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Abstract

This report describes the analysis of data used to characterize pronominal references to events and actions. We studied two different sets of data and propose mechanisms that will support the generation of text including pronouns referring to events and actions.

Comments

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**PRONOMINAL REFERENCE TO
EVENTS AND ACTIONS:
EVIDENCE FROM
NATURALLY-OCCURRING DATA**

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**MS-CIS-88-13
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July 1988

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**Pronominal Reference to Events and Actions:
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July 1988

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ABSTRACT

This report describes the analysis of data used to characterize pronominal references to events and actions. We studied two different sets of data and propose mechanisms that will support the generation of text including pronouns referring to events and actions.

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1. Introduction

A well accepted argument is that we can refer to events and actions using pronouns (or noun phrases) as shown in the following interaction:

- (1) U: Tell me how to define a region again. I forgot how to do *it*.
E: You set the mark with <esc>-M at one extreme of the text and you move the cursor to the other extreme. *That* defines a region.

This seems like a very natural piece of text which we, as speakers and hearers, can understand easily. One of the most direct ways to interpret the pronouns in (1) is to use subscripts to indicate the relation between the pronouns and their referents as pointed out by Neale [Neale 87]. Hence we could have:

- (2) U: Tell me how to [define a region again]_i. I forgot how to do *it*_i.
E: [You set the mark with <esc>-M at one extreme of the text and you move the cursor to the other extreme]_i. *That*_i defines a region.

While we could use the subscripts to indicate the anaphoric relations between the pronouns and their referents, it is not always the case that the correspondence between the two is as simple as finding the matching subscripts or the boundaries of the text corresponding to the referent.² Furthermore, in many cases finding the actual referent may require additional processing and/or inferencing. Also, the interpretation of the referent is based not only on the exact piece of text that describes the particular event or action but on the entire discourse or the context in which it appears. For example, in (2) we can almost certainly claim that the matching between the text with subscript *i* and its pronoun *it* is uniquely determined. However, when it comes to the pronoun *that* and its referent, it is not certain whether the referent should include "you set the mark...". We could say that *that*_i refers to "setting the mark with...", or even "X set the mark...", where X can be some agent that performs the action.

In general, pronouns serve as links between a given item introduced in the discourse and subsequent references to that particular item. These items can be of many sorts: objects, things, people, events, facts, states, actions, and so on. Rather than having to describe a particular object or event every time we want to talk about it, we can make use of a particular pronoun to refer to it. In this report, we concentrate on the use of pronouns such as *it*, *this*, and *that* as referring to events and actions as shown in (1). We present an analysis of the data used as the basis for our theory of pronominal reference to events and actions. We show the relationship between the pronouns and their referents for text generation: what roles they play in text generation, what is the purpose of their use, and what advantages they provide to a given piece of text. This work is part of a larger research project on pronominal reference to events and actions in text generation. The primary concern in this work is how these events are represented in order to refer to them pronominally, and the mechanisms that guarantee the use of such pronouns in text generation.

Text generation requires us to formulate the reasons for choosing among several options. A generator should be able to examine all the possibilities and choose which one is best for the specific situation or at least recognize which are appropriate in the specific situation. For the purpose of reference to events, the generator must make decisions such as whether to use a pronoun to refer to an event and when to refer

²In this work, we will use the term referent to describe the entity that is being referred to. While the interpretation of the referent is, in part, based on the linguistic text, it is usually considered to be a non-linguistic entity. On the other hand, the antecedent usually corresponds to the linguistic text that gives rise to an entity.

to an event explicitly (as opposed to leaving it implicit). Other issues involved include how often one can keep on referring to an event with a specific pronoun, when one can switch the particular pronoun and change the referent, and when it is necessary to re-introduce or re-specify the event in order to make the text coherent.

The work on generation of pronominal references to events and actions presented here is based on written text rather than spoken text. In spoken text, given a pronominal reference to an event or an action, the choice of the referent is affected by the intonation used. In developing our theory of pronominal reference to events, we restrict our focus to written text because of the effect intonation could have on the interpretation of a given pronoun. That is, when deciding on a referent of a given pronoun, intonation used in the form of contrastive stress can be used to change what would in written or unmarked text assumed to be the referent of the pronoun.

In the next section, we provide a definition of events and actions as viewed within this work. Section 3 is a brief view of how pronouns have been described in terms of reference in some of the literature. Section 4 describes the data and its analysis with respect to pronominal event reference. In section 5, we present our hypotheses on the choice of specific pronouns as well as their referents. We look at the predictions of each hypothesis and what the data shows. We then show the hypotheses that are supported by the data. In the larger project, the representation issues arising from the findings presented here will be implemented along with the hypotheses accounted for by the data.

2. Events and Actions: An Informal Definition

In this section, we provide a description of what characterizes events and actions in terms of this work.

We consider events to be associated with a clause or a sentence.³ Given,

- (3) E: OK. Now in Emacs there is something called the MARK. What you can do is
type <esc>-M,

we can describe the event in which the user types esc-M. The event characterization includes the agent. This event description can be referred to pronominally with *that* as in

- (4) E: and *that*₁ will set a mark wherever the cursor happens to be. Try *that*₂ (it should say mark set).

On the other hand, we can describe an action when the referent is the verb phrase of the sentence as in the following response of the user to (3) and (4),

- (5) U: I did *that*₅

A similar characterization has been proposed by Jackendoff. He considers events and actions as being primitives. He suggests that "expressions other than NPs can be used referentially, and that they refer to #entities# other than #things#, having equal ontological status" [Jackendoff 83, p. 53]. He claims that there is linguistic evidence to distinguish among the categories because each one permits the formation of a *wh*-question. Examples of the categories are as follows:

³In the examples listed from here on, we use numbers as subscripts of the pronouns referring to events or actions in order to distinguish among the various pronouns used, and to refer to those pronouns in a specific way.

