

Knowledge of Language and Knowledge about the World: A Reaction Time Study of Invited and Necessary Inferences*

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Necessary inferences (e.g., The jury was not able to deliver its verdict by 3 o'clock. The jury did not deliver its verdict by 3 o'clock.) depend on linguistic knowledge. Invited inferences, (e.g., The jury was able to deliver its verdict by 3 o'clock. The jury delivered its verdict by 3 o'clock.) depend on knowledge about the world. Responses were faster to necessary than to invited inferences when subjects verified only one of the two inference types (Experiments 1 and 3). When subjects verified both inference types there was no difference between invited and necessary inferences (Experiments 2 and 4). These data suggest that linguistic and world knowledge are psychologically distinct and that when factual knowledge is not needed in a task it is not processed. In Experiments 3 and 4 incongruent world knowledge slowed response times for both inference types. This suggests that linguistic and factual knowledge are both part of the initial representation of a sentence.

The distinction between knowledge of language and knowledge about the world is central to much recent work in linguistics, work based on the *formalist* position that linguistic and world knowledge are distinct (e.g., Lakoff, 1971; Morgan, 1975). On the other hand many theorists of long-term memory, while making extensive use of the linguists' work, take the *naturalist* position that linguistic abilities share the same underlying mechanisms as other cognitive abilities (e.g., Norman & Rumelhart, 1975; Schank & Abelson, 1977).

The present experiments were designed to examine the psychological valid-

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ity of the formalist distinction between linguistic and world knowledge by comparing the comprehension of invited and necessary inferences. Necessary inferences depend on knowledge of language; invited inferences depend on knowledge about the world (Karttunen, 1970; Harris & Monaco, 1977). For example, the necessary inference (1a) depends on the meaning of the verb *make* and commits the speaker to its conclusion:

- (1a) The trainer made the hungry lion wait before it ate its prey. The lion waited before eating. [**But the lion did not wait.*]

The invited inference (1b) depends on factual knowledge about the probable eating behavior of hungry lions and invites the conclusion that the lion did not wait before eating, but the speaker is not committed to this conclusion.

- (1b) The trainer did not make the hungry lion wait before it ate its prey. The lion did not wait before eating. [*But the lion did wait.*]

The difference between the two inference types can be observed by negating the conclusion and conjoining it to the premise with *but*. The result, given in brackets, is acceptable for invited (1b) but not for necessary (1a) inferences.

The formalist views language as a system that can be studied independently of its use and independently of other cognitive systems. Since linguistic and world knowledge are assumed to be distinct, the goal of providing an account of linguistic knowledge can be achieved independently of an account of world knowledge or of performance (Chomsky, 1965). The products of linguistic knowledge are assumed, in the tradition of Aristotle and Porte Royale, to be directly available to introspection (in the form of linguistic judgments), uncontaminated by world knowledge or by factors affecting performance (e.g. Bever, 1970). Direct access to linguistic knowledge is essential to the formalist enterprise. If linguistic judgments are to form the basis for an account of linguistic knowledge then these judgments must be the product of linguistic knowledge alone. The formalist approach to the study of language, therefore, embodies an empirical claim about the process of comprehension: linguistic and world knowledge can be processed separately.

The simplest version of the formalist position assumes that comprehension begins with the processing of linguistic knowledge which is normally followed by the processing of world knowledge (e.g., Clark & Lucy, 1975). This serial model predicts that, in a true/false decision task, subjects will respond faster to necessary inferences than to invited inferences. Another alternative is that linguistic and world knowledge are normally processed in parallel but that the processing of world knowledge can be completely attenuated when it is not needed, e.g., in making linguistic judgments. A parallel model would also predict faster responses to necessary than to invited inferences given the assumption that when world knowledge is not processed more processing capacity is available for linguistic knowledge.

The formalist prediction of an inference-type effect was not supported by the results of Springston and Clark (1973), who found no difference in decision times for invited and necessary inferences. However, in their experiment the two inference types were randomly interspersed. This may have led subjects to adopt the strategy of routinely processing knowledge about the world on every trial rather than deciding for each inference whether it was needed or not. In everyday communication, knowledge about the world is presumably processed routinely for every sentence. If the processing of world knowledge can be restricted, this would occur only under special circumstances, e.g., in making linguistic judgments or in reading a dull and difficult text without "really understanding" it. In the laboratory subjects might be induced to curtail the processing of knowledge about the world if they knew that this knowledge would never be needed in the task. Consequently, in Experiment 1 each subject responded to only one inference type, invited or necessary. For subjects responding to necessary inferences knowledge about the world was never needed. It was expected that these subjects would not process world knowledge and would respond faster than subjects who saw invited inferences for whom the processing of world knowledge was necessary. In Experiment 2 each subject saw both invited and necessary inferences randomly interspersed; it was expected that subjects would process world knowledge for both necessary and invited inferences and that response times to the two inference types would not differ.

