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The Role of Explicit Action Statements in Understanding and Using Written Directions

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In three experiments, subjects read directions in which the form of a step was varied independently of its content. In the drawing task used in Experiment 1, stating a step as either an explicit action or an implicit action had no effect on reading time. However, in the knob-turning/meter-setting task used in Experiment 2, directions were read faster when they began with an explicit action instead of an implicit action. These conflicting results were interpreted in terms of what subjects knew about the two tasks: The drawing task was familiar and well understood, while the knob/meter task was relatively novel. The third experiment confirmed this effect of prior knowledge. Subjects who were either high or low on cooking knowledge read and recalled several recipes, and an effect of stating an action explicitly was found only for low-knowledge subjects. It was concluded that the form in which a step is stated is a cue to whether or not that information is a central, important part of the procedure, but that this cue is not used when one's knowledge of the domain allows this judgment to be made on the basis of the nature of the information.

This article is concerned with the general issue of how the form of a discourse affects what has been termed its "referential representation" (Just & Carpenter, 1987). A referential representation is a mental representation of what the discourse is about or what it refers to, in contrast to a representation of the discourse itself and what it says. This type of representation is similar to the mental model representation of Johnson-Laird (1983) and the situation model representation of van Dijk and Kintsch (1983). We investigated the process of constructing referential representations by considering how people comprehend and use written procedural directions. Procedural directions are unique among discourse types in that they are generally used to perform a particular task. This means that in order to understand the directions, readers must construct a particular type of referential representation that will allow them to carry out the task as intended. For example, readers must represent the situation in which the task is to be performed, the objects that have to be manipulated, how they will interact, and what

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the results of one's actions are likely to be. Such a representation constitutes, in essence, a mental plan for how to perform the task.

The use of procedural directions as a domain of inquiry has a number of advantages in the investigation of referential representations. For example, the fact that a mental plan is used to carry out a given task imposes important constraints on the information that must be included in the plan and how it is organized; such constraints generally would not apply to the referential representations that might be constructed for other kinds of discourse. Asking subjects to follow a set of directions also imposes fairly explicit task demands on the kind of mental representation subjects construct: They must construct a mental representation that will allow them to perform the task. Similarly, asking subjects to actually perform the task can be used as a straightforward and valid method for assessing comprehension and the adequacy of the mental plan. Because a mental plan is strongly constrained in these ways, it may be easier to discern relatively subtle effects of text structure and form on this kind of referential representation.

In the present work, we were concerned with one particular issue: How does the presence of explicit action statements in directions affect mental plan organization? A variety of previous results suggest that there might be a relationship between such statements and the process of constructing a mental plan from directions. Wright and Wilcox (1978) and Dixon (1982) found that written directions were read faster when they began with an action statement than when they began with a condition related to that action. Hopper and Thompson (1980) indicated that there is a relationship between action statements and foregrounding in procedural discourse. Other findings illustrating the importance of actions can be found in Wright and Hull (1986), Black (1980), and Marcel and Barnard (1979). The hypothesis being investigated is that the presence of an explicit action statement flags that step in the procedure as being important or central in the plan representation.

This hypothesis will be explored within the hierarchical-planning framework proposed by Dixon (1987b). The main assumption in this framework is that mental plans have a hierarchical structure. At the top of the hierarchy would be a general description of the task to be performed. For example, if one has to fix a burnt-out light bulb, a general description of the task might be to "replace the light bulb." At the next lower level in the hierarchy this description would be analyzed into its major component actions. For example, replacing the light bulb might be broken down into removing the old bulb and then putting in the new bulb. Each of these actions would be broken down into more specific actions at lower levels of the plan hierarchy. For example, removing the old bulb might consist of removing the diffuser and unscrewing the bulb. Because each action in the plan is a part of the action in the hierarchy just above it, actions will tend to become more specific and detailed as the hierarchy is descended. In the approach described by Dixon (1987b), it is assumed that this kind of plan representation is used even for simple tasks that have only a few hierarchical levels.

There is a sense in which an action hierarchy of this sort is analogous to the goal/subgoal hierarchies that are common in the problem solving literature. In a goal/subgoal tree, each goal is broken down into a number of subgoals that must be achieved in order to achieve the overall goal. Each subgoal can be then broken down in a similar manner. The plan hierarchy described above is roughly equivalent to this representation if each action in the plan is interpreted as a description of the method by which a particular goal can be achieved. For example, the action of replacing a light bulb is the method by which one could achieve the goal of having a working light when the current bulb is burnt out. Or, the action of unscrewing the bulb is the method by which one could achieve the goal of having an empty socket in which to put the new bulb. The main difference between these two kinds of formulations is that the plan hierarchy focuses on the actions that must be performed, while the goal/subgoal hierarchy concentrates on the states that result from those actions.

Actions in a mental plan hierarchy can be conveyed by a set of directions either explicitly or implicitly. Explicit actions in directions typically take the form of imperatives, for example, "Remove the diffuser." Implicit action statements, on the other hand, indirectly convey information about what action to perform by referring to states or conditions that surround the action. For instance, the step of removing the diffuser could be conveyed by the direction, "With the diffuser off, unscrew the light bulb." Here, the step of removing the diffuser is not in the text at all, but instead must be inferred by the reader from the fact that it must be off prior to unscrewing the light bulb; it specifies an action in the mental plan by referring to the state that would result from that action, rather than describing the action directly. A given set of directions will generally contain both explicit and implicit action statements. The present research hypothesis is that explicit actions are viewed by the reader as more important or central than actions that are conveyed only implicitly. In terms of the mental plan hierarchy, this means that explicit actions will tend to be represented as high-level actions in the hierarchy, while implicit actions will occupy lower levels in the hierarchy.

Several findings in the linguistic literature are consistent with this hypothesis that explicitly stated actions go at the top of the plan hierarchy. For example, Hopper and Thompson (1980) suggested that transitive verbs are more often found in foreground statements than in background statements, and that one of the important properties of transitive verbs is that they tend to be explicit actions. This result is related to the notion that actions occupy the top level of the hierarchy if high-level information is identified with foreground information. A similar conclusion was reached by Longacre (1987). He hypothesized that the relative salience of different clauses is related to the rank of their main verbs, and that action verbs tend to have a high rank in English. Again, this scheme is consistent with the present thesis if salience is correlated with hierarchical height in procedural discourse. Thus, there is some linguistic support for the notion that action statements in discourse often convey important information, however "importance" may be defined.