In the work presented here, the relationship between the particular pronoun and its referent may not be as straightforward. If we have:

- (8) E:Oh. Well a simple way around that this time is to search for DEBUG, then do a down-line, front-of-line, and you're in the same position. Right?
 U:Yes but *that*₁ won't work for the application in mind. *It*₂ would lead to recursive multiple (unwanted) changes. I tried *it*₃.

We claim that the italicized pronouns *that*₁, *it*₂, and *it*₃ all refer to the same thing in spite of the fact that they are different pronouns. In this work, we will show how, based on results of our experiments, we can manipulate different pronouns to choose a different referent in the text. For instance, our experiments showed that given the paragraph:

- (9) John thought about becoming a street person. *It*₁ would hurt his mother and *it*₂ would make his father furious. *It*₃ was not a clever thing to do.

The subjects chose the referent to the pronoun *it*₂ as being "becoming a street person" 100% of the times. However, when we switched *it*₂ to a *that*₂, the referent "becoming a street person" was chosen only 20.83% and "hurting his mother" was chosen as the referent 62.50% of the times.

Given these results, our goal will be to show how to use those constraints as ways to generate text that includes the pronominal reference to events and actions, given the way people interpret the pronouns.

4. Discourse Analysis

4.1. Introduction

Two different sets of data were used as the basis for the work presented here. In this section we examine each of these separately and show its contribution to this work.

The first set consists of several dialogues collected in situations where two people were interacting, one acting as an expert and the other as a novice. The goal was for the novice to learn how to use the EMACS editing system by interacting in English, via a computer terminal, with the expert. From the point of view of building systems that use natural language for both understanding and generation, the main purpose of collecting these dialogues was to characterize the language used by both the expert and the novice. For the specific goal of this research, our main concern was to characterize the use and potential interpretation of pronouns referring to actions in the dialogues. In the next three sections we show how this was done and give the results of our analysis of these dialogues.

The second set of data consists of a large sample of questionnaires that were given to undergraduate students in the introductory classes in Computer Science and Linguistics at the University of Pennsylvania. Our goal was to see how different pronouns affected the choice of their referents in a given text. We were also interested in the use of the pronouns for generation purposes, in trying to describe the mechanisms that support the use of one pronoun versus another when referring to an action or an event. Indeed, as we shall see in the last three sections, the different pronouns affected the results in a consistent way.

For each set of data, we first describe in some detail how it was collected. We then show how it was analyzed in terms of the pronouns that appeared in the text. The analysis is presented in terms of: (1) the

actions and/or events introduced by the text, (2) the pronouns used to refer to those events or actions, and (3) how the choice of the pronouns affects the choice of the referent(s). Given the difference in the two sets of data, we show how the results of their analysis motivate the proposed mechanisms supporting the generation of text that includes event and action anaphora.

4.2. Collection of the EMACS Transcripts

4.2.1. Description of the Dialogues

The EMACS transcripts, as we shall refer to them, were collected as part of a project for a natural language seminar during the spring of 1982 [Lewis 82]. These 8 dialogues⁴ took place between two people, one acting as an expert and the other as a novice as they communicated via a computer terminal.

These transcripts are considered 'task dialogues' and they can be so characterized for several aspects. First, both the expert and the novice were working together on a task. In this project, the novice's goal was to edit a file on-line so that it would look exactly like a hard-copy of that file which s/he had been given. Ultimately, the goal was to learn how use EMACS. The expert's task was to help the user as much as possible in editing the file in the easiest way, i.e. with the smallest possible number of commands or keystrokes. Second, we could envision a computer or computer system taking over the role of the expert in this sort of interaction, even though in these transcripts it seems that the user realized that the expert was a person. And, of course, one of the ways to do so would require the computer to use a natural language to communicate with its users. Third, because the expert and the user had a particular task to achieve, they were not particularly concerned with the language they used. This indicates that the language used was spontaneous and it gives us a sense of how different people use language in different ways.

4.2.2. The Actual Task

As noted before, the novices that participated in these interactions were people who did not know how to use EMACS. They were given a hard copy of the contents of a file and a list of simple commands and key-bindings for EMACS. For example, they could see in the list that the command to capitalize a word was control-U and to lowercase it was control-L. On the terminal, they had two windows. In the top window they had a file which they had to modify in order to make it look like the hard copy they had been given. In the bottom window, they were able to "talk" with the expert by typing their requests. Each transcript consists of an interaction, as recorded in the bottom window. The novices could move back and forth from the windows and they could ask the expert how to do certain tasks. They were encouraged to ask questions if they found that something was taking them too long to do, as shown in the following:

(10) E: how are you doing??
 if something seems to be taking a long time there may be a shorter way to do
 it so please ask!!!!

Primarily, the user's task was to move blocks of text around, uppercase and lowercase regions. Since s/he did not know about "regions" in EMACS, the expert suggested their use and went about describing

⁴The original on-line files of these dialogues have been lost and only hard copies are available. One of the 8 was collected independently and a second one appeared in two different files so it's not clear whether it was part of an original dialogue or it was an interaction that took place at two separate times.

them and telling him/her how to use them. For instance, when a novice user (U) said that s/he was trying to delete a block of text, the expert (E) suggested defining a region and the interaction proceeded as follows:

- (11) E: Oh yeh. Most likely what you would like to do is to define a region and just kill that region (eg, with all those nasty transmission errors, right?)
 U: Ok. How do I define a region?
 E: Glad you asked. Do *this*₁: set a "mark" at some point (any old point) by typing <esc>-M. *It*₂ will say "mark set" try *it*₃. Yes?

Another task that the user had to do included repeating a set of actions several times which could be done faster and easier by defining a "macro". The next interaction (12) shows the expert telling the user about a macro.

