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The literary representation of space and identity: a model based on Directed Acyclic Graphs

Background

We live in a spatial universe. Spatial relations underlie many of our daily activities (giving directions, finding objects, arranging meetings), many of our abstract concepts (like space-based temporal metaphors such as “the holidays are fast approaching” or “you must leave the past behind”) and the vast majority of our narratives (“Once upon a time, in a faraway land…”). Think also of narrative quests for special locations.

We are beginning to get a sense of the linguistic and cognitive dimensions of spatial phenomena. So, for example, Pederson et al. (1998) show the diversity of linguistic devices used across a selection of the world’s languages to represent spatial relations. However, behind this diversity, it would appear that, at least in narrative descriptions, humans make use of one of two frameworks to represent spatial relations: the internal perspective represents space as seen by some participant in a scene, with the result that objects are presented as ‘surrounding’ some character, while the external perspective sees spatial representations in terms of a set of objects laid out before an observer. (For discussion, see, for example, Bryant et al., 1992.) It is clear that literary narratives can switch between these two perspectives.

In addition, as Rinck and Bower (2000) have illustrated,

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1 To take just one of their examples (p. 571), the Walpiri language uses compass directions to indicate orientation, as in “the bee is on your north shoulder”, rather than the more usual relative relation, as in “the bee is on your right shoulder”.

narratives tend to give greater emphasis to spatial relations related to the protagonist. In other words, readers tend to see the narrative universe ‘through the eyes of the protagonist’, so that, for example, items closer to the protagonist in the narrative universe are more salient for the reader, as are items presented as closer in the narrative. However, the amount of text between the presentation of different items did not appear to affect their salience, suggesting that readers construct an overarching representation of a scene.

The situation is particularly complex in the case of literary narratives which, as Pavel (1996) has shown, are fundamentally underspecified, in that they rely both on information provided explicitly by the author and background knowledge possessed by the reader. The interplay between these two sources of information is complex, as we will see below. However, it is clear that both play a role: thus, Bryant et al. (1992) have shown experimentally that response times for explicit and inferred relations between objects do not vary significantly when subjects are presented with a described scene. In fact, Ryan (2012) argues for the existence of at least four levels of spatial structure in narrative, including the spatial frame (immediately surrounding locations and events), the setting (the socio-historical and geographical location of the events of the narrative), the story space (composed of spatial frames plus other, mentioned, spaces), and the narrative world (including elements provided by the reader’s imagination).

One of the challenges facing both linguists and literary scholars is to represent the complexity we have just shown. In the following pages, as we grapple with several of these challenges, we will make use of several fundamental distinctions. First, we adopt a corpus-based approach, on the assumption that only authentic texts will provide both the richness and the complexity needed to inform our

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2 Consider, for example, the opening sentence of Maupassant’s novel Une vie: “Jeanne, ayant fini ses malles, s’approcha de la fenêtre, mais la pluie ne cessait pas.” [When she finished packing her bags, Jeanne walked over to the window, but it was still raining.] (Maupassant, 1883). The attentive reader will tend to construct a complex mental image of the room and possibly the outdoors, without the author specifying any of this.
analysis. Second, we make use of an onomasiological perspective (cf. Baldinger, 1964). In other words, we seek to represent not the low level form, but rather the meaning of a text. And finally, we assume that our analysis must be based on a formally precise representation.

In light of these distinctions, the ‘unit of measure’ we will adopt here is the topos, that is, a narrative sequence, of variable length, recognizable as recurrent and therefore conventional.\(^3\) It is important to remember that, although it is instantiated in text, a topos is a semantic entity. As a result, the same topos may be expressed in a phrase, a sentence, a paragraph or a long passage.

In order to represent the meaning of the topoi under analysis, we make use of two sorts of elements: 1) A graph structure composed of nodes and links between them, specifically a directed acyclic graph (henceforth, DAG), where the nodes carry information and the links between nodes are directed paths in which prior nodes represent information used in subsequent nodes. The acyclic nature requires that the paths form no loops. 2) A set of threads, which represent some traversal of the nodes. These two elements share many features with the well-known distinction between fabula and sujïhet or histoire and récit (for discussion of this distinction, see for example Bal, 1985, or Genette, 1983).

