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ABSTRACT

A reaction-time experiment measured the time that subjects needed to read and comprehend a series of sentences, the syntactic form of which was systematically varied. The focus was on the effect of syntactic structure on processing time, reflected in reaction time in a neutral context, and the effect of prior context on time needed to process a given type of syntactic structure. Undergraduate students were presented paired items in randomized order on a computer screen. After all the experiment items were presented, the subjects were asked to fill out a questionnaire about how they approached the task and what they felt about the items (interesting or not, natural sounding or nonnatural). The target sentences had two forms, related by transformations (passive, adverb preposing, there insertion, raising to subject, raising to object). These rules changed word order or grammatical relations. Results showed the transformed version, with a less perspicuous structure, was harder to process than the untransformed, in a neutral context. Reaction time decreased if the context mentioned the subject and the topic of the sentence. A mismatch between context and target subject/topic increased reaction time somewhat. The results have implications for the definition of sentence topic as subject rather than initial element and for grammatical complexity, which is not absolute. (Author/HOD)

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Technical Report No. 255

MEASUREMENT OF SYNTACTIC COMPLEXITY RELATIVE TO LINGUISTIC CONTEXT

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Abstract

This paper reports the results of a reaction-time experiment measuring the reading time for sentences with various structures, preceded by a context sentence. The target sentences had two forms, related by transformations (Passive, Adverb Preposing, There Insertion, Raising to Subject, Raising to Object). These rules change word order or grammatical relations. The transformed version, with a less perspicuous structure, is harder to process than the untransformed, in a neutral context. Reaction time decreases if the context mentions the subject and topic of the sentence. A mismatch between context and target subject/topic increases reaction time somewhat. The results have implications for the definition of sentence topic as subject rather than initial element, and for grammatical complexity, which is not absolute.

Measurement of Syntactic Complexity Relative to a Linguistic Context

In the literature on syntactic processing, the role of context and discourse connections has largely been ignored, with the exception of anaphoric relations between pronouns and antecedents. Determining the specific contribution of syntactic structures of sentences in discourse would provide a fuller account of the function of certain transformations in the Chomskyan tradition and of their psychological reality. Much earlier experimental work (e.g., Miller, McKean, & Slobin, cited in Miller, 1962; Miller & McKean, 1964; Olson & Filby, 1972) showed that the output of transformations such as Passive were somewhat harder to process in isolation than the corresponding active sentences. Subsequent work taking into account the role of context fails to define how linguistic context and sentence structure interact.

This paper reports the results of a reaction-time experiment, in which we measured the time which the subjects needed to 'read and comprehend' a series of sentences, the syntactic form of which was systematically varied. Each of these target sentences was preceded by a context sentence which had some semantic relation to what followed. We were interested in (a) the effect of syntactic structure per se on processing time, reflected in reaction time in a neutral context, and (b) the effect of prior context on time needed to process a given type of syntactic structure. That is, we were interested in whether passive sentences, for example, took longer to comprehend in general than the corresponding active sentences, and if so, do particular kinds of discourse context offset the extra time required by a more complex syntactic structure?

We found strong effect of linguistic context information on reaction time, which minimized or entirely did away with the differences between related sentence structures that might appear in a neutral context or in isolation. These rules have some implications for what constitutes inherently difficult constructions. Some sentence types seem to be 'marked' or non-canonical structures, not following the most general patterns existing in a language (cf. Bever, 1970). But from these features one cannot automatically conclude that these structures are always more difficult to process. Difficulty or syntactic complexity is a relative rather absolute property, affected by contexts of specific kinds. Hence, it is not always possible to base valid decisions of theoretical description solely on experimental results, measurements of errors or of reaction time, such as Bresnan's Realistic Theory of Grammar (1978). Generalizations from such experimental data have to take into account the normal use of language in connected discourse.

It appears from the results we report that processing time even for a syntactically complex sentence is shorter if the preceding context has given some information of what the subsequent sentence is about. We were interested in defining more closely how sentence structure serves to define what the sentence is about, or sentence topic. If the hearer/reader is able to establish a link between sentence topic and prior context, then it seems that the cognitive load of semantic processing is lessened to a considerable degree (compare results of studies discussed on p. 4). This is the case even when the syntactic structure of the sentence requires greater effort, as in the case of passive sentences, in parsing and assigning the correct grammatical and logical roles. Yet prior semantic

information alone does not in itself have the maximum effect on lowering processing time.

Previous Experimental Work

This experiment, like many others, attempts to relate Chomskyan theories of transformational syntax to phenomena about the processing of language. However, while early studies assumed a very direct, causal relationship between transformational grammar and language processing, subsequent research has revealed a much more complex connection to be the case. Earlier studies such as Miller, McKean, and Slobin (1962), Miller and McKean (1964), Mehler (1963), and Savin and Perchonock (1965) provided evidence that transformations such as Passive, Negation or Question were in some sense psychologically real and therefore took longer to process or required extra storage space in memory. Hence structures more complex in description will be more complex to process. However, this view, the derivational theory of complexity, fails to account for data in which shorter sentences with shorter derivational histories were no easier to process than longer ones (Miller & McKean, 1964), or where transformations showed no appreciable effect, such as particle and adverb movement (Bever, Fodor, Garrett & Mehler, Note 1), or where transformations such as deletion of agent in passive actually facilitate processing (Fodor & Garrett, 1967). Indeed, as Fodor and Garrett (1967) reasoned, whether or not a given transformation increases perceptual difficulty seems to depend in large measure upon the resultant surface form. Transformations which remove clues to deeper levels undoubtedly increase the processing load (e.g., WH,IZ-Deletion which removes the relative marker from relative clauses).

Not surprisingly, most of the early work of this sort followed the example of transformational grammarians in restricting investigation to sentences in isolation. Under these conditions, transformed sentences, particularly those which destroy clues to deep structure, can be shown to increase the processing load. When these same transformations are used in appropriate context, however, much of this difficulty decreases or disappears.

We accept the contention that "difficult constructions" such as Passive or There-insertion are automatically more difficult to process than their untransformed counterparts, because the underlying logical relations do not correspond directly to surface syntax. But, while we accept the view of Fodor and Garrett (1967) that surface clues to underlying structure do play a role in processing, we believe the effect of contextual information is considerable, in terms of how readily sentences are processed.

This claim is not entirely new. Contextual clues have been found to affect both reading time and comprehension in a number of previous experiments (cf. Bransford & Johnson, 1972; Havilland & Clark, 1974, etc.). However, the present experiment explicitly tests the effect of the specific notion of sentence topic upon a specific set of syntactic transformations. In most of the previous research, contexts were established by such extra-linguistic means as pictures or else involved a more general notion of discourse topic, not by the structural properties of specific sentences. The present experiment investigates the effect of previous mention of the sentential subject upon reaction time, for reasons which will be specified below.

Since the Passive transformation was one of the first to be described in detail in transformational literature, it is not surprising that it should receive an equal amount of attention in experiments on processing, both initially and when the Derivational Theory of Complexity was under criticism.

Two early works investigated the interaction of "focus of attention" and active vs. passive voice. Turner and Rommetveit (1968) conducted an experiment with young children (nursery school through third grade) which indicated that the focus of the S's attention at the time of sentence storage and retrieval influenced whether the sentence would be recalled in the active or passive. Pictures were shown to the S's which depicted either the actor, the acted-upon or the entire sentence context. While the relation between the extralinguistic context in this experiment and what we are terming sentence topic is not completely clear, the three contextual pictures seem to correspond with our three context sentences. The target sentences (e.g., The mommy was kissing the daddy., i.e., two definite NP's) were read to the S's as the picture was shown. Correct recall was facilitated when the picture shown was congruent with the grammatical subject. S's tended to recall sentences with the grammatical subject referring to the person in the picture, i.e., active when the actor (agent) was shown, passive when the patient or object was shown, although more active sentences were recalled overall.

Tannenbaum and Williams (1968) conducted a reading reaction time experiment with first year junior high school students, in which the target consisted of six-sentence preambles written in either active or passive voice, followed by a simple line drawing of the agent and object (e.g., a

dog carrying a bone). From the examples of the preambles included in their report, it would seem that all NP's were generic (e.g., language, the car in general, etc.). In keeping with the results of an earlier study in which the syntactic form responses was affected by the syntactic form of questions (active or passive voice), the latency difference between active and passive voice generation increased when focus (i.e., the preamble) was on the agent, but decreased when focus was on the object. These results are consistent with the latency periods found in the present experiment and, like the Turner and Rommetveit (1968) experiment, support the view that there is a discourse functional difference between active and passive forms based on the characteristics of the preceding context. It must be noted, however, that these studies dealt with extralinguistic contexts and not with a more syntactically defined notion of sentence topic.

Active and passive sentences differ both in word order and in the grammatical roles of agent and patient. Johnson-Laird (1968) found evidence that it is chiefly word order which determined the emphasis on the logical object in passive sentences. Adult subjects were to choose between active and passive sentences to describe a precedence relationship between two colors painted on rectangles (e.g., "There is a red area which precedes a blue area"). Cleft sentences such as the one just cited were varied for voice, as well as for the order of the logical subject and object. The passive was preferred when the logical object was "emphasized" (in terms of area painted). Real-world prominence such as this is only indirectly related to our specifically linguistic notion of

topic, though it seems reasonable that visual focus of attention should correlate with the kind of emphasis afforded the sentential subject position.

Many other more recent studies have been conducted which investigate the use of the passive voice in a visual context. One children's acquisition study (Gowie & Powers, 1972) showed that comprehension of sentences containing two definite NP's (e.g., The seal watches the kangaroo), was best when the expected agent (as determined by a drawing) was the sentential subject, followed by a neutral condition, and was worst when expected roles were reversed, e.g., when a preferred agent appeared as surface object. In another study involving pictorial focus-of-attention, Olson and Filby (1972) manipulated expectations by flashing pictures on a tachistoscope and asking (adult) S/s to generate sentences as responses to questions about the logical subject or object. As expected, the passive was employed most when the logical object was the focus of the question. It is important to note that in this and other studies, there was no complete reversal effect, i.e., passive sentences on the whole took longer to process (in appropriate contexts) than did active sentences, but the difference of processing time is widened or narrowed as a function of the focus in the visual contact.

These results are in keeping with the general consensus that passive is 'marked,' that it is acquired after the active voice, is encountered less often (at least in part due to an animacy hierarchy whereby subjects are more likely to be animate than inanimate, and more likely to be animate than are objects), and may be inherently more difficult a structure to process. Because passive sentences must be two words longer than the

corresponding active sentence, the difference may come from not considering sentence-length as a covariable. Indeed, at least one study (Tannenbaum & Williams, 1968) explicitly excludes the fact that passive automatically includes longer latencies (because of two extra words) from consideration since "the central concern was with how active and passive generation latencies varied as a function of the focus manipulations, not simply the latency difference between the two sentence forms as such" (p. 248). But we will see that the length difference between transformed or untransformed sentences did not affect our results.

