# AUTOMATIC GENERATION OF SUBWAY DIRECTIONS: SALIENCE GRADATION AS A FACTOR FOR DETERMINING MESSAGE AND FORM

Lidia Fraczak
LIMSI-CNRS, BP 133
F-91403 Orsay Cedex, France
lidia@limsi.fr

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

Michael Zock
LIMSI-CNRS, BP 133
F-91403 Orsay Cedex, France
zock@limsi.fr

**Abstract**

A frequently encountered problem in urban life is navigation. In order to get to some place we use private means or public transportation, and if we lack clear directions we tend to ask for help. We will deal in this paper with the descriptions of subway routes and their automatic generation. In particular, we will try to show how the relative importance of a given piece of information can effect not only the message but also the form.

## 1 Introduction: the problem

A frequently encountered problem in urban life is the use of public transportation: we have to get from here to there and quite so often we don't know how. As it is not always possible to get help from a person (be it because nobody is available, or able to speak our language), we might appreciate assistance of a machine.

In order to convey to the user "useful information", we must define what "usefulness" means. For example, if we tell someone how to get from one place to another, we hardly ever specify all the intermediate steps, in particular if there is no ambiguity. Also, not all information is of equal weight. Yet, as we will show, the notion of "relative importance" of information is gradual in nature rather than discrete, that is a simple binary value (important vs. unimportant)[1].

All this reflects, of course, in the content and form of the final text. Relative importance is signaled by different means at the text level (headers, paragraphs, etc.) and at the sentence level (word choice, syntactic structure: main clause versus subordinate clause, topic-comment structures).

Concerning the prominence status (i.e. relative importance of a piece of information), semioticians and text linguists have reached a similar conclusion by distinguishing between the "foreground/background" or "primary/secondary level" of a text [Bar66, vD77, AP89, Com92]. According to Combettes [Com92], the "primary level" deals with the core meaning, i.e. events and facts that make the text progress, while the "secondary level" deals with descriptions, evaluations, comments, and reformulations.

The distinction of levels, with information of varying shades (salience gradation), implies that it should be possible to identify corresponding linguistic "markers" for each one of them. Yet, as Combettes has pointed out [Com92], the means used for marking the relative importance of information may vary from one type of text to another. Nevertheless, certain markers do hold

[1] In this respect we deviate from most current generation systems.

regardless of the text type. This is particularly true for certain syntactic devices such as subordinate clauses, appositions, nominalization, all of which are, according to Combettes, markers of the secondary level, unlike main clauses which mark the primary level.

Analyzing a corpus of route descriptions in French we have identified correlations between the salience status of specific *conceptual* chunks (landmarks, segment distance, etc.) and *linguistic* structures (independent vs. subordinate clauses). In section 2, we will reveal how the salience status of some types of information may affect the content and form of the final text. In section 3 we will illustrate our use of these data in a generator of subway route descriptions.

## 2 A case study: subway route descriptions

Route descriptions are interesting for at least two reasons: first of all, as navigation aids in general they help to solve a real world problem; second, despite their apparent simplicity, especially with regard to surface form, they require the solution of a number of non trivial linguistic and discourse problems, problems which are intimately rooted in human cognition.

Our analysis is based on a corpus containing 30 subway route descriptions in French. The data were collected from ten subjects via e-mail. Each one of them had to describe three routes in the Parisian subway. These routes differ in terms of length and complexity. The first route involves 9 stops and one transfer. It is the longest. The second one contains 4 stops and no transfer. It is the simplest. The third route, though very short (4 stops), is the most complex one as it involves two transfers.

### 2.1 Analysis of the underlying content

The information contained in subway route descriptions can be divided into two broad categories: "global" and "local" information. We describe each one of them below, illustrating particular information types with examples taken from the corpus.

**Global information:**

- identification of the route by specifying departure and destination,
  eg. *Pour aller de Saint-Lazare à Jussieu... / To go from Saint-Lazare to Jussieu...*
- comments concerning the complexity of the whole route,
  eg. *C'est simple et rapide, pas de changement. / It's simple and fast, no transfer.*
- information concerning the distance of the whole trip,
  eg. *Ça doit faire 7 ou 8 stations en tout. / This should make 7 or 8 stops for the whole trip.*

