

Expressing Procedural Relationships in Multilingual Instructions*

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Abstract

In this paper we discuss a study of the expression of procedural relations in multilingual user instructions, in particular the relations of *Generation* and *Enablement*. These procedural relations are defined in terms of a plan representation model, and applied in a corpus study of English, French, and Portuguese instructions. The results of our analysis indicate specific guidelines for the tactical realisation of expressions of these relations in multilingual instructional text.

Introduction

In user instructions, it is common to find expressions like:

- (1) Pull down and remove the white plastic tray that holds the video cable and unpack the cable.(Apple)

Here we have what appears to be a simple expression of sequential actions. The reader is expected to pull down the white plastic tray, remove that tray, and then unpack the cable. Current studies of instructional text (e.g., Rösner and Stede, 1992; Vander Linden, 1993) typically represent the relationship found here in a simple multi-dependent structure such as that provided by the Sequence schema in Mann and Thompson's Rhetorical Structure Theory (RST) (1988) (see figure 1A). This rhetorical structure, which represents three sequential actions, directly matches the grammatical forms used in the actual text. Indeed, this sequential execution is precisely what the instruction writer desires the reader to

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do in this context. The complication comes when one finds, sometimes even in the same instruction manual, an alternate form of expression for the very same user action, such as the one shown in the following:

- (2) Pull down and remove to unpack the video cable.
(Apple)

RST analysts would most likely represent this with a purpose relation, as in figure 1B. Clearly, the representation formalism fails to capture the common semantics of these two examples.

This problem may be only rarely encountered in a monolingual context, but is exceedingly common in a multilingual environment (Delin et al., 1993). Consider the following example, taken from a trilingual, translated instruction manual for a step-aerobics machine:

- (3) The stepping load can be altered by loosening the locking lever and changing the position of the cylinder foot.(Liftmaster)

- (4) Pour modifier la charge d'appui, desserrer
To modify the load stepping loosen
les leviers puis déplacer le pied des
the levers then change the foot of the
vérins.(Liftmaster)
cylinder foot

- (5) Nach Lockern der Klemmhebel kann
After loosening of the levers can
durch Verschieben des Zylinderfußes die
by pushing of the cylinder foot the
Tretbelastung verändert werden.(Liftmaster)
load changed be.

Here we find the same information being conveyed through expressions that exhibit rather different RST

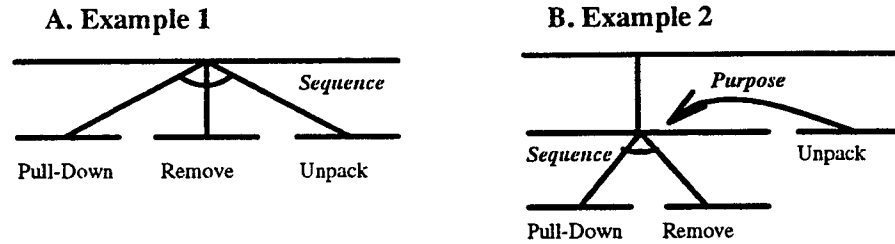


Figure 1: Contrasting Discourse Structures Representations

structures (see Figure 2). The English version is perhaps best characterised as a Means relation, whereas the French is a Purpose relation and the German a Circumstance.

The problem examples such as these raise for generation is twofold: (a) how do we endow our systems with the necessary flexibility to generate alternative expressions of the same basic information and (b) given this flexibility, how do we determine which of the available expressions are appropriate? The root of these problems is that, to date, research in the generation of instructions has failed to take account of the precise procedural relations that underlie the texts. In this paper, we make an excursion into the philosophical literature on Action Theory and the AI literature on plan recognition to find solidly defined procedural relations which can capture the underlying semantics of actions and their relationships in a way that will prove useful for our generation task: building multilingual instructional text generation systems. We present the results of part of an ongoing investigation of the utility of the *Generation* and *Enablement* relations in contributing to our stated goal.

Procedural Relations

The philosopher Alvin Goldman identified two basic procedural relations, *Generation* and *Enablement*, that apply between actions in a task (Goldman, 1970). These have been formalised within the Planning community and shown to be useful constructs for plan recognition (Pollack, 1986; Balkanski, 1993). In this section we review the definitions of *Generation* and *Enablement* and describe how we have applied them in our analysis of a corpus of instructional texts in English, French and Portuguese.

The Generation Relation

A simple test of *Generation* holding between action pairs is whether it can be said that by performing one of the actions (α), the other (β) will *automatically* occur (Pollack, 1986); if this is the case then it can be said that (α) *generates* (β). According to Goldman, *Generation* is a relation applying between two *act-tokens* in certain well-defined situations. For purposes of producing instructions, however, we find it necessary to view *Generation* as holding between *act-types*, since we are dealing

with actions that have not yet taken place; we are able to do this without distorting the general theory that Goldman presents (cf. Pollack, 1986). Here are some canonical examples of this relation taken from Goldman:

- (6)(a) John flips the switch. (α)
 (b) John turns on the light. (β)

where flipping the switch generates turning on the light and

- (7)(a) John moves his queen to king-knight-seven. (α)
 (b) John checkmates his opponent. (β)

where moving the queen to king-knight-seven generates checkmating the opponent.

