

Speeded recognition of ungrammaticality: Double violations*

TIMOTHY E. MOORE

Glendon College, York University

IRVING BIEDERMAN

State University of New York, Buffalo

Abstract

A model of sentence comprehension postulating that Subject-Verb-Object relations are specified prior to Noun-Adjective relations received support from a study of the speed at which sentences with various kinds of violations could be rejected. Compatible with the sequential model was the finding that Noun-Verb and Adjective-Noun double violations did not result in shorter RTs than Noun-Verb single violations – even though sentences with double violations were judged to be less acceptable.

Introduction

Anomalous sentences can vary in their degree of ungrammaticality. Thus most speakers of English judge: *Pretty dresses admire young bachelors* to be more ungrammatical than *Nosey ditches annoy suburb dwellers*. (Moore, 1972). Chomsky (1965) suggested that degrees of ungrammaticality could be assigned on the basis of where, in the sequence of steps by which a sentence is generated, the violation occurred. A hierarchy of three classes of grammatical rules was proposed such that the earlier in the hierarchy a violation occurred, the greater was the degree of ungrammaticality. First, *lexical category* rules specifying the locus of parts of speech are applied. Such rules determine, for example, that a verb phrase must have a verb and a noun phrase a noun. Second, *strict subcategorization* rules are applied. These specify the necessary features that the verb must possess for the major constituents of the sentence to agree. For example, such a rule would specify when

*We are grateful to Jan C. Rabinowitz for his help in running subjects and analyzing the data. Supported by NIMH Research Grant MH-22383 to Irving Biederman. Requests for reprints should be sent to Timothy E. Moore, Department of Psychology, Glendon College, York University, 2275 Bayview Avenue, Toronto, Ontario M4N 3M6 Canada.

a transitive instead of an intransitive verb was required. Third *selection restriction* rules were applied for subject-verb, verb-object or adjective-noun agreement.

Moore (1972) examined the speed at which a sentence was judged to be ungrammatical as a function of the level of the grammatical violation in Chomsky's hierarchy. Subjects first studied a sentence frame in which a word was deleted but its position designated by a dash. A word was then presented to the subject and he had to judge whether it would make a grammatical sentence if inserted in the designated position. Table 1 shows sample violations for the verb (V), subject (S) and object (O) positions. Since strict subcategorization is defined only for verbs, Moore (1972) distinguished between subject-verb (S-V) or verb-object (V-O), and adjective-noun (Adj-N) selection restrictions. In agreement with a direct extension of Chomsky's hierarchy to performance, Moore found that lexical category violations (Level 1) were most quickly detected. However, the other major comparisons ran counter to Chomsky's hierarchy. For nouns, S-V and V-O selection restriction violations were more quickly detected than Adj-S and Adj-O violations. For verbs, the detection of S-V selection restriction violations required no more time than the detection of strict subcategorization violations (viz., violations of transitivity). This latter finding for verbs represented a particularly serious failure of Chomsky's hierarchy to predict grammaticality judgments, since Chomsky had primarily constructed the hierarchy to handle the distinction between strict subcategorization and selection restriction for verbs.

To account for his results, Moore (1972) proposed that these grammaticality decisions depended upon whether the deviation occurred within the subject-verb-object (S-V-O) sequence of a sentence, or a subordinate part of the sentence. Since N-Adj violations were recognized less quickly than S-V-O violations, it was suggested that during the sentence comprehension process, the subject first considers S-V-O relations, and then N-Adj relations. The present study attempted to replicate and further extend these findings – particularly as they apply to the saliency of S-V-O relations in sentence comprehension. The study was also designed to distinguish between sequential and parallel models for the Moore (1972) findings.

