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ABSTRACT

This experiment sought to determine the effect of various pause-deletion schemes on the comprehension of oral language under time-compression conditions. Three pause-deleted versions of a 1540-word spoken message read at 164 words per minute (wpm) were prepared. The first version deleted all inter-lexical pauses occurring at significant Immediate Constituent boundaries. The second version deleted inter-lexical pauses corresponding to Deep Structure Analogue breaks. The third deleted all inter-lexical pauses of 50 milliseconds or greater duration. These three recordings, plus a control condition with pauses intact, were differentially time-compressed to six target rates from 225 to 350 wpm. A total of 168 college students served as subjects. The subjects listened to one of the 24 experimental conditions and subsequently took a 55-item comprehension test. Results of this experiment and an additional replication of the experiment involving 192 college students failed to confirm any significant differences between pause and non-pause-deleted conditions. These results were interpreted as disconfirming a two-stage model of speech perception and comprehension. (Author/WR)

Final Report

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This experiment sought to determine the effect of various pause deletion schemes on the comprehension of oral language under time-compression conditions. Three pause-deleted versions of a 1540 spoken message read at 164 wpm were prepared. The first version deleted all inter-lexical pauses occurring at significant Immediate Constituent boundaries. The second version deleted inter-lexical pauses corresponding to Deep Structure Analogue breaks. The third deleted all inter-lexical pauses of 50 msec. or greater duration. These three recordings, plus a control condition with pauses intact, were differentially time-compressed to six target rates from 225 to 350 wpm in 25 wpm intervals. A total of 168 Ss listened to one of the 24 experimental conditions and subsequently took a 55 item comprehension test.

Results of this experiment and an additional replication of the experiment involving 192 Ss failed to confirm any significant differences between pause and non-pause-deleted conditions. These results were interpreted as disconfirming a two-stage model of speech perception and comprehension. An alternate one-stage model is proposed with continuous perceptual, syntactic, and lexical analysis within phrases, leaving judgments of comprehensibility or understanding to be completed at phrase boundary or pause junctures.

PREFACE

The principal author wishes to thank Larry R. Yates for his invaluable assistance in the completion of this series of experiments. Mr. Yates ran most of the subjects and completed much of the preliminary data analysis.

In addition, the principal author wishes to stress that this series of experiments has forced a harsh reevaluation of several fundamental assumptions in speech processing models, as interpreted by this investigator. In particular, the lack of any overall significance in pause manipulation work with listeners has prompted several theoretical reworkings of previous language models. And that work, while not yet complete, should be realized in both a fuller interpretation of these research findings and in a subsequent language-based reading model.

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INTRODUCTION

Theoretical Framework

Almost all of the major experimental work on oral language processing in the past ten years has derived from the theoretical work of Noam Chomsky in linguistics. Adapting certain principles of symbolic logic and applied mathematics to the study of language structure, Chomsky (1957, 1965, 1967, 1968a, 1968b) had developed what has come to be called the transformational-generative theory of language. Convinced that the structuralist, Bloomfieldian school of descriptive linguistics and the behaviorist psychological models of verbal learning were inherently inadequate in their approach to the complexity of language, Chomsky turned to a "systems-like" approach to language that emphasized an innate rational schema in man capable of deriving the base or deep structure forms of language from its surface renderings. Chomsky ascribed a great deal to the syntactic or structural component of language; it must be capable of generating or deriving the infinite set of grammatical English sentences from a finite set of means. Almost necessarily this competence structure, attributed to the native speaker-hearer of a language, consisted of an ordered set of rules that transformed the surface structure of sentences to simple base forms which were more readily interpreted by a separate semantic system. To the basic syntactic system was also appended a phonological system that interpreted the syntactic surface structure to a phonetic realization or the actual sounds of the spoken language. These three interacting systems of phonology, syntax, and semantics were then thought capable of making explicit a sound-meaning correspondence.