Pilot work suggested that some subjects developed a strategy of reading only the verbs. This information was sufficient to allow correct responding in the task. Subjects were therefore questioned about how they made their decisions. The use of a *verb-reading* strategy would make the processing of world knowledge unnecessary for either inference type. For subjects using a verb-reading strategy no difference between invited and necessary inferences was expected in either Experiment 1 or 2. Only subjects who read the whole inference, a *read-all strategy*, were expected to show the predicted effect of inference type in Experiment 1.

EXPERIMENT 1

Method

Materials. Karttunen (1970) describes several classes of verbs which yield either an invited or a necessary inference depending on whether they are used in the affirmative or the negative. Such verbs allow a comparison to be made between invited and necessary inferences while the subject matter or *topic* of the inference remains unchanged. *Make* type verbs, when used in the affirmative, yield necessary inferences, e.g., (2a), and when used in the negative yield invited inferences, e.g., (2b).

- (2a) The bribe did make the conscientious judge alter his decision.
The conscientious judge did alter his decision.

- (2b) The bribe did not make the conscientious judge alter his decision.
The conscientious judge did not alter his decision.

For *able* type verbs the difference between affirmative and negative is reversed. The affirmative form yields an invited inference, e.g., (3b) and the negative yields a necessary inference, e.g., (3a).

- (3a) The doctor was not able to save the baby's life.
The doctor did not save the baby's life.
(3b) The doctor was able to save the baby's life.
The doctor did save the baby's life.

Prevent type verbs are like *make* in that, in the affirmative, the verbs yield necessary inferences, e.g., (4a), and, in the negative, invited inferences, e.g., (4b). Unlike *make*, however, the conclusion of the invited inference is expressed by an affirmative statement and the conclusion of the necessary inference is expressed by a negative statement.

- (4a) The watchdog did prevent the thief from escaping with the jewels.
The thief did not escape with the jewels.
(4b) The watchdog did not prevent the thief from escaping with the jewels.
The thief did escape with the jewels.

The three pairs of inferences (2, 3, & 4) illustrate how, for *make*, *able* and *prevent* type verbs, a necessary inference can be changed into an invited inference simply by deleting or adding a negative. The use of the negative in the premise and correct conclusion is counterbalanced for the comparison of invited and necessary inferences when the three verb types are taken together. The word *did* was used in the premise of necessary inferences using *make* and *prevent* type verbs so that an effect of inference type could not be attributed to a difference in sentence length.

Make type verbs were represented by the verbs *make*, *force*, *compel*, *scare into*, *cause to*, and *oblige to*. *Able* type verbs were represented by the verbs *able to*, *find it possible to*, *be in a position to*, *have the courage to*, *have the skill to* and *have the strength to*. *Prevent* type verbs were represented by the verbs *prevent*, *stop*, *keep from*, *dissuade*, *make it impossible for* and *deter from*.

Twenty-four topics served as the subject matter of the inferences, eight for each of the three verb types. Each topic provided four inferences, a true invited and a true necessary inference and a false invited and a false necessary inference. False inferences were created simply by exchanging the conclusions of corresponding true invited and necessary inferences, e.g., *The doctor was not able to save the baby's life. The doctor did save the baby's life.* In all there were 48 necessary and 48 invited inferences.

Procedure. Inferences were typed on 5 × 8 in. cards; the premise on one line, the conclusion immediately below it. The subject initiated each trial by pressing a footswitch, displaying the inference and starting a msec clock which stopped when the subject pressed one of two microswitch response keys. One key was labelled *true/probably true*, the other *false/probably false*. After responding the subject gave a confidence rating on the accuracy of the response on a four-point scale. The subject was then told whether the response was right or wrong.

Subjects were instructed to decide whether, given the first sentence of the inference, the second sentence was true or probably true or whether it was false or probably false. Accuracy was stressed over speed and subjects were cautioned whenever they made two errors within five trials. Subjects were instructed to give their confidence ratings on the basis of, "How sure you are that the experimenter will say you are correct." Each subject received 12 practice inferences, followed by 48 experimental inferences.

Subjects in all of the experiments reported were undergraduate students of Buena Vista College. Thirty-two subjects saw invited inferences and thirty-two saw necessary inferences. The 24 topics were each presented twice to each subject, once in a true and once in a false form. The inferences were divided into two blocks of 24 so that, in each block, each topic occurred once and truth value and verb type were counterbalanced.

After completing the verification task subjects were asked a series of questions about the strategies they used in making decisions. Initial questions about the subject's view of the experiment served to encourage open discussion of subjective impressions. Subjects were then asked whether they changed the way they made their decisions, whether they noticed any patterns or regularities in the inferences, and whether they skimmed parts of the sentences. Any answer that suggested the use of a verb-reading strategy was followed by further questioning.

