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Inferences in Sentence Processing: The Role of Constructed Representations

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Abstract

Recent studies have revealed interesting differences between lexical decision and naming tasks. Naming responses seem to be primarily sensitive to lexical processes and lexical decisions to both lexical and message-level processes. This differential sensitivity to level of representation was used to investigate the following questions: 1) Are probable instruments for an action routinely inferred during sentence comprehension? Previous work may have failed to show that instruments are inferred, in part, because processing measures were used that were relatively insensitive to the level of representation involved in the inference and 2) If instruments are inferred, does this process require accessing elements of the linguistic or the constructed representation? Four experiments were performed that used cross-modal lexical decision and naming tasks as measures of instrument priming in sentences that implied the use of an instrument. No priming was found for sentences with no context, replicating Dosher and Corbett (1982). When sentences were preceded by a context that explicitly mentioned the instrument, however, priming was found with the lexical decision task. In combination with the result of the first two experiments, this suggests that instruments are inferred when the instrument implied by a sentence is available from the context but not when sentences are presented without contexts. Priming was not found with the naming task, however. The lexical decision/naming data together suggest that making an instrument inference involves accessing elements of a constructed representation of the discourse.

In addition, in sentences that contained pronouns that referred to the instruments, priming was found for appropriate referents with the lexical decision task but not with naming. This suggests that locating antecedents for pronouns also involves a constructed representation.

Introduction

The lexical decision and naming tasks have both been widely used in the study of word recognition. Recently, interesting differences between the two tasks have surfaced, indicating that they are sensitive to different types of information. Seidenberg, Waters, Sanders, and Langer (1984) compared the two tasks and found that naming responses were sensitive primarily to linguistic (particularly lexical) -level processes and lexical decisions were sensitive to both lexical processes and post-lexical message-level processes. Seidenberg et al. suggested that this was because the lexical decision task requires an explicit yes-or-no discrimination that benefits from a post-access check to determine if the target is compatible with its context. Naming, on

the other hand, requires only procedural knowledge about pronunciation and is, therefore, more likely to be influenced solely by information tied directly to the lexical representation of the word.

This difference is potentially important because it may provide a methodological tool for discriminating the different levels of representation used in sentence comprehension. For example, based on the linguistic evidence provided by Hankamer and Sag (1976), Tanenhaus, Carlson, and Seidenberg (1985) suggested that antecedent assignment for different types of anaphors involves linking the anaphor to elements in either a linguistic representation of the surface or logical form of a sentence or a conceptual representation. The latter is a model of the discourse constructed by using the outputs of the linguistic system. An earlier study used the lexical decision/naming task difference to test this hypothesis for definite noun phrases (Lucas, Tanenhaus, Carlson, and Senytka, 1985). Knowledge-level processing is generally required to determine the antecedents of definite noun phrases, suggesting that a constructed representation is more likely to be involved in antecent assignment for that kind of anaphor than a linguistic representation. In the study, subjects listened to sentence pairs that contained definite noun phrases at the end of the second sentence. Subjects then made lexical decisions or naming responses to targets that were appropriate or inappropriate antecedents. Naming responses did not show an appropriateness effect indicating that linguistic representations were not involved in antecedent assignment. There was a sizeable appropriateness effect for lexical decision responses, however, suggesting that the definite noun phrases were linked to elements of the constructed representation.

One of the purposes of the present studies was to extend this methodology to other forms of inference, in particular to inferences involving knowledge of the tools or instruments typically used to accomplish some action. For example, upon hearing the sentence, "Mary cut into a steak" listeners might infer that Mary used a knife. Presumably, making such inferences requires accessing some form of representation of the instrument. One issue investigated in the studies reported here concerns the level of representation involved. This is a particularly interesting test of the lexical decision/naming difference because it is not obvious whether the linguistic or conceptual level is involved. Schema theories that maintain that words are mapped onto well-formed conceptual structures which form the basis for inference (Schank, 1974; Bobrow and Norman, 1975) would predict that instruments commonly used in certain actions would be inferred at the level of the schema or conceptualization for that action. On the other hand, Fillmore's case theory, in which case roles like instruments are part of the representation of the verb in the lexicon, is compatible with the view that typical instruments for actions can be derived from the lexical representation of the verb (Fillmore, 1971).