Following Goldman, *Generation* holds in cases where:

- the actions concerned are performed by the same agent (e.g., John). For reasons that will become clearer later on, we have found it necessary to qualify and extend this part of the definition to actions performed *or perceived to be performed* by the same human agent.
- the relation is asymmetric: if the agent does β by doing α then he does not do α by doing β (e.g., the switch cannot be flipped by turning on the light).
- neither action is subsequent to the other (e.g., the light does not come on after the switch is flipped, or *vice versa*)¹. A useful linguistic test for this is the invalidity of the expression " α and then β ".
- the actions are not co-temporal. Simply stated, if α and β are co-temporal, then one could validly say " α while also β " and *vice versa*, for example, "John strummed the guitar *while also* wriggling his toes". These actions are co-temporal, but not related by *Generation*. One could not validly say that John flipped on the switch while also turning on the light, or moved his queen to king-knight-seven while also checkmating his opponent.
- if the agent had not done α , then he would not have done β ;
- there is a (set of) condition(s) γ (say, George making sure that the light bulb was screwed in) such that

¹According to Goldman, this holds even if the light does not come on for a few seconds after the switch was flipped.

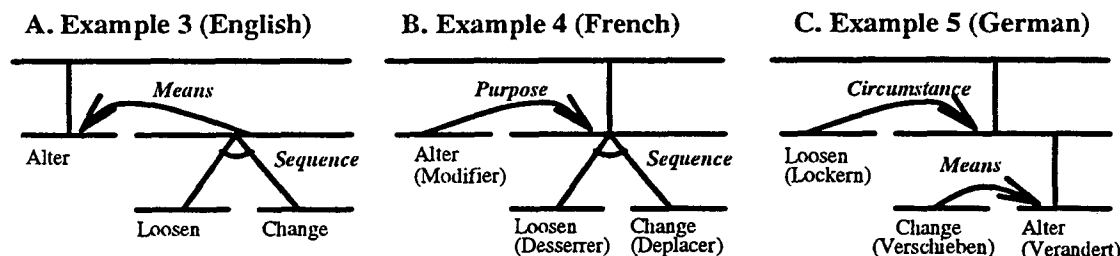


Figure 2: Contrasting Multilingual Discourse Structures Representations

- the conjunction of α and γ entails β ;
- if γ had not obtained, the performance of α would not have led to β .

A *Generation* relation between action pairs can receive a variety of linguistic realisations. Consider the following semantically equivalent instructions:

- (8) *Checkmate your opponent* by moving your queen to king-knight seven.
- (9) Move your queen to king-knight seven *to checkmate your opponent*.
- (10) *If you want to checkmate your opponent*, move your queen to king-knight seven.

Two points are worthy of note here. The first is that although causation plays a key rôle in *Generation*, β is not in a strict sense caused by α ; rather, β is the action of (to use Goldman's term) 'bringing about' the state that is the direct result of performing α under specific conditions (γ). Referring back to example 6, John's flipping of the switch *causes* the event of the light coming on; John's 'bringing about' of this event can be captured by the expression 'turning on the light'.

The second point to be noted is that in the domain of instructions for mechanical and electronic objects there is also a hidden agent – the machine itself, as an agent acting on behalf of the user. This leads to the possibility of equivalence of expressions such as "I deleted the file" and "My computer deleted the file". We consider these to be equally valid expressions of the *generated* part of a *Generation* relation. For example, we also count instructions such as the following (for using a cooking utensil)

- (11) *Imprimez un mouvement de rotation à la garniture, elle se démonte.* (Darty)
Impart a movement of rotation to the plate it itself removes.

as instances of *Generation*. Expressions of generated actions with non-human agents are relatively uncommon in English instructions but (as will be discussed later) this is not true of all languages.

The Enablement Relation

Instructions also include expressions such as the following:

- (12) *You must restart your Macintosh* to use your new software. (Microsoft)
- (13) Before using your data cartridge, *allow it to acclimate to your operating environment for eight hours or for the amount of time it has been exposed to dissimilar conditions whichever is less.* (3M)
- (14) 2 *Double-click the Installer icon with the mouse button.*
 The installer displays an introductory screen.
 3 *Click the OK button.* (Microsoft)
- (15) In order to operate remote control, *you must first have noted or memorised your code.* (Bell)

These are clearly not instances of *Generation*, since the execution of any member of the action pair does not 'automatically' result in the execution of the other. In each case, some intermediating action(s) is required. Following Goldman (1970), this type of relation between action pairs is most commonly referred to as *Enablement* (Pollack, 1986; Balkanski, 1993; Di Eugenio, 1992). Goldman does not provide a formal definition of this relation, but Pollack gives a useful general definition: "... when α enables β , then the agent needs to do something more than α to guarantee that β will be done." (Pollack, 1986, page 40). A more detailed definition is provided by Balkanski: "... Action A_1 enables action A_3 if and only if there is a set of conditions, C, such that one of the conditions in C, C_i , holds as a result of the performance of A_1 , and either there is a third action A_2 such that A_2 conditionally generates A_3 under C, or C is the executability condition of A_3 ." (Balkanski, 1993, page 41).