Results and Discussion

In the invited group 17 subjects used the verb-reading strategy and 15 used the read-all strategy. In the necessary group 18 used the verb-reading and 14 the read-all strategy. The data for the two strategies were analyzed separately.

Table 1 presents mean response times and error rates as a function of inference type, truth value, and verb type for subjects using the read-all and verb-reading strategies. Inspection of the mean response times given in the bottom row of data for each strategy shows that responses to invited inferences were slower than responses to necessary inferences. This difference was larger (.57 sec) and significant for the read-all strategy, $\min F'(1,15) = 6.09, p < .05$ and smaller (.15 sec) and nonsignificant for the verb-reading strategy, $\min F'(1,17) = 0.32$.

TABLE 1
 Weighted Mean Response Times in secs and Percent Errors (in parentheses), for the Two
 Strategies, as a Function of Inference Type, Truth Value, and Verb Type: Experiment 1

	Invited		Necessary	
<i>Read-all Strategy</i>				
Verb Type	True	False	True	False
Make	5.79 (1.8)	6.24 (3.6)	4.99 (4.5)	5.31 (3.6)
Able	5.13 (0.9)	5.45 (5.4)	5.33 (1.8)	4.89 (2.7)
Prevent	5.45 (6.3)	5.75 (6.3)	4.99 (2.7)	4.87 (9.8)
\bar{X}	5.46 (3.0)	5.81 (5.1)	5.10 (3.0)	5.02 (5.4)
<i>Verb-reading Strategy</i>				
Make	6.27 (5.9)	5.86 (3.7)	5.50 (5.1)	5.38 (2.2)
Able	5.15 (2.9)	5.09 (2.9)	5.51 (8.0)	5.12 (2.9)
Prevent	5.33 (3.7)	5.54 (2.9)	5.48 (5.9)	5.32 (8.1)
\bar{X}	5.58 (4.2)	5.50 (3.2)	5.50 (6.3)	5.27 (4.4)

The effect of inference type for the read-all strategy is consistent with the formalist model: decisions about necessary inferences required the use of linguistic knowledge alone and so were faster than decisions about invited inferences which required the additional use of knowledge about the world. No effect of inference type was expected for the verb-reading strategy since these subjects did not read the whole inference and presumably processed the same information for both inference types.

Error rates for invited and necessary inferences were almost identical for the read-all subjects, ruling out an explanation for the effect of inference type in terms of a speed-accuracy trade off. This conclusion was supported by the absence of a correlation of response times and errors, $r = .01$. (All correlations were performed with the means for the analyses of variance with subjects as the random factor.)

Confidence tended to be higher for necessary (3.95) than for invited inferences (3.90) for the read-all strategy. The effect was not significant, but there was a negative correlation of mean response time and confidence rating, $r = -.21$, $p < .05$. This relationship suggests that the faster response times for necessary inferences could have been due to subjects being more confident of their responses to them. Alternative explanations in terms of confidence will be discussed after Experiment 2 has been described.

The effect of verb type will not be discussed; no conclusions about this variable can be drawn since the three verb types were represented by different topics. There was an interaction of verb and inference type for both strategies. For the read-all strategy, the effect of inference type was greatest for *make* type verbs, smaller for *prevent* type verbs and smallest for *able* type verbs, $\min F'$ (2,39), = 3.83, $p < .05$. For the verb-reading strategy the pattern was similar: *make* type verbs gave the largest effect; there was a negligible effect for *prevent* type verbs, while for *able* type verbs the direction of the effect reversed, $\min F'$

(2,41) = 6.24, $p < .050$. The interaction can be attributed to the number of negatives in the premise and the correct conclusion.

EXPERIMENT 2

The effect of inference type found in Experiment 1 is consistent with the prediction of the formalist model that processing can be confined to knowledge about language for true/false decisions about necessary inferences. When subjects know that knowledge about the world will not be needed in a task they can restrict themselves to processing linguistic knowledge alone. In ordinary conversation, presumably, both kinds of knowledge are routinely processed for all utterances. Subjects might be expected to follow this normal strategy in a task in which world knowledge is required on some trials but not on others. This was suggested by the results of Springston and Clark (1973) who found that, when subjects were asked to make decisions about both necessary *and* invited inferences, there was no effect of inference type. Experiment 2 tested the prediction. The invited and necessary inferences used in Experiment 1 were randomly interspersed and presented to subjects under conditions that were otherwise identical to those used in Experiment 1. It was expected that there would be no effect of inference type.