Before this issue can be investigated, however, the issue of whether instrument inferences are drawn must be addressed. The empirical literature on this issue is mixed. There is some evidence that instrument inferences are encoded and stored as part of the memory representation of a sentence (Johnson, Bransford, and Solomon, 1973; McKoon and Ratcliff, 1981; Paris and Lindauer, 1976), but other evidence contradicts this (Corbett and Dosher, 1978; Dosher and Corbett, 1982; Singer, 1979). One possible reason for the discrepancy is that some studies used on-line measures of sentence processing,

but many involved recall or recognition. These latter studies, therefore, provide more information about memory processes than about the process of computing inferences on-line. Also, recognition tasks require the subject to explicitly consider the instrument in relation to the discourse and therefore may not reflect normal sentence processing. The one study that used an on-line processing measure that did not also require a recognition decision was Dosher and Corbett (1982). Using stroop interference, Dosher and Corbett found no evidence that implied instruments were activated following simple sentences. They argued that encoding implicit instruments is not necessary for discourse processing. Given the evidence that different priming tasks can tap different levels of representation, however, it is possible that the Stroop interference task is not sensitive to the representational level involved in instrument inferences. A different priming task may work where Stroop failed.

Also, Dosher and Corbett presented sentences with no context, but some previous research suggests that instrument inferences may occur when there is a context that explicitly mentions the instrument (McKoon and Ratcliff, 1981). This suggests that studies of instrument inferences must also be sensitive to the fact that comprehension strategies depend on the availability of context.

The first two studies reported here attempted to replicate the Dosher and Corbett findings with isolated sentences using cross-modal lexical decision and naming tasks. If Dosher and Corbett failed to find evidence for instrument priming because the Stroop interference task does not tap processes at the appropriate level of representation, then it is possible that the lexical decision or naming tasks will tap the appropriate processes. In any case, the results of these "no context" experiments will form a basis for comparison for the next two studies which examine comprehension strategies when the same stimuli are preceded by context.

Experiments 1 and 2

Method

Subjects. Thirty-two University of Rochester undergraduates participated in the first two experiments, sixteen in the lexical decision version and sixteen in the naming version.

Materials. The experimental sentences were generated from twenty-eight verb-instrument pairs. Sentences for each verb-instrument pair were composed whose verb phrases contained one of the verbs but which did not explicitly mention the instrument. An example of an experimental sentence is given in (1).

(1) He swept the floor every week on Saturday.

Each sentence was paired with either a target that was a plausible instrument or a control target that was an implausible instrument for the action specified by the verb. For example, targets for the sentence in (1) were "broom", the appropriate instrument and "closet" the inappropriate control. Instruments and controls were similar in length and frequency. Two presentation conditions were produced by combining the sentence list with two target lists that counterbalanced type of target (instrument or control). The

experimental sentences were intermixed with 88 filler sentences and the first six sentences in the list were fillers. In the lexical decision version, 60 of the filler trials were paired with non-word targets and the remaining 32 with word targets. Materials for the naming version were identical to the lexical decision version except that nonword targets were replaced by word targets in the filler sentences.

Procedure. In each experiment, eight subjects were assigned to each of the two presentation conditions. Each presentation version was preceded by 10 practice trials. Subjects heard the sentences binaurally over stereo headphones. A timing tone inaudible to the subject was placed at the end of the second phrase following the verb but never at the end of a sentence. For example, the tone in (1) appeared at the end of "week". Subjects, therefore, had plenty of time to make the inference before the target was presented if they were going to do so. The tone initiated presentation of a target stimulus midscreen on an Apple IIe computer monitor. In the lexical decision version, subjects pressed a button to indicate their response. Lexical decision times were recorded by a Digitry millisecond timer from the onset of the target to the subject's buttonpress. In the naming version subjects said the target word out loud as soon as it appeared. Responses were spoken into a microphone and naming times were measured from the onset of the target to the onset of the subject's spoken response. In order to ensure that subjects were attending to the sentences, comprehension questions were asked following one third of the trials.