The general role of verbal context and prior knowledge on comprehension has been measured in two influential studies. Haviland and Clark (1974) hypothesize that a listener or reader searches his/her memory for "antecedent information" which matches the given information of a sentence and then integrates the new information to the antecedent. The essential idea is that a statement contains both given and new information, and that in context, given information corresponds to previously mentioned information in the discourse. Haviland and Clark were able to demonstrate that the more closely the given information matched the antecedent material, the faster the second sentence was understood. "Direct antecedent" pairs were thus understood faster than were "indirect" antecedent pairs, which required inferences on the part of the reader to integrate new sentences into the context.

Similarly, a study by Bransford and Johnson (1972) showed how prior knowledge may affect comprehension and recall. By manipulating prior knowledge via pictures, the experimenters showed that both comprehension and recall were improved by prior presentation of the title which was the

(discourse) topic of the passages. Indeed, in the absence of discourse organizing information (e.g., that one passage was about doing laundry), at least some of the reading passages were nearly incomprehensible.

One important study (Gourley & Catlin, 1978) provides clear evidence that children, at least, are sensitive to the overall regularity in the distribution of given and new information in the discourse. The forms investigated included active/passive, cleft-agent/cleft-patient (i.e., It was agent who . . . vs. It was patient who . . .) and "prepositional beneficiary" (A. took the present to B.) vs. Indirect Object (usually called Dative Movement, e.g., A took B the present). The target sentences were presented to 5-7 year-olds in isolation, and in contexts in which either given-new strategies were either followed or broken. That is, an appropriate context for an active target sentence was one that mentioned the agent, and an inappropriate one mentioned the patient. A significant effect was found for the passive and cleft-patient sentences only, neither of which conforms in surface structure to basic perceptual patterns (e.g., NVN = agent-action-patient; cf. Bever, 1970). This effect was not found for active or cleft-agent forms, which essentially follow perceptual expectations. The lack of effect for context for Dative Movement was explained by the perceptual strategy N...V...N...N agent-verb-patient-beneficiary. Gourley and Catlin explain that both constructions were treated as instances of the perceptually basic form (untransformed) and that "it is reasonable to expect that constructions which are interpretable by such a basic perceptual strategy will be relatively immune to the disruptive effect of inappropriate context."

Another frequent target of investigation are anaphoric devices, specifically pronouns. Fishman (1978) studied the effect of topic statements upon the S's ability to organize and retain information. By means of a multiple choice recognition test, she presented data in which a paragraph contained several proper NP's of a subclass. Recognition was best when such a paragraph was preceded by a generic NP which was the topic of the following sentences. Organizing information is discussed in terms of old vs. new information, and thus, this study falls into the category of discourse topic-related phenomena rather than sentential topic, as in our study.

Nix (1978) performed a reaction-time experiment with third-graders which presented sentence pairs linked by an anaphoric pronoun. The arguments for the pronouns were specifiable by syntactic means (morphological clues such as plurality and gender) real-world knowledge, or a combination of both. Reaction time was significantly faster for the syntactic pair, although the other two conditions did not differ significantly from one another, suggesting that linguistic connections are stronger in some ways than "contextual" inferences.

A number of studies have been conducted which indicate that reader expectation is a significant factor in sentence processing. Wisher (1976) measured the effect of certain expected syntactic structures. Sentences were either grouped together according to the structure defNP-V-defNP-RELCL, e.g., "The old man in the big house/saw/the tired baby/who was crying," or were in a mixed group (passives, conjunctive NPs, subordinate clauses and adverbial phrases). Adult S's were tested for recall of an irrelevant number sequence presented prior to the target sentences.

Recall was best in the block format, presumably because less effort was spent on processing structures which conformed to the most usual subject-verb-object pattern.

Greeno and Noreen (1974) performed a reaction-time experiment which tested the effect of consistency of a sentence with expectations developed on the basis of prior sentences. Consistency involved categorical rankings of subsets and supersets, for example. Sentences which broke the expected ranking of the set took longer to process.

Finally, inconclusive results were gathered from a study by Flood (1978) in which subjects were presented with a topic sentence followed by paragraphs which were either consistent or inconsistent with the established topic. Data indicated that poor readers at the 8th grade level were adversely affected in some instances by the inconsistent passage.

The Effects of Transformations

In addition to the active-passive pairs of sentences, four other sets of syntactic relations were included in the experiment, which are perhaps less familiar and have not been as well studied. These are *There* Insertion, Adverb Preposing, Raising to Object Position and Raising to Subject Position. We will refer to all five of them as the "X transformation," to refer to a statement of syntactic equivalency in English, not necessarily to a process of derivation. The notion of transformation is basically a statement that a well-formed structure of the form A is syntactically (though not always semantically or pragmatically) equivalent to another well-formed structure, B. All the syntactic equivalencies studied in this experiment are what have been termed optional cyclic

rules in Chomskyan Standard Theory (cf. Akmajian & Heny, 1975; and Bach, 1974). There are other characterizations in other theoretical frameworks, but the differences are not important here, and we will continue to use this terminology.

In this section, the properties of each transformational operation will be described in brief, and the differences among them noted with respect to syntactic structure, processing difficulty and consequences for interpretation in discourse.

Passive

This rule replaces the logical subject (agent, experiencer, etc.) with another constituent, a post-verbal object or occasionally a prepositional object. The old subject is 'demoted' to the end of the sentence, and marked with by.

(1)a The cops chased the robbers.

b The robbers were chased by the cops.

All the passive sentences used in this study were full passives, with expressed agent phrases. The critical position is the pre-verbal subject position, which may contain either a logical subject with an active verb or an object followed by a passive verb. Hence the NP - V combination is ambiguous from the point of view of processing, and the surface structure of the passive form (object-verb) does not directly encode the logical relations contained in the sentence's meaning. Hence, the sentence processing model using Bever's strategies (NP - V = subject-verb, etc.) will predict that passive sentences should be harder to process than active ones, and hence take longer to process.

The difference in discourse, which has long been noted, rests on a difference between what is in pre-verbal position. Ziff (1966) points out that active and passive pairs like (2)a and b are 'about' different things, and assert different properties, eating John, and being eaten by a tiger:

(2)a A tiger ate John.

b John was eaten by a tiger.

If the preverbal subject is regarded as sentence topic, then (in comparison with each other) (2)a and b have different topics by virtue of their different syntactic forms, though they express the same semantic proposition. In discourse, a context which is biassed towards the active form might mention the subject A tiger, while a context biassed towards the passive might mention John. Since Passive causes a reversal of what is in subject position, a context biassed for the active would be biassed against the passive.

There Insertion

This rule applies in sentences with an instance of be (existential, progressive or passive) or an existential verb. The subject, which must be indefinite, except in the case of the 'enumerating' use of There (Rando & Napoli, 1978), is displaced by a non-referring there.

(3)a Three ideas were discussed by the authors.

b There were three ideas discussed by the author.

The old subject--which the verb agrees with--is moved to a position following be, where it ceases to function grammatically as a subject. From a processing point of view, the presence of a non-referring element there before the verb which functions as subject, vis-á-vis some grammatical rules, such as question inversion, and the presence of the 'real' subject

after the verb, creates some ambiguity and hence a possible increase in processing time. The discourse properties of the two versions of a sentence would also be different. In the untransformed version, such as (3)a, the initial element would be perceived as topic of the sentence, as in the active form in (2)a. In the transformed version, it might be inferred initially that the preverbal NP is topic, but since there refers to nothing, the sentence cannot be 'about' it, nor can it be regarded as given information. The displaced subject, since it is neither subject nor preverbal, still refers, but it would be reasonable to hypothesize that it is not a topic (cf. Milsark, 1977). Hence, as many have claimed, the discourse function of There Insertion sentences is to introduce into discourse some entity which is not a topic.

The kind of context which mentions the entity referred to by the subject NP of the untransformed version (3)a, is thus incompatible with the transformed version (3)b. A mild contradiction ensues if the context allows the hearer or reader to assume the existence of an item which is then introduced as a new element in the following sentences in discourse. The contradiction is perceived as a lack of connection between the sentences, or oddness of sequence. If the context is not biassed towards the displaced subject, we would expect neither compatibility nor incompatibility.

All of the There Insertion sentences in the experiment were of the existential type, and contained no passive be's. We wanted to make all the potential topic NPs indefinite, for reasons discussed in section 4, and the existential there requires such NPs. Passive be was excluded on

the general condition which we imposed that only one of the transformations being studied could occur in a single case.

Adverb Preposing

This rule takes an adverbial constituent such as carefully, on Tuesday, or In order to annoy Harry, from its 'unmarked' position following the verb and its object; and places it in initial position in the sentence.

(4)a We plan to leave on Tuesday.

b On Tuesday, we plan to leave.

In processing, the hearer or reader must store an element usually marked as a non-subject (morphologically by -ly, syntactically by an initial preposition or conjunction). The search for the subject of the verb must be postponed while the adverbial is kept in temporary memory, and then grouped with the whole sentence, or with a subconstituent of it, semantically.

The preposed adverbial is very interesting from the point of view of its status in discourse. In fact it is the critical case which distinguishes initial position from subject position. The preposed adverbial is in first position, but it does not affect the subject. The subject retains all grammatical marking of subject-ness, including preverbal position, unless inversion occurs, a case which we will exclude from the study, since it involves additional factors such as negation.

As Langacker (1974) has noted, transformational rules in English which move NPs to the left, to the beginning of the sentence, tend to increase their salience. This includes not only passive subjects, but also topicalized NPs, as in (5) and adverbials in (6):

(5) JOHN I'm not sure you know _____.

(6) (?? on) TUESDAY we plan to leave _____.

Here capital letters indicate the possibility of contrastive stress; the intonation typically has high pitch and there is no pause between the fronted element and the rest of the sentence. While Langacker may well be right about such cases, there is an important difference between (6) and (4)b. In these cases of adverbial preposing, there is typically a low, level intonation, and a pause between the adverbial and the following material. We will regard Langacker's preposing as a sub-case of NP topicalization, as in (5). Topicalization has a somewhat different status from the optional cyclic rules studied here, since it does not involve the change of grammatical relations within one or two clauses. Its operation is not bounded in this fashion. Further, it is stylistically not typical of written language, which was the medium used in this experiment.

Raising to Subject Position

This rule and the following one, Raising to Object Position, affect the subject of a clause within another clause. The lower clause subject becomes the subject of the higher clause verb, such as seem in (7):

(7)a It seems [that Carol has written a murder mystery].

b Carol seems [to have written a murder mystery].

