Tuning Themes

Finding an Appropriate Model of Roles for Translation

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Abstract. Many schemes have been proposed for describing the semantics of the relationship between entities and situations. The number of thematic or semantic roles posited ranges from few (2 for Dowty (1991)) to many (35 for Dixon (1991)). This empirical study examines the same short text in Irish, English, Chinese, German and Spanish to see what approximate level of specificity is sufficient to find cross-language agreement when assigning roles to translated sentences, and then what particular model of roles delivers the most faithful rendering of predicate-argument relationships.

Keywords: knowledge representation, machine translation, semantic roles, syntax-semantics interface, thematic roles

1. Introduction

Grammatical relations such as subject, object and adjunct are not always a reliable guide to the semantics of verb arguments, being dependent on the verb form and language chosen to express a proposition (see examples (4) to (11)). Semantic roles have been suggested to describe the relationships that hold between predicates and their arguments, and are believed by some to determine what grammatical form they take in language.

However many role sets have been suggested to explicate the syntax-semantics interface (van Valin, 1999) in many applications. These range from highly generalised schemes, for example (Dowty, 1991, see (1a)) which explains the ordering of object arguments in English, to highly specific schemes, such as (Sag and Wasow, 1999 see (1b)) which provides semantic indexing in a constraint based grammar formalism.

(1) a. Tara_{agt} told him_{pat1} to go_{pat2}^1
b. Tara_{speaker} told him_{speaker} to go_{spoken}

In this paper I concentrate on thematic roles, an intermediate level of description whose use is widespread in the linguistics literature (see e.g. Saeed, 1997). Since their appears to be no ‘right’ set of roles, I examine

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their applicability to automatic translation. Using a manual empirical study of a short text (the UN Declaration of Human Rights) in five structurally divergent languages (Irish, English, Chinese, German and Spanish), I apply three thematic role schemes (Dorr, 1993; Jackendoff, 1990; UNL Centre, 2001) to judge their comparative suitability for automatic translation.

In this paper, the next section (2) introduces the idea of thematic roles in detail and describes why and how they are used, with particular reference to automatic translation. Section 3 is a review of various models of roles that have been proposed, particularly thematic role schemes, and here also I introduce the two main motivating notions of roles: those of spatial relations and causality. I explain the main structural features by which the languages differ in section 4, together with the methodology I used to reduce multiple translations of a single text fragment to one quasi-logical form, revealing the predicate valency patterns appropriate for translation. In the evaluation section 5 I take the patterns corresponding to four broad classes of situations and compare how well each of the three role schemes under examination can be applied to them. In particular I examine whether the roles provide coverage while retaining adequate differentiation in the description of predicate-argument relations, and how reliable (i.e. unambiguous) they prove.

In the conclusion I show that the conflation of the causal and spatial dimensions in (Dorr, 1993) and (UNL Centre, 2001) results in an impoverished description, and that the Jackendoffian scheme, with the addition of roles for the cognitive domain, is a good candidate for semantic representation in interlingual translation systems.

2. What are thematic roles?

Thematic roles are semantic constructs posited by linguists to describe the nature of relationships between associated entities and situations. The sentence The motorist blew his horn at the young lad for cycling like an maniac, might be represented in this quasi-logical form:

\begin{equation}
\begin{align*}
\text{sound} & (\text{Motorist, Horn, YoungLad}) \\
\text{cycle} & (\text{YoungLad, LikeAManiac})^3
\end{align*}
\end{equation}

Here the order of predicates and arguments corresponds, by convention, to their order in English, but tells us nothing about their semantics. Thematic role labels such as agent, patient, goal, result, manner and cause can be used to label these intuitive distinctions.\(^4\)
(3) \[\text{sound(Motorist}_{\text{ag}} \text{, Horn}_{\text{at}}, \text{YoungLad}_{\text{gd}}}_{\text{res}}\]
\[\text{cycle(YoungLad}_{\text{ag}} \text{, LikeAManiac}_{\text{man}}}_{\text{cau}}\]

Thematic roles are generally used to describe three types of inter-
term relations: those of causality, location and, less frequently, focus
(Saeed, 1997). Causality encompasses what is affected by the situation
in question, what causes it, and whether that cause is intentional or
inadvertent. Location typically takes in where terms are located relative
to the situation, and, if they are moving, where from and to. Focus
describes what aspects of the situation are highlighted or emphasised. For
example while both sentences below express the same state of affairs,
corporation plays the focussed role in the first, and units does in the
second.

(4) a. The corporation contains three business units
b. Three business units comprise the company

Thematic roles describe the nature of an argument’s relationship
with its predicate, not its ontological category and so are not to be
confused with selectional restrictions. The term ‘thematic’ originates
in the linguistic notion of theme (sentential topic) and rheme (com-
ment) (see Trask, 1993), and is not related to subject area or discourse

Participant thematic roles are usually considered the ‘core’ roles,

describing the relationship between a situation and the entities that are
most directly involved with it. As such they are part of our knowledge of
verb and preposition meaning, and correspond to predicate/argument
relationships. Many schemes have been proposed. Table I shows a sam-
ple of commonly used roles and their typical interpretation (adapted
from Saeed (1997)). Other roles suggested include Actor (or alterna-
tively Effector, a non-volitional Agent), Recipient, Percept (or alterna-
atively Stimulus, that perceived), Possessor and Property (a state
attributed to an entity: e.g. I_{\text{man}} feel atemious_{\text{pro}}).

Circumstantial thematic roles (see table II) are included in role
theories less often, and generally describe relationships between sit-
uations (i.e. predicate to predicate) and so are part of our knowledge
of the function of clause types and clausal operators. As they are not
addressed by all of the role schemes under consideration I have limited
this study to participant roles.

