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Logical implications and presuppositions in English complement constructions.

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LOGICAL IMPLICATIONS AND PRESUPPOSITIONS IN ENGLISH COMPLEMENT CONSTRUCTIONS

A Dissertation Presented

By

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ABSTRACT

LOGICAL IMPLICATIONS AND PRESUPPOSITIONS IN ENGLISH COMPLEMENT CONSTRUCTIONS

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The question was asked whether the semantic representation of logical implications or presuppositions is the decomposed form of the input sentence or whether the sentence representation is relative close to the surface form of the input sentence and the implication and presupposition have to be derived from it. Experiment I-III showed the difficulties models have which assume that a person uses the decomposed form of a sentence in order to answer a question about the implication or presupposition. Experiment IV and V separated the stage of comprehending the implication and presupposition from the decision stage by presenting the matrix sentence (e.g. He forgot to pay his income tax) before the probe sentence (e.g. He didn't pay his income tax). Reaction time was measured from the onset of the probe sentence until the subject responded. The results of these two experiments (Experiment V differed from Experiment

IV by employing imaginal instructions) showed that decision time was influenced by the class of predicates used in the matrix sentence (factive, implicative and negative-implicative), by the different predicates within a class and by whether the first sentence was explicitly negated or not. This outcome was regarded as strong evidence that subjects did not use a decomposed form of the input sentence when answering the question. A model was proposed which assumes that the subject computes the value of the implication or presupposition (affirmative or negative) from the matrix sentence at the time when he is asked to answer a question about them.

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INTRODUCTION

When comprehending linguistic information, people generally know more about a given situation then what is directly presented to them. Consider as an example the sentence: "The policeman held up his hand and stopped the car". A person listening to this sentence easily understands that there is a driver involved who steps on a brake in response to seeing the policeman's hand. Yet nothing of this is explicitly stated in the above sentence (Schank and Abelson, 1977, p.9).

Several investigators have claimed that inferential information of this type is represented together with the original presented information in memory. (e.g. Kintsch, 1974; Thorndyke, 1976). For example, Schank and Abelson (1977) state: "Any information in a sentence that is implicit must be made explicit in the representation of the meaning of that sentence" (p.11). Bransford & Franks (1971) and Bransford, Barclay & Franks (1972) argue that subjects integrate sentences with each other and with the knowledge of the world they possess and form a unified representation. Potts (1972, 1974) also concludes that inferred information is stored together with the actual information presented. Kintsch (1974) in discussing how people comprehend

paragraphs concludes that comprehension consists in constructing an abstract representation of the content of the paragraph from whatever cues are available in a text. And furthermore, that people, in order to construct a coherent text base, frequently have to include propositions which are not directly represented in the surface structure of the text.

However, not everybody agrees that the semantic representation of a sentence has to include the possible inferences. For example, Fodor, Fodor and Garrett (1975) state that, "barring decisive evidence to the contrary, we should assume that the semantic representation of a sentence is as much like the surface form of the sentence as we can" (p.526). Kintsch (1974) formulates the question as follows: "If one asks the subject to make comparisons or inferences about presuppositions or implications, we know that subjects must and do, indeed, analyze these expressions (see, for example, Just & Clark, 1973, for inference experiments). But is this because the sentence itself is stored in its decomposed form, or because of the application of a meaning rule to a lexically complex expression? The Clark data can be accounted for either way" (pp.222-223).

While it is clear that subjects have to analyze complex expressions at least to some degree, the evidence as to whether inferences are stored together with the base sen-

tence or are derived through meaning postulates is either not conclusive or not available at all. Therefore, the question I will try to answer is this: Are inferences made at the time of initial comprehension or are they made when trying to answer a question? And I am going to ask this question for the limited domain of sentences containing logical presuppositions and implications.

Part of fully comprehending a sentence is understanding these presuppositions and implications. Consider the sentence Mary took into account that she kissed the king of France. Given that the whole sentence represents a true proposition, it follows that the complement sentence Mary kissed the king of France also represents a true proposition. The complement sentence Mary kissed the king of France will be called the logical presupposition of the sentence Mary took into account that she kissed the king of France and will be distinguished from the logical implication of a sentence. The complement sentence Mary kissed the king of France will be referred to as the logical implication if it is derived from a sentence of the form Mary took the opportunity to kiss the king of France. While both presupposition and implication refer to sentences which imply the truth of their complements, they differ with respect to negation. Negating the higher sentence does not change the presupposition, but does negate the implication. While the

sentence _Mary didn't take into account that she kissed the king of France_ still presupposes that Mary kissed the king of France, the sentence _Mary didn't take the opportunity to kiss the king of France_ implies that Mary did not kiss the king of France.

Of considerable interest in forming a theory of sentence comprehension is the question as to how the presuppositions and implications of sentences are stored and processed when a person understands a sentence. In particular I will consider the following alternatives:

1. The logical presupposition or implication of a sentence is extracted immediately (at comprehension time) and stored together with the representation of the main sentence.
2. The logical presupposition or implication is extracted when needed (at retrieval time), for example, when asked to answer a question. A person may use in this case the stored surface form of the sentence or some more abstract representation (deep structure).

Not all predicates (verbs, adjectives, nouns) in English complement constructions carry with them the presupposition or implication of their complement. If one replaces the predicate _take into account_ with the predicate _assume_, the sentence _Mary assumed that she kissed the king_

of France or the negated version Mary didn't assume that she kissed the king of France no longer presupposes that Mary actually did kiss the king of France.

The class of predicates which presuppose the truth of their complement (regardless of whether the main sentence was affirmative or negative) was termed factives (F) as opposed to non-factives (NF) (Kiparsky and Kiparsky, 1971). The Kiparskys (1971) list the following examples:

I. Subject-clauses (predicates which take sentences as their subjects).

Factives: significant, tragic, relevant, counts, suffices, odd, exciting, matters, makes sense, amuses

Non-Factives: likely, possible, false, appears, chances, sure, true, seems, happens, turns out.

II. Object-clauses (predicates which take sentences as their objects).

Factives: regret, grasp, take into consideration, take into account, bear in mind, ignore, make clear, be aware (of), comprehend, forget (about), deplore, resent, care (about).

Non-Factives: suppose, assert, allege, assume, claim, charge, maintain, believe, conclude, conjecture, intimate, deem, fancy, figure.

That the distinction between factive and non-factive predicates is not restricted to the semantic domain is shown

in the next two examples which demonstrate that these predicates also behave in a different way syntactically. (For additional examples see Kiparsky and Kiparsky, 1971).

1. The subject of the complement sentence can be raised for non-factives into the upper sentence where it becomes the surface object of its verb (subject raising), while this transformation results in an ungrammatical sentence (*) for factive predicates.

NF: He believes that Mary has kissed the king of France vs.
He believes Mary to have kissed the king of France.

F: He regrets that Mary has kissed the king of France vs.
*He regrets Mary to have kissed the king of France.

2. Placing the complement at the end of a sentence (extraposition) is an optional transformation for factive predicates, but an obligatory one for non-factives.

F: That she kissed the king of France in our kitchen made sense to me vs.
It made sense to me that she kissed the king of France in our kitchen.

NF: *That she kissed the king of France in our kitchen seems to me vs.
It seems to me that she kissed the king of France in our kitchen.

That the factive/non-factive distinction is not limited to that-clauses was demonstrated by Karttunen (1971). He noted that certain adjectives such as glad, proud, lucky also presuppose the truth of their complement. The sentence John was glad to see his parents, John wasn't glad to see his parents and Was John glad to see his parents? all presuppose that John saw his parents. If one replaces however the verb glad with eager, ready or willing, etc., no presupposition remains.

However, many predicates taking a to-complementizer belong to the class of implicative verbs (Karttunen, 1971), so called because they imply the truth of their complement. Karttunen (1971) defines "imply" as:

> P implies Q iff
> whenever P is asserted
> the speaker ought to believe that Q

So for example, John managed to solve the problem implies that John solved the problem, while John didn't manage to solve the problem implies that John did not solve the problem. Karttunen lists the following implicative and non-implicative predicates:

Implicatives: manage, remember, bother, get, dare, care, venture, condescend, happen, see fit, be careful, have the misfortune, have the sense, take the time, take the opportunity, take the trouble, take it upon oneself.

<u>Non-implicatives</u>: agree, decide, want, hope, promise, plan, intend, try, be likely, be eager, be ready, have in mind.

Besides the class of implicative predicates he further introduces the class of negative-implicatives. The name results from the fact that verbs of this class imply the truth of the negated complement. The predicate <u>fail</u> may serve as an example: The sentence <u>John failed to solve the problem</u> has the implication that John did not solve the problem, while the negated sentence <u>John didn't fail to solve the problem</u> has the implication that John did solve the problem. (I will disregard for my purposes the possible reading: It wasn't that John failed to solve the problem, he simply refused to try). Karttunen (1971) lists the following examples:

<u>Negative-implicatives</u>: forget, fail, neglect, decline, avoid, refrain.

It is tempting to regard the negative-implicative verbs as just the negative counterparts of the implicative predicates. In this sense <u>forget</u> would be equal to <u>not remember</u> and <u>fail</u> to either <u>not do</u> or <u>not succeed</u>. However, positive forms don't seem to exist for the predicates <u>neglect</u> and <u>avoid</u>. Furthermore, the two sentences <u>All of the board members forgot to come to the meeting</u> and <u>All of the board members did not remember to come to the meeting</u> do

not necessarily have the same meaning. While the first sentence can only be interpreted to mean that none of the board members came to the meeting, the second sentence has the additional interpretation that not all of the board members came to the meeting. (Examples from Karttunen, 1971).

So far I have discussed some linguistic facts about presuppositions and implications as used in English complement constructions. I showed how they behaved under negation and how they depend on the nature of the main verb. I will use those properties to answer my original question about storage and retrieval of inference information after I have outlined a recent methodological and theoretical approach to sentence verification.

General Method.

Recent work in psychology (Clark and Chase, 1972; Trabasso, Rollins, & Shaughnessy, 1971) has provided us with a paradigm and theory which can be adopted to answer the question of whether there is immediate or delayed extraction of presupposition and implication or not. Clark and Chase (1972) devised a sentence-picture verification task, where the subject is shown a sentence like Star isn't below plus and a picture showing a star either above or below a plus sign. The subject is instructed to read the sentence, look at the picture and respond as quickly as possible by

pressing one of two buttons indicating whether the sentence is true or false of the picture.

Let us assume the sentence is presented before the picture and that we have the true negative condition with the sentence reading Star isn't below plus and a picture showing a star above a plus sign. It is postulated that in a first stage the subject encodes the sentence as false(star below plus). In a second stage, he encodes the picture as true(plus below star) if the sentence as in our example contained the word below and that he uses above if the sentence contained the word above. In a third stage he compares the subjects of the embedded sentences. For our example this comparison would result in a mismatch which is supposed to change a truth-index (originally set at "true") to "false". As a next step the subject compares the embedding strings. The result would be another mismatch which would set the truth-index back to "true". The last stage is the response stage, where the subject executes the value of the truth-index and therefore responds "true".

One can summarize the different conditions by specifying if the decision is either true (T) or false (F) and if the sentence is either affirmative (A) or negative (N). Using the true-affirmative (TA) condition as the base line, false-affirmatives (FA) should take the additional time i because of a mismatch of the embedded strings (inner

mismatch or falsification time), while false-negatives (FN) should add the extra time _o_ since the mismatch occurs with the embedding strings (outer mismatch or negation time). Finally, true-negatives (TN) should add the additional times _i_ plus _o_ since the embedded as well as the embedding strings mismatch.