The surface structure of the transformed version is misleading for processing, since it allows the hearer or reader to pair Carol with seems as subject and verb, though the logical subject of seem is the whole complement clause (or possibly the pronoun it which is identical in reference to the complement). Thus the transformed version ought to take longer in isolation to process than the untransformed version. In

discourse, the transformation places the lower subject in a position where it might be regarded as sentence topic, and hence sensitive to information in prior context. But there are additional factors, which will be discussed with the results. Raising to Subject is a governed rule, only applying if the higher clause verb is a member of a specified class of verbs and adjectives, such as seem, happen, likely, but not imply, difficult, etc. These predicates have meanings as well as syntactic properties, which may affect perception of the sentences the rule applies to. The context biassed towards the transformed version mentions the raised subject, logically the subject of the lower clause. The context biassed towards the untransformed version mentions something other than this subject. As the untransformed version has no real subject other than it or a clause, it is not possible to bias the context towards the higher clause subject.

Raising to Object Position

Like the preceding rule, this one is also governed, applying to the object clauses of verbs like declare, believe and report, but not regret or try. It gives object marking to the subject of the lower clause:

(8)a John believes [that he is entitled to more respect].

b John believes himself to be entitled to more respect.

The surface structure of the transformed version is misleading with respect to underlying logical relations. The NP following the verb appears to be its object, though the real object is the entire subordinate clause, and the raised NP is the subject of the lower clause in spite of its grammatical object-like properties. The boundary of the subordinate clause is unclear in (8)b, though it is unambiguously marked by that in (8)a.

The discourse properties of these sentences are not readily apparent, and they have been controversial for other reasons as well (Postal, 1974; Chomsky, 1973). The structure in which a NP has been raised to object position, or acquired object marking ought to be a very difficult one to process, and hence be highly 'marked' or unusual in comparison with more straightforward structures. For this reason it might serve specific discourse functions, more closely associated with it than with less difficult or marked structures. Because of the restrictions on what kinds of NPs may undergo Raising, it has been suggested that raised NPs are the topic of the entire sentence (Davison, 1979). Only NPs whose inherent semantic or pragmatic properties make 'good' topics--their referent is possible or easy to identify--may undergo Raising. Hence the contexts biassed towards Raising to Object sentences made mention of the lower clause subject. Contexts which did not establish a discourse referent for the following sentence would be strange if the sentence were in the transformed version.

Predictions

We may summarize the predictions in the following way. The transformed versions of all the sentence types will be harder to process than the untransformed versions, all other things being equal. This means that the preceding neutral context will be equally compatible with either version. But in the contexts which establish a discourse referent for some item in the following or target sentence, it will be the grammatical structure of the sentence which determines which constituent will be linked to previous context, reducing processing time. Since the transformed and untransformed

versions differ in grammatical relations and also in word order, in most cases, the sentence structure will define different linkable elements.

There are two possible hypotheses about which sentence constituents will be perceived as salient, as linkable to previous context, or as sentence topic. Hypothesis A defines topic purely by position. Hence any initial item will be topic, and perhaps the closer it is to the beginning of the sentence, the more salient it will be. Thus preposed adverbs ought to be more salient and topic-like than subjects if they occur together. Hypothesis B defines sentence topic in terms of subject, including both preverbal position and grammatical marking. Subjects are often initial in the sentence, if nothing else precedes, but if they retain their grammatical role and preverbal position, they should remain salient.

Adverb Preposing is the crucial case which distinguishes Hypothesis A from Hypothesis B, since adverbials are moved to initial position but do not acquire subject marking. If Hypothesis A is correct, there should be a difference in processing time between transformed and untransformed version in biassed contexts, just as predicted for active and passive sentences. There should be no difference under Hypothesis B. The Raising to Object case is also an interesting test of whether grammatical subject marking is always required for topic-status. In the transformed version, the lower clause subject remains in preverbal position, but has acquired object marking. If grammatical subject marking is invariably and hence linguistically associated with topic, then the lower clause object should not be perceived as topic in the transformed version, and there should be a difference in processing time in biassed contexts. If it remains topic, then this fact would suggest that the association of grammatical marking

with topic is pragmatic and essentially not the result of the operation of rules of grammar.

Defining Sentence Topic and Discourse Topic

These notions are exceedingly difficult to define exhaustively, and the most probable reason for the difficulty is that they are pragmatic and not grammatical categories. Yet topic, particularly sentence topic, is closely linked to linguistic structures, both semantic and syntactic. Differences of syntactic structure often convey differences of sentence topic, and features of syntax or morphology are often used, in many languages, to mark a sentence topic to be related to the topic of the discourse as a whole (cf. Li, 1976). One of the most common regularities is the identification of grammatical subject with sentence topic (Li & Thompson, 1976). All other things being equal, it is generally the case that subject = sentence topic. While the subject may indicate what the sentence is 'about,' it also has consequences for the referring properties of the NP in subject position. Strawson (1964), who was concerned with the consequences of reference and failure of reference for evaluating the truth of a proposition, noted that failure of reference of NPs in the predicate rendered the sentence false, while failure of reference for subject NPs made the sentence without truth value. Thus there are several reasons, intuitions of difference of actives and passives for example, as well as intuitions about truth value, which tend to confirm the identification of subject and topic.

Yet it is also clear that subjects are not always sentence topics, if discourse context is any indication. For example, the sentence in

(9)a introduces a topic which could either be the subject of the following sentence (9)b, or not, as in (9)c.

(9)a Something unpleasant happened to my brother.

b He was accosted by a stranger.

c A stranger accosted him.

So we could define sentence topic pragmatically, and say that it is a normal and expected general inference to identify the grammatical subject with sentence topic, just as events which are mentioned first in a conjoined structure are assumed to have happened first (Grice, 1975). Thus, subject as topic is a conversational inference, based on grammatical structure but not part of grammatical structure, as tense and case marking are part of grammatical structure. As an inference, the equation of subject = topic can be cancelled when there are stronger indications that something else is topic. Such indications include more distinctive structure, as in (10)a, and fuller indications of what the NP refers to (10)b:

(10)a That guy, people are always taking advantage of (him).

b Anything can upset my uncle.

In (10)a, the topicalized structure, which forms a phrase in its own right, that guy, is more strongly marked as topic than the subject people. In (10)b, the object phrase my uncle has more clearly defined reference than the vague generic anything.

So we may take as an operational definition of sentence topic that (a) it is what the sentence is perceived as being about (cf. Reinhart, to appear), (b) it is normally and conversationally inferred that the grammatical subject is sentence topic; (c) this inference may be cancelled either by the referring properties of the NPs in the sentence or by more

'marked' syntactic structure defining some other constituent as topic. Finally, it appears that no sentence has more than one sentence topic. If grammatical features define two topics, then the sentence is ill-formed:

(11) That guy, the cops believe Fred to have beaten (him) up.

This stipulation of unique topic would follow from the communicative function of topics, to identify to the hearer what the sentence is about. If more than one referent has the salient properties in discourse of a topic, then it is harder to distinguish salient from non-salient items.

The Task

The subjects were 59 undergraduates at the University of Illinois, who volunteered to participate in the experiment as part of a requirement for the introductory course in Educational Psychology. They performed the task one by one, because the computer program did not allow simultaneous presentations. The items were presented in randomized order on the screen of a PLATO 4.5 terminal and response times were recorded for the target sentences. Each subject was instructed to read the paired items in each sequence as though they were excerpts from ordinary texts, such as newspaper or magazine feature articles or news items. After a subject had read and comprehended (as in the study by Haviland & Clark, 1974) the first sentence in a pair, he or she was to press the space bar. This action would erase the context sentence and cause the target sentence to appear on the terminal screen. Time was measured in milliseconds from the onset of the second sentence (which was very rapid) to the time that the subject pressed the spacebar. The next item was presented in the same fashion after a short interval. The full set of instructions is

included in Appendix B. Note that the subjects were instructed to read at whatever rate was normal for them for the kind of material in the task--e.g., newspapers or magazines. After all the experiment items were presented, the subject was asked to fill out a questionnaire about how they approached the task, and what they felt about the items (interesting or not, natural sounding or non-natural). Data from one subject was discarded, out of the original 60 subjects, because this subject reported that she read the items as though studying for a test.

The Experimental Items

The pairs of context sentence and target sentence were constructed according to several criteria by the two experimenters with the assistance of another graduate student research assistant, Jean Hannah. All three had to agree in their responses to the contexts in combination with the target sentences. That is, the neutral context had to be equally compatible with both the transformed and untransformed target versions. In context 2, biassed towards the untransformed version, that version had to be preferred over the transformed version as a continuation of the discourse. Similarly, the sequence with the transformed version had to be preferred when the context was biassed towards that version (context 3). Ideally, the reverse was the case when context and target version were not matched. That is, when the transformed version followed the context biassed for the untransformed version (context 2), and when the untransformed version followed context 3, there tended to be an impression of 'disconnectedness,' illogic, or topic shift. The experimental items were thus normed by three experimenters and several others for preferred sequence and for intuitions of nonmatching items.

The neutral contexts made reference to the target sentence as a whole. The biassed contexts made reference to a noun phrase in the target sentence. Since these target sentence noun phrases were indefinite (general plurals, single NPs with indefinite determiners a, some, etc.), there could not be a direct antecedent in the context. Instead, the antecedent was either a class which included the NP which followed (e.g., animals . . . cats), or another term for the same thing (UFOs . . . flying saucers). It was intended that this NP serve as topic of the target sentence, defined on the basis of the sentence structure, without confounding factors of definiteness or lack of choice. For this reason, the crucial NP was indefinite, and there were two or three NPs in each target sentence.

For a given target sentence, there were six combinations of context and target version (see sample in Appendix A). To guarantee that each subject would not see the same target sentence twice, there were six sets of the six combinations, in a Latin square design. Thus each subject saw an exemplar in each of the six possible combinations (e.g., Context 1 - with untransformed target version), but not two from the same paradigmatic set. There were three complete arrays of these paradigms for each of the five transformation types, so that there were 540 sentence pairs in all. Of these, each subject saw 90, representing three comparable pairs for each of 30 combinations (6 paradigms x 5 transformation types). The sentence pairs of the correct type were chosen and presented in randomized order by the PLATO program used. . .

Results

The 59 subjects responded to 90 items each, generating a total of 5310 items. A very small number of these (about 18) were discarded because

they were deviant, below 1000 msec or above 8000 msec, and probably represent errors of response or recording. The 90 responses represent three responses to the same type of context-sentence combination, and these were averaged for each subject. Mean response times for all transformation classes, transformed version and untransformed version, in three contexts, are given in Table 1. The results were analyzed using an ANOVA with transformation type (passive, etc.), target version (transformed and untransformed) and context properties (neutral, biassed to untransformed, biassed to transformed version) as factors. Initially, the ANOVA included all 5 transformation types. The analysis revealed a significant effect for transformation type, $F(4,232) = 14.82$, $p < .001$, and a significant interaction of transformation type by target version, $F(4,232) = 4.63$, $p < .01$. The effect of context was significant, $F(2,116) = 3.85$, $p < .05$, but in this analysis the difference of target versions alone was not significant. Other interactions were not significant.