In this descriptive and explanatory analysis of language competence, syntax played the central creative role and was thus more fully explored in the early period of generative theory. For the system to properly function a number of assumptions or linguistic universals were proposed as characteristics of all human languages. First among these was the distinction between linguistic competence and performance; that linguistics was concerned only with what a system might be like that would properly describe the structural complexity of human language, accounting for the creativity of its use, and not with psychological performance variables such as attention, memory limitations, slips of the tongue, etc. As such, the area of psycholinguistics may be defined as the study of man's linguistic performance, a subject which is obviously related and yet distinct.

A second assumption was the distinction between surface and deep structure in language in order to account for the phenomena of synonomy, paraphrase, anomaly, and semantic ambiguity in performance and facilitate semantic interpretation from simpler abstract underlying structures. In other words as native speakers of English we recognize, for example, that the active and passive forms of a sentence have essentially the same meaning. If this is true then the underlying structure of these two utterances must be the same. To explicate the differences in surface arrangement from a unitary underlying form we need in addition to a simple phrase structure grammar for the underlying logical "sentences" the third assumption of a transformational component that will rearrange and delete the elements of a linguistic string. A fourth assumption was that the phrase structure and transformational components acquire their generative capacity through an ordered set of context-free rewrite rules, a lexicon, and a sequence of singularly transformation rules that make up the competence factor of a native speaker of the language. These rules in a sense activate this generative derivational component. They have as a special subset a recursive attribute. That is, certain subsets of the ordered rules can be applied repeatedly to various levels of structured derivation, much as a computer will perform repetitive operations on a set of data within certain constraints.

As Chomsky has repeatedly asserted, the study of linguistic competence is not to be construed as a theory of performance. However, it is obvious that his theories have serious implications for psychological studies of language-processing. There is, for example, considerable experimental evidence that language is stored and remembered in terms of its deep structure representation (see Miller, 1962; Mehler, 1963; Mehler and Bever, 1967; Rohrman, 1968; et al.) The following study is yet another experimental investigation of the psychological ramifications of Chomsky's theory of language. It seeks, in particular, to further articulate the algorithm necessary for the recovery of deep structure in the decoding of oral language.

Experimental Background

In the past several years there has been comparatively little work on pause time as a variable in the comprehension of speech. Maclay and Osgood (1959) investigated the role of filled and unfilled pauses in spontaneous speech relative to a grammatical and uncertainty analysis; Boomer (1965) attempted to refute the transitional probability theory of hesitation phenomena; and Martin and Strange (1968) found that perceived pause was displaced to constituent boundaries. However, with the exception of the important and extensive work of Goldman-Eisler (1968), this area of psycholinguistic research seems to have been dominated by the analysis-by-synthesis view that most of the prosodic features of speech can be regularly predicted by the phonological rules of English from the abstract surface-structure ordering of formatives (see Chomsky & Halle, 1968). Yet even if this theoretical framework is formally correct as a model of competence, the problem remains as to what cues exist in the speech stream that will guide the listener to the correct deep structure interpretation, hence to a surface structure, phonetic rendering, and a perceptual match and acceptance. It increasingly appears that prosodic features may have a large role in guiding the listener's actual performance, and unfortunately most of the work thus far on pause has concentrated on the planning or hesitation phenomenon in spontaneous speech as an indicator of encoding complexity.

If speech is time-ordered in both its production and comprehension (and that is not entirely clear; see for example, Liberman, Cooper, et al., 1967), and if we minimize the role of parallel processing for the sake of conceptual clarity, then the derivation of syntactic and semantic structure takes time. One of the important questions is when and how this computation takes place. What schema guides the initial segmentation of speech for STM, and what defines these essential decoding units.