**Local information:**

- stop of departure, eg. *À partir de Jussieu, tu prends... / Starting from Jussieu, you take...*
- destination, eg. *tu arrives à Gare de Lyon / you arrive at Gare de Lyon*
- lines to take, eg. *prendre la ligne 5 / take the line number 5*
- transfers, eg. *changer à Opéra / change at Opera*
- directions to take, eg. *tu prends la direction Gallieni / you take the direction Gallieni*
- partial distances to cover, eg. *il y a une seule station / there is only one stop*

According to Wunderlich and Reinelt [WR82], "local information" is the core of route descriptions, while "global information" is additional as it serves mainly interactional purposes. In the remainder of our analysis we will concentrate on the "local route information" and the way it is expressed in the domain of subway route descriptions, the objective being to determine whether some information is obligatory or not. Of course, we could have defined on a priori grounds what should be mentioned explicitly and what not. Yet, we preferred to ground our work on empirical data.

We assume that "obligatory information" is information that is contained in all descriptions of the corpus, whereas "optional information" occurs only occasionally[2]. We have also tried to find explanations for the omission of optional information. For example, the stations of *departure* and *destination* could be considered as optional, since they are already known by the "questioner" (either because they are a part of the question, or because they are given with the context/situation). Indeed, our data reveal that, while the *destination* stop is always mentioned, the *departure* is mentioned only in 50% of the cases (eg. *À Jussieu*, tu prends... / *At Jussieu*, you take...). In the light of these data we conclude that it is useful to make a distinction between *given* and *new*, or *known* and *unknown* information. The problem concerning the "known" information is to decide whether to make it explicit or not. This is not a conceptual problem, – the known information must already be present at the conceptual level, – the choice is pragmatic in nature (what information should be conveyed, because it is really useful?), with possible stylistic side effects. For example, the fact that the *destination* (known information) is mentioned systematically in the corpus seems to be based on "stylistic" considerations: if it were not, the description would look like being incomplete. On the other hand, decisions concerning "new" information do involve conceptual choices. They consist in determining whether to include a given piece of information in the message or not, and in determining its degree of salience.

The rest of our paper deals only with the analysis of "new" information, since we are mainly interested in the choices at the conceptual level and their consequences on the linguistic form. As the data show, information concerning *transfer stations* and *directions of lines* is obligatory: both types of information systematically occur in the corpus. The corpus also reveals that information concerning *partial distances* (number of stops to travel on a given line) and the *names of the lines* (eg. "line 7" or "orange line") is optional.

It should be noted, that *partial distance* may be represented in two ways in the domain of subway route descriptions: either as the length of a route segment (eg. "two stops"), or as the result of the number of stops counted (eg. "second stop"). This kind of information is not mentioned at all in 30% of the cases. We have noticed that the inclusion/exclusion of information concerning *partial distances* depends on contextual factors such as the "value" of the distance itself (one stop vs. several) and the position on the route (last route segment or not). A "one-stop distance" is more important than a segment containing several stops. Also, the distance of the last segment seems to be more important than the distances of the intermediate segments (unless they are equal to one stop). Other strategies concerning information on *partial distances* have been observed: some subjects have mentioned all of them in each one of their description, regardless of the number of stops and the relative position of the segment, while others did not mention them at all. Another kind of optional information are the *names of the lines* to take. This may vary from place to place, but at least in Paris it is the *direction* (final destination) of the train that tells the user which train to take. The *names of the lines*, represented by numbers, were omitted in one third of the descriptions in the corpus.

In the next section we describe the results of our linguistic analysis. We will show what spe-

[2]Of course, this poses the problem of completeness and representativeness of the corpus.

cific linguistic resources (independent clauses vs. subordinate structures) are used for expressing obligatory or optional parts of information.

## 2.2 Correspondence between conceptual saliency and linguistic resources

It comes as no surprise that independent clauses are the major syntactic structure used. Their function is to convey information of primary importance. Our analysis of the corpus shows that independent clauses are mostly used in order to convey "obligatory" information, namely information specifying the *names of the stations where to get off* and *directions to take.* This is the case in example 1 below[3], where only these two chunks of information are contained in the independent clauses.

**Ex. 1** À Saint-Lazare, *prendre la direction Gallieni. Descendre à Opéra* (deux stations plus loin). *Prendre* alors *la direction Mairie d'Ivry/Villejuif jusqu'à Jussieu* (7-ème station).

At Saint-Lazare, *take the direction Gallieni* (two stops ahead). Then *take the direction Mairie d'Ivry/Villejuif until Jussieu* (7th stop).