With the additional assumption that it takes longer to encode the word _below_ than to encode the word _above_, adding a constant to all the conditions using the word _below_ in the stimulus sentence, Clark and Chase (1972, Experiment I) were able to show that the outlined model provided a good fit to their data. Since then the general approach has been proven fruitful for a variety of situations (Carpenter, 1973; Carpenter & Just, 1975; Clark & Chase, 1972, Experiment II and III; Gough, 1966; Just, 1974; Just & Carpenter, 1971; Trabasso, Rollins, & Shaughnessy, 1971, Experiment IX).

The Just and Clark Experiment.

Just and Clark (1973, Experiment I) asked the question whether subjects are "able to access and make use of the presuppositions and implications of a sentence independently of each other" (p. 22). They presented a statement together with a question and the subject responded by pressing one of two buttons labeled "in" or "out". The stimulus sentences were of the form: _If John remembered to let the dog out,_

then where is the dog? The predicates used were the pairs remember-forget and thoughtful-thoughtless. They tested for both the implication (where is the dog?) and the presupposition (where is the dog supposed to be?). The results showed that forget took 438 msec longer than remember and the question where is the dog supposed to be? took 178 msec longer than the question where is the dog? They argued that, given the independence hypothesis is true, the presence of a negative component should only have an effect on the comparison process when the implication is questioned but not the presupposition (which does not change under negation). In their experiment this should have shown up as an interaction between remember-forget and the question. However, their results showed a nonsignificant interaction of 67 msec in the wrong direction ($F<1$).

In a second experiment they used stimulus sentences of the form: if John forgot to let the dog out, then the dog is in and the subject responded by pressing a button labeled either "true" or "false". They wanted to test the hypothesis that the subject uses the components of the main sentence, always checking the implication first, and only if this fails looks at the presupposition (ordered model).

With respect to the implication of the predicates remembered to and forgot to they obtained the following results: TA=28.14 msec, FA=3252 msec, TN=3670 msec and

FN=3536 msec. The *remember-forget* by true-false interaction was significant ($F(1,11)=13.35$, $p<.01$), while the true-false difference was not ($F(1,11)=1.19$). This outcome, they took as support for their ordered model.

However, Just and Clark do not specify a processing model. If we agree with Just and Clark as to what the implication of a given sentence is we would get the following representations for sentences with *remember* = true(out,dog) and *forget* = false(out,dog). Assuming further that the last part of the sentence *then the dog is in* or *out* is encoded as true(in,dog) or true(out,dog) and that the comparison-process is as in the Clark and Chase (1972) model, then we can derive the following predictions for the four conditions: TA=k1, FA=k1+i, FN=k2+o and TN=k2+i+o. (k1 and k2 are the different encoding times for the predicates *remember* and *forget* while *i* and *o* stand for the additional time an inner or outer mismatch requires). As can be seen easily, this model not only predicts a *remember-forget* by true-false interaction, but in addition it predicts that the TN-FN difference should be equal to the FA-TA difference, which clearly was not the case in their experiment.

It is not obvious that the implication of *John forgot to let the dog out* is, as they state, *false*(*out*,*dog*) and not *true*(*in*,*dog*). The latter case is regarded by Just and Clark as the conversion model and rejected (it predicts TN<FN).

However, without specifying the underlying processing assumptions there is little to choose between one proposed representation over another. Therefore, in my first experiment not only will I consider different underlying representations but also different control processes and their relations to each other. Furthermore, since the processes and representations involved may depend on the time the subject has for encoding the implication or presupposition of a sentence, the order of presentation of main sentence and question will be varied.

Plan of Investigation.

Clark and Chase (1972) presented both the picture and the sentence, controlling the order of processing by either presenting the picture first (picture to the left of the sentence) or the sentence first (sentence to the left of the picture). Their results made it necessary to assume a different representation for the encoded picture, as well as different control processes, depending on what was encoded first, the sentence or the picture. Furthermore, the encoding times of both picture and sentence were part of the measured decision times.

It seems desirable to control the amount of preprocessing of the presupposition or implication of a sentence using English complement constructions as discussed above. I will consider two extremes:

1. In a first experiment a subject sees the complement sentence (e.g. He paid his tax) or the negated form (He didn't pay his tax) before the main sentence (e.g. He forgot to pay his tax) containing the complement. The main sentence has either a presupposition or implication which is the same as expressed in the first sentence or contradictory to it and the subject so indicates by responding "true" or "false". Reaction time (decision time) is measured from the onset of the main sentence. From previous research one might expect sentences containing an explicit negative to be verified more slowly than affirmative sentences (Clark & Chase, 1972; Trabasso, Rollins, & Shaughnessy, 1971; Wason, 1961) and sentences containing an implicit negative predicate more slowly than sentences with implicit affirmative predicates (Clark, 1971; Just & Carpenter, 1971; Just and Clark, 1973).
2. In a second experiment a situation is created where the subject has time to extract the correct presupposition or implication of a given sentence. This is achieved by presenting the main sentence first (e.g. He forgot to pay his tax) and following it either by the affirmative complement sentence (He paid his tax) or the negative one (He didn't pay his tax). As in Experiment I, the subject indicates if the complement sentence reflects the correct

presupposition or implication of the main sentence. However, decision time is now defined as the time from the onset of the complement sentence until the subject responds.

Given the hypothesis that a person stores the presupposition or implication of a sentence separately from its assertion one no longer expects main effects of verbs, verb class, polarity of the main sentence, or interactions of these factors. These parameters should be reflected only in the encoding time (inspection time) of the first sentence.

Given the alternative hypothesis that a person extracts the presupposition or implication at time of retrieval, these factors, however, should still influence decision time.

EXPERIMENT I

Method.

Subjects. The subjects were 10 paid students from the University of Massachusetts who participated in three consecutive daily sessions of approximately one hour each. They received $2 per session.

Apparatus. The experiment was controlled by a digital computer. Subjects were seated behind a table and had a display scope and response panel in front of them. The response panel consisted of 4 response buttons, one for the inspection time, two for the "true-false" decision time and one for restarting the trial sequence after the occurrence of an error and for starting the next block of trials.

Stimulus material. The main sentences used in the experiment were of the form: NP-VP-(NP-complement). The subject of the sentence was always He. Three different VP-classes according to the classification of Karttunen (1972) were used: Factives, implicatives and negative-implicatives. Each verb class contained four different verbs. The four factive predicates were: forgot, remembered, was happy, was sorry which were combined with a that-complementizer. The implicative predicates used were remembered, condescended, managed and happened and were combined with a to-complementizer. Forgot, refused, declined and

neglected made up the class of negative-implicative predicates using a to-complementizer also. Notice that the verb remember with a to-complementizer belongs to the class of implicatives, the verb forget to the class of negative-implicatives, while both verbs become factives when used with a that-complementizer.

The factive predicates was happy and was sorry may also be classified as emotives, a distinction used by the Kiparskys which cuts orthogonally across the concept of factivity. Furthermore, the factive predicates remembered that and was happy can be regarded as inherently positive predicates, while forgot that and was sorry have a negative connotation.

Four different NP-complements were used and were randomly assigned to a given condition on a given trial, with the restriction that on two successive trials the same complement could not occur. The four complements were: He paid his tax, he ate his dinner, he wrote his mother and he went to work. On a given trial the complement of the main sentence was used in either its affirmative or negative form as the first sentence.

Half of the stimulus sentences required a positive response and half a negative. All in all, there were 48 conditions: three verb classes, with four predicates in each, the first sentence either explicitly affirmative or

negative and the second sentence either explicitly affirmative or negative. It took two blocks of 24 trials each to show all the conditions to a subject.

I will denote the required decision as either true (T) or false (F), the extracted presupposition as always affirmative (A) since it does not depend on the polarity of the main sentence and the implication as either affirmative (A) or negative (N). For factive predicates we obtain two TA and two FA conditions, in each case one originating from an affirmative main sentence and one from a negative one. For implicative and negative-implicative predicates we obtain four different conditions: TA, FA, FN and TN. Let us consider as an example a TN condition involving the implicative verb <u>remember</u>. The subject would see as his first sentence the complement sentence <u>He didn't pay his tax</u>, followed by the second sentence (the main sentence) <u>He didn't remember to pay his tax</u>. The implication of the main sentence is that he did not pay his tax which is congruent with the first sentence and therefore the subject responds "true".

<u>Procedure</u>. Each trial started with a 2 sec blank period, after which the sentences were displayed successively, each one on a single line with each letter taking up about .2 cm per space. The first sentence the subject saw was the complement sentence, either in an affirmative or negative form. The subject was instructed to read the sen-

tence and to press a button with his left index finger as soon as he comprehended the sentence. Immediately after the subject's response, the complement sentence was taken off the screen and after a 200 msec delay the main sentence was presented. The subject's task was to judge if the first sentence reflected the correct presupposition or implication of the second sentence by answering either "true" or "false" using the index and middle finger of his right hand. Finger assignment of the right hand was balanced over subjects. The necessity of responding as fast as possible without making mistakes was emphasized.

On a given day, a subject received 10 blocks of 24 trials each, with a brief rest period after each block. At the end of each block the subject received information about his mean reaction time and about the total numbers of errors he made. On the first day the subject was familiarized with the stimulus material. He received on a sheet of paper a list of all possible stimulus sentences, together with a complement sentence and he indicated whether the complement sentence was the correct presupposition/implication of the main sentence or contradictory to it by either marking "true" or "false". Errors were few in this preliminary task and the subjects agreed with the experimenter's interpretation of the sentences. At the beginning of the actual experiment the subjects received one block of 24 practice

trials, randomly chosen from the 48 conditions. On days two and three the subject received 8 warm-up trials at the beginning of the session instead of the 24 practice trials.

Results

Analyses of variances were performed for both the inspection and the decision times: one analysis involving factive verbs with subjects (S), days (D), verbs (V), main sentence affirmative or explicitly negative (S2), and complement sentence affirmative or explicitly negative (S1) as factors; and one involving implicative and negative-implicative verbs with subjects (S), days (D), class of verbs (C=either implicative or negative-implicative), verbs within a class (V/C), main sentence affirmative or explicitly negative (S2) and complement sentence affirmative or explicitly negative (S1) as factors. All factors with the exception of subjects were considered fixed effect variables.

Inspection Times.

Subjects inspected the first sentence an average of 1630 msec per trial on day 1, 1201 msec on day 2 and 950 msec on day 3. Complement sentences which contained an explicit negative were viewed 185 msec longer than affirmative sentences for conditions involving "factive predicates"

(F(1,9)=87.6, MSe=46,880) and 197 msec longer for conditions involving "negative-implicative" predicates (F(1,9)=58.1, MSe=160,090).

Decision Times.

The mean decision times for each condition as well as the average over verbs for each verb class are shown in Table 1.

Table 1 about here

The standard errors estimated from the error terms of the S1*S2*V and S1*S2*V/C interactions were 27 msec and 33 msec for the conditions involving factive verbs and implicative/negative-implicative verbs respectively.

Class of factive verbs. Negation of the first and second sentence affected decision time. The true-false difference for factive verbs is reflected in the S1 main effect. If the first sentence (the complement sentence) was explicitly negative, decisions took 202 msec longer than when affirmative. (F(1,9)=12.61, p<.01, MSe=386,443). This difference did not change over days.

Mean reaction time for explicitly negative second sentences was 164 msec slower than for affirmative sentences. (F(1,9)=61.21, p<.01, MSe=52,957). This difference of 258 msec on day 1 dropped to 124 msec on day 2 and to 111 msec on day 3. (F(2,18)=9.94, p<.01, MSe=26,428).