The click displacement work of Garrett, Fodor, and Bever (see Garrett, 1965; Fodor and Bever, 1965) indicated that irrelevant acoustic bursts when simultaneously presented with linguistic material were displaced to adjacent I.C. boundaries. This early work indicated that at least some gross grammatical knowledge was important in the segmentation of speech. Theoretically these results were congruent with the hypothesis that low-priority events (i.e., the "click") were not processed or perceived from STM. But in the course of time the I.C. boundary as perceptual unit gave way to the clause (Garrett, Bever & Fodor, 1966) and the clause to deep structural analogues in the surface structure (Bever, Lackner, & Kirk, 1969; Bever, Lackner, & Stoltz, 1969). If speech is then segmented according to its deep structure interpretation, the problem is what clues in the speech stream make it possible to recover the putative deep structure. A recent series of papers has proposed that such optional features as the presence or absence of relative pronouns in center-embedded constructions, or more generally, the lexical quality of the verb (in the sense of the types of grammatical functions it may enter into) can be crucially important in the rapid determination of sentence structure (Fodor & Garrett, 1967, 1968; Bever, 1970). Nor do these authors confine their hypothesis to these two lexical classes, but instead suggest that the lexical complexity or probabilities of all lexical form classes as to what underlying sentence forms they may enter in, may be important in the recovery of deep structure. This would suggest that within the clause or perceptual unit, transitional probabilities of form classes or lexical items may have an important role (Bever, Lackner, & Stoltz, 1969) along with inflection, order, and various suprasegmental features, recalling the earlier work of Yngve (1960) and the information theorists. The hypothesis is that certain lexical items have greater importance than others, and in fact, guide the search routine for deep structure sequences that are transformable to the surface structure and phonetic rendering of the speech stream segments under consideration. Such an hypothesis suggests stochastic measures as another important variable in sentential complexity. Some exploratory work by Bever (1967) demonstrates that the actual length of the verb in a sentence can affect the comprehensibility of an utterance. Those sentences with longer multisyllabic verbs are better comprehended than their monosyllabic counterparts. This would suggest that if there is an initial word filter or recovery device, greater time can be spent evaluating the multisyllabic verb as an important guide to the structure of the sentence. The counterpart in the actual speech stream would be that some lexical items might be more redundantly actualized than others in terms of their information content and thus require less processing time.

If sentences are segmented for further processing according to their deep structure representation, then necessary syntactic processing time at the end of perceptual segments ought to be less a factor than earlier hypothesized -- and indeed, preliminary data (Miron and Brown, 1968, 1969) would tend to confirm this. Instead, processing time at the end of perceptual units may be a function solely of deep structure complexity, or the time necessary for a semantic reading of the deep structure strings. It is a common observation that the segmental boundaries of speech appear to condition the perception of pause even in the absence of physical pause in the speech stream. Physical pause distribution may thus be a redundant correlate of an encoder's organizational intentions not required by the listener, but instead providing supportive cues to the algorithmic recovery of deep structure. Disturbance of the normal structure-pause correlation may seriously impair rapid recovery of structure and hence comprehension, especially in those instances where the surface structure masks deep structure regularity or when speech input begins to overload the processor as in speech compression.

Research Problem

The literature indicates that pause time in the comprehension of oral messages may serve one of three purposes: 1) it may function as an important indicator of structural complexity as the creator of linguistic segments for STM -- that is, it may literally demarcate computable segments for STM; 2) it may provide necessary processing time at the completion of linguistic segments in STM; 3) it may reflect some psychological necessity in the listening habits of subjects and thus function as a redundant aspect of the speech stream. The following study sought to explore these hypothese through two dependent experiments: 1) the prediction of pause time in an extended spoken message from linguistic and stochastic analyses; 2) the effect of pause deletion schemes on speech comprehension under time compression conditions.

Experiment I. Predictability of Pause Time in Spoken Messages

The first experiment was completed prior to the commencement of this project (Brown and Miron, 1971). In it the predictability of pause time in a 1540 work spoken message was investigated. The so-called "Meteorology Message" has received extensive analysis in the past 15 years (see Fairbanks, Guttman, and Miron, 1957a, b. c.; Miron and Brown, 1968). In this instance a professionally read rendition paced at 164 wpm was analyzed from four points of view. An IC, or Immediate Constituent, analysis was performed on each of the 84 sentences in the message. A simple IC boundary depth measure was calculated between each successive pair of words, counting all left and right facing brackets at that juncture. This measure would generally reflect surface structure complexity. A second measure (SCI) provided a slight variation on this procedure, following Chomsky and Miller's (1963) suggestion of a node-to-terminal-node ratio in the tree diagram of the terminal string. The third measure attempted to specify corresponding deep structure breaks in the surface structure. These deep structure analogues (DSA) generally coincided with clauses; however, additional specifications of other conjoining transformations were noted as well. This analysis was thought to account for deep structural breaks that might not occur in a surface structure analysis alone. The fourth measure, based on a stochastic model, consisted of information estimates on all 1540 lexical items based on a cloze-type task as a modification of Shannon's (1951) letter-guessing scheme and earlier developed by Miron and Brown (1968). An oscillographic recording of the entire message was performed, and text then appended so that all pauses could be related to morphemic analysis.