Results and Discussion

Analyses of variance (ANOVA's) with subjects and items as random factors and Appropriateness (plausible instrument or implausible control) as a fixed factor were run separately on the lexical decision and naming data. For each subject outlier scores greater than or less than 2.0 standard deviations from the subject mean were replaced by the 2.0 standard deviation cutoff score. Condition means for both the lexical decision and naming experiments are presented in Table 1. There was no evidence for an Appropriateness effect in either the lexical decision version, $F(1,15) = .01$ by subjects and $F(1,27) = .001$ by items, or the naming version, $F(1,15) = 1.91$ by subjects and $F(1,27) = 1.64$ by items. This is true even when the results of both experiments are combined. An ANOVA on the combined data with Task as an additional factor revealed only a main effect of Task, $F(1,30) = 25.2$, $p < .0001$ by subjects and $F(1,54) = 160.8$, $p < .0001$ by items. This was due to lexical decision times being about 300 ms slower than naming times on the average. But there was still no main effect of Appropriateness, $F(1,30) = .39$ by subjects and $F(1,54) = .34$ by items, and no interaction between Task and Appropriateness, $F(1,30) = .61$ and $F(1,54) = .36$.

The fact that there was no appropriateness effect in either experiment indicates that the implied instrument was no more accessible than an inappropriate control. The results, therefore, replicate Dosher and Corbett in finding no evidence for instrument priming in sentences without context, using lexical decision and naming tasks instead of Stroop interference. In the next two experiments we sought evidence that providing a context that explicitly mentions the instrument would cause subjects to infer the use of the instrument.

One problem addressed in the next set of studies concerned the fact that concluding that instrument inferences are not routinely made depends on getting a null result. In such cases it is unclear whether the effect did not occur because the null hypothesis is correct or because there is a defect in the materials or the technique. To counter this possibility, in the following studies instrument inferences were directly compared with another form of inference - antecedent assignment for pronouns. Although instrument inferences may not be necessary for comprehension, antecedents must be assigned to pronouns if sentences are to be understood. Antecedent assignment, then, can serve as a check on the experimental design, to insure that the technique is sensitive to inferences drawn using our materials.

In addition, using the lexical decision/naming difference as a diagnostic, the levels of representation involved in both instrument inferences and antecedent assignment for pronouns could be determined. Earlier, it was argued that instrument inferences could require access to either a linguistic or a constructed representation. Likewise, Tanenhaus, Carlson, and Seidenberg (1985) have argued that finding the referent of a pronoun could require linking the anaphor to elements in either a linguistic or a constructed representation.

The next two experiments, then, were undertaken with several goals in mind. One was to determine if instrument inferences would be made when sentences with implied instruments were presented following contexts that explicitly mentioned the instrument. Sentences that referred to the instrument by using pronouns would serve as a check on the materials and design of the experiment should there be another null result for the instrument inferences. Also, the lexical decision/naming difference would reveal whether representations for implied instruments and pronoun antecedents were found at a linguistic or a conceptual level.

<div align="center">Experiments 3 and 4</div>

Method

Subjects. Forty-eight subjects from the University of Rochester participated in the next two experiments, twenty-four in the lexical decision version and twenty-four in the naming version.

Materials. The sentences from the first two experiments were also used in these experiments. There were two modifications to the experimental design. First, a context sentence was constructed for each of the experimental sentences. This context sentence contained both the instrument and control target words from the first study. For example, the sentence "He swept the floor every week on Saturday" from the first experiments was given the context, "John took the broom out of the closet". In half the context sentences the implied instrument occurred earlier than the control. The reverse was true for the remaining half. A second modification involved the introduction of an additional set of sentences, contructed from the same sentences that implied the instruments, in which the second phrase following the verb was replaced by a phrase that contained a pronoun. The pronoun always referred to the instrument explicitly mentioned in the preceding

sentence. In the example sentence, the sentence in the pronoun condition would become "He drove to work in it every morning".

Procedure. Subjects all heard the same context sentences but heard final sentences in either their pronoun or non-pronoun form. Four presentation conditions were formed combining two sentence lists which counterbalanced pronoun and non-pronoun versions of the final sentence with the two target lists from the first two experiments. For both the lexical decision and naming versions, six subjects were assigned to each of the four presentation conditions. The procedure for these experiments was identical to that for the first two experiments with one exception. In sentences containing pronouns, targets were presented at the end of the pronoun. Since phrases with pronouns replaced phrases from the original sentences, targets were the same distance from the verb in the pronoun versions as they were in the non-pronoun versions.