TABLE 1

Decision Times For Experiment I

S2 Sentence

		forgot		was sorry		remembered		was happy		FACTIVES	
		aff	neg	aff	neg	aff	neg	aff	neg	aff	neg
S1	aff	1439	1354	1193	1204	1014	1475	997	1254	1161	1322
	neg	1476	1618	1385	1420	1260	1589	1315	1479	1359	1527
		remembered		condescended		managed		happened		IMPLIC.	
S1	aff	944	1403	1085	1541	886	1322	904	1261	955	1382
	neg	1152	1601	1294	1522	1092	1293	1121	1309	1165	1431
		forgot		refused		declined		neglected		NEG-IMPL.	
S1	aff	1137	1346	1067	1333	1096	1425	1094	1360	1092	1366
	neg	1366	1504	1197	1383	1244	1530	1158	1360	1241	1441

The verb factor was also highly significant ($F(3,27)=13.24$, $p<.01$, MSe=75,872). Decisions concerning implicitly negative verbs took an average of 89 msec longer (forgot that = 1472 msec, was sorry that = 1301 msec) than their respective positive counterparts (remember that = 1334 msec, was happy that = 1261 msec).

Both the polarity of the first and second sentences interacted with the verb factor: the S2*V interation was significant ($F(3,27)=13.79$, $p<.01$, MSe=68,021), as well as the S1*V interaction ($F(3,27)=3.47$, $p<.05$, MSe=23,073). The triple interaction S1*S2*V was also significant: $F(3,27)=9.08$, $p<.01$, MSe=21,588. The S2*V interaction was due to the fact that sentences containing the implicitly negative verbs forget that and was sorry that showed a small difference between explicitly negative and affirmative main sentences (29 msec and 23 msec respectively), while this difference was large for sentences containing the implicitly positive verbs remember that and was happy that (395 msec and 211 msec respectively). A similar, but much less marked pattern resulted in the S1*V interaction: the difference in decision time to negative vs. affirmative first sentences was larger for conditions with implicitly affirmative predicates than implicitly negative predicates (181 msec vs. 150 msec for remember and forget and 271 msec vs. 204 msec for was happy and was sorry).

<u>Class of implicative/negative implicative verbs</u>. If the first sentence was explicitly negative decisions took 120 msec longer than when affirmative ($F(1,9)=14.05$, $p<.01$, MSe=246,339).

Negation of the second sentence also had a large effect on mean reaction time: explicitly negative main sentences increased reaction time by 291 msec ($F(1,9)=55.79$, $p<.01$, MSe=364,530). Negating the second sentence had a bigger effect on decision time when the first sentence was affirmative (347 msec) than when negative (235 msc), resulting in a significant S1*S2 interaction ($F(1,9)=6.41$, $p<.05$, MSe=117,909).

Decisions about negative-implicative verbs took 55 msec longer than about implicative verbs ($F(1,9)=8.53$, $p<.05$, MSe=83,162). The verbs within a class differed from each other ($F(6,54)=11.31$, $p<.01$, MSe=70,775): the implicative verbs <u>remembered to</u> (1275 msec) and <u>condescended to</u> (1361 msec; some subjects were not very familiar with this verb), were more difficult to process than <u>managed to</u> (1148 msec) and <u>happened to</u> (1149 msec). The negative-implicative verbs <u>forgot to</u> (1339 msec) and <u>declined</u> (1324 msec) took longer than <u>refused</u> (1245 msec) or <u>neglected</u> (1243 msec).

Other significant factors involving the two verb classes were the S2*V/C interaction ($F(6,54)=2.86$, $p<.05$, MSe=47,404), and the D*V/C interaction ($F(12,118)=2.56$,

$p<.01$, MSe=30,452). Over days, the average reaction time decreased from 1492 msec to 1233 msec to 1057 msec ($F(2,18)=46.22$, $p<.01$, MSe=331,783).

Decision Errors.

The overall error rate was 6.9%. Sentences involving factive verbs produced 7.1% errors, implicative verbs 5.7% and negative-implicative verbs 7.9%. Errors were about twice as frequent for conditions involving an explicitly negative first sentence. (9.4% vs. 4.7% for factives, 8.2% vs. 3.2% for implicatives and 10.2% vs. 5.5% for negative-implicatives). Conditions, where the first and second sentence were explicitly negative showed the highest error rate (11% for factive and negative-implicatives, 12.3% for implicatives).

Discussion

To describe the data a processing model in the tradition of Clark and Chase (1972) is presented and after it is shown that it fails, alternatives are considered. To simplify the discussion, only conditions involving implicative and negative-implicative predicates are considered; sentences with factive predicates are discussed later on.

Representation of first and second sentence.

It is assumed that sentences are encoded in propositional form (Anderson and Bower, 1973; Clark, 1969, 1974; Clark and Chase, 1972; Kintsch, 1974) and that the representation of the affirmative or negative complement sentence (the first sentence) is either true(he paid his tax) or false(he paid his tax).

Furthermore, it is assumed that a person when reading the second sentence extracts its implication and represents it too as either true(he paid his tax) or false(he paid his tax) before entering the comparison stage. The time to derive at the implication depends on whether the second sentence was explicitly affirmative or negative and on whether the predicate belonged to the class of implicative or negative-implicative predicates.

Comparison process and response stage.

Model IA. As in the Clark and Chase (1972) model the assumption is made that the internal representations of the first sentence and the encoded implication of the second sentence are being compared for identity ("principle of congruence", Clark 1969) and that in case of a mismatch an additional operation is required. Since the inner strings for the two representations are always congruent, only the comparison of the outer strings is logically necessary. If

a mismatch occurs between the outer strings it is assumed that a truth index, originally set to "true", is changed to "false" and passed on to the response stage. During the response stage the value of the truth index is executed. The model as outlined is presented in Figure 1

Figure 1 about here

and the prediction it makes are shown in Table 2 (Model IA).

Table 2 about here.

From the conditions involving implicative and negative-implicative predicates, it is possible to derive two independent estimates each for the _n_ and _o_ parameters of the model.

The _n_ parameter is estimated from sentences containing implicative predicates as 220 msec (FN-FA) and 476 msec (TN-TA), and as 349 msec (FA-FN) and 125 msec (TA-TN) from sentences containing negative-implicative predicates.

The estimated values of the _o_ parameter are 207 msec (FA-TA) and -49 msec (FN-TN) from conditions with implicative predicates and -149 msec (FN-TN) and 75 msec (FA-TA) from conditions with negative-implicative predicates.

Since the 95% confidence intervals can be estimated as +92 msec, the notion that these comparisons reflect the same parameters can be rejected. Furthermore, the model does not

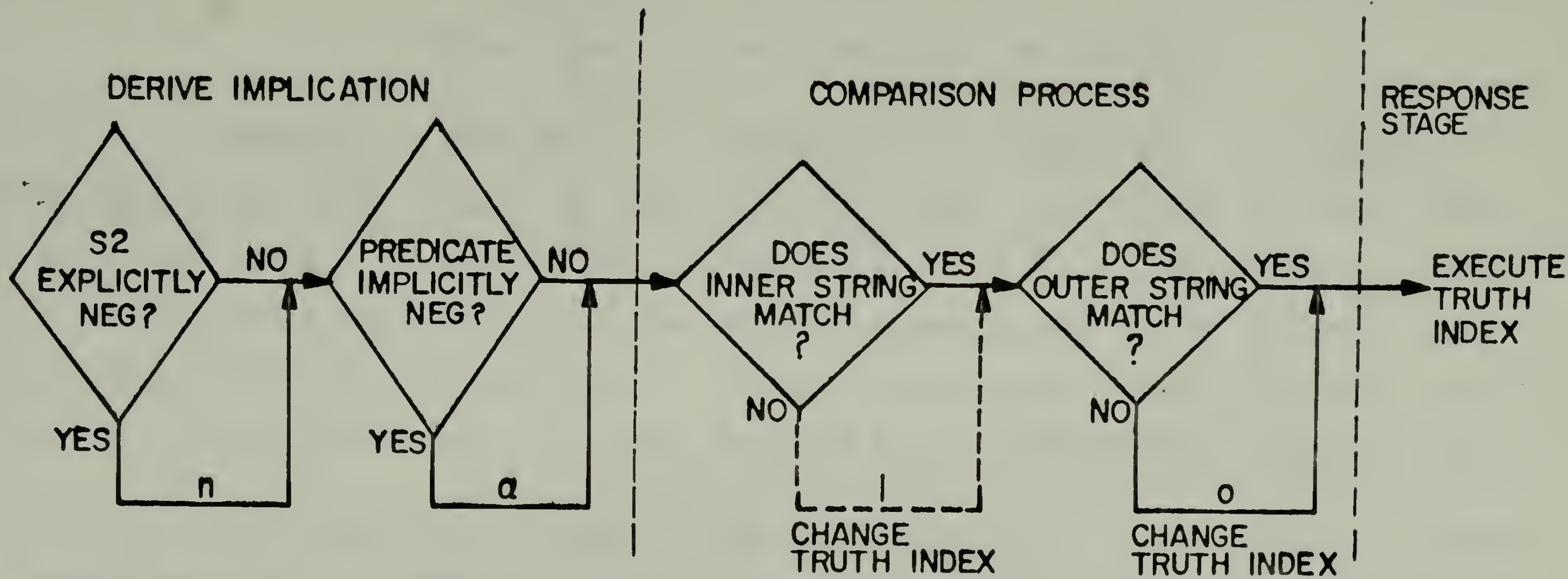


FIGURE 1 FLOWCHART FOR MODEL IA-IC, EXPERIMENT I. TRUTH INDEX SET ORIGINALLY TO "TRUE", FOR MODEL IA AND IB. TRUTH INDEX DETERMINED BY POLARITY OF THE FIRST SENTENCE FOR MODEL IC.

TABLE 2

Different Models and Their Predictions for Experiment I

				MODEL IA		MODEL IB			MODEL IC			MODEL ID			MODEL IE		
S1	S2	DI	RTob	INre	pred	INre	TI	pred	INre	TI	pred	pred	RTpr	D	pred	RTpr	D
A	I+	TA	955	T(X)	K_1	T(T(X))	T	K_1	T(T(X))	T	K_1	K_1	1026	-71	K_1	955	0
A	I-	FN	1382	F(X)	K_1+N+O	F(T(X))	T	K_1+N+O	F(T(X))	T	K_1+N+O	K_1+N_2	1319	63	K_1+N+O	1382	0
N	I+	FA	1162	T(X)	K_1+O	T(T(X))	T	K_1+O	T(T(X))	F	K_1+i+O	K_1+N_1	1146	16	K_1+O+I	1162	0
N	I-	TN	1431	F(X)	K_1+N	F(T(X))	T	K_1+N	F(T(X))	F	K_1+N+i	$K_1+N_1+N_2$	1439	-8	K_1+N+I	1431	0
A	NI+	FN	1092	F(X)	K_2+O	T(F(X))	T	K_3	T(F(X))	T	K_2+i	K_2	1079	13	K_2+O	1094	-2
A	NI-	TA	1366	T(X)	K_2+N	F(F(X)	T	K_3+N+O	F(F(X))	T	$K_2+N+i+O$	K_2+N_2	1372	-6	K_2+N	1363	3
N	NI+	TN	1241	F(X)	K_2	T(F(X))	T	K_3+O	T(F(X))	F	K_2+O	K_2+N_1	1199	42	K_2+I	1143	98
N	NI-	FA	1441	T(X)	K_2+N+O	F(F(X))	T	K_3+N	F(F(X))	F	K_2+N	$K_2+N_1+N_2$	1492	-51	$K_2+N+O+I$	1570	-129

MODEL IA: $K_2=K_1+\alpha$, RMSD=72, r^2=.67

MODEL IB: S1aff=T(T(X)), S1neg=F(T(X)), $K_3=K_1+\alpha+i$, RMSD=67, r^2=.71

MODEL IC: S1aff=T(X), S1neg=F(X), $K_2=K_1+\alpha$, RMSD=67, r^2=.62

MODEL ID: K_1=1026, $K_2=K_1+\alpha$, α=53, N_1=120, N_2=293, RMSD=42, r^2=.89

MODEL IE: K_1=955, $K_2=K_1+\alpha$, α=60, N=348, O=79, I=128

predict a S1 main effect, which was significant at the .01 level.

