Towards Generating Procedural Texts: an exploration of their rhetorical and argumentative structure

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Abstract

Instructional texts consist of sequences of instructions designed in order to reach an objective. The author or the generator of instructional texts must follow a number of principles to guarantee that the text is of any use. Similarly, a user must follow step by step the instructions in order to reach the results expected. In this paper, we explore facets of instructional texts: general prototypical structures, rhetorical structure and natural argumentation. Our study is based on an extensive corpus study with the aim of generating such texts.

1 Introduction

Instructional texts, also equivalently called procedural texts, consist of a sequence of instructions, designed with some accuracy in order to reach an objective (e.g. assemble a computer). Procedural texts explain how to realize a certain goal by means of actions which are at least partially temporally organized.

Procedural texts often exhibit a quite complex rational and 'irrational' structure, outlining different ways to realize something, with arguments, advices, conditions, hypothesis, preferences, evaluations, user stimulations, etc. They also often contain a number of recommendations, warnings, and comments of various sorts.

Another feature is that procedural texts tend to minimize the distance between language and action. Plans to realize a goal are made as immediate and explicit as necessary, the objective being to reduce the inferences that the user will have to make before acting, and therefore potential errors or misunderstandings.

In our perspective, procedural texts range from apparently simple cooking receipes to large maintenance manuals (whose paper versions are measured in tons e.g. for aircraft maintenance). They also include documents as diverse as teaching texts, medical notices, social behavior recommendations, directions for use, assembly notices, do-it-yourself notices, itinerary guides, advice texts, savoir-faire guides etc. Procedural texts obey more or less to a number of structural criteria, which may depend on the author's writing abilities and on traditions associated with a given domain. There is obviously a big contrast between maintenance manuals and people magazines which both contains such texts. Procedural texts can be regulatory, procedural, programmatory, prescriptive, injunctive, or may introduce advices (for social of psychological behavior) [1].

The study we present in this paper has three main goals:

- First, to be able to accurately respond in natural language to How? (procedural) questions. Procedural question answering systems are much of interest both to large public via the web, and to more technical staff for example to query large textual databases dedicated to various types of procedures [6].

- Next, to be able to select the best text (assuming a single text is selected as a response) w.r.t. the user profile when there are several responses (a frequent phenomenon on the Web),

- Finally, and for the long term, to be able to merge procedural texts or fragments of procedural texts to construct an optimal text, in terms of level of detail, illustration, etc. Integrating texts is obviouly a long-term challenge.

This paper basically relates the structure of procedural texts as they are in French. English translations of examples are just glosses, they are given when space constraints permit. We believe that besides language realization variants, most of the characteristics we present here are language neutral. This study is based on an extensive corpus study, within a language production perspective. This approach allows us to integrate logical, linguistic (e.g. [17], [5]) and philosophical views of argumentation.

In this paper we first introduce some elements of a general typology of procedural texts, outlining the number of components, rational and irrational, that compose them. We then give the most important structural elements, and the rhetorical structure that characterizes the relations between elements. Finally, we focus on argumentation, a major dimension of procedural texts and we briefly present the forms of arguments which are the most important, and under what constraints they can be generated.

2 State of the art

2.1 General typology

Procedural texts have been studied in psycholinguistic, linguistic and didactic circles. We briefly survey various ap-

proaches here, outlining elements of interest for our objectives.

Under the heading of procedural texts, there is a quite large diversity of texts. J.M. Adam [1] notices the variability of judgments in procedural text categorization. Texts can, for example, be grouped into families according to their main objectives and style. We have, for example:

- regulatory texts [16] that characterize expected behaviours,

- procedural texts [13] defined as rather liear sets of instructions,

- 'programmatory' texts [11] which include receipes, musical scores and architectory plan, identifie how knowledge from an expert is transferred via these texts to users who are expected to follow strictly the instructions which are given.

- instructional-prescriptive texts [21], where a quite detailed analysis of temporal and event structures is carried out,

- injunctive texts, where [2] show the form and style used in short notices that relate e.g. fire instructions, security measures, etc.,

- advice texts [14], which include advice texts of various sorts, such as those found in large public magazines.

- receipe texts [18], which is a domain quite well-studied, for example in language generation.