Some authors make an additional distinction between ‘internal’ and
‘external’ temporal and spatial relations (e.g Andrews, 1985), depend-
ing on how closely bound the entity is to the situation described. Somers
(1987) refers to them as ‘inner’ and ‘outer’ complements, loosely cor-
responding to the argument/adjunct distinction found in syntax. For
Table I. Typical Participant Roles

<table>
<thead>
<tr>
<th>Role</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agent</td>
<td>the (typically volitional) initiator, or doer of an action</td>
</tr>
<tr>
<td>Patient</td>
<td>the affected party, or undergoer of the action</td>
</tr>
<tr>
<td>Theme</td>
<td>the entity whose state, movement or location is described</td>
</tr>
<tr>
<td>Experiencer</td>
<td>the entity aware of, but not affected by the situation</td>
</tr>
<tr>
<td>Beneficiary</td>
<td>the entity for which the action is performed</td>
</tr>
<tr>
<td>Instrument</td>
<td>the entity with which the action is performed</td>
</tr>
<tr>
<td>Goal</td>
<td>the location towards which an entity moves</td>
</tr>
<tr>
<td>Source</td>
<td>the location away from which an entity moves</td>
</tr>
</tbody>
</table>

Table II. Typical Circumstantial Roles

<table>
<thead>
<tr>
<th>Role</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cause</td>
<td>the situation that precipitated this one</td>
</tr>
<tr>
<td>Condition</td>
<td>the situation that would precipitate this one</td>
</tr>
<tr>
<td>Purpose</td>
<td>the aim of the situation</td>
</tr>
<tr>
<td>Manner</td>
<td>the way in which a situation takes place</td>
</tr>
<tr>
<td>Measure</td>
<td>the extent (e.g. in cost, time or distance) associated with the situation</td>
</tr>
<tr>
<td>Location</td>
<td>the location at which the situation takes place</td>
</tr>
<tr>
<td>Temporal</td>
<td>the time at which the situation takes place</td>
</tr>
</tbody>
</table>

example, in the first two sentences below (5a and 5b), the locative and temporal arguments are internal, since they are required by the verbs situate and go on; whereas the third sentence (5c) can drop either or both phrases. This should not be confused with the related but distinct view in Chomskian grammar that complements (object arguments) are internal and that both subjects and adjuncts are external (Radford, 1997), owing of the point at which they attach to the verb phrase.

(5)  
   a. The development$_{thm}$ is situated [in town]$int_{-loc}$
   b. The talk$_{thm}$ went on [for ages]$int_{-tem}$
   c. She$_{agt}$ hung about [in town]$ext_{-loc}$ [for ages]$ext_{-tem}$

2.1. Why do we need roles?

The grammatical roles found in sentences (subject, direct object, indirect object and adjuncts), though driven by semantic structure, are far from a direct mapping of it (Dowty, 1991; Jackendoff, 1972). While people may feel that the subject is usually the ‘doer’ and the object the ‘undergoer’, this is often not the case.
For example, depending on the choice of active or passive form the proposition hugged(Bertie, Enda) can be variously realised as:

(6) a. Bertie$_{agt}$ hugged Enda$_{pat}$
b. Enda$_{pat}$ was hugged by Bertie$_{agt}$

A single verb often has multiple realisations depending on the number of arguments made explicit (Levin, 1993):

(7) a. Bruce Lee$_{agt}$ snapped the table$_{pat}$ in half$_{man}$ with his little finger$_{ins}$
b. His little finger$_{ins}$ snapped the table$_{pat}$ in half$_{man}$
c. The table$_{pat}$ snapped in half$_{man}$

Choice of verb can also affect the resultant sentence structure. For example fear(Who, Virginia Wolff) could be:

(8) a. Who$_{exp}$ fears Virginia Wolff$_{src}$?
b. Virginia Wolff$_{src}$ frightens who$_{exp}$?
c. Who’s$_{exp}$ afraid of Virginia Wolff$_{src}$?

A combination of these effects can result in an explosion of possible realisations for a simple proposition such as sold(Charlie, Albert, UsedConstituencyOffice), of which these are just a few:

(9) a. Charlie$_{src}$ sold Albert$_{gol}$ a used constituency office$_{thm}$
b. Charlie$_{src}$ sold a used constituency office$_{thm}$ to Albert$_{gol}$
c. Albert$_{gol}$ was sold a used constituency office$_{thm}$ by Charlie$_{src}$
d. A used constituency office$_{thm}$ was sold to Albert$_{gol}$ by Charlie$_{src}$
e. Albert$_{gol}$ bought a used constituency office$_{thm}$ from Charlie$_{src}$

When we make comparisons across languages, there can be an even more dramatic divergence in structure. The English sentence Dustin$_{sub}$ likes cream cake$_{dobj}$ translates as (literal translations are added for illustration):

(10) a. Is maith$_{sub}$ le Dustin$_{adj}$ cáca uachtar$_{dobj}$ [Irish] be good with Dustin cake cream
b. 达斯汀喜欢奶油蛋糕
   Dustin$_{sub}$ xiǎn huan náiyóu dànngťào$_{dobj}$ [Chinese] Dustin like cream cake
c. Sahnkekuchen$_{sub}$ gefällt dem Dustin$_{obj}$ [German] cream-cake please Dustin
d. Le$_{ref}$ gusta tartar$_{sub}$ de nata a Dustin$_{obj}$ [Spanish] him please cake of cream to Dustin
Cream cake (the *percept*) is realised as the direct object in English, Irish and Chinese, but moves to the subject position in Spanish and German. Dustin (the *experiencer*) is variously subject, reflexive, direct object and indirect object. Of course one could claim that the Spanish and German versions are describing ‘pleasing’ situations that are subtly distinct from ‘liking’ situations. However, these are translational equivalents, and truly telic pleasing situations (where the experiencer’s psychological state is actively changed by the percept) are lexicalised with the verbs ‘zufriedenstellen’ and ‘erfreuen’ in German, and ‘agrada’ and ‘dar gusto’ in Spanish.

An additional complication is that a single predicate can have differing realisations, depending on the ontological type of its arguments. In German, the concept of ‘liking’, expressed above with the verb ‘gefallen’ when directed at an object, takes a reversed argument structure with the verb ‘mögen’ when applied to people, and becomes the adverbial adjunct ‘gern’ when applied to actions.