The content of nodes is represented by means of a set of semantic representations described in Levison et al. (2012). The representation, which is inspired by the Haskell programming language (Bird, 1998), is based on the notion of semantic expressions. The basic units for these expressions are typed functions. So, for example, the functions child() and book() belong to the type entity, while the function read() belongs to the type action. All functions have a valency, that is, a fixed number of arguments which they must take. Some, like book() above, are 0-valent, in that they take no arguments, while others, like read() above, take some fixed number of arguments, two in this case, so that read(child, book) (with the meaning, ‘a child reads a book’) is a valid semantic

\(^3\) Some examples of topoi include ‘boy meets girl’, ‘father favours younger son’, ‘stranger comes on the scene’, ‘brothers quarrel’. For additional details, see Lessard et al. (2004).
expression. Note however that the system of semantic expressions we have defined is not constrained to be ‘sensible’. Thus, in our system, \texttt{read(book, child)} with the meaning, ‘a book reads a child’ is also a valid semantic expression. This absence of semantic constraint is necessary to capture the full richness of literary texts, some of which do not follow the constraints of traditional logics like first-order predicate calculus.

Functions are defined in a semantic lexicon, which specifies three sets of information:

a) the function type-signature which specifies in this case that the function \texttt{read()} applies to two entities and returns a completion:

\[
\text{read} :: (\text{entity}, \text{entity}) \rightarrow \text{completion}
\]

b) the arguments to the function, in this case, a reader and a thing which is read:

\[
\text{read}(\text{reader}, \text{thing_read})
\]

c) an informal semantic equivalent expressed in some natural language, such as:

\[
\text{a [reader] causes some content [thing_read] to enter his or her consciousness}
\]

In what follows, we will use semantic expressions as the content of a number of nodes within DAGs.

Spatial descriptions

Previous work has distinguished two sorts of topoi: narrative topoi, that is, events in a plot, and descriptive topoi, that is, settings and descriptions of characters. Our interest here lies with the latter. We
will begin by looking at several instances of spatial description. To begin, consider the opening sentences of Flaubert’s novel *Salammbô* (Flaubert, 1863).

C’était à Mégara, faubourg de Carthage, dans les jardins d’Hamilcar. Les soldats qu’il avait commandés en Sicile se donnaient un grand festin pour célébrer le jour anniversaire de la bataille d’Eryx, et comme le maître était absent et qu’ils se trouvaient nombreux, ils mangeaient et ils buvaient en pleine liberté. [It was in Megara, on the outskirts of Carthage, in the gardens of Hamilcar. The soldiers he had commanded in Sicily were feasting to celebrate the anniversary of the battle of Eryx, and since the master was absent, and they were many, they ate and drank freely.]

We may represent the nodes of the DAG underlying this passage by means of the following semantic expressions:

`exist(megara)`
`exist(carthage)`
`exist(hamilcar)`
`exist(gardens)`
`near(megara, carthage)`
`possess(hamilcar, gardens)`
`in(megara, gardens)`

If we add the appropriate links between these nodes, where each arrow signifies that the following element depends semantically on those which precede it, we obtain a DAG as shown in Figure 1.

Note that this DAG represents the information ‘behind’ Flaubert’s text. So, for example, it shows that the statement that Hamilcar possesses gardens requires the existence of Hamilcar and of gardens. In the text as written by Flaubert, this DAG is ‘threaded’ as shown by the dotted lines in Figure 2. In other words, the dotted line

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4 In this case, and in the future, we will provide an English gloss in square brackets.
shows the sequence of nodes which are presented explicitly in the text, in the order of their presentation.

Figure 1: Hamilcar DAG

Figure 2: Threading of Flaubert’s text

Of course, other threadings are possible. Figure 3 shows the threading
underlying a sentence with an alternative ordering of elements, such as *Hamilcar possessed gardens at Megara, near Carthage.*

**Figure 3: Threading for an alternative formulation**

Let us turn now to another Flaubert novel, *L’Éducation sentimentale* (Flaubert, 1880). The novel opens with the description of a crowded dock, with a boat about to depart, various characters rushing about, and miscellaneous impediments.

Le 15 septembre 1840, vers six heures du matin, la *Ville-de-Montereau*, près de partir, fumait à gros tourbillons devant le quai Saint-Bernard. Des gens arrivaient hors d'haleine ; des barriques, des câbles, des corbeilles de linge gênaient la circulation ; les matelots ne répondaient à personne ; on se heurtait ; [On September 15th, 1840, at around 6 a.m., the *Ville-de-Montereau* was about to depart, and large clouds of smoke rose from it as it stood in front of the Saint-Bernard dock. People were arriving out of breath; barrels, cables and baskets of cloth made movement difficult; the sailors answered no one; people were bumping into each other...]

