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Strategies for Sentence Perception

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Three experiments are reported in which rapid sequential visual presentation of sentences–RSVP–was used to determine some perceptual processes in sentence perception. It was found that adjectives, when they are actually or potentially modifiers of a noun, are far less likely to be reported than any other part of the sentence. On the other hand, adjectives which are attribute adjectives are as likely to be reported as any other part of the sentence. Conclusions are drawn concerning sentence perception in general.

INTRODUCTION

An increasing amount of research in psycholinguistics has served to demonstrate the importance of the part played by syntactical and lexical variables in sentence perception. In particular, surface structure or some homologous feature has on several occasions been shown to play a very major structuring role (Mehler and Carey, 1967; Fodor and Bever, 1965; Garrett *et al.*, 1966). Similarly, sentence complexity also seems to occupy a position of some importance in the visual perception of sentences (Forster and Ryder, 1971). In addition, the lexical characteristics of the elements in a sentence have been demonstrated to be indispensable in the inference of underlying logical relationships (Fodor *et al.*, 1968). Nonetheless, although the work which has been undertaken this far is unquestionably of interest and would appear to throw

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some light on the psychological pertinence of certain aspects of language, we know little about how the different structural levels embodied in a sentence (lexical, syntactical, semantical, etc.) intervene in sentence processing. Furthermore, it seems obvious that this particular problem may well, if satisfactorily solved, hold the key to a valid model of sentence perception.

By far the greatest problem encountered in the study of sentence perception resides in the fact that the processing of information in natural speech takes place extremely rapidly. As a result, the integration of information gathered on the presentation of a stimulus occurs virtually immediately (except when material is particularly complex). In consequence, the method designed by Forster (1970) would appear to be particularly relevant to any work in the area. In this procedure, known as Rapid Sequential Visual Presentation (R.S.V.P.) words are presented one by one on a screen in a given position, at rates that can go up as high as one word every few milliseconds with a remanence of 12 msec. With this technique, Forster demonstrated that subjects report more words from a simple sentence than from a complex one. Such a correlation, however, seems valid only for presentation rates of 60 msec per word and appears to collapse if the presentation rate is increased over this limit. In some recent experiments, Forster and Ryder (1971) and Holmes and Forster (1972) have noted that response probabilities for different words seem to be related to the lexical category to which they belong. Nouns and verbs are said to be easier to report than adjectives and adverbs. Similarly, Segui (1973), Martin and Walker (1969), and Wearing (1971) have shown through the use of memory techniques that nouns and verbs are better recalled than adjectives and adverbs. This phenomenon for the time being remains unexplained. Furthermore, it is not even likely that its manifestation in the cases of both perception and memory can be traced back to the same single mechanism. The purpose of the experiment reported here was to understand how perceptual processes can account for variations in response probabilities on words of differing lexical categories.

In this article, we present two different experiments. In the first, we found that adjectives which directly precede or follow the noun they qualify tend to be reported less frequently than the nouns themselves. This, moreover, is true both for true qualification and nominal composition, i.e., *blue sky* and *bluestocking*. In the second experiment, attribute adjectives are reported as frequently as the other items in the sequence.

EXPERIMENT 1

In several pilot experiments conducted prior to this experiment, we found it easy to replicate Forster's claim that adjectives are reported with

greater difficulty by subjects than the nouns they qualify. The reason for this could be attributed to the position occupied by the adjective in the sequence of words in a sentence. It could also be that the information provided by an adjective is, in general, dispensable. In addition, adjectives play a qualifying role most of the time, and it could be this function that is disregarded by subjects. There are cases where the adjective performs different functions, but it is not yet possible to state whether it is the function that matters or whether it is the lexical category *per se* that is the predominant factor. French is a language well suited to understanding this phenomenon (first reported in English) because it allows one to test all the possible factors that may account for the difficulty encountered by subjects with adjectives. Consider the following sentences:

1. *Le soir les chauves-souris ont envahi le grenier.*
   At night the bats invaded the attic.
2. *Le soir les grosses souris ont envahi le grenier.*
   At night the big rats invaded the attic.
3. *Le chauffeur a apporté le coffre-fort dans un camion.*
   The driver brought the safe in a truck.
4. *Le chauffeur a apporté le coffre gris dans un camion.*
   The driver brought the gray box in a truck.