Alternative Models.

Why does the previous model fail? The theory of sentence verification distinguishes at least three separate stages (encoding, comparison and response stage) and the assumptions underlying each one of them could have been violated in the present task. For example, it was assumed that the implication for both the sentences He didn't remember to pay his tax and He forgot to pay his tax is It is false that he paid his tax and is encoded as false(he paid his tax). However, as suggested earlier, forgot may not be equal to not remember and this may be reflected in the encoded implication. The implication of the sentence He didn't remember to pay his tax might take the form It is false that it is true that he paid his tax and be internally represented as false(true(he paid his tax)), while the sentence He forgot to pay his tax might lead to It is true that it is false that he paid his tax and is represented as true(false(he paid his tax)).

Second, the processes during the comparison stage may be different from the ones assumed and third, the response stage might be more complex than assumed. One major difference between our task and the sentence-picture verifica-

tion task is the separation in time between the two elements (S1 and S2) which are to be compared. It is conceivable that this change in procedure could have changed the response bias of the subject. In the Clark and Chase model a positive response bias is assumed, which is reflected in the original setting of the truth index to "true". In our task however, the encoding of the first sentence might have influenced the response bias of the subject, resulting in setting the truth index originally as either positive or negative, depending on whether the first sentence was either explicitly affirmative or negative.

Furthermore, it is conceivable that the encoding and comparison stages are not two separate stages, that the subject does not derive the implication of the second sentence before comparing it to the first sentence, but rather that he computes the right answer from the surface structure of the second sentence. I will consider next some of these alternatives in order to restrict the range of plausible theories.

For comparing different models with each other, a statistic is needed which gives a value of the goodness of fit of a given model to the data. The root mean square deviation (RMSD) is such a statistic. However, this measure does not take into account the different degrees of freedom associated with each possible model. Therefore a form of r^2, suggested by Reed (e.g. 1976) will be used too.

$$r^2 = 1 - \frac{\sum_{j=1}^{m} (\hat{x}_j - x_j)^2/(m-k)}{\sum_{j=1}^{m} (x_j - \bar{x})^2/(m-1)}$$

where x_j are the m empirical measurements of the dependent variable, and $\hat{x}_j$ are the corresponding model predictions using the k fitted parameters.

Model IB. As a first alternative consider an internal representation which preserves the affirmative-negative characteristics (implicitly or explicitly) of the sentence components. The sentence He didn't forget to pay his tax is now assumed to be internally represented as false(false(he paid his tax)). The first sentence is assumed to be encoded as either true(true(he paid his tax)) when affirmative, or as false(true(he paid his tax)) when negative. The truth index is assumed to be set at "true" originally. The predictions can be derived by using the flowchart of Figure 1 and are shown in Table 2, Model IB.

The model fails in several ways. For example, it cannot predict the observed S1 main effect.

Model IC. Adding the assumption that encoding the first sentence determines the original setting of the truth index leads to the next model. However, in order to arrive at the correct decision outcomes it has to be assumed that the internal representation of the first sentence is again either true(he paid his tax) or false(he paid his tax) and

that both inner and outer string of the internal representation of the second sentence are compared against the outer string of the first sentence. Consider the case where the first sentence presented is He paid his tax. The subject encodes the sentence as true(he paid his tax) and sets his original truth index accordingly. Assume further that the main sentence presented is He didn't forget to pay his tax, which the subject encodes as false(false(he paid his tax)). This adds time n for the explicit negation (didn't) and time α for the implicit negation (forget) to the encoding time. The subject then compares the inner string of the second sentence (false) to the value of the first sentence (true). He obtains a mismatch and therefore changes the truth index from "true" to "false" which adds time i to the comparison stage. Next he compares the outer string of the second sentence (false) to the value of the first sentence (true) which again results in a mismatch and in a change of the truth index (now from "false" to "true"), adding time o to the comparison process. The predictions are shown in Table 2, Model IC. The flowchart is still that of Figure 1.

Although the model can predict the mean reaction times for the four conditions involving implicative predicates, it does badly for the conditions involving negative-implicative predicates. The model as outlined would predict no overall S1 main effect, but a C*S1 interaction instead, which is

contrary to the obtained data. (C*S1: F(1,9)= .28, MSe=79,749).

Model ID. The models outlined so far all assumed that the subject first forms an internal representation of the logical implication before comparing its truth value to that of the encoded first sentence. A different strategy seems possible: the subject, while reading the second sentence, determines that its components are either affirmative or negative, changing the truth index each time he encounters a negative part. He then retrieves the truth value of the first sentence and if it is negative he once more changes the current value of the truth index. The final value of the truth index is then executed. The model is outlined in Figure 2.

Figure 2 about here.

Now the parameters n_2 and α reflect two distinct operations each: the extra time for reading and encoding negative sentence parts (explicitly or implicitly) and the performing of a mental operation. The predictions the model makes as well as the differences between observed and predicted mean reaction times (least square criterion) are shown in Table 2, Model ID.

Although the model is capable of predicting the correct ordering of the mean reaction times for the different condi-

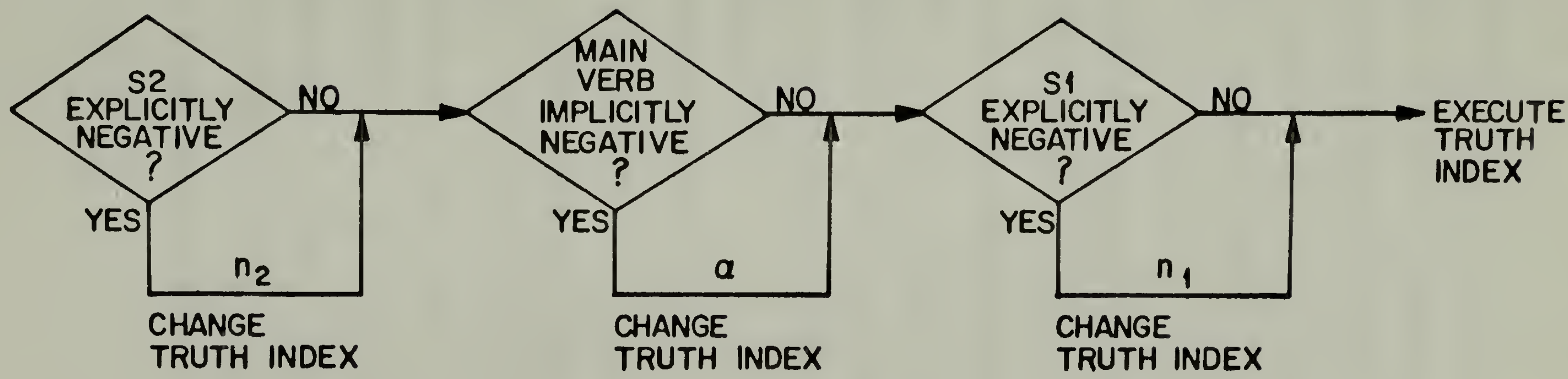


FIGURE 2 FLOWCHART FOR MODEL ID, EXPERIMENT I. TRUTH INDEX SET ORIGINALLY TO "TRUE".

tions (it correctly predicts the S1, S2 and C main-effects, but does not predict the obtained S1*S2 interaction), the RMSD is still quite large (42 msec). The model which requires only 4 parameters has a computed $r^2 = .89$.

<u>Model IE</u>. So far I have shown that models which assume that in a first stage the implication of the sentence is derived and encoded before the comparison stage is entered cannot account for the obtained data, while the last model, which assumes that the subject operates directly on the main sentence, can at least predict the correct ordering of the different conditions. But is it therefore possible to conclude that in the present experiment subjects do not first derive the implication?

In discussing the first model it was assumed that the response stage consisted of executing the value of the derived truth index. However, this may have been an oversimplification. How easy it is to execute the response may depend on whether the extracted implication is consistent with the response to be executed. By adding an incompatibility parameter <u>I</u> to the conditions where the truth value of the implication is incongruent with the response to be executed, one can derive Model IE, Table 3, whose flowchart is given in Figure 3.

Figure 3 about here.

By fitting the model only to the data of the four conditions involving implicative predicates one obtains a perfect fit, but the same parameter values do not do as well in fitting the conditions involving negative implicative predicates.

The case where the model fails involves the two conditions where the first sentence is explicitly negative and the predicate of the second sentence implicitly negative. It is possible that under these conditions the subject sometimes recoded the predicate of the second sentence before entering the comparison stage (_forget_ into _not remember_ and _didn't forget_ into _remember_). This would increase the predicted reaction time for the condition involving _forget_ and decrease the predicted reaction time for _didn't forget_, thereby resulting in a better overall fit. (e.g. Wason 1961, who found evidence for recoding of explicit negatives. His subjects reported to convert expressions like _Six is not odd_ into _Six is even_).

The revised model can on the surface also account for the overall data involving factive predicates, if one allows the _n_ parameter to take on a smaller value. The _n_ parameter reflects the extra reading and encoding time for explicit negative second sentences. The negative version of _remember_

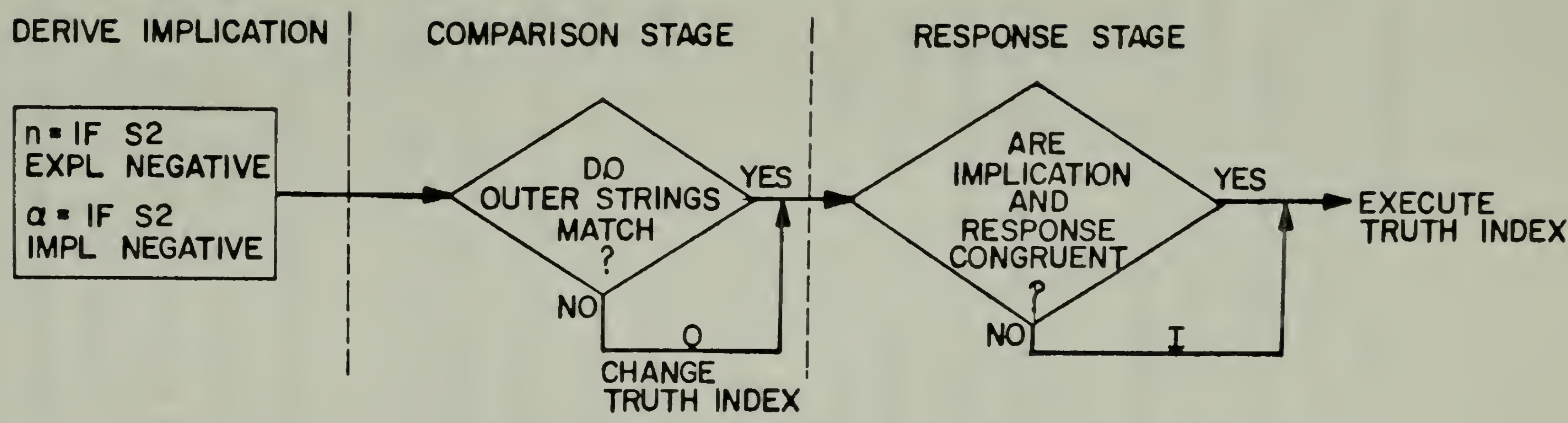


FIGURE 3 FLOWCHART FOR MODEL IE, EXPERIMENT I.

that and forget that is didn't remember that and didn't forget that, while the negative of was glad that and was sorry that is wasn't glad that and wasn't sorry that. Presumably the reading and encoding time of negatives might be larger for the first pair of sentences than for the second. This would result in a lower n value when averaged over all four predicates as compared to sentences with implicative and negative-implicative predicates where negation is always formed with to do. The observed and predicted data for factive predicates are shown in Table 3.