Why are violations of S-V-O relations detected faster than Adj-N violations? Two kinds of *serial* models, in which only one relation can be tested at a time, can be postulated to account for this result. In the *fixed-order* serial model, S-V-O relations are always tested prior to the test of Adj-N relations. Alternatively, a *random-order* serial model would hold that sometimes S-V-O relations and sometimes Adj-N relations are tested first. The faster RTs for S-V-O relations could reflect that violations of these relations are simply easier to detect. Some support for this latter interpretation can be found in

Table 1. *Example sentences and violations*

| Violation Location | Example | Violation | Violation Level |
|--------------------|---|--|-----------------|
| Verb | 1. Noisy dogs <i>growl</i> night animals. | Strict subcategorization | 2 |
| | 2. Oil patches <i>enjoy</i> California beaches. | S-V selection restriction | 3 |
| | 3. Old houses <i>quarrel</i> valuable relics. | Redundant (S-V + Strict subcategorization) | 2 + 3 |
| Subject | 4. Pretty <i>dresses</i> admire young bachelors. | S-V selection restriction | 2 |
| | 5. Nosey <i>ditches</i> annoy suburb dwellers. | Adj-S selection restriction | 3 |
| | 6. Benevolent <i>walls</i> care for aging parents. | Redundant (S-V + Adj-S) | 2 + 3 |
| Object | 7. Artful speakers intrigue large <i>trucks</i> . | V-O selection restriction | 2 |
| | 8. College students dislike arrogant <i>desks</i> . | Adj-O selection restriction | 3 |
| | 9. Stage nudity offends prudish <i>handles</i> . | Redundant (V-O + Adj-O) | 2 + 3 |

Moore's (1972) data on the scaling of the degree of ungrammaticality of the various violations: S-V-O violations were judged to be more ungrammatical than Adj-N violations. That violations of S-V-O relations might be easier to test than Adj-N violations makes Moore's result also compatible with a *parallel* model in which testing of the two kinds of relations is initiated simultaneously but in which the S-V-O violations tend to be completed first.

The experimental strategy by which we sought to distinguish among these possibilities employed a condition in which both S-V-O *and* Adj-N violations were violated within the same sentence. For example, "Ailing *windows* enjoy pleasant company", violated the S-V relation (windows-enjoy) as well as a Adj-N relation (ailing-windows). For the fixed-order serial model, the addition of an Adj-N violation to a S-V-O violation would not be expected to affect latencies (compared to a sentence with only a S-V-O violation), since the S-V-O relation is always tested first. The serial-random order model holds that since the subject will sometimes initiate the slower Adj-N test, before the S-V-O test, RTs will be lengthened by the presence of a double violation. Therefore, RTs for sentences with two violations should be somewhere between the RTs to detect the individual violations (The random order model also must assume that a test of a given relation that is not violated is completed faster than when the relation is violated. Compatible with this result is Moore's finding that RTs to acceptable sentences were faster than to sentences with a violation.)

A parallel model assumes that the component processes by which various violations are detected are initiated simultaneously. If it is further assumed

that the distribution of latencies of the two component processes overlap and are uncorrelated with one another, then in a sentence with two violations, sometimes one and sometimes the other violation will be detected first. On the average, the time for the first violation to be detected will be less than the average of each of the violations taken individually. If a response can be initiated as soon as any violation is detected, then a sentence with two violations should yield faster RT's. This apparent gain in speed when there is a surfeit of violations would be achieved by capitalizing upon the variability of the two component times. Biederman and Checkosky (1970) further describe these predictions and assumptions and present evidence for such parallel processing in a multidimensional identification task.

The logic of testing these models can also be considered for the detection of violations in the V position. These violations were either of S-V incompatibility (and thus identical to the S-V violations in the S position) or violations of transitivity in which an intransitive verb was followed by a NP. Moore (1972) found that detection of S-V violations (in the V position) required no more time than detection of transitivity violations.

The above predictions of the absence or presence of a redundancy gain for the serial and parallel models respectively, are based on the assumption that as soon as a violation is detected, a response is initiated. If this is not done, then RTs to sentences with two violations would be longer than the longest of the individual violations. When the subject is judging grammaticality at a leisured pace as in a paper-and-pencil rating task, however, double violation sentences would be expected to yield the worst ratings by both the parallel and the sequential model. Since there are two independent sources of deviation in the same sentence, the subject can exhaustively process the sentence for violations before responding with his grammaticality rating. This prediction, tested in Experiment II, is based on the assumption that the greater the number of violations that the subject detects, the higher will be the ungrammaticality rating.

Experiment I

Experiment I was designed to determine whether S-V-O and Adj-N relations are detected sequentially or simultaneously by noting whether a redundancy gain in RT would result from multiple violations in a speeded detection task.