This view of explicit and implicit actions in directions affects the interpretation of several previous studies of direction comprehension. It has been found in a number of experiments that direction reading time is faster when the directions begin with explicit action statements rather than information about conditions or states (Dixon, 1982, 1987b; Sebrechts & Deck, 1983; Wright & Wilcox, 1978). From the present point of view, the condition information should be thought of as an implicit action statement. For example, subjects in Dixon (1982) read directions such as, "The alpha meter should read 20 as a result of turning the left knob." In this case, turning the knob is an explicit statement of an action to be performed, while the clause "the alpha meter should read 20" implicitly conveys information about the action of checking the alpha meter to ensure that it has the correct value. Thus, the previous results can be interpreted as saying that directions are read more quickly when they begin with an explicit action statement rather than an implicit one.

Following Dixon (1987b), two assumptions are used to interpret this reading time effect. First, it is assumed that the mental representation of a set of directions (that is, the hierarchically organized mental plan) is constructed while the directions are being read. This is similar to the "immediacy of interpretation" assumption used by Just and Carpenter (1980, 1987) in accounting for word-by-word reading times. Second, it is assumed that hierarchical plans are constructed from the top down (cf. Sacerdoti, 1977; Wilensky, 1983). This seems plausible because the way in which actions at lower levels of the hierarchy should be carried out often depends on the nature of the higher level actions. These two assumptions together imply that the comprehension of directions typically will be most efficient when the directions begin with the high-level information. If readers identify the information that begins a sentence as being relatively low-level information, they may either buffer that information (thereby giving up immediacy of interpretation) or incorporate the low-level information into their plan without benefit of high-level information that might be found later in the sentence. Presumably, both of these options entail some cost in processing time or efficiency. The results of Dixon (1987a) suggest that under some conditions readers first make a guess about the top level of the plan and then attach the low-level information to this top-level node before processing the balance of the sentence. In this case as well, there is a cost in the time needed to process and understand sentences beginning with low-level information.

Given these assumptions, the finding that reading time is faster for sentences beginning with explicit actions is consistent with the hypothesis that the distinction between explicit and implicit actions affects the mental plan structure. That is, when readers encounter an explicit action first in the sentence, they interpret the information as high level and incorporate the information into their emerging plan representation accordingly. But when they encounter an implicit action first, they interpret it as relatively low-level information and consequently must adopt some less efficient processing strategy for dealing with the information. In this view of direction processing, it is assumed that readers evaluate whether an action is stated explicitly or implicitly while they are reading a sentence and use this distinction in deciding how to fit the action into their mental plan for the task. This view can be referred to as a "form-cue" hypothesis because it assumes that stating something in the form of an explicit action is a strong cue to represent that information high in the mental plan hierarchy. In a sense, the form of the action statements causes them to be high level.

As an example of what this hypothesis might mean for the process of understanding directions, consider how readers would process a sentence such as "Press button A while light Y is on" (Dixon, 1987b). After constructing a propositional representation for the initial clause, "Press button A," the reader would begin to build a mental plan representation. Because the initial clause contains an explicit action, the reader would use this action as the top node in the mental plan, and then proceed to process the second clause in the sentence. But if the sentence were "While light Y is on press button A," the reader would note that the initial clause implicitly describes the action of checking the status of light Y. Because this action is described indirectly, it would be interpreted as belonging to a lower level of the plan hierarchy. In this case, the reader's strategy may be to first generate a hypothesis about what the top-level action might be, and then attach as a subordinate step the (implicit) action information about checking light Y. If necessary, the hypothesized top-level action would be modified on the basis of the second clause in the sentence. In this way, whether an action is described explicitly or implicitly would determine the structure of the mental plan.

An alternative to this form-cue hypothesis is that explicit action statements do not have a causal role in how the mental representation is constructed. Instead, the previous results may have been the product of an unintentional confounding between explicit action statements and the nature of the information. For example, sentences such as "Press button A while light Y is on" were read more quickly when they began with the explicitly-stated action of pressing the button than when they began with information about the implicit action of checking the light. However, this result may have occurred because button pressing is a more important action in this situation than checking the light, and hence enters the mental plan at a higher level. In this view, the simplest or most efficient plan representation would have one kind of action (such as button pressing in this example) at the top level and other actions (such as checking the status of the light) at lower levels in the hierarchy. Presumably, the reader would come to realize this through experience with the task or domain. Thus, when processing a sentence, the reader would consider the nature of the actions to decide whether it should go at the top level of the plan, rather than whether it was stated as an explicit or implicit action. This will be referred to as a "content-cue" hypothesis because it is assumed that the content of the actions in the directions is the only cue as to how they should be represented.

The content-cue hypothesis is consistent with the results of Dixon (1987c). In those experiments, subjects read and carried out directions containing a figure to be drawn and several component steps needed to make the drawing. For example, in the direction, "You can make a wagon by drawing a long rectangle with two circles underneath," the figure was the wagon, and the component steps were to draw the long rectangle and the two circles. Such directions were read more quickly when they began with the figure clause than with the component step clause. This suggests that the figure information was used in the mental plan at a higher level, even though both clauses were in the form of explicit actions. Presumably, subjects noticed that the content of the figure clause was a more general, higher level description of the task than the component steps and used this fact to determine the organization of their mental plan. Thus, these results indicate that the content of the directions can be used as a cue for the mental structure, at least in the absence of differential form cues.

The content-cue hypothesis must make further assumptions about why a consistent relationship between action statements and high-level information has been found in previous research. For example, it might be hypothesized that high-level actions tend to be stated as explicit actions when directions are produced, even though the form has no direct effect on how they are represented by the comprehender. Thus, when researchers attempted to construct natural-sounding directions for their materials, they may have selected the more important steps in the task to be stated as actions and the less important steps to be stated as conditions. This would account for the correlation between actions and high-level information without assuming that there is a causal relationship between action statements and the comprehender's mental representation. On this interpretation, the relationship found in earlier experiments between explicit action statements and reading time may indicate more about the production of procedural directions than their comprehension.

In the experiments reported below, we compared the form-cue and content-cue hypotheses as explanations of how the structure of mental plans is determined. The general strategy was to manipulate the form of an action statement independent of its content, and observe reading time and other measures of mental structure. This kind of design eliminates the confounding that may have existed in previous research. In Experiment 1 this approach was used with the drawing task developed by Dixon (1987a, 1987c). In Experiment 2, the approach was applied to a knob-turning and meter-adjusting task similar to that used in Dixon (1982). Both of these experiments used direction reading time as the principal dependent measure. In contrast, recall of cooking recipes was used as a dependent measure in Experiment 3.