Table 3 about here.

However, the data did not confirm this. While it is true that the negation time of remember that (395 msec) is much larger than the negation time of was happy that (211 msec), it is about the same for the two implicitly negative verbs forget that and was sorry that (29 msec and 23 msec respectively).

In developing the last model several ad hoc assumptions were made in order to obtain a reasonable fit to the data. Especially the introduction of the incompatibility factor I requires further justification. There is evidence from the comparative judgement literature (e.g. Marks, 1972) that when the stimulus and the judgement to be made are compatible, subjects respond faster than when not. For ex-

TABLE 3

Observed and Predicted Decision Times for Factive Predicates, Mode IE, Experiment I

S1	S2	D	I	MODEL	RTobs	RTpred	D
A	F+	T	A	$RT=K_3$	1161	1157	4
A	F-	T	A	$RT=K_3+N'$	1322	1321	1
N	F+	F	A	$RT=K_3+O+I$	1359	1364	-5
N	F-	F	A	$RT=K_3+N'+O+I$	1527	1528	-1

$K_3 = 1157$

$N' = 164$

$O = 79$

$I = 128$

ample, subjects discriminate more rapidly between preferred colors when asked to chose the more pleasant color. On the other hand discriminations are more rapid between unpreferred colors when the task is to choose the less pleasant color (Shipley, Coffin, and Hadsell, 1945; Shipley, Norris, and Roberts, 1946). In the linguistic realm Clark (1969) demonstrated that solutions to two- and three-term series problems take less time when the information to be searched and the question to be answered are congruent in their base strings than when they are incongruent.

The next two experiments attempted to measure the presence of an I-factor directly. The propositional forms presumably being compared under Model IE were made external to the subject. It was assumed that these forms are very close to the surface forms of complement sentences or to simple sentences in general. Therefore, only simple sentences were presented to the subjects for identity judgements. The two successively presented complement sentences could either be both affirmative (AA), both negative (NN), or one of them affirmative and the other negative (AN or NA). The subject responded "yes" when both sentences had the same form, but "no" when they did not. If an incompatibility factor is operating under these conditions than mean reaction time should be faster when the response is congruent with the polarity of the second sentence (AA and

AN conditions) than when not (NN and NA conditions), which will show up in the experiment as a S1 polarity effect.

EXPERIMENT II

Method.

Subjects. The subjects were 10 paid students, who had not participated in the first experiment.

Apparatus. The experimental setup was the same as in Experiment I; however, a response panel with only two response buttons was used.

Procedure. Each trial started with a 2 sec. blank interval, followed by the stimulus sentence. The subject saw one of the four complements used in Experiment I, either as an affirmative or as an explicitly negative sentence. The sentence stayed on the screen for 2 sec. After a 250 msec delay interval, the probe sentence appeared on the screen and stayed there until the subject responded. The probe sentence was the same complement as the stimulus sentence, either in its affirmative or negative form. The subject responded "yes" if the stimulus and probe sentence were either both affirmative (AA) or both negative (NN) and "no" if one of them was affirmative and the other negative (AN, NA).

Results

Reaction Times. The overall reaction times for the four different conditions were as follows: AA=553 msec,

AN=576 msec, NN=647 msec and NA= 710 msec. An analysis of variance was performed with S1 (first sentence affirmative or negative), S2 (second sentence affirmative or negative), C (the four different complements of Experiment I) and S (subjects) as factors. The main effect of negation on the first sentence ((AA+AN) vs. (NA+NN)) was significant, affirmative sentences were 114 msec faster than negatives (F(1,9)=66.6, p<.01, MSe=7,808). However, with respect to the second sentence ((AA+NA) vs. (AN+NN)), decisions about explicitly negative sentences were 20 msec faster than about affirmative sentences (F(1,9)=3.8, p<.10, MSe=4,114). Given that the first sentence was affirmative, "yes" decisions were 23 msec faster than "no" decisions. When the first sentence was negative "no" decisions were faster than "yes" decisions (63 msec). This resulted in a significant S1*S2 interaction (F(1,9)=7.7, p<.05, MSe=9,636). The C-factor and all the interactions involving C were not significant.

Discussion

The response bias part of model IE predicted that the average of the NA+NN condition should exceed the average of the AA+AN condition by the value of the I parameter. The obtained value is 114 msec, close to the value of 128 msec estimated in Experiment I.

However, decisions on negative second sentences were actually faster than on affirmative second sentences, which leads one to believe that subjects might have used special strategies which were not operating in Experiment I. One weakness in the design of Experiment II was the way the sentences were displayed on the screen. Both sentences were displayed at the same physical location on the video screen. This may have resulted in subjects not actually encoding and comparing the two sentences but in using some kind of perceptual strategy instead.

Therefore, Experiment II was repeated and two changes were made: First, the second sentence was displaced towards the right hand corner of the video display away from the first sentence (2 cm to the right and 1.5 cm down) and second, the inter-stimulus interval was lengthened (from 250 msec to 550 msec).

EXPERIMENT III

Method.

Subjects. The subjects were 8 paid students, who had not participated in any of the other experiments.

Apparatus. The same experimental setup as in Experiment II was used.

Procedure. The procedure was the same as in Experiment II with two exceptions. The delay interval between offset of the first sentence and onset of the second sentence was lengthened to 550 msec and furthermore the second sentence was displayed 2 cm to the right and 1.5 cm down with respect to the first sentence.

Results

Reaction Times. Although the overall reaction times were faster, the order of the reaction times for the different conditions was the same as before: $AA<AN<NN<NA$.

The mean reaction times for the different conditions were as follows: AA = 530 msec, AN = 533 msec, NN = 553 msec and NA = 596 msec. The analysis of variance showed a main effect of negation of the first sentence: affirmative sentences were 43 msec faster than negative ones. ($F(1,7)=13.1$, $p<.01$, $MSe=4,434$). However, as in Experiment II, decisions on negative second sentences were 20 msec

faster than on affirmative sentences. This difference again was only marginally significant ($F(1,7)=4.6$, $p\sim.075$, $MSe=2,885$). As in Experiment II "no" decisions were faster (43 msec) than "yes" decisions given the first sentence was negative. However, given the first sentence was affirmative, "yes"and "no" decisions did not differ from each other. The S1*S2 interaction did not approach significance ($F(1,7)=1.8$, $p\sim.20$, $MSe=9,038$) and neither did the C-factor or any of the interactions involving C.

The results of Experiment III were qualitatively quite similar to those of Experiment II. However, the size of the estimated *I* parameter dropped from 114 msec in the last experiment to 43 msec, while decisions on negative second sentences were again 20 msec faster than on affirmative sentences.

Although the combined results of Experiment II and III (instability of the size of the *I* parameter, decisions on negative sentences faster than on affirmative sentences) do not exclude the possibility of an incompatibility factor, they do not seem strong enough to justify by themselves the introduction of additional response bias into Model IE, in

order to explain the data of Experiment I.

Discussion

Just and Clark's (1973) experiments did not answer conclusively what exact representations people are using and how they arrive at them when trying to answer a question about the implication or presupposition of a sentence. In discussing the results of Experiment I several underlying representations were proposed and several processing models considered. Although the results were not conclusive, they did point in a certain direction. Simple models, which assume that a person first extracts the presupposition or implication and then compares the result to the complement sentence (MODEL IA, IB, IC), proved to be inadequate. A computation model (Model ID) needing only 4 parameters, which assumed that the subject operates directly on the affirmative or negative components of the main sentence, did at least as well.

However, as outlined in part two of my Plan of Investigation it seems possible to address the original question in a different way. If the implication and presupposition is indeed extracted at initial comprehension, then decision times to subsequent probe sentences should no longer show differences due to main verb, class of verb etc. If the implication or presupposition is not extracted during

comprehension, it is still conceivable that a person does so just prior to the comparison stage, but it seems more likely that he uses other mechanisms in order to arrive at the right decision. The next experiment presents the main sentence first, followed by the probe sentence.

EXPERIMENT IV

Method

Subjects. Eight students, none of whom participated in any of the earlier experiments, served as paid subjects for 3 daily sessions.

Design and Procedure. The design and procedure of Experiment IV were identical to those of Experiment I. However, instead of presenting the complement sentence first and the main sentence second, the order of presentation was reversed. On a given trial a subject may first see the sentence *He didn't forget to pay his tax* followed by the complement sentence *He didn't pay his tax*, which would require the response "false" of the subject. As in Experiment I, inspection time for the first sentence and decision time for the second sentence were recorded.

Results

Inspection Times.

The mean inspection times for each condition are shown in Table 4.

Table 4 about here

Class of factive verbs. The implicitly negative verbs *forgot that* and *was sorry that* were inspected 125 msec

TABLE 4

Inspection Times For Each Sentence For Experiment IV

S1 Sentence

forgot		was sorry		remembered		was happy		FACTIVES	
aff	neg	aff	neg	aff	neg	aff	neg	aff	neg
1562	1780	1602	1717	1489	1540	1465	1674	1529	1678

remembered		condescended		managed		happened		IMPLIC.	
1428	1744	1483	1834	1325	1753	1430	1642	1417	1743

forgot		refused		declined		neglected		NEG-IMPL.	
1431	1788	1374	1794	1451	1775	1445	1825	1425	1796

longer than the implicitly affirmative verbs <u>remembered that</u> and <u>was happy that</u>, although the overall verb factor was only marginally significant ($F(3,21)=2.96$, $p \sim .06$, $MSe=183,467$).

If the main sentence was explicitly negative it was viewed 149 msec longer than when affirmative (1678 msec vs. 1529 msec, $F(1,7)=4.49$, $p \sim .08$, $MSe=474,299$).

Overall an average time of 1603 msec was spent to examine sentences containing factive predicates. The inspection time diminished from 1884 msec on day 1 to 1460 msec on day 2 and stayed on that level on day 3 ($F(2,14)=13.95$, $p<.01$, $MSe=543,672$).

<u>Class of implicative and negative-implicative verbs.</u> Negative-implicative verbs were studied 30 msec longer than implicative verbs (1610 msec vs. 1580 msec, $F(1,7)=12.07$, $p<.05$, $MSe=14,754$). However, the different verbs within each class did not differ from each other ($F(6,42)=1.94$, $p \sim .10$, $MSe=91,878$).

Sentences containing an explicit negative were viewed 348 msec longer than affirmative sentences ($F(1,7)=18.08$, $p<.01$, $MSe=1,289,935$). This difference was 326 msec for implicative verbs and 371 msec for negative-implicative verbs. However, the C*S1 interaction was unreliable ($F(1,7)=.82$, $MSe=110,426$).

As for factive verbs, inspection time decreased with days, from 1810 msec on day 1 to 1507 msec on day 2 to 1469 msec on day 3 ($F(2,14)=9.52$, $p<.01$, MSe=938,565).

Decision Times.

The mean decision times for each condition, as well as the average over verbs for each verb class, are shown in Table 5.