- (12) U: Tell me about keyboard macros.
 E: a kbd macro is where you tell EMACS that you want it repeat some series of actions (normally keystrokes) whenever you type some given key. Would you like to build one?
 U: Oui.
 E: OK. To open a macro, type ^X(, then type the body of the macro, and close it with ^X). EMACS will then ask for a key to attach it to. Write a simple macro, say that does three forward-characters. Do *that*.
 U: How do I erase the binding?
 E: You don't, but why would you want to? (You ought to always choose ^H or some unused key to bind it to in the first places of course).
 U: How do I restore a binding to its orig. val then?
 E: Hmmm. Now *that's* harder. What do you wish to rebind?
 U: Just asking in general.
 E: Oh. Does your kbd macro work now?
 U: Yes.
 E: Do you want to write a fancier one (say one involving a search?)
 U: Y.
 E: OK. Now you have to understand that the incremental search you've been using can't be used in macros. You have to use the "simple-search" (ie blind), invoked with <esc>-S. understand?
 U: Y.
 E: OK. Try writing a macro that just does a search. (say for "DEBUG")
 U: How do I abort a macro learn in mid-learn (^G didn't work)?
 E: JUST close it and bind it to ^H and start over again.

4.3. The Analysis

The focus of the analysis in these transcripts are the pronouns *it*, *this* and *that* as well as *do it*, *do that* and *do this* which refer to events and actions. We analyzed all of the pronouns used by the expert and user. We only considered those which did not refer to objects or individuals, in particular, those referring to events and actions. Determining the processes needed to identify an event or an action referred to by a pronoun was a goal in analyzing these dialogues. The particular pronoun used, what it picked as a likely referent, and how and when it was used were all taken into account.

In order to analyze the relationship between the pronoun and its referent, we focused on:

- the events and actions as they are introduced by the text,
- the pronouns that refer to the event(s) and/or action(s),
- determining the relationship between the event(s) and the pronoun and

- the necessary context for interpreting the pronouns and their referents correctly.

We use the results to provide methods that can guarantee the generation of pronominal reference to both events and actions.

We started by formulating some questions about the correlation between the specific pronouns and what they chose as their referent. For example, did *this* refer to one action or to a sequence of actions? Was it the same for *that* and/or *it*? Because of these questions about the pronouns, we classified them and their referent(s) in terms of referring to one action, a sequence of actions or parts of sequences of actions.

In general, a pronoun can refer to either one individual action or event or it can refer a to set of events or actions related in different ways to form one unit. We shall describe how these classifications are characterized in terms of what we found in the EMACS data.

4.3.1. A Pronoun Referring to One Action or Event

When a pronoun appears in the text, the initial assumption is that the pronoun refers to one event or one action, as shown in example (13):

- (13) U: How do I center the comment headers?
E: Type <esc>-C. *That* will center them.

That refers to "U typing <esc>-C" which is one action. When describing pronouns that refer to individual events or actions, we can distinguish between (i) a specific event or action characterized by a given sentence which we call the "token", and (ii) a general characterization of that event or action which corresponds to the "type". For example, in (13) the token is described by the particular event in which the user types <esc>-C. If we generalize on any part of this description of the token, we can obtain various types of events which are related to the original event. Such is the case of the event in which anybody types <esc>-C, or the event in which anybody types anything. The types are obtained by generalizing on parts of the representation of individual events as characterized by the initial sentence. A representation using higher-order λ calculus to represent the individual events along with a detailed explanation of how the generalization can be done on those predicates appears in [Schuster 86].

4.3.2. A Pronoun Referring to a Sequence of Actions or Events or Parts of a Sequence

As noted before, a pronoun can be used to refer to individual events or actions. However, there are times when a pronoun can refer to more than one action or event. Here, we will describe one way in which those events or actions can be related to each other in order for a particular pronoun to refer to them.

The relationship we identified was the notion of a sequence of events or actions. In terms of the EMACS data, a sequence is a list of events or actions ordered sequentially and temporally. Given this notion of a sequence, a pronoun can refer to the entire sequence or to parts of it.

When a sequence of actions occurs in the EMACS transcripts, it is possible to say that both the (entire) sequence of actions generates the goal action and/or the final action generates the goal action. An example inspired by Werner [Werner 66] is the following:

chop down tree

^
|
|
|

swing axe-1 swing axe-2 swing axe-3 swing axe-4

We can say that both the swinging of the axe four times generates the chopping down of the tree, and that swinging the axe the fourth time generates the chopping down of the tree. Because of this, when characterizing the referent(s) of a pronoun in the transcripts we have taken the pronoun to refer either to the entire sequence or to the last action in the sequence.

For instance, *this* in (14) refers to a sequence of three actions: (1) spacing up the desired work, (2) deleting it, and (3) typing in the word.

- (14) E: In a kbd macro, you normally just space up the desired work, delete it and type in the new word. Is *this* what you're up to?

We could describe this sequence as the "keyboard macro sequence" which includes those three actions. Then, the pronoun refers to that particular sequence as one.

In the EMACS data, there is only one case where the pronoun seems to refer to the initial action of the sequence. The text appears as follows:

- (15) U: As I was saying, is there a way to have the editor search through the entire file for "fc"s, and ask me whether I want a particular occurrence to be changed to
E: Yes, there is.
OK? Yes, there is. If you go to the top of the file (or wherever you want to start), and do a "replace" (via ^X R), EMACS will prompt for the old & new strings (terminate with a CR), and then at each instance of the old string, ask you if it should replace. Do *that*₁ much, and when it finds the first occurrences of "FC", type "?"

In this interaction, it seems like the expert is using *that*₁ to refer to the first part of the "replace sequence" which includes (1) going to the top of the file, (2) typing the command for the replace, and (3) responding to the prompt of the replace command. The last action, which is not included as part of the referent is the actual performing of the replace, which has to be done one at a time.

One example in which the pronoun can refer to the last action in the sequence is (16):

- (16) E: To kill a region, the whole thing at one time you should set the mark <esc>-M at the top of the region, then move the cursor down to the bottom of the region and type <esc>-control-K. *This*₁ will kill the region ok??