EXPERIMENT 1

In the first experiment, the distinction between explicit and implicit actions was pitted against the figure-component step distinction studied in Dixon (1987a, 1987c). As described above, the earlier studies showed that directions were read more quickly when they began with general information about what figure was to be drawn than when they began with more specific information about what the component drawing steps were. This result suggests that subjects used the content of the directions to guide what information was used at what level of the mental plan hierarchy. In the present experiment, either the figure or the component steps were described with explicit actions, and the other clause used implicit actions. According to a simple-minded form-cue hypothesis, the clause with the explicit action should be interpreted as high-level information, regardless of its content. Thus, the prediction is that sentences beginning with an explicit action should be read faster than those in which the explicit action comes second. However, according to the content-cue hypothesis, the explicit/implicit action distinction should have no effect, and reading time should be determined only by the content of the clauses. Specifically, sentences beginning with the figure to be drawn should be read more quickly regardless of their form.

The form-cue hypothesis predicts that when the figure information is stated as an implicit action, it should be represented at a relatively low level in the mental plan. For instance, the direction, "Draw two circles underneath a long rectangle to have a picture of a wagon," uses an explicit action to convey the component steps and an implicit action to convey the figure information. If the form-cue hypothesis is correct, subjects reading this direction would construct a mental plan in which the information about drawing a wagon is used at a relatively low level. Although this seems intuitively implausible, it is important to note that it is at least logically possible in some interpretations of the task. For example, the figure information could be interpreted as merely a check on how well the component steps were executed. Such an interpretation might occur if subjects thought that the main intent of the task was to draw two circles and a rectangle, and that what the figure looked like was incidental. In this case, the mental plan would contain two major component steps: drawing a long rectangle and drawing two circles underneath it. The figure information might be used in a subordinate step underneath the second major component; the action would be to check whether the completed drawing looked like a wagon. This kind of check would have the same status as other checks that are presumably done in the course of drawing the picture, such as checking that the sides of the rectangle are parallel, or that the circles are positioned below the rectangle. The question being tested in the present experiment is whether the explicit/implicit action distinction can be used to induce subjects to construct something like this type of mental plan, even though it may be more natural to put the figure information at the top of the hierarchy.

A somewhat weaker version of the form-cue hypothesis might predict that the distinction between explicit and implicit actions would help determine the mental plan structure, but that content cues are used as well. Such a view might predict that comprehension would be more difficult in those cases where the form and content cues conflict. For instance, a reader might find it confusing if a relatively unimportant piece of information is stated as an action. Presumably, he or she would eventually realize that the information was unimportant and put it in an appropriate, low-level position in the plan hierarchy, but it would take more time to process such directions than those in which the form and content cues were consistent. Thus, this version of the form-cue hypothesis predicts that the drawing directions should be read more quickly when they begin with a description of the figure being drawn (because that is the most general, high-level information) rather than the specific component steps. Additionally, there should be an effect of how the figure and component steps are stated: Directions should be read more quickly when the figure is stated as an action than when the component steps are stated as actions. Essentially, this hypothesis is that the form of the directions affects the process of understanding the directions, but not the final plan representation.

Method

In this experiment, subjects read and carried out single-sentence directions for drawing simple schematic figures. Each direction indicated the name of a common object and at least two component steps needed to draw the figure. The directions varied in terms of whether the figure or the component steps were stated as an explicit action and whether that action came first or second in the sentence (see Table 1 for examples). Each sentence form contained the same number of words and syllables. Thus, the experiment used a 2 × 2 factorial design with type of explicit action (figure or component) being one factor and sentence form (explicit action first or explicit action second) being the other.

The procedure on each trial was as follows. Subjects sat in front of a standard 30-cm video monitor. When they were ready to start the trial they pressed and held down a button labeled "Sentence." After 500 ms the direction was presented on two 40-character lines in upper and lower case. Letter spaces subtended about 0.3° of visual angle at a typical viewing distance of 70 cm. When subjects were finished reading the sentence, they released the button and the direction disappeared. They then attempted to draw the indicated figure in a designated area in the response booklet. Reading time was measured from the time the sentence was presented on the screen until the sentence button was released. A drawing was judged to be correct if it used the component steps to form a reasonable depiction of the intended figure. Errors were scored blind to the form of the direction.

Each subject read and carried out 60 directions, divided equally between explicit figure action and explicit component action sentences, and between explicit action first and explicit action second sentences. (A complete list of these materials is available in Dixon, 1987a). The assignment of direction content to sentence form was done randomly for each subject. This procedure deliberately confounded variance due to materials with variance due to subjects and ensured that the results would generalize to both subject and materials populations. Analyses were conducted on the median correct reading times for each subject and sentence form. Subjects were 20 undergraduates at the University of Alberta, all of whom were native English speakers.

Results

The reading times in Fig. 1 show that there was no effect whatsoever of whether or not a piece of information was stated as an explicit action. As can be seen, there

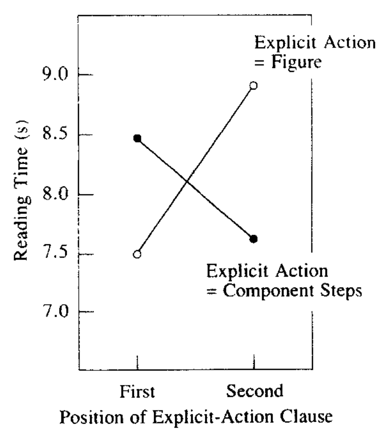

FIG. 1. Reading time in Experiment 1 as a function of type of explicit action and clause order.

was no overall effect of whether the explicit-action clause was first or second ($F(1,19) < 1$), and there was no effect of whether the explicit action was the figure or the component steps ($F(1,19) < 1$). The only significant effect was that sentences were read faster when they began with the name of the figure to be drawn rather than the component steps ($F(1,19) = 10.55$, $p < .005$). This effect can be seen as the interaction in Fig. 1: Sentences in which the figure to be drawn was stated as an explicit action were read more quickly when the explicit action was first, while sentences in which the component step information was stated explicitly were read more quickly when the explicit action was second and the implicit action information about the figure came first. The overall error rate in drawing figures was 5.3%, and did not vary with sentence form (see Table 1).

Discussion

The results demonstrate that reading time in this task is determined by the content of the directions rather than their form. The only significant effect was that sentences were read more quickly when they began with the figure rather than the component steps. This finding can be taken as evidence that the figure information is used first in constructing a mental plan, presumably because the figure information goes at the top of the mental plan hierarchy. Readers of these directions were apparently able to decide that the figure information was the high-level information independently of whether it was stated as an explicit or implicit action. In fact, there was no evidence in these results that the explicit/implicit action distinction affected comprehension at all.