Table 5 about here

The standard errors for the decision times estimated from the error-terms of the S1*S2*V and S1*S2*V/C interactions were 17 msec and 16 msec for the conditions involving factive verbs and implicative/negative-implicative verbs respectively.

Class of factive verbs. The polarity of the complement sentence (affirmative or negative) was highly significant ($F(1,7)=13.83$, $p<.01$, MSe=126,719). However, for factive verbs this comparison is confounded with the true-false difference: mean reaction time was 135 msec slower for negative complement sentences (the subject responded "false") than for affirmative complement sentences (the subject responded "true"). The true-false difference changed over days ($F(2,14)=6.36$, $p<.05$, MSe=32,010). The difference dropped from 225 msec on day 1, to 73 msec on day 2 and increased slightly on day 3 to 106 msec.

TABLE 5

Decision Times For Experiment IV

S1 Sentence

		forgot		was sorry		remembered		was happy		FACTIVES	
		aff	neg	aff	neg	aff	neg	aff	neg	aff	neg
S2	aff	510	515	518	489	492	532	471	503	498	510
	neg	647	666	685	610	593	650	621	638	637	641
		remembered		condescended		managed		happened		IMPLIC.	
S2	aff	529	727	493	698	509	679	486	696	504	700
	neg	640	696	630	698	603	659	614	667	622	680
		forgot		refused		declined		neglected		NEG-IMPL.	
S2	aff	740	542	676	535	676	531	672	528	691	534
	neg	740	674	700	692	668	692	692	638	700	674

The verb factor (V) was significant ($F(3,21)=3.19$, $p<.05$, $MSe=3{,}891$). Sentences involving implicitly negative verbs took longer than those with positive verbs: *forgot that* was slower than *remembered that* (585 vs. 567 msec) and *was sorry that* was slower than *was happy that* (576 vs. 558 msec). The verb factor interacted with the polarity of the main sentence. Decisions about conditions containing implicitly affirmative predicates took 36 msec longer when the first sentence was explicitly negative than when affirmative, while for implicitly negative predicates this relationship was reversed.(Decisions on explicitly negative first sentences were 20 msec faster than on affirmative ones.) ($F(3,21)=2.61$, $p\sim.08$, $MSe=16{,}866$).

Class of implicative/negative-implicative verbs. Decisions involving negative-implicative predicates took 23 msec longer than decisions involving implicative predicates. However, this difference was only marginally reliable ($F(1,7=4.25$, $p\sim.09$, $MSe=24{,}418$). Verbs within a class also differed marginally from each other ($F(6,42)=2.04$, $p\sim.09$, $MSe=13{,}437$).

The polarity of the main sentence did not matter ($F(1,7)=2.83$, $p>.10$, $MSe=21{,}703$). However, there was a reliable C*S1 interaction ($F(1,7)=24.17$, $p<.01$, $MSe=94{,}629$): decisions involving implicative verbs were easier when presented within an affirmative main sentence than within an

explicitly negative main sentence (the difference was 127 msec), while the opposite was true for decisions involving negative-implicative verbs (decisions on explicitly negative main sentences were 91 msec faster than on affirmative sentences). The average difference between an affirmative and negative main sentence dropped from 147 msec on day 1, to 98 msec on day 2, to 29 msec on day 3 for negative-implicative verbs, while for implicative verbs the difference between negative and affirmative main sentence increased on day 2 from 109 msec to 171 msec and was about the same on day 3 as on day 1 (102 msec). ($F(2,14)=4.0$, $p<.05$, $MSe=22{,}999$).

Decisions involving negative complement sentences took 62 msec longer than their positive counterparts. However, this difference which reflects the encoding time of a negative complement sentence and is not confounded by the true-false difference was only marginally reliable ($F(1,7)=5.12$, $p\sim.06$, $MSe=143{,}229$).

The true-false difference is reflected in the S1*S2*C triple-interaction ($F(1,7)=9.52$, $p<.05$, $MSe=87{,}207$). True decisions were 138 msec faster than false decisions for implicative verbs and 131 msec faster for negative-implicative verbs. The true-false difference changed over days, resulting in a reliable 4-way interaction ($F(2,14)=4.66$, $p<.05$, $MSe=6{,}734$). This interaction was due to the fact that the true-false difference was larger on day 1 for im-

plicative verbs (by 57 msec), while on day 2 and 3 the true-false difference was bigger for the negative-implicative verbs by 29 and 21 msec respectively.

Decision Errors.

The overall error rate was 3.2%. It amounted to 1.9% for sentences involving factive verbs, 3.2% for those with implicative verbs, and 4.5% for those with negative-implicative verbs. Error-rates were higher for conditions involving negative complement sentences for all three verb classes (2.6 vs. 1.2% for factives, 4.0 vs. 2.5% for implicatives and 5.7 vs. 3.4% for negative-implicatives). For factive and implicative predicates, explicitly negative main sentences had a higher error rate than affirmative sentences, 2.2 vs. 1.7% and 5.2 vs. 1.2% respectively, while for negative-implicative predicates, explicitly negative sentences had a lower error rate than affirmative sentences (3.5 vs. 5.6%).

Discussion

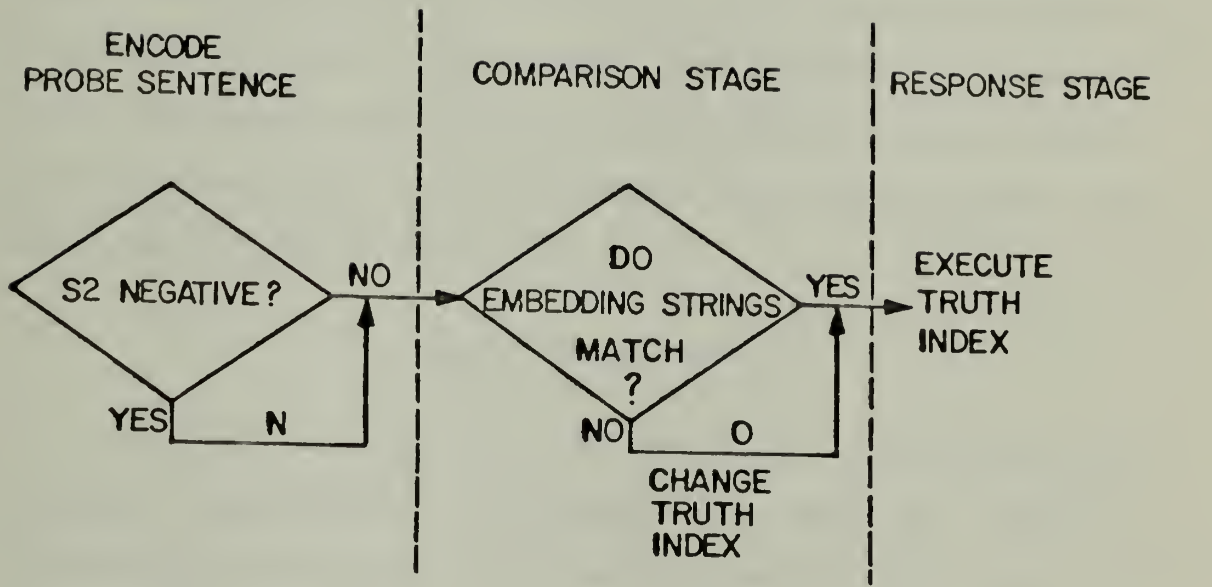
As with Experiment I, I will first assume that the subject has extracted the correct implication and has it available for comparison purposes. After showing that this is insufficient to explain the data I will consider again the situation under additional response bias. Also, I will

consider an alternative model and finally propose a model which is able to account for the main results of Experiment IV by assuming that the subject operates on the encoded representation of the main sentence.

Direct Representation Model.

The direct representation model assumes that the subject encodes the presupposition of the first sentence as always *true*(*he paid his tax*) and the implication as either *true*(*he paid his tax*) or *false*(*he paid his tax*) depending on whether the first sentence represented an affirmative or negative implication. As a second step he encodes the probe sentence *He paid his tax* as *true*(*he paid his tax*) and *He didn't pay his tax* as *false*(*he paid his tax*). Furthermore, it is assumed that encoding the negative probe sentence takes additional time *N*. During the comparison stage the subject compares the embedding strings of the encoded presupposition or implication with the embedding string of the encoded probe sentence. If a mismatch occurs a truth index (originally set at "true") is set to "false" and the value of the truth index is then executed during the response stage. A flowchart representing this model is given in Figure 4.

Figure 4 about here



$$\overline{RT} = K + (N) + (O)$$

FIGURE 4 THE DIRECT REPRESENTATION MODEL, EXPERIMENT IV
TRUTH INDEX SET ORIGINALLY TO "TRUE."

For sentences involving implicative as well as negative-implicative predicates the model predicts, since the embedded strings always match, that false-affirmatives (FA) should take longer than either false-negatives (FN) or true-negatives (TN). Furthermore, the increase in decision time with respect to the N and O parameters should be additive (FA=FN+TN-TA). The predictions the model makes are outlined in Table 6, Model IA.

Table 6 about here

The model clearly fails: FA decisions on sentences containing implicative predicates as well as negative-implicative predicates were actually faster than the corresponding FN or TN conditions. The major shortcoming of the model is its inability to predict the obtained C*S1 interaction. For comparison purposes, the model nevertheless was fitted to the data. The resulting RMSD was large (RMSD=56.2 msec) and the value of r^2 quite low (r^2=.36).

Alternative Model.

Logically it seems possible that the subject not only derives the implication of the first sentence but in addition also sets his truth index to either "true" or "false", depending on whether the implication was affirmative or negative. Then in order to arrive at the correct answer all

TABLE 6

Different Models and Their Predictions for Experiment IV

S1	S2	DI	RTob	MODEL IA	RTpr	D	ITI	MODEL IB	MODEL IC	RTpr	D
F+	A	TA	498	RT=K	550	-52	T	RT=K	RT=K	512	-12
F-	A	TA	510	RT=K	550	-40	T	RT=K	RT=K	512	-2
F+	N	FA	637	RT=K+N+O	682	-45	T	RT=K+N	RT=K+N+O	643	-6
F-	N	FA	641	RT=K+N+O	682	-41	T	RT=K+N	RT=K+N+O	643	-2
I+	A	TA	504	RT=K	550	-46	T	RT=K	RT=K	512	-8
I-	A	FN	700	RT=K+O	619	81	F	RT=K	RT=K+O+I	695	5
I+	N	FA	622	RT=K+N+O	682	-60	T	RT=K+N	RT=K+N+O	643	-21
I-	N	TN	680	RT=K+N	613	67	F	RT=K+N	RT=K+N+I	690	-10
NI+	A	FN	691	RT=K+O	619	72	F	RT=K	RT=K+O+I	695	-4
NI-	A	TA	534	RT=K	550	-16	T	RT=K	RT=K	512	22
NI+	N	TN	700	RT=K+N	613	87	F	RT=K+N	RT=K+N+I	690	10
NI-	N	FA	674	RT=K+N+O	682	-8	T	RT=K+N	RT=K+N+O	643	31
				K=550 N=63 O=69	RSMD=56.2 r^2=.36	K=573 N=86		RSMD=65 r^2=.24	K=512 N=63 O=68	RSMD=14.2 r^2=.95	

that is logically necessary is to encode the probe sentence and change the truth index to the opposite if the second sentence was negated. However, as in Experiment I, there is no evidence that such a process exists. A flowchart outlining this model is given in Figure 5

Figure 5 about here

and the derived predictions are shown in Table 6, Model IB.

<u>Response Bias Model</u>.

