmore's Case Grammar promoted studies in linguistics semantics in which semantic roles had (still has) a prominent role.

Fillmore made semantic roles popular!

A Summary So Far

Semantic role relations were introduced by the (mostly) generative grammar clan in 1960s and early 70s (Fillmore is named here but we will also talk about Gruber, Chomsky, Jackendoff, Levin, etc.).

The aim was to introduce a system for classifying the arguments of natural language predicates (predicate-argument-structure) into a *small finite set of participant types*.

This small finite set was/is (depend who is speaking about them) believed to be important in natural language grammar: they are tools in syntax–semantics analyses.

Evidently, analyses of semantic role can be exploited for semantic representation.

List of Generic Semantic Roles

A list of Semantic Roles mostly based on Fillmore's list of deep cases:

Role	**Description**	**Example**
Agent	Initiator of action, capable of volition	**John** went home.
Patient	Affected by action, undergoes change of state	John broke **the window.**
Theme	Entity moving, or being located	He rolled **the ball**.
Experiencer	Perceives action but not in control	**John** noticed a sound.
Beneficiary	For whose benefit action is performed	He gave **me** a flower.
Instrument	Intermediary/means used to perform an action	He shot John with**a gun**
Location	Place of object or action	He went **home**.
Source	Starting point	We heard it from **John**
Goal	Ending point	John lectured to **the class**.

Table 1: The List of *Generic Semantic Roles* from Palmer et al. (2010); Palmer et al. introduce these roles also as Theta-roles. In the listed examples, the fillers for the corresponding role is in bold face.

Exercises: Labeling Semantic Roles

Assign a semantic role to the bracketed phrases (what are the theta-grids?)

1. [The ball] flew [into the outfield.]
2. [Jim] gave [the book] [to the professor.]
3. [Laura] talked [to the class][about the bomb threats.]
4. [Laura] scolded [the class.]
5. [Bill] cut [his hair] [with a razor] in his hotel room.
6. [Gina] crashed [the car] [with a resounding boom].

Exercises: Labeling Semantic Roles

1. [Theme The ball] flew [Goal into the outfield.]
2. [Agent Jim] gave [Patient the book] [Goal to the professor.]
3. [Agent Laura] talked [Goal to the class][Theme about the bomb threats.]
4. [Agent Laura] scolded [Patient the class.]
5. [Agent Bill] cut [Patient his hair] [Instrument with a razor] in his hotel room.
6. [Agent Gina] crashed [Patient the car] with a resounding boom.

These are the annotations asserted in (Palmer et al., 2010).

List of Generic Semantic Roles, a more precise description

This list appeared in EAGLES report (Sanfilippo et al., 1999).

Agent: A participant which the meaning of the verb specifies as doing or causing something, possibly intentionally. Examples: subjects of kill, eat, hit, smash, kick, watch.

Patient: A participant which the verb characterizes as having something happen to it, and as being affected by what happens to it. Examples: objects of kill, eat, smash but not those of watch, hear, love.

Experiencer: A participant who is characterized as aware of something. Examples: subject of love, object of annoy.

Theme: A participant which is characterized as changing its position or condition, or as being in a state or position. Examples: objects of give, hand, subjects of walk, die.

Location: The thematic role associated with the NP expressing the location in a sentence with a verb of location. Examples: subjects of keep, own, retain, know, locative PPs.

Source: Object from which motion proceeds. Examples: subjects of buy, promise, objects of deprive, free, cure.

Goal: Object to which motion proceeds. Examples: subject of receive, buy, dative objects of tell, give.

Defining Roles: Not so easy!?

Despite the picture we imagined earlier

Defining Roles: Not so easy!? (contd.)

Despite the picture we imagined earlier, there are a number of problems

Defining Roles: Not so easy!? (contd.)

Despite the picture we imagined earlier, there are a number of **serious problems regarding the case theory and the idea of classifying arguments of predicates using semantic roles (see below).**

In reality, even after almost 50 years, linguists are debating and cannot arrive to a set of deep cases or devise a set of tests that can be used for determining them (in real-world situations/empirically).

Defining Roles: Not so easy!? (contd.)

In our textbook, Palmer et al. mention that a general agreement exists on the cases (or Thematic Roles or Semantic Roles or as Palmer et al. used elsewhere Theta roles – shown in Table 1) but there is no agreement regarding

* exactly when and where they can be assigned (probably due to the lack of precise definitions),
* and, which additional cases should be added (again, their definitions which can tell us how many of them are there).