The three syntactic variables plus several additional lexical measures were entered into a multiple regression equation for the prediction of pause time. The final multiple R was .80, accounting for 64% of the pause time variance. Both the surface structure (IC) and deep structure analogue (DSA) measures of syntactic complexity yielded reliable predictive variance not accounted for in the overlap of the two variables, suggesting that both levels of linguistic representation were important determiners of pause structure in an oral reading performance.

Experiment II. Pause Manipulation in the Comprehension of Rate-Incremented Oral Messages

The second experiment, which this grant supported, sought to determine the effect of various pause deletion schemas on the comprehension of oral language under conditions of time-compression. Fairbanks, et al. (1957) and Foulke & Sticht (1969) have indicated that comfortable oral reading performances of 150-175 wpm may be rate-incremented through time compression to approximately 275 wpm without significant loss in comprehension. At this speed it was hypothesized that oral processing strategies utilized at lower listening speeds become maximally efficient. Earlier research by Miron and Brown (1969) had suggested that in a range of plus or minus 50 wpm around this 275 wpm, 100% pause deletion might have a greater detremental effect on comprehension than the same material with no pause deletion, time-compressed to approximately the same rate. At higher speeds it was hypothesized that a greater sampling strategy is used by listeners; at lower speeds there is suficient time for comprehension at other than pause junctures.

The same 165 wpm professional read version of the "Meteorology Message" used in the previous experiment was to be time-compressed with and without pause excision through the 225-350 wpm range in 25 wpm target rate steps. It was hypothesized that the pause compressed versions would have some maximally detremental apex in this wpm range as compared to the randomly compressed control. Furthermore, three different pause compression schemes were to be used. The first would delete all pauses of 50 mSec. duration or greater in the 1540 word message and thus reflect the speaker's intended pausing. The second would delete all pauses that occur at major I.C. boundaries as determined from Experiment 1. The third would delete all pauses that occur at major clause or deep structure analogue boundaries as determined from the previous analysis.

Hypotheses to be tested were: 1) there is a critical wpm range in which pause compression has a greater detrimental effect on comprehension by random sampling procedure; 2) pause deletion and subsequent compression in general will have a greater detrimental effect on comprehension than simple random compression to equivalent wpm speeds; 3) it is possible to predict from a study of speech-pause performance the order of effect.

In attempting to confirm these hypotheses, both the original proposed experiment was run as well as a complete additional replication. Since both of these experiments had essentially the same results the discussion will sometimes coalesce these findings for the purpose of theoretical interpretation. However, for reasons of clarity, methodologies and results will be presented sequentially.

METHOD

Stimulus Preparation

Previous published work (Brown & Miron, 1971) has documented the details of message preparation and speaker selection and control. In brief, the 1540 word message selected for study has been well-researched, along with an accompanying 55 item comprehension test requiring factual recall. The message deals with weather information for pilots--a topic with minimum pre-knowledge for subjects. Its length is related to an attempt to obtain more natural stimulus material, as compared with single sentence and word list experiments.

A professional talker read this material at seven different rates, ranging over his minimum to maximum sustained rates of articulation. From this sequence the "normal" speed recording (164.2 wpm) was selected for further analysis and experimental manipulation. That this normal speed message is not deviant from other oral reading performances can be determined both in terms of rate (Lane & Grosjean, 1973; Carroll, 1966; Foulke, 1966; Hutton, 1954; Darley, 1940) and a 30% pause/phonation ratio statistic (Hutton, 1954; Goldman-Eisler, 1968). Lane & Grosjean (1973) further indicate that variations in rate are determined by the number of pauses a speaker produces and not in phonation or pause duration per se.