Experiment 2 also provided more information about the role of confidence in Experiment 1. One difference between invited and necessary inferences is that conclusions of necessary inferences are certain while conclusions of invited inferences are probabilistic. The inference type effect in Experiment 1 might, therefore, have been due to subjects' confidence in their judgments. If, however, the confidence ratings in Experiment 2 were similar to those in Experiment 1 but no inference type effect was found in Experiment 2, then the effect of inference type in Experiment 1 could not be attributed to confidence.

Method

The inferences and procedure were the same as in Experiment 1 except that each subject saw half the topics in their necessary and half in their invited forms, 48 inferences in all, as in Experiment 1. Inference type was counterbalanced with other experimental variables within subjects and with topics across subjects.

Results and Discussion

Fifteen subjects used the read-all strategy and 36 used the verb-reading strategy. The author was conservative in classifying subjects as using the read-all strategy in the present experiment to avoid weakening any effect of inference type with data from verb-reading subjects.

Mean response times and error rates are presented in Table 2 as a function of inference type, truth value and verb type, for the read-all and verb-reading strategies. For the read-all strategy the effect of inference type was in the opposite direction from that obtained in Experiment 1: invited inferences were somewhat faster than necessary inferences (.08 sec). For the verb-reading strategy the effect of inference type was similar to that found in Experiment 1: invited inferences were slightly slower than necessary inferences (.23 sec). The effect did not approach significance for either strategy, *min F*'s < 1.0. As expected, the inference-type effect observed for the read-all strategy in Experiment 1 did not occur when the two inference types were intermixed. When subjects did not know, for any trial, whether knowledge about the world would be needed or not, they processed such knowledge for both necessary and invited inferences.

The effects of inference type on error rate and confidence ratings were similar to those found in Experiment 1. There was no effect of inference type on error rate and no overall relationship of response time and error rate, $r = -.07$. The difference in confidence between the two inference types was not significant but, as in Experiment 1, confidence ratings tended to be higher for necessary (3.78) than for invited inferences (3.73), and mean confidence ratings and response times were negatively correlated, $r = -.53$, $p < .01$. The effect of inference type on response time in Experiment 1 cannot, therefore, have been due to subjects' lack of confidence in their decisions about invited inferences. The same relationship of confidence and response time occurred in both experiments, but the inference type effect occurred only in Experiment 1, as predicted.

The effect of verb type and the interaction of verb and inference type were similar to those obtained in Experiment 1.

TABLE 2
Weighted Mean Response Times in secs and Percent Errors (in parentheses), for the Two Strategies, as a Function of Inference Type, Truth Value, and Verb Type: Experiment 2

	Invited		Necessary	
Read-all Strategy	True	False	True	False
Verb Type				
Make	7.48 (5.0)	7.45 (6.7)	6.68 (3.3)	7.26 (3.3)
Able	5.73 (0.0)	6.35 (8.3)	6.91 (6.7)	6.57 (5.0)
Prevent	6.37 (11.7)	6.42 (15.0)	6.41 (5.0)	6.46 (8.3)
\bar{X}	6.53 (5.6)	6.74 (10.0)	6.67 (5.0)	6.76 (5.5)
Verb-reading Strategy				
Make	7.28 (2.8)	7.25 (4.0)	5.87 (3.4)	6.75 (4.5)
Able	5.46 (1.1)	6.01 (4.0)	6.07 (3.4)	6.11 (3.4)
Prevent	6.23 (4.5)	6.68 (5.1)	6.31 (2.3)	6.40 (4.0)
\bar{X}	6.32 (2.8)	6.65 (4.4)	6.08 (3.0)	6.42 (4.0)

Discussion of Experiments 1 and 2

The inference-type effect found in Experiment 1 indicates that subjects presented with necessary inferences attenuated the processing of world knowledge. These subjects did not need to process world knowledge and by attenuating its processing were able to respond faster than the subjects shown invited inferences for whom world knowledge was necessary. The inference-type effect thus indicates that the formalist distinction between linguistic and world knowledge is more than a heuristic convenience; the distinction reflects the way in which knowledge is organized in memory. In contrast, the inference-type effect is not consistent with the naturalist view that the distinction between linguistic and factual knowledge cannot be made. In Experiment 1 subjects shown necessary inferences did distinguish between linguistic and world knowledge and did so rapidly enough to save time in the reaction-time task.

The naturalist claim that linguistic and world knowledge are inseparable was not supported by Experiment 1 but the naturalist claim that world knowledge is normally a part of the communication process was supported by the results of Experiment 2. In Experiment 2 subjects did not know on each trial whether world knowledge would be required or not. Under these conditions subjects processed world knowledge on every trial and there was no effect of inference type. This suggests that subjects cannot readily decide, while in the midst of processing a sentence, whether or not to process world knowledge. The decision must be made before the sentence is presented. For everyday purposes, therefore, the strategy that must be used is to process world knowledge for every sentence. It is only under unusual circumstances that one can dispense with world knowledge, e.g., when making linguistic judgments. The results of Experiment 2 thus support the naturalist view that world knowledge normally plays a role in communication.