In (16), *this*₁ can refer to the last action described by the expert, that is "typing <esc>-control-K" which allows the user to kill the region. More specifically, the actual commands that the user must type in order to kill a region are <esc>-control-K. Here, the expert has described a sequence of three actions: (1) setting the mark by typing <esc>-M at the top of the region, (2) moving the cursor down to the bottom of the region, and (3) typing <esc>-control-K to perform the actual killing of the region. We could also characterize this sequence in terms of two actions: (1) defining the region which in turn requires setting

the mark at one end and moving the cursor to the other end, and (2) typing <esc>-control-K to kill the region. When the expert uses *this*₁, he is referring to "typing <esc>-control-K". Note however that the referent and the actual execution of this last action will not succeed if the region is not defined. That is, the expert can refer to the last action because he is aware that the user knows about the previous actions--defining the region-- which he told the user, and he can assume that the user has understood those actions as being in a sequence, of which "typing <esc>-control-K" is the last.

-G" which will allow the user to move from one end of the region to the other. The expert has described a sequence of three actions: (1) setting the mark at one place, (2) going down several lines, and (3) typing <esc>-G which allows the cursor to move from one end of the region to the other. When the expert uses *that*₃, he is referring to the cursor moving from one end of the region to the other when the user types <esc>-G. Note however that the "typing <esc>-G" action will not work if there is no mark set at a different place from the location of the cursor. That is, the expert can refer to the last (third) action because he is aware that the user knows about the previous two actions (the expert himself told him) and he can assume that the user has understood the three actions as being related in a sequence.>

The results from the EMACS data in terms of individual actions, sequences or parts of sequences are as follows:

	1 action	sequence	first	tail	totals
that	16	14	0	1	= 31
this	3	8	0	2	= 13
it	13	6	0	0	= 19
do that	6	3	1	0	= 10
do this	3	2	0	0	= 5
do it	7	1	0	0	= 8
Totals	48	34	1	3	= 86

The four categories in the columns correspond to the possible groups of events or actions that a particular pronoun can refer to in terms of individual event or actions, as sequences or as part of sequences. Note that in our results we have counted twice those cases where it is possible for the pronoun to refer to either the sequence or to the last action in the sequence.

4.3.3. A Pronoun Referring to Events or Actions Related by Generation and Enablement

In analyzing the data we found the need for two additional relationships among events that can be referred to pronominally. One was "generation" as proposed by Goldman [Goldman 70] and the other one was "enablement". Both of these relationships were developed by Pollack [Pollack 86a] in her thesis. As Pollack describes them, generation and enablement are distinct relationships. Roughly, if an agent performs one action and thereby, without any effort on his/her part, does another, then we can say that his/her performance of the former action generated the performance of the latter. For example,

(17) E: Do *this*: set a "mark" at some point (any old point) by typing <esc>-M. It will say "mark set" try *it*.

(18) E: <esc>-M will give set-mark. Do *it*.

In both cases, the referent(s) of the pronoun *it* can be either "setting the mark" or "typing <esc>-M" or even both: "setting the mark by typing <esc>-M". By viewing the referent in terms of the generation

relationship, we can claim that "typing <esc>-M at a given time can generate setting the mark at that given time". This relationship allows us to establish the connection between "typing <esc>-M" and "setting the mark" and it can be understood as one relationship. When the pronoun *it* is used as is the case in both examples, neither of the two referents need to be specified because the generation relationship indicates that they are both related to each other. If the generation relationship is not established properly between actions, the referent of a pronoun can be easily misunderstood. Consider for example the following interaction

(19) E: Set the mark at the beginning of the region. Type <esc>-M and once you have done *that*₁, move to the end of the region.

Here the user, when reading the instructions as given by the expert, may fail to understand that the expert is referring to "typing <esc>-M" as the way to set the mark. If, on the other hand, the expert provides his instructions as follows, the generation relationship guarantees that the user understands "typing <esc>-M" and "setting the mark" as being related to one another and interprets the pronoun referring to them appropriately:

(20) E: Set the mark at the beginning of the region by typing <esc>-M and once you have done *that*₁, move to the end of the region.

Enablement, as opposed to generation, has been described as follows: "one act enables the generation of a second by a third if the first brings about circumstances that are necessary for the generation" [Pollack 86b, p. 208]. That is, if an agent performs an action and thereby puts the world in a state in which a second action will generate a third action, then we can say that the agent's performance of the first action enabled the generation of the third by the second. For example,

(21) U: I want to quote a character in order to insert a control character in the text.
How can I do it?
E: The way you quote a character, say control-X is by typing control-Q followed by control-X. Typing control-Q enables you to enter the control-X commands in the text. Go ahead, try *that*.

In this example, the pronoun *that* refers to the sequence of actions related by the enablement relationship: "typing control-Q" enables "typing control-X" which in turn allows the user to enter the control-X into the text.

In summary, our representation of events and actions has to allow for the following in order to refer to them pronominally: (1) individual actions, (2) sequences of actions and/or the last action of each sequence, (3) a generation relationship, and (4) an enablement relationship between the actions. Once we represent the individual events and actions as well as the relationships among them, we can use pronouns to refer to them as units, where those units can be individual events, sequences of events or actions, parts of sequences, or events/actions related by generation and/or enablement.

4.4. The Questionnaires

The questionnaires provided us with a more restricted environment in which to test the use and interpretation of the two pronouns *it* and *that*. We were interested in the "life-time" of the referent given the pronoun in a sequence. We considered the following points:

- Does the choice of one pronoun over the other affect the choice of the referent?
- What happens to the referent when the pronoun is switched?

- Is there a way to decide how to maintain a referent with a specific pronoun and if so, what guarantees that maintenance? Is it only the particular pronoun or something else?

As we shall see later on, the results from the questionnaires do show a significant difference with respect to the choice of the pronouns. In the next section we describe the questionnaires and the methodology we used.

4.4.1. Description of the Questionnaires

The students were given the basic questionnaire as it appears in Appendix I. Versions only differed in the pronouns used, which were mixed in the six positions $P_1(x1)$, $P_2(y1)$, $P_3(z1)$, $P_1(x2)$, $P_2(y2)$, and $P_3(z2)$.

We only considered those answers given by students who were native speakers of English, hence our asking for their native language. We eliminated 25 questionnaires which were answered by non-native speakers of English.