The means for the individual transformation types, which will be discussed in detail in the next section, revealed one transformation type where the results did not conform to the overall pattern found elsewhere. This transformation type, Raising to Subject, was dropped from the subsequent statistical analyses (see also the Discussion Section, pp. 34-35). An ANOVA similar to the first one was done, but without the means for this transformation, and the results were the same except that the difference between transformed and untransformed versions was significant, $F(1,58) = 6.70$, $p < .05$. Another ANOVA was performed using as a covariate the average word length and the transformed and untransformed versions for each transformation type (e.g., passive sentences average 13.5 words, while

active sentences are two words shorter; and these in turn are both longer than Adverb Preposing sentences, both versions having 11.6 words on average). The effect for transformation, and for target version were of the same degree of significance as before (respectively, $F(3,173) = 10.99$, $p < .001$, and $F(1,57) = 6.70$, $p < .05$). The difference of number of words is therefore not sufficient to account for the characteristic response times for transformation types, or for the difference of transformed and untransformed versions. Other effects were not significant in the co-variate analysis. The results are summarized in Table 1. Overall the difficulty in parsing created by the sentence structure of the transformed version is offset, or more than offset, by the facilitating effect of the 'right' kind of context. This is true for the means over all 5 transformation types (Figure 1) and even more so over 4 transformation types, excluding Raising to Subject (Figure 2).

The 'right' kind of context was defined in terms of the topic of the target sentence. As we have seen, there are several ways that sentence topic could be viewed. It could be regarded as the initial element in the sentence, including main clause preverbal subjects in general, and also preposed elements (Hypothesis A). Alternatively, topic might include just preverbal subjects, regardless of what is initial in the sentence (Hypothesis B). If Hypothesis A is correct, we would expect complete uniformity in the results for each transformation type, that is, some gap between higher values for transformed versions in Context 1 and 2, and lower values for the untransformed version, with the gap widest in context 2 and narrowest in context 3. In fact, what we find is some variation in the transformation types, sufficient to show that Hypothesis A is incorrect, and that

sentence topic, which indeed does serve as the facilitating link between context and target, should be regarded as a preverbal subject. Position alone does not define topic; the grammatical role of subject is also a critical factor, as is the composition of the whole sentence. In some cases, subordinate clause subjects may also be topic of the whole structure. The results for individual types, which will be discussed in detail in the following section, point towards Hypothesis B as the correct view.

Discussion

Figure 1 shows the overall effects of context and target sentence. Note that in the neutral context there is some difference between means for transformed and untransformed versions of the target sentence. The difference is in the direction that was predicted, according to the parsing difficulty hypothesis mentioned earlier. The context biassed for the untransformed version does lower response time for the untransformed version, much more than for the transformed version. Any difference between the two versions disappears in Context 3, biassed towards the transformed version. Response time for the transformed version is lowered still more in Context 3, while not being increased overall for the untransformed version. Figure 3 gives means for contexts.

The results for four of the types fall into natural pairs. Passive and There Insertion follow approximately the same pattern, Figures 4 and 5. Note that Context 2 and the untransformed version are highly congruent, as shown by the sharp drop in reaction time. The context leads the reader to expect the topic of the following sentence in subject position, and this expectation is borne out by the form of the untransformed version. The transformed Passive sentence is incongruent with Context 2, as shown

by an increase in reaction time. There is little change in Context 3 from the neutral case, even with the incongruence of Context 3 and the active version. There is a significant difference between the active and passive versions, $p < .001$. The overall difference between active and passive in the 3 contexts is consistent with the results of other similar experiments (Olson & Filby, 1972). The difference of 260 msc between response times for the passive and active forms in Context 2 (which is biassed for the active form) shows a clear interaction between sentence form and this context.

In the case of there insertion, the untransformed version shows a similar sensitivity to sentence form in Context 2, which is biassed for that sentence form. But information about discourse topic and topic of the following sentence does not much affect response times for the transformed version. This insensitivity to topic information would follow directly from the hypothesis that there insertion sentences are without a topic. If the dummy element there replaces a referring lexical NP in subject position, the inference that the grammatical subject is topic of the sentence will not be made, or if it is, the net result will be vacuous, since there expresses nothing for the sentence to be about. The effect of context is significant, $p < .05$.

Adverb Preposing (Figure 6) and Subject to Object Raising (Figure 7) illustrate opposite effects of Context 2, and different roles of potential topic material. The untransformed version in Figure 6, Adverb Preposing, shows the same effect of context on grammatical subject that is seen in Figures 4 and 5. Thus, the subject is topic, and the form of the sentence is highly congruent with the context. There is little change for Context 3,

which introduces as potential topic some adverbial material which occurs at the end of the sentence. But since the values for the untransformed version are not very different in Context 2 and Context 3, we can conclude that there is not much difference in how topic is perceived, even though the contexts are different. The grammatical subject is topic, while the link between Context 3 and the adverbial at the end of the sentence has the facilitating effect of being a specific link to the context.

For the adverbial to be perceived as topic, by virtue of its initial position, we would expect incongruence of the transformed version with Context 2, which is biassed towards the grammatical subject as topic, as in the case of Passive. Further, we would expect congruence of the transformed version with Context 3, but instead reaction time is increased in Context 3. Moreover, the general trend is for reaction times to both versions of the sentence to go in the same direction. This case is decisive against Hypothesis A, initial elements as topic, and for Hypothesis B, preverbal grammatical subjects as topic. Preposed adverbial material is usually felt to express old information, taken for granted, and thus similar to some definitions of topic, as given information or information previously mentioned. But we see that the preposed material is apparently not taken as topic in contexts which bias the reader towards the grammatical subject as topic. The response times simply parallel the times for the untransformed version. Note also that there is a slight rise for the transformed version in Context 3, biassing the reader towards the adverbial as topic. We may therefore conclude that preposed adverbials are taken perhaps as background information, to be held in store while waiting for the real sentence topic to appear, in grammatical subject position. If

anything, the initial position of the adverbial probably confuses a reader expecting it to be topic, since it really functions as background information.

The results for Raising to Object sentences show the opposite effect from Adverb Preposing (Figure 7), in contexts 2 and 3. In the neutral context, the transformed version takes about 60 msc longer than the untransformed version. In Contexts 2 and 3, the reaction times for both versions are parallel, both about 2460 msec in context 2, and 100 msec lower in context 3, or 2360 msec. These responses argue that the topic of the sentence is perceived as the same constituent, whether or not the transformation has applied. This topic constituent must be the lower clause subject, towards which context 3 was biassed:

(12) 5. -Object Raising, context favors Raising

There are reports of UFOs on the West Coast.
Some people believe that a flying saucer is heading towards L.A.

(13) 6. +Object Raising, context favors Raising

There are reports of UFOs on the West Coast.
Some people believe a flying saucer to be heading towards L.A.

In this example, the NP a flying saucer has an antecedent UFOs in context 3 which establishes it as an existent thing and part of the discourse. Contrast this pair above with the corresponding pairs of context 2 and Raising to Object sentences:

(14) 3. -Object Raising, context disfavors Raising

Southern California might soon become a dangerous place to live.
Some people believe that a flying saucer is heading towards L.A.

(15) 4. +Object Raising, context disfavors Raising

Southern California might soon become a dangerous place to live. Some people believe a flying saucer to be heading towards L.A.

There is clearly an incongruence between the transformed version in 4 and the context which does not contain an antecedent for flying saucer. Apparently the combination in 4 was treated the same way, in that flying saucer was perceived as topic without a discourse antecedent, and thus not clearly compatible with the context which preceded.

The Raising to Object combinations are somewhat different from other cases such as Passive and Adverb Preposing. If grammatical subjects are generally perceived as topics, then the topic in Raising sentences ought to be the subject of the main clause, such as People in the previous examples. But there are some arguments for saying that the topic is really the lower clause subject, which also is the grammatical object of the transformed version. In this position, there are some restrictions on the kinds of NPs which can occur, and undergo Raising. As Borkin (1974) has noted in an exhaustive study of preferred versions of Raising sentences, there is a hierarchy of felicitous and infelicitous NPs which have been raised. The worst cases are NPs with vague or hard to determine reference, including parts of idioms such as tabs, headway, generics and superlatives, as in

(16) a ??We believe the slightest noise to be irritating to him.

b ??They supposed any doctor to know the answer.

c ??They declared tabs to have been kept on the smugglers.

NPs of this type also make bad topics, since they do not indicate anything particular. The best cases are those which make good topics, indicating particular entities, especially ones known at first hand by the speaker.

It is argued in Davison (1979) that two factors work together to define the lower clause as topic. First, the higher clause material including verbs like believe and declare function more as modifiers of a proposition than as asserted content. Second, the structure created by Raising is so 'marked,' or unusual and misleading about logical relations, that it has acquired a distinct communicative function. This is the definition of lower clause subject as topic of the whole sentence. While subjects are often inferred to be topics, the inference is also cancellable. In a general discussion of the relation of topic and grammatical structure, it is proposed (Davison, Note 2) that the pragmatic inference of topic-ness varies in whether it is obligatory or cancellable depending on the 'markedness' of the grammatical structure. The more marked the sentence structure is, the less easily the inference of topic can be cancelled. This principle seems to be very much operative in the Raising to Object cases.

It is somewhat less the case for Raising to Subject sentences. The structure created by the transformation is marked, in that the lower clause logical subject is the surface subject of the higher verb. But the identity between higher and lower clause subjects is also found in another construction, not studied in this experiment, an example of which is:

(17) Miss Garbo wants [Ø to be left alone].

So it may well be the case that the structures such as the target sentence in (18) below are less marked and less topic defining than the Raising to Object cases.

The responses to Raising to Subject sentences are given in Figure 8, in which the two biasing contexts decrease response time for the transformed version approximately equally well. We would expect such results for Context 3 which leads the reader to expect in topic/grammatical subject position the promoted subject of the complement clause. For example, in (18), the mention of immigrant workers in the context (Context type 3) may be linked to Algerians in subject position in the target sentence:

(18) (+Raising to Subject, context favors Raising)

Immigrant workers have suffered much prejudice in recent years. Algerians seem to have an especially hard time in France.

It is not surprising in Context 2 that the subject of the target sentence is perceived as topic. The Context 2 sentence for this set of sentences mentions unemployment figures, and the subsequent subject/topic refers to a group of people, Algerians, who might be affected by unemployment. Hence the context sentence is linked to the whole proposition which follows, the grammatical subject of which refers to possible instances.

What is most hard to understand is the sharp increase in response times for the untransformed version. In the neutral context, Context 1, we expect and find a difference, with the transformed version requiring about as much more time to process as passive sentences in the same context (cf. Figure 4). But in contexts 2 and 3, response times for the untransformed version are exactly the reverse of Context 1. Where closely linked contexts even of the incongruent sort usually increase response time here the presence of semantically and pragmatically closely linked context interferes with comprehension.