Despite their goals, all these forms share common structures: specification of goals, description of lists of prerequisites to reach the goal, and description of sequences of instructions. They also share common stylistic forms, e.g. preferences for imperative forms, and a number of typographic elements such as enumerations.

2.2 Informational content

Two works will be used as the starting point of the development of the discursive structure of procedural texts that we have elaborated (see section 3.). G.R. Bieger [7] propose a taxonomy of the contents of instructions in 9 points: inventory (objects and concepts used), description (of objects and concepts), operational (information that suggest the agent how to realize an action), spatial (spatial data about the actions), contextual, covariance (of actions, which evolve in conjunction), temporal, qualificative (manners, limits of an information), emphatic (redirects attention to another action).

One of the main works in Computational Linguistics is due to [12]. She isolated 9 main structures or operations, called *semantic elements* from corpus analysis:

1. sequential operations: a necessary action that the agent must realize,

2. object attribute: description meant to help understand the action to realize,

3. material conditions: environment in which an action must be carried out,

4. effects: consequences of the realization of a group of operations on the world,

5. influences: explain why and how and operation must be realized,

6. co-temporal operations: expresses synchronization of operations,

7. options: optional operations,

8. preventions: describes actions to be avoided,

9. possible operations: possible operations to do in the future.

She also identified 7 rhetorical relations (sequence, c-condition, elaboration, goal, result, manner, concurrence) which present those semantic elements. She positionned her work on automatic text generation : how to select the information and how to present it into a coherent text.

2.3 Argumentation

Procedural texts are specific forms of discourse, satisfying constraints of economy of means, accuracy, etc. They are in general based on a specific discursive logic, made up of presuppositions, causes and consequences, goals, inductions, warnings, anaphoric networks, etc., and more psychological elements (e.g. *to stimulate a user*). The goal is to optimize a logical sequencing of instructions and make the user feel safe and confident with respect to the goal(s) he wants to achieve (e.g. *clean an oil filter, learn how to organize a customer meeting*).

Procedural texts, from this point of view, can be analyzed not only just as sequences of mere instructions, but as efficient, one-way (i.e. no contradiction, no negotiation) argumentative discourses, designed to help a user to reach a goal, making the best decisions (see e.g. [3], [4]). This type of discourse contains a number of facets, which are all associated in a way to argumentation. Given a certain goal, it is also of much interest to compare or contrast the means used by different authors, possibly for different audiences.

In most types of procedural texts, in particular social behavior, communication, etc. procedural discourse has two dimensions: an explicative component, constructed around rational and objective elements, and a seduction component whose goal is (1) to encourage the user, (2) to help him revise his opinions, (3) to enrich the goals and the purposes, by outlining certain properties or qualities or consequences of a certain action or prevention.

Producing explanations is a rather synthetic activity whose goal is to use the elements introduced by knowledge explicitation mechanisms to induce generalizations, subsumptions, deductions, relations between objects or activities and the goals to reach. This is particularly visible in the lexical choices made and in the choice of some constructions, including typographic; procedural discourse is basically interactive: it communicates, teaches, justifies, explains, warns, forbids, stimulates, evaluates.

Let us finally note a few NLG-oriented papers centered on the generation of arguments such as [22], which focus on generic types of arguments (ad absurdum, from cases, etc.) and [8].

3 A Discursive analysis of procedural texts

The complexity of procedural texts leads us to proceed very gradually in the study of their structure before being able to produce even simple such texts. At an intermediate level, responding in natural language to How? questions, using underspecified templates is an interesting step which can be evaluated.

We collected a corpus of procedural texts from which we extracted the main structure via the design of a grammar. The corpus contains several types of procedural texts: receipes, maintenance manuals, medical notices, assembly, advice texts, etc. The grammar was enriched as the analysis progresses. Finally a second corpus was gathered to conduct a manual evaluation of the grammar. An annotation tool based on the grammar and on related marks has been developped in order to automatically evaluate on larger samples. The structures reported below essentially correspond to (1) the organization of the informational contents: how tasks are planned, according to goals and subgoals, and (2) to the argumentative strategies used (planning, progression of tasks, warnings, advices, evaluations, etc.). General principles of argumentative discourse are given e.g. in [9].

In what follows, parentheses express optionality, + iteration, the comma is just a separator with no temporal connotation a priori, / is an or and the operator < indicates a preferred precedence. Each symbol corresponds to an XML-tag, allowing us to annotate procedural texts,.

