

A dynamic model of route description

Lidia Fraczak and Guy Lapalme
DIRO, Université de Montréal, CP 6128, Succ. Centre-Ville,
Montréal, Québec H3C 3J7, Canada
`fraczak,lapalme@iro.umontreal.ca`

Abstract

Producing a route description involves two tasks: *determination* of the route and its *description*. The result of the first task is the *referential representation* of the route, which is used as an input to the second task. We try to explain how this representation gives rise to the text. Our model is dynamic as it accounts for the transitions between different stages of the processing. It allows to explain some corpus-observed characteristics of route descriptions and the differences in descriptions of the same route. Our first application of the model is an automatic generator of subway route descriptions.

1 Introduction

Route description is a widely used type of discourse which has been the subject of cross-disciplinary research within Cognitive Science [Rie80, WR82, Kle82, PC90, Car92, Maa93, Maa94, GL95, Den97, DB97]. The theoretical interest of route descriptions is the study of cognitive processes involved in producing and understanding them, whereas their practical interest concerns designing computer systems for assisting people in navigation.

Producing a route description involves two tasks: *determination* of the route and its *description*. In order to modelize the way people describe routes, it must be explained how the route representation which results from the determination process, and which is analogical in nature (be it mental or real), gives rise to a linguistic representation. Several authors have addressed this problem. Klein [Kle82] proposes that the route that has been determined in the form of a “primary plan” is then processed into a “secondary plan”. The latter consists of information progressively selected from the “primary plan”. This information includes “fixed points”, “directions” related to these points, and “actions”, and it is described in the text by using appropriate expressions. Denis [Den94, Den97] mentions similar elements:

“landmarks” and “actions”, implicitly situating them on an intermediate level of representation between the source route representation and the text. In Gryl’s model [Gry95, GL95] “landmarks” and “actions” are parts of larger structuring components: “local descriptions”, which correspond to places where a decision must be made concerning direction, and “paths”, which represent the sections of the route without any change of direction. Maaß [Maa93, Maa94] defines two intermediate representations between the route, such as determined on a map and then perceived in the environment (in a co-piloting situation), and the text. The first one, called “spatial representation”, contains the representation of a path “segment”, “landmarks”, and “spatial relations”, whereas the second one, called “presentation representation”, contains the information which will be expressed in the text (for example “actions”).

The previous route description models lack a “dynamic” aspect. This means that, while defining different stages of the process, they do not take account of the transitions between those stages: they do not explain *how* some intermediate representation and its constituents appear or give rise to a text. For example, many authors mention “actions” as information expressed in route descriptions but they never explain where these actions come from. In Klein’s model, “actions” are part of the “secondary plan”, but it is not well specified how they relate to the “primary plan”, which is defined as a fragment of the “cognitive map”. A similar problem appears in the model of Maaß: “actions” are included in the “presentation representation” but it is not clear how they appear given the previous stage, which is the “spatial representation”.

The “how” of discourse producing or understanding is a challenge for Cognitive Science in general. In the perspective of discourse understanding, cognitive psychologists have proposed two main levels of mental representation: a text-based representation and a referential representation (“mental model” or “model of the situation”) [JL83, vDK83]. Some hypotheses concerning the formats and contents of these two types of representation have been made, but little is known about the transitions between them. Our paper sheds some light on this aspect in the context of route description.

We start by reporting on the empirical data that we used. Then we present our cognitive model of producing route descriptions. We concentrate on the discursive part of the process, i.e. on the *description* task, with the objective of showing how the *referential representation* of the route, resulting from the *determination* task, gives rise to a *textual representation*. At the end, we describe our first application of the model: an automatic generator of subway route descriptions.

2 Empirical data

Empirical study is an essential step of cognitive modeling. Since our objective was to model the processing underlying route descriptions, we used examples of such descriptions as empirical data. We analyzed different kinds of route descriptions, mostly in French. Our data is mainly constituted by three corpora, collected by Gryl [Gry92], Corpinot [Cor93], and Lebib [Leb94]. They contain altogether one hundred and forty examples describing pedestrian routes in an urban area (town and university campus). Example 1 below comes from the corpus of Gryl.¹

Ex. 1 *Tu descends la rampe. Tu prends la première à droite. Tu vas voir le bâtiment F et tu vas toujours tout droit. Tu vas arriver sur le restaurant universitaire et sur la gauche tu as la bibliothèque.*

(You go down the footbridge. You take the first turn to the right. You will see the building F and you continue straight on. You will arrive at the university restaurant and on the left you have the library.)

We also collected and analyzed a similar corpus of route descriptions in Polish in order to check that the regularities observed before are not language dependent. Other types of route descriptions have been taken into consideration. We collected and analyzed a corpus of thirty descriptions of Parisian subway routes [Fra98]. We give below an example from this corpus.