Enablement applies to all four examples above because in them, one action brings about conditions that are necessary, but not necessarily sufficient for the subsequent performance of the other. In example 12, the reader must restart the Macintosh in order to be in a position to be able to use the new software. There are in fact other actions necessary for the use of the software, but they are not mentioned. Acclimating the cartridge in example 13 is not sufficient to make it in use. Similarly, in example 14, clicking on the Installer icon only brings about a set of conditions (in this case, the appropriate menu) for the user to click the OK button. In example

15, the reader must know the code in order to be able to operate the remote control, although knowing the code is not enough.

Note that in some cases of *Enablement* (e.g., in 12 and 13), the intermediate action can in fact be performed in the absence of the enabling condition; the result will simply be that the enabled action will not occur. In others however (e.g., examples 14 and 15), the intermediate action is impossible to perform when the enabling condition does not hold.

An important property of *Enablement* which distinguishes it from *Generation* is that the *enabled* and *enabling* actions can be carried out by *different* human agents. Goldman alludes to this in his discussion of example 6, where he introduces a necessary condition for the *Generation* of John turning on the light: George's screwing the bulb into the socket.

As in the case of some of the *Generation* examples we saw before, actions in *Enablement* relations can be expressed as an activity carried out by a human agent or by, say, a machine or in terms of the associated state of the agent. For example, example 15 could equally have been expressed as the following:

- (16) In order to operate remote control, *you must know your code.*
- (17) For the remote control to operate, *you must first have noted or memorised your code.*

A Formalisation

From our discussion so far, it is clear that the relations of *Generation* and *Enablement* should be identifiable aspects of plans for performing procedures. We employ a plan formalism that is a simple extension of STRIPS-styled operators developed by Fikes (1971) and expanded in the NOAH system (Sacerdoti, 1977). In our representation, plans comprise:

goal(s): an action (or set of actions) which motivate(s) the use of the plan;

constraints: states which must hold before a plan can be employed. Constraints cannot be achieved through planning;

side-effects: states which arise as unplanned effects of carrying out a plan;

a body: an action or action complex which executes the plan; if these are not primitive, they can themselves be achieved through another plan;

preconditions: an action or action complex which, when carried out, leads to conditions necessary for the successful execution of the plan; i.e., the body will be executable but its execution will not generate the goal (even if the constraints hold) unless the precondition is realisable. Preconditions can be planned for.²

²This type of preconditions relates to Pollack's (1986) *generation-enabling condition*.

Plans must minimally have a body and goal. Actions, in turn, comprise:

constraints: these have the same properties as the constraints on plans;

side-effects: these also have the same properties as the side-effects on plans;

effects: states which arise from the *bringing-about* of the action;

preconditions: like the preconditions of plans, these are either an action or an action complex and can be planned for. Unlike the preconditions of plans, however, their effects must hold before the action can take place (i.e., the action cannot result if the precondition does not hold).³

Actions must minimally have an effect. Finally, states can have evidences. These are phenomena which signify that the state holds.

As in all STRIPS-based planning formalisms, plans in our representation can have associated sub-plans. In our case, sub-plans arise through the body of a plan, the preconditions of a plan, or through the preconditions of an action.

Having set out this scheme, we can now proceed to identify instances of *Generation* and *Enablement* within our representation for instructions:

α generates β iff α is the body of a plan ϵ whose goal is β .

α enables β if α is a precondition of a plan ϵ and β is the goal of plan ϵ , or if β is the body of ϵ and α is a precondition of β .

Figure 3 shows graphically the relationship between the notion of a plan and the *Generation* and *Enablement* relations.

Generation and Enablement in Instructions

We have shown through examples that *Generation* and *Enablement* can be expressed in a variety of ways. In instruction generation, it is clearly important to signal the correct relationship between actions, since failure to do so could lead to situations where the user diligently carries out the action without achieving the desired effect. For example, if the following *Enablement* relation

- (18) To clean the case: disconnect the power plug.(Microsoft)

is misperceived as *Generation* (as it might be were it to be expressed as "Clean the case by disconnecting the power plug"), the user would believe that by disconnecting the plug she would be guaranteed to achieve her goal of cleaning the case; this would only result in frustration, bewilderment and a still dirty case. We are thus

³This notion is closely related to Balkauski's (1993) definition of *executability condition*.

