The Perception of Sentences: A Linguistic and Perceptual Comparison
Author(s): Ralph Norman Haber and Lyn R. Haber
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The Perception of Sentences: A Linguistic and Perceptual Comparison*

Ralph Norman Haber and Lyn R. Haber
University of Rochester

Does how sentences are perceived relate to their structure? A number of cognitive psycholinguists, such as Carpenter and Just (1975) and Clark (1972), have argued that some transformations of sentences, such as Negatives, are more difficult than others, in that more processing time is needed to understand them. We wished to determine whether such transformations were also harder to perceive, and, if so, what the errors were like.

Does how sentences are perceived relate to their structure? This question can be explored in another way. Is a sentence more difficult to perceive if it contains a larger number of characters (a perceptual feature) or a larger number of words (a linguistic one)? If only a single glance is permitted the perceiver, will a particular place in the sentence (an aspect of perception) or a particular part of speech (an aspect of language) be reported?

Little is known about the perception of sentences. Perceptual psychologists are now debating whether perceptual strategies (i.e., where the eye looks next in a text) are related to the syntactic properties of the text at all. In fact, the majority vote of these scholars is that eyemovements over text are not related to its linguistic structure (for a full discussion of such models, see Haber, 1975). Our assumption, contrary to most current opinion, is that eyemovements and the perception of a text and its linguistic structure are interrelated.

Previous research on single sentences has tended to use auditory presentation (e.g., Fodor and Bever, 1965), or to permit multiple fixations for visual presentations (e.g., Wanat, 1971; Rayner, 1975). In order to set up a baseline to study the effect of varying syntactic structure, in a first experiment we held structure constant and varied the number of words and the number of character spaces they occupied. This enabled us to analyze the effects of sentence length, word position, and number of words independently. Then, with these results under our collective belts, in a second experiment we chose a constant sentence length and systematically varied syntactic structure by presenting each of a number of kernel sentences in 24 different syntactic configurations. For both studies, we permitted the viewer only a 200 millisecond glance at the sentence, so that he could not move his eyes to a second point of fixation.

Before describing the procedures and the results of the two studies in detail, some comments are in order about the variables we manipulated. Since it is known that the effective visual field is large enough to permit a viewer to perceive a number of words in a single glance, we wished to determine whether there is a systematic effect on the extraction of information as a result of the number, the position, and the syntactic function of each of the words in the sentence, and of the syntactic structure of the sentence as a whole.

It seems reasonable that if a reader is given only a single glance of a sentence, so that he cannot move his eyes over it, then the longer the sentence the less of it he will perceive. But sentences can be made longer either (1) by inserting more words or (2) by having longer words (more character spaces). Do both of these variables have equal effects? Consider the three sentences:

1. Katherine hit Bartholomew
2. Fat Sue hit small weak Jo
3. Joe hit Sal

Sentences 1 and 2 are matched in character spaces but not in words, while sentences 1 and 3 are matched in the number of words but not in character spaces. We predicted that the number of words in a sentence would not effect performance, holding structure constant, but that the more space on the page the sentence occupied, given the limitation of a single glance, the poorer information extraction would be.

In the first experiment, all of our sentences were of the same form, based upon a kernel of a three-word simple declarative sentence: subject (common noun, proper, or pronoun) a verb (where Aux was tense only) and an object, (common, proper, or pronoun). To add words, adjectives were inserted before either or both the subject or/and the object (except when pronouns were used, which normally do not permit co-occurance with adjectives). Some examples are given in Table 1. All words in each sentence

Table 1
Some of the Sentences of Experiment 1

John read it.	Ann hates big fat boys.
He brews beer.	Some old pens leak ink.
Tony avoided her.	Terry sacrificed her old dog.
They confused us.	Nice old ladies knit sweaters.
Banks purchase stocks.	He teaches second year students.
They demanded justice.	New ideas clarify many problems.
Jim lost his keys.	He told his long sad story.
Fat rats scare Dan.	Some cats have big blue eyes.
Tom tells funny jokes.	Few bold actors earn much money.
Hard work inspires Kim.	Nice little green men inhabit Mars.
They visited their friends.	We utilized his clever new invention.
Some bookstores sell posters.	Large red Indian carpets frighten her.

