Effects of Ambiguity on Stuttering: Towards a Theory of Speech Production at the Semantic Level

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Received August 20, 1968

Abstract. Pathologische Stotterer und normale Versuchspersonen erhielten verzögerte auditive Rückmeldung (VAR), während sie Sätze vervollständigten. Wir fanden:

1. Die Vpn. nahmen nur eine der Bedeutungen der zweideutigen Fragmente wahr, obgleich die Zweideutigkeit ihre Sprache beeinflußte (s. unten).

2. Normale Vpn. brauchten länger für die Vervollständigung von zweideutigen Sätzen als von eindeutigen mit ähnlicher semantischer und syntaktischer Komplexität.

3. Dieses Mehr an Zeit wurde hauptsächlich zur Findung der Satzvervollständigung benötigt und nicht für die Aussprache des vollendeten Satzes. Dies ist ein Hinweis, daß Zweideutigkeit mit dem Verständnis von Sätzen interferiert.

4. Ein Ermüdungseffekt für eindeutige Sätze wurde gefunden: Am Ende des Experiments wurde mehr Zeit zur Vervollständigung eindeutiger Sätze verwendet als am Anfang. Für zweideutige Sätze wurde kein Ermüdungseffekt festgestellt.

5. VAR verursachte mehr Stottern beim Lesen der zweideutigen als beim Lesen des eindeutigen Fragments.

6. Es trat mehr Stottern beim Vervollständigen der zweideutigen Fragmente auf als beim Lesen des Fragments, das die Zweideutigkeit enthielt. Dagegen wurde beim Vervollständigen der eindeutigen Teile nicht mehr gestottert als beim Lesen.

7. Die Versuche wurden ohne VAR mit pathologischen Stotterern als Vpn. wiederholt. Die Ergebnisse zeigten, daß alle wichtigen Resultate, die oben zusammengefaßt sind, auch für pathologisches Stottern gelten.

8. Traditionelle Modelle über die Beziehung zwischen Konflikt und Stottern können diese Ergebnisse nicht ohne erhebliche Veränderungen erklären. Unsere Ergebnisse unterstützen eher das folgende Modell: Die wahrgenommene Bedeutung eines zweideutigen Fragments wird in ein motorisches Programm für Vervollständigung des Satzes integriert. Ein ähnliches Programm für die andere Bedeutung wird partiell und gleichzeitig aktiviert. Die Wechselwirkung zwischen den beiden Programmen reduziert die Kontrolle über die Sprache und erhöht die Stotterwahrscheinlichkeit bei pathologischen Stotterern und bei normalen Vpn. unter VAR.

Es wurde gezeigt, daß die Komponenten dieses Modells ähnlich sind wie die Annahmen, die zur Erklärung des Einflusses der Synonymität auf die Sprachproduktion benötigt werden.

9. Ein Modell für die Erklärung abwegiger oder irrelevanter Vervollständigungen basiert auf dem Prinzip der Disinhibition (von Holst).

10. Als mögliche Erklärung für die nicht-grammatikalischen Vervollständigungen der zweideutigen Sätze wurde die Verschmelzung beider Aspekte der schwach wechselwirkenden motorischen Programme diskutiert.

Introduction

The questions which motivated this study were these: Does ambiguity influence the rate of speech in completing sentences, or just the time to think up a completion? Does ambiguity reduce the control over speech under delayed auditory feedback (DAF)? Do pathological stutterers stutter more in reading ambiguous than unambiguous sentences? Do the traditional conflict theories of stuttering fit the effects of ambiguity on DAF and pathological stuttering? Do subjects use more words in completing the ambiguous than unambiguous sentences?

In sentence completion experiments such as this, the subject is presented with a sentence fragment (e.g. 1), he thinks up a relevant completion, and says the entire sentence (e.g. 2).

1. *Although they sent the requisition over a week ago.*

2. *Although they sent the requisition over a week ago, it has not arrived yet.*

An earlier study (MacKay, 1966) showed that subjects take more time to complete ambiguous fragments than unambiguous ones such as 3.

3. *Although they sent the requisition almost a week ago.*

In the present experiment, we wished to determine whether this additional time went into understanding the ambiguous fragment, reading it, or saying the completion.

Ambiguity also appeared to interfere with the control of speech in MacKay (1966). More ambiguous than unambiguous fragments were misread or evoked ungrammatical, irrelevant or tangential completions. Most interesting, normal subjects tended to stutter (repeat speech sounds) more frequently for ambiguous fragments than unambiguous ones (a difference significant at the 0.001 level).

In the present experiment we wished to determine whether ambiguity tended to augment the stuttering of normal individuals under DAF and of pathological stutterers. This experimental plan appeared relevant to several theories of sentence production. Among them are:

1. The Conflict Theory of Stuttering

Conflict is defined as a situation in which two incompatible tendencies are simultaneously present (Miller, 1944). For example, if food is placed at the end of an electrified runway, a hungry rat confronts what is termed an approach-avoidance conflict. Several theorists have viewed conflict as casually related to stuttering (Johnson, 1959). For example, Sheehan et al. (1950, 1951, 1953, 1954, 1957, 1958, 1966, 1967) proposed that stuttering reflects a vascillation between tendencies to speak and not to speak during or before a point of conflict in producing sentences. According to Sheehan's model, which is formally identical to that of Miller (1944 and 1959), stuttering should become maximal at some point before saying the words which cause conflict. But once the conflict situation is past, the tendency to stutter should no longer exist.

Demonstration that ambiguity in sentences constitutes a conflict situation is trivial. Consider the am-

biguity in 1. Radically different timing and stress patterns are needed for reading the two different meanings of this sentence. Clearly, reading these ambiguous words constitues a situation in which two incompatible tendencies are simultaneously activated. Thus, since ambiguity in the sentence completion task fits the definition of conflict, conflict theory can be said to successfully account for the increase in stuttering for ambiguous sentences reported in MacKay (1966).

In the present study we wished to examine this model of stuttering in greater detail. Based on the assumption that conflict causes stuttering, our hypotheses were as follows:

Hypothesis 1. *When reading an ambiguous sentence, more stuttering should occur on or just before the ambiguous words, rather than after.*

Hypothesis 2. *In the sentence completion task, stuttering should be greater in reading ambiguous fragments than unambiguous ones, but not in completing them.*

Hypothesis 3. *If the conflict theory of stuttering also applies to the stuttering of normal individuals under DAF, as suggested by* Yates (1963), *then the above predictions should also hold for sentence completion by normal subjects under DAF.*

In the first experiment, our plan was to have normal subjects complete ambiguous sentences under DAF in order to: 1. compare their stuttering before and during reading the ambiguous words; 2. compare the stuttering for ambiguous and unambiguous sentences during reading and completing the fragment.

The second experiment was a precise replication of the first, using identical materials, instructions, and procedure, expect that the subjects were pathological stutters and their auditory feedback was not delayed. The aim of this second experiment was to determine whether ambiguity has similar effects on DAF and pathological stuttering.

2. *Non-Interaction Theory*

Foss, Bever, and Silver (1968) suggested that "ambiguity *per se* does not ... interfere with understanding the meaning of sentences." In this theory the time to understand one of the readings of an ambiguous fragment should be no longer than for unambiguous fragments, and DAF would hamper the control of speech as much for unambiguous as ambiguous fragments.

Experiment I. Delayed Auditory Feedback

Method: Apparatus. The apparatus for delaying the auditory feedback was an Echovox (Kay Electric Co.) variable feedback device with the delay set at 0.2 sec. The subject spoke into a microphone (Monarch TM-18) which was adjusted to about six inches from his lips. The microphone was connected to a Knight (KN-724) Stereo Amplifier, which boosted the output of the delayed feedback. The amplification system transmitted the subject's speech to the Permoflux PDR 600 stereo earphones he was wearing to an average sound pressure level of about 95 db. A stand held the earphones in fixed position so that the subject could not move his head relative to the microphone.