This confused scene contains the elements represented by the
DAG shown in Figure 4.

The passage written by Flaubert ‘threads’ this DAG as shown in Figure 5.

As we noted earlier, narrative texts, particularly literary narratives, are massively underspecified. It is left to the reader to ‘fill in the blanks’. Consider, for example, the first and second sentences. We are told in the first sentence that the boat is at the dock. In the second sentence, we are told that passengers are arriving out of breath, but it is not specified that the place where they are located is the dock. It is the DAG and the threading which leads us to that conclusion, along with our previous knowledge of boats and docks. Flaubert’s description is thus an impressionistic selection of visual images whose combination elicits our sense of crowded confusion.
In fact, Flaubert might have ‘threaded the DAG’ in other ways. Consider, for example, the following possible version:

Le 15 septembre 1840, vers six heures du matin, des gens arrivaient hors d’haleine au quai Saint-Bernard où la Ville-de-Montereau, près de partir, fumait à gros tourbillons devant le quai Saint-Bernard. On se heurtait ; les matelots ne répondaient à personne ; des barriques, des câbles, des corbeilles de linge gênaient la circulation ; [On September 15th, 1840, at around 6 a.m., people were arriving out of breath at the Saint-Bernard dock, where the Ville-de-Montereau, about to depart, was wreathed in smoke. People were bumping into each other; the sailors answered no one; barrels, cables and baskets of cloth made movement difficult; ...]
Although the order of the elements has changed, the overall impression of confusion remains.

The examples we have just seen show that spatial descriptions may be represented by the formalism we have described. In addition, this formalism makes it possible to pose the following empirical question: do there exist regularities in the ordering of spatial descriptions in narratives? More precisely, can these be seen as a type of ‘grammar’ which captures the usual transitions found in spatial descriptions?

As a preliminary step toward examining this problem, in earlier work (Lessard and Levison, 2005) we analysed narrative transitions in the representation of scenes in a corpus of 19th Century French novels shown in Table 1. The choice of this corpus was based on reasons of practicality and accessibility: all these texts are available online and all adopt a traditional novelistic approach to description.\(^5\)

5 See for example the site <http://abu.cnam.fr>.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Works</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balzac</td>
<td>La fille aux yeux d’or, Le chef d’oeuvre inconnu, Le colonel Chabert, L’elixir de longue vie</td>
</tr>
<tr>
<td>Flaubert</td>
<td>L’Éducation sentimentale, Salammbô, Un coeur simple</td>
</tr>
<tr>
<td>Th. Gautier</td>
<td>Arria Marcella, Souvenir de Pompéi</td>
</tr>
<tr>
<td>V. Hugo</td>
<td>Notre Dame de Paris</td>
</tr>
<tr>
<td>J.-K. Huysmans</td>
<td>À rebours</td>
</tr>
<tr>
<td>G. de Maupassant</td>
<td>Contes de la bécasse, La maison Tellier, Une vie</td>
</tr>
<tr>
<td>P. Mérimée</td>
<td>Colomba</td>
</tr>
<tr>
<td>G. de Nerval</td>
<td>La main enchantée</td>
</tr>
<tr>
<td>Stendhal</td>
<td>La Chartreuse de Parme, Le Rouge et le Noir</td>
</tr>
<tr>
<td>É. Zola</td>
<td>L’argent, Germinal</td>
</tr>
</tbody>
</table>
Analysis of the opening pages of these texts brings to light recurring tendencies in the transitions from one element of a scene to the next (or from one node of the DAG to the next, to use the terminology of this chapter). As illustration, we provide several examples.

One frequent model is based on the part-whole relation, such as the naming of an object, followed by a description of its parts:

Ses maisons blanches avec leurs toits pointus de tuiles rouges ...  
[Its white houses with their pointed roofs covered in red tiles...]  
(Stendhal, 1854)

A subset of this is based on the presentation of a container, followed by the presentation of its contents:

...le canal Saint-Martin, fermé par les deux écluses était en ligne droite son eau couleur d’encre. Il y avait au milieu, un bateau plein de bois, et sur la berge deux rangs de barriques. [...the Saint-Martin canal, enclosed by two locks, spread out in a straight line its inky water. In mid-canal there was a boat full of wood, and on the bank two rows of barrels.] (Flaubert, 1881)

Another variant of the part-whole representation is the presentation of a setting, followed by presentation of the players in the setting and their actions, as in the following example:

Assises autour d’une table éclairée par des bougies parfumées, sept joyeuses femmes échangeaient de doux propos...  
[Seated around a table lit by perfumed candles, seven joyous women exchanged soft words...] (Balzac, 1830)\textsuperscript{6}

\textsuperscript{6} In fact, all of these relations could be seen as variants of an even more general structure, increasingly explored in a cognitive linguistics framework, of figure
Given what we have presented earlier, we assume that the reader could construct both the DAGs and the threadings for these examples, and that this would permit the creation of a tagged corpus of texts with their descriptive topoi. We would then be in a position to begin to address a number of specific questions, including:

a) What are the general tendencies in the elements presented in a narrative description? For example, how specifically do narrative texts embody Pavel’s observation of underspecification?

b) Do the transitions present in texts with respect to the ordering of descriptive elements vary from author to author, language to language, culture to culture, or over time?

c) How specifically do readers construct their representations of spatial worlds in literary narratives, and how can these be represented?

d) Can texts play against these tendencies, or propose variants to them?

e) If there exists a ‘grammar’ of threading, can this be used to generate textual sequences?

Description of characters

Let us now turn to the description of characters. As we will see, this brings to light a number of issues regarding the psychology of perception, the interplay of reader and writer, and the structure of DAGs and threads.

We will begin by examining another facet of *L’Éducation sentimentale*. One of the characters on the dock described above is Frédéric Moreau, a young man who has just finished his studies and is

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and *ground*, or, in an alternative terminology, *landmark* and *trajectory*. See, for example, Langacker (1987, 1991).
Figure 6: Part of the DAG for Madame Arnoux's body
about to return home. As he casts his eyes about, he notices Madame Arnoux, the woman who will become the unattainable love of his life. Flaubert’s representation of this moment is terse.

Elle était assise, au milieu du banc, toute seule; [She was seated on the bench, all alone; …]

From these words alone, we can draw the conclusion that this is a female (because of the pronoun elle) that she is probably a woman (because she is sitting on a bench alone), but we know no more than this. However, as readers, we can use this sparse information to draw from our own internal ‘libraries’, a rich collection of background knowledge. Since the elle is probably an adult woman, we will generate the image of an adult woman. Since we know the date, we can clothe her, with more or less precision, in the accoutrements typical of the 1840’s, and since she is travelling, we can assume that she will be dressed appropriately for that context.

This rich set of background knowledge regarding Madame Arnoux as a woman is also expressible in the form of a DAG, of which Figure 6 is an extract. Flaubert then begins to fill in more elements of the description:

Elle avait un large chapeau de paille, avec des rubans roses qui palpitaient au vent derrière elle. Ses bandeaux noirs, contournant la pointe de ses grands sourcils, descendiaient très bas et semblaient presser amoureusement l’ovale de sa figure. [She was wearing a large straw hat with pink ribbons which waved behind her in the wind. Her black curls passed close to the points of her thick eyebrows, and as they fell, seemed to caress the oval of her face.]

These supplementary elements (shown in dotted lines) attach themselves to the pre-existing DAG of Madame Arnoux’s body, as shown in Figure 7.

Then this richer DAG, the product of the reader’s mental library and explicit elements provided by the text, is ‘threaded’ further in the
narrative. Appendix 1 shows the parts of the text on which this threaded DAG is based, Appendix 2, the threaded DAG itself, where solid lines indicate dependencies in the DAG, while numbered dotted lines show the order of the threading\(^7\). Finally, Appendix 3 shows the actual coding from which the program called Graphviz \(^8\) has constructed the threaded DAG.

![DAG Diagram]

Figure 7: Additions to description of Madame Arnoux

Examination of Appendix 2 allows us to make several observations.

First, unlike the DAG, which is non-cyclical, the threading of this text involves the repeated return to particular nodes. So, for example, arcs 4-8 show that the protagonist’s gaze moves from

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\(^7\) The because of its size and the constraints of the printed page, the DAG shown in Appendix 2 is very difficult to read. A larger version may be found at <http://research.cs.queensu.ca/CompLing/>.