We can only speculate about the reason for this. But on examination of the sets of sentences we used, we find that the kinds of contexts whose properties are appropriate for the other sentences may not work exactly the same way in the Raising to Subject cases. This we believe, is because of the semantic content of the verbs which govern Raising to Subject, such as seem, appear, turn out and happen. These verbs all have to do with indirect knowledge, rather than direct certainty. Thus they are generally used to indicate doubt, uncertainty and second hand knowledge, unlike the verbs which govern Raising to Object, such as know, prove, ascertain, suppose, believe, acknowledge, etc. These verbs are used either to assert directly or indirectly, or to indicate the source of a belief. Raising to Subject verbs on the other hand, generally cannot be used to assert strongly some proposition or to attribute a definite belief to a particular source.

Hence, in retrospect, it seems that there was something pragmatically odd about the context-target sequences of sentences in which Raising to Subject did not apply but could have. The context made a definite assertion, e.g., have suffered, as in (19), while the target sentence, instead of further supporting the assertion or giving a specific instance, gave the impression of diminishing the certainty of the previous assertion:

(19)a Immigrant workers have suffered much prejudice in recent years.

b. It seems that Algerians have an especially hard time in France.

Thus the phrase it seems that diminishes the certainty of the fact expressed in the clause which follows. These two-sentence discourses proceed from more definite to less certain and definite assertions. The four other sentence types did not have this relation to their contexts. If these experiments were to be done again, we would change the sentences used for

contexts 2 and 3, so that they made a reasonably natural discourse in combination with the untransformed versions.

Because of the fact that the results for the untransformed version for Raising to Subject sentences are so unlike the results for other transformations, we wondered whether subtracting the responses for this transformation would make a difference in the overall results. Another analysis of variance was done, including responses for Passive, Adverb Preposing, There-Insertion, and Raising to Object, but not Raising to Subject. The major difference between this analysis and the others was that the difference in means between Transformed and Untransformed versions for these four transformations is statistically significant ($p < .05$).

Conclusion

We have seen from Figures 1 and 2 that context in general has an effect on response time, with the exception just noted above. The right kind of context, mentioning an antecedent for the topic of the following sentence, facilitates response time for the untransformed version, and the same context has no facilitating effect for the transformed version. Response time for the transformed version becomes equalized with the untransformed version, provided that the transformed version is preceded by a context which sets up the right expectation of the initial or subject element of the target sentence. The moral to be drawn from these results seems to be that even if the transformed version requires more processing effort, reflected in more processing time, the difference makes no difference in the right kind of context. Hence it is hard to draw conclusions from the kind of experimental data cited in Bresnan (1978) which

she uses to support her hypotheses about a realistic theory of grammar based on psychological models of processing and production. The experiments cited there involved matching pictured situations to sentences, where errors were measured, and decisions about grammaticality, where response time was measured.

But it seems that the situations all involved sentences without verbal contexts. Actual spoken sentences, and written ones involving the same linguistic structures with the added task of interpreting written symbols, generally occur in connected discourse of some kind. The connections need not be very tight, as observations of actual conversations show, but at least the participants have some shared notion of what is being discussed. While sentence structures requiring special parsing efforts might be acquired later, and might be 'marked' in some sense (cf. Davison, 1979), experimental results about sentences out of context do not really address the problem of exactly how complex a given structure is either for children or adults. If the semantic processing work is shortened by information in the context, then the additional load of untangling logical relations makes no ultimate difference. Hence it would not always be the case that speakers would actually experience greater difficulty in processing certain constructions, and construct grammars on the basis of perceived difficulty. Therefore, it would not necessarily follow that the grammars representing a linguistic competence have to represent 'marked' constructions in one particular way (for example as lexically related constructions to be found in each verb entry, Bresnan, 1978).

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APPENDIX A

Examples of Transformation Types and Contexts

1. Passive (see 1 above) (Av. 12.5 words per sentence)

   A. Contexts

      1. Police reported the details of a recent kidnapping. (Neutral)

      2. Strange men have been on the prowl recently. (Favors untransformed version)

      3. Children should never be allowed to walk home alone at night. (Favors transformed version)

   B. Target sentences

      1. A man abducted a six-year-old girl in California. (Untransformed version)

      2. A six-year-old girl was abducted by a man in California. (Transformed version)

2. There Insertion (av. 10 words per sentence)

   A. Contexts

      1. Political instability is a common feature of life in the Third World.

      2. Revolutions are typically glossed over in American textbooks.

      3. South America is a difficult continent to study.

B. Target sentences

1. Numerous revolutions have occurred in South America since 1900.

2. There have occurred numerous revolutions in South America since 1900.

3. Adverb Preposing (av. 11.6 words per sentence)

A. Contexts

1. The English have different work habits from Americans.

2. Shopping in other countries can be frustrating for Americans.

3. The English in general do not work in the evenings.

B. Targets

1. Most English shops are not open after 6 p.m.

2. After 6 p.m. most English shops are not open.

4. Subject-Subject Raising (av. 12.6 words per sentence)

A. Contexts

1. There's an interesting article in the newspaper about immigrant workers.

2. I have just been looking at the unemployment figures for Europe.

3. Immigrant workers have suffered much prejudice in recent years.

B. Targets

1. It seems that Algerians have an especially hard time in France.

2. Algerians seem to have an especially hard time in France.

5. Subject-Object raising (av. 12 words per sentence)

A. Contexts

1. It's amazing what you can read in local newspapers.

2. Income-tax evasion is a very common crime.

3. Elected officials are not always trustworthy.

B. Targets

1. Judges have ruled that several mayors were guilty of tax-fraud.

2. Judges have ruled several mayors to be guilty of tax-fraud.

APPENDIX B

Instructions to Subjects

1. You will see pairs of sentences written out on the screen--these will be part of the same paragraph, so that they will be connected in some way.

The first sentence will be written out by itself. Read it and when you have finished reading it and feel you have comprehended it, press the spacebar. This will bring on the next sentence. Do the same thing--read and comprehend the second sentence, and as soon as you have done this, press the spacebar.

2. There will be a practice session to show you how the sentence pairs work, and what you are supposed to do. You can go through all the items in the practice, or go on at any time to the experiment.

3. You can pause at any time between items. You can tell when this is because it is when the middle of the screen says

Press the spacebar to continue.

Please don't pause between sentences, or when the second sentence is still on the screen.

4. The texts in the experiment are about a lot of different things. The information in the sentences is not necessarily true, though most of it is true.

5. You should rest your hand near the spacebar, so that you don't have to reach each time you press it. (But don't keep your finger right on the spacebar all the time.) Have you ever used a PLATO terminal before? If so, you can use another key if it is more comfortable for you; all of them will work to activate the program.

6. When you read the sentence pairs, read at your normal rate. Don't try to speed up and hurry, or go slower than normal. Read as though you would read something from a feature article or news story in the newspaper. There are no right or wrong answers, and there are no tricks in the task you are asked to do.

7. There may be some short delays between items while the machine is choosing the next sentences.

When the experiment is over, there will be a sentence on the screen telling you this. After you have finished, you will be told more about what the experiment was about.

(Administer debriefing questionnaire.)

Footnotes

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We are grateful to a number of colleagues who gave useful comments at different stages of planning and analysis. These include Georgia Green, Robert Kantor, C. C. Chen and J. Ronayne Cowan of the University of Illinois and Marilyn Adams, of Bolt, Beranek and Newman. The final results of the experiment were presented in talks at the University of New Mexico, Albuquerque, and the University of California, La Jolla, and as a paper presented at the 1980 Winter Meeting of the Linguistic Society of America, San Antonio, Texas. We are grateful for the comments and criticisms from various people present. All remaining errors are ours alone, of course.

[1]Bresnan (1978:48-50) justifies the choice of active structures as lexically basic not only because they involve a more direct association of syntactic form with logical structure than passive sentences but also because passive sentences require longer response times in various latency experiments. The study she cites as decisive measures "on line" processing of sentences outside of a context (Forster & Olbrei, 1973), contradicting Slobin's results matching sentences to pictures contexts (1966).

Table 1

Statistical Analyses

Variables	Analysis 1		Analysis 2		Analysis 3	
Transformation	F = 14.82	p .00	F = 21.95	p .00	F = 10.99	p .00
Context	3.85	.05	3.37	.05	1.78	n.s.
Target version	2.02	n.s.	6.70	.02	6.70	.02
Transformation x target	4.63	.01	4.15	.01	1.35	n.s.

Analysis 1: 5 transformations, Analysis of variance

Analysis 2: 4 transformations (excluding Raising to Subject transformation), Analysis of variance

Analysis 3: 4 transformations (excluding Raising to Subject), average sentence length a co-variate

Figure Captions

Figure 1. Comparison of mean response times (5 transformations) for transformed and untransformed versions of target sentences, in three contexts.

Figure 2. Comparison of mean response times (msec) (4 transformations, excluding Raising to Subject).

Figure 3. Mean response times (msec) to both versions of target sentences, in 3 contexts.