The top node is termed objective:
objective → title, (summary), (warning)+, (prerequisites), (picture)+ < instruction sequences.

summary → title+
Summary describes the global organization of the procedure, it may be useful when procedures are complex (summary can be a set of hyper-links, often pointing to titles).

warning → text , (picture)+, (pre-requisites).

pre-requisites → list of objects, instruction sequences.
Pre-requisites describe all kinds of equipments needed to realize the action (e.g. the different constituents of a receipe) and preparatory actions. It may also include presuppositions on the user profile and abilities.

picture describes a sequence of charts and/or schemas of various sorts. They often interact with instructions by e.g. making them more clear.

Instruction sequences is structured as follows:
instruction sequences → instseq < discursive connector < instruction sequences / instseq.

instseq is then of one of four main types below:
instseq → (goal), imperative linear sequence / (goal), optional sequence / (goal), alternative sequence / (goal), imperative co-temporal sequence.
Goal may contain, besides the target itself motivations,

manners, references etc.

Each type of instruction sequence is defined as follows:
imperative linear sequence → instruction < (temporal mark), imperative linear sequence/ instruction. (e.g. *inspect carefully if the filter is clean and then open the valve*)

optional sequence → conditional expression, imperative linear sequence. (e.g. *if you prefer a stronger flavor, add curry powder and cream.*)

alternative sequence → (conditional expression), (argument) imperative linear sequence, (alternative-opposition mark) < instseq / (conditional expression, instseq)+. (e.g. *if you can locate the COM1 port, then ... otherwise, or if you wish to be more cautious or cannot locate it, dismount ....*).

imperative co-temporal sequence → imperative linear sequence < co-temporal mark, < imperative co-temporal sequence / instruction.
A co-temporal sequence relates instructions which must be realized at the same time.

Finally, Instruction is the lower level and has the following structure, with recursion on objective:
instruction → (iterative expression), action, (reference)+, (goal)+, (manner)+, (motivation), (limit), (picture)+, (warning) / objective.
Instructions can be complex since they may contain their own goals, warnings and pictures. If an instruction is complex it is analyzed as an objective.

As an illustration, the annotation of an alternative sequence which is analysed as "embedded conditions" is given, page 4.

3.1 Rhetorical structures

Rhetorical structures play several roles in our approach. They first give a semantics to the discursive structure syntax given above. They also contribute to enhancing the production of well-designed responses [12]. They are also useful, as shall be seen below, to allow for the integration of procedural texts dealing with similar objectives or goals, but this is an extremely difficult task. Finally, they are used to answer questions with a higher accuracy by clearly identifying e.g. instruments (for the instrumental how), risks (via the warnings) and equipment needed (via the prerequisites).

The RST [15] is a descriptive theory that specifies 23 possible relations showing how two portions of a text are linked. Previous work on procedural texts [12], [20], [19], used limited RST relations and suggested additional relations that fit procedural texts, which we use for our own analysis (limit, alternative, concurrence). We identified 16 rhetorical relations among which we introduced 6 new relations from our corpora analysis:

- **Option**: is considered when an action depends on the existence of a conditional situation. Note that this relation can also link two sequential actions, where one is

Figure 1: An example of an annotated alternative sequence

compulsory and the other depends on the subject will or on the situation itself (*steam the fish for 10 minutes and put it 5 minutes in the oven if you want it to turn brown*).

- **Reference**: holds between an action and a segment which provides the localisation (in the text or in related texts via hyperlink) of the detailed procedure, (*remove the reductor (see page 18)*); This relation occurs also between the summary (which contains the subgoals of the global objective) and the related instruction sequences.

- **Prevention**: is usually a relation between an action and its warnings. Satellites include expressions such as: be careful not to ..., and 'don't' expressions (*cut the wood planks, don't draw any line!*).

- **Prerequisites**: occur between an action or an objective and a list of of entities and instruments or a set of actions without which the action or the objective cannot be realized (*changing a car wheel : to change a wheel is not difficult, with the proviso of having in one's car the good tools : wheel brace, jack, clean rag, torch (if dark), warning triangle*).

- **Concurrence**: occurs between two rival co-temporal actions (*to choose the best computer, run the program A on Mac, at the same time run the program B on PC. If Mac detects the component before the PC, then use Mac, otherwise use PC*).