\(^8\) Graphviz is a set of programs which read the specifications of graphs and output a graphical representation. Appendices 2 and 3 illustrate this in detail. For additional details on Graphviz, see <http://www.graphviz.org>.
Madame Arnoux’s hair, to her face, to her dress, then her hands, and then back to two elements of her face, first her nose, then her chin.\footnote{It is for this reason that the arcs for the threading in Appendix 3 are labelled with digits, while the arcs for the DAG itself are not.}

Second, three elements of Madame Arnoux’s body attract repeated fixations by Frédéric Moreau: her face, her hands, and the lower part of her body, with the first of these being by far the most dominant. This focus on the face is not surprising. Already in the mid 20th Century, research on fixations on parts of a scene showed the strong attention paid to faces. As an illustration, Appendix 4, reproduced from Yarbus (1967, p. 177) shows the areas of a complex scene (the portrait, \textit{An Unexpected Visitor}, by Ilya Repin) which were focused on by an experimental subject whose eye movements were measured to show what was being looked at and in what order. The first of the eight images in Appendix 4 shows the portrait itself, while each of the following seven images shows areas of fixation at five-second intervals. It is clear that faces receive much attention, although other elements, like clothing and hands, are also focused on. The correspondence with the DAG of Flaubert’s description is striking, an illustration of the psychological plausibility of his description.\footnote{The tendency to focus on faces and to rescan areas of interest has been confirmed by more recent research. See for example Fletcher-Watson et al. (2008). We wish to thank several colleagues in the Queen’s Psychology Department (Jill Atkinson, Kevin Munhall, Monica Castelhano, Vernon Quinsey) for their valuable suggestions in this area.}

Third, this descriptive sequence is not anomalous in the literary perspective. Similar findings regarding a focus on the face have been made for other authors, including contemporaneous ones like Sand (see for example Massardier-Kennedy, 1988). However, what is perhaps more surprising is the close correspondence between Flaubert’s description and experimental results. Is it possible that this is due to family influence (his father was a surgeon and he was perhaps aware of work on vision which was beginning at the time in France; see Bénéjam, 2009)? Or could it be explained by the fascination that observation apparently always held for him, as argued by Genette (1966), or by a desire to accentuate the ‘reality’ of the text,
as argued by Barthes (1966)?

Fourth, it is important to take account of the role of emotion. There is no doubt, from Flaubert’s text, that the sight of Madame Arnoux has profoundly affected Frédéric Moreau. The specific effects of this are, however, harder to determine. Although there is work on perception that supports the view that emotional scenes (like one person attacking another) draw the attention of an observer more than scenes without such emotional content (see for example, Nummenmaa et al., 2008), such work focuses on the emotion present in the scene, not on the emotions of the observer, something much more difficult to manipulate in an experimental context.

Conclusions

The study of narrative is vast and complex. Even the more delimited area of narrative treatments of space has multiple dimensions and perspectives, including the literary, the psychological, and the linguistic, to name just these. Perhaps because of this richness of perspectives, we continue to face a disciplinary and empirical divide.

On the one hand, literary specialists have provided a rich set of concepts and terms to guide the analysis of narrative. They have also provided numerous examples of close reading of particular passages. However, such analyses are almost never formalized, nor are they extended to corpora of texts. As a result, whatever their interest – and it is considerable – such analyses tend not to be read or considered by those doing more ‘scientific’ work on the perception and manipulation of spatial information by humans. The situation is further complicated by the fact that literary narratives are, by their very nature, complex and individual. Psychologists and linguists often prefer texts whose

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11 See, for example, Bal (1977, part 3), which presents a detailed analysis of space in Flaubert’s Madame Bovary.
parameters can be more easily controlled.

On the other hand, the growing body of empirical work on the processing of spatial information, including the perception and analysis of other humans and objects in the world, has provided an increasingly clear picture of how we deal with space in the ‘real world’. Unfortunately, these findings are not often extended to the fictional worlds that most humans inhabit for at least part of their lives, when they read fictional narratives, or tell stories.

In an important article, Ryan (2007) argued that the use of diagrams can provide a tool for analysis of narrative that not only makes clear the relations under study, but actually permits new insights. We agree wholeheartedly with that view. We would extend it by claiming that one of the ways of bridging the gap between the literary and the scientific treatment of space is provided by computational modelling of the sort described in this chapter. We do not claim that the model we present is the only possible one, or even necessarily the best one, but we do believe that by imposing formal constraints, it provides a healthy discipline. At the same time, by its application to authentic texts, it requires us to deal with the actual complexities of literary narratives. Finally, and perhaps most importantly, it makes it possible to share findings across disciplinary boundaries.
References


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Lessard, Greg / Sinclair, Stéfan / Vernet, Max / Rouget, François /


Appendix 1: Description of Madame Arnoux

Excluded sections are shown by suspension points (...); descriptive items are in bold. Each descriptive item corresponds to a node in Appendix 2. The number after each item corresponds to the number on the thread leading to the corresponding node. The word following is an English gloss of the descriptive item.