To me, somehow, disagreement on the itemized matters contradicts the former claim (general agreement on the cases).

Defining Roles: Not so easy!? (contd.)

To this discussion, we have to add debates regarding the number of cases/roles per argument:

So far, we have mentioned that an argument, usually a noun phrase can only have one role. This is the so called Theta Criterion by Chomsky in which he assert a *one-to-one* correspondence between noun-phrases and thematic roles.

Defining Roles: Not so easy!? (contd.)

In contrast to Chomsky's theta criterion, Ray Jackendoff introduced a two layer system in which arguments are analyzed at a *thematic level* and an *action level*. For

(1) John kissed Mary

John is Theme and Mary the Goal at the thematic level; but also, John is the Actor and Mary is the Patient at the action level.

This two-level representation was his response to contradiction that he found in the 1-to-1 system.

Defining Roles: Not so easy!? (contd.)

Even, the very nature of semantic roles can be questioned:

> Are they elements of syntax or semantics? or, they are lexical semantic/conceptual entities?
>
> Are semantic roles primitive part of our linguistic knowledge, or a product of the form–meaning mapping?

The usual, but not necessarily the best or correct, answers are that they are semantic/conceptual elements, and they are primitive semantic properties of predicates (as Fillmore put, decided by the semantics of verbs/words).

Semantic Roles: Examples of Debates/Refinements

Jackendoff on Agent vs. Patient

The Agent is the initiator of the action, the doer, and can typically be described as acting deliberately or on purpose.

The question *What did X do?* can be applied, with *X* being the Agent.

In contrast, the Patient is being acted upon and mot-likely has a change of state as a result of the Agent's actions.

The questions *What happened to Y?* or *What did X do to Y?* is applicable when *Y* is the Patient.

Semantic Roles: Examples of Debates/Refinements (contd.)

How about Patients vs. Themes?

Patients undergo a *change of state* but Themes simply *change location*:

(2) Window breaks.

(3) Ball rolls down the hill.

in (2), window will be shattered into several pieces (change of state) but in (3) only the location of the ball changes (it is still in one piece and the same 'state').

Semantic Roles: Examples of Debates/Refinements (contd.)

Palmer et al. bring the example of

(4) My kitty is licking my finger.

is the finger undergoes a change of state or a change of location, or none?

But what about when you wrap (or *coat*) something with something?!

(5) To build it, he wrapped a coil of wire around a metal inner.

Sorry, I have not definite answer!

Semantic Roles: Examples of Debates/Refinements (contd.)

Even determining Agents is not so simple: Does Agent do something intentionally or unintentionally? If unintentional, is it still an Agent?

(6) The hurricane destroyed my home).

Related to this, Cruse (1973) proposed four subclasses of Agents: Volitive, Effective, Agentive, Initiative.

Semantic Roles: Examples of Debates/Refinements (contd.)

Volitive: presence or absence of willingness (the volitionality feature);

Effective: the ability of exerting power due to its position (the effectiveness feature);

Initiative: the ability to order the start of a process (the initiation feature);

Agentive: the ability to do something due to its internal capacity (human/animals can move, certain machines are able of certain actions)

Maybe looking at the listed categories as features be more helpful (one or more features can be used/invoked at once?!).

Semantic Roles: Examples of Debates/Refinements (contd.)

There are a few more examples in the book which can further convince of you of the necessity of studies that were/have been initiated to find answers for questions regarding the nature of semantic roles.

Several frameworks have proposed a more detailed analysis of semantic roles (wrt. their nature, definition, and their determination) have been proposed, which we look at a few of them, starting with Lexical Conceptual Structures.

Lexical Conceptual Structures

Jackendoff developed the Lexical Conceptual Structures (LCS) theory based on an earlier work of Gruber (1965).

In LCS, semantic roles are primitive semantic entities that are defined in terms of a few semantic *subfunctions*: `CAUSE`, `BE`, `GO`, `STAY`, `LET`.

Put simply, `CAUSE`, `BE`, `GO`, `STAY`, `LET` are our super-predicates.

These five subfunctions are the building blocks of lexical conceptual representations.