Four different pause-manipulated versions of this original 164 wpm message were prepared for Experiment II. In the first version all inter-lexical pauses of 50 mSec. or greater duration were excised from the message. In the second version only those pauses that occurred at major IC boundary junctures were deleted. These junctures were operationally defined as Immediate Constituent boundaries with a depth of three or more as determined by the analyses in Experiment I. A third version of the message deleted all pauses occurring at grammatical junctures corresponding to Deep Structure Analogue breaks, as determined by analyses in Experiment I. Finally the fourth version of the message acted as a control, with all inter-lexical pauses left intact.

Pauses were excised with a cut and splice method to a tolerance of approximately one inch or 67 mSec. on a 15 ips recording. That is, all pauses corresponding to the appropriate criteria for each version were excised if they exceeded approximately 50 mSec. This limit was imposed by the working method of diagonal splices at the conclusion and onset of phonation. Puases corresponding to the various grammatical and durational criteria were located by rocking the tape through the playback head of a Magnecord Model 1022 Tape Recorder, and marking the beginning and end of the pause as determined by ear. This section was then deleted and the ends spliced.

Table 1 shows the resultant speeds following the various pause deletion schemes both in total duration and words per minute. Since overall rate was to be held constant in 25 wpm intervals from 225 wpm to 350 wpm, varying levels of compression were needed to achieve the target rates. These percent compression figures (R_c) and target

TABLE 1

Rates and Percent Compressions for Four Pause-Altered

Versions of Message

Target Rate (wpm)	Time (Secs)	Treatment Conditions			
		$100P_c$	0	DSA	IC
		Original Time (Secs)			
		454.1	557.3	469.16	462.6
		Original Rate (wpm)			
		203.1	165.5	196.4	199.4
		R_c Treatments (%)			
		$100P_c$	0	DSA	IC
225	409.9	10	26	13	11
250	368.9	19	34	21	20
275	335.4	26	40	29	28
300	307.4	32	45	35	34
325	283.8	38	49	40	39
350	263.5	42	53	44	43

rates are also found in Table 1 for the four different versions of the message.

The four stimulus tapes were time-compressed to the six target rates from 225 to 350 wpm at the Perceptual Alternatives Laboratory at the University of Louisville, Louisville, Kentucky. The research machine functioning in this laboratory is generally conceded to the best Fairbanks-type compressor in the country. The degree of accuracy achieved is indicated in the resultant rates for the four stimulus tapes shown in Table 2.

Subjects

The four stimulus tapes by six wpm levels design resulted in 24 testing situations. One hundred sixty eight students from the Introductory Psychology Subject Pool were haphazardly assigned to the 24 experimental conditions. Subjects were run in groups of four or five, with a total of seven Ss in each cell. All Ss had no apparent speech or hearing defects, and there was a roughly equal sex division.

Procedure

In the context of an experimental hour, subjects were first told of the nature of the experimental procedure. They then listened to an introductory recording that described the time compression process in some detail, in addition to acclimating them to the phenomenon itself. Both this and the subsequent test recording were played back from a Tandberg 1200X Tape Recorder to Superex ST-PRO stereo headphones. Following the test recording, a 55 item multiple-choice comprehension test on the message was completed. No time limit was imposed on the completion of the comprehension test.

RESULTS

The resulting experimental design of four experimental conditions by six wpm rates was analyzed as a 4 X 6 factorial ANOVA. Cell means and SDs are displayed in Table 3. The analysis yielded no significant main effects or interactions as can be seen in Table 4. Not only was there no differentiation in pause manipulated conditions, but also a much-documented difference in comprehension along the rate dimension (Carver, 1973; Foulke, 1968) also failed to materialize. Inspection of the SDs in Table 3 and the large error term in Table 4 suggested that subject variation might be accounting for this general lack of significance. Consequently, a replication of the experiment was conducted with additional methods and procedures to reduce subject variability.