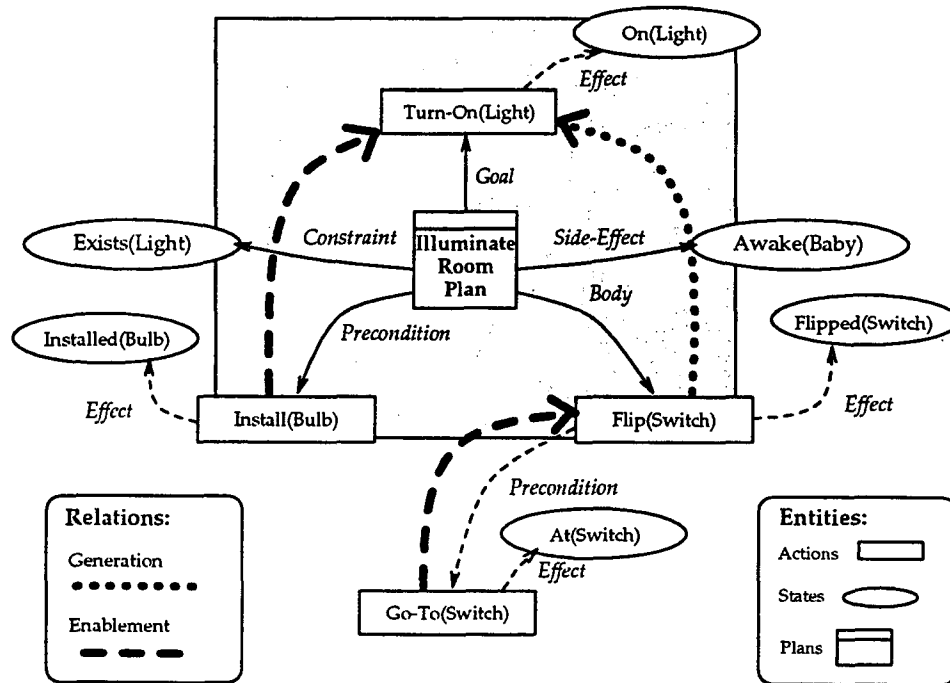


Figure 3: Generation and Enablement in the Plan for Turning on the Light

concerned to generate only the *appropriate* expressions for *Generation* and *Enablement*.

Our approach to this problem is to look to the data: we are analysing a corpus of commercially-produced instructions for manual tasks to extract the mappings between *Generation* and *Enablement* and linguistic form. The results of our study inform our design of a system for generating draft instructions in multiple languages from a common, language-independent, representation. We describe some of our results in this section, based on our analyses of English, French and Portuguese instructions.

The data we report are from original texts written in the particular language being addressed; they are not the product of translation. Our method of analysis is to identify instances of *Generation* and *Enablement* from the corpus and to register its grammatical form. We report here only on data for which we all agree on the chosen procedural relationship.

In analysing the data, our main concern has been to determine:

1. What are the commonly used mappings from *Generation* and *Enablement* onto language?
2. Which forms are ambiguous between *Generation* and *Enablement* and how can we exploit this information for generation?
3. What are the factors that influence the 'appropriateness' of a selected form?

The English Results

The English corpus is made up of 451 clauses (approximately 3500 words) taken from 9 instruction manuals intended for non-expert readers. A detailed accounting of the grammatical forms used to express *Generation* relations is shown in table 1. Similar statistics for *Enablement* relations are shown in table 2.

The general results of these mappings are shown graphically in figure 4, and as can be seen, there are grammatical forms which tend to be exclusively used for either *Generation* or *Enablement* (imperative + by, sequence, and before conditions) and other forms that are common to both relations (to infinitives and for phrases).

The most common forms shown in tables 1 and 2 appear to be clear patterns of use which can be exploited in text generation, rather than just random selections or artifacts of this particular corpus.

Expressing Generation in English In our corpus, *Generation* relations tend to be expressed with either the imperative + by, the imperative + to infinitive, or one of a set of *for* phrases. These forms, which together constitute 80% of the *Generation* relations identified, are exemplified here in examples from manuals for a Macintosh colour monitor and for a Bell telephone answering machine:

- (19) If your computer system does cause interference to radio or television reception, try to correct the interference by using one or more of the following mea-

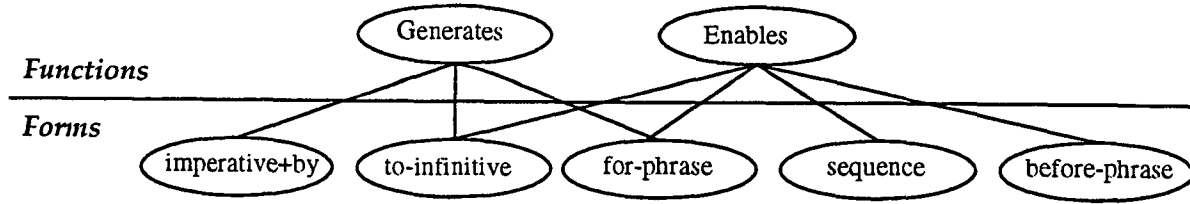


Figure 4: The English function to form mapping of Generation and Enablement Relations