met a high frequency of usage criteria, at least according to word frequencies computed for words in isolation (Kucera and Francis, 1967). We should comment, however, that controlling for frequency in isolation in no way controls for frequency in context, and some of our sentences seemed very strange. In the process of analyzing them, we tried to sort out the strange ones and all the sentences got stranger and stranger, so we left well enough alone.

In addition to an analysis of number of words and number of characters, it is also possible to examine these data for the perception of specific classes of words and for specific positions of words. Since a verb always follows the subject in these sentences, we cannot look at all permutations of word classes, but we can determine whether, for example, adding an adjective to a phrase affects perception of the noun it modifies, or whether an adjective added before the subject is treated similarly to one added before the object, and so forth. These manipulations permit analysis of perceptual information extraction processes as a function of part of speech, position of a word in a sentence, word length, and number of words; analyses that to our knowledge have never been reported before.

In the second study we chose a fixed character space length and systematically varied the syntactic configuration for a number of kernel sentences. Table 2 gives an example of the 24 configurations tested for each kernel. This manipulation allowed us to examine the relationship between the syntactic structure of the sentences and the information extracted from them. Are Negative sentences more difficult than Statements, in that more processing time is needed to understand them? If so, such sentences should be harder to perceive, and given a single glance of limited processing time, less would be reported. Further, from such analyses we hoped to determine which syntactic configurations are more basic or fundamental. It is our expectation that these effects will be evident even in the processing of single sentences from a single glance, and might even be clearer here when the complicating effects of multiple fixations are eliminated. Further research will have to carry these findings into the area of normal multiple fixations and into context.

Method

We used the same method and procedures in both experiments. The subjects, numbering 28 and 24 for each of the 2 experiments respectively, were University of Rochester undergraduate college students. They were recruited as volunteers to serve one hour individually in an experiment described as studying the perception of sentences.

Each sentence to be read was presented on the 15 inch television cathode-ray tube display operated by a Nova data acquisition computer. Initially a small fixation dot was lit on the

Table 2
The 24 Configurations of One Kernel Used in Experiment 2

1.	S	Elizabeth hit Julia.
2.	N	They didn't hit her.
3.	Q	Did she hit Tony?
4.	P	We were hit by him.
5.	QP	Were we hit by him?
6.	NP	He wasn't hit by it.
7.	NQ	Didn't they hit her?
8.	NQP	Wasn't he hit by it?
9.	PD	Christopher was hit.
10.	PDN	Jonathan wasn't hit.
11.	PDQ	Was Alexander hit?
12.	PDNQ	Wasn't Barbara hit?
13.	W	Why did he hit Sue?
14.	WP	Why was he hit by Jo?
15.	WPD	Why was George hit?
16.	I	Lou hit a red ball.
17.	II	Lou hit a ball far.
18.	NADV	He never hit Louise.
19.	Emp	Bernice did hit him.
20.	G	Katherine got hit.
21.	NG	John didn't get hit.
22.	QG	Did Esther get hit?
23.	NQG	Didn't she get hit?
24.	WG	Why did he get hit?

screen. When the subject pressed a button, the dot was replaced by one of the sentences, centered equally on either side of the dot, for a duration of 200 milliseconds (1/5 of a second). Following the presentation, the screen was blank for two seconds, and then the dot returned, signifying readiness for the next trial. One-fifth second is sufficiently long to easily see, though not necessarily to process, the entire sentence, but it does not permit more than the one fixation the subject is making when the sentence appears. The room lights were on throughout the experiment, so the screen was visible even when nothing was on it.