A Tannberg (model 152A) tape recorder was used to record the subject's responses.

Materials. The materials consisted of twenty-four sentence fragments, typed on 5×3 inch index cards (see Appendix A). Half of the fragments were ambiguous at the surface structure level. Since the surface structure represents the manner in which words are grouped into higher level phrases (Chomsky, 1965), ambiguity at the surface structure level involves two possible groupings of words. For example, the words *with the president* in 4 may be grouped with either the verb *mentioned* or the object, *problem.*

4. *Although he mentioned the problem with the president.*

The remaining unambiguous fragments were identical to the ambiguous fragments except for a single word change which disambiguated them. Further, the meaning of the disambiguated fragments corresponded to one of the meanings of the ambiguous fragments, chosen at random. For example, the unambiguous version of 4 was 5.

5. *Although he mentioned the problem to the president.*

All of the fragments were eight (plus or minus one) words in length.

Subjects. The subjects were twenty undergraduates at UCLA who received course credit for their participation in the experiment. The subjects were randomly divided into two groups of ten. One group received ambiguous fragments 1 to 6 in Appendix A and unambiguous fragments 19 to 24. The other group received the remaining sentences. Consequently the same subject never received both the ambiguous and unambiguous forms of the same sentence.

Instructions. Each subject was individually instructed as follows:

This is an experiment in Psycholinguistics involving two aspects:

1. Sentence completion: You will be given a card on which a clause is typed such as, *When John saw the lieutenant.* You are to flip over the card and read this clause to yourself and think up a relevant completion such as *he asked him if he was on leave.* An example of an irrelevant completion (which is against the rules) would be — *he sneezed.* Also, your completion must result in a *grammatical* sentence. You will be asked to defend the grammaticality and relevance of your completions after the experiment.

Continue thinking about the clause until you have a relevant completion in your mind. You are then to say the entire sentence aloud, reading what is on the card, and saying your completion. You are not to rephrase or change your wording while *saying the sentence aloud.*

2. The second aspect is the delayed auditory feedback. You will hear your own voice delayed. This frequently causes errors in speech. Don't worry about errors, however. You are to say the sentence as fast as you can without pausing. Do not speak in stacatto bursts as for example, *some-times-fish-swim-up-side down.* If you pause like that, your data for that sentence will have to be discarded. Are there any questions?

If you are unable to complete the sentence within 90 sec, I will stop you and we will go on to the next sentence. Remember, make your completions relevant, grammatical, and concise and say the sentence as fast as you can.

Procedure. The sentence cards were thoroughly shuffled for each *S*.

The *E* presented each card face down, started a stop watch as soon as the subject flipped over the card and stopped it as soon as he completed the sentence. The *E* did not know whether or not a sentence was ambiguous prior to any trial.

After each sentence, *E* recorded the trial number, the completion (verbatim) and the total completion time (the time from flipping over the card to finishing the sentence). The total completion times consisted of three distinct intervals — the time to think of a relevant completion (Thinking Time), the time to read the sentence fragment (Reading Time), and the time to say the completion, (Completion Time)[1]. Speaking Time was defined as the sum of Reading and Completion Times. The Reading and Completion Times were determined from the tape recording of the subjects' responses, with the Thinking Time calculated as:

Thinking Time = Total Completion Time — Speaking Time.

At the end of the experiment, *E* read the subject's completion for each fragment and asked *S* whether he felt his completion was grammatical and relevant for the fragment[2]. The *E* then informed *S* that half of the sentences he had completed were ambiguous, told him the two meanings of each ambiguous sentence, and asked *S* whether he had seen both of these meanings while thinking up his completion. If *S* saw only one of the meanings, he then specified which one he saw[3].

Results. The results will be divided into three parts: (A) *Time measures:* An analysis of the Thinking, Reading, and Completion Times, (B) *Errors:* An analysis of the frequency of errors induced by DAF, and (C) *Nature of the Completions.*

A. Time Measures

1. Thinking Time

The average Thinking Time was 8.78 sec for ambiguous fragments and 8.19 sec for unambiguous fragments (see Table 1). This 0.5 sec difference was significant at the 0.05 level using a two-tailed Mann Whitney test[4].

Thus, the time to think up a completion was longer for ambiguous than unambiguous fragments.

[1] Completion Time in this study is to be distinguished from the same term in MacKay (1966), which corresponds to our Total Completion Time.

[2] Note that this procedure overcomes a possible criticism of the MacKay (1966) study, namely that the experimenter tended to question grammaticality and relevance more frequently for ambiguous than unambiguous fragments.

[3] Note that this procedure overcomes the possible criticism that the subjects in MacKay (1966) had actually seen some of the other meanings of ambiguous fragments, but were unable to recall this at the end of the experiment.

[4] Since all of the statistical analyses in this study incorporated twotailed tests of significance, this information will no longer be specified.

Table 1. *Normal subjects under DAF. The average thinking, reading, and completion times for ambiguous and unambiguous fragments.* (See Text for explanation.)

	Ambiguous fragments		Unambiguous fragments	
	Total time	Time per word	Total time	Time per word
Thinking time	8.78		8.19	
Reading time	2.78	0.392	2.80	0.395
Completion time	2.25	0.425	2.27	0.437
Total time	13.81		13.26	

2. Word Rates

The Reading and Completion Times are shown in Table 1 both as mean time per sentence and per word. The average Reading Time per word was 0.392 sec for ambiguous fragments and 0.395 sec for unambiguous fragments. This difference was non-significant at the 0.50 level using a sign test with subjects as the unit of analysis.

The average Completion Time was 0.425 (sec per word) for ambiguous fragments and 0.437 for unambiguous ones. This difference was non-significant at the 0.30 level, using a sign test, with subjects as the unit of analysis.

This virtual identity of speech rates for ambiguous and unambiguous sentences obviates the necessity of speech rate controls in comparing error rates under DAF for these sentences (see MacKay, forthcoming; MacKay, 1968; Kodman, 1967; Fillenbaum and Wiessen, 1961; Beaumont and Foss, 1957; and Guttman, 1954 for discussions of the effect of speech rate on errors under DAF).

3. Controls for Structual Complexity

It might be argued that the meanings of unambiguous fragments were structurally more complex than the perceived meanings for the ambiguous sentences. There are two ways to control for structural complexity of this sort. One was to complicate the experimental design with another group of subjects and twice as many unambiguous fragments as in the present study — one for each of the readings of the ambiguous sentences. A simpler method was to compare the data for the unambiguous fragments and those trials on which the identical meaning of the ambiguous fragment was seen. This latter analysis was used in the present study (see Table 2). The Thinking Time for

Table 2. *A comparison of errors per word and average thinking and speaking. Times (in sec) for the unambiguous fragments and the trials for ambiuous fragments on which the subjects saw the same meaning as that in the unambiguous fragments*

	Ambiguous fragments		Unambiguous fragments
	Different meaning from unambiguous fragments	Same meaning as unambiguous fragments	
Thinking time	8.68	8.88	8.19
Speaking time	5.05	5.50	5.07
Total time	13.73	14.38	13.26
Errors (per word)	0.070	0.080	0.053

subjects seeing the same meaning as given in the unambiguous fragments. As before, this difference was significant at the 0.02 level using a Mann Whitney test,