(11) a. Ich$_{sub}$ esse gern$_{adj}$
   I eat gladly
   ‘I like eating’

   b. Ich$_{sub}$ mag dich$_{dobj}$
   I like you
   ‘I like you’

Since the relationship between sentence structure and underlying semantic form is so variable, many turn to thematic roles for a stable semantic representation. In varying forms, the descriptive device of thematic roles is central to grammar formalisms such as Chomsky’s (termed θ-roles, e.g. see (Radford, 1997; Rappaport and Levin, 1988)) and Jackendoff’s Lexical Conceptual Structure (1972; 1990), and are also used in Halliday’s Functional Grammar (1985) and Pustejovsky’s Generative Lexicon (1995). Knowledge representation schemes make frequent use of them (Uchida and Meiyng, 2001; Sowa, 2000) as do NLP applications including machine translation (Dorr, 1993, p.110).

The general description of locational and causal relationships might also provide rich input to reasoning systems, for example when determining resultant positional information or resolving causal chains.

2.2. Why use Roles in Translation?

The predominant methods used in commercial automatic translation systems today are the direct and transfer models (Hutchins, 2003a). In these paradigms grammars are developed for each language pair
and translation direction. This has the advantage that the analysis of the source language can be tuned to facilitate the generation of the target language. Additionally, when translating between very similar languages (for example French and Spanish) a shallow analysis is often sufficient, avoiding the computational expense of deep parsing and complete ambiguity resolution. However the drawback is that at least two software modules are required by every language pair. For a translation system that translates in both directions between every pair among \( n \) languages, the number of modules required is \( n(n - 1) \). That would amount to 110 for the eleven official languages of the EU. From a software engineering point of view this far from optimal.

An interlingual approach is more ambitious, but potentially more efficient – examples include (Dorr, 1993) and (Nyberg and Mitamura, 2000). In this paradigm (Hutchins, 2003b) all analysis and generation is via a language neutral semantic representation, the *interlingua*. Deep analysis of the source text results in a stepping-stone representation that can be input to any of the target language generation modules. This decoupling of source and target language involves only \( 2n \) modules (22 for the EU languages), and grammar writers only need have knowledge of their own language. Modules developed to process or produce interlingual representations can also be applied generally to language understanding and generation tasks.

For illustration, consider below how the present-tense pattern corresponding to interlingual like (*expericner, percept*) (see example (10)) might be generated (words that may require inflection are shown with angle brackets).

**English** “expericner<sub>sub</sub> <like> percept<sub>obj</sub>”

**Irish** “Is maith <le> expericner<sub>adj</sub> percept<sub>sub</sub>”

**Chinese** “expericner<sub>sub</sub> xihan percept<sub>obj</sub>”

**Spanish** “expericner<sub>refl</sub> <gustar> percept<sub>sub</sub> expericner<sub>obj</sub>”

For German the generation algorithm would be more complicated (see example (11)) as shown below, but importantly the analysis grammars that produce the interlingual form from other languages need make no allowance for this.

**German** if Person(percept) then “expericner<sub>sub</sub> <mogen> percept<sub>obj</sub>”

else if Event(percept) then “expericner<sub>sub</sub> percept<sub>verb</sub> gern”

else then “percept<sub>sub</sub> <gefallen> expericner<sub>obj</sub>”
2.3. Requirements for Roles

There are three key requirements for thematic roles, by which their suitability can be measured (adapted from (Dowty, 1991) and (Saeed, 1997)). First a successful set of thematic roles must be comprehensive, in that it can be applied to all arguments and clauses in all usages and contexts. Exceptions to this are semantically vacuous elements such as syntactic dummies (e.g. *It* in *It’s raining, it’s pouring*) and speech fillers (e.g. *eh um*).

The role set should also be differentiating. In a given utterance, every argument or clause should have an associated role that is unique to its function. Arguments can share a role, but this only happens when coordinated structures occupy a single grammatical role, as in example (12a), or when they are split across grammatical roles as in (12b) – so called comitatives.

(12) a. [Fergal and Fergus]_{thm} bumped into each other on the street
    b. Fergus_{thm} bumped into Fergal_{thm} on the street

Sentence and nominal modifiers (roles *manner* and *property*) can also have duplicate roles, as in *Truly*_{man}, *Madly*_{man}, *Deeply*_{man}.

Lastly, all assignment of roles should be unambiguous, so that one and only one can be applied to a given argument or clause. It should not be the case that one argument qualifies for multiple roles, or seems to fall ‘between’ roles. There is no principled upper bound for multiple roles, and so such an approach can develop towards a compositional feature based semantics, with obvious consequences for computational performance. A caveat to this involves schemes that specify more than one level of thematic description (Halliday, 1985; Jackendoff, 1990). However roles should remain unambiguous at a given level. In a two tier system such as Jackendoff’s, an argument can have one role from each tier, as in example (19). It would not be allowed for a participant to be both *goal* and *source*, as both belong to the location tier.

3. Models of Roles

While many authors agree on the utility of thematic roles, precisely what set to apply is still open. A primary question is what level of specificity the roles should have (van Valin, 1999).

Pollard and Sag’s HPSG (Sag and Wasow, 1999) uses verb specific roles such as *giver, given* and *givee*, but these add little semantic description, being a systematic restatement of the verb’s (in this case
subject-V-direct object-indirect object) syntactic structure, expressed through verb morphology particular to English. Other ‘splitters’ (i.e. those who have tended to make finer role distinctions) such as Dixon (1991), Halliday (1985) and Fillmore (in his current research programme, Frame Semantics (1982)) have roles that are more general, but still specific to classes of verbs or situations. Dixon’s 30 or so English verb types include classes such as SPEAKING, with the roles speaker, addressee, medium and message and OWN, with the roles owner and possession.