Method

Subjects

The 16 subjects were one faculty member, five graduate student volunteers, and ten freshmen psychology students.

Design

Three levels of grammatical violations (Level 2, Level 3, and Level 2 + 3) were varied in three deep structure locations (subject, verb, and object). Three different sentence types were used (active, passive, and prepositional), with six exemplars of each kind of violation for each type in each location. This resulted in 162 different ungrammatical sentences. The first three and the last three exemplars were separately analyzed to yield a practice variable. Thus a $3 \times 3 \times 3 \times 2$ (Violation Level \times Location \times Sentence Type \times Practice) design characterized the ungrammatical sentences. An equal number of grammatical sentences was added in order to equalize Yes and No responses. Table 1 contains examples of the three types of violations, in each of the three locations, for active sentences. For prepositional sentences, strict subcategorization violations in the verb position consisted of a transitive verb in a context requiring an intransitive verb. In the object positions, the object was incompatible with either the preposition (e.g., "...during the vicious *tiger*."), the adjective (e.g., "...through the terrified *bushes*."), or both (e.g., "...inside the damp *emotion*."). The *underlined* words were the ones which were omitted when the sentence frames were presented. This design is similar to the Moore (1972) study, except that lexical category violations were omitted, and a redundant condition (level 2 + 3) was added. Note that sentences in the redundant (2 + 3) condition have two independent sources of ungrammaticality, i.e., Level 2 and Level 3 violations occur simultaneously. Thus in "Colored posters *talk* dorm rooms", *talk* is unacceptable both because a transitive verb is required, and because there is subject-verb disagreement. A strict subcategorization rule and a selection restriction are both being violated at the same time. Similarly in "Benevolent *walls* care for aging parents", *walls* is inadmissible because there is subject-verb disagreement *and* subject-adjective disagreement. A more extensive discussion of these various violations can be found in Chomsky (1965).

For presentation purposes, the sentences were divided into six blocks of 54 sentences each. A block contained 18 sentences of each of the three types. Sentences within any one block were presented in a random order. A different random order was used for each block, and each subject received a different order of blocks. All subjects received the same random order of sentences within any one block. A practice block of 20 sentences was administered to

each subject at the beginning of the experiment. Although the practice sentences were not drawn from the sentences used in the experiment, they were representative of those used.

Apparatus

Each sentence frame was typed onto a sheet of a 5 × 8 inch looseleaf book. Six booklets contained the 54 sentence frames for each block. The words were projected onto a screen in front of the subject by means of a slide projector. The subject responded by depressing one of two microswitches in front of him. The response and the RT were monitored and recorded by the experimenter. Reaction times to the nearest 100th of a second were measured from the onset of each word.

Procedure

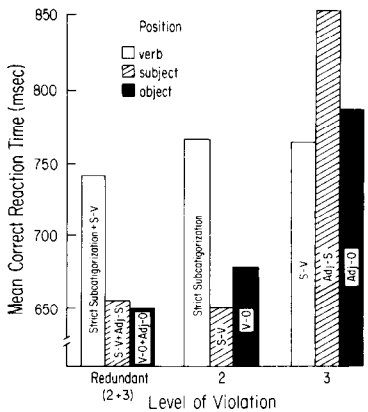
The subject read each sentence frame and then pushed a button which initiated the projection of a word one second later. If the word, in the subject's opinion, appropriately completed the sentence, he was to press the key labelled 'Yes'; if it did not, he was to press the 'No' key. The subject was urged to be as fast and as accurate as possible. There was a pause of about one minute after each block to enable the experimenter to change slide trays and card sets.

Materials

Level 2, level 3, and correct sentences were taken from Moore (1972), with a few modifications and substitutions.¹ New sentences were constructed for the redundant (2 + 3) condition. All sentences could have been perfectly acceptable by the addition of an appropriate word in the blank slot. "Correct" sentences matched the ungrammatical ones with respect to the position of the blank and sentence type (but had different words). Thus the subject had no way of knowing whether or not the sentence would be acceptable until the word had been presented.