The subject sat in a chair 30" distant from the screen. At this distance, a sentence of 10 character-spaces in length was about 2-1/2° in visual angle, the same size that most normal readers see for that length sentence when they hold the text of a book at normal reading distance.

The subject was instructed to report as much of the sentence as he could, saying "blank" for words he could not name. In this sense each report contained as many items (words named or called "blank") as the subject thought appeared in the sentence. Subjects were encouraged to guess, but were not forced to name words of which they were unsure. Thus for the sentence "Girls love pretty dresses" a report might be "Girls love blank --- I think it was 'dolls'". Subjects were given a set of practice sentences before the experiment began.

All responses were both written down by the experimenter and also tape-recorded for reliability checking later. To score the data, the experimenter entered each response into a data file in the same computer. The computer then compared the presented sentence with each response, deleted all words that were literally letter-for-letter matches, and typed out for each sentence those portions of the 28 subjects' responses that were incorrect. Table 3 gives an example of how such a computer output looked for one sentence in the first experiment.

To check the reliability of the immediately transcribed responses the complete data for eight subjects were transcribed by another scorer from the tape recordings. When the new transcripts were compared to the ones made directly, only 30 of the 4000 words were scored differently, that is, less than 1%. For 21 of these 30, it was determined that the tape recording was ambiguous. We decided in these instances to rely on the experimenter doing the on-the-spot transcription. In any event, the overall procedure for scoring the sentence performance seems relatively error free.

The scoring done by the Nova computer used a strict criterion. Each word in the response had to match the presented word perfectly, letter for letter. Still looking at Table 3, it can be seen that some of the errors scored by the computer were not grievous at all. To take account of these we computed by hand a lenient score as well, in which we accepted as "correct"

Table 3
Computer Output of Scoring of a Sentence from Experiment 1
Only errors or omissions are reproduced. C indicates perfect.

#56		THEY	VISITED	THEIR	FRIENDS
1.	C				
2.	C				
3.	C				
4.			invited		
5.	C				
6.			visit		
7.					-------
8.				-----	-------
9.					-------
10.		----	twisted		feelings
11.	C				
12.		----			
13.				her	
14.				-----	-------
15.			invited		
16.		Tim			
17.					-------
18.		----			
19.			invited		
20.					-------
21.					-------
22.		Tom			-------
23.		----			-------
24.					-------
25.		----	-------		-------
26.					relatives
27.					-------
28.					-------
Totals		7	6	3	15

all mismatches in which a) one proper name was substituted for another of the same sex; b) one pronoun was substituted for another pronoun; c) number or person differed between stimulus and response; d) one adjective was substituted for another adjective, but the same semantic relations among the words was maintained (e.g., 'short' for 'small'); and e) the verb differed in tense or in the number from the stimulus form.

In the first experiment each subject was shown 125 sentences; of these, 107 were simple declarative sentences as previously described. The remaining 18 were "distractor" sentences using different syntactic configurations. Since the location of the sentence on the screen was important, all sentences of a given word length and character-space length were presented in a block together. The order of the 12 blocks was systematically varied from subject to subject so that some began with long sentences, some short, and so forth. Table 4 illustrates the arrangements

Table 4
Number of Sentences Used in Experiment 1
Broken Down by Number of Words and Number of Character Spaces

Number of Character Spaces in Sentence	Number of Words in Sentences: 3	4	5	6	
10-15	13				13
16-20	7	11			18
21-25	7	11	10		28
26-30		8	10	9	27
31-35			7	7	14
36-40				7	7
	27	30	27	23	107

of number of words and number of character-spaces in the 12 blocks. Subjects were told how many words were in each block. Nevertheless, their reports did not always coincide with this number. All 125 sentences were stored in a presentation file in the computer. For each subject, the experimenter simply specified the actual presentation order to be followed by the computer program beforehand, and from that point on the computer ran the experiment.