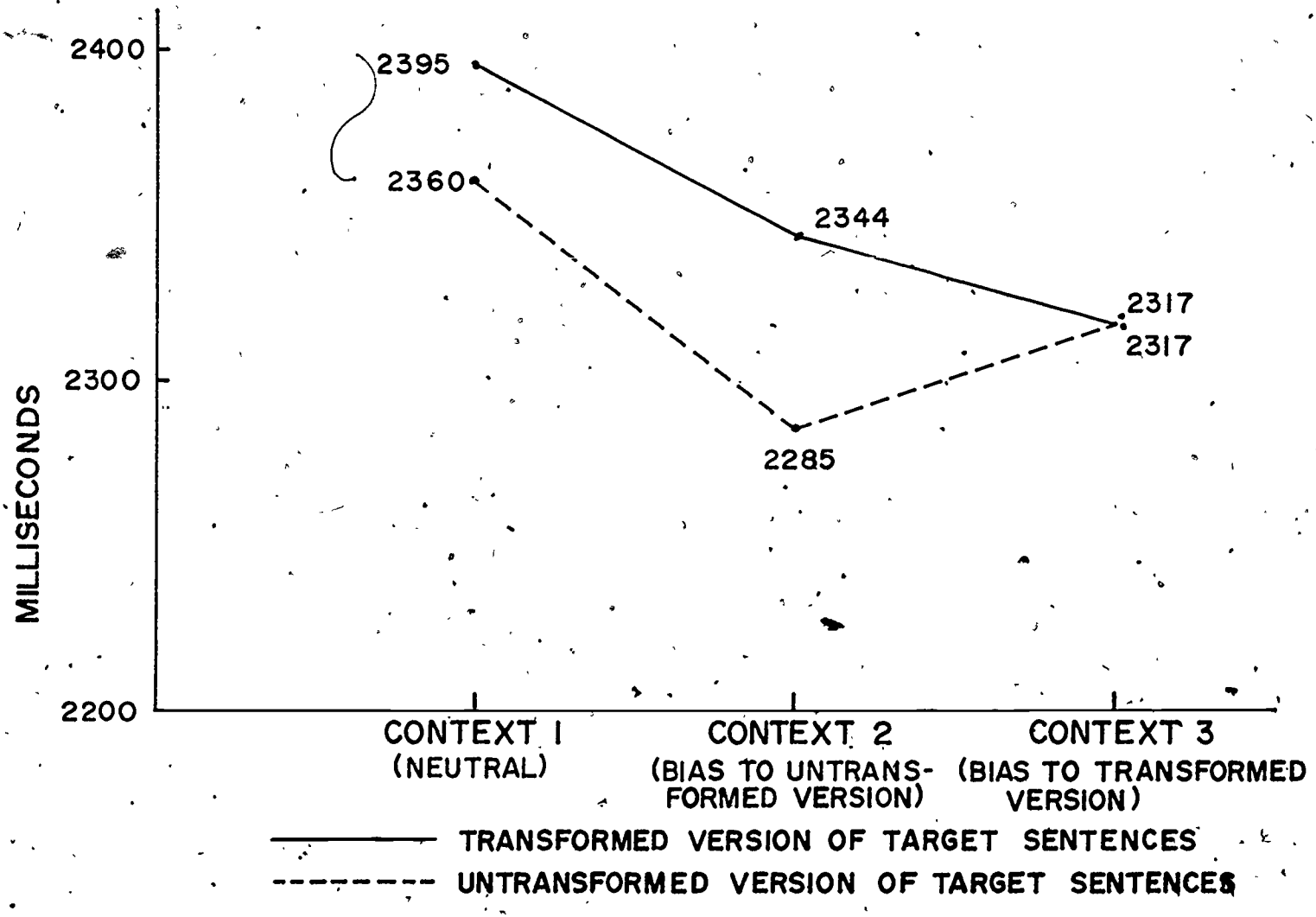
Figure 4. Mean response times (msec) for the Passive transformation.

Figure 5. Mean response times (msec) for There Insertion transformation.

Figure 6. Mean response times (msec) for the Adverb Preposing transformation.

Figure 7. Mean response times (msec) for the Raising to Object transformation.

Figure 8. Mean response times (msec) for the Raising to Subject transformation.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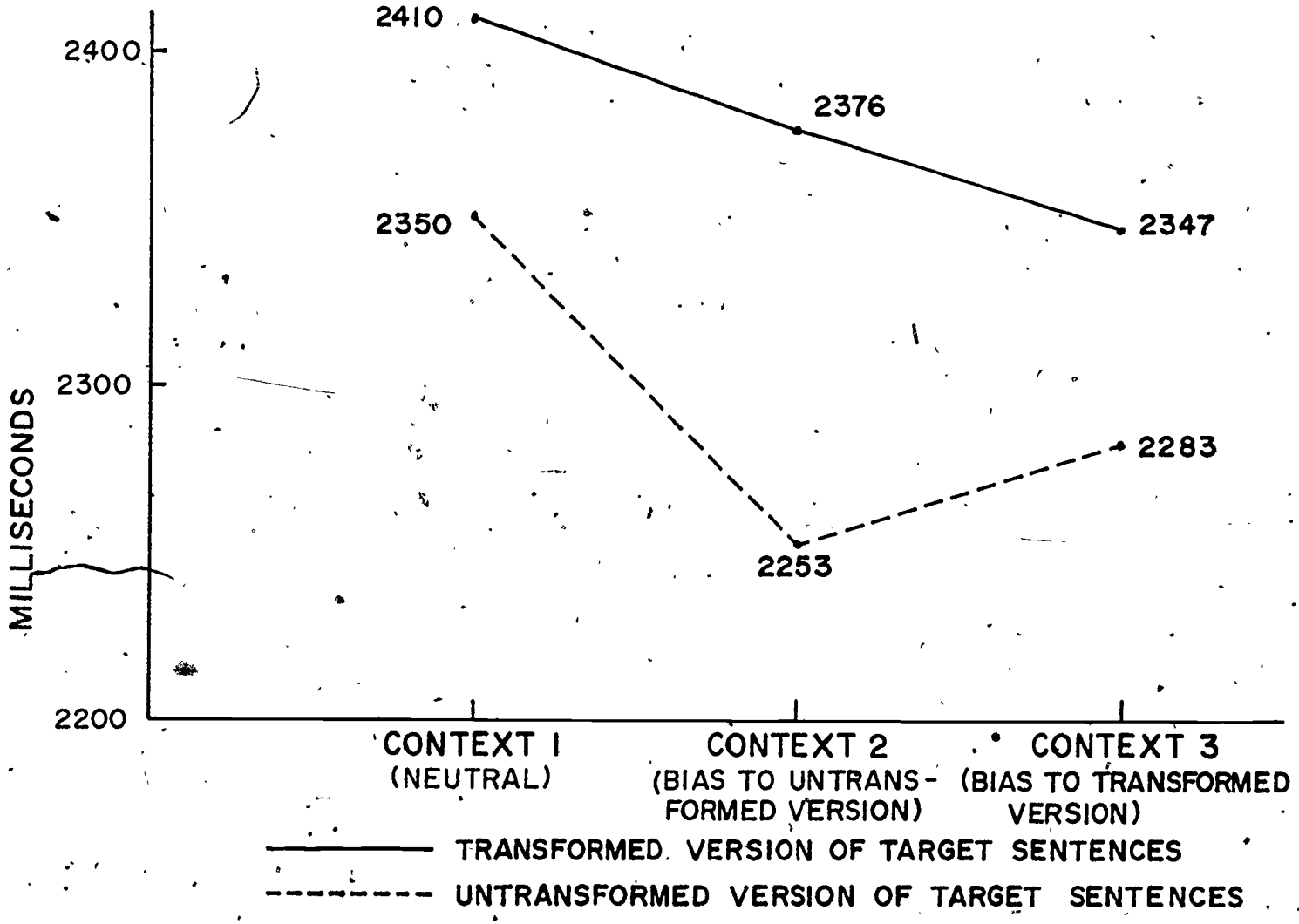
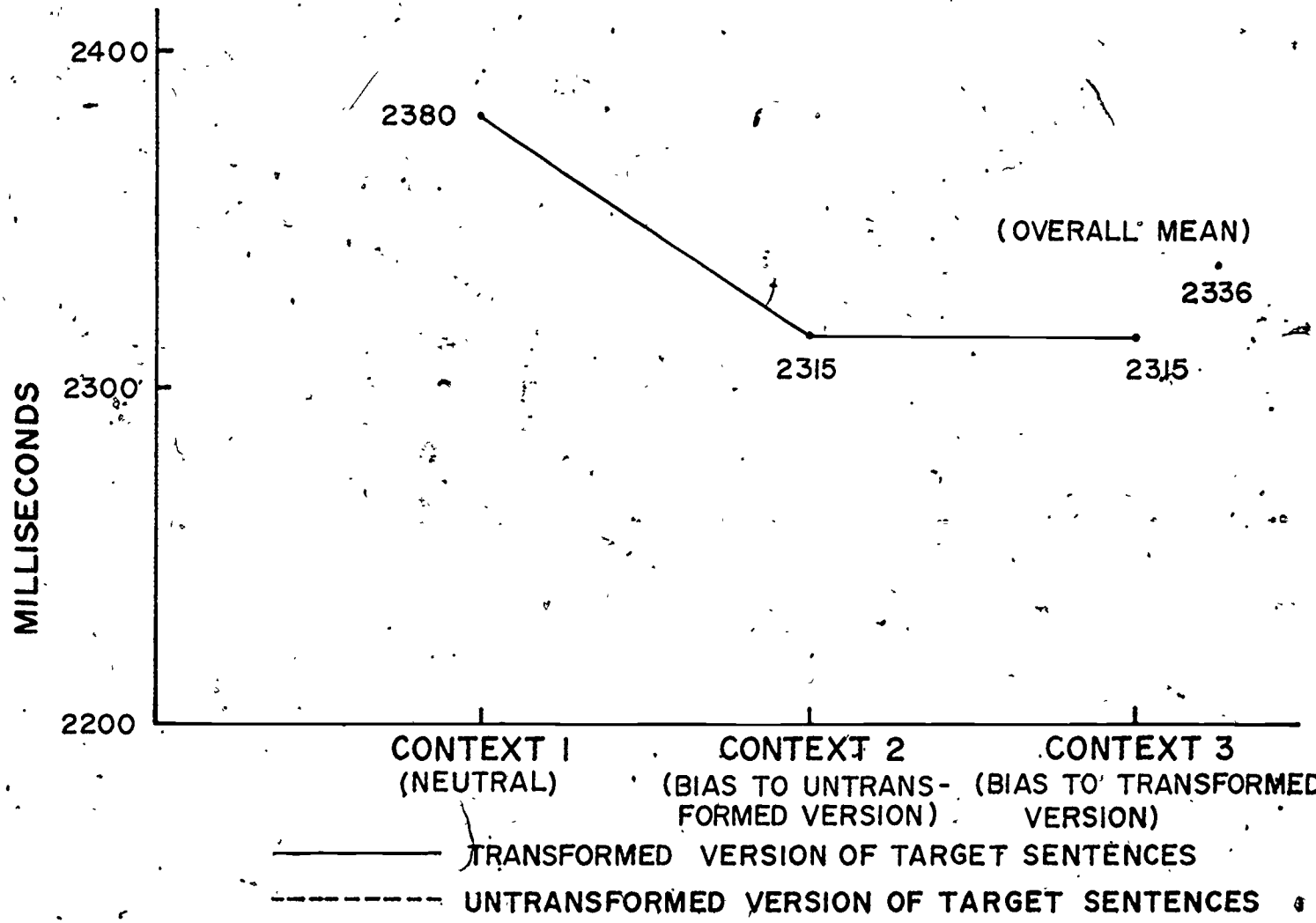
2300
2200
MILLISECONDS
2395
2360
2344
2317
2317
2285
CONTEXT 1
(NEUTRAL)
CONTEXT 2
(BIAS TO UNTRANS-
FORMED VERSION)
CONTEXT 3
(BIAS TO TRANSFORMED
VERSION)
TRANSFORMED VERSION OF TARGET SENTENCES
UNTRANSFORMED VERSION OF TARGET SENTENCES