¹The assignment of the different kinds of relations to "levels" requires some explanation. Level 1, which was not manipulated in this experiment, refers to lexical category violations. Level 2 and Level 3 represent different kinds of violations for the subject and object positions than they do for the verb position. For subject and object position, Level 3 violations are violations of Adjective-Noun (Adj-N) selection restrictions and Level 2 violations are violations of Noun-Verb (either S-V or V-O) selection restrictions. For the verb position, Level 3 violations were all violations of S-V selection restrictions and Level 2 violations were violations of strict subcategorization (all of transitivity). 'Level' was originally intended to indicate the relative position of a given violation within the sequence of derivational rules for that sentence. In this respect, the assignment of 'levels' for S and O violations is theoretically incorrect. N-Adj compatibility is actually specified *earlier* in the derivation than are N-V or V-N relations. This *faux pas* does not affect the data, or their interpretation.

Figure 1. Mean correct reaction times as a function of Level and Position of Violation.



Results and Discussion

Figure 1 shows the effects of violation level and location. The mean RT for Level 3 sentences (801 msec) was over 100 msec longer than the means for Level 2 (697 msec) or Level 2 + 3 (681 msec). (The mean RT for correct sentences was 661 msec.) The differences produced a highly significant main effect of Level of violation; $F(2,30) = 57.3, p < 0.001$. RTs in the verb position were slightly longer than those in the subject or object positions (756, 719, and 705 msec, respectively), $F(2,30) = 10.21, p < 0.001$.

As shown in Figure 1, there was no difference in RTs between Level 2 and Level 3 violations in the verb position, but RTs for Level 2 violations in the subject and object positions were substantially faster than Level 3 RTs. This interaction between Location and Level was highly significant $F(4,60) = 24.21, p < 0.001$, and closely replicates Moore's (1972) findings. The group data shown in Fig. 1 is also representative of individual subjects. Thus all 16 subjects had shorter RTs in Level 2 than in Level 3 for both subject and object positions but only 7 had shorter RTs in Level 2 in the verb position.

The comparison of critical interest in this study is that between Level 2 (the faster of the two violation levels) and Level 2 + 3. As can be seen from Figure 1 there was a slight redundancy gain in the verb and object positions, and a minuscule loss in the subject position. Since the RTs in the subject and object position were not intermediate between Level 2 and Level 3, we can rule out a random order serial model. (In the verb position, Level 2 and Level 3 violations were equivalent so a test of the random versus fixed order serial models was not possible.) A separate analysis of variance was performed upon RTs from Level 2 and Level 2 + 3. The effect of Level fell short of sig-

nificance, $F(1,15) = 3.21$, $0.10 > P > 0.05$. The main effect of Location was significant, $F(2,30) = 40.34$, $p < 0.001$, due to longer RTs in the verb position. The Level \times Location interaction, $F(2,30) = 1.04$, $p < 0.25$, was not significant.

The borderline (nonsignificant) presence of a possible redundancy gain required a more detailed analysis of the data. In order for a redundancy gain due to parallel processing to occur, there must be sufficient overlap in the distributions of RTs between Level 2 and Level 3. For 'sufficient overlap', we required that the difference in mean RTs between Level 2 and Level 3 be less than 1 S.D. (calculated for the Level 3 distribution). Fourteen subjects met this criterion in the Object position, but only eight showed a redundancy gain, while five showed a loss, and there was one tie. In the Subject position, 12 subjects met the criterion; six showed a gain, and six showed a loss. The result of this analysis, therefore, is that those subjects who met conditions more conducive for a redundancy gain did not reveal it in any greater magnitude than those subjects whose distributions for Level 2 and Level 3 did not show enough overlap for a redundancy gain to occur. It should be noted that redundant violations in the verb position consisted of two different types of S-V-O disruption – namely strict subcategorization and selection restriction rules. A serial self-terminating search of these two relations would account for the absence of a redundancy gain in the verb position, although it cannot be determined from these data which component is the first to be tested. The slight, nonsignificant, gain in speed for Level 2 + 3 for the verbs might, in fact, have represented a redundancy gain produced through parallel processing. However, parallel processing should also have produced a reduction of variance – since responses would be triggered by sampling from only the faster portions of the separate distributions. While 11 of the 16 subjects when responding in the Verb position had shorter RTs in Level 2 + 3, only 4 of these people showed a reduction in variance in Level 2 + 3 compared to Level 2. None of the five people who were actually slower in Level 2 + 3 for the Verb position showed a reduction in variance. Consequently, we conclude that the apparent small gain in speed for Level 2 + 3 for the verb position does not provide evidence for parallel processing. A fixed order serial model provides the best account of these data. The similarity in RTs between Level 2 and Level 2 + 3 provides support for the idea that violations from different levels have *independent* effects on these judgments of grammaticality. If, instead, multiple violations had an integrated or interactive effect, it would have been highly unlikely for the Level 2 + 3 condition to yield RTs that were so similar to those of Level 2.