However, independent clauses may also convey optional information. In this case, we consider it as a way of signaling prominence. For example, in our corpus there are cases where a "one-stop distance" (*distance* being optional information) is expressed by an independent clause:

**Ex. 2** À Bastille, prendre le métro n 1 direction Château de Vincennes et *descendre à la prochaine station* qui est la Gare de Lyon.

At Bastille, take the line number 1, direction Château de Vincennes, and *get off at the next stop* which is Gare de Lyon.

The *names of the lines* (optional information), together with information concerning the *direction* (obligatory information), are also quite frequently mentioned in independent clauses (see example 3). Again, we consider this as a sign for signaling high prominence.

**Ex. 3** À Saint-Lazare, *prendre la ligne 3* direction Gallieni et changer à Opéra. *Prendre* ensuite *la ligne 7* direction Mairie d'Ivry et descendre à Jussieu.

At Saint Lazare, *take the line 3* direction Gallieni and change at Opera. Then, *take the line 7* direction Mairie d'Ivry and get off at Jussieu.

Subordinate structures are generally used to convey optional information or information of minor importance. This is in our case information concerning *partial distances* and *names of lines.* In example 4 below, the information concerning *partial distance* is included only for the last segment, which is expressed by an "anaphoric clause". Example 5 illustrates a strategy whereby prominence of the *names of the lines* is decreased: they are expressed in bracketed appositions.

**Ex. 4** À Saint-Lazare prendre le métro n 3 direction Gallieni, changer à Opéra et prendre le métro n 7 direction Mairie d'Ivry/Villejuif et descendre à Jussieu *(c'est la 7-ème station).*

At Saint-Lazare take the number 3, direction Gallieni, change at Opera and take the number 7 direction Mairie d'Ivry/Villejuif and get off at Jussieu *(it's the 7th stop).*

**Ex. 5** Prendre direction Gallieni *(ligne 3).* Sortir à Opéra (2 stations). Prendre direction Mairie d'Ivry *(ligne 7).* Descendre à Jussieu (7-ème station).

Take direction Gallieni *(line 3)* and change at Opera (2 stops). Take the direction Mairie d'Ivry *(line 7)* and get off at Jussieu (7th stop).

[3]Examples from the corpus are followed by their English equivalents.

We distinguish between two cases of subordinate structures: subordinate *clauses* and *appositions*. The former include *relative clauses* (eg. "descends à Opéra *qui est la 2-ème station*" / "get off at Opera, *which is the second stop*") and *anaphoric clauses* (eg. "tu prends la direction Mairie d'Ivry, *c'est la ligne 7*" / "you take direction Mairie d'Ivry, *it's the line 7*"). We divide *appositions* into *nominal* and *prepositional appositions*. *Nominal appositions* occur after an independent clause and may be used with various punctuation devices such as comma, colon, or brackets. In our corpus, they generally occur in brackets, for example: "descendre à Gare de Lyon *(station suivante)*" / "get of at Gare de Lyon *(the following stop)*". *Prepositional appositions* occur before an independent clause. They are used to mention "known" information like "get-on stations" (the "departure station" or a "get-on station" that has been mentioned before as a "get-off" or "transfer station"), for example: "Descendre à Bastille. *De Bastille*, prendre..." / "Get off at Bastille. *From Bastille* take...".

In order to be able to automatically generate route descriptions in line with these linguistic data, we have defined a set of rules that map the relative salience of a given piece of information onto one or several syntactic structures (cf. section 3 below, table 1 and table 2).

# 3 A subway route description generator based on empirical data

As we have shown, when people give directions they tend to use specific strategies for signaling the relative importance of a given piece of information. These strategies have been encoded in a program, written in GNU Emacs Lisp, that generates subway route descriptions. The generator is, at its present state, operational for two subway networks: Paris and Montreal. The examples used to illustrate our approach deal with a route in the subway of Montreal.

The generator is composed of two main modules: a *referential* module and a *discourse* module. The former computes the fastest route between two stations, while the latter generates the corresponding text. The discourse module is divided into two components. The first one divides the route given by the referential module into conceptual clusters, whereas the second one plans the *textual* structure of the description.

The conceptual structuring consists in dividing a route into segments and landmarks [Maa93]. *Landmarks* are defined in terms of attribute-value pairs of relevant "places" and "paths" which, in our application, correspond respectively to "stops" (stations) and to "portions of subway lines in a given direction". The output of the conceptualizer takes the form of a list of attribute-value pairs, representing *landmarks* for route segments and for stops. Examples of such representations and their corresponding texts are given in section 3.1.