In the second experiment, 24 kernel sentences were written in each of 24 different syntactic configurations, a total of 576 sentences. (The 24 configurations have been illustrated in

Table 2 above.) For these sentences, the number of character spaces was limited to a range of 18 to 23. The number of words varied from 3 to 6. Each of the 24 subjects was shown 2 of each of the 24 configurations of the kernels, a total of 48 sentences. The data were scored by the same stringent criterion as in the first experiment. The scored output provided by the computer was arranged by configuration. As an example, Table 5 gives the 48 responses, 2 for each of the 24 subjects, for the configuration NQP.

Results of Experiment One

The stringent and the lenient scores provided the same pattern of results throughout all analyses except that the error rates given by the former were between 5 and 10 percent higher. All analyses are based on the percent of words in each sentence incorrectly reported, and use the stringent scoring only.

Table 6 presents the results for the number of words and number of character spaces. As can be seen from the means given in the margins, increasing the number of words in a sentence, or increasing the number of character spaces in a sentence, or both together all increase errors. For the shorter sentences only about one-tenth of the words were incorrectly reported whereas nearly 2/3 of the words in the longest six word sentences were missed.

The cell entries in Table 6 show that, looking down, adding character spaces while holding number of words constant increases errors substantially. However, the converse is not true: holding the number of character spaces constant (that is looking across the table) adding more words to a sentence does not consistently cause more errors. The only dramatic exception to this is for sentences 16 to 20 character spaces in length. Going from three to four words, there is a substantial increase in errors. We shall have more to say about these four word short sentences below.

This general pattern can be seen more clearly in Table 7 where we expanded the data from Table 6 to include the position of each word in each sentence. Adding an extra word does not create additional errors. (Again, the same exception is for each of the word positions in the shortest four word sentences. Two of these sentences were particularly difficult, and if they were removed from the data, there would be no general exception at all. However, we cannot find any linguistic basis for their removal, so we just note this as an exception.) Thus, of the two general variables manipulated, number of words and number of character spaces, only the latter has any substantial effect on the perception of these sentences. This suggests that adding words to a sentence while holding syntactic structure constant leaves the perceptual and linguistic difficulty of processing the sentence unchanged.

Table 5
Computer output scoring of each of 2 responses of 24 subjects for the NQP transformations. First column is sentence number, third column is subject number, '=' means perfect response. Only incorrect or omitted words are indicated.

226	WASN'T HE HURT BY IT?/	1					HER?
346	WASN'T HE SOLD BY IT?/	1	=				
202	WASN'T HE HELD BY IT?/	2				AT	
370	WASN'T HE SHOT BY IT?/	2					HIM
178	WASN'T HE HIDDEN BY IT?/	3			------	--	----
394	WASN'T HE SLAIN BY IT?/	3				--	----
154	WASN'T HE EATEN BY IT?/	4			-----	--	----
418	WASN'T HE STUCK BY IT?/	4	=				
130	WASN'T HE DRAWN BY IT?/	5	=				
442	WASN'T HE TAKEN BY IT?/	5		--			
106	WASN'T HE LOST BY IT?/	6				--	----
466	WASN'T HE TOLD BY IT?/	6	=				
82	WASN'T HE FED BY IT?/	7			---	--	----
490	WASN'T HE WON BY IT?/	7			---	--	----
58	WASN'T HE SEEN BY IT?/	8		SHE	----	--	----
514	WASN'T HE FOUND BY IT?/	8			F**	--	----
34	WASN'T HE CUT BY IT?/	9				--	OFF?
538	WASN'T HE BORED BY IT?/	9	=				
10	WASN'T HE HIT BY IT?/	10	------			--	
562	WASN'T HE KNOWN BY IT?/	10		--			
562	WASN'T HE KNOWN BY IT?/	11	=				
10	WASN'T HE HIT BY IT?/	11	WAS	--			
538	WASN'T HE BORED BY IT?/	12	=				
34	WASN'T HE CUT BY IT?/	12	=				
514	WASN'T HE FOUND BY IT?/	13	------			--	----
58	WASN'T HE SEEN BY IT?/	13			NEW	--	----
490	WASN'T HE WON BY IT?/	14	WAS				
82	WASN'T HE FED BY IT?/	14	=				
466	WASN'T HE TOLD BY IT?/	15				--	----
106	WASN'T HE LOST BY IT?/	15			LAY	--	----
442	WASN'T HE TAKEN BY IT?/	16	------	--		--	----
130	WASN'T HE DRAWN BY IT?/	16		--		--	----
418	WASN'T HE STUCK BY IT?/	17				--	
154	WASN'T HE EATEN BY IT?/	17				--	
394	WASN'T HE SLAIN BY IT?/	18				--	----
178	WASN'T HE HIDDEN BY IT?/	18				--	----
370	WASN'T HE SHOT BY IT?/	19			----	--	----
202	WASN'T HE HELD BY IT?/	19		THE	----		
346	WASN'T HE SOLD BY IT?/	20	WAHN'T	IT		--	----
226	WASN'T HE HURT BY IT?/	20			----	--	----
322	WASN'T HE PAID BY IT?/	21				FOR	
250	WASN'T HE KEPT BY IT?/	21				FOR	
298	WASN'T HE MET BY IT?/	22			HIT		
274	WASN'T HE LED BY IT?/	22	WAS				
274	WASN'T HE LED BY IT?/	23			LEFT	TO	BE?
298	WASN'T HE MET BY IT?/	23			---		
250	WASN'T HE KEPT BY 'IT?/	24			----		
322	WASN'T HE PAID BY IT?/	24	WHY	WASN'HE		PAID	----