Note that in later revisions, the five super-predicates were extended with some additional subtypes.

Lexical Conceptual Structures (contd.)

For example, GO can describe *changes* of location, possession, and state (the latter demands a *initial* and *final state*). We can use $\overset{\text{GO}}{\underline{\quad}}_{Posit}$, $\underline{\quad}^{\text{GO}}_{Poss}$, and $\underline{\quad}^{\text{GO}}_{Ident}$ to denote these three sub-types, respectively.

The GO predicate (disrgarding the subtype) takes three arguments:

1. The object undergoing the change;
2. The initial location/state/possessors;
2. The end location/state/possessors;

Lexical Conceptual Structures (contd.)

For instance, for

(7) John drove from Denver to San Francisco.

the basic lexical conceptual representation would be:
$\texttt{GO}\,(\mathit{John},\ \mathit{Denver},\ \mathit{SanFrancisco})$

OR, a little more elaborated version

$$\overset{\texttt{GO}}{\underset{\mathit{Posit}}{}}\ (_{\mathit{thing}}\mathit{John},\ _{\mathit{loc}}\mathit{Denver},\ _{\mathit{loc}}\mathit{SanFrancisco})$$

Lexical Conceptual Structures (contd.)

(8) The bird left the cage.

$\overset{\texttt{GO}}{\underset{Posit}{}}\ (_{thing}\,Bird,\ _{loc}\,cage,\ y)$ (y is an uninstantiated variable)

(9) john took the bird from the cage.

$\texttt{CAUSE}\,(John, [\ \overset{\texttt{GO}}{\underset{Posit}{}}\ (_{thing}\,Bird,\ _{loc}\,cage,\ y)\ ])$

Similarly, Palmer et al. (2010) define give as a $\overset{\texttt{GO}}{\underset{Poss}{}}$ +CAUSE:

(10) John gave Mary a book.

$\texttt{CAUSE}\,(John, [\ \overset{\texttt{GO}}{\underset{Poss}{}}\ (Book,\ John,\ Mary)\ ])$

Does this representation always work?

Lexical Conceptual Structures (contd.)

The remaining conceptual predicates other than `CAUSE` and `GO`:

BE Assert stationary location: *John is at office* will be `BE`(*John*, *office*);

STAY Stationary location over a temporal duration: *John remained silent* will be `STAY`(*John*, *silent*);

LET Denotes permission: John dropped his pen. `LET`(*John*, `GO`(*Pen*, x, y));

Lexical Conceptual Structures (contd.)

For instance, Jackendoff applied the exemplified representations to all motion verbs in English, which means that now all have arguments *initial state* (FROM/SOURCE) and the *final state* (TO/GO), no matter adjunct/optional or argument/obligatory.

In other words, although the Source and Goal can be syntactically adjuncts, they always appear in the conceptual representation (semantic argument), even if there is no trace of them in the syntactic structure.

Sources and Goals: Are they arguments or adjuncts? As seen, Jackendoff has a solution for it.

Lexical Conceptual Structures (contd.)

Some notes:

The focus of Jackendoff is on fundamental concepts concerning the mapping between syntax and semantics and not a system for detailed meaning representation.

Causation was at his focus due to its importance, and that it is often morphologically marked.

In his system, Agent comes first, then Patient (rest embedded) in a hierarchical ordering of the semantic roles.

Jackendoff assumes a mapping between an ordered list of semantic roles (a thematic hierarchy) and an ordered list of syntactic constituents.

Lexical Conceptual Structures (contd.)

> **Hierarchical Argument Linking:** *Following the thematic hierarchy, order the roles in the LCS of a verb V from first to nth. To derive the syntactic argument structure of V, map this ordering of roles into the first through nth roles in the syntactic hierarchy . . .*

Apart from its impact in linguistics, the LCS proved to be a helpful representation systems in practice, for natural language processing applications devloped late 80s and early 90s.

Extending this elegant system to a large list of verbs, and across languages, is not so easy, particularly for verbs with abstract meanings.

Homework

Bring a lexical conceptualization representation for the following sentences:

John opened the door.

The door is open.

The ball rolled to the other end of the hall.

Jim gave the book to the professor.

Mary ejected Jim from the room.

Laura quickly whispered the latest rumour about the Queen to her cousin.

Bill cut his hair with a razor.

Gina crashed the car into the embankment.

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