EXPERIMENT 3

The inference-type effect found in Experiment 1 suggested that decisions about necessary inferences were based on linguistic knowledge alone while decisions about invited inferences required additional processing of world knowledge. This account is consistent with a serial formalist model in which linguistic knowledge is retrieved and evaluated before world knowledge (e.g., Clark & Lucy, 1975). The account is also compatible with a parallel model in which both types of knowledge are normally processed in parallel but, when world knowledge is not needed in a task it is not processed and additional processing capacity can be devoted to linguistic knowledge.

In Experiment 3 the serial and parallel models were compared by presenting necessary and invited inferences to separate groups of subjects, as in Experi-

ment 1, and manipulating the congruity of knowledge about the world. Each topic had a congruent and an incongruent form in which the situation described was either consistent or inconsistent with normal behavior and outcomes. For example, the differences between the congruent and incongruent versions of invited inferences (5) – (8) depend on factual knowledge about the typical behavior, abilities, and interests of privates and colonels, pilots and little girls, rescuers, nurses and janitors.

- (5) The sergeant did not make the $\left\{ \begin{array}{l} \text{private} \\ \text{colonel} \end{array} \right\}$ clean the latrines. The $\left\{ \begin{array}{l} \text{private} \\ \text{colonel} \end{array} \right\}$ did not clean the latrines.
- (6) The $\left\{ \begin{array}{l} \text{airline pilot} \\ \text{little girl} \end{array} \right\}$ was able to land the plane safely. The $\left\{ \begin{array}{l} \text{airline} \\ \text{little} \end{array} \right\}$ $\left\{ \begin{array}{l} \text{pilot} \\ \text{girl} \end{array} \right\}$ did land the plane safely.
- (7) The snow did not prevent the rescuers from reaching the $\left\{ \begin{array}{l} \text{airplane} \\ \text{wreck} \end{array} \right\}$ $\left\{ \begin{array}{l} \text{party} \\ \text{birthday} \end{array} \right\}$.
The rescuers did reach the $\left\{ \begin{array}{l} \text{airplane wreck} \\ \text{birthday party} \end{array} \right\}$.
- (8) The $\left\{ \begin{array}{l} \text{nurse} \\ \text{janitor} \end{array} \right\}$ did hesitate to turn off the patient's artificial heart machine.
The $\left\{ \begin{array}{l} \text{nurse} \\ \text{janitor} \end{array} \right\}$ did not turn off the patient's artificial heart machine.

The retrieval of incongruent information was expected to slow response time (Hoosain, 1974). According to the serial formalist model, factual information is retrieved for invited but not for necessary inferences, and so a congruity effect would be expected for invited but not for necessary inferences. The parallel model predicts a congruity effect for both inference types since, on this view, factual knowledge is retrieved for both invited and necessary inferences.

Both the serial and the parallel models predict an inference-type effect in Experiment 3. A second purpose of the experiment was to replicate the inference-type effect found in Experiment 1 with additional topics and with the use of negation more fully counterbalanced. Complete counterbalancing of negation was achieved by the introduction of *hesitate* type verbs, e.g. (8), to counterbalance *prevent*. In the affirmative *hesitate* gives an invited inference, in the negative a necessary inference. The conclusion of the invited inference is expressed in the negative, that of the necessary in the affirmative. The use of negation is the opposite of that found with *prevent* type verbs.

Method

Materials. Four verb types were used: *make*, *able prevent*, and *hesitate*. In addition to the verbs used in Experiment 1 and 2, *make* type verbs were represented by *frighten into* and *lead to*, the *able* type by *find a way to*, *find the*

time to, have the time to, have the endurance/speed/nervelpatience to. No new *prevent* type verbs were used; *hesitate* type verbs were represented by *hesitate to* and *falter in the intention to*.

Twenty-four topics were generated for the *make* and *able* type verbs, 12 each for *prevent* and *hesitate*.

Each of the 72 topics produced four invited and four necessary inferences: a true congruent and true incongruent and a false congruent and false incongruent inference. Corresponding congruent and incongruent inferences were created by altering a noun or verb phrase. The change was made equally often in the main and complement clauses of the premise, and the words exchanged were approximately equated in length and written frequency (Kucera & Francis, 1967).

Apparatus and Procedure. The apparatus and procedure were the same as in Experiment 1 except that each subject saw each of the 72 topics only once. Thirty-two subjects saw invited and thirty-two saw necessary inferences. Truth value, congruity, and verb type were counterbalanced across trials and across subjects each inference appeared equally often in each of its forms. Confidence ratings were made on a seven-point scale. Unlike Experiments 1 and 2 subjects were not cautioned about errors during the experimental trials.