In sentence 1, the adjective and the noun constitute a nominal compound which figures as a separate lexical entry in any dictionary. Literally, joining the adjective *chauve* (bald) and the noun *souris* (mouse) results in a compound that has a meaning corresponding to *bat*. Obviously, unless one has already learned the word for bat, its meaning cannot be grasped from combining the meaning of the adjective and the noun. Sentence 1 differs from sentence 2 through a change in adjective that results in a noun phrase whose meaning is directly predictable from the meaning of its two components. Sentences 3 and 4 are homologous to 1 and 2 except that whereas in the first two sentences the adjective precedes the noun, in the second two the adjective follows the noun. This material will allow us to study the different factors intervening in the suppression of adjectives since it allows us independently to determine the role of position and function.

In one of the pilot experiments that preceded the experimentation described here, we used a procedure which was not really suited to our purpose. It consisted in determining a threshold at which an average of eight out of ten words were detected by subjects during the presentation of training sentences. Once this threshold had been determined, the rate was used throughout the presentation of the experimental sentences. This meant, of course,

that a number of subjects never saw some sentences at all, while others saw all the sentences in their entirety. Apart from the fact that this method was somewhat uneconomical from the data-gathering point of view, the varying lengths and structures of the sentences made interpretation of results extremely difficult. In consequence, in the present experiment, although the aims remained pretty much the same, we altered both the procedure and the materials.

Procedure

Sentences were presented on the visual display screen of a PDP 12 computer. Each sentence was initially presented much too fast for anyone to be able to make a report. After initial failure, the sentence was presented at a slower rate and so on until all the words in the sentence had been reported or until there were only one or two omissions. This same procedure was followed for all subjects and for all sentences. Records were kept on the partial reports made by subjects in the course of the presentations leading to a correct global perception of the sentence. Subjects were instructed to take the end of the sentence as the cue to start writing their full or partial report of what they had seen. All the words of any given sentence appeared in the same position on the screen at each repetition, with the first letter aligned on the left. Subjects controlled the presentation of sentences themselves by pressing on a key which either allowed them to see a sentence they had already seen or permitted them to proceed to a new one if the experimenter indicated that their preceding report was adequate. The time employed by each subject was controlled by the experimenter, who sat beside the subject during experimentation.

Materials

Sixteen experimental sentences were used (see Appendix I). In terms of words, all sentences were the same length and roughly speaking had the same syntactic structure of NP_1 + aux + V + NP_2 + NP_3. NP_1 always consisted of an article and a noun, while NP_2 was made up of an article plus an adjective and a noun in any order, and NP_3 consisted of a preposition plus an article and a noun. It should be noted that the adjective always appears in serial position 6 or 7. Furthermore, half of the adjective noun pairs are compound nouns, while the other half are simply noun phrases.

Method

Each subject was shown six training sentences plus eight experimental sentences. Subjects were divided into two groups. One of them was shown set A sentences while the other saw set B. Subjects were instructed to look at a mark on the screen where the words would be flashed. After each exposure they were told to write down everything they remembered seeing. Instructions were given in such a way that subjects could merely write down elements of a sentence if this was all they could remember. A response booklet was provided for this purpose. We asked each subject to press a given key in order to trigger the next sentence once he had finished giving the response to the preceding one.

Subjects

Two groups of 20 subjects each were used for this experiment. All belonged to the French university system and were paid four french francs each for their participation.