All the students were given the same basic text, two paragraphs of four sentences each. Their task was to answer two questions for each paragraph. The only variants were the use of the pronouns *it* and *that* in three different places of the paragraphs--the $P_1(x1)$, $P_2(y1)$ and $P_3(z1)$ in the first sequence and the $P_1(x2)$, $P_2(y2)$, and $P_3(z2)$ in the second sequence. Given that there were two different pronouns in three places, there were eight different versions of the questionnaires. Because the patterns of the sequences were the same, for each questionnaire we made sure that the first sequence was different from the second one, that is, if the first sequence included ' $P_1(x1)=it/P_2(y1)=it/P_3(z1)=it$ ', the second sequence included ' $P_1(x2)=that/P_2(y2)=that/P_3(z2)=that$ ' and vice versa. The point of this variation between the pronouns in each sequence was to make the sequences look as different as possible, though in reality they were almost exactly the same.

4.4.2. Issues Affecting the Results

The first set of questionnaires we ran included a "secretly" in the last sentence of the first paragraph as in:

1. **Mary thought of getting a PhD in English. $P_1(x1)$ would have pleased her father and $P_2(y1)$ would have infuriated her husband. But $P_3(z1)$ was just what she secretly wanted.**

and so did question b:

What did Mary secretly want?

We were told by some of the subjects that the "secretly" semantically loaded the paragraph: it may be a secret that Mary wanted to infuriate her husband but it may not be a secret that she wanted to get a ph.d. in English. We therefore removed it from the following questionnaires that we gave the students. Nevertheless, when we looked at the answers of the questionnaires with the "secretly" and those without, the results were exactly the same. What we feel now is that the "secretly" may have made the students stop and think a bit longer about their answers but it did not affect their answers in terms of the pronouns.

Some subjects have also pointed out that the "but" at the beginning of the last sentence in the first paragraph may also affect the interpretation of the entire sequence. However, the second paragraph

(which mirrors the first) did not have a conjunction in that position and the results, as we shall see later on, are the same.

One last issue is the conjunction in the second sentence of both paragraphs. We will show the results exactly in terms of that conjunction, that is, the choice of the referent is either the entire conjunction or the last event in the conjunction. In the future, we plan to repeat the experiments with the exact same sequences but eliminate the conjunction, to assess the effect that the conjunction could have had on the results.

In the next section, we will describe the results of the questionnaires with the different permutations of the pronoun chain. In the section after that, we will go over every hypothesis and consider how it accords with the data. Those hypotheses that are supported by the data will be used as the basis of an algorithm for deciding if a pronoun can be used to refer to an event or action, and if so, which.

4.4.3. The Results

In order to count the answers, we assigned a number to each possible answer as listed below. Note that there was a problem in the first paragraph sequence where the choice of the referent was either 'Mary getting a Ph.D. in English' or the object itself: 'the Ph.D. in English'. We took both answers into account. Then, the assignment of the answers was the following:

For paragraph 1, we assigned the following numbers to each answer:

- 1 = Mary (thought of) getting a Ph D in English
- 2 = a Ph D in English
- 3 = pleasing her father
- 4 = infuriating her husband
- 5 = 3 and 4
- 6 = ambiguous, they listed several answers

For paragraph 2, the assignment of the answers was analogous to those of the first sequence:

- 1 = John (thought about) becoming a street person
- 3 = hurt his mother
- 4 = make his father furious
- 5 = 3 and 4
- 6 = ambiguous

These numbers appear along the vertical axis in the following tables. The letters along the horizontal axis stand for the following permutations of the pronouns:

	P ₁	P ₂	P ₃
i/i/i =	it	it	it
i/i/t =	it	it	that
i/t/i =	it	that	it
i/t/t =	it	that	that
t/i/i =	that	it	it
t/i/t =	that	it	that
t/t/i =	that	that	it
t/t/t =	that	that	that

Given that there were two paragraph sequences with two questions each, there are four different questions that each subject responded to. Therefore we have a chart for each question: **Chart 1a** has the

results of the answers to question a of the first paragraph sequence while **Chart 1b** has the answers to questions b of the same paragraph sequence.

The four charts that appear in Appendix II show the results of each question, along with their percentages, given the chain of pronouns as shown in the immediately preceding table. There is one additional chart (Chart 1b') where we have added rows 1 and 2 in order to account for both the object and the event as possible referents.

The values in the chart indicate the number of those answers, given the particular chain of pronouns. For example, let us consider position i/t/i-3 in Chart 1a. It means that the pronouns used were 'it/that/it', the paragraph sequence read

1. **Mary thought of getting a PhD in English. It would have pleased her father and that would have infuriated her husband. But it was just what she wanted.**

Here, 20 of the subjects (80%) answered 'pleasing her father' to the question 'What would have infuriated Mary's husband'.

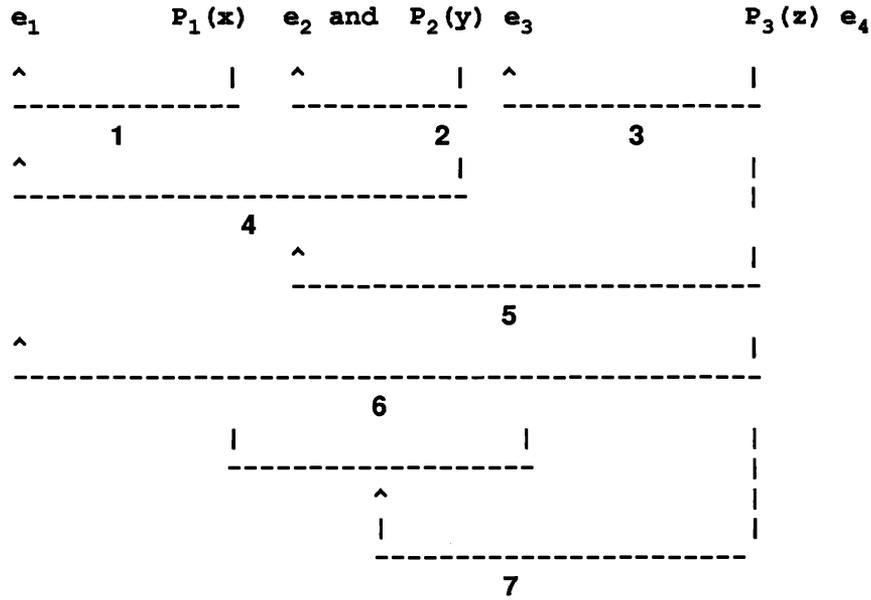
Since the paragraph sequences mirror each other, we have added the results of the first two questions and the last two questions into two additional charts. That is, we have added the results of the answers to question a for both paragraph 1 and 2 and the same for question b. These charts appear in Appendix III.