Previous work with this task has suggested a locus for the additional time used in processing directions that begin with the component steps rather than the figure (Dixon, 1987a). In the earlier study, reading times were collected for both the figure clause and the component-step clause. The results indicated that most of the effect of clause order occurred in the processing of the component steps. It was hypothesized that the additional time spent on components-first sentences was used to evaluate how the component steps went together to form a reasonable drawing of a figure, before subjects knew for certain what the intended figure was. Interpreting the component steps was much easier when the figure clause was presented first. In a sense, extra time was needed with components-first sentences in order to guess the nature of the high-level information in the plan. The present results suggest that this model of processing is appropriate regardless of the form in which the information is conveyed.

Another possible interpretation of the present results is that the reading times reflect an effect of temporal order. In this view, the figure represents the goal of performing the task, and readers interpret the

TABLE 1
PERCENTAGE ERRORS IN EXPERIMENT 1

Explicit action = figure / explicit action first Draw a picture of a wagon with two circles underneath a long rectangle.	6.7
Explicit action = figure / explicit action second With two circles underneath a long rectangle draw a picture of a wagon.	6.0
Explicit action = component steps / explicit action first Draw two circles underneath a long rectangle in order to have a wagon.	5.7
Explicit action = component steps / explicit action second In order to have a wagon draw two circles underneath a long rectangle.	3.0

goal as a precondition for carrying out the component steps. For example, a sentence might be interpreted as, "If your goal is to draw a wagon, then draw a long rectangle and put two circles underneath." Presumably, the reading time results occur because processing directions is more efficient when the clauses are presented in the order in which they occur in time. There is no evidence in the present results that would be inconsistent with this interpretation. However, it is also possible to think of the figure information as the *result* of carrying out the component steps, rather than as a precondition. For example, the direction might be interpreted as, "After you have drawn a long rectangle and put two circles underneath, you will have a wagon." In this analysis, one might expect sentences to be read faster when they begin with the component steps rather than the figure. To be adequate, a temporal-order account of these reading times must include some principled method for deciding between these two analyses. Our view is that neither analysis is completely correct, and that there exists a hierarchical, part–whole relationship between the figure and the component steps that cannot be captured simply in terms of temporal order. Other evidence against the temporal order account can be found in Dixon (1987b) and Experiment 2 below.

Experiment 2

Experiment 1 was a severe test of the form-cue hypothesis because the figure information and component-step information were designed to have a hierarchical relationship, independent of the form of the information (Dixon, 1987a). That is, performing the component steps was part of drawing the figure. Thus, it is perhaps not surprising that this relationship dominated the pattern of reading times. In Experiment 2, the form- and content-cue hypotheses were tested in a situation where the information was more neutral; there was no obvious reason to expect one type of information to be more important than another in the mental plan. In other words, the experiment tested whether an effect of the form of the directions, independent of the directions' content, can be obtained when there are few strong content cues.

The task used in this experiment was to turn a knob to adjust a meter. On some trials the knob-turning action was stated explicitly, while on others the action of checking the meter reading was stated explicitly. In both cases, the explicit action could be stated either first or second (see Table 2 for examples). This task has the advantage that a robust effect of sentence form has already been demonstrated with it; it is essentially a replication of Experiment 1 in Dixon (1982), in which a substantial difference in reading time was found between action-first and action-second sentences. However, in the present design the use of explicit-action clauses was varied orthogonally to the nature of the information.

Method

In this experiment, subjects followed directions for turning a knob to adjust a meter. The directions were phrased with either the knob-turning action stated explicitly or the meter-checking action stated explicitly; in addition, the explicit action could come either first or second (see Table 2). This experiment used a factorial design analogous to that in Experiment 1; the two factors were type of explicit action (knob or meter) and sentence form (explicit-action first or explicit-action second). As can be seen in Table 2, sentences in which

TABLE 2
Percentage Errors in Experiment 2

Explicit action = knob / explicit action first Turn the left knob to set the top meter to 20.	1.8
Explicit action = knob / explicit action second To set the top meter to 20 turn the left knob.	2.0
Explicit action = meter / explicit action first Check that the top meter reads 20 after the left knob adjustment.	2.2
Explicit action = meter / explicit action second After the left knob adjustment check that the top meter reads 20.	3.6

checking the value of the meter was stated as an explicit action had a different structure and were somewhat longer than sentences in which turning the knob was stated as an explicit action. Thus, the reading times for these two classes of sentences were not directly comparable. However, the critical contrasts in this experiment involved the effect of clause order within each type of sentence, and clause order was manipulated independently of sentence structure, sentence length, and vocabulary. That is, within each type of sentence, the explicit-action-first version and the explicit-action-second version used exactly the same words and sentence structure; they differed only in the order of the two clauses.

The procedure was as follows. Subjects sat in front of a response panel with three knobs and a button. Behind the panel was a 30-cm video monitor on which the directions and meters were presented. When the computer was ready to start a trial, the message "Push the button to begin" was displayed. When the subjects were ready as well they pressed the button on the response panel and held it down. As in Experiment 1, the direction appeared on the screen on two 40-character lines after 500 ms. When subjects had finished reading the sentence, they released the button and the direction disappeared. In its place was a display representing two analog meters, one above the other. The meters were labeled with the values 0, 10, 20, 30, 40, 50, 60, and 70 around the perimeter of a circle. Turning any knob caused a "needle" on one meter to turn in a clockwise direction, while the "needle" on the other meter turned in a counterclockwise direction. When subjects finished carrying out the direction, they pressed and released the button again, causing the display to disappear. Subjects turned the knobs back to their starting positions before starting the next trial. Reading time was measured from the onset of the sentence display until subjects released the button. A trial was scored as an error if subjects turned the wrong knob, or if they set the indicated meter to an incorrect value.

Subjects participated in 120 trials in which there was an equal number of sentences of each form in a random order. A short break occurred after every 20 trials. The first 5 presentations of each sentence form were considered practice and were not analyzed. The choice of knob (left, middle, or right), meter (top or bottom), and setting (10–60) was random on each trial. Twenty undergraduates at the University of Alberta served as subjects.