Table 6
Percent Errors in Reporting Words, Broken Down
by Number of Words and Number of Character Spaces

Number of Character Spaces in Sentence	Number of Words 3	4	5	6	
10-15	11.2				11.2
16-20	16.8	29.2			23.0
21-25	40.7	34.7	42.8		39.4
26-30		53.9	50.3	52.9	52.4
31-35			62.9	62.1	62.5
36-40				62.4	62.4
	22.9	39.2	52.0	59.1	43.3

Table 7
Percent Error in Reporting Words According To
Position of Word in Sentence

Character-Spaces	Number of Words	Word Position 1st	2nd	3rd	4th	5th	6th	Mean
10-15	3	8.8	6.3	18.4				11.2
16-20	3	14.8	14.3	21.4				16.8
	4	23.3	16.9	25.3	51.3			29.2
21-25	3	42.9	28.1	51.0				40.7
	4	32.1	18.5	30.8	57.5			34.7
	5	37.5	22.8	28.9	58.9	66.1		42.8
26-30	4	48.2	29.9	53.6	83.9			53.9
	5	55.7	26.4	34.6	57.1	77.5		50.3
	6	57.5	42.5	21.8	44.8	75.4	75.4	52.9
31-35	5	65.8	44.4	42.3	69.9	92.3		62.9
	6	73.5	52.6	26.0	50.5	78.6	91.3	62.1
36-40	6	67.3	62.2	31.6	32.7	82.1	98.5	62.4

Several other findings are apparent in Table 7. First, greater accuracy is always found for the words in the center of the sentence. This is undoubtedly because the fixation point was located in the center. Further, there is always a substantial asymmetry between the left and right sides of each sentence in which words to the left of center are reported more accurately than words to the right of center. This is true for 23 of 24 comparisons possible in Table 7, regardless of the number of words or the number of character spaces.

A part of speech analysis. Since all sentences have an SVO surface structure, part of speech and word position are usually confounded in these data. A different design would be needed to analyze these separately. However, several comparisons are possible and these will be briefly considered.

Subject nouns. The subject in each sentence tested is either a proper, common or a pronoun. Considering all the sentences, regardless of other variables, pronouns are reported more accurately by half than either common or proper nouns, with the latter two not differing from each other. This could be because pronouns have fewer letters or that there are so few of them that they are more redundant. To distinguish these, we compared pronouns with common and proper nouns matched for number of letters. The two-to-one difference remained. So redundancy seems a more likely explanation for this great advantage. This suggestion is further borne out by analysis of the adjectives.