However, before discarding the direct representation model, I will again introduce additional response bias into the model, analogous to Experiment I. The direct representation model fails mainly because it underpredicts mean reaction times for the FA and TN conditions. Those are both conditions where the subject is required to make a response which is inconsistent with the polarity of the probe sentence. He has either to answer "false", when the polarity of the probe sentence is affirmative, or "true" when it is negative. Therefore, by assuming that in the response stage additional response bias is operating, it seems possible to save the direct representation model. The assumption is made that if the response to be made (yes-no) is consistent with the value of the probe sentence (affirmative-negative) it is much easier for the subject to execute his response, then

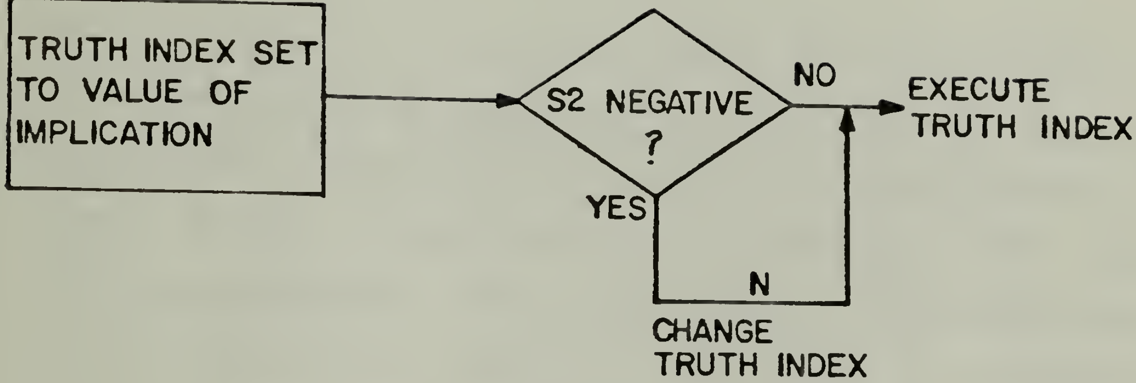


FIGURE 5 AN ALTERNATIVE MODEL, EXPERIMENT IV

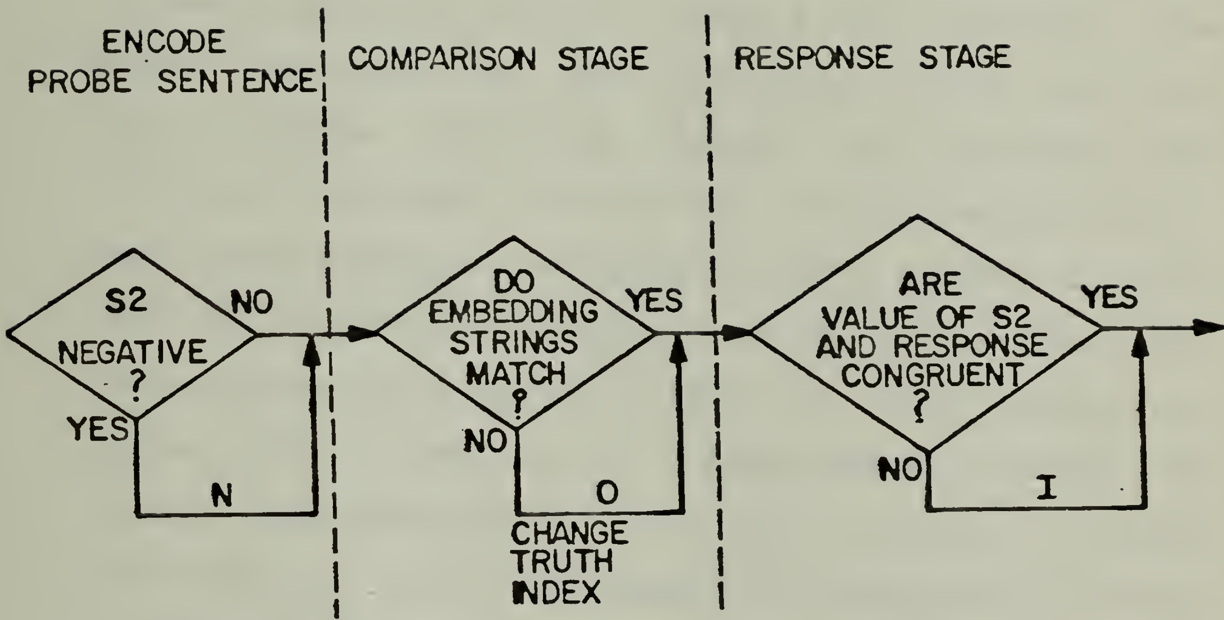
when not. This adds an inconsistency parameter I to the direct representation model for the FA and TN conditions. The response bias model is outlined in Figure 6

Figure 6 about here

and the predictions it makes are shown in Table 6, Model IC.

The model which requires only 4 parameters for the 12 data points provides overall a good fit (RMSD=14.2 msec, r^2 = .95). However, several aspects of the response bias model are unsatisfactory. The assumption of a truth index which is initially set to "true" is equivalent to introducing response bias into the model. It seems therefore somewhat excessive to postulate additional response bias for only a few conditions. Although the value of I was positive in Experiment II and III, other aspects make these experiments suspect. For example, while in Experiment IV decisions on negative second sentences were on the average 62 msec slower than decisions on affirmative sentences (for implicative and negative-implicative predicates), this relationship was reversed in Experiment II and III (difference 20 msec in the opposite direction).

The most serious challenge to the response bias model, however, comes from results of the analysis of variance. The analysis for factive predicates showed that the verb factor was significant, while the analysis for implicative



$$\overline{RT} = K + (N) + (O) + (I)$$

FIGURE 6 THE RESPONSE BIAS MODEL, EXPERIMENT IV, MODEL IC. TRUTH INDEX SET ORIGINALLY TO "TRUE".

and negative-implicative predicates showed marginal significance for the two verb classes. Since the direct representation model clearly predicts that decision time should not depend on the original form of the first sentence, a further analysis of variance was performed with subjects (S), class of verbs (C; factive, implicative and negative-implicative predicates) and verbs within a class (V/C) as factors. In order to be able to generalize over both subjects and predicates, S and V/C were regarded as random effect variables, C a fixed effect variable. The results, contradictory to all models assuming a direct representation of the implication or presupposition, showed significant effects of both the C factor (Quasi $F(2,27)=8.43$, $p<.01$, $MSe=6,164$) and the V/C factor ($F(9,63)=2.19$, $p<.05$, $MSe=855$).

One aspect of the data that the direct representation model was unable to account for was the finding that decisions on implicitly affirmative factive predicates (remembered that, was happy that) differed from those on implicitly negative ones (forgot that, was sorry that). A model which takes these differences into account will be proposed next.

The Computation model.

The model is outlined in Figure 7. It assumes that the subject encodes the second sentence, taking additional

Figure 7 about here

time N for negative second sentences. He then goes through a series of operations on his internal representation of the first sentence before executing his response. In a first step, the number of negation markers (both explicit and implicit) is evaluated. If the result is greater than one, they are combined to an affirmative value, taking additional time α. Then the sentence is checked for the remaining negation marker, if present. For sentences containing a that-complementizer the negation marker is dropped (adding time β), while for sentences with a to-complementizer the subject changes the value of the complement sentence in the presence of a negation marker (adding time S). Then in a last step, the polarity of the probe sentence (S2) is compared to the polarity of the complement. If the two match, the subject responds "true", if not he responds "false".

The predictions this model makes are shown in Table 7,

Table 7 about here

together with the observed and predicted reaction times for each condition. (The conditions for factive predicates are

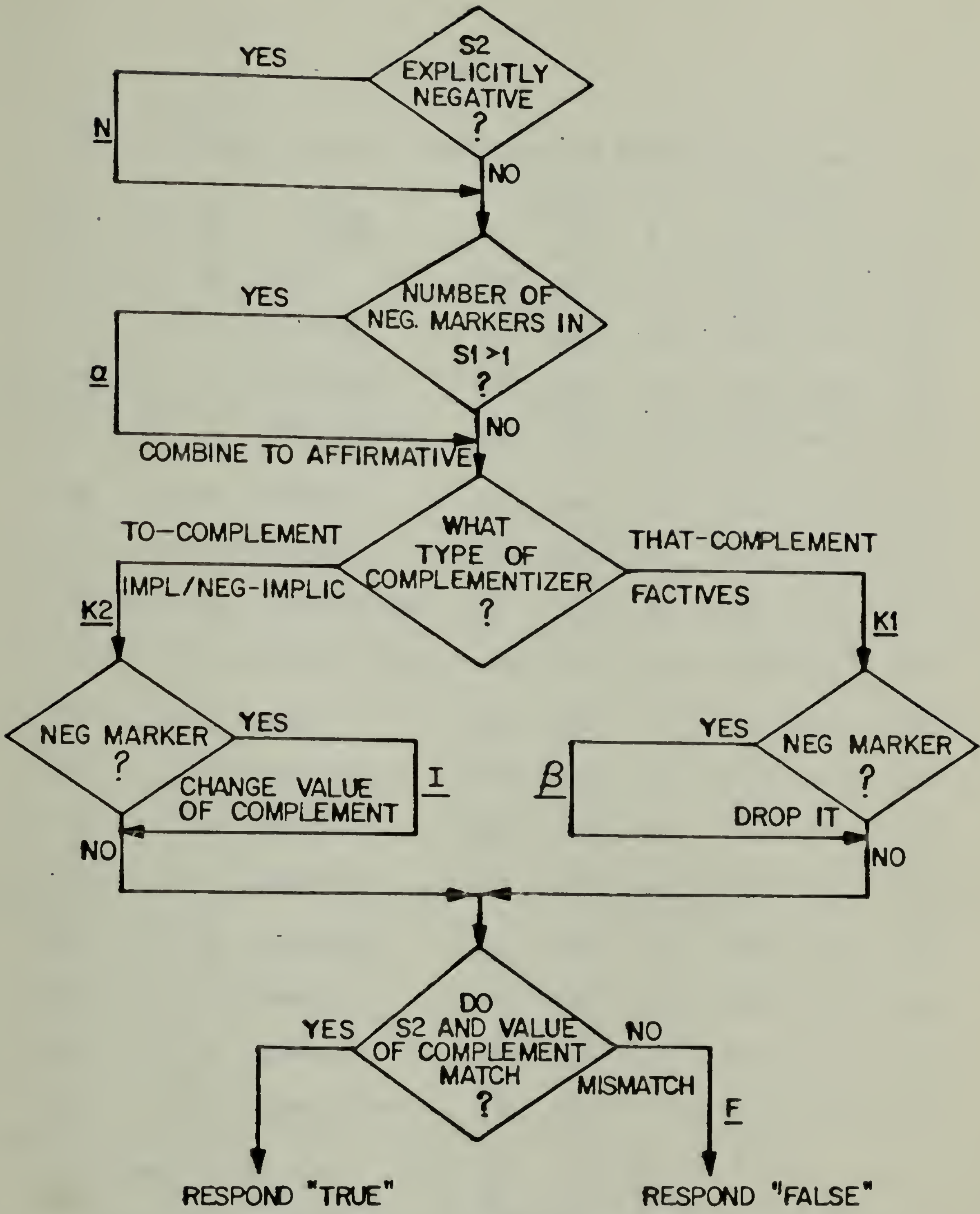


FIGURE 7 THE COMPUTATION MODEL

TABLE 7

Computation Model, Data and Predictions For Experiments IV and V

S1	S2	DI	MODEL	EXP IV O	EXP IV P	EXP IV D	EXP V O	EXP V P	EXP V D
F+	A	TA	RT=K1	481	475	6	654	638	16
F-	A	TA	RT=K1+β	516	520	-4	694	704	-10
F+	N	FA	RT=K1+N+F	607	607	0	813	829	-16
F-	N	FA	RT=K1+β+N+F	644	652	-8	905	895	10
F+	A	TA	RT=K1+β	514	520	-6	713	704	9
F-	A	TA	RT=K1+α	503	509	-6	656	679	-23
F+	N	FA	RT=K1+β+N+F	666	652	14	882	895	-13
F-	N	FA	RT=K1+α+N+F	638	641	-3	892	870	22
I+	A	TA	RT=K2	504	501	3	657	631	26
I-	A	FN	RT=K2+S+F	700	696	4	942	940	2
I+	N	FA	RT=K2+N+F	622	633	-11	795	822	-27
I-	N	TN	RT=K2+N+S	680	690	-10	946	945	1
NI+	A	FN	RT=K2+S+F	691	696	-5	935	940	5
NI-	A	TA	RT=K2+α	534	535	-1	652	672	-20
NI+	N	TN	RT=K2+N+S	700	690	10	943	945	-2
NI-	N	FA	RT=K2+α+N+F	674	667	7	884	863	-21