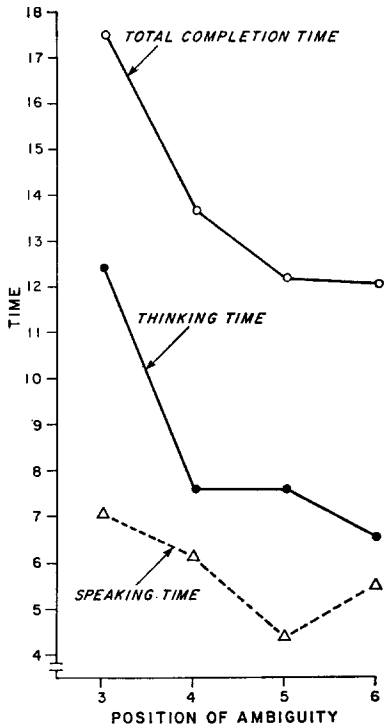

Fig. 1. The Thinking Times, Speaking Times and Total Completion Times as a function of position of the ambiguities in sentences

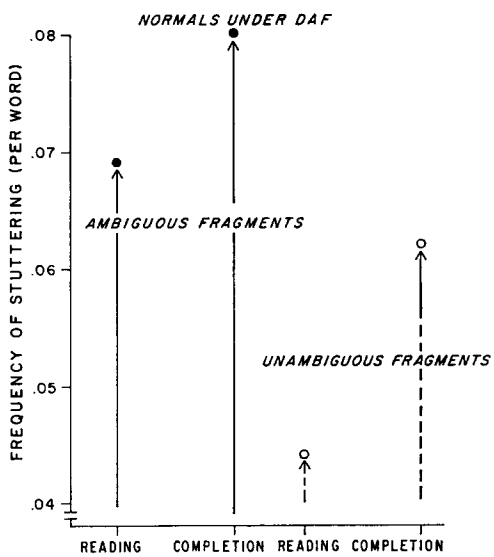

Fig. 2. The frequency of stuttering per word for normal subjects under DAF: separated into reading and completion errors for the ambiguous and unambiguous fragments

allowing as to reject the structural complexity hypothesis for this aspect of the completions.

The Speaking Time for subjects seeing the same meaning as in the unambiguous fragments was 5.50 sec or about 500 msec longer than for the corresponding unambiguous fragments (see Table 2). However, as before, this difference was non-significant at the 0.30 level using a sign test with subjects as the unit of analysis.

4. Position

MacKay (1968) found that the Total Completion Time for ambiguous fragments varied with the position of the ambiguity in the fragment: the later in the sentence the ambiguity occurred, the less time was required to complete the sentence.

This same analysis was carried out on the present data. The fragments were submitted to four independent judges with instructions to mark the exact position in the sentence where they thought the ambiguity occurred. The Thinking, Reading, and Completion Times were then calculated as a function of mean position of the ambiguity in the fragments as determined by the judges.

The results are shown in Fig. 1. All three time measures decreased as a function of position. The later in the fragment the ambiguity occurred the less the Thinking, Reading, and Completion Times. This finding both confirms and extends the results of MacKay (1968), adding further support to the Cybernetic hypothesis discussed there. Specifically, MacKay (1966) assumed that the subject perceives neither meaning of ambiguous words until a bias for one of the meanings can be formed from analysis of the unambiguous context of the sentence. If the ambiguity occurs at the end of the sentence, a bias can be fed forward so that one of the readings of the ambiguity is readily appreciated. But ambiguous words at the beginning of the sentence would have to be held in short-term store until a bias could be formed from analysis of the subsequent unambiguous context, explaining the increase in time measures for ambiguities at the beginning of the sentence.

B. Errors in Speech

Delayed auditory feedback is known to induce several types of errors in speech (Fairbanks and Guttman, 1956). Using a 0.2 sec delay, stuttering is the most common error and the easiest error to analyze. In the present study, a stutter was defined as the repetition of speech sounds of syllable length or shorter[5].

Two independent judges analyzed the tapes for stutters and only when both judges agreed in their analysis was a stutter recorded. Stuttering under DAF was separately analyzed for reading and completing the fragment (see Fig. 2).

1. Reading Errors

As can be seen in Table 3, stuttering occurred more frequently in reading ambiguous fragments than unambiguous ones. This difference was significant at the 0.01 level using a sign test with subjects as the unit of analysis.

Table 3. *The frequency of stuttering and DAF in reading and completing the ambiguous and unambiguous sentences. (Analyzed per word for all sentences)*

	Ambiguous fragments		Unambiguous fragments	
	Total	per word	Total	per word
Reading	58	0.069	37	0.044
Completion	51	0.080	39	0.062
Total	109	0.075	76	0.053

[5] In fact, however, no repetitions longer than a syllable occurred in the present study.

2. Completion Errors

As can be seen in Table 3, stuttering occurred more frequently (per word) in completing ambiguous than unambiguous fragments. This difference was significant at the 0.01 level using a sign test with subjects as the unit of analysis.

As a control for structural complexity, subjects seeing the same meaning of the ambiguities as given in the unambiguous fragments were separately analyzed, with the results shown in Table 2. The probability of stuttering was 0.53 for the unambiguous fragments, and 0.80 for subjects seeing the same meaning in the corresponding ambiguous fragments. This difference was significant at the 0.01 level using a sign test with subjects as the unit of analysis. The probability of stuttering (per word) is shown in Fig. 2 for reading and completing the ambiguous and unambiguous fragments.

Next the probability of Reading and Completion Errors were compared for the unambiguous fragments. No significant difference was found at the 0.50 level using a sign test with subjects as the unit of analysis.

However, the same comparison for ambiguous sentences was significant at the 0.02 level. That is, a higher probability of stuttering was found for saying the completions than reading the ambiguous fragments. Thus, ambiguity significantly increased the probability of Completion Errors relative to Reading Errors.

In this regard it will be recalled that the speech rate was faster in reading the fragments than in saying the completions. But since errors in speech under DAF increase in direct proportion to speech rate (MacKay, 1968), the above finding cannot be viewed as an effect of speech rate.

C. Nature of the Completions

The nature of the completions was disregarded in the quantitative analyses discussed above. However, any theory of the mechanisms underlying the comprehension and production of ambiguous sentences must take into account the qualitative aspects discussed below.

1. Misreadings

If a subject made an error in reading what was on the card, without correcting himself, and if the error could not have been the result of DAF, a reading error was scored. For example, forty percent of the subjects read *run in* as *run into* in 6.

6. *Because the children had run in the house.*

As in the above example, many of the misreadings eliminated ambiguity in the fragments corroborating the findings of MacKay (1966).

Similarly more misreadings occurred for ambiguous than unambiguous fragments. Although this difference in the present experiment was in the same direction as MacKay (1966), it was non-significant at the 0.05 level using a Chi-square test. Undoubtedly the statistical significance of this result in MacKay (1966) lies in his use of twice as many subjects and nine times as many sentences.

2. Tangential Completions

The instructions emphasized that completions had to be relevant to the meaning of the sentence fragment. A Tangential Completion was operationally defined as one which the subject agreed had no logical connection with the fragment.

Only five completions were operationally tangential, four for ambiguous fragments and one for unambiguous fragments (see Table 4). Sentences 7 and 8 are examples:

7. *Knowing how little jockies drove cars, I decided to get a new one.*

8. *Knowing how little jockies drove cars, I decided to learn how myself.*

These data, although not statistically reliable, are congruent with the 1966 data which were significant.

Table 4. *The frequency of word indecisions, misreadings, tangential completions and ungrammatical completions*

	Ambiguous fragments	Unambiguous fragments
Word Indecisions	9	8
Misreadings	10	7
Tangential Completions	4	1
Ungrammatical Completions	1	1
Total	24	17

3. Word Indecision

When subjects changed their phrasing in either reading or completing a fragment, this was scored as a Word Indecision. For example, see 9 below.

9. *While, I mean, when I saw the wild Indian dance.*

Almost as many instances of Word Indecision occurred for unambiguous as ambiguous sentences (see Table 4).