Ex. 2 *À partir de Saint-Lazare, prendre la ligne 3 en direction de Gallieni. S'arrêter à la station Opéra et changer pour prendre la ligne 7 en direction de Mairie d'Ivry. La station Jussieu est la 7-ième après Opéra.*

(From Saint-Lazare, take the line number 3 in direction of Gallieni. Stop at station Opera and transfer to the line number 7 in direction of Mairie d'Ivry. Station Jussieu is the 7th after Opera.)

We also looked at a corpus of route dialogs in a car co-piloting situation in the area of Paris [BD96]. The use of this variety of data was necessary insofar as not to restrict our model to some particular context of producing route descriptions.

3 Global cognitive model

The process of route *determination* (see figure 1) uses two kinds of knowledge: *referential* knowledge, which concerns the environment of the route, and *pragmatic* knowledge, which concerns the communication situation and, in particular, the needs

¹French examples are followed by their English translations.

of the “questioner” (such as his/her place of departure, destination, means of transportation, preferences, time and cost constraints, etc.). The *determination* process gives as a result a *referential representation* of the route.

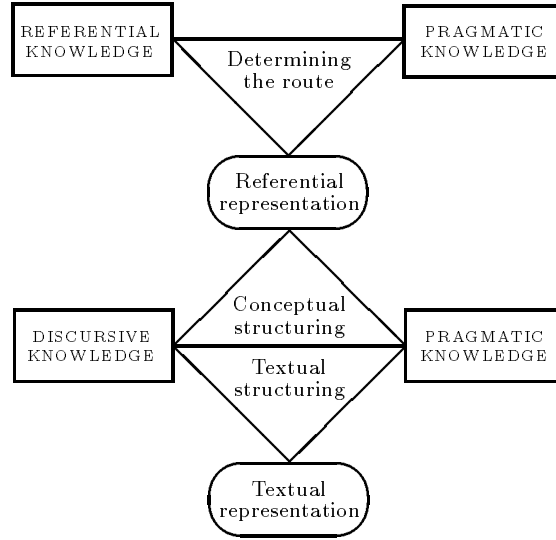


Figure 1: Model of the cognitive processes involved in the producing of a route description.

The *referential representation* has a spatial and a temporal aspect. The spatial aspect comes from the referential knowledge of the environment, whereas the temporal one is related to the pragmatic knowledge, namely concerning the fact that the questioner’s intention is to travel (which implies temporal progression). Thus, the *referential representation* is an ordered succession of spatial representations. It does not have to be entirely “mental” in nature, which is the case when it is based on a long-term referential knowledge. It may also merge the “mental” and the “real”; then it appears as a delimitation performed mentally on the environment or on the map. For example, in a car co-piloting situation where the co-pilot is not familiar with the route (situation considered by Maaß), this delimitation is performed on both the map and the surrounding area. In the situation of robot guiding [LMMV97], the *referential representation* used by a human guide is the result of the guide’s mental delimitation of successive parts of the environment in which the robot has to navigate. A *referential representation* may also be of a purely “real” nature, for example a graphic plan of the route which is to be verbalized.

The *referential representation* is the input of the *description process*. This process is divided into two tasks: *conceptual structuring* and *textual structuring*, the

underlying principles being part of the *discursive knowledge*. *Pragmatic knowledge* is also used at this level of processing: it is concerned with such factors as the questioner’s cognitive and linguistic capacities. The *description process* results in a *textual representation* of the route, i.e. in a “route description”. We analyze this process more precisely in the following.

4 Route description process

The route description process consists in “translating” the *referential representation* of the route into its *textual representation*. Given the temporal constraints of the working memory and of the verbalization, we assume that this process is incremental, i.e. that a part of the referential representation is processed and “translated” into a part of the text at one time.

The description process is composed of two parts: *conceptual* and *textual*. We discuss the principles underlying conceptual and textual structuring in the following sections. Since both are inter-dependent, the description of one has to be done in relation to the other. Thus, to illustrate the principles of conceptual structuring we will use text fragments, and to define the principles of textual structuring we will refer to conceptual entities.

4.1 Conceptual structuring

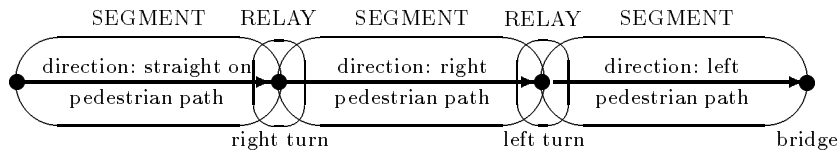
By *conceptual structuring*, we mean a set of cognitive operations which “adapt” the reference in view of the verbalization. The conceptualization of the route, such as we define it, is specific of the verbal task. This is why we consider it to be a part of the *description process*.