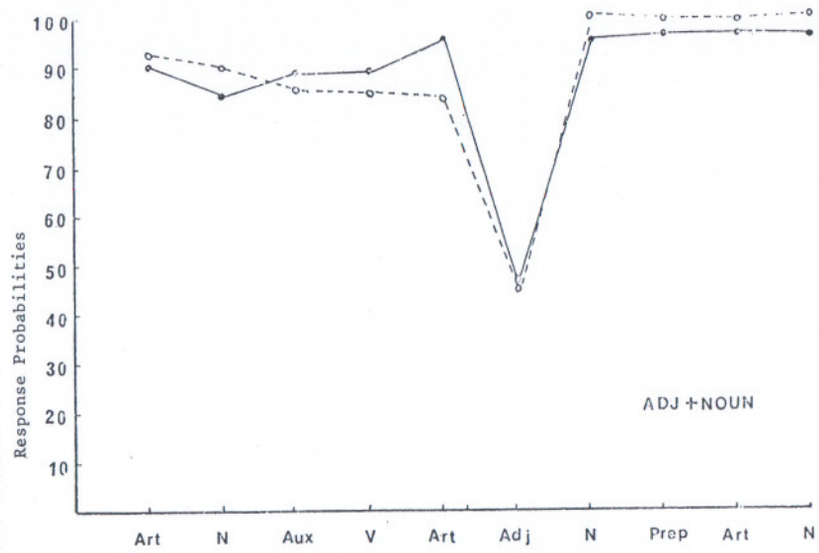

Fig. 1. Probability of response to each word of the sentence presented under RSVP when the adjective precedes the noun in nominal compound sentences and noun-phrase-like sentences.

Results

Figures 1 and 2 show the cumulative results for the four kinds of experimental sentences averaging all subjects' detections for each word. For each type of sentence, we calculated the response probability for the corresponding element. From simple inspection of the figures, it immediately becomes apparent that there is a selective failure to report the adjective irrespective of whether it is preceded or followed by a noun and of whether it has appeared in a compound-noun or noun phrase.

In Tables I and II, we have indicated the frequencies with which the adjective and the noun are reported for all cases: pre- or post-posed, in compound nouns, and in nominal phrases. In all instances, the noun is reported twice as frequently as the adjective, regardless of the adjective's role or position. A sign test across sentences or across subjects showed a $p = 0.01$. In fact, the response probabilities for adjectives are the same regardless of

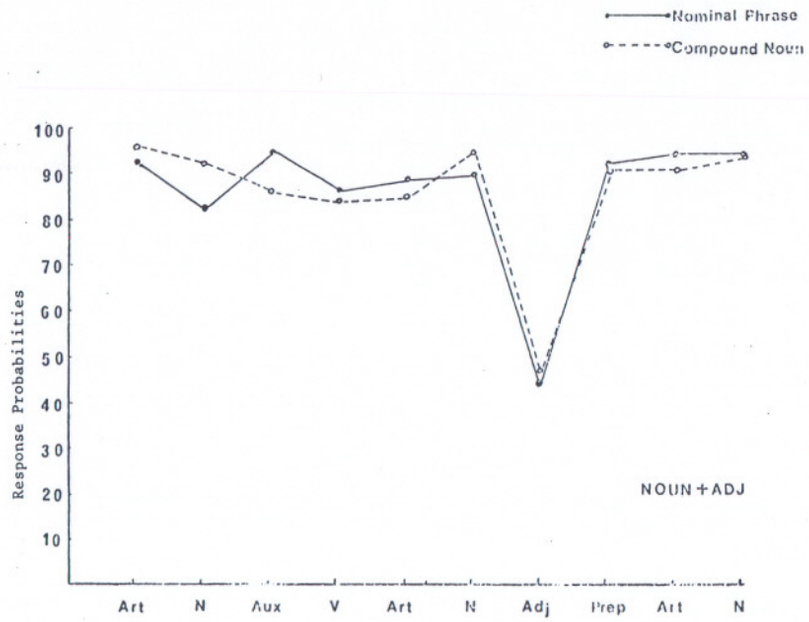

Fig. 2. Probability of response to each word of the sentence presented under RSVP when the noun precedes the adjective in nominal compound sentences and noun-phrase-like sentences.

Table I. Probabilities of Response for Noun-Adjective and Adjective-Noun Pairs

	N	Adj	Pair
Noun + adjective	92.5	45.0	42.5
Adjective + noun	95.0	45.6	45.0

Table II. Probabilities of Response for Compound Noun and Nominal Phrase

	N	Adj	Pair
Compound noun	95.0	45.6	45.0
Nominal phrase	91.2	46.2	45.0

whether the sentences are inspected as a function of the position of the adjective or its role. The same pattern can be observed for the compound noun and nominal phrase. These results therefore demonstrate that subjects omit reporting words that, depending on their lexical category, modify other terminal elements in a string. What remains to be seen, of course, is why adjectives are disregarded. Is lexical category the one and only parameter that can account for the results obtained in this experiment?

Before attempting to answer this question, we will present a control experiment in which it will be shown that the lower response probability on adjectives as compared to nouns does not depend, even in the case of nominal compounds, on whether the elements in the sentences are presented in sequence rather than simultaneously. This additional experiment appears important since, without it, it might be possible to attribute our preceding results to the fact that the terms of one lexical unit (compound noun) were presented disjointedly.