4. Ungrammatical Completions

An Ungrammatical Completion was operationally defined as one which the subject himself agreed could not be used in normal conversation. Examples of such completions may be seen in 10 to 12 below:

10. *Although he mentioned the problem with the president, he was unable to offer good conclusion.*

11. *Knowing how much jockies drove cars, I decided more careful.*

12. *Although the officers were convincing men, the message they gave were not.*

5. Number of Words

The subjects completed ambiguous fragments with about as many words as unambiguous ones. The average number of words was 5.28 for ambiguous fragments and 5.20 for unambiguous ones. This difference was non-significant at the 0.50 level using a sign test with sentences as the unit of analysis. Thus, no more words were used to complete ambiguous than unambiguous fragments, corroborating MacKay (1966).

6. Bias

As an estimate of the probability of the two meanings of an ambiguous fragment, Bias was calculated. Precisely defined, Bias, B, of an ambiguity is:

$$B = \left(\frac{X}{N}\right)(100) \quad \text{for} \quad X \geqq Y$$

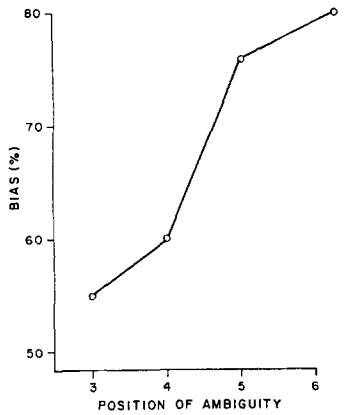

Fig. 3. Bias as a function of position of ambiguity in sentences

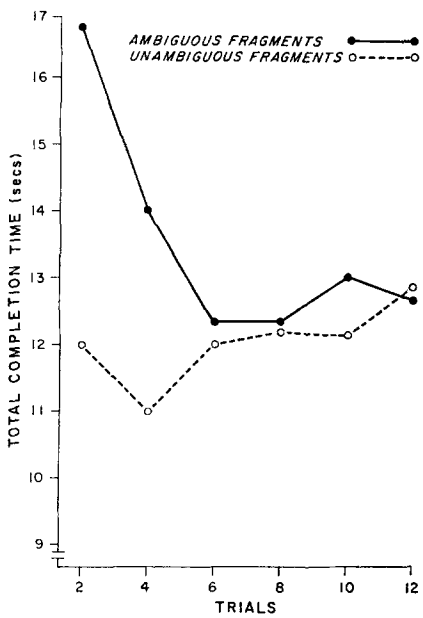

Fig. 4. The Total Completion Time as a function of trials or position of sentences in the experimental session (separately analyzed for ambiguous and unambiguous fragments). A practise effect for both ambiguous and unambiguous fragments can be seen but a fatigue effect occurred only for the unambiguous fragments

where N is the total number of subjects, X the number of subjects seeing the more likely meaning, and Y the number seeing the less likely meaning. For example, if eighteen subjects report seeing one meaning and two report seeing the other, the Bias of the ambiguity is ninety percent, $X = 18$, and $Y = 2$.

The average Bias of ambiguous fragments in the present experiment was seventy percent.

A check was carried out as in MacKay (1968) to determine whether the same subjects tended to perceive the improbable meanings. In no case did the same subject perceive an unlikely meaning twice for ambiguities with eighty percent to ninety percent Bias. This finding corroborates MacKay (1968) that subject-specific factors are not responsible for perception of the unlikely meanings of ambiguous fragments[6].

6. The Relation of Bias to Position

MacKay (1968) found that Bias varied with position of the ambiguities in the fragment. The closer to the end of a sentence an ambiguity occurred, the greater its Bias.

This same analysis was carried out on the present data with the results shown in Fig. 3. As can be seen there, Bias increased in direct proportion to the position of the ambiguity in the sentence. The later in the sentence the ambiguity occurred, the greater the Bias of the ambiguity.

This finding corroborates the results of MacKay (1968) adding further support to the Cybernetic Hypothesis presented there. Specifically, MacKay (1968) assumed that reading the unambiguous context of a sentence allows the subject to feed forward or feed back a bias for one of the meanings of the ambiguous words. If the ambiguity occurs at the end of the sentence, the ambiguity would be pre-biased. But if the ambiguity occurs at the beginning of the sentence a bias could not be fed forward, and one derivational path would be taken as often as the other, as was found.

7. Practise Effects

In order to check the possibility of randomization errors, the distributions of the ambiguous and unambiguous fragments in the experimental session were compared. This analysis showed that the trial numbers for the ambiguous and unambiguous fragments were evenly distributed over the experimental session and the average trial number for both was 6.5. Consequently, the differences between ambiguous and unambiguous fragments cannot be attributed to practice *per se*.

The Total Completion Times for the ambiguous and unambiguous fragments are shown in Fig. 4 as a function of practise. For ambiguous fragments the Total Completion Time decreased sharply over the first six trials and remained asymptotic for the remainder of the experiment.

But for the unambiguous fragments the Total Completion Time decreased only slightly over the first four trials, and then increased during the remainder of the experiment (see Fig. 4). This increase looks much like a fatigue effect, but it is curious that fatigue should differentially effect unambiguous but not ambiguous fragments.

The frequency of stuttering is shown in Fig. 5 as a function of trials. For the ambiguous fragments, stuttering decreased for most of the experiment, and then increased slightly at the last two trials. However, for the unambiguous fragments stuttering decreased slightly for the first half of the experiment but increased markedly for the last half. In fact, the probability of stuttering was significantly greater for unambiguous than ambiguous fragments for trials 9 to 12. This difference was significant at the 0.02 level using a Mann Whitney test. For some reason, fatigue seems

[6] The relation between Bias and Completion Time was analyzed and fits the general form of these functions in MacKay (1968) for eighty-four ambiguities. However, these data are not plotted here. Because of the small number of ambiguities in this study several data points would have been represented by a single sentence.

to effect the production of unambiguous sentences more than ambiguous ones.

8. Non-Perception of Ambiguity in the Sentence Completion Task

Several subjects in the present experiment volunteered that they initially got no meaning from some of the ambiguous fragments, corroborating MacKay (1966). In the questioning after the experiment only one subject out of twenty on one trial out of one hundred twenty was uncertain as to which meaning he saw, claiming he responded before seeing either meaning. It is of interest that for this trial the subject agreed his completion was tangential. None of the twenty subjects noticed a second meaning either while completing the sentences or during the entire experiment.

Experiment II. Effects of Ambiguity on Pathological Stuttering

The present data for stuttering under DAF contradict the Conflict Theory outlined in the introduction. Of course this does not mean that Conflict Theory is invalid for pathological stuttering. As a test of this question, we repeated the above experiment without DAF, using pathological stutterers as subjects.

Subjects. The subjects were two students (age 17 and 21) who were paid for their participation in the experiment. To qualify for this experiment, a subject had to stutter (repeat syllables) more than five times per minute (on the average) in reading a standard Psycholinguistics text.

Method. The instructions, procedure, materials and apparatus were the same as in the preceding experiment, except as relating to DAF, which was not used.

Results. Of necessity, treatment of the data for this experiment on pathological stuttering was slightly different from the DAF experiment. First, on several trials the stutterers were unable to complete or even finish reading the sentences within the 90 sec limit. We controlled this factor by analyzing our data on a per word basis. Second, the stutterers frequently committed what we have called Inertial errors. That is, they would start to speak, stop, and then begin again at an earlier point in the sentence. This factor was also controlled by counting in our per word analyses the total number of words attempted.

1. Time Measures

The Thinking, Reading, and Completion Times are shown in Table 5 for the ambiguous and unambiguous fragments. As before, the Reading Time for ambiguous and unambiguous fragments was about the same. Also the Completion Time was longer for ambiguous than unambiguous fragments, a difference significant at the 0.03 level using a sign test with sentences as the unit of analysis. However, for some reason the pathological stutterers began to speak sooner for ambiguous than unambiguous fragments. Their Thinking Time was slightly longer for unambiguous than ambiguous fragments. However, this difference was non-significant at the 0.40 level using the above test.