The first, or “global”, level of conceptualization consists of structuring the route into successive spatio-temporal units: *segments* and *relays*. A *segment* corresponds to a part of the route (such as represented in the *referential representation*) having the same characteristic(s), whereas a *relay* corresponds to a change of route characteristic(s). The problem that arises here is what kinds of referential characteristics are considered for this structuring. The structuring units distinguished by other authors (for example, “segments” of Maaß, or “paths” and “local descriptions” of Gryl), tend to be defined on the basis of direction. Our corpus analysis has shown the possible use of other criteria for structuring the route into *segments* and *relays*: for example, the type of the road or the surrounding environment. The distinction of these criteria allows to explain some differences observed in descriptions of the

same route. We compare below two pairs of examples, by illustrating with graphic sketches the structuring that they express.

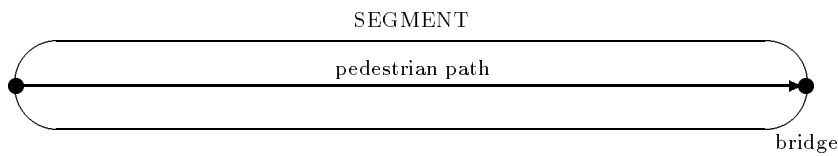
Ex. 3 *Prendre le chemin piétonnier qui va tout droit. Descendre, ensuite tourner à droite puis à gauche. [Arrivé au pont, ...]*

(Take the pedestrian path that goes straight on. Go down the path, then turn to the right, then to the left. [When you arrive at the bridge, ...])



Ex. 4 *Continuer par un chemin piétonnier jusqu'à un petit pont.*

(Continue by a pedestrian path until you get to a little bridge.)

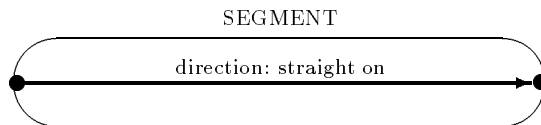


Examples 3 et 4 refer to the same route fragment: a pedestrian path which contains two turns. In example 3, the changes of direction have been used to structure this fragment into three *segments*, whereas in example 4, the criterion that was used is that of the road type, and this is why only one *segment* has been distinguished.

We compare below two other examples, which describe another route fragment and which also structure it differently, using different referential criteria.

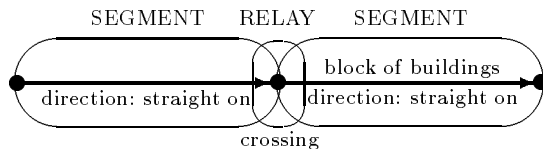
Ex. 5 *[Tu descends le grand pont,] tu vas tout droit [et c'est à gauche].*

([You go down the big bridge,] you go straight on [and it's on the left]).



Ex. 6 *[Suivre la passerelle qui descend. À son extrémité, prendre à droite] puis tout droit jusqu'à l'intersection. De là, on poursuivra tout droit par la route qui longe le corps de bâtiments situé à sa gauche.*

([Follow the footbridge that goes down. At its end, turn to the right] then go straight on up to the crossing. From there, you will continue straight on by the road along a block of buildings situated on your left.)



Example 5 expresses only one *segment* from the “big bridge” (“footbridge”) to the end of the route, using the criterion of the continuous direction (“straight on”). In example 6, on the other hand, the same route fragment is structured into two *segments*: the second segment is distinguished with respect to the characteristic of the surrounding area corresponding to “block of buildings”. The *relay* between two segments corresponds to the characteristic “crossing”.

The temporal aspect of the route is conceptualized in terms of *steps*. We define four kinds of steps: *start-segment*, *transfer-segment*, *end-segment*, and *transfer-relay*. They are illustrated in figure 2. Table 1 below gives textual examples referring to each kind of step.

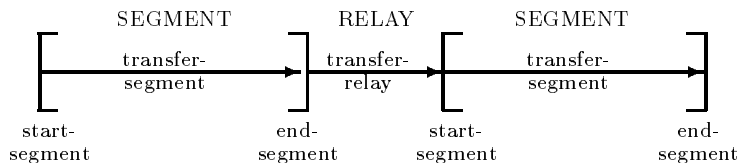


Figure 2: Conceptualization of the temporal aspect of the route.

Steps	Route description
start-segment	<i>prendre la rue perpendiculaire à la voie (take the street perpendicular to the railway)</i>
transfer-segment	<i>descendre en direction de l'église (go down in the direction of the church)</i>
end-segment	<i>on arrive à une intersection (you arrive at an intersection)</i>
transfer-relay	<i>traverser (cross it)</i>

Table 1: Textual illustration of *steps*.

Another type of conceptual entities are *landmarks*. They represent the spatial aspect of the route. We define a *landmark* as a conceptual entity having the form of attribute–value pairs which correspond to the characteristics of some part of the reference. A *landmark* can be composed of only one attribute, such as the “type” of the referential object (ex. “a building”), or several attributes, for example the

“type” and the “name” (“building A”), the “type” and the “dimension” (ex. “a big building”), etc. We also consider the “location” to be a landmark’s attribute. Thus a description such as “the buildings which are on the right” corresponds to a *landmark* composed of the following attributes: “type: building”; “quantity: several”; “location: left”.