Results and Discussion

In the invited inference group, 16 subjects used the read-all and 16 the verb-reading strategy. In the necessary inference group, 17 subjects used the read-all and 15 the verb-reading strategy.

Table 3 presents mean response times and confidence ratings as a function of inference type, congruity, and verb type for true and false inferences for the read-all strategy; data for the verb-reading strategy are not presented.

TABLE 3
Weighted Mean Response Time in secs and Percent Errors (in parentheses), for the Read-all Strategy, as a Function of Inference Type, Congruity, Verb Type and Truth Value: Experiment 3

	Invited		Necessary	
<i>Read-all Strategy: True</i>				
Verb Type	Congruent	Incongruent	Congruent	Incongruent
Make	7.55 (12.5)	8.25 (18.7)	6.15 (1.0)	6.48 (8.3)
Able	6.24 (3.1)	6.71 (12.5)	7.53 (0.0)	7.38 (10.4)
Prevent/Hesitate	8.10 (20.8)	8.26 (30.2)	7.17 (12.5)	7.91 (10.4)
\bar{X}	7.30 (12.1)	7.74 (20.5)	6.95 (4.5)	7.26 (9.7)
<i>Read-all Strategy: False</i>				
Make	7.27 (14.6)	7.99 (17.7)	6.64 (8.3)	6.98 (1.0)
Able	7.12 (13.5)	8.02 (17.7)	6.91 (9.4)	7.32 (12.5)
Prevent/Hesitate	8.12 (30.2)	8.64 (25.0)	7.32 (17.7)	7.77 (28.1)
\bar{X}	7.50 (19.4)	8.22 (20.1)	6.96 (11.8)	7.36 (13.9)

Responses were slower (.56 secs) and error rates higher for invited than for necessary inferences, $\min F' (1,32) = 5.42, p < .05$ and $\min F' (1,37) = 5.34, p < .05$, respectively. (The slowest subject in each group was discarded for these analyses because of the extremely slow responses of one subject.) This result replicates the evidence for the inference-type effect obtained in Experiment 1 with a larger sample of inferences and with the use of negation fully counterbalanced.

As in Experiment 1, confidence ratings for the read-all strategy tended to be higher for necessary (6.62) than for invited inferences (6.51), but the effect was not significant. Unlike Experiment 1, there was no overall correlation of mean response times and confidence ratings, $r = -.04$.

The results for the verb-reading strategy were similar to those obtained in Experiment 1; there was no effect of inference type, responses being slightly but not significantly faster (.09 sec) for invited than for necessary inferences. Also the effect of congruity was smaller than that for the read-all group and did not reach significance.

The parallel formalist model predicts a congruity effect for both invited and necessary inferences; the serial model predicts an effect only for invited inferences. Response times were slower for incongruent than for congruent inferences for both inference types $\min F' (1,81) = 4.48, p < .05$. The effect appears to be smaller for necessary (.35 secs) than for invited inferences (.58 secs) but the interaction did not approach significance for either the items or the subjects analysis, $\min F_s < 1.0$. This result supports the parallel model and is inconsistent with the serial model.

The effect of verb type and its interaction with inference type were similar to those obtained in Experiments 1 and 2. In addition, these variables interacted with truth value, $\min F' (2,94) = 3.59, p < .05$, an effect attributable to the response selection process (Just & Clark, 1972).

EXPERIMENT 4

In Experiment 4 the invited and necessary inferences used in Experiment 3 were randomly interspersed, as in Experiment 2, and presented to subjects under conditions that were otherwise identical to those in Experiment 3. It was expected that, as in Experiment 2, subjects would process knowledge about the world for both invited and necessary inferences. Both the parallel and the serial formalist models, therefore, predict an effect of congruity for both inference types and the absence of an inference-type effect, as in Experiment 2. The relationship of confidence and response time was expected to be similar to that in Experiment 3, allowing the conclusion that the inference-type effect in Experiment 3 was not due to an effect of confidence.

Method

The inferences, apparatus and procedure were the same as in Experiment 3, except that each subject saw half of the topics in their invited and half in their necessary form.

Results and Discussion

Eighteen subjects used the read-all strategy; fourteen used the verb-reading strategy. Mean response times and error rates for the read-all strategy are presented in Table 4 as a function of inference type, congruity, and verb type for true and false inferences.

TABLE 4

Weighted Mean Response in secs and Percent Errors (in parentheses), for the Read-all Strategy, as a Function of Inference Type, Congruity, Verb Type and Truth Value: Experiment 4.