Table 5. *For pathological stuttereres: The average thinking, reading and completion time for ambiguous and unambiguous fragments*

	Ambiguous fragments		Unambiguous fragments	
	Time per sentence	Time per word	Time per sentence	Time per word
Thinking time	15.96		29.0	
Reading time	25.2	2.58	25.6	2.67
Completion time	47.4	4.20	13.5	1.90
Total time	88.56	6.78	68.1	4.57

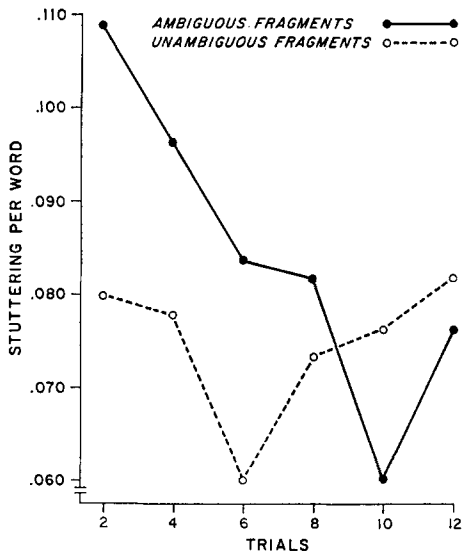

Fig. 5. The frequency of stuttering (per word) as a function of trials or position of sentences in the experimental session (separately analyzed for ambiguous and unambiguous fragments). Practise and fatigue effects for both ambiguous and unambiguous fragments can be seen, but the fatigue effect is much greater for unambiguous sentences than ambiguous ones (see discussion for explanation)

2. Error Measures

a) Stuttering. As before, a stutter was defined as the repetition of speech sounds of syllable length or shorter, the subject's responses were recorded on tape and stutters were analyzed from the tape. Stuttering was so frequent and perfect agreement of the two judges so seldom, that the average of their judgments was recorded for each sentence.

The frequency of stuttering in reading and completing the fragments is shown in Table 6. The average frequency of stuttering per word was plotted in Fig. 6. There it can be seen that the results for pathological stuttering were basically similar to the results for stuttering under DAF. Stuttering was greater for completing the ambiguous fragments than reading them. This

Table 6. *For pathological stuttereres: The frequency of stuttering per word in reading and completing the ambiguous and unambiguous fragments*

	Ambiguous fragments		Unambiguous fragments	
	Total	Per word	Total	Per word
Reading	113	1.52	162	1.40
Completion	189	1.85	150	1.31
Total	302	1.68	277	1.36

difference was significant at the 0.01 level using a sign test with sentences as the unit of analysis. But there was no difference between Reading and Completion errors for the unambiguous fragments (using the same statistical test).

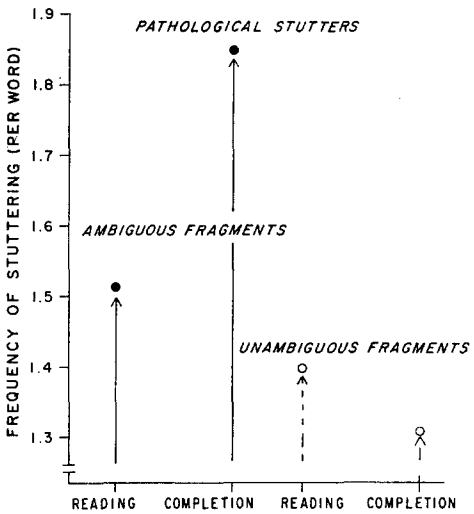

Fig. 6. The frequency of stuttering per word for pathological stutterers (separated into reading and completion errors for the ambiguous and unambiguous fragments)

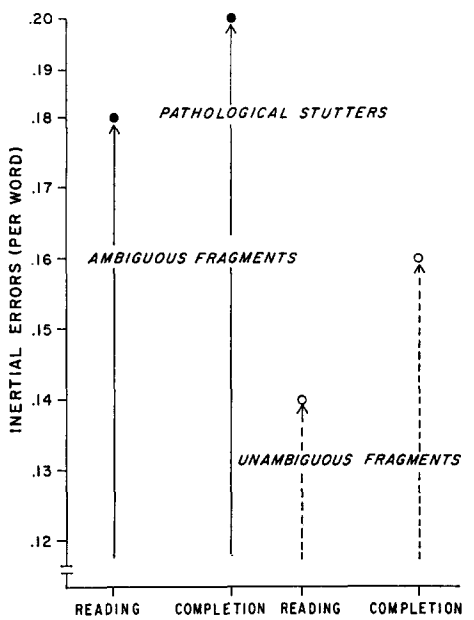

Fig. 7. The frequency of Inertial errors (per word) for pathological stutterers (separated into reading and completion errors for the ambiguous and unambiguous fragments)

Also similar to the DAF results, pathological stuttering was greater for ambiguous than unambiguous fragments, both for reading and completing the fragments.

b) Inertial Errors. An Inertial error was scored each time a subject paused for a second or longer and then began again at an earlier point in the sentence. The total frequency of Inertial errors is shown in Table 7. The frequency of Inertial errors per word is shown in Fig. 7. There it can be seen that the frequency of inertial errors matched the probability of stuttering: for both reading and completion, more Inertial errors occurred for ambiguous than unambiguous fragments.

Table 7. *For pathological stuttereres: The frequency of Inertial errors in reading and completing the ambiguous and unambiguous fragments*

	Ambiguous fragments		Unambiguous fragments	
	Total	Per word	Total	Per word
Reading	12	0.18	16	0.14
Completion	20	0.20	7	0.14
Total	32	0.19	23	0.14

Discussion

The discussion will first consider the hypotheses discussed in the introduction. Then preliminary outlines for a more adequate model of speech production at the semantic level will be sketched.

1. Conflict Theory

Without serious revision, the traditional Conflict model of stuttering is incapable of handling the present results for either DAF or pathological stuttering. Conflict Theories predicted no differences in pathological stuttering (Sheehan) and DAF stuttering (Yates, 1963) in the Completion Time for ambiguous and unambiguous fragments. Our data contradicted these hypotheses. The Completion Time was greater for ambiguous than unambiguous fragments for both DAF and pathological stuttering.

Conflict Theories predicted less stuttering after the ambiguous words were read. Our data indicated the opposite. Significantly more stuttering occurred after the ambiguity was past, than during or before reading the ambiguous words.

Of course these results do not rule out the original Miller (1944) theory for explaining certain types of conflict, although there are other grounds for questioning that model (see Guthrie, 1938; Haner and Brown, 1955).

Further, it is possible that the Conflict Theory of stuttering applies only to certain kinds of conflict and not others. This question deserves serious testing.

2. Non-Interaction Theory

The present results also cast doubt on the Non-interaction theory proposed by Foss, Bever and Silver (1968). If a single reading of ambiguous fragments can be computed at the same rate as for unambiguous fragments, then the time to think up a completion should be no longer for ambiguous fragments than unambiguous ones, all other factors being equal (such as number of words in the completions). Contrary to this hypothesis, our data showed that Thinking Time was longer for ambiguous fragments than unambiguous ones (and all other factors were equal). Theories for explaining this effect are outlined in MacKay (1968).

Similarly, we must look to some other theory to explain why more pathological and DAF stuttering occurred for ambiguous than unambiguous fragments, and for completing the ambiguous fragments as compared to reading them.

3. The Structural Complexity Hypothesis

A general criticism of sentence completion studies of this sort is that the unambiguous fragments are structurally less complex than the two readings of the ambiguous fragments or that more words are used in

completing ambiguous than unambiguous fragments. Several attempts were made to control for this hypothesis. First, the syntactic and semantic structure of the ambiguous and unambiguous fragments was identical, except for one word which disambiguated the fragment. Second a control for the complexity of the perceived meaning of ambiguous sentences was carried out. That is, the data for the unambiguous fragments and for the subjects seeing the identical readings of the ambiguous fragments were compared. These comparisons allowed us to reject the structural complexity hypothesis in all cases.