Other than their increased complexity, a drawback of these approaches is that they go beyond describing predicate-argument relationships, as some semantic aspects properly belonging to the verb are duplicated in the role labels (for example, surely agent is adequate to identify the subject of speaking verbs. Speaker seems unnecessarily explicit).

‘Lumpers’ include Anderson (1971), whose localist approach posits three roles (source, location and goal), and Dowty (1991), who proposes just two prototype roles (proto-agent and proto-patient). These compact systems appear to lack the expressive power needed for many common utterances. Dowty’s approach plots arguments in terms of obliqueness and cannot account for verbs of similar meaning but displaying inverted grammatical role structure, such as contain/comprise and fear/frighten (see (4) and (8)). It is also difficult to see how minimal schemes can account for large numbers of arguments, e.g.:

\[(13) \quad \begin{align*}
\text{a.} & \quad \text{I have insured} \ [\text{my house}] \ [\text{against fire}] \ [\text{to a value of} \ $130,000] \ [\text{for} \ $105 \ \text{per month}] \\
\text{b.} & \quad \text{I have insured} \ [\text{my house}] \ [\text{for} \ $105 \ \text{per month}] \ [\text{to a value of} \ $130,000] \ [\text{against fire}] \\
\text{c.} & \quad ? \ \text{I have insured} \ [\text{my house}] \ [\text{to a value of} \ $130,000] \ [\text{for} \ $105 \ \text{per month}] \ [\text{against fire}] \\
\text{d.} & \quad * \ \text{I have insured} \ [\text{against fire}] \ [\text{my house}] \ [\text{to a value of} \ $130,000] \ [\text{for} \ $105 \ \text{per month}]^6
\end{align*}\]

Presumably all three prepositional phrases in this example would be proto-patients for Dowty. The direct object is certainly more proto-patient-like, explaining why other arguments cannot precede it (as in (13d)). But there is no obvious explanation for the relative acceptability of the other possible orderings. And as with Anderson’s three-role system, we have to apply the same label to multiple arguments, violating our requirement for role differentiation.

In this paper I examining the middle ground of semantic relations in the hope that they prove adequate for the description of argument function when translating across languages. Thematic roles aim for the
Table III. Fillmore’s Cases (1968)

<table>
<thead>
<tr>
<th>Role</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agentive</td>
<td>(typically animate) instigator</td>
</tr>
<tr>
<td>Instrumental</td>
<td>inanimate force/object causally involved</td>
</tr>
<tr>
<td>Dative</td>
<td>affected animate being</td>
</tr>
<tr>
<td>Factitive</td>
<td>resulting entity</td>
</tr>
<tr>
<td>Locative</td>
<td>location or spatial orientation</td>
</tr>
<tr>
<td>Objective</td>
<td>affected entity (most neutral case)</td>
</tr>
</tbody>
</table>

economy that specific roles schemes lack, and the level of description that is not offered by generalised roles.

3.1. Roles as Cause and Effect

Charles Fillmore first introduced a set of causal thematic relations in 1968 as Case Grammar (1968): “...semantically relevant syntactic relationships involving nouns and the structures that contain them.” He identified a preliminary list of six differentiating ‘cases’, primarily describing causation (see table III).

Fillmore did not consider this scheme comprehensive, saying that “…additional cases will surely be necessary” – something that he appears not to have pursued.

Sowa (2000, pp.506-512) has adapted the classical model of roles for knowledge representation in a line of research independent of the linguistics literature (see table IV). He loosely bases his scheme on Dick’s (1991) application of a proposal by Somers (1987). Sowa replaces the locational column labels (Source, Path, Goal and Local) of Somers and Dick with the four causes from Aristotle’s Metaphysics: Initiator – initial cause; Resource – material cause; Goal – final cause and Essence – formal cause.

Somers concedes (1987, p.201) that he cannot give a precise characterisation for his original row categories (Active, Objective, Dative, Locative, Temporal and Ambient). Dick describes these labels as “grammatical relations”, but fails to elaborate (1991, p.88).

Sowa replaces these categories with six intuitively clear verb classes, which combined with the participant type and several additional distinguishing features (such as animacy for differentiating agent and effector) correspond to more conventional roles (table V). As such it is a radical reworking and a clear improvement. However, taken literally it seems unworkable. A simple sentence like (14) cannot be expressed with the spatial roles alone, which do not cover causality (14a), nor with the action roles, that do not cover location (14b).
Table IV. Somers-Dick-Sowa Grid

<table>
<thead>
<tr>
<th>Initiator</th>
<th>Resource</th>
<th>Goal</th>
<th>Essence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Action</strong></td>
<td>Agent, Effector</td>
<td>Instrument</td>
<td>Result, Recipient</td>
</tr>
<tr>
<td><strong>Process</strong></td>
<td>Agent, Origin</td>
<td>Matter</td>
<td>Result, Recipient</td>
</tr>
<tr>
<td><strong>Transfer</strong></td>
<td>Agent, Origin</td>
<td>Instrument, Medium</td>
<td>Experiencer, Recipient</td>
</tr>
<tr>
<td><strong>Spatial</strong></td>
<td>Origin</td>
<td>Path</td>
<td>Destination</td>
</tr>
<tr>
<td><strong>Temporal</strong></td>
<td>Start</td>
<td>Duration</td>
<td>Completion</td>
</tr>
<tr>
<td><strong>Ambient</strong></td>
<td>Origin</td>
<td>Instrument, Matter</td>
<td>Result</td>
</tr>
</tbody>
</table>

(14)  
\[ \text{a. } \text{I left work}_\text{origin} \text{ yesterday}_\text{destination}\]  
\[ \text{b. } \text{agent left work}_\text{result} \text{ yesterday}_\text{result}\]  
\[ \text{c. } \text{agent left work}_\text{origin yesterday}_\text{pointInTime} \text{ for my holidays}_\text{result}\]

However, by relaxing the verb class principle and selecting freely from all rows a satisfactory description can be arrived at (14c). Still, some distinctions remain unclear. For example a communication device such as a telephone could be seen as both instrument and medium, while the difference between an experiencer and recipient is more a quality of the event than of the participants.