Adjectives. Two general types of adjectives were used--quantifiers (cardinal numbers, plus FEW, MANY, SOME, ALL, etc.) and common adjectives. Again controlling for position in a sentence and number of letters, quantifiers were easier to report than common adjectives. This is also probably due to their restricted number, making them much more predictable from partial letters, syntactic or semantic information, as compared to the much greater number of possibilities among the common adjectives.

Placement of adjectives. The object noun is always the last word in the sentence. It is either preceded immediately by the verb or has one or more adjectives between it and the verb. Is the report of the object influenced by what precedes it? The answer is clearly yes. The object is reported better in every case in which it is preceded by an adjective than by the verb. This is probably also a redundancy process--the adjective reduces the number of alternatives the object can take.

Verb. Since these sentences are all SVO and the middle is reported better, naturally the verbs are reported best. To demonstrate that this is not due to part of speech but to fixation point, we compared all combinations in which the verb was the word on fixation with those in which the verb was either to the right or the left of fixation. In all comparisons tested, the verb is the best reported word only when centered on fixation. However, this result is partially confounded here with the insertion and position of adjectives. Even so, we can have some confidence that the superiority of the center word is not due to the confounding of word position with part of speech, but rather with the fixation point placement.

In summary, these results show that a subject can see and report a number of words of a briefly flashed sentence. When syntactic structure is held constant the number of words he can accurately report depends primarily upon the number of character spaces occupied by the sentence, a perceptual variable resulting undoubtedly from the rapid fall-off of visual acuity on either side of the point of fixation. The same visual acuity seems to be the cause of the greater accuracy which occurs for the word nearest fixation. In addition to the visual acuity effects, we found a strong left-to-right asymmetry suggesting that, regardless where the subject is fixated, he either internally processes each sentence from left to right, or the redundancies of the syntax and meaning in the language are such that left hand items are more easily processed. There is already a substantial psychological literature in support of this type of finding (see Haber and Hershenson, 1973).

Results of Experiment 2

Unlike the first experiment, which was scored for errors in reporting each word, we now wished to consider the accuracy with which the subject maintained the syntax of the presented sentence. While we could still score for accuracy of words in first position, or in four-word sentences, these analyses are uninteresting variables given the syntactic manipulations we specified. Therefore, all scoring is for the accuracy with which the transformations were reported. We tested 24 configurations, but will report the results of only 15 of them here. (Of the remaining 9, 5 transformations involved GET, one was an Emphatic, one involved NEVER, and 2 contrasted adjective and adverb placement.)

Scoring presented real difficulties in that merky area where the informant, instead of saying he couldn't report any of the words, reported only one, or created an anomalous sentence. For example, in the statement frame, "Elizabeth [(hit) (told) etc.] Julia," 8 of the 48 responses reported only the first word. A ninth response was "Elizabeth old." These were all scored as Ø. In the Passive, the last two words were missed in 13 responses, resulting in a surface Deleted Passive: "We were [(hit) (told) etc.]" instead of the sentence as presented, "We were [(hit) (told) etc.] by him." These responses were scored as Passive since the transformation was correct.

In principle, we scored for as much information as we could. Thus for the WP question, "Why was he [(hit) (told) etc.] by Joe?" we scored the 2 word response, "Why wasn't" as a WN. We shall return below to the impact of some of these scoring decisions.