Third, in comparing the speech rate in completing ambiguous and unambiguous fragments the number of words in the completions were taken into consideration. Similarly, DAF and pathological stuttering was calculated on a per word basis for the ambiguous and unambiguous completions.

Finally, the conclusion that stuttering is greater in completing than in reading ambiguous fragments was supported by the lack of difference in reading and completing the corresponding unambiguous fragments.

4. Towards a Theory of Speech Production at the Semantic Level

Since motor systems must incorporate the output of perceptual systems, we will begin by outlining a simplified model for speech perception at the semantic level (see Fig. 8). Evidence for this model is outlined in detail in MacKay (1968). In this model ambiguity activates two semantic analyzers which interact in mutually inhibitory fashion, during which time neither meaning is seen. In order to perceive the meaning of ambiguous words, hypotheses (based on the unambiguous context of the sentence) are generated and tested for grammaticality in the system labelled Perceptual Integration in Fig. 8. Confirmation of one of these hypotheses results in dominance of the corresponding semantic analyzer and perception of that meaning.

An oversimplified model of speech production[7] at the semantic level is outlined in Fig. 9. It is based on the assumption that ambiguity has an indirect rather than a direct effect on errors in speech, reflecting our finding that more stuttering occurred after rather than on or before the ambiguous words in the present study.

The semantic hypotheses or schema of Fig. 8 prime or partially activate two speech production programs for completion of ambiguous fragments in this model. These programs are assumed to interact in mutually inhibitory fashion. Consequently output results only when one of the programs becomes dominant. The components of this speech production model will now be outlined in detail.

The Sensori-motor Relationship

The nature of the connection between sensory and motor systems has always been a major problem in psychological models (Miller, Callanter and Pribiam, 1960; Lashley, 1951). There are several reasons for assuming a connection between motor programs and the Perceptual Integrator rather than directly between the perceptual and motor systems themselves in speech production models. One is the fact that subjects perceived only one meaning of the ambiguous fragments they completed even though the unseen meaning influenced the rate, relevance, grammaticality, and nature of their completions. This outcome would be impossible if perceptual systems affect motor systems directly.

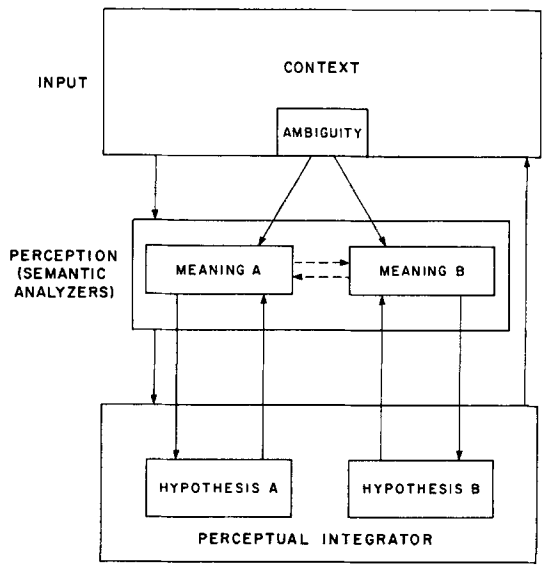

Fig. 8. An oversimplified model for the comprehension of sentences (ambiguous and unambiguous). Context here refers to both situational context and the unambiguous context of the sentence. This context is perceived directly by semantic analyzers, and also feeds forward a bias to the Perceptual Integrator (discussed subsequently). The ambiguous words activate two conflicting semantic analyzers (*A* and *B*) which interact in mutually inhibitory fashion (during which time neither meaning is seen). Hypotheses based on the subject's set and the remaining unambiguous context of the sentence, are generated, biasing perception in favor of one semantic analyzer or the other. Because of the mutual inhibitory relation between the analyzers, biasing one meaning will suppress perception of the other. On the basis of this perceived meaning the integrator may feed back on the ambiguous input (proximal, rather than distal), introducing perceptual distortions (e.g., misreadings). Inhibitory relations are shown with broken lines

Another source of evidence is found in MacKay and Bowman (forthcoming) who showed that practise influenced a system for perceptual and motor integration of speech rather than the perception and output systems *per se*. Specifically, they had German-English bilinguals practise (i.e., repeat) a sentence such as 12 at their maximum rate of speech. The bilinguals then produced a translation such as 13 as fast as they could. Note that the meaning of 13 is identical to 12 but the word order, surface structure and phonology of the two sentences differ radically.

12. *Then the wanderlust seized him as it once had his grandfather.*

13. *Dann packte auch ihn wie einst den Großvater die Wanderlust.*

MacKay and Bowman found that practising 12 facilitated the production of 13. Their subjects were able to speak faster (without DAF) and stuttered less

[7] The formal properties of the model to be described are identical to Licklider's (1960) model of audioanalgesia. The reader is referred to that paper for description of the mathematical properties of the model.

under DAF in producing 13 after repeating 12. No such facilitation for 13 was found when the subjects repeated a semantically irrelevant sentence such as 17.

The next question was whether this semantic facilitation effect depended on integration of the meaning of individual words within the context of the sentence. (See Katz and Fodor (1963) for a discussion of context dependent meaning.) Consider 14 and 15 below.

14. *Denn auch wie packte dann Großvater einst Wanderlust ihn die.*

15. *The also as seized then grandfather once wanderlust him the.*

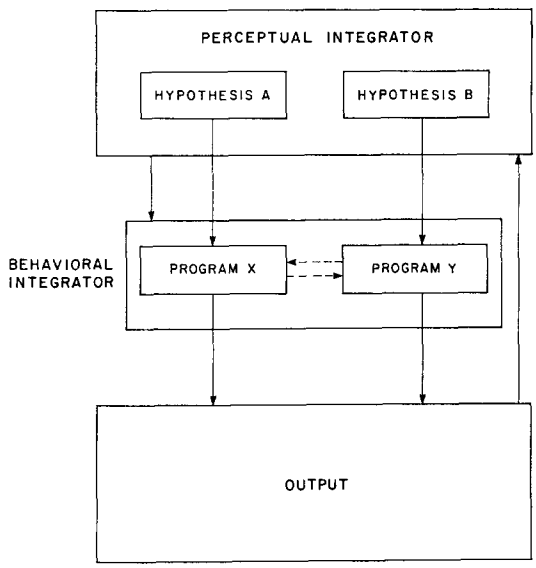

Fig. 9. An oversimplified model of speech production processes in completing ambiguous and unambiguous sentences. In this model, ambiguity activates two hypotheses (*A* and *B*) which prime or partially activate two conflicting speech production programs (*X* and *Y*). These preprimed programs interact in mutually inhibitory fashion (during which time, neither program is instigated). These programs are integrated with programs for the remaining (unambiguous) context of the sentence. When one of the hypotheses becomes dominant (see MacKay, 1968 for details of this process), priming of the corresponding motor program increases, boosting the level of activation of that program; and because of the mutual inhibitory relation between the two programs, the level of activation of the other program decreases. When the threshold of the resulting integrated program is reached, this program is instigated, resulting eventually in acoustic output (not represented in this model). Evidence for the various components of the model is presented in the text

The individual words of these strings are identical to 12 and 13, but their order has been scrambled so as to destroy their sentential or contextual meaning. Note also that 15 is a literal translation maintaining the same word order as 14.

As before, the subjects practised 14 and then produced 15, the translation. However, no facilitory effects of practise on either speech rate or fluency under DAF were found. Clearly the semantic facilitation effect must depend on the contextually determined meaning of the sentence as a whole rather than the meaning of individual words.