We distinguish four kinds of landmarks depending on the part of the route that they are associated with: a *segment-landmark* is associated with a whole segment, a *relay-landmark* is associated with a relay, a *step-landmark* is associated with only one step, and a *frame-landmark* is associated with a larger part of the route, for example two segments and one relay.

Landmarks are considered by the other authors as components of a route description or as kinds of information expressed in it. They are, however, defined directly with respect to the referential objects, such as buildings, streets, etc. In our view, a referential categorization of *landmarks* is not interesting because *landmarks* referring to the same kind of object may fulfill different functions in a route description. Thus, a building may be used, for example, as a *relay-landmark*: “you arrive at building A”, or as a *segment-landmark*: “you take the building on your left and you go to the end”. In example 7 below, the building “church” (French “église”) has the function of a *step-landmark*, as it is only associated with one step: *start-segment*. Note that the “crossroads” (“carrefour”), which is mentioned before, is a *relay-landmark*, and the “little road” (“petit chemin”), mentioned later, is a *segment-landmark*.

Ex. 7 *Prendre la rue jusqu’à un carrefour. Là, traverser. Il y a une église juste avant la pente. Prendre le petit chemin et descendre jusqu’en bas.*

(Take the street up to a crossroads. Cross it. There is a church just before the slope. Take the little road and go all the way down.)

Also, the same referential object may be used in a route description as a landmark having more than just one function. This is the case in example 8 below, where landmark “campus” is used as a *relay-landmark*, but it also has an implicit function of a *frame-landmark*, being associated with all the following parts of the route.

Ex. 8 *En descendant du RER, tu tournes à gauche. Tu arrives directement sur le campus. Tu prends la rue qui se trouve en face. Tu vas jusqu’aux panneaux d’informations. Tu tournes à droite. Tu vas jusqu’au bout de cette rue. Tu arrives devant le restaurant universitaire. Tu tournes à gauche et tu arrives à la bibliothèque.*

(When you get off the train, turn to the left. You arrive directly on the campus. You take the street in front of you. You go up to the information signs. You turn

right. You go as far as the end of the street. You arrive in front of the university restaurant. You turn left and you arrive at the library.)

Given the conceptual structuring of the route that we have introduced, we are able to define the notion of *action*. This notion appears in previous route description models at some level close to the text. For example, Maaß places *actions* in the “presentation representation” and Klein in the “secondary plan”, both these representations being considered as directly underlying the verbalization. However, as we have already remarked, the origin of the concept *action* seems to be taken for granted. The problem is not trivial though if we consider the intuition that one has of a “dynamic”, or “temporal”, aspect of an *action*, and the fact that the representations proposed by the authors as preceding the appearance of this concept in the route description process are often of a purely spatial nature (e.g. “cognitive map”, “spatial representation”). Some authors do mention a dynamic feature at some time or another (e.g. “procedure components” in the “internal representation” of Denis, or the notion of “imaginary travel” through the “primary plan” of Klein), but this still does not allow for a model-based definition of *action*. The reason is that the dynamic (temporal) aspect of the route is not conceptualized within those models. We have addressed this problem by representing the temporal structuring of the route in terms of four kinds of *steps*.

We define an *action* as a relation between a *step*, which is a temporal entity, and a *landmark*, which is a spatial entity. This relation is operated in view of the verbalization of a part of the route. However, not each such relation will have a status of an *action*. Two supplementary conditions apply: (1) both entities that are being related, a *step* and a *landmark*, must be associated with the same “global” conceptual unit of the route: a *segment* or a *relay*; (2) at least one of these entities must be “new” with respect to the linear progression of the route. If one of the conditions is not satisfied, then we call the relation a *pseudo-action*. We illustrate the differences between *actions* and *pseudo-actions* with the textual examples below. Such an illustration is indeed possible because, as we have observed in our data, the conceptual opposition between *actions* and *pseudo-actions* is often marked by the textual opposition of different verb forms used to express them.

Ex. 9 *Prenez la rue... Au bout, vous tombez à l'intersection.*

(Take the street... At the end, you come to the intersection.)

In example 9 above, the expression “prenez la rue” (“take the street”) describes an *action*: relation between a step *start-segment* and a *segment-landmark* (the

street). The expression “vous tombez à l’intersection” (“you come to the intersection”) corresponds to a *pseudo-action*. The condition (1) is not fulfilled here because the step and the landmark described do not belong to the same global route unit: a *start-segment* is related to a *relay-landmark* (the intersection). The conceptual opposition between the two kinds of relations is marked by a textual opposition of verbal forms: the imperative is used for the *action* and the present indicative is used for the *pseudo-action*. Other forms may be used to mark such an opposition. In example 10 below, the present tense is used for an *action* (“tu prends la passerelle”) and the future (French “futur proche”) is used for a *pseudo-action* (“tu vas arriver...”). We have another verbal form in this example: “tu auras...” (“you will have...”), which is another type of future tense (French “futur simple”). Our explanation is that this expression has still another conceptual function, which may be called *landmark indication*. Indeed, it is not an expression of the relation between a step and a landmark; the expression introduces a landmark (“series of buildings”) without marking a step.