Information concerning *partial distances* is represented either as an attribute of *path landmarks* (`dimension`) or as an attribute of *stop landmarks* (`order`). The relative importance of this information is represented by the attributes `degree-dim` and `degree-order`. The *names of the lines* are represented by the *path-landmark's* attribute `name`, and their importance is specified by the attribute `degree-name`.

The function creating the conceptual representation (the message) takes as input two "pragmatic" parameters. The first one specifies the relative importance (with values ranging from 0 to 3) of *partial distances* (represented by the attributes `dimension` and `order`), while the second one specifies the relative importance (possible values: 0–2) of the *names of the lines* (attribute `name`). The values of the attributes `degree-dim` and `degree-order`, which express the "local importance" of *partial distances*, are computed on the basis of the value of the "global importance", as specified by the input parameters, and by looking at a given segment's distance (one stop vs. several) and checking the segment of the route currently processed (the last one or not). The obtained values of "local importance" (i.e. values of the attributes `degree-dim` and `degree-order`) allow for making later on certain choices at the text level. Table 1 shows the rules for making these choices: the most important information (value 3) is expressed by an independent clause, the next highest (value 2) is expressed by a relative or anaphoric clause, while the least important information (value 1) is expressed by a bracketed apposition.

| Global import. | Conditions of inclusion | Local import. | Textual realization |
|---|---|---|---|
| 0 | never included | none | none |
| 1 | if only one stop | 1 | apposition between brackets |
| 2 | if only one stop | 2 | subordinate or anaphoric clause |
| | if last route segment | 1 | apposition between brackets |
| 3 | if only one stop | 3 | independent clause |
| | if last route segment | 2 | subordinate or anaphoric clause |
| | in all other cases | 1 | apposition between brackets |

Table 1: Correspondences between the saliency of *partial distances* and linguistic forms.

The attribute `degree-name`, which represents the importance of information concerning the *names of the lines* ("local importance"), takes the value of the input parameter ("global importance"). This value (between 0 and 2) determines whether and how to express the information in the final text. The rules presented in table 2 are simpler than the ones given for *partial distances* (table 1). This is so because the *names of the lines* are either included or not in a description, and this is valid for all the segments described. The relative importance of this information shows up at the text level via its linguistic form: independent clauses signaling higher prominence than appositions.

| Global import. | Conditions of inclusion | Local import. | Textual realization |
|---|---|---|---|
| 0 | not included | none | none |
| 1 | included | 1 | apposition between brackets |
| 2 | included | 2 | independent clause |

Table 2: Correspondences between the saliency of *names of the lines* and linguistic forms.

The text module relies on schemata which, for a given conceptual input, specify the possible linguistic forms on a local and global level[4]. It should be noted though that, even if the global and local choices depend fairly much on one another and on the conceptual input, there is still quite some freedom for "stylistic" variation: the way the schemata are defined allow us to generate a whole class of texts for a given conceptual input.

### 3.1 Examples and analysis of results

In this section, we illustrate through automatically generated examples how the relative importance of *partial distances* and *line names* lead to quite different texts.

The examples given below refer to the route from "Charlevoix" to "Acadie" in the subway of Montreal (see figure 1). As the route contains two transfers (one at "Lionel-Groulx" and another one

[4]The reason why we believe in the virtue of a "schema-driven approach" is based on the observation that people operate on larger "chunks" rather than on atomic units such as words or concepts [Zoc96].

at "Snowdon"), we divide it into three segments, the distances of each segment being respectively one, four and five stops.