	Invited		Necessary	
<i>True</i>				
Verb Type	Congruent	Incongruent	Congruent	Incongruent
Make	7.95 (14.8)	8.26 (14.8)	6.56 (5.5)	7.18 (1.9)
Able	6.80 (7.4)	7.45 (7.4)	8.39 (9.3)	8.29 (14.8)
Prevent/Hesitate	7.88 (13.0)	8.10 (29.6)	7.55 (1.9)	8.28 (9.3)
X	7.54 (11.7)	7.94 (17.3)	7.50 (5.6)	7.92 (8.7)
<i>False</i>				
Make	9.07 (7.4)	8.72 (31.5)	6.64 (7.4)	7.99 (7.4)
Able	7.45 (7.4)	8.39 (7.4)	7.35 (7.4)	8.27 (5.5)
Prevent/Hesitate	8.25 (24.1)	9.31 (24.1)	8.41 (11.1)	9.23 (18.5)
X	8.26 (13.0)	8.81 (21.0)	7.47 (8.6)	8.49 (10.5)

The inference-type effect was smaller than that in Experiment 3 (.29 secs) and, as expected, did not approach significance, $\min F'(1,57) = 1.06$. As in Experiment 2, when invited and necessary inferences were intermixed there was no effect of inference type. When subjects did not know on which trials knowledge about the world would be needed they processed this type of knowledge on every trial.

As in Experiment 3, necessary inferences tended to receive higher confidence ratings (6.63) than invited inferences (6.51), but the effect was not significant. The correlation between mean confidence ratings and response time was $r = -.14$, $p < .01$. The relation of response time and confidence was thus similar to and stronger than the relationship in Experiment 3. The inference-type effect in Experiment 3 cannot, therefore, be attributed to a direct effect of confidence.

Error rates were higher for invited than for necessary inferences, $\min F' (1,76) = 5.65, p < .05$. The size of the effect (7.41%) was similar to that in Experiment 3. The difference between Experiments 3 and 4 in the effect of inference type on response time cannot, therefore, be attributed to a speed-accuracy trade-off.

A congruity effect was expected for both inference types. Responses were slower to incongruent than to congruent inferences for both invited (.47 secs) and necessary inferences (.72 secs), $\min F' (1,85) = 3.97, p < .05$. The effect appears to be larger for necessary than for invited inferences but this interaction did not approach significance, $\min F' < 1.01$. When Experiments 3 and 4 were analyzed together the interaction of experiment with congruity and inference type also did not approach significance, i.e., the effect of congruity was the same for necessary and invited inferences in both experiments.

There was an interaction of inference and verb type as in all of the previous experiments and a main effect of truth value as in Experiment 2.

Discussion of Experiments 3 and 4

The results of Experiments 3 and 4 strengthen the conclusion of Experiments 1 and 2, that necessary inferences can be processed faster than invited inferences. In Experiment 3, the inference-type effect was replicated with an expanded set of topics and with an additional verb type. The inference-type effect supports the formalist analysis of the difference between invited and necessary inferences. Decisions about necessary inferences can be based on linguistic knowledge alone while decisions about invited inferences require, in addition, the use of knowledge about the world. The inference-type effect indicates that the distinction between linguistic and factual knowledge has psychological consequences and that the processing of factual knowledge can be curtailed. This result is consistent with the formalist approach to language.

Subjects presented with necessary inferences in Experiment 3 attenuated their processing of knowledge about the world; they did not, however, eliminate it. This was indicated by the congruity effect for necessary inferences. Incongruent world knowledge took longer to process than congruent world knowledge. This result supports a parallel formalist model in which linguistic and world knowledge are retrieved in parallel, as opposed to a serial model in which linguistic knowledge is the basis of the initial representation of a sentence (Clark & Lucy, 1975). The parallel model predicted the congruity effect for both invited and necessary inferences in Experiment 3, while the serial model predicted an effect only for invited inferences.

GENERAL DISCUSSION

The distinction between linguistic and world knowledge has been the source of longstanding debate in the study of language. The distinction is central to the formalist view that language is a formal system whose properties can be under-

stood without reference to its use in communication (e.g., Carnap, 1942; Miller, 1962; Chomsky, 1965). The distinction is antithetical to the naturalist view that language is essentially a system for communication and its properties can only be understood when it is viewed in this light (e.g., Austin, 1962; Halliday, 1968; Schank & Abelson, 1977).

In philosophy the formalist position is represented most clearly, although not uniquely, by the school of formal semantics (e.g., Carnap, 1942), and the naturalist view by natural language philosophy (e.g., Austin, 1962). In linguistics the formalist view is represented by the syntacticists (Chomsky, 1965) and the naturalist view by sociolinguistics (e.g., Halliday, 1968) and by the work of Chafe (1970). Psychology has followed the swing of the pendulum in linguistics, the work between 1960 and 1966 being directed by Chomsky's formalist position and the work since 1966 representing a swing back to the naturalist position (e.g., Bever, 1970).