TABLE 2

Achieved Durations for Time-Compressed Recordings

	WPMS					
Conditions	225	250	275	300	325	350
0	397.1	357.5	325.3	296.95	275.55	255.55
100% Pause	396.6	358.7	325.75	297.25	274.0	255.15
IC Pause	394.85	358.4	323.95	301.1	274.3	254.4
DSA Pause	295.55	357.55	324.2	297.25	276.4	256.25

TABLE 3

Means and SDs for the Full Data Matrix

WPM	0 PAUSE	100%	IC	DSA
225				
$\bar{X}$ =	36.29	26.57	28.29	32.86
SD=	5.59	6.79	9.05	10.96
250				
$\bar{X}$ =	28.00	29.86	30.00	33.00
SD=	7.02	5.01	7.79	9.73
275				
$\bar{X}$ =	33.71	25.57	34.43	27.57
SD=	8.90	8.86	9.54	3.99
300				
$\bar{X}$ =	28.00	25.43	26.71	28.29
SD=	7.16	7.95	6.26	9.82
325				
$\bar{X}$ =	29.71	28.00	28.57	25.14
SD=	6.50	7.28	5.44	6.31
350				
$\bar{X}$ =	25.57	24.86	27.86	28.00
SD=	7.48	8.88	6.26	11.97

TABLE 4

Analysis at Variance: Experiment I

SOURCE	PROP. OF VAR.	SS	df	MS	F
Treat. A (Pause)	.03	314.2	3		1.70 n.s.
Treat. B (Speed)	.05	537.3	5		1.74 n.s.
A X B	.07	769.5	15		71.00
W Cell	.85	8901.5	144		
TOTAL		10522.5	167		

REPLICATION OF EXPERIMENT II

Subjects

Eight Ss per experimental condition were run from the same student population for a total of 192 Ss in the 24 conditions. As an additional inducement to good performance on the listening task, a cash award of $5.00 was paid to the top quarter of each experimental condition population as ranked on the comprehension test results.

Procedure

Two covariate measures were added to the experimental hour to reduce subject variation. Before listening to the orientation recording or the experimental recording, the Ss took a five minute reading speed measure based on a text unrelated to the experimental recording. They then completed a 50 item cloze-type word deletion test based on the material used in the speed reading measure. Both the speed and reading comprehension measures were adapted from the Michigan Adult Reading Test, an unpublished instrument used in prior experimentation (Miron & Brown, 1968, 1971). The combined experimental time for the administration of both of these instruments was approximately twenty minutes. All other procedures remained the same.

Results

Means and SDs for the 24 experimental conditions are exhibited in Table 5. The N for each cell was eight Ss. In this instance the 4 treatment X 6 wpm rate design was treated as an analysis of covariance. The general method of Cohen (1968) was adopted, where analysis of covariance is treated as a special case of multiple regression. The two covariates used were reading speed and reading comprehension. The dependent variable was listening comprehension, subsequent to hearing the recorded test message. Table 6 presents a summary of this analysis. The assumption was met that the within-group regression coefficients are all estimates of the same common population regression coefficient ($b_{CI} = -.06$, $b_{CI} = -.05$). However, the size of the common coefficients principally reflected the randomization effect in the assignment of subjects to experimental treatments, and did not justify adjustment of the group means.

Inspection of Table 6 reveals that a significant main effect along the rate dimension was established. Moreover, a further analysis for trends revealed that this was primarily a linear function. Both these results are anticipated in the work of Carver (1973) and Foulke (1968), who found an essentially linear decrement in comprehension as rate increased in these ranges. Again, no pause

TABLE 5

Means and SDs for the Full Data Matrix:

Replication of Experiment II

WPM	0 PAUSE	100%	IC	DSA
225				
Mean	40.12	27.00	34.25	34.50
SD	2.94	6.18	7.47	8.38
250				
Mean	29.37	29.25	28.62	33.87
SD	7.90	8.43	9.72	11.20
275				
Mean	25.62	30.62	22.50	29.00
SD	10.33	8.73	5.39	7.28
300				
Mean	29.75	28.62	31.37	30.50
SD	4.55	9.69	4.77	8.33
325				
Mean	25.25	25.50	19.25	30.50
SD	8.48	8.66	5.00	6.32
350				
Mean	26.50	30.75	27.62	22.25
SD	7.15	8.10	7.44	7.08