2410
2376
2347
2350
2283
2253
2400
2300
2200
MILLISECONDS
CONTEXT 1
(NEUTRAL)
CONTEXT 2
(BIAS TO UNTRANS-
FORMED VERSION)
CONTEXT 3
(BIAS TO TRANSFORMED
VERSION)
TRANSFORMED VERSION OF TARGET SENTENCES
UNTRANSFORMED VERSION OF TARGET SENTENCES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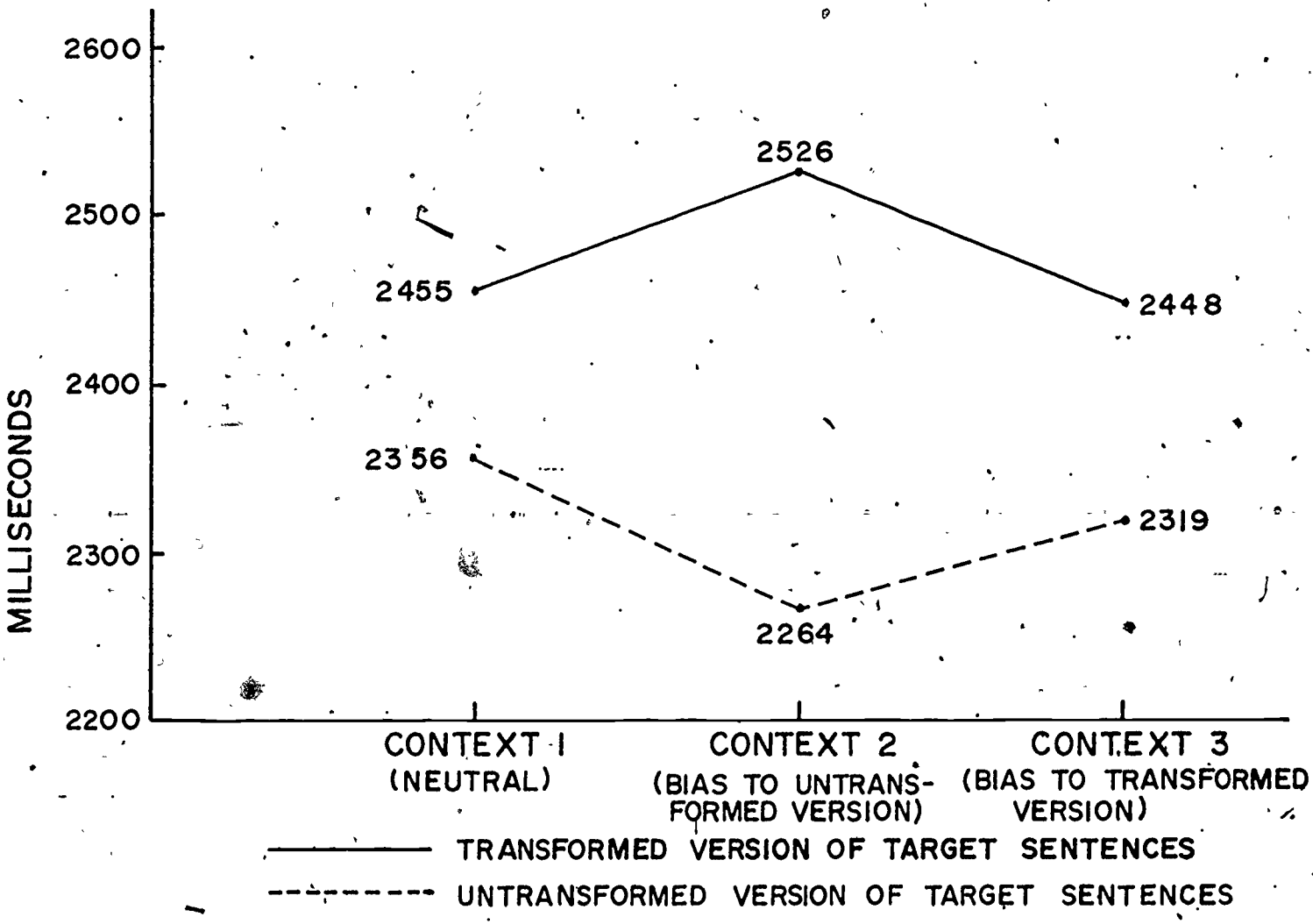
2300
2200
MILLISECONDS
2380
2315
2315
2336
(OVERALL MEAN)
CONTEXT 1
(NEUTRAL)
CONTEXT 2
(BIAS TO UNTRANS-
FORMED VERSION)
CONTEXT 3
(BIAS TO TRANSFORMED
VERSION)
TRANSFORMED VERSION OF TARGET SENTENCES
UNTRANSFORMED VERSION OF TARGET SENTENCES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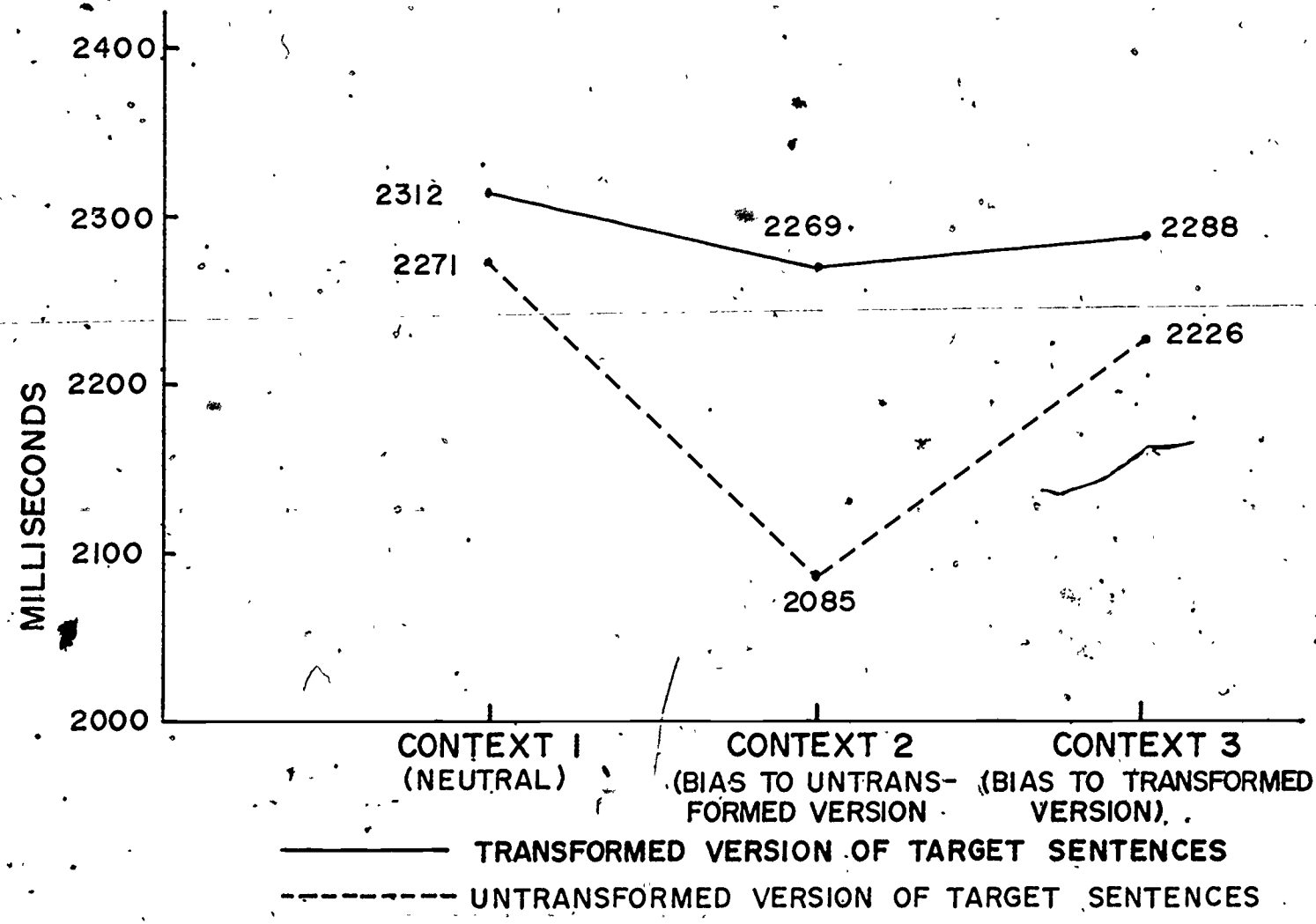
2500
2400
2300
2200
MILLISECONDS
2526
2455
2448
2356
2319
2264
CONTEXT 1
(NEUTRAL)
CONTEXT 2
(BIAS TO UNTRANS-
FORMED VERSION)
CONTEXT 3
(BIAS TO TRANSFORMED
VERSION)
TRANSFORMED VERSION OF TARGET SENTENCES
UNTRANSFORMED VERSION OF TARGET SENTENCES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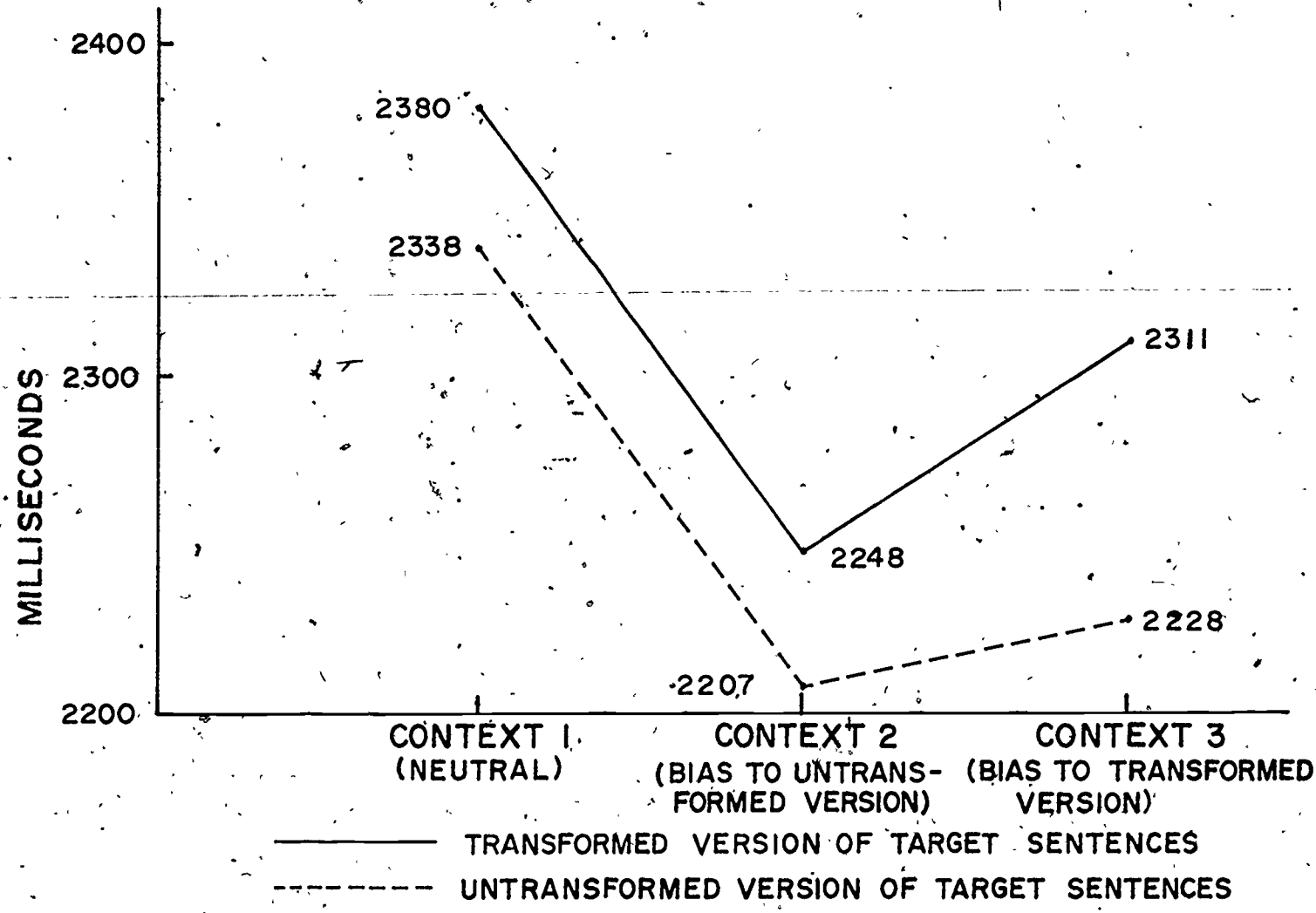
2300
2200
2100
2000
MILLISECONDS
2312
2269
2288