Grammatical Form	Count	Percentage
To Infinitive	30	46.1%
For Phrases	14	21.5%
Imperative + by	8	12.3%
Clause Sequences	3	4.6%
7 other forms	10	15.4%
<i>Total:</i>	65	

Table 1: The frequency of English grammatical forms for Generation Relations

Grammatical Form	Count	Percentage
Sentence Sequence	22	47.8%
To Infinitive	10	21.7%
For Phrases	5	10.9%
Before Conditions	4	8.7%
Imperative + by	1	2.2%
4 other forms	4	8.7%
<i>Total:</i>	46	

Table 2: The frequency of English grammatical forms for Enablement Relations

sures:(Apple)

- (20) To interrupt playback, rotate the VOLUME knob towards the rear, past the 'click'.(Bell)
- (21) See your authorized Apple dealer for information on screen save programs.(Apple)

In example 19, the action of using "one or more of the following measures" generates the action of correcting the interference. They are performed by the same human agent, asymmetric, one does not occur before the other, and there exist the specified conditions γ ; the same pattern is repeated in examples 20 and 21.

The first question is what to make of the gaps? Why are *Generation* relationships so infrequently expressed using sequences of clauses, and never expressed using *before* clauses? This clearly follows from the definition of *Generation* that neither action can be subsequent to the other, a relationship that is strongly implied by sequences. There are cases where *sentence sequences* are used to express *Generation*, but these are infrequent and occur in very specific syntactic situations (Vander Linden, 1993). In general, grammatical forms which

typically function as expressions of sequence should be avoided when expressing *Generation* relationships because they tend to mislead the reader by suggesting the performance of two distinct actions.

Concerning the question of identifying the contexts in which the imperative + by, the to infinitive, and the for phrase arise, it has been observed that syntactic constraints and lexical availability appear to motivate the use of the imperative + by form and the for phrasal forms (Vander Linden, 1993).

Expressing Enablement in English *Enablement* relations tend, in 89% of the cases, toward *before* conditions, one of a set of *sequence* forms, imperative + to infinitive and other for phrasal types. Examples of these forms are given here:

- (22) Quit all applications before beginning the following procedure.(Microsoft)
- (23) Switch off at the mains, disconnect the power adaptor and remove the cassette. Wipe the tape heads and pinch roller gently with a cotton-wool bud dipped in tape head cleaning fluid or methylated spirits.(Bell)
- (24) Return to seat to place calls.(Airfone)
- (25) PLEASE SAVE THESE INSTRUCTIONS FOR FUTURE USE.(Playschool)

In example 22, quitting all applications is an action intended to bring about a set of conditions compatible with "beginning the following procedure", as are the actions of removing the cassette, returning to the seat, and saving these instructions in examples 23, 24, and 25 respectively. None of them are sufficient to achieve their intended goal.

The gap in the expressions of *Enablement* is that they are seldom expressed using the imperative + by form. As can be seen in tables 1 and 2, there is only one *Enablement* expressed as an imperative + by as opposed to eight *Generation* relations expressed that way. It seems inappropriate, for instance, to express the actions in example 24 as "Place calls by returning to your seat" because it tends to imply that returning to your seat is all you have to do to achieve the goal. We, thus, would restrict the use of the imperative + by to the expression of *Generation* relations only.

The French Results

The French corpus comprises 14 sets of instructions

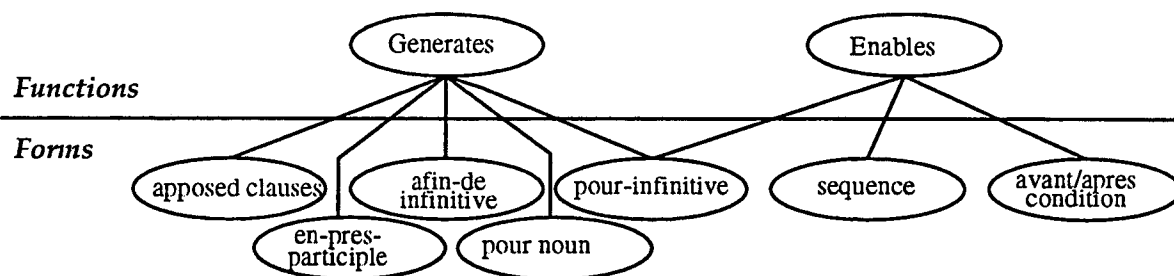


Figure 5: The French function to form mapping of Generation and Enablement Relations

Grammatical Form	Count	Percentage
En-present-participle	12	33.3%
Pour-infinitive	8	22.2%
Apposed clause	5	13.9%
Pour-noun	4	11.1%
Afin-de-infinitive	4	11.1%
3 other forms	3	8.3%
<i>Total:</i>	36	

Table 3: The frequency of French grammatical forms for Generation Relations

Grammatical Form	Count	Percentage
Et-sequence	13	40.6%
Pour-Infinitive	6	18.8%
Avant-conditions	6	18.8%
Après-conditions	4	12.5%
2 other forms	3	9.4%
<i>Total:</i>	32	

Table 4: The frequency of French grammatical forms for Enablement Relations

for French-produced domestic appliances and for home improvement. Thus, the texts are intended for non-specialists. Most have a word-count of between 200 and 400 words. We set a target of collecting some 30 examples of each relation, expressed in single sentences rather than across sentence boundaries. The examples were vetted by a native speaker.