CONTROL EXPERIMENT

Materials and Procedure

Sentence material was identical to that already employed in Experiment 1. Although the experimental procedure was also analogous to that previously used, the important difference was that we presented the sentences two words at a time on the screen. This presentation was selected in order to compare

the performance on adjectives and on nouns when these items were presented one by one and in pairs.

Subjects

Two groups of 20 subjects each were presented, respectively, with the A and B sets of sentences. All subjects saw three training sentences before the actual experimental material was presented.

Results

Since in global terms our results were very similar to those we obtained in Experiment 1, we will concentrate only on those aspects of the results that bear on the specific control hypothesis that we set out to test. The results presented in Table III show that the probability of responding with an adjective is lower than that of responding with a noun irrespective of whether the two are presented together in the same window or successively.

Discussion of Experiment 1 and the Control

Our results, like those of Forster, demonstrate that adjectives are selectively omitted from subjects' responses when they operate under RSVP. This phenomenon could be due to two main factors:

1. Subjects scan words in terms of their lexical category and select to leave adjectives out of their responses. They do so even if the adjective plays a role other than that of a strict modifier as in the case of nominal compounds.
2. Subjects scan elements in RSVP under strong distributional hypotheses or heuristics. Hence, when an adjective either precedes or follows a noun in a nominal phrase, it is considered a modifier and dropped. If, however, an adjective appears in another position such as following a copula verb, its function is considered one of importance (attribute and comment of the sentence) and will be preserved in subjects' reports. It should be noted that under this second possibility it is not the role or function of the adjective that is significant but rather its potential function as a consequence of its sequential appearance in the sentence.

Table III. Probabilities of Response for Noun and Adjective of the Compound Noun

	N	Adj	Pair
Noun + adjective	92.6	37.0	30.0
Adjective + noun	94.1	44.1	43.8

EXPERIMENT 2

Since our first experiment and control did not allow us to come to any conclusion regarding the two possible reasons for omission of adjectives, we decided to run a second experiment. We did this by presenting subjects with sentences in which the adjectives played a major role but nonetheless remained unambiguously adjectives. For instance, consider the sentence

5. At the beach the sand is warm all day long.

In sentences like this, the adjective is the principal item in the statement expressed. It was our contention that if adjectives were still not reported in sentences like 5 presented under RSVP, one would tend to opt for the first reason stated above. If, however, adjectives were well reported, then the second possibility would appear to be the more likely one.

Procedure

The procedure followed was almost identical to that used in the earlier experiments. The only difference was that subjects were requested to provide a verbal report of what they had seen on the computer screen rather than write it down in a response booklet as in Experiment 1 and the control.

Materials

We constructed a list of eight sentences which all had the same syntactic structure and number of words (ten words as previously). The adjective was always in the same position as before, namely, sixth and seventh. The syntactic structure of all the sentences displayed was identical to that in 5, i.e., $NP_1 + NP_2 + V + NP_3$. (See Appendix II.)

Method

All subjects received four training sentences and eight experimental sentences. In order to reduce the subjects' syntactic expectations, five padding sentences were mixed into the experimental sentences.

Subjects

Two groups of 20 subjects each were used for this experiment. They all belonged to the French university system. They were not remunerated for their participation.

Results

The results are presented in Fig. 3. Response probabilities by words in the sentence are presented for all subjects as well as for all sentences. The curves presented appear to indicate that there might be a very slight serial position effect (see Forster, 1970). There seems to be virtually no difference between the two curves, and in general there would not appear to be any selective response suppression for the adjective as compared to the noun nor, for that matter, for any other lexical item. The mean response frequency for adjectives is 68%, while the mean for verbs is 73% and for N_2 is 78%. This result for the attribute adjectives contrasts with the results presented in Experiment 1 where adjectives occupied positions in which they would normally only be called on to play a modifying-of-the-noun role. These results suggest that the inclusion of a term in subjects' responses is a function of several parameters of which the most important sems to be the potential role