The main results will be presented in a series of confusion matrices in which the transformation of the presented sentence is listed across the top of the matrix and the transformation of the subjects' responses is listed down the side of the matrix. The first matrix, Table 8, includes the Statements, Negatives,

Table 8
Confusion Matrix for Accuracy of Reporting the Transformation of a Sentence. Entries of Number of Subjects Who Gave Each Response

Transformation of Sentence Reported	Transformation of Sentence Presented							
	S	N	Q	P	QP	NP	NQ	NQP
S	38		1	3	3		1	2
N	1	46				16	2	
Q			44	1	4		4	
P				39	7	1		
QP				1	24	1		3
NP						27		
NQ			2				41	12
NQP					1	2		28
WH					1			
WHNP								1
Ø	9	2	1	4	8	1	0	2

Questions, Passives and all their 2- and 3-way combinations. We have arranged the columns by the number of optional transformations contained in the sentence.

As an aside, it might be thought that by placing the Statement configuration first, we are implying that it has fewer transformations than the next three listed: Negative, Question and Passive. Further, when we talk about "simplifying" transformations, as we will below, this might seem to imply an ordering to transformations, with implicit a Ø kernel form. Transformational theory has several divergent views on this matter, and we do not wish to take sides on it. Thus, this organization of the data, and comments about simplification or losing transformations, should be taken as descriptive of the data, not derived from theory.

Several observations are apparent from Table 8. First, the configurations containing a single transformation (N, Q or P) are generally easier than those involving two or more. Second, the errors made are heavily dependent upon what was presented. Virtually all the errors are above the diagonal: that is, they represent a "simplification" of the configuration. Of the seventy errors in this matrix, only nine (12%) represent adding a transformation, while 88% of the errors represent deleting one or more of the transformations. The particular errors cluster also. Most striking are the combinations of N with P. For NP nearly all errors (16 out of 20) result from loss of the Passive, while for QNP 14 of the 18 errors lose the Passive.

We also tested the Passive form with the agent deleted. These are shown in Table 9. Clearly, when subjects report these

Table 9
Confusion Matrix for Accuracy of Reporting Deleted Passive (PD) Transformations

Transformation of Sentence Reported	Transformation of Sentence Presented: PD	PDN	PDQ	PDNQ
S	15			
PD	19			
N		24		
PDN		17		
Q			25	
PDQ			17	
NQ				27
PDNQ				19
Ø	14	7	4	1

transformations inaccurately, they do so by losing the Passive altogether, not by making other kinds of errors. We also tested for the W question alone and in combination with the Passive as is shown in Table 10. By itself, W is handled quite accurately, but adding a Passive or a Passive Deleted makes the transformation much more difficult. Table 10, like Table 9, shows that Passives are easily lost, but, in this case at least, so is the W marker. Whether this would be true when W is

Table 10
Confusion Matrix for Accuracy of Reporting
WH Question Transformation

Transformation of Sentence Presented (columns); Transformation of Sentence Reported (rows)

	W	WP	WPD
W	41	11	22
WP		3	
WPD		8	10
Q	2		7
NQ	1		
NQP	1	1	
WN	1	1	
P		1	
S		5	1
QP		5	3
PD		1	
EMP	1		
Ø	1	12	5

combined with other transformations, such as Negative, is not known, since we did not test that configuration here. We do, however, have confidence in the conclusion that the Passive transformation, with or without the agent, is a weak appendage. and rather easily gets lopped off when processing demands are high. This finding is in line with the difficulty children have in acquiring the Passive form (Menyuk, 1969; Brown and Hanlon, 1970), and with the data that the Passive is lost from memory when sentences have to be retrieved (Savin and Perchonock, 1965).

We need to point out a bias introduced into these data by our rigorous method of scoring. When the presented sentence was "We were hit by him" and the response was "We were," we scored this as a Statement, since that is all we know from the informant. But the subject could have had a Passive in mind, but could not and therefore did not tell us what the next word was. We rescored all the data noting this ambiguity. In every case, taking whatever ambiguity there was into account, while numbers for the correct score were raised, responses below the diagonal were never added. For example in Table 9, 7 of the 15 Statements given for the PD sentence could have been PD if the subject had given more words. None could have been N or Q or any combination of these. Still, proportionally, the Passive retains its difficulty.