The statistical analysis of surface forms is given in tables 3 and 4. The graphical representation of these data, shown in figure 5, indicates only one form to be common to both relations.

Expressing Generation in French French has a realisation of this relation that is distinct from English, as we showed in example 11, and can see again here in an instruction from a Philips telephone manual:

- (26) Appuyer 2 fois sur la touche MEMO,
Press 2 times on the key MEMO,
 le numéro se compose alors
the number itself dials then

automatiquement.(Philips)
automatically.

Here the information is expressed through clauses which are in apposition. The same information could have been expressed as:

- (27) Appuyer ... sur la touche pour
Press ... on the key for
 composer ...
to dial ...

It is examples such as these that led us to modify Goldman's definition of *Generation*. In French it is common to achieve agent deletion by using a reflexive verb whose syntactic subject is the semantic theme of the corresponding full transitive verb. Although there is no explicit agent of the action, agency is readily inferred and the spirit of Goldman's definition is preserved. Moreover, the word "automatically" is in a sense redundant, serving to emphasize the fact that the result is achieved with no further action on the part of the agent.

Agent deletion may also be achieved by de-verbal nominalization, as in the following examples from manuals for a cooking utensil and for do-it-yourself home improvement:

- (28) La poussée du ressort interne dégage
The push of the spring internal releases
 le poussoir.(Darty)
the push button.

The most frequent realization is by the *en* present participle form, for example in:

- (29) Soulever manuellement le flotteur au
Raise manually the float to the
 maximum en tirant sur le
maximum by pulling on the
 bras.(Castorama 50.11)
arm.

Although it is tempting to view this form as the direct equivalent of "by + ing", it is also available for relating distinct co-temporal actions, with no implication that one is achieved by execution of the other, as in the following instruction for a jar opener:

- (30) Serrer la poignée de blocage d'une
Tighten the blocking-handle with one
 main en maintenant le bocal de
hand while holding the jar with
 l'autre main.(Tefal)
the other hand.

The next example illustrates a further common realization using "pour" which reinforces the observation that generated actions and evidences appearing in the same sentence are expressed differently:

- (31) Sélectionner une touche du clavier (de
Select a key of the pad (from
 1 à 9) pour rendre la ligne (la tonalité
1 to 9) to return the line (the tone
 revient).(Philips)
returns).

It is worth noting that, although "pour" and "afin de" are generally considered interchangeable in this syntactic construction, the latter is, in our corpus, used exclusively to express *Generation* while "pour" realizes both procedural relations.

Expressing Enablement in French It is in the expression *pour* infinitive that *Generation* and *Enablement* overlap. However, the construction so strongly signals *Generation* for French readers that they may have difficulty construing an *Enablement* relation:

- (32) Dévisser le flotteur de son bras pour
Unscrew the float from its arm for
 le remplacer.(Castorama 50.11)
it to renew.
- (33) Tracer deux parallèles à l'axe
Draw two parallel-lines to the axis
 vertical pour tapisser l'intérieur du
vertical for to paper the inside of the
 cadre.(Castorama 70.04)
frame.

While the intermediate steps between action and goal are obvious in example 32, it is far from self-evident in example 33 that the action enables the placing of the moulding that will frame the wall-paper when it is eventually hung.

Interestingly, in half of its occurrences in *Enablement* expressions, "pour" precedes "pouvoir" ("to be able"), making the goal explicitly an enabling state and denying other expectations:

- (34) Diluer la peinture pour pouvoir la
Dilute the paint for to be able it
 pulvériser.(Castorama 20.11)
to spray.

The unacceptability of the following example supports this analysis:

- (35) ?? Flip the switch to be able to turn on the light.

The most frequent realization within the sentence is with the conjunction "et" ("and"), which coincides with the English findings:

- (36) Démonter la buse et la nettoyer
Dis-assemble the nozzle and it clean
 avec un petit pinceau.(Castorama 20.11)
with a brush small.

Temporal markers of sequence account for the remaining 41% of the examples. By definition, they cannot express *Generation*. In contrast to the English results, we noted a number of instances of "après" ("after"), as well as "avant" ("before"):

- (37) Démonter le réservoir après avoir
Dismantle the tank after having
 dévissé les deux
unfastened the two
 vis de fixation.(Castorama 20.11)
fixing screws.

The ordering of the action descriptions in the text is the reverse of that required in the world. The same is often true, of course, of expressions using "avant". However, the latter appear calculated to preempt rather than provoke a rash action on the part of the reader.