Ex. 10 Tu prends la passerelle. Tu vas arriver devant un panneau indicateur et tu auras une série de bâtiments à gauche. Tu entres dans le premier.

(You take the footbridge. You are going to arrive in front of an indication sign and you will have a series of buildings on your left. You enter the first one.)

Example 11 below is interesting because the same verb is used with two different functions. The functional difference is marked by the use of different forms. The imperative is used for an *action*: the expression “traversez Marolles” (“go through Marolles”) marks the relation between the step *transfer-segment* and the *segment-landmark* (the town “Marolles”). The same verb appears later in a present indicative form: “on traverse” (“you go through”). It is a *pseudo-action* this time because the condition (2) mentioned above is not fulfilled: the described step (*transfer-segment*) is not “new”. Indeed, we remark that it is the same step as the one already introduced in the preceding sentence by “suivez ce chemin” (“follow this road”): one goes through the fields *while* following the road and not *after* that.

Ex. 11 Traversez Marolles. À la sortie de la ville, la route tourne naturellement à droite. Suivez ce chemin. On traverse des champs.

(Go through Marolles. At the end of the town, the road turns naturally to the right. Follow this road. You go through the fields.)

4.2 Textual structuring

By *textual structuring* we mean the process which leads to verbal expression of the conceptual content determined during the phase of the conceptual structuring. We distinguish two tasks within the textual structuring: the determination of the *textual content* (“what to express”) and the determination of the *textual form* (“how to express”).

The models traditionally used in automatic text generation contain two modules: “what to say” and “how to say”. The “what to say” module determines the content of the text with respect to the available data. We distinguish between two types of “contents”: the *conceptual* content and the *textual* content (thus replacing the task “what to say” by two tasks: “what to transmit” and “what to express”). The *textual* content corresponds to those parts of the *conceptual* content which are explicitly expressed in the text, in opposition to the parts which are not expressed and which constitute implicit information.

The choices related to textual content in route description are concerned with expressing *steps* and *landmarks*. Since the principles of the conceptual structuring of a route are part of the knowledge shared by both participants of the communication act (the informer and the questioner), it is not necessary to explicit the conceptual content thoroughly. We illustrate this with respect to the expression of *steps* by analyzing in table 2 a route description from one of our corpora. In table 3, we propose a different description of the same route and of the same conceptual content in order to show that other textual choices are possible: some of the *steps* which are explicit in the first description are implicit in the second and vice versa. Since exactly the same message is (explicitly or implicitly) transmitted by both descriptions, the differences between them may be considered as purely stylistic.

As for *landmarks*, the knowledge that allows for leaving them implicit in some parts of the description consists in principles about their association with the *steps*. It is known, for example, that a *segment-landmark*, such as introduced by the expression “take the pedestrian path”, is associated not only with the step *start-segment*, which is described by this expression, but also with the following step of the segment: *transfer-segment*. This is why it is not necessary to mention the landmark again while describing this following step. For example, if one only says “continue”, it is nevertheless clear that one talks about continuing on the same pedestrian path.

Steps	Route description
transfer-relay	<i>traverser la voie [cross the railway]</i>
start-segment	
transfer-segment	<i>continuer à descendre [go down the road]</i>
end-segment	<i>on rencontre un croisement [you come to a crossing]</i>
transfer-relay	
start-segment	
transfer-segment	<i>continuer par un chemin piétonnier [continue by a pedestrian path]</i>
end-segment	<i>jusqu'à un petit pont [as far as a little bridge]</i>
transfer-relay	
start-segment	<i>prendre le bâtiment à gauche [take the building on the left]</i>

Table 2: Illustration of textual content choices concerning *steps*.

Steps	Route description
transfer-relay	<i>traverser la voie [cross the railway]</i>
start-segment	<i>prendre la descente [take the road going down]</i>
transfer-segment	
end-segment	
transfer-relay	<i>traverser un croisement [pass a crossing]</i>
start-segment	<i>prendre un chemin piétonnier [take a pedestrian path]</i>
transfer-segment	
end-segment	
transfer-relay	<i>passer un petit pont [pass a little bridge]</i>
start-segment	<i>prendre le bâtiment à gauche [take the building on the left]</i>

Table 3: Illustration of alternative textual content choices concerning *steps*.

Also, some attributes of a landmark may be left implicit in some part of the description, while others are introduced explicitly. For example, in the expression “continue straight on” in the same context, the landmark’s attribute “type” (“pedestrian path”) is implicit, whereas its attribute “direction” (“straight on”) is explicit.