3.2. Roles as Location and Movement

Jackendoff (1972), building on Gruber’s (1965) work, suggested a set of primarily localist roles as an alternative to Case Grammar. Noticing patterns in the extension of verbs of location and movement to more abstract situations, he posited a single set of “thematic relations” for both (15) – his “Thematic Relations Hypothesis”.

(15)  
\[ \text{a. } \text{Ciara}_\text{them} \text{ stayed at work}_\text{loc/angry}_\text{loc}\]  
\[ \text{b. } \text{Saoirse}_\text{them} \text{ went from Larne}_\text{src to Bantry}_\text{goal} [/from hopeful}_\text{src to exasperated}_\text{goal}\]

He later (1983) extended his hypothesis to temporal and possessive expressions:
Table V. Sowa’s Roles in Detail

<table>
<thead>
<tr>
<th>Role</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agentive</td>
<td>(typically animate) instigator</td>
</tr>
<tr>
<td>Agent</td>
<td>An active animate entity that voluntarily initiates an action</td>
</tr>
<tr>
<td>Beneficiary</td>
<td>A recipient that derives a benefit from the successful completion of the event</td>
</tr>
<tr>
<td>Completion</td>
<td>A goal of a temporal process</td>
</tr>
<tr>
<td>Destination</td>
<td>A goal of a spatial process</td>
</tr>
<tr>
<td>Duration</td>
<td>A resource of a temporal process</td>
</tr>
<tr>
<td>Effector</td>
<td>An active determinant source, either animate or inanimate, that initiates an action, but without voluntary intention</td>
</tr>
<tr>
<td>Experiencer</td>
<td>An active animate goal of an experience</td>
</tr>
<tr>
<td>Instrument</td>
<td>A resource that is not changed by an event</td>
</tr>
<tr>
<td>Location</td>
<td>An essential participant of a spatial nexus</td>
</tr>
<tr>
<td>Matter</td>
<td>A resource that is changed by the event</td>
</tr>
<tr>
<td>Medium</td>
<td>A physical resource for transmitting information, such as the sound of speech or the electromagnetic signals that transmit data</td>
</tr>
<tr>
<td>Origin</td>
<td>A passive determinant source of a spatial or ambient nexus</td>
</tr>
<tr>
<td>Path</td>
<td>A resource of a spatial nexus</td>
</tr>
<tr>
<td>Patient</td>
<td>An essential participant that undergoes some structural change as a result of the event</td>
</tr>
<tr>
<td>PointInTime</td>
<td>An essential participant of a temporal nexus</td>
</tr>
<tr>
<td>Recipient</td>
<td>An animate goal of an act</td>
</tr>
<tr>
<td>Result</td>
<td>An inanimate goal of an act</td>
</tr>
<tr>
<td>Start</td>
<td>A determinant source of a temporal nexus</td>
</tr>
<tr>
<td>Theme</td>
<td>An essential participant that may be moved, said, or experienced, but is not structurally changed</td>
</tr>
</tbody>
</table>

(16) The meeting$_{hm}$ will be at 6pm$_{loc}$

(17) The tricycle$_{hm}$ is mine$_{loc}$!

However, ultimately he admits that his mapping from location to causality is incomplete, and he is forced to introduce an *agent* to his scheme to explain the difference between intended and inadvertent movement of themes.

(18) a. Cian$_{hm}$ rolled down the hill$_{loc}$ (in his sleep)

b. Cian$_{agt&thm}$ rolled down the hill$_{loc}$ (just for fun)
3.3. Hybrid Roles

There are obvious problems with both the purely causal or localist approaches. It is unclear how a localist scheme would tag an instrumental role, as in example (7), and with verbs of perception (e.g. hear, look) whether the experimenter is the goal or the source. Nor is it obvious how a purely causal scheme would distinguish between positional source and goal (e.g. (9)). Because of these difficulties Jackendoff proposes a two-tier scheme (1990) with his localist roles on a ‘thematic’ tier, and causal roles in an ‘action’ tier:

(19)  Pete_{\text{src\&agt}} kicked the ball_{\text{thm\&pat}} down the field_{\text{goal}}

He does not fully expand on this proposal. In particular, besides thematic roles, his version of the Lexical Conceptual Structure (LCS) representation, includes three operators AFF (‘affected’), CAUSE and BECOME that overlap in function with the actor, agent and patient roles. His ‘conceptual parts of speech’ of EVENT, STATE, PATH, MANNER, PROPERTY and THING seem to duplicate some locational and circumstantial roles.

Saeed suggests completing the Jackendoffian scheme as such (1997), and it is this version that I have used in my evaluation:

**Thematic Tier** theme, goal, source, location

**Action Tier** actor, agent, experiencer, patient, beneficiary, instrument

Halliday’s Functional Grammar takes another tack at the question, separating the description of argument function into three tiers: grammatical, psychological and logical (1985). The grammatical tier corresponds to the traditional grammatical roles of *subject, object*, etc. The psychological tier describes salience and focus with the classical notions of *theme* and *rheme* (i.e. topic and comment) and also covers modality (e.g. *must, might, could*) and discourse conjunctions (e.g. *in short, likewise, actually*).

The logical tier concerns participant and circumstantial roles. His participant roles depend upon process types: for example concrete processes have an *actor* and *goal*, mental processes have a *phenomenon* and *senser* and attributive processes (including possession) have a *carrier* and *attribute*. His set of circumstantial roles is particularly rich, but like the participant roles are closely tied to English sentence structure.