The Portuguese Results

The Portuguese corpus discussed here comes from 8 sets of instruction manuals written in Brazilian Portuguese. The manuals are taken from consumer products; they are aimed at a non-specialist audience and they vary from between 2 to 7 pages in length. As with our analysis of the French data, we set ourselves the task of examining the relationships between the *Generation* and *Enablement* relations and syntactic forms in approximately 30 examples of each relation. In what follows, we present the result of our analysis of the 33 *Generation* and 32 *Enablement* relations taken. A detailed accounting of the grammatical forms used to express *Generation* relations is shown in table 5. Similar statistics for *Enablement* relations are shown in table 6.

The results of these mappings, displayed graphically in figure 6, show a pattern of almost exclusive use of grammatical realizations for the two underlying relations; we will argue that in fact there is *no* overlap in our data between expressions of the two relations. In general, the pattern of results for Portuguese is rather closer to our findings for French than for English.

Expressing Generation in Portuguese In our Portuguese data, expressions of *Generation* most often involve the "para" connective, primarily followed by an infinitive (*Para* + *Infinitive*) and on rarer occasions by a nominal phrase (*Para Noun*). Consider, for example, the following instructions from manuals for an electric saw and a mini vacuum cleaner:

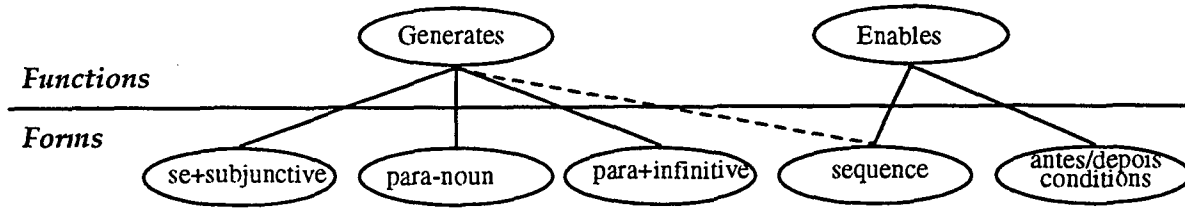


Figure 6: The Portuguese function to form mapping of Generation and Enablement Relations

Grammatical Form	Count	Percentage
Para+Infinitive	23	70%
Se+Subjunctive	3	9%
Para+Phrases	2	6%
Sequence	1	3%
2 other forms	4	12%
<i>Total:</i>	33	

Table 5: The frequency of Portuguese grammatical forms for Generation Relations

Grammatical Form	Count	Percentage
Sequence	25	78%
Depois Conditions	4	12%
Antes Conditions	3	9%
<i>Total:</i>	32	

Table 6: The frequency of Portuguese grammatical forms for Enablement Relations

(38) Para colocar a serra na posição de
To put the saw in the position of
 corte oblíquo, solte a porca borboleta e
cut oblique free the screw butterfly and
 incline a sapata para o ângulo
incline the shoe to the angle
 desejado. (Black&Decker)
desired.

(39) Para a montagem, encaixe os
For the mounting, fit the
 implementos conforme demonstra a
implements consistent with what shows the
 figura 07. (Dustbuster)
figure 07.

Of the remaining forms, two are a direct consequence of the preference for using *para* forms, combined with the tendency in the language towards long sentences. A good example of this is shown in the following, taken from a manual for a garden tractor:

(40) A CADA 100 HORAS,
Every 100 hours,

drene o resto de combustível quando
drain the rest of the fuel when
 o nível estiver no mínimo
the level is at the minimum
 para retirar a água e impurezas
to get rid of the water and impurities
 contidas no tanque
contained in the tank
 para não sobrecarregar o filtro
to not overload the filter
 e dar melhor durabilidade na bomba
and give better endurance in the pump
 injetora e bico injetor,
injector and jet,
 resultando em consequência, em melhor
resulting in consequence, in better
 funcionamento do motor. (Tobatta)
performance of the motor.

Sentences such as these, with long chains of *Generation* relations, are not unique in Brazilian Portuguese⁴. As noted, the preferred signal of the *Generation* relation is “para”. For stylistic reasons (i.e., to avoid using the same connective to link the four instances of *Generation* within this sentence), the author has chosen to introduce some elegant variation. The third connective “e” (“and”) appears as a *Sequence*, but what is in fact happening here is that the author has elided the “para” from the expression “e para” (“and to”). *Sequence* is in fact reserved for *Enablement*, but here the “e” (a typical example of a *Sequence* marker) is not misleading, since the reader has been primed by the ‘rhythm’ of the preceding sequence of “para”s to interpret it as yet another one. Similarly, the choice of the expression *resultando em consequência* seems to be motivated by the desire to avoid using yet another *para*. This expression of *Generation* on its own would be extremely awkward:

(41) ?? Não sobrecarregue o filtro
Do not overload the filter
 resultando em consequência em melhor
resulting in consequence in better
 funcionamento do motor.
performance of the motor.