In philosophy the formalist view has combined with a belief in the inadequacy of natural language as a formal system (e.g., Russell, 1956) to produce the school of formal semantics (e.g., Carnap, 1942). The logical form of language, it is claimed, can best be represented by formal logical systems which are based on a few logical operators like "not" and "or." The truth conditions of these formal propositions provide the meaning of the sentences which are their natural language equivalents. The naturalist view has led to the detailed study of the use of language in certain communication situations, for example, in the study of speech acts. The naturalist view has also led to the position that the meaning of an utterance can be analyzed in terms of the communicative intentions of the speaker (Grice, 1957) and to the view that an account of truth has to start from the idea of truth in a certain communication situation (Strawson, 1971).

In linguistics the formalist position is embodied in Chomsky's (1965) distinction between competence and performance. This distinction is many sided, but one part of it represents the formalist claim that language is properly studied when abstracted from the communication situation. This claim is plausible because of a second aspect of the distinction, the assumption that the products of the purely linguistic operations in which competence is involved are available to introspection (Bever, 1970). This assumption in turn requires the psychological claim that the processing of linguistic and world knowledge proceed separately. This is necessary in order for linguistic intuitions to be based on linguistic knowledge alone. If linguistic knowledge is not processed separately from world knowledge, then world knowledge could affect linguistic judgments. No independent theory of linguistic knowledge or competence would then be possible. The assumption that linguistic and world knowledge are or can be processed separately is thus central to the formalist program.

Recently linguists have begun to examine the relationship of linguistic and world knowledge through the study of, for example, conversational implicature (Grice, 1975), invited inferences (Geis & Zwicky, 1971) and presupposition

(Kiparsky & Kiparsky, 1970). This work retains marks of its formalist origins. The distinction is still made between competence and performance and there is often a heavy reliance on logical notation. However, the work represents an attempt to develop a formalist theory which takes into account the communicative function of language and which is consistent with commonsense notions of how people speak and understand.

For psychology and artificial intelligence the formalist view of language seems to have little to recommend it. Even if language can be viewed as a formal system, it is the use of language in communication, i.e., performance, that is of interest. The formalist is, however, making an empirical claim, that knowledge of language and knowledge of the world are processed separately. If correct, this claim must be recognized by any account of communication. The present investigation was designed to test the claim.

The present results provide equivocal support for the formalist position. The formalist distinction between linguistic and world knowledge was supported by the findings in Experiments 1 and 3 that necessary inferences can be processed faster than invited inferences. Subjects shown necessary inferences attenuated the processing of world knowledge which was unnecessary for their task. This indicates that the distinction between linguistic and world knowledge is more than just a heuristic convenience for linguists and philosophers. The ability of subjects to attenuate the processing of world knowledge to save time in a comprehension task suggests that the distinction of linguistic and world knowledge is an important aspect of the organization of information in memory rather than the result of metalinguistic processes. This conclusion would seem to indicate that the formalist program is a viable one, that linguistic judgments can be made on the basis of linguistic knowledge alone and are not influenced by world knowledge.

The support that the inference-type effect provides for the formalist program is, however, qualified by two other aspects of the results, the absence of an inference-type effect in Experiments 2 and 4 and, more importantly, the congruity effect for necessary inferences obtained in Experiment 3. The results of Experiments 2 and 4 suggested that, as the naturalists have emphasized, world knowledge is an important part of ordinary language use. In Experiments 2 and 4 invited and necessary inferences were intermixed so that on any trial the subject did not know whether knowledge about the world would be needed or not. Subjects were not able to decide during each trial whether world knowledge would be needed or not and so processed it on every trial. Response times for invited and necessary inferences were, consequently, the same. This result suggests that world knowledge would normally be used in comprehension and that processing would be attenuated only under special circumstances.

A more serious qualification to the formalist program is suggested by the congruity effect in Experiment 3. Incongruent world knowledge affected response time for necessary as well as for invited inferences. This occurred even

though the necessary inference group did attenuate the processing of world knowledge, as shown by the inference-type effect. The attenuation of world knowledge was not complete; some world knowledge was processed by the necessary inference group. This result raises the question of the viability of the formalist enterprise. The result suggests that it may not be possible to completely attenuate the processing of world knowledge. If linguistic judgments are affected by world knowledge, then the formalist goal of a purely linguistic theory is unattainable. It is possible that explicit instruction not to process world knowledge or training in the making of linguistic judgments might have enabled subjects to attenuate their processing of world knowledge completely. However, by showing that the processing of world knowledge may be partially attenuated, the results of Experiment 3 raise the question of whether the attenuation is ever complete. The current attention of linguists (e.g. Morgan, 1975) to the interaction of linguistic and world knowledge appears to reflect this concern.

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