The other problem within textual structuring is the choice of the *textual forms* to express different parts of the content. Our corpus analysis has permitted us to define some principles underlying this task. We have distinguished two basic types of textual units: *sequences*, which describe steps and landmarks, and *connections*, which serve to link the progression of the description with the conceptual, spatio-temporal structure of the route. A *sequence* can be divided into a *core* and a *complement*. The *core* part may have one of the three functions that we have discussed above: *action*, *pseudo-action* or *landmark indication*. The function of the *complement* is to provide some complementary information about a landmark which is already known by the questioner, either because it has been mentioned previously (in the *core*) or because it is the destination. The table 4 presents the division into textual units of the route description quoted in example 12 below.

Ex. 12 *Vous descendez la passerelle et vous vous dirigez vers les panneaux où il y a les directions des bâtiments. Et puis, vous tournez à droite, vous allez jusqu’au restaurant universitaire qui se trouve au bout. Et après, c’est le bâtiment à côté du restaurant universitaire.*

(You go down the footbridge and you head towards the panels where are the directions for the buildings. And then, you turn right, you go as far as the university restaurant which is situated at the end of the road. And then, it’s the building next to the restaurant.)

Connection	Sequence	
	Core	Complement
	<i>vous descendez la passerelle (you go down the footbridge)</i>	
<i>et (and)</i>	<i>vous vous dirigez vers les panneaux (you head towards the panels)</i>	<i>où il y a les directions (where are the directions)</i>
<i>et puis (and then)</i>	<i>vous tournez à droite (you turn right)</i>	
	<i>vous allez jusqu’au restaurant (you go as far as the restaurant)</i>	<i>qui se trouve au bout (which is at the end)</i>
<i>et après (and then)</i>		<i>c’est le bâtiment... (it’s the building...)</i>

Table 4: Division of a route description into textual units.

A *connection* may be constituted by different kinds of linguistic elements. The route description analyzed above contains one connection realized by the conjunction “et” (“and”) and two realized by the conjunction “et” followed by the adverb “puis” or “après” (“then”, “after”). There is a difference of “range” between the connection “et” and the connections such as “puis”, “après” and “ensuite”: while the former one marks the moving of the description to another *step* or *landmark* (“local range”), the latter ones mark the moving to another *segment* (“global range”). There are other types of *connections* that are contained in our data. The function of a “local range connection” may also be attributed to the preposition “pour” or “afin de” (“to”, “in order to”). In example 13 below, we have both “et” and “pour” functioning as local connections, whereas global connection is represented by “après”. There are, of course, some semantic constraints that differentiate the applicability of “et” and “pour”, but in some contexts they are interchangeable.

Ex. 13 *Je prends la passerelle pour arriver directement sur le campus. Après, je vais donc tout droit et j’arrive à un carrefour.*

(I take the footbridge to arrive directly on the campus. Then, I go straight on and I arrive at a crossroads.)

There are some “global range connections” which announce a description of a new route *segment* while connecting it at the same time to the preceding *relay*. It is the case of the connections “là” (“there”) in example 14 and “à Opéra” (“at Opera”) in example 15.

Ex. 14 *On arrive sur un rond-point avec des panneaux d’indications. Là, on prend sur la gauche, on va tout droit jusqu’au stade.*

(You arrive on a roundabout with direction panels. There, you take the road on the left, you go straight on as far as the stadium.)

Ex. 15 *Tu prends la direction Gallieni et tu descends à la station Opéra. À Opéra, tu prends la direction Mairie d’Ivry et tu sors à la station Jussieu.*

(You take the direction Gallieni and you get off at station Opera. At Opera, you take the direction Mairie d’Ivry and you get out at station Jussieu.)

5 Application

We applied our cognitive and discursive model to the automatic generation of subway route descriptions [FLZ98b, FLZ98a]. In order to account for the specificities of the context at hand, we used a corpus containing thirty subway route descriptions in

French. The data were collected from ten subjects via e-mail. Each subject described three routes in the Parisian subway, differing in length and complexity.

The generator, programmed in GNU Emacs Lisp, is at its present state operational for two subway networks: Paris and Montreal. It is composed of two main modules: a *referential* module and a *discursive* module. The former computes the fastest route between two stations, while the latter generates the corresponding text. The discursive module is divided into two components: *conceptual* and *textual*. The first component provides the segmentation of the route (which is direction dependent in this case) and the representation of landmarks (corresponding to subway lines and stations), whereas the second component plans the textual structure of the description. The latter task is performed by using different textual schemata: *sequence* schemata, which define different types of sequences according to the steps that they describe; *block* schemata, which define the combinations of sequences into “blocs” of text and which symbolize the choices concerning explicit and implicit steps; *connection* schemata, which define the use of connections between blocks (“global range connections”); *description* schemata, which define combinations of blocks depending on the number of route segments.