Results

As shown in Fig. 2, there was a clear effect of the form of the directions: Sentences were read 122 ms faster when the explicit action was first ($F(1,19) = 10.25$, $p < .005$). There was no interaction with type of sentence (explicit-knob-action vs. explicit-meter-action; $F < 1$), suggesting that the advantage for sentences beginning with an explicit action held regardless of the nature of the action. This replicates the results of Dixon (1982) using a similar task, and demonstrates that the effect is not due to the use of knob turning as the action and the state of the meter as the condition. Sentences with knob turning as the explicit action were read faster overall ($F(1,19) = 53.10$, $p < .001$), although this may have

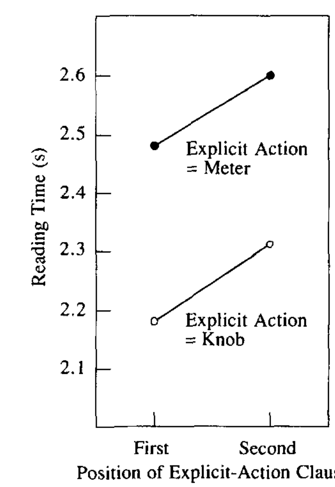

FIG. 2. Reading time in Experiment 2 as a function of type of explicit action and clause order.

been due to the shorter length and different structure of these sentences. The pattern of results was the same using time per word as the dependent measure: There was an effect of direction form ($F(1,19) = 10.97, p < .005$), and an effect of type of sentence ($F(1,19) = 4.90, p < .05$), with the explicit-knob-action sentences being read more quickly. This residual effect of sentence type in the time-per-word analysis may be due to the more difficult words and sentence structure used in the explicit-meter-action sentences; in general, the two kinds of sentences may not be directly comparable. No other effects or interactions were significant. The overall error rate in carrying out the task was 2.4%, and did not differ across different sentence forms (see Table 2).

Discussion

The pattern of results obtained in this experiment is diametrically opposed to that in Experiment 1. In the first experiment there was a strong effect of information content, but no effect of its form. However, here there was a strong effect on reading time of the form of the directions, but no effect of their content. These results indicate that an effect of direction form, independent of content, can be obtained when there are few strong content cues indicating which information should go at the top of the mental plan. However, the results do not indicate what the difference is between the drawing task and the knob–meter task that provides strong content cues in one case but not in another. One hypothesis is that the nature of the difference lies in what subjects knew about the tasks before reading the directions. Presumably, readers already know a great deal about the general nature of making simple schematic drawings such as those in Experiment 1; both the figures and the kinds of steps needed to draw them were familiar and well understood. Because of this prior knowledge, they may have anticipated that the figure information should form the high-level action in the mental plan and the component steps the lower levels. Thus, subjects would already have in mind an organization for the mental plan based on their knowledge of the task.

On the other hand, subjects had very little prior knowledge about the task they were asked to perform in the second experiment and no information about the relative importance of the knobs and meters. Before reading the directions, it was possible to imagine that either turning the knob or setting the meter would be the overall goal of the task. In one case, the task would be about turning the knob, and reading the meter would be a minor condition tested along the way. In the other case, the whole point of the procedure would be to set the meter to a particular value, and turning the knob would be just the means to that end. Thus, the prior information subjects had about the task would not have dictated a particular organization of the mental plan, and several organizations may have been possible. Even after some experience with the task, readers would have little conceptual knowledge about the actions they were performing. Although they may have become facile at manipulating the controls, they still would have little information about what the important aspects of the task were, how well they were performing, what the implications of an error were, and so on. Under such circumstances the form of the directions may be important in determining how subjects interpret the directions and how they structure their mental plan.

This analysis suggests a limited version of the form-cue hypothesis: The form of the directions is used to determine the mental plan structure only in the absence of other good sources of information. Thus, in Experiment 1 the direction form would be ignored because subjects already knew how to organize their mental plans: Figure information would always constitute the high-level description, and the component steps would constitute the lower levels. However, in Experiment 2 subjects had no predisposition to organize their plans one way or the other, and consequently used the form of the directions to decide whether knob turning or meter checking should go at the top level of the plan. Experiment 3 investigated this limited form-cue hypothesis.

Several other accounts of the results from Experiment 2 should also be discussed. The first is a temporal-order account. As described earlier, one possible explanation of the results of Experiment 1 is that some information in the directions is used before other information in carrying out the task and that sentences might be easier to read when they begin with the information that is used first. This kind of explanation has also been proposed for directions very much like the ones used in Experiment 2 (Spoehr, Morris, & Smith, 1983). However, the present results make this account untenable. Presumably, the order in which information is used during task execution is determined by the nature of the task and should remain unchanged regardless of whether actions are described explicitly or implicitly. The present results show that, averaged across sentences, there is virtually no difference between sentences that begin with information about the knob turning and those that begin with information about the meter. Moreover, the explicit-meter-action sentences clearly invite the interpretation that checking the meter occurs second (e.g., "Check that the top meter reads 20 after the left knob adjustment"). Thus, according to the temporal order account, these sentences should be read more quickly when they begin the knob turning information. This prediction is precisely the opposite of the obtained results. Although temporal order has a clear effect under some circumstances (e.g., Dixon, 1987b; Clark & Clark, 1968), it does not appear to contribute to the present results.

A second type of account involves differences among conditions in the nature of the sentences. It might be argued that the reading time effects were due to differences among the sentences in sentence length and vocabulary. However, the effect of stating explicit actions first or second cannot be explained in this way because the effect occurred even when sentence length and vocabulary were unchanged. For instance, the explicit-meter-action sentences were read faster when the action came first rather than second. The only difference between the action-first form of this sentence and the action-second form was the order of the two clauses; everything else was unchanged. The same was true for the explicit-knob-action sentences. Thus, sentence length, vocabulary, and similar variables cannot account for the effect shown in Fig. 2. The only sentence variable that could conceivably be related to this effect was the order of the main and subordinate clauses. Because the syntax of the sentences was unchanged when the order of the explicit and implicit actions was varied, explicit actions always remained in the main clause of the sentence. Thus, one might attempt to account for the reading time effect by assuming that sentences are read more quickly when they begin with the main clause rather than a subordinate clause. However, main/subordinate clause order had no discernible effect on reading time when it was independently manipulated in a number of previous studies using similar materials (Dixon, 1982, 1987b). Consequently, it is unlikely to be the cause of the present pattern of results.

Another type of account of the difference between Experiments 1 and 2 focuses on the structure of the information provided in the sentences. In Experiment 1, there were always several pieces of information in the component step clause and only a single piece of information in the figure clause. This fact may have suggested to the reader that the component step clause contained information that was subordinate to the single action described in the figure clause. It might be hypothesized that the results of Experiment 2 were different because the information in the sentences did not have this structure. However, it should be noted that the meter clauses used in Experiment 2 also contained two pieces of information: the meter that should be checked and the value to which it should be set. In this case, though, there was no overall tendency for sentences beginning with the meter clause to be read more slowly or more quickly than other forms. Instead, the reading times were completely dominated by the position of the explicit action in the sentence. In any event, the mental plan may contain any number of other actions that are not mentioned in the directions. For example, the action of turning a knob might be broken down into grasping the knob, twisting it, monitoring the value of the meter, and then releasing the knob at the appropriate time. Whether or not these additional actions are mentioned in the directions may not have any direct impact on the nature of the mental plan people construct.