Fodor, Bever, and Garrett (1968) and Moore (1972) have both argued that the verb has much more of a syntactically constraining influence upon subject

and object, than subject or object have on the verb. Supporting these arguments is our finding that when the verb was missing, the reader was more at a disadvantage than when subject or object were missing. RTs for Level 2 and Level 2 + 3 were longer in the verb position than in subject or object – hence the main effect of Location. As in the Moore (1972) experiment, Level 3 violations in the verb position, and Level 2 violations in the subject position each consisted of the same kind of deviation – subject-verb disagreement. Such disagreement was recognized much more quickly (>100 msec) when the verb was present and the subject missing, than it was with the subject present and the verb missing.

These data provide no support for the notion that the verb phrase (VP) is a psychological unit. Bloom (1970), Chomsky (1965), and McNeill (1971), usually within a developmental context, have all argued that certain syntactic structures such as VP, whether innate or learned, play an instrumental role in early language acquisition (see Bowerman, 1973, for a critique of this approach). Anderson and Bower (1973) provided some marginal evidence in support of their claim that V-O constitutes a more natural memory unit than S-V, during cued recall of sentences. If the VP is an independent, or partly independent, unit in sentence recognition then, in the present study, we would expect a difference in RTs between subject and object positions for Level 2 or 2 + 3 violations. Specifically, RTs in the object position should be faster, since the verb would reduce uncertainty concerning the anticipated object more than it would for an anticipated subject. No such differences exist in these data ($F(1,120) < 1$, in all cases, across all sentence types). To the extent that the main verb provides heuristic clues for the recovery of deep structure, its influence upon the subject and object appears to be symmetrical. There does not appear to be some extra redundancy present in a VP which could allow the subject to predict (and thus reject) a candidate for object any more efficiently than for the subject.

Practice and secondary interactions

Reaction times were 65 msec shorter during the second half of the experiment than in the first half, ($F(1,15) = 19.07, p < 0.001$). In addition to Violation Level \times Location, there were three significant interactions: Level \times Type ($F(4,60) = 4.33, p < 0.005$), Level \times Location \times Type ($F(8,120) = 5.3, p < 0.001$) and Level \times Location \times Practice ($F(4,60) = 3.12, p < 0.025$). The latter interaction was the result of a lack of an effect of practice for Level 2 violations in the verb position. The Level \times Location effect (Fig. 1) was, nonetheless, representative of both practice blocks. There is no obvious reason why RTs in this particular cell should not have benefited from

Table 2. *Mean correct reaction times (msec) as a function of Violation Level, Location, and Sentence Type*

| | Active | | | Passive | | | Prepositional | | |
|---------|--------|-----|-------|---------|-----|-------|---------------|-----|-------|
| | Level | | | Level | | | Level | | |
| | 2 | 3 | 2 + 3 | 2 | 3 | 2 + 3 | 2 | 3 | 2 + 3 |
| Verb | 798 | 753 | 716 | 746 | 781 | 766 | 749 | 752 | 738 |
| Subject | 666 | 835 | 648 | 618 | 938 | 659 | 664 | 790 | 656 |
| Object | 680 | 775 | 634 | 692 | 758 | 663 | 660 | 830 | 653 |
| Mean | 715 | 788 | 666 | 685 | 826 | 696 | 691 | 791 | 682 |

practice, as did the others. It was possibly due to sampling variability since there were no interactions with practice in the Moore (1972) data.