Our generator reproduces the textual variations that have been observed in the corpus, making it possible to obtain a number of different descriptions for the same route. There are two types of variations. The first one is “stylistic” and it results from the fact that different textual schemata may be used to describe the same route (due to different decisions as to express a step explicitly or not, to different choices of connections, etc.). Our corpus analysis has also permitted us to define another factor of variation, namely the salience of information. This factor is applied to two kinds of information (represented as landmarks’ attributes): segment distances (ex. “two stops”) and the names of the lines (ex. “line number 7”, “blue line”). Both these kinds of information are optional, which means that they may or not be included in a subway route description (at least in the case of Parisian and Montreal subways). Whenever they are included, they may be attributed a different degree of salience. This is reflected in the text by the use of different linguistic forms, with the general principle to express the more important information in the *core* of a sequence and the less important information in the *complement*.

In the following, we illustrate different parts of the processing, by using automatically generated outputs. The route described is illustrated in figure 3: it goes from the station Villa-Maria to the station Université-de-Montréal and contains one transfer at Snowdon.

This route, after having been determined by the referential module, is repre-

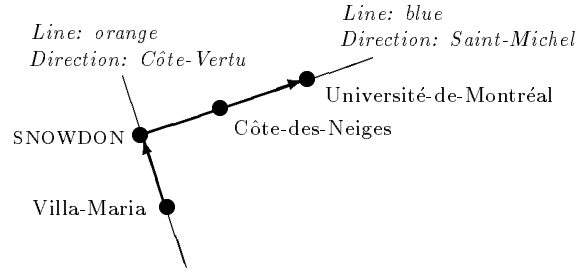


Figure 3: A subway route in Montreal: from Villa-Maria to Université-de-Montréal.

sented as shown below.

```
((Villa-Maria Cote-Vertu) (Snowdon Cote-Vertu) (Snowdon Saint-Michel)
 (Cote-des-Neiges Saint-Michel) (Universite-de-Montreal Saint-Michel))
```

It is the *referential representation* of the route, which is then used by the discursive module. It is constituted by a list of pairs whose first element is the indicator of a station (e.g. *Villa-Maria*) and the second one is the indicator of a direction (e.g. *Cote-Vertu*).

The first “conceptual” output of the discursive module is the representation which divides the route into *segments* and *steps*:

```
((((Villa-Maria Cote-Vertu) nil (Snowdon Cote-Vertu))
 ((Snowdon Saint-Michel) ((Cote-des-Neiges Saint-Michel))
 (Universite-de-Montreal Saint-Michel)))
```

No variation is possible at this level because only one criterion of segmentation is used for subway routes, namely direction (which is indicated by the name of the last station). Each segment is represented by a list which contains three lists corresponding to different *steps*. Thus, the step *start-segment* of the first segment is represented by the list (*Villa-Maria Cote-Vertu*), the step *transfer-segment* is represented by the empty list (*nil*), as there is no station between Villa-Maria and Snowdon, and the step *end-segment* is represented by (*Snowdon Cote-Vertu*). The *relay* and the step *transfer-relay* between two segments are implicit in this representation.

The second “conceptual” output is the representation of *landmarks*: *segment-landmarks*, which correspond to fragments of subway lines going in one direction, and *relay-landmarks*, which correspond to subway stations (there are no *step-landmarks* nor *frame-landmarks* in this context). The landmarks are represented as lists of attribute-value pairs, as shown below.


```

(((entity . line) (direction . "Côte-Vertu") (name . "orange")
  (degree-name . 2) (dimension . 1) (degree-dim . 3))
((entity . station) (name . "Snowdon") (order . 1)
  (degree-order . 3))
((entity . line) (direction . "Saint-Michel") (name . "bleue")
  (degree-name . 2) (dimension . 2) (degree-dim . 2))
((entity . station) (name . "Université-de-Montréal")
  (order . 2) (degree-order . 2)))

```

At this level, there is a possibility of variation of representation for two kinds of optional information: distance (represented by the attribute *dimension* of a *segment-landmark* and by the attribute *order* of a *relay-landmark*) and the name of the line (attribute *name* of a *segment-landmark*). This variation consists in different degrees of salience that these pieces of information may obtain. The salience degrees are represented in the attributes *degree-dim*, *degree-order*, and *degree-name*.

In the representation above, the distance (*dimension*) of the first segment has obtained a higher degree of salience (*degree-dim*) than that of the second segment (3 versus 2) because it is considered that the one-stop distance is more important than others. This difference is reflected in the text (see the description below) by the expression of the “more important” (one-stop) distance in the *core* of the *sequence* and the expression of the “less important” distance in the *complement*. The salience of the information *name* of line is given its maximum value (2) and, consequently, this information is expressed in the *cores*.

À partir de Villa-Maria, prendre la ligne orange en direction de Côte-Vertu et s’arrêter à la station suivante qui est Snowdon. Là, changer pour prendre la ligne bleue en direction de Saint-Michel et descendre à Acadie qui la 2-ième station.

(From Villa-Maria, take the orange line in direction of Côte-Vertu and stop at the next station which is Snowdon. There, transfer to take the line blue in direction of Saint-Michel and get off at Acadie which is the 2nd stop.)