EXPERIMENT 3

The goal of the third experiment was to test the limited form-cue hypothesis. In this hypothesis, it is assumed that the form of the directions is used to determine the structure of the mental representation only when the reader has no other useful sources of information. The contrast between Experiments 1 and 2 was explained in terms of what readers knew about the nature of the tasks: Readers were assumed to know a great deal about how to plan and perform the drawing task in Experiment 1 and to know relatively little about knob–meter task used in Experiment 2. Experiment 3 tested whether this kind of prior knowledge was the critical difference between the two patterns of results. A task was selected for which a range of prior knowledge could be found in our subject population. It was anticipated that subjects with a great deal of prior knowledge would generate results like those found in Experiment 1, while those with less prior knowledge would generate results like those found in Experiment 2. The task in this case was reading and evaluating cooking recipes, and a questionnaire was used to divide subjects into high- and low-knowledge groups. The design of the experiment was similar to the previous ones in that a given action in a set of directions was stated either explicitly or implicitly. According to the limited form-cue hypothesis, only low-knowledge subjects should be affected by the form of the directions; high-knowledge subjects should be able to use the content of the directions to come up with their own organization for their mental plan.

Experiment 3 also used a different dependent measure. In Experiments 1 and 2, the information used at the top of the mental plan was inferred from the reading time for different sentence constructions. In the present experiment, recall was used as a converging measure of the nature of the mental plan representation. The assumption was that information at the top level of the plan hierarchy would be more likely to be recalled on a subsequent incidental recall task than information at lower levels. Similar results have been found in the recall of other kinds of text (e.g., Meyer, 1975; Kintsch, Kozminsky, Streby, McKoon, & Keenan, 1975). The prediction of the limited form-cue hypothesis is that low-knowledge subjects will put explicit actions into their mental plans at a relatively high level and hence will be more likely to recall those actions subsequently. On the other hand, high-knowledge subjects should be unaffected by the form of the directions and should organize their mental plans based on the content of the directions and their knowledge of the domain. Consequently, their recall should be unaffected by whether an action is stated explicitly or implicitly.

Method

In this experiment, subjects read four recipes and were later given an incidental recall test of them. In each recipe there were four target actions that could be phrased either explicitly or implicitly. Subjects' recall protocols were scored for whether they had mentioned the target actions, and whether they had described the action explicitly or implicitly. In addition, subjects were given a cooking questionnaire to separate them into two groups based on their cooking knowledge.

There were two versions of each recipe. In one version, two of the target actions were stated explicitly and the other two were stated implicitly; in the other version the explicit/implicit assignment was reversed (see Table 3 for an example). Half of the subjects read one version, and half read the other, so that across subjects, each target action was stated explicitly half the time. The order of the recipes was random for each subject. The recipe was printed in the form of a paragraph with a title and occupied the top half of a page in a response booklet. In the bottom half of the page were questions asking subjects to indicate how long they thought the dish would take to prepare, how difficult they thought it would be to make, and how good tasting they thought the dish would be. The intent of these questions was to encourage subjects to construct a mental plan for following the recipe similar to the plan that they would use to actually follow the directions. The time spent reading the recipes and answering the questions was recorded.

After reading and evaluating the four recipes, subjects returned their booklets and were given questionnaires designed to evaluate their experience and expertise in cooking. The questionnaire contained three parts. The first part contained 12 multiple-choice questions about cooking (e.g., "A double boiler is used (a) to keep heat constant and even at 212 degrees, (b) to prevent heat from escaping, (c) to retain the vitamin content of vegetables, (d) to add pressure which cooks food faster"). The second part contained 12 true/false questions such as, "When frying breaded meat the patties should be turned regularly." The third part was a 12-point questionnaire about the subjects' cooking experience and habits (e.g., "Approximately how many spices do you have in your kitchen?"). A subject's cooking score was the total of the three parts.

After completing the questionnaire, subjects were given four pages, each with the title of one of the recipes, and were asked to recall as much of the recipes as they could. Recall of the four recipes was in the original order of presentation. The recall protocols were scored blind to condition. They were evaluated on the number of steps recalled,

TABLE 3
EXAMPLE OF STIMULUS MATERIAL IN EXPERIMENT 3[a]

Version A

Cheddar Pennies

Soften 4 tablespoons of butter by leaving it at room temperature. In a deep bowl cream the softened butter by beating and mashing it against the side of the bowl until it is light and fluffy. Stir in *one cup freshly grated cheddar cheese* and ¼ teaspoon of salt until smooth. Beat in ½ cup of flour, adding extra flour if necessary to make the dough firm. Shape and roll the dough into a cylinder 1¼ inches in diameter. *Wrap in wax paper* and refrigerate 1 hour. Place *⅓ inch thick slices of the dough* on a buttered baking sheet. Place in the centre of a preheated 350 degree oven for 12 to 15 minutes or until golden color. Transfer to metal rack to cool.

Version B

Cheddar Pennies

In a deep bowl cream *4 tablespoons of softened butter* by beating and mashing it against the side of the bowl until it is light and fluffy. *Grate one cup of cheddar cheese.* Stir in the cheese and ¼ teaspoon of salt until smooth. Beat in ½ cup of flour, adding extra flour if necessary to make the dough firm. Shape and roll the dough into a cylinder 1¼ inches in diameter. Refrigerate *in wax paper* for one hour. *Slice the dough into ⅓ inch thick rounds* and place on a buttered baking sheet. Place in the centre of a preheated 350 degree oven for 12 to 15 minutes or until golden color. Transfer to metal rack to cool.

[a] Target actions are italicized in both versions. In this recipe, the first and third target actions are explicit in Version A, while the second and fourth actions are explicit in Version B.

whether they mentioned each of the four target actions, and on whether the target actions were described explicitly or implicitly. The interval between reading the recipes and when they were asked to recall them averaged about 50 s, and was not significantly different for high- and low-knowledge subjects.

Subjects were 30 undergraduates at the University of Alberta. The subjects were divided into high and low cooking knowledge groups based on a median split of their questionnaire scores; data from 2 subjects whose scores were exactly on the median were not used. There were 13 subjects in the high-knowledge group and 14 in the low-knowledge group. The median of the scores was 20, and ranged from 11 to 19 in the low-knowledge group and 21 to 40 in the high-knowledge group. A preliminary analysis revealed no effects or interactions involving the two forms of the recipes, so this factor was not used in the analyses reported below.