5. Hypotheses

Our initial motivation in undertaking this study was to determine how the choice of the particular pronouns affected the choice of their referents. One of the issues we were interested in was the 'chaining' of the pronouns so as to assess the duration that a particular referent remained available or how salient it was given a pronoun referring to it, as the text proceeded.

Before running the questionnaires, we developed a set of possible hypotheses which either individually or in some subset might account for the data. Here, we describe this set of hypotheses. The goal is for the hypotheses that are supported by the results to become rules used as mechanisms for generating text that includes pronominal references to events and actions. That is, because people interpreted the pronouns in various ways which can be characterized by the hypotheses, a generator should be able to generate pronominal references using those hypotheses as rules.

Given the following skeleton of the paragraph sequence:



In the diagram, e_1 is the first event characterized by the first sentence in the sequence, $P_1(x)$ is the first pronoun, followed by e_2 , which is the second event, followed by the conjunction "and", the second pronoun $P_2(y)$ and the third event e_3 . Last is the third pronoun $P_3(z)$ followed by the last event in the paragraph. The diagram above shows the seven combinations of referents for each pronoun. Our goal in collecting the data was to determine which of those links exist in reality and which pronouns guarantee that the links are indeed appropriately made.

The relationship between the first event e_1 and the first pronoun $P_1(x)$ follows from e_1 being the only available referent to the pronoun up to that point, leading to the first hypothesis.

Hypothesis 1:

The first pronoun in the sequence can be randomly generated. Given one event, we can refer to that event either with *it* or *that*.

Hypothesis 2 - Retainer:

It acts as a retainer of the referent, that is, as long as *it* is chosen in the sequence, the originally introduced event is maintained as the referent.

Hypothesis 3 - Most Recent:

That selects the most recently mentioned event, the one immediately preceding the pronoun.

Hypothesis 4 - Switch:

That tends to switch the referent of the pronoun to a new referent. That is, if there is a referent available so far and *that* appears in the text, the referent of the pronoun *that* is likely to be a new referent, not the one available so far.

Hypothesis 5 - Parallelism:

If the same sequence of pronouns is used twice in a row, the tendency is to select the same event as the one chosen by the first pronoun.

Hypothesis 6 - Strong Parallelism:

Given hypothesis 5 and using a different pronoun, one can select a different event.

Hypothesis 7 - Chaining:

Given the chain of 3 pronouns in a paragraph, the first and the second pronoun affect the interpretation of the third pronoun in a consistent manner. That is, that choice may also depend on what the particular pronoun-referent pair is up to the point where a new pronoun is found.

Hypothesis 8 - Reference to a Sequence:

When the sentence(s) preceding the pronoun is a conjunction or a sequence of events, the pronoun can either refer to the entire conjunction or the last event in the sequence but it cannot refer to the first one. The difference in the choice of the conjunction or the last event as the referent may be guided by the particular pronoun chosen.

Hypothesis 9 - Maintenance of the Referent:

As the paragraph proceeds and the chain of pronouns becomes longer, the retention of the referents becomes weaker. That is, no matter what the choices of the pronouns are, after a certain point in the sequence, the referent is lost and it is necessary to re-introduce that event should we want to refer to it with a pronoun.

6. Predictions and the Data

Here we show what the predictions of each hypothesis are. We then examine the results of the data and show which of those predictions are compatible with the data.

To start with, given one event and a pronoun following that event description,

e_1 . Pronoun e_2 ,

the only event the pronoun in the second sentence can refer to is the event in the first sentence, no matter which pronoun is used. As we will see later on, hypothesis 1 will serve as a guide to which particular pronoun is used.

Once more than one event has been introduced in the text, the particular pronoun choice and its referent will be guided by the other hypotheses.

The next table shows the predictions for Hypotheses 2 through 6 where the concern is primarily with the role that the second pronoun plays in the sequence.

$P_1/P_2/P_3$	P_2 refers to	
	e_1	e_2
<i>it/it/_</i>	Hypothesis-2 Hypothesis-5	
<i>it/that/_</i>		Hypothesis-3 Hypothesis-4 Hypothesis-6
<i>that/it/_</i>	Hypothesis-2	Hypothesis-6
<i>that/that/_</i>	Hypothesis-5	Hypothesis-4

The results from the first two rows of Chart 1a + 2a in Appendix III show the following facts. Note that we have listed two percentages in each entry below because we have only considered the first two pronouns, P_1 and P_2 . Our results also include P_3 , which can be either *it* or *that*, hence our having the two options listed.

$P_1/P_2/P_3$	P_2 refers to		Data from Chart 1a+2a, Column
	e_1	e_2	
<i>it/it/it</i>	96.07%	0	<i>i/i/i</i> (first)
<i>it/it/that</i>	100.00%	0	<i>i/i/t</i> (second)
<i>it/that/it</i>	16.32%	71.42%	<i>i/t/i</i> (third)
<i>it/that/that</i>	13.63%	75.00%	<i>i/t/t</i> (fourth)
<i>that/it/it</i>	89.58%	4.16%	<i>t/i/i</i> (fifth)
<i>that/it/that</i>	93.47%	4.34%	<i>t/i/t</i> (sixth)
<i>that/that/it</i>	43.18%	45.45%	<i>t/t/i</i> (seventh)
<i>that/that/that</i>	57.77%	31.11%	<i>t/t/t</i> (eighth)

The high percentage for P_2 being taken to refer to e_1 in the *it/it/_* and *that/it/_* sequences supports hypothesis 2. The high percentage for P_2 being taken to refer to e_2 in the *it/that/_* sequence supports both hypothesis 3, and 4. Only the *it/it/_* sequence supports hypothesis 5, the *that/that/_* sequence is equivocal. When it comes to hypothesis 6, only the sequence *it/that/_* is supported by the results with high percentages while for the pronoun sequence *that/it/_*, the low percentage numbers do not support its predictions but leads us to modify hypothesis 2 as follows:

Modified Hypothesis 2 - Retainer:

It acts as a retainer of the referent, that is, as long as *it* is chosen in the sequence, the originally introduced event is maintained as the referent. *It* retains the initial referent no matter what the first pronoun in the sequence is, that is, *it* provides access to the initial event.