In order to illustrate another case, we consider the situation in which the salience of the information *name* of lines is lower (value 1), and in which the distance is considered as not salient at all and therefore is not represented. A corresponding route description will then express the names of the lines in the *complements* (in form of bracketed appositions) and will not express the distances. For the same conceptual representation, a large number of different descriptions can be generated,

by making different “stylistic” choices. We quote two of them below and we compare them in table 5 with respect to the expression of *steps*.

D’abord, prendre la direction Côte-Vertu (ligne orange) et descendre à Snowdon. Ensuite, prendre la direction Saint-Michel (ligne bleue) jusqu’à Université-de-Montréal.

[First, take the direction Côte-Vertu (orange line) and get off at Snowdon. Then, take the direction Saint-Michel (blue line) up to Université-de-Montréal.]

À partir de Villa-Maria, prendre la direction Côte-Vertu (ligne orange) et changer à Snowdon. Là, prendre la direction Saint-Michel (ligne bleue) et descendre à Université-de-Montréal.

[From Villa-Maria, take the direction Côte-Vertu (orange line) and change at Snowdon. Then, take the direction Saint-Michel (blue line) and get off at Université-de-Montréal.]

Steps	Description 1	Description 2
start-segment	prendre la direction... <i>(take the direction...)</i>	prendre la direction... <i>(take the direction...)</i>
transfer-segment		
end-segment	descendre à Snowdon <i>(get off at Snowdon)</i>	
transfer-relay		changer à Snowdon <i>(change at Snowdon)</i>
start-segment	prendre la direction... <i>(take the direction...)</i>	prendre la direction... <i>(take the direction...)</i>
transfer-segment		
end-segment	jusqu’à Université... <i>(up to Université...)</i>	descendre à Université... <i>(get off at Université...)</i>

Table 5: Comparison of two automatically generated descriptions with respect to the expression of *steps*.

Concerning the expression or not of the *steps*, not all the choices are actually possible in subway route descriptions. It appears in our data that the step *start-segment* is always explicit, which is due to the fact that the type of *sequence* that expresses it (e.g. “prendre direction Côte-Vertu”) also contains information about the landmark’s attribute “direction”, which is an obligatory information in this context. Another regularity observed is that the step *transfer-segment* is never explicit,

which may be explained by the situation at hand: once aboard, the passenger does not have any other choice than to “continue”.

The two descriptions quoted above also differ with respect to some textual form choices. They use different schemata of global *connections*, respectively: “d’abord... ensuite...” (“firstly... then...”) and “à partir de X... là...” (“from X... there...”). Also, they use different means to express the second *end-segment*: “jusqu’à...” (“up to...”) in the first description and “descendre à...” (“get off at...”) in the second.

6 Conclusion and perspectives

Based on a study of a large amount of empirical data, we proposed a cognitive and discursive model of the processing involved in the task of producing route descriptions. The main contribution of our model with respect to the previous route description models is that it is dynamic, which means that it not only describes different stages of the processing, but also accounts for the transitions between them. This could be obtained thanks to the two-level modelization of the conceptual structuring of the route: the “global” level corresponding to *segments* and *relays*, and the “local” level to *steps* and *landmarks*, and by defining the conceptual entities in relation to the referential level as well as to the textual one. The explicit inclusion and the definition of the temporal aspect (in the form of the *step* structure) and its relations with the spatial aspect (different modes of association of *steps* with *landmarks*) constitutes an important improvement in the modeling of route description. It allows for the precise definition of *actions*, which are dominant “functions” in this type of discourse.

The “theoretical” validation of our model is the fact that it helps to explain a number of text-level, corpus-observed phenomena. The first one concerns variation in descriptions referring to the same route (which goes beyond purely lexical choices). One type of variation can be explained with respect to the *segment-relay* structuring and the possibility of using different referential criteria for it. Also, within the same “global” structure, different *landmarks* and their attributes may be used and given different degrees of salience, which is reflected in the text form. Another type of variation can be accounted for thanks to the distinction between the “conceptual” and the “textual” contents, which allows for defining “explicit” and “implicit” information and, consequently, the choices concerning the expression of *steps* and *landmarks* in the description. Another phenomenon observed in the corpus, and which we were able to deal with on the basis of our model, is the use of different verb forms (ex. present tense and future tense, or imperative and present

indicative) in one description. It has turned out that such textual oppositions reflect the conceptual opposition between *actions* and other functions.

For the sake of “practical” validation of our model, we have developed an automatic generator of subway route descriptions. It is able to produce a number of different descriptions of the same route, by exploring some variety of choices at the conceptual and at the textual level. However, due to a rather restricted nature of the environment involved, which is necessarily reflected on the discursive level, not all the characteristics represented in our model could be reproduced. This is why we are going to extend the existing generator in order to deal with more complex situations of navigation, for example combining subway and pedestrian routes.

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