Results

The percentage of the target actions recalled correctly is shown in Fig. 3. There was a marginal overall effect of stating the actions explicitly ($F(1,25) = 3.69$, $p < .07$). However, this effect occurred solely in the low-knowledge group ($F(1,13) = 6.66$, $p < .05$), and not in the high-knowledge group ($F(1,12) < 1$). This led to an interaction between explicit/implicit actions and knowledge group ($F(1,25) = 3.69$, $p < .07$). This interaction is also indicated by a significant correlation between the size of explicit/implicit action effect and the questionnaire scores ($r = -.37$, $p < .05$; this correlation was based on data from all 30 subjects). As one might expect, high-knowledge subjects recalled significantly more of the steps overall (42.2% vs. 28.0%; $F(1,25) = 4.79$, $p < .05$), but the superior recall of the high-knowledge group only approached significance for the target actions ($F(1,25) = 3.09$, $p < .10$).

The percentage of target actions recalled explicitly, given that they were recalled at all, is shown in Table 4. Overall, actions were more likely to be recalled in an explicit form if they were originally stated explicitly ($F(1,25) = 10.27$, $p < .005$). However, there was no effect or interaction with knowledge group ($F(1,25) < 1$). Finally, there was no significant difference between high- and low-knowledge groups in the time to read and evaluate the recipes (94 vs. 99 s; $F(1,25) < 1$).

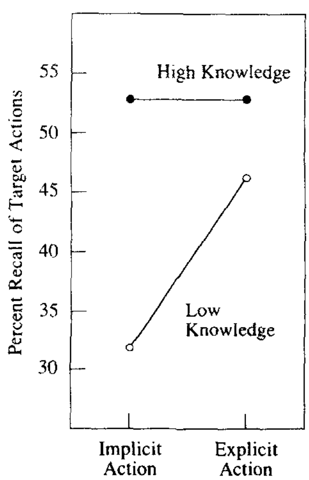

FIG. 3. Percentage recall of target actions in Experiment 3 as a function of form and knowledge group.

Discussion

These results provide support for the limited form-cue hypothesis. The form of the directions had a consistent effect on the mental plan representation when subjects knew relatively little about the task, but no effect whatsoever when the subjects were knowledgeable. The limited form-cue hypothesis accounts for this finding with the

TABLE 4
PERCENTAGE EXPLICIT ACTION STATEMENTS IN RECALL PROTOCOLS

Low-knowledge subjects	
Explicit target actions	46.6
Implicit target actions	25.6
High-knowledge subjects	
Explicit target actions	52.0
Implicit target actions	31.0

assumption that the form of the directions is used as a cue for the mental representation only when there is no other source of information about what the important or central steps are. Presumably, the high-knowledge subjects were able to tell from the content of the directions how to organize the task and which were the important and less-important steps. Low-knowledge subjects may have been less able to make such judgments on the basis of the content and were more influenced by linguistic cues to the importance of various steps. Specifically, they tended to regard explicit actions as more important and central than implicit actions.

Experiment 3 also provides a replication, using a different task and a different dependent measure, of both Experiment 1 and Experiment 2. The results for the high-knowledge subjects replicated the results of Experiment 1. In both experiments, there was no effect of whether an action was stated explicitly or implicitly. Presumably, there was no effect in the first experiment because all of the subjects were knowledgeable about how to perform the task: The figures being drawn were common and familiar, and all of the subjects knew general strategies for making simple drawings. This parallels the situation that occurred in Experiment 3 with cooking recipes and high-knowledge subjects. Although it is unlikely that these subjects would have encountered these particular recipes before, they probably had experience preparing similar dishes and may have understood a recipe by noting how it was like or unlike other recipes with which they were familiar. In a sense, high-knowledge subjects may have understood a recipe by instantiating a schema for a particular type of dish. This prior knowledge would have suggested an organization for the recipe and would have determined where in the plan hierarchy to put each of the steps.

The results for the low-knowledge subjects replicated the results of Experiment 2; in both cases, the results indicated that the explicit action information was represented higher in the mental hierarchy for the task than implicit actions. In Experiment 2, this meant that directions were read faster when they began with the explicit action, and in Experiment 3, this meant that explicit actions were better recalled at a later time. The limited form-cue hypothesis explains both of these results by assuming subjects knew relatively little about the two tasks. In Experiment 3 the low-knowledge subjects were selected on precisely this criterion. This assumption also makes sense in the knob turning/meter setting task used in Experiment 2; subjects had no knowledge of the operation of the device they were interacting with and no knowledge of the meaning of the knobs and meters. In this sense they were like the low-knowledge subjects in Experiment 3. Presumably, these results would change if subjects knew more about the knob/meter device they were operating, and the explicit/implicit action distinction would have little effect.

General Discussion

In these experiments, we explored the effect of explicit actions in written directions on the mental representation of a procedure. In Experiment 1, stating an action explicitly or implicitly had no effect on the pattern of reading times. This was taken as evidence that the mental representation of the directions was unaffected by this manipulation of form. However, in Experiment 2, directions were read faster when they began with an explicit action, independent of the nature of that action. This suggested that, in at least the knob–meter task of Experiment 2, the action that was stated explicitly was interpreted as the more important, central action in the procedure. The limited form-cue hypothesis was proposed as an account of these discrepant results. The explanation was that readers of directions only attended to the form of the directions when they were unsure of how to organize their mental plan for the task. Because the drawing task used in Experiment

1 was familiar and well understood, subjects ignored the distinction between explicit and implicit actions. But in Experiment 2, the function and relationship of the knob and meter was never explained. Consequently, subjects were receptive to any additional information about how to structure their mental plans, and the form of the action statements had an effect. The third experiment provided a direct test of this account. Instead of manipulating task familiarity by varying the nature of the procedure, two groups of subjects were found with different levels of familiarity with the same task. The results were exactly as predicted: Only subjects who were relatively unfamiliar with the domain of the procedure were affected by the form of the action information.

These results are consistent with the hierarchical planning framework proposed by Dixon (1987b). The crucial assumptions in the framework were that plans have a hierarchical structure and that this hierarchical representation is constructed from the top down. Together these assumptions imply that sentences beginning with high-level information should be read faster than sentences beginning with lower level information. This result was obtained in both Experiments 1 and 2. However, the two experiments differed in how height in the hierarchy was determined: In Experiment 1, the nature of the information determined the mental representation, while in Experiment 2, the form of the information was crucial.