This experimental paradigm was repeated with a variety of procedures. For example, semantic transfer within a single language was found for synonymic sentences such as 16 and 17, but not the contextually disintegrated 18 and 19 (below). Similarly, fluency and speech rate increased for 17 following *auditory repetition* of 18, but not 19 following auditory repetition of 18, which lacks contextual meaning.

16. *The woman noticed a famished little infant on the road.*

17. *The lady observed a small hungry child in the street.*

18. *Road the on noticed woman the a infant famished little.*

19. *Street the in observed lady the a child hungry small.*

These findings suggested that practise at the semantic level effected some mechanism for integrating the semantic context of sentences rather than the analyzers for perceiving and producing the words themselves.

These findings also led us to suggest that motor programs for completing ambiguous sentences are based on the semantic schemata of the Perceptual Integrator rather than the perceptual analyzers themselves, as indicated in Fig. 9.

Reciprocal Inhibition

Another assumption of the model was that the mutually incompatible aspects of the motor programs for completing ambiguous sentences interact in reciprocal inhibitory fashion. Reciprocal inhibition is, of course, a well-known property of low level motor systems (Sherrington, 1906; Eccles, 1959). Moreover, reciprocal inhibition has also been demonstrated in high level motor systems (von Holst; Tinbergen, Kennedy and Booth; Kennedy; Andrew; Hinde, 1966). It would perhaps be surprising, even interesting, if reciprocal inhibition could not be found for motor processes in the speech areas of man.

For our present purposes, however, the formal properties of the reciprocal inhibition assumption are of interest. Some of these properties are discussed below:

1. Rebound Afterdischarge

The property of negative afterdischarge has been well established even for high level motor systems. As Bullock (1965) points out, a reciprocal inhibitory network becomes a dictatorial system, given sufficient input to one of its components. But once activation of the dominant component ceases, rebound excitation of the other system occurs (similar to the negative afterdischarge phenomenon of von Holst and von Saint Paul, 1963).

This property of reciprocal inhibitory systems may explain the frequent occurrence of Word Indecision for ambiguous fragments in MacKay (1966) and the present experiment. Consider 21, one subject's completion of 20 (from MacKay, 1966).

20. *After stopping arguing in the court, Wimbleton ...*

21. ... *was perjured I mean disqualified.*

The subject producing 21 perceived the meaning of court relating to tennis, even though the other meaning (i.e., relating to law) must have contributed to his initial choice of words. Such effects suggest that:

a) Programs for completing both of the derivations of an ambiguous fragment must be simultaneously activated, but,

b) Normally, only one of the programs is carried out and the other inhibited.

c) However, under certain circumstances release from inhibition or rebound activation of the other program may occur.

2. Displacement

Another well-established property of reciprocal inhibitory systems is the possibility of displacement activity. Displacement refers to the occurrence of an irrelevant activity when two incompatible tendencies are strongly and simultaneously activated. That displacement activities may be the result of disinhibition or rebound afterdischarge has been pointed out by Kennedy (1954), Andrew (1956), van Iersel and Bol (1958, Rowell (1961), Fentress (1965) and Hinde (1966). A model for displacement activities which incorporates this property is outlined in Fig. 10.

In the present experiment the tangential completions for ambiguous fragments may be viewed as displacement activities occurring in a conflict situation, and can easily be shown to fit the model in Fig. 10. Assume that the programs relevant to completing an ambiguous fragment are X and Y in Fig. 10 and that the irrelevant subroutines are tangential programs such as 22, 23, and 24 (from MacKay, 1966; tangential completions underlined).

22. Although I asked how old George was, *I mumbled.*

23. Knowing that visiting relatives could be bothersome, *I was confused.*

24. In ordering the police to stop drinking, *he became very undecided.*

The model is constructed in such a way that activation of either X or Y alone would inhibit these irrelevant subroutines. However, for ambiguous sentences both X and Y are activated, and due to their mutually inhibiting relationship, these relevant programs may inhibit one another for a period of time. Inhibition of X and Y would release the irrelevant subroutines from inhibition, resulting in the rebound activation of a tangential completion which normally would be held in check.

Laughter during the completion of ambiguous fragments may also be viewed as a displacement activity and explained in a similar way. Recall that MacKay (1966) found more laughter in completing ambiguous than unambiguous fragments (a difference significant at the 0.02 level). If laughter is viewed as an irrelevant program inhibited by the relevant programs for completing the sentences, then the mutual inhibition of these relevant programs would release laughter by rebound afterdischarge. It is interesting to note that this view of laughter is compatible with a theory proposed by Piddington (1963) based on a thorough review of the literature on laughter.

3. Reliability

Another property of reciprocal inhibitory networks is known as reliability. Fatigue need not reduce the output of systems with mutually inhibitory cross-connections since the several analyzers of these systems may be shifted from active to standby to recuperatory status (Bullock, 1966). This is one possible explanation of the lack of fatigue effects in completing ambiguous sentences in contrast to unambiguous ones (see Fig. 4). Another possible explanation is that conflict leads to a temporary state of arousal which overcomes the effects of fatigue on completing an ambiguous sentence (see Berlyne, 1960). Further research on this question is needed.

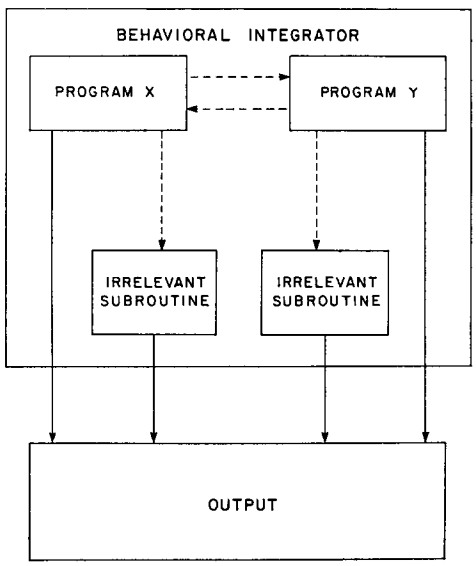

Fig. 10. An oversimplified model for Tangential Completions: Programs relevant to the completion of ambiguous fragments (i.e., X and Y) normally inhibit irrelevant programs such as laughter or tangential completions such as *I mumbled,* or *I was confused* or *I became very undecided* (from MacKay, 1966). Normally one of the motor programs (let's say X) becomes dominant, and activates the motor output directly. However, if program X becomes inhibited by program Y, then these irrelevant programs may occur as a result of disinhibition or rebound afterdischarge (after Andrew, 1954)

4. Fusion

Compromise is another possibility in reciprocal inhibition models. When reciprocal inhibition is incomplete (not total), fusion of the two mutually inhibitory programs may occur (Bullock, 1966). This aspect of the model may explain the apparent fusion of the two programs for completing ambiguous sentences reported in MacKay (1968). Consider the ungrammatical completions in 26, 27, and 28 (completions underlined).

26. Knowing the minister's hope of marrying Anna was impractical, *he disbanded the idea.*

27. Because Stalin liked the old school, *he decided to exterminate the new one.*

For 27 the subject volunteered that his sentence was ungrammatical since schoolhouses cannot be exterminated.

28. When Freud fed her dog biscuits, he thought *he saw them secrete saliva.*

After the experiment when *E* outlined the two meanings of 28 to the subject, she suggested that both meanings, *fed her biscuits* and *fed biscuits to her dog*, somehow combined in their effects on her completion causing her to say them.

Similar overtones of the unseen meaning were also found in many of the grammatical completions, such as 29, 30, and 31 (below).

29. Claiming the work was done over on the roof, *he asked them to do it again.* (The subject perceived the meaning *completed over there.*)

30. Discussing the problems with the mathematicians in Germany, Oppenheimer *grew red in the face.* (The subject perceived the meaning *mathematical problems*).