TABLE 6

Analysis of Covariance: Replication

of Experiment II

SOURCES	PROP. OF VAR.	SS	df	MS	F
Treat. A (Pause)	.01	120.42	3		1.00
Treat. B (Speed)	.11	1500.80	5		5.49*
Linearity	.08	1053.26	1		(t=3.99)*
Dev./Linearity	.02	447.55	4		
A X B	.10	1294.06	15		1.58
Covariate I (Cloze)	.13	1748.79	1		32.10*
Covariate II (Reading Speed)	.03	446.33	1		8.15*
W Cell	.63	8576.55	166		
TOTAL		13685.94	191		

*p $<$ .01

differentiation is seen--either in differences between pause deletion conditions, or in overall effects of deleting pauses versus no deletion of pauses.

A rescoring of the test was subsequently initiated. Following the method of Carver (1973), a subset of the original 55 items in the comprehension test was used that maximally discriminated knowledge gained from the listening situation itself. A control group of 25 Ss was run who took the comprehension test without listening to the passage on which it is based. They then listened to the passage at normal rate (165 wpm) and retook the comprehension instrument. Nineteen test items were selected that showed the greatest difference in pre-post knowledge gained. These were items which 64% or more of the Ss were unable to answer correctly on first testing, but which subsequently were correctly answered following the presentation of the message. Recomputing the entire comprehension test results in terms of these maximally-discriminating items yielded no significant differences in the overall results.

CONCLUSIONS

Results of these experiments show no differentiation of pause conditions according to grammatical schemes when comprehension scores are compared, nor is there any overall effect attributable to pause deletion in general as opposed to leaving pauses intact. With speed held constant, the availability of pause time at phrase boundaries appears to make no significant difference in the comprehension of speech.

Thus it would appear that we must alter the two-stage model of language processing. Time is certainly needed to understand language -- comprehension generally declines as rate of input increases. But little if any of that time is required at segmentation or phrase boundaries for higher-order processing. This may stand in marked contrast to lower order tasks as is suggested by Aaronson (1973 a, b). The model that emerges is that of the listener who is performing two simultaneous functions as he listens to speech input within phrase units. He is "attending to the external acoustic stimulus and (simultaneously) developing an internal perceptual representation of it" (Bever, Lackner, & Stoltz, 1969). In the corresponding reading model (Brown, 1970) the present author has called this a continuous stochastic expectancy analysis that seeks to generate acceptable abstract representations of the input sufficient for a generated match through an analysis-by-synthesis process. Perceptual, syntactic, and lexical analysis is rapid and continuous, certainly terminating by the completion of the phrase input. What is left to do at the phrase boundary is to decide whether or not the generated abstract structure is an acceptable match to the input held in short term memory. This is a judgment of comprehensibility or understanding (Deese, 1969) in line with well-formedness conditions shading off into knowledge of the real world. It is preceded by earlier judgments of perceptual syntactic, and laxical acceptability. Judgments of comprehensibility and appropriateness at phrase boundaries are probably more-or-less instantaneous and arise from a need for conceptual consistency. These final output monitors recognize assimilation to conceptual categories within long-term memory where meaning is completely transformed for permanent storage. Thus Chomsky's famous line, "Colorless green ideas sleep furiously," passes every test of acceptability except this one. As Jackendoff (1972) in his new book on interpretive semantic states, "What is not necessarily determined by the grammar is whether this collection if disparate (semantic) elements actually forms a sensible meaning."

It is proposed that these judgments and other decision procedures within the language system are based on processes that take place in time. That they represent an increasingly abstract judgment about information from various subcomponents in the system functioning at different rates and at different points on a time continuum. Except at the very earliest stages or perception, processing is serial in nature and not parallel; it proceeds in time at a fairly uniform rate regardless of input modality. As the semanticists in linguistics have recently been telling us, understanding is probably not so much an outcome, as it is the accretive collection of semantic information leading to a judgment that is more or less, outside of time.

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