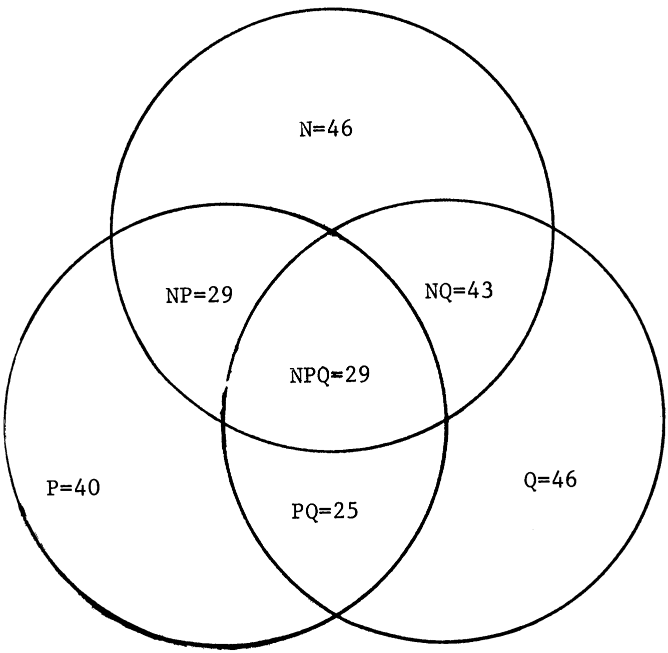
We have presented these results in confusion matrices rather than more traditional tabular form because of the extra power such organization of data provides. In addition to displaying overall level of difficulty, the types of errors can be clearly seen as simplifications in a highly patterned form.

These data taken together present strong evidence in support of the cognitive psycholinguists who have argued that sentences are processed as kernels plus transformation markers. Virtually all errors conform to a model in which a transformation has been "lost" and the resulting sentence contains fewer transformations. It is difficult to say which transformations are most easily lost, since we did not test all possible combinations. Clearly Q and N survive much better than P, while P and W are fragile.

This can be seen in the Venn diagram in Table 11 for the transformations N, Q and P. Most subjects got the single transformation correct, but any combination containing a Passive is markedly reduced in the accuracy with which subjects can report the complete combination.

We have said nothing about the absolute magnitudes of these numbers, because we have not controlled everything necessary in order to do so. Specifically, the fact that the Question transformation is reported more accurately than the Statement, does not imply that English is a VSO language any more than the reverse would have implied an SVO deep structure. To make such a claim, all of the words chosen in each configuration

Table 11
A Venn diagram showing the number of subjects out of 48 who maintained the correct transformation of N, Q, P, and their combinations.



would have to have been counterbalanced and we could not do this in this design.

A number of other comparisons and analyses are available in these data, but we do not have time or space to report them here. The most important set concern whether the particular configuration affects the accuracy with which different parts of the sentence are reported. For example, is the subject or noun equally perceived in a Statement, Question or Negative? Does the swapping of subject and object in changing from a Statement to a Passive affect the report of these two nouns? Does the insertion of DO in questions affect the main verb? Does the Negative marker affect the verb, the Aux, or the Subject? And so forth. If some transformations are harder to process than others, where specifically does this difficulty manifest itself?

The technique employed in the second experiment can be used for other contrasts, and we intend to pursue some of these in the future. For example, we can construct a set of sentences which differ only in their Aux configurations, as a way of extending the results reported by Kypriotaki (1974) on the pattern of acquisition of Aux.

Summary

In conclusion, the first of two experiments have shown that the difficulty of reporting the words in a sentence is generally independent of the number of words (holding syntactic structure constant) but is highly dependent on where the subject is looking during that one glance, how many character spaces are occupied by the sentence, and on a left-to-right internal processing strategy. In the second study we demonstrated that the subjects' accuracy in representing the syntax of the sentence is a function of the type and number of optional transformations contained in the sentence. Further, these results support a model which views word processing as separate from transformation marking.

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