Dorr (1993) took Jackendoff’s (1972; 1983) and Levin’s (1993) work as a departure point when designing the semantic representation lexicon
Table VI. Doer’s LCS Roles

<table>
<thead>
<tr>
<th>AG</th>
<th>agent</th>
<th>TH</th>
<th>theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXP</td>
<td>experiencer</td>
<td>INFO</td>
<td>information</td>
</tr>
<tr>
<td>SRC</td>
<td>source</td>
<td>GOAL</td>
<td>goal</td>
</tr>
<tr>
<td>PERC</td>
<td>perceived item</td>
<td>PRED</td>
<td>identificational predicate</td>
</tr>
<tr>
<td>LOC</td>
<td>locational predicate</td>
<td>POSS</td>
<td>posessional predicate</td>
</tr>
<tr>
<td>BEN</td>
<td>benefactive modifier</td>
<td>INSTR</td>
<td>instrument modifier</td>
</tr>
<tr>
<td>PROP</td>
<td>event or state</td>
<td>PURP</td>
<td>purpose modifier or reason</td>
</tr>
<tr>
<td>MANNER</td>
<td>manner</td>
<td>TIME</td>
<td>time modifier</td>
</tr>
</tbody>
</table>

for her interlingual machine translation system UNITRAN, seeking to “...strike a balance between the causal and motion/location dimensions...” (1993, p.111). Computationally her one-tier thematic scheme is more efficient and it mixes roles from both approaches (table VI). She has also adopted Jackendoff’s operators and conceptual parts of speech. As with the Jackendoffian (1990) scheme, I have applied the roles in isolation of the other LCS machinery. A unique feature of her scheme is that she has made freely available a database of verbs (11,000 entries), annotated with argument syntax and thematic structure (2001).

The Universal Networking Language (UNL Centre, 2001) is a machine-tractable (as opposed to theoretically oriented) interlingua for storing and sharing knowledge across computer systems. Thematic roles are at the core of its ‘relations’, describing the relationships between its ‘universal words’. Table VII lists the UNL relations that correspond to participants. Its circumstantial roles and logical relations have been omitted. Besides its richness, an interesting feature of this scheme are the three comitative roles, to express focus distinctions between principal (e.g. Fergus in (12b)) and accompanying entities (Fergal in (12b)) among shared roles.

4. Procedure

To test the candidate role schemes a short representative text that is available in a wide range of world languages (including Irish) was required. The UN Declaration of Human Rights (United Nations General Assembly, 1948) is a 1500 word text, available in translation to more than 300 languages. Despite its legalistic style, it does cover a very wide range of topic areas, including education, politics, religion, law, the family, asylum, ownership, employment, leisure, culture and health.
Table VII. UNL Participant Roles

<table>
<thead>
<tr>
<th>Abbrev</th>
<th>Role Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>agt</td>
<td>agent: a thing which initiates an action</td>
</tr>
<tr>
<td>cag</td>
<td>co-agent: a thing not in focus which initiates an implicit event which is done in parallel</td>
</tr>
<tr>
<td>aoj</td>
<td>thing with attribute: a thing which is in a state or has an attribute</td>
</tr>
<tr>
<td>cao</td>
<td>co-thing with attribute: a thing not in focus is in a state in parallel</td>
</tr>
<tr>
<td>gol</td>
<td>goal/final state: the final state of object or the thing finally associated with object of an event</td>
</tr>
<tr>
<td>ins</td>
<td>instrument: the instrument to carry out an event</td>
</tr>
<tr>
<td>obj</td>
<td>affected thing: a thing in focus which is directly affected by an event or state</td>
</tr>
<tr>
<td>cob</td>
<td>affected co-thing: a thing which is directly affected by an implicit event done in parallel or an implicit state in parallel</td>
</tr>
<tr>
<td>ptn</td>
<td>partner: an indispensable non-focused initiator of an action</td>
</tr>
<tr>
<td>src</td>
<td>source/initial state: the initial state of an object or thing initially associated with the object of an event</td>
</tr>
</tbody>
</table>

The five languages chosen are those that I am familiar with: English, Irish, Chinese, Spanish and German. These cover several branches of the Indo-European family of languages (Celtic, Romance and Germanic) together with a Sino-Tibetan language. Though sharing English's subject–verb–object word order, German differs in allowing object fronting, while Spanish allows object fronting and subject deletion. Irish has a verb–subject–object word order, while Chinese argument realisation is very flexible.

All 30 articles of the Declaration were manually aligned, and then paraphrased in a simplified predicate form that I felt adequately represented the meaning of each article and sub-article of the Declaration as commonly expressed in all five languages. This often resulted in predicate structures quite unlike those that would have resulted from a literal transcription of any of the individual languages.

Then three of the schemes examined were applied to the predicate form: Uchida and Zhu’s UNL, Dorr’s LCS and the expanded version of Jackendoffian Thematic/Action tier model. Some major predicate types (e.g. verbs of movement, cognition, creation etc.) were then evaluated comparatively across the three representations in terms of coverage, differentiation and lack of ambiguity.

4.1. Predicate Form Used

As already mentioned, some simplifying assumptions were made in producing the paraphrased predicate form. Firstly, I assumed that
meaning is compositional at the clause level, so that external relations between predicates will not influence participant relations within those predicates. Hence tense, logical (e.g. and, or) and modal conjunctions (e.g. if, until) have not been annotated.

Complex sentences were deconstructed into component predicates, and nominalisations were given predicate translations (e.g. offence becomes offend(x, y)) where possible. Passive sentences were expressed actively with an undefined subject, and verbal and nominal modifiers (e.g. innocent, according to law) were expressed as one-place predicates.\(^8\)

\[
\begin{align*}
\text{(20) } & \text{Everyone charged with a penal offence has the right to be presumed innocent until proved guilty according to law in a public trial.} \\
\text{(21) } & \text{charge(U,P,penally(offend(P)))} \\
& \text{lawfully(publicly(prove(U,P,guilty(P))))} \\
& \text{entitled(P, presume(U, innocent(P))))}^9
\end{align*}
\]