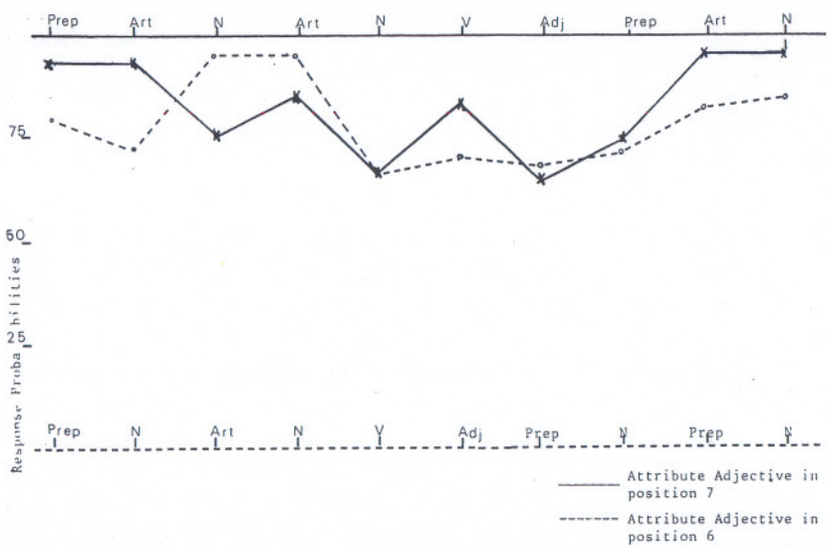

Fig. 3. Probability of response to each word of the sentence presented under RSVP in sentences where the adjective is an attribute in either position 6 or 7.

that the term may be called on to play in the sequence. This potential role is generally specified by the lexical category to which the term belongs and by the position it occupies relative to the other relevant terms in the sequence. When the item is an adjective preceding a noun (or following a noun), its most probable role is that of a modifier to that noun and it is consequently missing from the report when subjects are performing under severe time pressures. Conversely, when an adjective follows immediately after a stative verb as is the case with sentences like those used in this experiment (sentence 5), subjects generally tend to include it in their report even when they are operating under heavy time pressure.

GENERAL DISCUSSION

The results that we have reported here are consistent with those written up by Forster and Ryder (1971). As a matter of fact, under time pressure like that which is present with the RSVP technique, subjects tend to drop adjectives from their reports if they are presented with very simple sentences.

It was our assumption that subjects fail to report adjectives in simple sentences because of the way in which they organize their responses. Our experiments throw some light on this for subjects operating under RSVP. In fact, the principal notion emerging from our work is that of the *potential* role of an item in a well-formed sequence. Since our subjects were asked to report the "sentences" they saw rather than "lists" of unrelated words, they had a tendency to employ whatever heuristics they could in order to improve their performance. Given the pressure of time, rather than report all the items presented, subjects were obliged to simplify the material. One way of doing this, of course, may have been to preserve the key lexical items of the sentence irrespective of the effect this might have on all the other items in the sentence. However, it seems dubious that subjects could achieve such simplification without the formulation of overall strategies based on the syntactic regularities of the sentences. For instance, subjects could make the assumption that words should be treated as pairs or triplets in order to discover the surface constituents. If constituents are longer than two words, subjects may preserve elements that can serve as subjects, objects, and verbs while dropping other content words.

Although the *ad hoc* strategies stated above may be important, the notion of potential role tends to support the view by which subjects respond within an active frame of hypothesis generation. In fact, the general idea we are proposing is that subjects generate hypotheses on the structure of a

sentence on the basis of partial information. Several other authors have postulated similar views (Fodor and Garrett, 1967; Bever, 1970) in somewhat different contexts. Nonetheless, what is important is that when subjects process a stimulus consisting of a sequence of elements, not only are its appearance and category of some importance, but also the potential role attributed to individual items in a series from the information that has been gathered during the reception and organization of the previous items.

The notion of potential role accounts for the similarity in the results obtained with adjectives in nominal compounds and nominal phrases. In both cases, the actual functions are different but the potential role is the same, i.e., an adjective before or after a noun is usually a modifier. The potential role can also account for the frequency with which an attribute adjective is generally reported. In fact, in sentences like 5, if the subjects have seen all the items up to and including the verb, the most likely item they can expect is one whose potential and actual role is that of attribute. That is why in all likelihood the attribute, the main aspect of the comment of the sentence, is present in the subjects' reports. The distinction between the actual and the potential role of a term allows us to understand the difference in behavior when subjects are attempting to understand a sentence under normal conditions and when they are processing it perceptually—more particularly, under time pressure, as in RSVP.