Elle était assise, au milieu du banc, toute seule ; ... elle leva la tête [1, head] ; ... Elle avait un large chapeau [2, hat] de paille, avec des rubans [3, ribbons] roses qui palpitaient au vent derrière elle. Ses bandeaux [4, curls] noirs, contournant la pointe de ses grands sourcils [5, eyebrows], descendaient très bas et semblaient presser amoureusement l'ovale de sa figure [6, face]. Sa robe [7, dress] de mousseline claire, tachetée de petits pois, se répandait à plis nombreux. Elle était en train de broder [8, embroider] quelque chose ; et son nez [9, nose] droit, son menton [10, chin], toute sa personne [11, body] se découpaient sur le fond de l'air bleu. ... Jamais il n'avait vu cette splendeur de sa peau [12, complexion] brune, la séduction de sa taille [13, waist], ni cette finesse des doigts [14, fingers] que la lumière traversait. ... L'enfant, dont les yeux roulaient des larmes, venait de s'éveiller. Elle la prit sur ses genoux [15, knees], ... Cependant, un long châle [16, shawl] à bandes violette était placé derrière son dos [17, back], sur le bordage de cuivre. ... Leurs yeux [18, eyes] se rencontrèrent. ... Quand la musique s'arrêta, elle remua les paupières [19, eyelids] plusieurs fois, comme si elle sortait d'un songe. ... Mme Arnoux blâma son mari de sa faiblesse pour son enfant. Il chuchota dans son oreille [20, ear], une gracieuseté, sans doute, car elle sourit [21, smiled]. Puis il se dérangea pour fermer derrière son cou [22, neck] le rideau de la fenêtre. ... Frédéric, en face, distinguait l'ombre de ses cils [23, eyelashes]. Elle trempla ses lèvres [24, lips] dans son verre, cassait un peu de croûte entre ses doigts [25, fingers]; le médaillon de lapis-lazuli, attaché par une chaînette d'or à son poignet [26, wrist], de temps à autre sonnait contre son assiette. ... Elle lisait un mince volume à couverture grise. Les deux coins de sa bouche [27, mouth] se relevaient par moments, et un éclair de plaisir illuminait son front [28, face].
Appendix 2: The threaded DAG for Madame Arnoux
Appendix 3: Graphviz code for the Mme Arnoux DAG

digraph arnoux {
    # The DAG of Madame Arnoux's body
    arnoux -> head
    arnoux -> body
    arnoux -> hands
    head -> hat
    hat -> ribbons
    head -> face
    head -> hair
    hair -> curls
    head -> ear
    head -> neck
    eyes -> eyelids
    eyes -> eyelashes
    face -> eyes
    face -> eyebrows
    face -> nose
    face -> chin
    face -> complexion
    face -> mouth
    mouth -> lips
    hands -> fingers
    hands -> wrist
    body -> knees
    body -> dress
    body -> waist
    body -> shawl
    body -> back
    # The threading of the DAG
    arnoux -> head [label=1, style=dotted]
    head -> hat [label=2, style=dotted]
    hat -> ribbons [label=3, style=dotted]
    ribbons -> curls [label=4, style=dotted]
    curls -> eyebrows [label=5, style=dotted]
    eyebrows -> face [label=6, style=dotted]
face -> dress [label= 7, style=dotted]
dress -> hands [label= 8, style=dotted] # [embroidering]
hands -> nose [label= 9, style=dotted]
nose -> chin [label= 10, style=dotted]
chin -> body [label= 11, style=dotted]
body -> complexion [label= 12, style=dotted]
complexion -> waist [label= 13, style=dotted]
waist -> fingers [label= 14, style=dotted]
fingers -> knees [label= 15, style=dotted]
knees -> shawl [label= 16, style=dotted]
shawl -> back [label= 17, style=dotted]
back -> eyes [label= 18, style=dotted]
eyes -> eyelids [label= 19, style=dotted]
eyelids -> ear [label= 20, style=dotted]
ear -> mouth [label= 21, style=dotted] # [she smiled]
mouth -> neck [label= 22, style=dotted]
neck -> eyelashes [label= 23, style=dotted]
eyelashes -> lips [label= 24, style=dotted]
lips -> fingers [label= 25, style=dotted]
fingers -> wrist [label= 26, style=dotted]
wrist -> mouth [label= 27, style=dotted]
mouth -> face [label= 28, style=dotted]
Appendix 4: Areas of fixation in a complex scene
(from Yarbus, 1967; reproduced with permission)