- **Development**: allows for the identification of the procedure and sub-procedures in a text. It usually links the titles or the goals to the instruction sequences.

The chart below summarizes, for the rhetorical relations we use, the elements in our grammar which are involved.

Rhetorical relations	kernel-sattelite or multi-kernel pairs
Sequence	Instruction-imperative linear sequence
	Instruction sequence - instseq
Result	Goal-imperative linear sequence
	Goal-optional sequence
	Goal-alternative sequence
	Goal-imperative co-temporal sequence
	Instruction-imperative linear sequence
	Goal-action
Purpose	Imperative linear sequence - goal
	Optional sequence - goal
	Alternative sequence- goal
	Imperative co-temporal sequence - goal
	Action - goal
Evaluation	Goal-imperative linear sequence
	Goal-optional sequence
	Goal-alternative sequence
	Goal-imperative co-temporal sequence
	Goal-action
Limit	Action - limit
Alternative	Imperative linear sequenc - instruction sequence
	Instruction sequence - instseq
Means	Action - manner
Reference	Action - reference
	Summary - Instruction Sequences
Prerequisites	Title-prerequisites
Option	Optional expression-imperative linear sequence
	Instruction sequence - instseq
Prevention	Title-warning
	Action - warning
Condition	Imperative linear sequence - optional expression
	Imperative linear sequence - conditional expression
	Instruction sequence - instseq
Concurrence	Imperative linear sequence - imperative co-temporal sequence
Co-occurrence	Imperative linear sequence - imperative co-temporal sequence
Motivation	Action - motivation
Development	Goal - imperative linear sequence
	Goal - optional sequence
	Goal - alternative sequence
	Goal - imperative co-temporal sequence
	Goal - action
	Title - instruction sequences
	Summary - instruction sequences

4 Argumentation in procedural texts

Argumentation is found in the expression of procedural text objectives, in the expression of disjunction, alternatives, warnings, and within instructions.

Let us review here the four major forms of arguments we frequently found in corpora. We outline here the main conceptual and syntactic structures that characterize each of these forms. Verb classes referred to are in general those specified in WordNet [10]:

- **'Objective or goal' arguments**: are the most usual ones. They usually introduce a set of instructions or more locally an instruction. Their target is the "goal" symbol of the grammar. They basically introduce causality between a goal and the set of instructions that realize it. The abstract schemas are the following: (1) purpose connector-infinitive verb, (2) causal connector-deverbal and (3) titles.

  - purpose connectors : pour, afin de, etc. (to, in order to) (e.g. *to remove the bearings*, *for lubrification of the universal joint shafts*).
  - titles : infinitive verbs or deverbals (e.g. *engine dismount*).

- **Prevention arguments**: embedded either in a 'positive' or a 'negative' formulation. Their role is basically to explain and to justify. Negative formulation is easy to identify: there are prototypical expressions that introduce the arguments. Negative formulation follows the abstract schemas : (1) negative causal connector-infinitive risk verbs; (2) causal connector-modal +VP(negative polarity, infinitive); (3) negative causal mark-risk verb class VP; (4) causal connector-VP(with negation); (5) causal connector-prevention verb.

  - negative causal connectors: sous peine de, sinon, car sinon, sans quoi, etc. (otherwise, under the risk of) (e.g. *sous peine d'attaquer la teinte du bois*).
  - risk verb class: risquer, causer, nuire, commettre etc. (e.g. *pour ne pas commettre d'erreur*).
  - prevention verbs: éviter, prévenir, etc. (e.g. *afin d'éviter que la carte se déchausse lorsqu'on la visse au châssis*, gloss: *in order to prevent the card from skipping off its rack*).
  - causal connector and negation: de facon à ne pas, pour ne pas, pour que ... ne ...pas etc. (in order not to) (e.g. *pour ne pas le rendre brillant*, gloss: *in order not to make it too bright*).
  - modal VP: pouvoir, pouvoir-être (e.g. *car il peut être usé prématurément par la défaillance d'un autre*, gloss: *because it may be prematurely worn due to the failure of another component*).

Positive formulation marks are the same as for the first category of arguments described above. We have the following abstract schemas: (1) purpose mark-infinitive verb; (2) causal subordination mark-subordinate proposition, (3) causal mark-proposition:

  - purpose marks: afin de, pour (so as to, for).
  - causal marks: car, c'est pourquoi etc. (e.g. *car ceux-ci sont les plus délicats*).
  - causal subordination marks: afin que, pour que, etc. (so that, for).
  - the verbs encountered are usually of conservative type : conserver, maintenir, etc.