⁴This example demonstrates the transitivity feature of *Generation*, discussed by Goldman (1970).

Expressing Enablement in Portuguese The 8 Portuguese manuals we report on here contained many fewer instances of *Enablement* than *Generation*. Interestingly, although *para* is normally also the default expression of *Enablement*, we found no instances of it in our data, presumably because this form is such a strong marker of *Generation*. Instead, we find *Enablement* to be expressed through signals of the temporal ordering of the actions involved. This we refer to as *Sequence*: a string of imperatives, either in consecutive sentences, or within a sentence and linked by the conjunction “e” (“and”).

- (42) Recoloque o filtro de pó e monte
Re-put the filter of dust and mount
 novamente o aparelho.(Dustbuster)
once again the appliance.

or *Antes/Depois* Conditions, sequential steps signaled by the use of “antes de” (“before”) or “depois de” (“after”) or their equivalents (e.g. “diante” (“before”) or “após” (“after”)):

- (43) Antes de usá-lo leia atentamente as
Before using it read carefully the
 instruções.(Dustbuster)
instructions.

- (44) Após colocar o plugue na tomada,
After to put the plug in the outlet,
 pressione para baixo a tecla do
press downwards on the key of the
 interruptor.(Café Quatro coffee machine)
interruptor.

As in the French examples, the use of expressions such as *antes de* tend to arise in cases where the writer appears to be attempting to preempt rather than provoke a rash action, as in the following:

- Desligue a serra da tomada, antes de
Unplug the saw from the outlet, before
 fazer qualquer ajuste.(Black&Decker)
to make whatever adjustment.

Discussion

Our study so far provides some important guidelines for representing and expressing *Generation* and *Enablement*, which we are soon to begin implementing in our system for generating multilingual drafts of instructions for software use and for carrying out administrative procedures. The *Generation* and *Enablement* relations have proved here to be a valuable means for capturing, in a language-independent form, some of the deep semantic relationships underlying procedures. The data analysis we report on has suggested the range of appropriate syntactic expression of *Generation* and *Enablement* in English, French and Portuguese, and regions of potential ambiguity. For example, the indications are that *Pour* infinitive expressions in French should be avoided where possible (except where followed by “*pourvoir*”),

as should be expressions in English which use the *To* infinitive despite the fact that they are by far the most frequent form of *Generation* in our English corpus.

Clearly, the results we present here are only indicative; as we increase the size of our corpus we expect to gain a clearer picture of the relationships between the procedural relations and their linguistic expressions. So far we have not examined the influence of the wider context in which the instances of *Generation* and *Enablement* occur in the corpus, and although we are informed on the allowable and preferable mappings from *Generation* and *Enablement* to language, we are not yet in a position to identify the influences affecting the selection of the most appropriate expression for a given instance of *Generation* or *Enablement* in a particular context. In addition, the rôle of RST in our final architecture is still not clear; we suspect that if a rôle exists, it will be to inform the choice of expression from within the allowable set.

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References

- Balkanski, C. T. (1993). *Actions, Beliefs and Intentions in Multi-Action Utterances*. PhD thesis, Harvard University.
- Delin, J., Scott, D., and Hartley, T. (1993). Knowledge, intention, rhetoric: Levels of variation in multilingual instructions. In *Proceedings of the Workshop on Intentionality and Structure in Discourse Relations*, June 21, Columbus, OH, pages 7–10.
- Di Eugenio, B. (1992). Understanding natural language instructions: The case of purpose clauses. In *Proceedings of the Annual Meeting of Association for Computational Linguistics*, Newark, DE, pages 120–127.
- Fikes, R. E. and Nilsson, N. (1971). STRIPS: a new approach to the application of theorem proving to problem solving. *Artificial Intelligence*, 2:189–208.
- Goldman, A. I. (1970). *A Theory of Human Action*. Prentice Hall, Englewood Cliffs, NJ.
- Mann, W. C. and Thompson, S. A. (1988). Rhetorical structure theory: Toward a functional theory of text organization. *Text: An Interdisciplinary Journal for the Study of Text*, 8(2).
- Pollack, M. E. (1986). *Inferring Domain Plans in Question-Answering*. PhD thesis, University of Pennsylvania. SRI Technical Report SRIN-403.
- Rösner, D. and Stede, M. (1992). Customizing RST for the automatic production of technical manuals. In Dale, R., Hovy, E., Rösner, D., and Stock, O., editors, *Aspects of Automated Natural Language Generation*, Lecture Notes in Artificial Intelligence 587, pages 199–214. Springer Verlag, Berlin.
- Sacerdoti, E. D. (1977). *A Structure for Plans and Behavior*. Elsevier, New York.
- Vander Linden, K. (1993). *Speaking of Actions: Choosing Rhetorical Status and Grammatical Form in Instructional Text Generation*. PhD thesis, University of Colorado. Available as Technical Report CU-CS-654-93.