The Level \times Type and Level \times Location \times Type interactions are shown in Table 2. Slight and unsystematic differences between types across the three levels result in the Level \times Type interaction. The main effect of Level is obviously the same for all three sentence types. Similarly, the Level \times Location interaction remains prominent across the three sentence types. Most of the Level \times Location \times Type interaction appears to be attributable to differences between subject and object RTs in Level 3. For actives and passives, RTs were faster in the object position – significantly so for passives ($F(1,120) = 27.6, p < 0.001$), while for prepositional sentences the direction of the difference was reversed. Although the Level \times Location \times Type interaction was not significant in the Moore (1972) study, the same pattern of differences existed there – including a significant subject-object difference for passives ($F(1,88) = 7.8, p < 0.01$), and the reversal for the prepositionals. Objects in prepositional sentences are governed by a preceding preposition. To the extent that this might result in different noun types for these sentences, adj-object disagreement might be more difficult to perceive. There is no apparent reason why adj-subject disagreement should be more difficult to recognize than adj-object disagreement for passives, but since the same difference was noted in the Moore (1972) study, it is probably a reliable effect.

The absence of any strong differences due to sentence type is more noteworthy than the above-mentioned discrepancies. Whatever the nature of the process a person uses to uncover S-V-O relations, it appears to be relatively unaffected by the surface order of S, V, and O.

Errors

The error rate was 4.5%, with an approximately even split between false positives and false negatives (113 vs. 121). The total number of errors com-

mitted for Levels 2, 3 and 2 + 3 were 25, 67, and 21, respectively. Since the Noun-Verb level contained the most errors, as well as the longest RTs, an interpretation in terms of a speed-accuracy trade-off is unwarranted.

Experiment 2

The results of Experiment 1 were consistent with a model of sentence recognition whereby the subject can initiate a response as soon as a violation is detected. Moreover, at least for violations in the S or O location, it was clear that violations of S-V-O rather than Adj-Noun relations control the response. This interpretation was substantiated by the lack of a redundancy gain for sentences containing a compound violation. In a scaling task, where a subject is rating the grammaticality of sentences, we would expect sentences with multiple violations to receive worse ratings than those containing either of the violations alone. When judging grammaticality, the processing of S-V-O relations may be completed (serially or in parallel) prior to Adj-Noun relations. However, since there is no time constraint, the relations can be exhaustively processed and both errors can be discovered. Thus, ratings should reflect the presence of these double violations.

Method

The subjects were 25 students enrolled in Introductory Psychology at the State University of New York at Buffalo. They were tested in groups of 5 or 6 each. All sentences were presented once to each subject. A different pseudo-random order of sentences was used for each subject. The complete instructions were as follows:

“This is part of an experiment on the psychology of language. The objective of such research is to knit together the sciences of psychology and linguistics. We regard it as important and would appreciate your cooperation. We are interested in your impression as to how sentences may deviate from acceptability. By acceptable, we mean sentences that could occur in normal, everyday usage. Some of the sentences you will see will be more unacceptable than others. Some will be perfectly all right. For example, *The plane flew into a raging temper* is unacceptable, as is *The heavy book talked to the table*. This task is subjective. There are no right or wrong answers. We want to know *how* deviant you think the sentences are. On the line after each sentence, rate the acceptability of that sentence by assigning it a number from 1 to 100. If it is completely acceptable, give it a 1. If it is less than completely

acceptable, give it a number from 2 to 100, depending upon *how* unacceptable your feel it to be. You may read over a few of the sentences first, in order to get an idea of the range within which you are working. Try to utilize the entire range from 1 to 100."

Results and Discussion

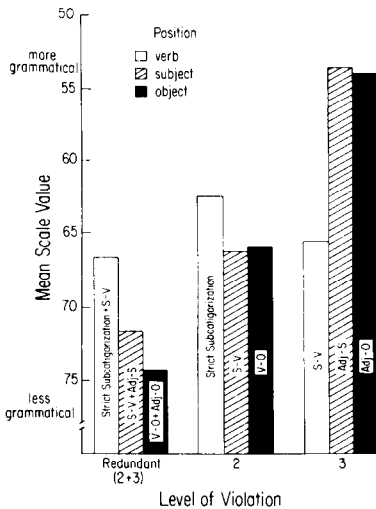
The means of the 18 sentences in each Violation Level \times Location cell were used in an analysis of variance in a 3×3 (Violation Level \times Location) within-subject design. There was a main effect of Violation Level ($F(2,48) = 36.44$, $p < 0.001$) and a Violation Level \times Location interaction ($F(4,96) = 14.84$, $p < 0.001$). The mean scale values for Level 2, 3, 2 + 3, and correct sentences were 64.7, 57.6, 70.7, and 4.7 respectively. The Violation Level \times Location interaction is shown in Fig. 2. The location of violations in Level 2 and 3 had much the same effect upon the ratings as it did upon RTs in Experiment 1, in that, (as Moore, 1972 found), the most quickly recognized violations received the worst ratings. Note also that since Noun-Verb violations in the verb position, and Noun-Verb violations in the subject position both consist of the same sort of violations (S-V disagreement), mean ratings for these two cells do not differ ($F(1,96) < 1$).