Helper verbs (e.g. ‘give education’, ‘subject to limitations’ etc.) are ignored and their nominal object becomes the predicate. Thus the meaning of shall enjoy . . . protection is expressed as entitled(P, protect(U, P)):

\[
\begin{align*}
\text{(22) } & \text{a. All children . . . shall enjoy the same social protection. [English]} \\
& \text{b. Bháirfear an chaomhantáisteoiríochta chéanna don uile leanbh} \\
& \text{. . . [Irish]} \\
& \text{given the protection social same to all children . . .} \\
& \text{c. 一切儿童 . . . 都应享受同样的社会保护。} \\
& \text{yīqiě értóng . . . dōuyīng xiàngshòu tóngyuànghé shèhuì bāohù} \\
& \text{[Chinese]} \\
& \text{all child . . . all should enjoy same society protect} \\
& \text{d. Alle Kinder . . . genießen den gleichen sozialen Schutz. [German]} \\
& \text{all children . . . enjoy the same social protection} \\
& \text{e. Todos los niños . . . tienen derecho a igual protección social.} \\
& \text{[Spanish]} \\
& \text{all the children . . . have right to equal protection social}
\end{align*}
\]

I used two subjective criteria to resolve conflicts when deciding on a common predicate structure across languages. Majority rule was one. For example the original form of the English right to be presumed innocent in the other four languages was:
(23) a. is tuigthe é a bheith neamhchiontách [Irish]
be understood that be innocent
b. 有权被视为无罪
yōu quán běishìwéi wúzuì [Chinese]
have right regarded innocent
c. hat das Recht, als unschuldig zu gelten [German]
have the right as innocent to count
d. tiene derecho a que se presuma su inocencia [Spanish]
have right to that one presume their innocence

In this case, the predicate presumed won out, as it was used in both
Spanish and English, and I judged it semantically close to both regarded
(Chinese) and understand (Irish).

Secondly, the most deconstructed predicate form available was used.
Hence, in the example below, the German version which yielded
expel(U,P,Country) was preferred over exile(U,P).

(24) a. No one shall be subjected to...exile
b. Ní déanfar...aon duine...a chur ar deoraíocht [Irish]
not make...single person...that put in exile
c. 任何人不得加以...放逐
rénhé rén būdé jiāyì...fāngzhú [Chinese]
any person must-not be-made...exile
d. Niemand darf...des Landes verwiesen werden [German]
no-one may...the country expel be-made
e. Nadie podrá ser...desterrado [Spanish]
no-one will-be-able to-be...exiled

At present I am not insisting on any particular logical or semantic
model (though I believe this can be done). Rather I am using predicate
form as a vehicle to reveal predicate valency patterns that adequately
reflect meaning as variously expressed in several translations of the
same text. The resulting logical form resembles a higher-order logic, or
a first-order logic with named Skolem functions.

5. Comparative Evaluation

The four classes of situations examined are chosen to cover aspects
of the spatial, causal and psychological domains and are also those
that appeared most often in the Declaration. For each class all the
relevant predicates were identified, and then tagged following each of
the three schemes under consideration, in order to identify problems
and inconsistencies in terms of of coverage, differentiation and lack of
ambiguity.

5.1. Movement and Location Situations

Unsurprisingly these predicates (stay, locate, reside, leave, enter and
move) are straightforward in the Jackendoffian scheme. Subjects are
theme (25a) and, when the movement is intentional, additionally agent
(25b). The object is goal, source or location.

(25)  a. Everyone has the right to recognition everywhere . . .
entitled(P,recognise(U,P)) located(P,Everywhere)
   b. Everyone has the right . . . to return to his country
entitled(P,return(P,possess(P,Country)))
   c. Everyone has the right to freedom of . . . residence . . .
entitled(P,reside(P,Anywhere))
   d. Everyone has the right to leave any country . . .
entitled(P,leave(P,AnyCountry))

In UNL movement situations require an agent subject and the static
situations a thingWithAttribute subject, whether intentional (25c) or
not (25a). The location is assigned place, placeTo or placeFrom.

Dorr’s scheme has the same problem with volition, and it seems that
an agent subject forces a theme object. Both leave(agent, theme) and
leave(theme, source) are possible, but leave(agent, source) apparently
not (25d).

5.2. Directed Action Situations

Situations that do not necessarily bring about a change in the object
(e.g. protect) have theme&agent subjects, and goal objects in the Jack-
endoffian analysis. Affected objects (in telic situations like enslave)
have the additional role patient.

(26)  a. Everyone has the right to . . . protection . . .
entitled(P,protect(U,P))
   b. No one shall be subjected to . . . arrest . . .
not(arrest(U,P))
   c. No one shall be subjected to torture . . .
not(torture(U,P))
Telic situations (26b) are unproblematic for UNL, being agent-V-object, but non-telic situations (26a) are assigned the same pattern.

Dorr’s account of these situations seems to vary somewhat, apparently depending on the ontological type of common arguments. All these situations have an agent subject, but the object is variously theme (e.g. enslave, remedy), goal (e.g. protect, defend) and experiencer (e.g. torture).

5.3. Possession and Transfer Situations

Jackendoff sees possession as an analogy of location: possessions are themes and owners locations; donors sources and recipients goals. It is interesting to note that the syntax of possession in Irish corresponds exactly to this model:

(27) a. Tá [ag gach uile dhuine]loc [an ceart]thm ... be [at every every person]loc [the right]thm ... ‘Everyone has the right ...’ entitled(P,Right)

b. ...rights granted him by the constitution ...

grant(Constitution,Rights,P)

UNL has a dedicated possessor role, and the object carries object, though, as in the previous subsection, it is difficult to see in what respect it is ‘affected’. Transfers (e.g. deprive, grant, provide) originate in the from role, arriving at the to role.

Dorr’s possessor role makes ownership straightforward, but transfer is irregular, variously agent-V-theme-goal (e.g. grant, pay) and agent-V-theme-possessor (e.g. deprive, provide).

5.4. Cognition and Communication Situations

The situations of thinking found in the texts (e.g. believe, think, enjoy, recognise) might be tagged with an theme@experiencer subject and locative object (one believes in something) for Jackendoff. But in contrast to the previous subsection, the structure in Irish is inverted, with the experiencer given a localist realisation.