Experiment IV: K1 = 475 K2 = 501 α = 34 β = 45
N = 63 F = 69 S = 126
RMSD = 7.1 r^2=.986

Experiment V: K1 = 638 K2 = 631 α =41 β = 66
N = 98 F = 93 S = 216
RMSD = 16.3 r^2= .967

separated into those which are implicitly affirmative and those which are implicitly negative.) The model requiring 7 parameters for the 16 data points fits extremely well. The RMSD is 7.1 msec, with the highest deviation of observed vs. predicted reaction time in any condition of only 14 msec. This is within the error estimated from the original analysis. The computed r^2 was .986.

The last experiment queried the subject only about the implication or presupposition of an earlier presented sentence. Although this would seem to make it advantageous to the subject to figure out the implication or presupposition in advance, he does not do so. Perhaps what is needed is a more full and deep comprehension of the first sentence, of the kind you might get when a person forms a visual image of an object or an event. The next experiment was designed to test this notion and see if by changing the instructions to the subject, results could be obtained which were more in accordance with the direct representation model.

EXPERIMENT V

Method.

Subjects. 24 students, none of whom participated in the earlier experiments, served as paid subjects for 2 daily sessions.

Design and Procedure. Experiment V differed from Experiment IV in that it required the subject to form an image of the event expressed in the first sentence, instead of just reading and comprehending it. In order to make the image formation somewhat easier, the noun phrase He was replaced with four different noun phrases: The judge, the slave, the clerk and the pupil. In addition the complement sentences were changed to: spanked the child, ate his dinner, cut his hair and signed the paper. The predicates used were the same as in Experiment I and IV.

As in the last experiment, the subject, after finishing processing the first sentence, pressed a button (the inspection time was recorded) which removed the main sentence from the screen and displayed the probe sentence.

Results

Inspection Times.

The mean inspection times for each condition are shown in Table 8.

Table 8 about here

Class of factive verbs. As in the last experiment explicitly negative main sentences were processed longer (172 msec) than affirmative ones. ($F(1,23)=12.79$, $p<.01$, $MSe=448,072$). This difference differed for the different predicates. It was 186 msec and -24 msec for the predicates forgot that and was sorry that respectively, while it was 412 msec for was happy that and 116 msec for remembered that.

Class of implicative/negative-implicative verbs. Sentences containing negative-implicative predicates were, as in Experiment IV, studied longer (150 msec) than sentences with implicative predicates ($F(1,23)=13.93$, $p<.01$, $MSe=616,376$).

As before, explicitly negative sentences were viewed 200 msec longer than affirmative sentences ($F(1,23)=4.69$, $p<.05$, $MSe=3267,187$). Again this difference was somewhat larger (although unreliable) for negative-implicative predicates (212 msec) than for implicative predicates (188 msec).

Decision Times.

The mean decision times for each condition, as well as the average over verbs for each verb class are shown in Table 9.

TABLE 8

Mean Inspection Times For Experiment V

S1 Sentence

forgot		was sorry		remembered		was happy		FACTIVES	
aff	neg	aff	neg	aff	neg	aff	neg	aff	neg
2209	2395	2270	2246	2220	2336	2004	2416	2176	2348
remembered		condescended		managed		happened		IMPLIC.	
2009	2197	2078	2197	1980	2250	1958	2131	2006	2194
forgot		refused		declined		neglected		NEG-IMPL.	
2234	2236	2024	2362	2167	2411	2149	2414	2144	2356

Table 9 about here

The standard error for the decision times, estimated as before, was somewhat larger than in the last experiment. It amounted to 22 msec for both the factive and the implicative/negative-implicative verb class.

Class of factive verbs. "True" decisions were 194 msec faster than "false" decisions ($F(1,23)=58.8$, $p<.01$, $MSe=122,535$). This difference is again confounded with the presence or absence of a negation marker in the second sentence. If the first sentence was negative, decisions took an average of 21 msec longer than when affirmative ($F(1,23)=3.8$, $p\sim.07$, $MSe=22,223$).

As in Experiment IV and contradictory to predictions from the direct representation model, the verb factor was significant ($F(3,69)=3.2$, $p<.05$, $MSe=26,494$). Furthermore, the pattern of reaction times to the different factive predicates was the same as in the last experiment: decisions on sentences containing implicitly negative predicates took longer than those on implicitly affirmative predicates (*forgot that* vs. *remember that* = 12 msec, *was sorry that* vs. *was happy that* = 28 msec). And as in the last experiment, this factor interacted (this time highly reliably) with the polarity of the first sentence: decisions on explicitly negative first sentences were an average of 66 msec slower

TABLE 9

Decision Times For Experiment V

S1 Sentence

		forgot		was sorry		remembered		was happy		FACTIVES	
		aff	neg	aff	neg	aff	neg	aff	neg	aff	neg
S2	aff	729	653	697	658	669	683	639	704	684	674
	neg	885	920	879	863	832	956	793	854	847	898

		remembered		condescended		managed		happened		IMPLIC.	
S2	aff	646	956	665	973	654	887	662	943	657	942
	neg	802	970	813	941	786	960	778	915	795	946

		forgot		refused		declined		neglected		NEG-IMPL.	
S2	aff	935	673	957	644	945	659	901	631	935	652
	neg	989	903	933	867	900	885	949	882	943	884

for implicitly affirmative predicates, while 25 msec faster for implicitly negative predicates (F(3,69)=5.14, p<.01, MSe=25,429).

<u>Class of implicative/negative-implicative verbs</u>. Decisions involving negative-implicative predicates took 18 msec longer than those on implicative predicates. As in the last experiment, this difference was, however, only marginally reliable (F(1,23)=3.53, p<.08, MSe=36,441). Decisions on the different verbs within a class did not differ from each other (F(6,138)=1.46, p>.10, MSe=26,970).

As in the last experiment, there was no S1 main effect (F(1,23)=2.47, p>.10, MSe=88,439) but a highly reliable S1*C interaction (F(1,23)=103.85, MSe=139,957). Again decisions on implicative predicates were easier when they occurred together with an affirmative main sentence (218 msec), while decisions on negative implicative predicates were easier with negative main sentences (171 msec). The advantage of implicative predicates with an affirmative main sentence over a negative one dropped more from day 1 to day 2 (from 269 msec to 168 msec) than the advantage of negative-implicative predicates with a negative main sentence (from 187 msec to 154 msec) (F(1,23)=8.50, p<.01, MSe=49,799).

"True" decisions were 89 msec faster than "false" decisions (F(1,23)=11.97, p<.01, MSe=256,466). This difference was 69 msec for implicative predicates and 112 msec for negative-implicative predicates.

Decisions on negative second sentences took 96 msec longer than on affirmative ones (F(1,23)=47.46, p<.01, MSe=47,166), reflecting the extra reading and encoding time of negative complement sentences. This difference was larger for decisions involving negative-implicative predicates (121 msec) than implicative predicates (72 msec). (F(1,23)=8.89, p<.01, MSe=22,045). However, this pattern occurred only on day 1, while on day 2 this difference was about the same for both verb classes (D*C*S2 interaction: F(1,23)=10.29, p<.01, MSe=17,500).

Departing from the last experiment, there was a reliable S1*S2 interaction (F(1,23)=8.89, p<.01, MSe=22,045). While it did not matter for positive probe sentences whether the main sentence was explicitly affirmative or negative, for negative second sentences it did. Decisions were 46 msec faster if the main sentence was affirmative than when negative.

All in all, the results look very similar to the ones obtained in the last experiment. The analysis of variance showed again factors to be significant (e.g. the V main effect and the S1*V interaction for factive predicates as well as the S1*C interaction for implicative/negative- implicative predicates) that cannot be explained by the direct representation model, but are easily handled by the computation model. The computation model was fitted to the new set

of data (least square criterion) and the observed and predicted values are shown in Table 7, Experiment V. The fit is good. The computed r^2 is .97 and RMSD is 16.3 msec with the largest deviation in any one condition being 27 msec.

SUMMARY AND CONCLUSIONS

The question was asked whether a person can or cannot extract and store the implication and presupposition of sentences together with the representations of entire sentences. The results of the first three experiments showed the difficulties models have which assume that a person uses the decomposed form of a sentence in order to answer a question about the implication or presupposition. Yet a relative simple computation model which assumes that the subject operates on the original matrix sentence could account for most of the data of Experiment I and was at least suggestive. Therefore, a new paradigm was introduced which separated the stage of comprehending the implication and presupposition of a sentence from the decision stage. In addition, the data analysis was performed such that it included factors pertaining to the input stage which under the assumption of direct representation of implication and presupposition, should no longer influence the decision stage.

Experiment IV gave strong evidence that subjects derive the implications or presuppositions of a sentence at the time they are asked to answer a question about them and not at the time of original comprehension. When measuring reaction time to the probe sentence it was found that decision

time was influenced by the class of predicates (factive, implicative, negative-implicative), by the different predicates within a class and by whether the first sentence was explicitly negated or not. None of these factors should have had an effect on reaction time of the second sentence.

A model was developed which assumes that the subject at the time he is asked to answer a question computes the value of the implication or presupposition (affirmative or negative) from the representation of the full sentence. He the arrives at the correct decision by comparing the value of the computed implication or presupposition to the value of the probe sentence. The developed model did fit the data extremely well.

In order to be able to generalize to a less specific situation the experiement was repeated under imaginal instructions. Although the overall reaction times were somewhat slower, the same pattern for the different conditions emerged as before and again a good fit was obtained by employing the computation model and using the same parameters as before.

It is still possible that the obtained results are specific to the employed experimental situation, that subjects developed special strategies to deal with the task. Two aspects argue against this notion: first, subjects were tested for three days (Experiment IV) on the implication or

presupposition only, they were only rewarded for fast and accurate decision times, but no pay-off systems were involved with respect to the inspection times. Therefore it would have been to the subject's advantage to have the simplest possible representation available for comparison purposes. Models considering those type of representations could clearly be rejected. Second, the results of Experiment V, which were obtained under imaginal instructions were so similar to those of Experiment IV, that one is tempted to assume that the same underlying representations and the same control processes were used in both cases.

Not much can be said about the form of the underlying representation of the main sentence. But again, the similarity in results of Experiment IV and V, as well as the differences in inspection time for different sentence forms, verbs and verb classes at least suggests that subjects are not just operating on the stored surface form of the main sentence, but on a somewhat more abstract representation of the original (not decomposed) sentence.

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