As in Experiment 1, a separate analysis of variance was performed upon scale values from sentences with Noun-Verb and double violations. There was a main effect of Violation ($F(1,24) = 11.1$, $p < 0.005$), no effect of location, and no interaction. Thus, as predicted, multiple violations affect grammaticality judgments by decreasing the acceptability of such sentences. The lack of any asymmetry between ratings in subject and object positions (see Fig. 2) argues further against the view that the VP operates as a psychological unit.

General Discussion

As predicted, the multiple violation condition had an appreciable effect upon grammaticality ratings, but neither increased nor decreased RTs in the recognition task, compared to Noun-Verb violations. These results suggest that caution be exercised during the interpretation of studies which use only scale values or ratings as the dependent variable. Grammaticality judgments provide useful information about linguistic intuitions (Moore, 1975) but they do not permit strong inferences to be made about the processing by which those judgments might be produced. Similarly, manipulations which can be

Figure 2. Mean scale values as a function of Level and Position of Violations.



shown to affect prompted or free recall of sentences, need not be related in any direct or necessary way to the sentence perception process (McKoon, 1977).

The results of these studies, in conjunction with the Moore (1972) experiments, cast further doubt on the psychological validity of Chomsky's (1965) hierarchy of grammaticality. However, it should be emphasized that Chomsky (1965) is correct in the sense that intuitions about well-formedness are related to grammatical structure, although not in the precise manner in which he proposed it. In Experiment 1 the data support a process of sentence recognition whereby a subject independently uncovers the S-V-O structure and the Noun-Adj relations in that order (i.e., a fixed order serial process rather than either a random order serial or parallel process). We may also infer that a subject uses knowledge of the syntactic or semantic dependencies between S-V and V-O when computing the S-V-O relation. The absence of any effect of the serial position of the missing S or O element (either in the surface or deep structure) suggests a hierarchical rather than left-to-right computation of S-V-O. This is consistent with Garrod and Trabasso's (1973) preference for a case-grammar (verb, argument) scheme, rather than a canonical S-V-O structure. It is also compatible, in a general sense, with the findings of a recent study conducted by Rips, Shoben and Smith (1978). Using similar methodology, these authors investigated the role of N-Adj and S-V-O relations in sentence comprehension. While their procedures and materials do

not permit a detailed comparison with the present study, they are alike in that neither support a comprehension model compatible with a TG constituent structure analysis of sentences.

All the S-V-O violations used in the present study consisted of S-V or V-O disagreement of one kind or another. Another study using violations, the locus of which resides in S-O disagreement (e.g., Sincerity may strengthen the table) might provide further insight into the nature of the S-V-O computation process. Violations within passive or prepositional sentences were not recognized with any more difficulty than those within active sentences. Olson and Filby (1972) and Wright (1969) have suggested that the comprehension of a passive sentence may not necessarily be more complicated than the comprehension of actives. The results from Experiment 1 are consistent with their claim that passives can be comprehended directly from an object-verb-subject word order. However, since most of the passives in this study, including those in the 'correct' set, were non-reversible, such a comparison may not be entirely appropriate.