Segui (1974) has demonstrated that the frequency with which a word is recalled is a function of the actual role of this word in the sentence. Nevertheless, under RSVP, it is the potential rather than the actual role that determines the frequency with which the word is reported. This appears reasonable, since subjects participating in a memorization task are in possession of the explicit actual role of an item, while under RSVP subjects have only very poor notions of the roles and of the items they are receiving. In the latter case, the subjects are almost compelled to assign a potential or even hypothetical role to the items to be received. It is because the actual role might not coincide with the potential role that the subjects tend to assign to an item that the discrepancy between memory tasks and RSVP tasks arises.

APPENDIX I

Set A

Les laboureurs ont trouvé des grosses souris dans le grenier.
La pluie a inondé la basse-cour de la ferme.

Le chauffeur a apporté le coffre gris dans un camion.
Les domestiques ont installé des chaises-longues dans le parc.
Le docteur a besoin de sang frais pour cette opération.
Les enfants ont reconnu leur grand-père à la gare.
Le medecin a mis la jolie femme à la porte.
Le redacteur a supprimé quelques mots-croisés de cette édition.

Set B

Les laboureurs ont trouvé des chauves-souris dans le grenier.
La pluie a inondé la petite cour de la ferme.
Le chauffeur a apporté le coffre-fort dans un camion.
Les domestiques ont installé des chaises blanches dans le parc.
Le docteur a besoin de sang-froid pour cette opération.
Les enfants ont reconnu leur grand frère à la gare.
Le medecin a mis la sage-femme à la porte.
Le rédacteur a supprimé quelques mots grossiers de cette édition.

APPENDIX II

Sentences with Adjective in Position 6

Au Maroc les maisons restent fraiches aux heures de chaleur.
A table les enfants sont sages pendant tout le repas.
Au lycée les fenêtres restent fermées aux heures de cours.
En Bretagne la mer parait grise la plupart du temps.

Sentences with Adjective in Position 7

Dans les musées les visiteurs restent silencieux pendant des heures.
A la campagne la pluie est nécessaire avant la moisson.
Dans les restaurants les tables sont prêtes depuis le matin.
Sur les plages le sable est chaud toute la journée.

REFERENCES

Bever, T. G. (1970). The cognitive basis for linguistic structures. In Hayes, R. (ed.), *Cognition and the Development of Language*, Wiley, New York.
Fodor, J. A., and Bever, T. G. (1965). The psychological reality of linguistic segements. *J. Verb. Learn. Verb. Behav.* 4:414-420.

Fodor, J. A., and Garett, M. (1967). Some syntactic determinants of sentencial complexity. *Percept. Psychophys.* **2**:289-296.

Fodor, J. A., Garrett, M., and Bever, T. G. (1968). Some syntactic determinants of sentencial complexity. II: Verb structure. *Percept. Psychophys.* **3(6)**:453-461.

Forster, K. I. (1970). Visual perception of rapidly presented word sequences of varying complexity. *Percept. Psychophys.* **8**:215-221.

Forster, K. I., and Ryder, L. A. (1971). Perceiving the structure and meaning of sentences. *J. Verb. Learn. Verb. Behav.* **10**:285-296.

Garrett, M., Bever, T. G., and Fodor, J. A. (1966). The active use of grammar in speech perception. *Percept. Psychophys.* **1**:30-32.

Holmes, V. M., and Forster, K. I. (1972). Perceptual complexity and underlying sentence structure. *J. Verb. Learn. Verb. Behav.* **11**:148-156.

Martin, E., and Walter, D. A. (1969). Subject uncertainty and word class effects in short-term memory for sentences. *J. Exp. Psychol.* **80**:47-51.

Mehler, J., and Carey, P. (1967). Role of surface and base structure in the perception of sentences. *J. Verb. Learn. Verb. Behav.* **6**:335-338.

Segui, J. (1973). Contribution à l'étude de la mémorisation des phrases. Unpublished doctoral dissertation, Université René Descartes, 1973.

Segui, J. (1974). La rétention différentielle des composants de la phrase: rôle fonctionnel ou catégorie syntaxique? *Ann. Psychol.* **74(1)**:171-178.

Wearing, A. J. (1971). Word class and serial position in the immediate recall of sentences. *Psychon. Sci.* **25(6)**:338-340.