To discriminate arguments using purpose marks from those of the first class, we can use a reformulation criterion. Positive prevention arguments can be reformulated to a negative form using negative causal connectors or verbal inferences (e.g. *afin que la semence adhère bien au sol → car sinon la semence n'adhèrera pas au sol* (gloss: in order for the crop to adhere to the ground / otherwise the crop will not adhere to the ground)).

- **Performing arguments**: These arguments are less imperative than the others, they are rather advices, evaluations. The corresponding abstract schemas are: (1) causal connector-performing NP; (2) causal connector-performing verb; (3) causal connector-modal-performing verb; (4) performing proposition.

  - performing verbs: e.g. *permettre, améliorer, etc.* (*allow, improve*).
  - performing NP: e.g. *Pour une meilleure finition; pour des raisons de performances*.
  - performing proposition: e.g. *Have small bills. It's easier to tip and to pay your fare that way*.

- **Threatening arguments**: These arguments have a strong impact on the user's intention to realize the instruction provided, the instruction is made compulsory by using this kind of argument. This is the injunctive form. It follows the following schema: (1) otherwise connector-consequence proposition; (2) otherwise negative expression-consequence proposition

  - otherwise connectors: sinon.
  - otherwise negative expression: si ... ne ...pas... (e.g. *si vous ne le faites pas, nous le périmerons automatiquement après trois semaines en ligne*, if you do not do it, we will revoke it immediately).

Besides these four main types of arguments, we found some forms of stimulation-evaluation (what you only have to do now...), and evaluation.

5 Injunctive forms

Let us now say a few words about interesting syntactic and morphological characteristics. First, we found no sign of author positioning: there is no use of personal pronoun like 'I' or 'We'. However, the author's enunciation is made visible in French by the use of imperative and infinitive verbal forms. The most important form is certainly the injunctive discourse. It characterizes certain modalities of discourse: orders, preventions, warnings, avoidances, advices. These all have a strong volitive and deontic dimension.

Injunctive discourse shows how the author of an procedural text imposes his point of view to the user. The goal is that the user knows how to execute it in a way as explicit and less ambiguous as possible. The user is assumed to have the required competences to realize it.

Procedural texts are an example of a logic of action. Injunction is particularly frequent in cooking receipes, security notices, etc. Its strength is measured via the illocutionary force of the statement. In general we observed that infinitive or imperative modes are used in French. Some examples of injunction forms are given below, from which we could construct dedicated NLG templates:

- infinitive: *Mettre la poudre dans le verre* (put the powder in the glass).

- imperative: *Enlevez la bague supérieure du bol d'articulation à l'aide d'un burin* (gloss: *remove upper bushing from socket using a chisel*).

- modal verbs: *Vous devez enduire la face intérieure du pivot de pâte d'étanchéité SILICOMET* (gloss: *you must coat internal face of pivot with SILICOMET sealing compound*).

- preference expresssion : *"il est conseillé de ...", "nous vous recommandons de ...", "il est préférable de ..."* (it is advised to, we recommend that).

- negative infinitive form: *Ne pas utiliser de facon prolongée sans avis médical* do not use on the long term without medical advice.

In everyday life, we encounter many injunctions posted in public areas. In French, these injunctions follow in general these regular structural schemas:

- deverbal-infinitive (e.g. *défense d'afficher* (gloss: *stick no bills*).

- courtesy formula-negative infinitive (e.g. *prière de ne pas fumer* (gloss: *no smoking (please)*).

6   Conclusion

In this paper, we briefly shown the variety of structures, rational and somewhat irrational that organize procedural texts. We conducted this research with the main goal of generating responses in a cooperative way to How? and Why? questions. The long-term goals are to select the best text w.r.t. a user profile, and then to be able to integrate texts on the same topic to get a better text.

This preliminary step is now stabilized, and we designed an annotation tool, based on the grammar and related marks, to implement and evaluate our results. However, to get a more accurate view of the diversity of argumentation in this type of text, we need to also consider more subtle language forms such as: modalisators, tonality, opinion marks, evaluation marks, illocutionary force in injunctions, etc.

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