2271
2226
2085
CONTEXT 1
(NEUTRAL)
CONTEXT 2
(BIAS TO UNTRANS-
FORMED VERSION
CONTEXT 3
(BIAS TO TRANSFORMED
VERSION)
TRANSFORMED VERSION OF TARGET SENTENCES
UNTRANSFORMED VERSION OF TARGET SENTENCES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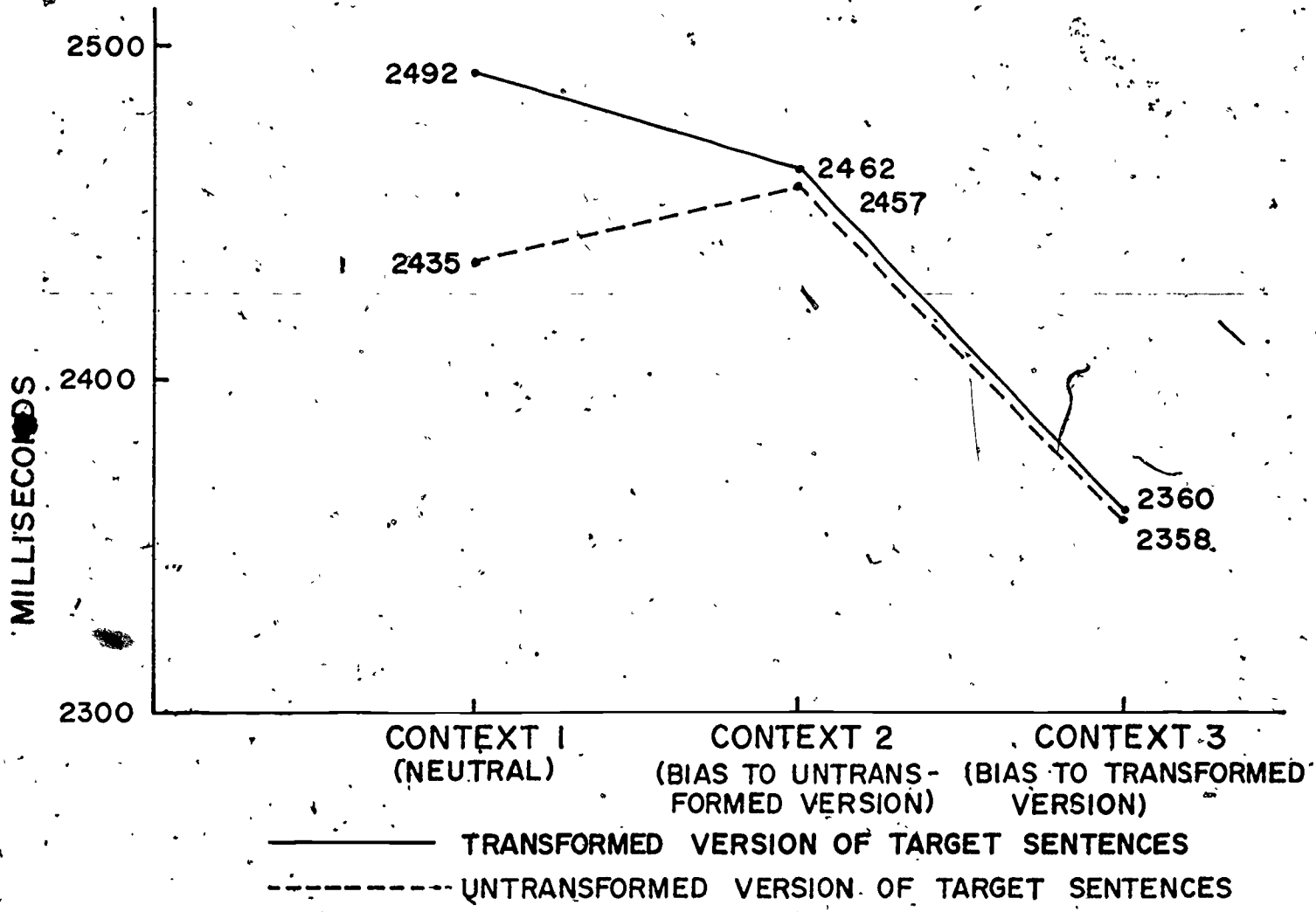
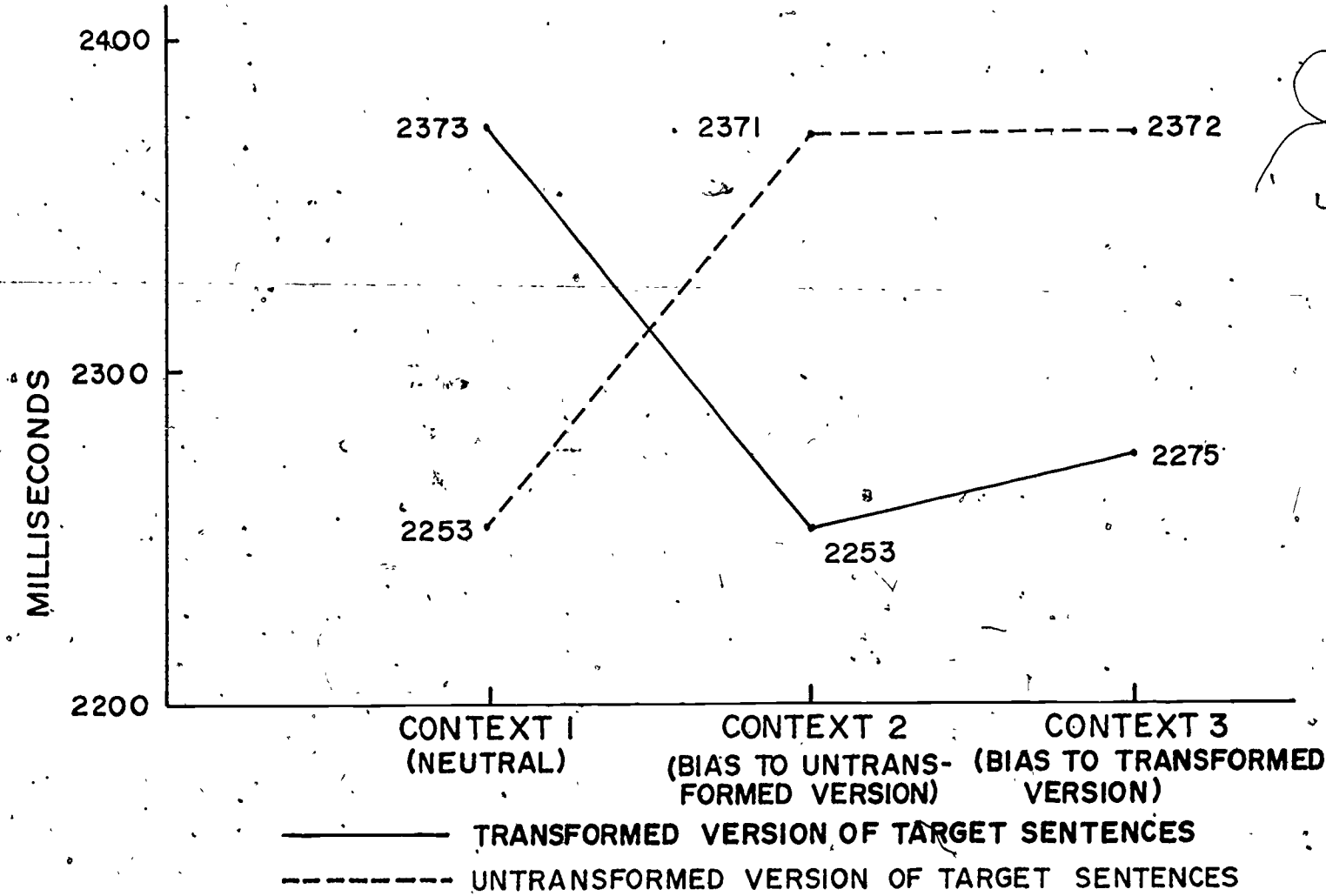
2380
2338
2300
MILLISECONDS
2311
2248
2228
2207
2200
CONTEXT 1
(NEUTRAL)
CONTEXT 2
(BIAS TO UNTRANS-
FORMED VERSION)
CONTEXT 3
(BIAS TO TRANSFORMED
VERSION)
TRANSFORMED VERSION OF TARGET SENTENCES
UNTRANSFORMED VERSION OF TARGET SENTENCES


2500
2400
2300
MILLISECONDS
2492
2462
2457
2435
2360
2358
CONTEXT 1
(NEUTRAL)
CONTEXT 2
(BIAS TO UNTRANS-
FORMED VERSION)
CONTEXT 3
(BIAS TO TRANSFORMED
VERSION)
TRANSFORMED VERSION OF TARGET SENTENCES
UNTRANSFORMED VERSION OF TARGET SENTENCES


2400
2300
2200
MILLISECONDS
2373
2371
2372
2253
2253
2275
CONTEXT 1
(NEUTRAL)
CONTEXT 2
(BIAS TO UNTRANS-
FORMED VERSION)
CONTEXT 3
(BIAS TO TRANSFORMED
VERSION)
TRANSFORMED VERSION OF TARGET SENTENCES
UNTRANSFORMED VERSION OF TARGET SENTENCES