Many experiments investigating sentence comprehension have made use of sentence verification tasks of some kind. Usually a subject is presented with a sentence followed by some additional referent (frequently a picture), and is required to compare the truth values of the events (Clark and Chase, 1972; Garrod and Trabasso, 1973; Gough, 1965, 1966; Trabasso, 1972). Such tasks are conceptualized as entailing three mental operations: (1) the formation of an internal representation of the information contained in the sentence, (2) the formation of an internal representation of the picture or to-be-compared referent, and (3) a matching process during which the two representations are compared to one another. By examining the response latencies in verification tasks which utilize various sentence forms (actives, passives, negatives) it is possible to make inferences about the nature of the internal representation (Clark and Chase, 1972). However little is known about how the initial sentence representation is formed. How does a subject construct from the printed (or spoken) sequence of words a mental representation of its meaning? This issue is debated by Tannehaus, Carroll, and Bever (1976) and Carpenter and Just (1976). The present study suggests that an initial step in sentence encoding involves the computation of a S-V-O sequence — accomplished by subject's capitalizing upon his knowledge of the syntactic and/or semantic constraints between verb-actor and verb-object.

References

- Anderson, J. R. and G. H. Bower (1973) *Human Associative Memory*. Washington, Winston & Sons.
 Biederman, I. and S. Checkosky (1970) Processing redundant information. *J. Exper. Psychol.*, 83, 486-490.

- Bloom, L. (1970) *Language Development: Form and Function in Emerging Grammars*. Cambridge, Mass., MIT Press.
- Bowerman, M. (1973) Structural relationships in children's utterances: Syntactic or semantic? In T. E. Moore (ed.) *Cognitive development and the acquisition of language*. New York, Academic Press.
- Carpenter, P. and M. Just (1976) Models of sentence verification and linguistic comprehension. *Psychol. Rev.*, 83, 318–322.
- Chomsky, N. (1965) *Aspect of the Theory of Syntax*. Cambridge, Mass., MIT Press.
- Clark, H. and W. G. Chase (1972) On the process of comparing sentences against pictures. *Cog. Psychol.*, 3, 472–517.
- Fodor, J. A., T. G. Bever and M. Garrett (1968) Some syntactic determinants of sentential complexity II, Verb structure. *Percep. Psychophys.*, 3, 453–461.
- Garrod, S. and T. Trabasso (1973) A dual-memory information processing interpretation of sentence comprehension. *J. verb. Learn. verb. Behav.*, 2, 115–168.
- Gough, P. B. (1965) Grammatical transformations and speed of understanding. *J. verb. Learn. verb. Behav.*, 5, 107–111.
- Gough, P. B. (1966) The verification of sentences: The effects of delay of evidence and sentence length. *J. verb. Learn. verb. Behav.*, 5, 492–496.
- McKoon, G. (1977) Organization of information in text memory. *J. verb. Learn. verb. Behav.*, 16, 247–260.
- McNeill, D. (1971) The capacity for the ontogenesis of grammar. In D. I. Slobin (ed.) *The Ontogenesis of Grammar*. New York, Academic Press.
- Moore, T. E. (1972) Speeded recognition of ungrammaticality. *J. verb. Learn. verb. Behav.*, 11, 550–560.
- Moore T. E. (1975) Linguistic intuitions of twelve year olds. *Lang. Sp.*, 18, 3, 213–218.
- Olson, D. R. and N. Filby (1972) On the comprehension of active and passive sentences. *Cog. Psychol.*, 3, 361–381.
- Rips, L. J., E. Shoben and E. Smith (1978) Semantic composition in sentence verification. *J. verb. Learn. verb. Behav.*, 17, 345–401.
- Tannehaus, M., J. Carroll and T. Bever (1976) Sentence-picture verification models as theories of sentence comprehension: A critique of Carpenter and Just. *Psychol. Rev.*, 83, 310–317.
- Trabasso, T. (1972) Mental operations in language comprehension. In J. B. Carroll and R. O. Freedle (eds.) *Language Comprehension and the Acquisition of Knowledge*. Washington, Winston & Sons.
- Wright, P. (1969) Transformations and the understanding of sentences. *Lang. Sp.*, 12, 156–166.

Résumé

Une étude portant sur la vitesse de rejet des phrases comportant différents types de violations dans les relations Sujet-Verbe-Objet et Nom-Adjectif a permis d'appuyer la proposition que les relations S-V-O sont spécifiques antérieurement aux relations N-A. Le fait qu'une double violation Nom-Verbe et Adjectif-Nom n'entraîne pas un temps de réaction supérieur à celui qu'entraîne la violation Nom-Verbe seule semble compatible avec un modèle séquentiel même lorsque les phrases avec double violation sont jugées moins acceptables.