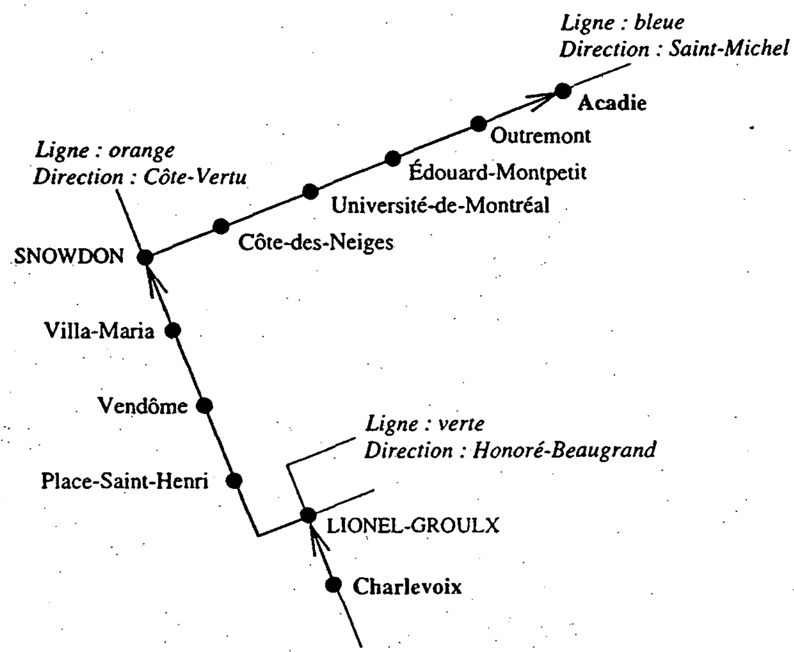


Figure 1: The route from "Charlevoix" to "Acadie" in the Montreal subway.

If the "global importance" of *partial distances* and *names of the lines* is 0, no reference will be made to them, neither in the conceptual output representation, nor in the final text. This is the case in our first example.

**Example 1.** Parameters of "global importance": partial distances = 0, names of the lines = 0.

```
(((entity . line) (direction . "Honoré-Beaugrand"))
 ((entity . station) (name . "Lionel-Groulx"))
 ((entity . line) (direction . "Côte-Vertu"))
 ((entity . station) (name . "Snowdon"))
 ((entity . line) (direction . "Saint-Michel"))
 ((entity . station) (name . "Acadie")))
```

```
D'abord, prendre la direction Honoré-Beaugrand et changer à Lionel-Groulx.
Ensuite, prendre la direction Côte-Vertu et changer à Snowdon. Enfin, prendre
la direction Saint-Michel et descendre à Acadie.
```

In the following two examples, the "global importance" concerning *partial distances* remains 0 while the importance of the *names of the lines* changes respectively to 1 (example 2) and to 2 (example 3). In consequence, the information concerning *partial distances* is neither represented nor expressed, while the information concerning the *names of the lines*, including their "local importance" values (attributes degree-name), is represented and expressed accordingly either by a subordinate structure (apposition) or by an independent clause.

Example 2. Parameters of "global importance": partial distances = 0, names of the lines = 1.

```
(((entity . line) (direction . "Honoré-Beaugrand") (name . "verte") (degree-name . 1))
 ((entity . station) (name . "Lionel-Groulx"))
 ((entity . line) (direction . "Côte-Vertu") (name . "orange") (degree-name . 1))
 ((entity . station) (name . "Snowdon"))
 ((entity . line) (direction . "Saint-Michel") (name . "bleue") (degree-name . 1))
 ((entity . station) (name . "Acadie")))
```

```
À Charlevoix, prendre la direction Honoré-Beaugrand (ligne verte) et changer à Lionel-
Groulx. À Lionel-Groulx, prendre la direction Côte-Vertu (ligne orange) et s'arrêter à
Snowdon. Enfin, prendre la direction Saint-Michel (ligne bleue) et sortir à Acadie.
```

Example 3. Parameters of "global importance": partial distances = 0, names of the lines = 2.

```
(((entity . line) (direction . "Honoré-Beaugrand") (name . "verte") (degree-name . 2))
 ((entity . station) (name . "Lionel-Groulx"))
 ((entity . line) (direction . "Côte-Vertu") (name . "orange") (degree-name . 2))
 ((entity . station) (name . "Snowdon"))
 ((entity . line) (direction . "Saint-Michel") (name . "bleue") (degree-name . 2))
 ((entity . station) (name . "Acadie")))
```

```
De Charlevoix, prendre la ligne verte en direction de Honoré-Beaugrand et changer à
Lionel-Groulx. À Lionel-Groulx, prendre la ligne orange en direction de Côte-Vertu
jusqu'à Snowdon. À Snowdon, changer pour prendre la ligne bleue en direction de
Saint-Michel et descendre à Acadie.
```

The following three examples illustrate how the relative importance of *partial distances* may influence the surface form. (In order to produce more variations we have changed simultaneously the importance of the line names.) In example 4, the importance of *partial distances* is 1. Hence, according to the rules given in table 1, only the information concerning "one-stop distance" (first segment of the route here) is included (attributes `dimension` and `degree-dim`, and attributes `order` and `degree-order`) and expressed by a bracketed apposition.