Results and Discussion

ANOVA's with subjects and items as random factors and Appropriateness (plausible instrument or implausible control) and Type (pronoun or non-pronoun version) as fixed factors were run separately on the lexical decision and naming data. Condition means for both experiments are presented in Table 2. There was a main effect of Appropriateness in the lexical decision data, $F(1,23) = 10.15$, $p < .005$ by subjects and $F(1, 26) = 6.31$, $p < .02$ by items, but not in the naming data, $F(1,23) = .52$ by subjects and $F(1,26) = .63$ by items. The main effect of Type and the interaction of Type by Appropriateness was not significant in either the lexical decision or the naming data.

The fact that there was a significant Appropriateness effect in the lexical decision data and no significant interaction of Type by Appropriateness indicates that there was instrument priming not only in the pronoun version of the sentences, where listeners needed to locate the instrument antecedent if they were to understand the sentence, but also in the non-pronoun versions where the use of the instrument was merely implied. In combination with the results of the previous experiments, these results support the hypothesis that, although instrument inferences are not drawn for sentences out of context, they will be drawn when sentences are presented in context, particularly if the sentences explicitly mention the instruments.

The results just discussed suggest that certain forms of inference, instrument inferences and antecedent assignment for pronouns, are made when the right context conditions are in place. What can be said about the form of representation accessed in both types of inference? Because the Appropriateness effect occurred only in the lexical decision data and not in the naming data it seems that the constructed representation of the discourse is the sole level accessed for both types of inference. An ANOVA with Task, Type, and Appropriateness as factors was run on the combined lexical decision and naming data for further confirmation of this. Although there was a main effect of Task, $F(1,46) = 20.04$, $p < .0001$ by subjects and $F(1,27) = 332.26$, $p < .00001$ by items and a main effect of Appropriateness, $F(1,46) = 7.51$, $p < .01$ by subjects and $F(1,27) = 5.39$, $p < .05$ by items, no other main effects or interactions were significant. If the conceptual level (and not the linguistic level) of representation had been accessed, we would expect an interaction of Task by Appropriateness. But this was only

marginally significant by subjects, $F(1,46) = 2.92$, $p < .10$ and not by items, $F(1,27) = 1.84$. An inspection of the means shows that this may be due to a small Appropriateness effect for instrument inferences in the naming version. This suggests that listeners accessed linguistic representations when these inferences were made but this is not confirmed elsewhere in the analysis (either by a main effect of Appropriateness in the naming data alone or in any interactions involving type in either the naming or the combined data). The tentative conclusion remains, therefore, that both antecedent assignment for pronouns and instrument inferences require access to a constructed representation.

Conclusion

The studies reported here provide further evidence that the lexical decision/naming task difference can be used as a diagnostic test for different levels of representation in sentence comprehension. Comparing results in the two tasks suggests that drawing an instrument inference and finding an antecedent for a pronoun both involve making links to elements in a constructed representation of the discourse. In addition, the evidence showed that inferences are not routinely made under all conditions of sentence processing. There was no instrument priming in sentences out of context, but, when sentences were presented in contexts that explicitly mentioned the potential instrument, instrument priming did occur.

This research provides a demonstration of how the lexical decision and naming paradigms can be used together to reveal more about the systems involved in sentence comprehension than either task could reveal alone. This methodology should prove valuable in future investigations of different forms of inferential processing.

Table 1

Mean reaction times in ms for experiments 1 (lexical decision) and 2 (naming)

Type of Target

Type of Task	Appropriate (Plausible Instrument)	Inappropriate (Inplausible control)
Lexical Decision	929	926
Naming	604	630
Combined	766	778

Table 2

Mean reaction times in ms for experiments 3 (lexical decision) and 4 (naming)

Type of Target

Pronoun

Type of Task	Appropriate (Plausible Instrument)	Inappropriate (Inplausible control)
Lexical decision	987	1032
Naming	735	739
Combined	861	886

Non-Pronoun

Type of Task	Appropriate (Plausible Instrument)	Inappropriate (Inplausible control)
Lexical decision	982	1040
Naming	718	738
Combined	850	889

Pronoun/Non-Pronoun refers to whether or not the sentence contained an anaphor that referred to the instrument.

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