Experiment 3 is important in these conclusions because it provides additional support for the general approach of inferring mental structure from reading time. On the basis of the reading time results in Experiments 1 and 2 it was hypothesized that explicit actions would be represented at a high level in the mental plans of low-knowledge subjects. And based on other work on memory for discourse (e.g., Meyer, 1975), it was predicted that such high-level information would be better recalled. The results are consistent with this prediction and support the assumptions on which the initial analysis was based. Specifically, it is evidence for the assumption that sentences are read more quickly when they begin with high-level information.

These results can also be used to elaborate the model of direction processing proposed by Dixon (1987a). According to this model, readers need at least some information about the top level of their plan in order to interpret low-level information, even if the low-level information is encountered first. The present results indicate something about what must occur when readers encounter the first clause in a direction. First, they must evaluate whether the information belongs at the top level of the plan hierarchy. If the reader knows something about the domain of the task, this can probably be done on the basis of the nature of the information; those with less knowledge would have to rely, in part, on the form in which the information was stated. If readers conclude that the information is not high-level, they would have to generate a hypothesis about what the high-level information was in order to start constructing their mental plan. This additional processing would be the source of the reading time effects found in Experiments 1 and 2.

The present results also suggest an interesting hypothesis about the *production* of procedural discourse. If producers of directions intuitively know that explicit action statements can aid uninformed readers in organizing their mental plans, they may change the form of the directions with the intended audience. For example, directions intended for domain experts may state many actions implicitly or indirectly, even though they may be important for the task; the producer of the directions may simply assume that an expert would be able to infer the appropriate organization of the steps. On the other hand, directions intended for novices may contain a careful delineation between explicit, important steps and implicit, subordinate steps. Presumably, this distinction would have to be carefully observed in order to avoid confusing the comprehender of the directions.

If the present conclusions hold in a wide range of tasks, they may provide an important prescriptive guide for writing better directions. For instance, the appropriate use of the implicit/explicit action distinction may be a determinant of the effectiveness of a set of directions. Experiment 3 indicates that such effects may be related not only to reading time and ease of comprehension of directions, but also to how well they are retained. The ability to retain the important steps in a set of directions is often much more important practically than an increase of a few hundred milliseconds in reading time. However, the results also indicate that such effects may be limited to those situations where the reader has relatively little knowledge of the task to be performed. If the readers of a set of directions can be assumed to be generally knowledgeable about the domain, extensive attention to the form of the directions may be unnecessary. But if the readers cannot be assumed to be knowledgeable, the present results indicate that important steps should be stated first and stated in the form of explicit actions.

Although the present research has been concerned primarily with the processes by which a mental plan is constructed from a set of directions, the results have implications for the construction of referential representations in general. In particular, the present results show that prior knowledge can have an important effect in determining the nature of such representations. For example, in Experiment 1 subjects used their knowledge of drawing tasks to organize their mental plans and to interpret the incoming information. And the high-knowledge subjects in Experiment 3 presumably used their knowledge of cooking to identify and retain important steps in the recipes. However, the results also indicate that even in the absence of extensive prior knowledge, a referential representation can be constructed. This is demonstrated, for example, by the fact that subjects in Experiment 2 were able to perform the knob-meter task with reasonable accuracy. However, in this case the explicit/implicit action cues in the text became much more important. In general terms, the results suggest that referential representations are largely determined by the reader's prior knowledge of the situation and that this prior knowledge often dominates any linguistic and structural cues to the organization of this representation. Such cues may be important only when material is encountered out of context or when the reader has little knowledge of the domain.

References

Black, J. B. (1980). *Memory for state and action information in narratives.* Presented at the Psychonomic Society Meetings, St. Louis, November.

Clark, H. H., & Clark, E. V. (1968). Semantic distinctions and memory for complex sentences. *Quarterly Journal of Experimental Psychology,* **20**, 129–138.

Dixon, P. (1982). Plans and written directions for complex tasks. *Journal of Verbal Learning and Verbal Behavior,* **21**, 70–84.

Dixon, P. (1987a). The processing of organizational and component step information in written directions. *Journal of Memory and Language,* **26**, 24–35.

Dixon, P. (1987b). The structure of mental plan for following directions. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* **13**, 18–26.

Dixon, P. (1987c). Actions and procedural directions. In R. Tomlin (Ed.), *Coherence and grounding and discourse.* Amsterdam: John Benjamins.

Hopper, P. J., & Thompson, S. A. (1980). Transitivity in grammar and discourse. *Language,* **56**, 251–299.

Johnson-Laird, P. (1983). *Mental Models.* Cambridge, MA: Harvard University.

Just, M. A., & Carpenter, P. A. (1980). A theory of reading: From eye fixations to comprehension. *Psychological Review,* **87**, 329–354.

Just, M. A., & Carpenter, P. A. (1987). *The psychology of reading and language.* Newton, MA: Allyn & Bacon.

Kintsch, W., Kozminsky, E., Streby, W. J., McKoon, G., & Keenan, J. M. (1975). Comprehension and recall of text as a function of content variables. *Journal of Verbal Learning and Verbal Behavior*, 14, 196–214.

LONGACRE, R. E. (in press). The correlativity of verb ranking and constituent structure. In R. Tomlin (Ed.), *Coherence and grounding and discourse*. Amsterdam: John Benjamins.

MARCEL, T., & BERNARD, P. (1979). Paragraphs of pictograms: The use of nonverbal instructions for equipment. In P. A. Kolers, M. E. Wrolstad, & H. Bouma (Eds.), *Processing of visible language*. New York: Plenum.

MEYER, B. J. F. (1975). *The organization of information of prose and its effects on memory*. Amsterdam: North-Holland.

SACERDOTI, E. D. (1977). *A structure for plans and behavior*. New York: Elsevier North-Holland.

SEBRECHTS, M. M., & DECK, J. G. (1983). *When do actions speak louder than goals?* Presented at the meeting of the Psychonomic Society, San Diego, November.

SPOEHR, K. T., MORRIS, M. E., & SMITH, E. E. (1983). *Comprehension of instructions for operating devices*. Presented at the meeting of the Psychonomic Society, San Diego, November.

VAN DIJK, T. A., & KINTSCH, W. (1983). *Strategies of discourse comprehension*. New York: Academic Press.

WILENSKY, R. (1983). *Planning and understanding*. Reading, MA: Addison-Wesley.

WRIGHT, P., & HULL, A. J. (1986). Answering questions about negative conditionals. *Journal of Memory and Language*, 25, 691–709.

WRIGHT, P., & WILCOX, P. (1978). Following instructions: An exploratory trisection of imperatives. In W. J. M. Levelt & G. B. Flores d'Arcais (Eds.), *Studies in the perception of language*. New York: Wiley.

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