(28) a. ...áineas [na n-ealaíon]thm a bheith [aige]exp ...
...pleasure [of-the arts]thm that be [at-he/she]exp ...

enjoy(P,Arts)

b. Everyone has the right ... to enjoy the arts ...

entitled(P,enjoy(P,Arts))
For intentional thought (29a) agent would have to replace Jackendoff’s experience - the tier system does not permit multiple roles on a single level. Judgement situations (\textit{conclude, prove, determine}) may have the same structure, but the motivation for tagging the object as \textit{location} is rather weak. Situations of communication (\textit{speak, teach}) have the pattern source\&agent (subject) and theme (direct object) and goal\&experiencer (indirect object).

(29) a. Everyone has the right to freedom of thought …

\hspace{1cm} \text{entitled}(P, \text{think}(P, \text{Anything}))

b. Everyone … has the right to be presumed innocent until proved guilty …

\hspace{1cm} \text{prove}(\text{U}, \text{guilty}(P)) \text{ entitled}(P, \text{presume}(U, \text{innocent}(P)))

c. … to manifest his religion or belief in teaching …

\hspace{1cm} \text{teach}(P, \text{U}, \text{possess}(P, \text{Belief}))

UNL would have to select agent for subjects of all these situations (thus not allowing for inadvertent thoughts). As regards the object, the documentation does not make it clear whether object or thing\textit{WithAttribute} is appropriate.

Finally Dorr’s model is well equipped for cognitive situations. Thinking situations use the \textit{experience\textit{V-percept}} pattern, judgements situations \textit{agent\textit{V-information}} and communication situations \textit{agent\textit{V-goal-information}}.

6. Conclusions

The first thing to note is that there was less divergence in text structure across the languages than was anticipated. Perhaps this is because it is a legalistic text, and so the translation is particularly literal.

The hypothesis that thematic (rather than verb-specific) roles are adequate is supported by the data, as there were no instances where they offered insufficient differentiation or lacked coverage.

As regards which thematic roles to use, the comparison between the three systems regarding coverage, differentiation and lack of ambiguity was perhaps somewhat unfair for several reasons. Firstly, while none of the schemes is accompanied by clear criterial documentation for the assignment of roles, the categories used in the Jackendoffian scheme are better established in the literature, and so easier to apply. Like Jackendoff’s, Dorr’s scheme was handicapped by being in isolation from the rest of the LCS (the roles are not designed to be a wholly independent system) but also because the use of the verb database
removed any flexibility of interpretation for marginal uses (i.e. roles were being assigned on a type rather than token basis). This seems to demonstrate the shortcomings of a class-based subcategorising lexicon such as Levin’s (1993), on which Dorr’s database is based. It also has to be noted that the publicly available UNL documentation is particularly sparse.

Nevertheless, it is surprising that the Jackendoffian scheme proved so convincing, despite having the smallest number of roles. For situations of location, action and possession, Jackendoff’s two-tier system gives the most convincing analyses in terms of differentiation and lack of ambiguity. Dorr’s scheme is the most successful for cognitive situations. Coverage does not present problems for either of these schemes.

The volume of data examined in this study was small, the style restricted and linguistic judgements were not verified by other speakers. However, even under these limited conditions, two of the schemes were manifestly inadequate for the task of translation. More extensive studies with other annotators and text from wider domains might expose further weaknesses in the Jackendoffian scheme, but are unlikely to redeem the single-tier models.

This is compelling vindication of the decoupling of the action and thematic tiers. Dorr’s scheme in particular seems to suffer as a result of the conflation of causality and location. Hence a two tier system, adopting some of Dorr’s participant roles (such as information and property), together with the possible addition of UNL’s comprehensive circumstantial roles, suggests itself as a promising way forward. And as already mentioned, any scheme suited to interlingua-based translation could be applied to a wide variety of language understanding and generation tasks.

While any multi-tier model could complicate computation, it could be precompiled to a single tier of all permutations, such as theme@agent, omitting semantically anomalous combinations such as location@agent and source@experiencer.

Appendix

**Thematic role abbreviations** act – actor; agt – agent; cau – cause; 
exp – experiencer; got – goal; ins – instrument; loc – location; man – manner; pat – patient; pro – property; res – result; src – source; 
tem – temporal thm – theme; twa – thing with attribute;

**Grammatical role abbreviations** adj – adjunct; dobj – direct object; 
ext – external argument; int – internal argument; iobj – indirect object; obj – object; rftx – reflexive; sub – subject;
Notes

1 The roles and interpretations used in these and following examples are intended to illustrate the range of concepts that are encoded using roles, and do not follow any one scheme consistently. See the Appendix for abbreviations used.

2 The term 'spatial' refers to concrete locations and paths, while 'localist' refers to the extension by analogy of spatial concepts into other domains.

3 In this paper I use a simplified logical form to express predicate valency. See section 4.1. for a fuller discussion.

4 These distinctions can also be seen as variable typing restrictions. As such this work can be viewed as a study of the typing patterns that predicates impose on their arguments.

5 Selectional restrictions are semantic requirements that verbs are thought to impose on their arguments. For example the pottery sense of the verb fire requires something made of ceramics as its object, while the military sense requires a weapon.

6 I use the linguistic convention of an asterisk to label a grammatically inadmissible sentence and a question mark to label a doubtful sentence.

7 The term 'thematic' originates in Jackendoff's hypothesis. However over time it has come to be used generally for any semantic role set with a similar level of granularity.

8 Entity abbreviations used are P a person, U undefined entity.

9 The predications guilty(P) and innocent(P) do not constitute a contradiction as they are embedded in intensional contexts. And as mentioned earlier, logical and tense information has been omitted as I consider it external to role relationships.

10 In (Jackendoff, 1990, p.130-141) a react operator is considered to account for cognitive situations, but this suggestion is not developed.

References


Tuning Themes