Example 4. Parameters of "global importance": partial distances = 1, names of the lines = 2.

```
(((entity . line) (direction . "Honoré-Beaugrand") (name . "verte") (degree-name . 2)
  (dimension . 1) (degree-dim . 1))
 ((entity . station) (name . "Lionel-Groulx") (order . 1) (degree-order . 1))
 ((entity . line) (direction . "Côte-Vertu") (name . "orange") (degree-name . 2))
 ((entity . station) (name . "Snowdon"))
 ((entity . line) (direction . "Saint-Michel") (name . "bleue") (degree-name . 2))
 ((entity . station) (name . "Acadie")))
```

```
À Charlevoix, prendre la ligne verte en direction de Honoré-Beaugrand et s'arrêter à
Lionel-Groulx (station suivante). Puis, changer pour prendre la ligne orange en direction
de Côte-Vertu et sortir à Snowdon. Enfin, prendre la ligne bleue en direction de
Saint-Michel jusqu'à Acadie.
```

In the example 5 below, the "global importance" of *partial distances* is set to 2. This yields including the information concerning the "one-stop distance" and expressing it by a subordinate clause. This also yields including the information concerning the distance of the last segment and expressing it in a bracketed apposition.

**Example 5.** Parameters of "global importance": partial distances = 2, names of the lines = 2

```
(((entity . line) (direction . "Honoré-Beaugrand") (name . "verte") (degree-name . 2)
  (dimension . 1) (degree-dim . 2))
 ((entity . station) (name . "Lionel-Groulx") (order . 1) (degree-order . 2))
 ((entity . line) (direction . "Côte-Vertu") (name . "orange") (degree-name . 2))
 ((entity . station) (name . "Snowdon"))
 ((entity . line) (direction . "Saint-Michel") (name . "bleue") (degree-name . 2)
  (dimension . 5) (degree-dim . 1))
 ((entity . station) (name . "Acadie") (order . 5) (degree-order . 1)))
```

```
De Charlevoix, prendre la ligne verte en direction de Honoré-Beaugrand et sortir à
Lionel-Groulx qui est la station suivante. À Lionel-Groulx, prendre la ligne orange
en direction de Côte-Vertu et s'arrêter à Snowdon. Changer pour prendre la ligne bleue
en direction de Saint-Michel et descendre à Acadie (5-ème station).
```

In our last example, the importance of *partial distances* is set to its maximum value: 3, which requires including the relevant information for all three segments. The distances of the first segment (1 stop), the second one (4 stops), and the last one (5 stops) are expressed respectively by an independent clause, a bracketed apposition and a relative clause.

**Example 6:** partial distances = 3, names of the lines = 0

```
(((entity . line) (direction . "Honoré-Beaugrand") (dimension . 1) (degree-dim . 3))
 ((entity . station) (name . "Lionel-Groulx") (order . 1) (degree-order . 3))
 ((entity . line) (direction . "Côte-Vertu") (dimension . 4) (degree-dim . 1))
 ((entity . station) (name . "Snowdon") (order . 4) (degree-order . 1))
 ((entity . line) (direction . "Saint-Michel") (dimension . 5) (degree-dim . 2))
 ((entity . station) (name . "Acadie") (order . 5) (degree-order . 2)))
```

```
À partir de Charlevoix, prendre la direction Honoré-Beaugrand et changer à la station
suivante qui est Lionel-Groulx. À Lionel-Groulx, prendre la direction Côte-Vertu et
s'arrêter à Snowdon (4-ème station). Changer pour prendre la direction Saint-Michel et
descendre à Acadie qui est la 5-ème station.
```

## 4 Conclusion and perspectives

Analyzing a corpus of route descriptions we have found correlations between the relative importance of a given piece of information and its linguistic counterparts: according to its relative importance, an attribute is either expressed by an independent clause (salience high) or by a subordinate structure (salience low). We have also noticed that different subordinate devices vary in terms of their status of importance. For example, relative clauses seem to be used for signaling information of higher prominence than bracketed appositions.

We have applied the results of our analysis to a generator that can automatically produce subway route descriptions in French. By taking into account the relative importance of information, we are able to get a better control than otherwise over the use of linguistic resources observed in the corpus. This enables us to generate route descriptions which are in line with the ones produced by people.

While our work is not the only one dealing with route descriptions (see, for example, [Kle82, WR82, May90, Maa93, GL95]), it is original in that it is, according to our knowledge, the only attempt to show how the notion of "relative importance" of route information maps onto linguistic form.

The results obtained so far are encouraging. Yet, they have to be evaluated by users, in order for us to see to what extent and with respect to what particular needs different versions of texts produced by our generator are helpful for navigating in the subway. We will also investigate possible extensions of the generator to other types of routes.

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