With respect to the last combination of the pronouns *that/that/*_, the results are relatively even. While they do support hypothesis 4, the numbers are not significant enough to make any specific decisions. These results suggest that in a paragraph sequence, the choice of the pronouns *that/that* does not provide any definite relationship between the pronouns and their referents. This is a very important issue for our work in text generation. As it becomes clear when we consider the three pronoun chain, the combinations *that/that/it* and *that/that/that* create a problem for the listener or reader of the text. That is, given those two permutations in the pronoun chain, our results suggest that the choices of the pronouns can go either way: they can choose the first event mentioned or the one preceding the pronoun (or the conjunction of the two preceding events). This is due to the initial *that* and the continuation of the sequence with a second *that*. The pronoun *that* in those two roles, serves different purposes as shown by hypotheses 3 and 4 but it fails to make definite predictions when used in such a sequence. We therefore conclude that their use in that order must be avoided in text generation. Because of this issue, we propose a modification to hypothesis 1,

Modified Hypothesis 1:

The first pronoun in the sequence can be randomly generated. Given one event, we can refer to that event either with *it* or *that*. However, in most cases there is a strong preference to refer to the initial event with *it*, rather than *that*.

Evidence for or against hypotheses 7 and 8 can be gathered from Charts 1b + 2b in appendix III. These charts show the relationship between the third pronoun and its referent, given the first and the second pronoun. We found that, as long as the third pronoun was *it*, the most likely choice for its referent was the initially introduced event e_1 . The results, which in the chart appear in the first row e_1 , are as follows:

$P_1/P_2/P_3$	P_3 's referent was	
	e_1	Data from chart 1b+2b, 1st row, column
<i>it/it/it</i>	72.54%	i/i/i (first)
<i>it/it/that</i>	28.30%	i/i/t (second)
<i>it/that/it</i>	65.30%	i/t/i (third)
<i>it/that/that</i>	22.72%	i/t/t (fourth)
<i>that/it/it</i>	66.66%	t/i/i (fifth)
<i>that/it/that</i>	26.08%	t/i/t (sixth)
<i>that/that/it</i>	68.18%	t/t/i (seventh)
<i>that/that/that</i>	26.66%	t/t/t (eighth)

Therefore, our hypotheses are supported by the data, i.e. as long as the third pronoun was *it*, the referent was the original event introduced by the text.

A different relationship appeared when the third pronoun was *that*. Here, there were 4 potential

referents: the first event e_1 , the second event e_2 , the third event e_3 , and the conjunction of the two events e_2 and e_3 which preceded the third pronoun. From the data, we found that the second event was hardly ever chosen as a referent (see row e_2 in chart 1b + 2b in Appendix III). We were left with 3 likely referents for the third pronoun *that*. The results from the first, third and fourth rows in Chart 1b + 2b appear as follows:

P_3 's referent was			
$P_1/P_2/P_3$	e_3	e_2 and e_3	e_1
<i>it/it/it</i>	1.96%	5.88%	72.54%
<i>it/it/that</i>	16.98%	32.07%	28.30% *
<i>it/that/it</i>	10.20%	2.04%	65.30%
<i>it/that/that</i>	52.27%	13.63%	22.72% **
<i>that/it/it</i>	8.33%	6.25%	66.66%
<i>that/it/that</i>	26.08%	34.78%	26.08% ***
<i>that/that/it</i>	13.63%	2.27%	68.18%
<i>that/that/that</i>	31.11%	22.22%	26.66% ****

The starred rows in the table suggest the following: when the third pronoun was *that*, the choice of its referent was affected by what the immediately preceding pronoun was. We will consider two such cases. If the third pronoun was *that* and the second pronoun was *it*, which appear with * and *** in the previous table, the highest percentage for the choice of referent of the third pronoun was the conjunction e_2 and e_3 , the second percentage being for the first event e_1 , and last for e_3 . This could lead us to suggest that if the third pronoun is *that* and the second pronoun is *it*, the most likely referent is the conjunction. However, the relatively even percentages among the three potential referents require us to be cautious about making this commitment. We propose the conjunction as the most likely referent with attention to the possibility of ambiguity when using the pair *it/that* for the second and third pronouns. That is, while we can claim that the most likely referent of the third pronoun is the conjunction of the events e_2 and e_3 , there is a relatively high chance that the referent for that pronoun also be e_1 .

The other case, where both the second and the third pronouns were *that*, marked with ** and **** in the table, was clearer. In this case, the most likely referent was the last event in the sequence e_3 . The percentages in the case of *it/that/that* are significant enough to allow us to make this claim. However, when the first pronoun was *that*, as in the case of *that/that/that*, the results show that the referents can be any of the three possibilities. This, together with our previously mentioned view that an initial *that* followed by a second and third *that* creates problem for the reader, allow us to claim that the most likely referent is the third event e_3 . This latter point works in support of hypothesis 3 which predicts that *that* selects the most recently mentioned event.

While these results also provide support to hypothesis 8 in which the third pronoun can refer to either the conjunction or sequence of events or to the last event in the sequence, we must be cautious and

specify that the referent of the third pronoun can be the last event in the sequence or conjunction. Should we choose to refer to the conjunction, we can run the risk of having an ambiguous referent between the entire conjunction (e_2 and e_3) and the initially introduced event (e_1) as shown above.

Looking back at our diagram of the paragraph sequence, it is interesting to note that the data supports all but one of the possible links of pronouns with their referents. This link, labelled **5**, which the data fails to support (see row e_2 in chart **1b+2b**) is the one where the third pronoun refers to the second event described in the text. That is, the third pronoun can refer to (1) the first event introduced in the text, (2) the conjunction of the second and the third event, or (3) the last (third) event but it cannot refer to the second event in the sequence.

6.1. Relationship among the Hypotheses

The hypotheses given above were developed to show how different pronouns can be interpreted, given a sequence of events where the maximum number of pronouns referring to those events is three. Some hypotheses act as rules for the first pronoun (e.g., hypothesis 1), some act as rules for the second pronoun (e.g. hypotheses 3 and 4), and some act as rules for the third pronoun (e.g. hypotheses 7 and 8). But there are additional relationships among some of the hypotheses.

Hypothesis 1 is independent of the rest. Since it handles the role of the first pronoun, given one event, it is the first one to operate when using a pronoun to refer to that event. According to this hypothesis, given one event, we can refer to that event with either *it* (preferably) or *that*.

Hypothesis 3 is a special case of hypothesis 4. Conversely, hypothesis 4 is the general form of hypothesis 3.

Hypothesis 5 and 6 are related to one another. From the results, we have seen that hypothesis 5 is only supported in the case where the two pronouns are *it/it_* but not for the cases when the pronouns are *that/that_*. Similarly, hypothesis 6 is only supported in those cases where the switching is from *it* to *that* but no vice versa.

Hypothesis 7 and 8 are independent of each other but they both predict the relationship between the third pronoun and its referent(s). And hypothesis 9 is independent of the rest. Though it might be difficult if not impossible to formulate the point when the actual referent of a pronoun "gets lost" and needs to be re-introduced, it still remains an interesting point to pursuit.

7. Relationship between the Two Sets of Data: the EMACS transcripts and the Questionnaires

In the previous sections we have analyzed two different sets of data which have provided us with the basics that are necessary for dealing with pronominal reference to events and actions. The first set of data, the EMACS transcripts, have led us to characterize events and actions in terms of relationships among them in order to refer to them pronominally. That is, while it is possible to represent individual or "atomic" events or actions which can be referred to pronominally, there is a need to also represent "compound" events which are formed by the "atomic" ones and one way to do so is to characterize various relationships among the individual ones. These relationships form part of the representation which is needed when describing events which later on can be referred to pronominally. They are divided into

two groups: (1) an individual event or action or what I call an "atomic" event or action which is not formed by any other event or action but itself, and (2) groups of events or actions which I call "compound" and which are related in various ways. They can be a set of events or actions in a given order or sequence as well as individual events or action which form part of the sequence, events or actions related by generation and/or enablement. That is, even before one considers how to refer to events or actions pronominally, there is a need to characterize these events or actions in various way which then, when using the pronoun to refer to them will obtain the correct referent, that being one individual event or one "compound" event characterized in terms of more than one event. In summary, what the EMACS transcripts have shown is that it is possible to refer to more than one event or action with a pronoun but in order to do so, it is necessary to establish the relationships among those events so as to be able to refer to them as a unit with one pronoun.

On the other hand, the results from the questionnaires have shown some evidence on how the particular pronouns *it* and *that* (referring to events and actions) can behave in terms of what they choose as their referents. While the results are not rigid, they have shown ways in which, given various potential referents for a pronoun, the specific pronoun used can indicate the preference of one referent over another. For instance, given three "atomic" events as potential referents of a pronoun such as *that*, it is more likely that the pronoun choose the last or the third event as its referent as opposed to the first or second. If on the other hand, the pronoun is *it*, the choice of the referents may not be as strongly specified. More specifically, the referent of the pronoun *it* is as likely to be the first event as the third is.

8. Summary

In this report we have presented the analysis of two different sets of data: the EMACS transcripts and a set of questionnaires. Both sets have provided two levels that will be used in the generation of text which includes pronominal reference to events and actions. The EMACS transcripts have shown what requirements are necessary for the representation of those events and actions in order to refer to them with pronouns. The questionnaires have shown the need to establish rules that guide the relationship between particular pronouns and their referents. The goal in this work will be to use both of these levels in designing a system that generates pronominal reference to events and actions, and to show how both of these levels can enhance or just participate in the generation of pronominal reference to events and actions.

We have described how the results of our analysis can be used to account for a theory of pronominal reference to events and actions. Our findings from the EMACS transcripts have provided us with descriptions of what are the needs to account for pronominal reference in terms of the representation of the events and actions. Our findings from the questionnaires have provided us with the mechanisms that can support the generation of pronouns referring to events and actions. These mechanisms suggest when it is possible to use a particular pronoun to refer to an event or an action. They also suggest how we can manipulate different pronouns in order to control what is chosen as its referent. These mechanisms provide us with rules on how to choose pronouns that we can use when generating text describing a set of events, and how the specific pronouns affect their referents. We propose hypotheses that provide us with the rules on how to generate pronouns that refer to one or several events or actions. For example, Hypothesis 1 provide us with a rule to generate the first pronoun referring to one event, hypotheses 2, 3 and 4 provide us with rules that guide the second pronoun in the text and the rest of the hypotheses provide us with rules for the choice and referent of the third pronoun. Our future work will

concentrate on developing the representation of events given the analysis of the data, and the rules that support the hypotheses that guide the generation of pronouns.

I. The Questionnaire

Native language: _____

1. mary thought of getting a ph.d. in english. $P_1(x_1)$ would have pleased her father and $P_2(y_1)$ would have infuriated her husband. but $P_3(z_1)$ was just what she wanted.

a. what would have infuriated mary's husband?

b. what did mary want?

2. john thought about becoming a street person. $P_1(x_2)$ would hurt his mother and $P_2(y_2)$ would make his father furious. $P_3(z_2)$ was not a clever thing to do.

a. what would make john's father furious?

b. what was not a clever thing to do?

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