31. Sailing the two-masted ships into the dock, Drake accidentally *rammed the pilings.* (The subject perceived the meaning *to dock the ship.*)

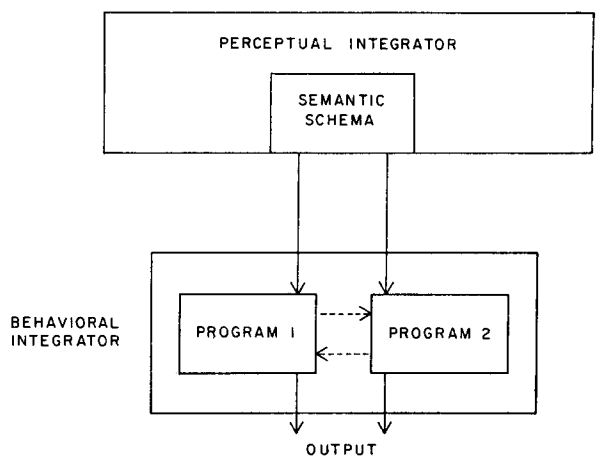

Fig. 11. An oversimplified model for explaining synonymic errors. In certain contexts the semantic component may activate two synonymic programs which interact in partially inhibitory fashion. Usually one of the programs becomes dominant, but the other program may interfere with output either directly, resulting in errors such as *sotally responsible* and *ich miteinander* — or indirectly by reducing the control over speech under DAF. Compare Fig. 9

These outcomes further suggest that two programs for completing ambiguous fragments are simultaneously activated and that when the programs for completing the sentence are not completely incompatible, a grammatical compromise or fusion of the two programs may occur (see von Holst (1950) and Mittelstaedt (1960) for discussion of the precise mechanisms that may underly such compromise behavior)[8].

[8] There is also some evidence that the outcome of the perceptual analysis of ambiguous words may not always be as mutually exclusive as was suggested in Fig. 8. For example, one subject in MacKay and Bever (1967) reported that he had difficulty in perceiving the two meanings of 38.

38. *The soldier put the gasoline into the tank*

He claimed that he perceived a soldier putting gasoline into the gas tank of a tank. Clearly the conflicting alternatives of ambiguous sentences are not always completely incompatible, nor perceived completely independently.

Motor Control Hypothesis

An attempt will now be made to demonstrate the formal similarity of the problem of synonymity to that of ambiguity in the production of sentences. Consider 33, an error in natural speech reported by Merringer and Mayer (1895) for an individual attempting to say 32.

32. *Ich auch* (German for *me too*).

33. *Ich miteinander* (*me together*).

This error clearly indicates interference from the synonymic expression in 34.

34. *Wir miteinander* (literally *we're together*, but figuratively, *me too*).

Synonymic errors of this sort are quite common in natural speech (see Merringer, 1908; Bawden, 1900; Cornish, 1855; MacKay and Bowman, 1968). Consider 35, an error which the subject spontaneously attributed to interference between 36 and 37.

35. *He is sotally responsible* (observed by author).

36. *He is totally responsible.*

37. *He is solely responsible.*

Such errors suggest that the semantic component may sometimes simultaneously activate two synonymic programs in natural speech production. And although one of the programs usually becomes dominant for a given context, the other program may interfere with its production and may even gain control over output resulting in errors such as 33 and 35. This oversimplified model for explaining synonymic errors is outlined in Fig. 11.

The Motor Control Hypothesis for explaining the effects of ambiguity on speech production is basically similar. It assumes that ambiguity activates two conflicting programs for completing ambiguous fragments. But even after one of the programs becomes dominant the other program may interfere and even gain control over output as in 21, 26, 27, and 28. Consequently, the obtained increase in DAF and pathological stuttering for reading and completing the ambiguous fragments in the present study may reflect this interference and consequent reduction in the control over speech.

Thus synonymity and ambiguity may disturb speech production for essentially similar reasons; in both cases, conflicting motor programs are simultaneously activated, and their interaction reduces the control over speech. The similarity of the models for synonymity and ambiguity can be seen by comparing the speech production aspects of Figs. 8 and 11.

Note that in the Motor Control Hypothesis, conflict has an indirect rather than direct effect on stuttering; ambiguity does not directly cause stuttering but increases its probability by reducing the motor control over speech. The direct cause of pathological stuttering is some as yet unknown factor (perhaps related to auditory feedback mechanisms as suggested in Cherry and Sayers, 1954).

Finally, the author hopes that he has only mildly insulted the reader's intelligence with these oversimplified outlines, and that these cybernetic models will stimulate research leading to more precise specifications of the mechanism underlying speech production at the semantic level.

Summary and Conclusions

The study investigated speech rate and stuttering in a sentence completion task using normal individuals under DAF and pathological stutterers as subjects. The data supported the following conclusions:

1. The subjects perceived only one meaning of the ambiguous clauses they completed.

2. No more words were used in completing ambiguous clauses than unambiguous ones.

3. The subjects took more time to complete ambiguous than unambiguous sentences.

4. This difference mainly reflected an increase in the time to think up a completion for ambiguous fragments rather than an increase in the time to produce them.

5. More DAF stuttering was found for reading ambiguous fragments than unambiguous ones.

6. Less DAF stuttering occurred in the words containing the ambiguity than in the remainder of the sentence, indicating that ambiguity may have an indirect rather than a direct effect on the control of speech.

7. These differences in stuttering could not be viewed as an effect of speech rate.

8. Control procedures showed that none of the above results were due to differences in structural complexity of the ambiguous and unambiguous sentences.

9. The time to complete an ambiguous fragment varied with the position of the ambiguity in the fragment. When the ambiguity occurred at the end of the fragment Thinking Time was less than when it occurred at the beginning.

10. The Total Completion Time for ambiguous fragments decreased with practise.

However, for unambiguous fragments the total Completion Time first decreased slightly, and then increased sharply at the end of the experiment. This finding suggested that fatigue may differentially effect the production of ambiguous and unambiguous sentences.

11. DAF stuttering decreased with practise for ambiguous fragments. However, for the unambiguous fragments a significant increase in stuttering occurred at the end of the experiment. This suggested that fatigue may greatly effect the production of unambiguous sentences, but not ambiguous ones.

12. Pathological stutterers were given the same sentences to complete without DAF and all of the main results above were replicated for pathological stuttering.

13. Traditional theories of the relation between conflict, and stuttering could not explain these results without serious revision. Rather these data supported models incorporating the following processes: In perceiving the meaning of sentences, ambiguity activates two hypotheses which prime or partially activate two conflicting speech production programs for completing sentences. These pre-primed programs interact in mutually inhibitory fashion so as to reduce the control over speech and increase stuttering in completing ambiguous sentences. The identity of these assumptions to those required in explaining the effects of synonymity on speech production was pointed out.

14. A model for explaining the frequent occurrence of laughter and tangential completions for ambiguous sentences was based on the disinhibition or rebound afterdischarge principle discussed by von Holst.

15. Ungrammatical completions of ambiguous fragments were explained as the fusion of incompatible aspects of the semi-independent motor programs. Similar fusions of compatible aspects of the motor programs for completing ambiguous sentences were shown in the grammatical completions.

Appendix A

The sentence fragments: the first group of subjects received the ambiguous fragments 1—6, and the unambiguous fragments 19—24; the second group received the remainder of the sentences.

Ambiguous Fragments

1. Knowing how little jockies drove cars
2. After John read her baby stories
3. Noticing that they were cooking apples
4. When he was working on the porch
5. Knowing how much more rapid progress was needed
6. Although he mentioned the problems with the president
7. Because the children had run in the house
8. Although the recruiting officers were convincing men
9. When he told me to go without thinking
10. Although I asked how old George was
11. Although Hannibal sent troops over a week ago
12. When I saw the wild Indian dance

Unambiguous Fragments

13. Knowing how much jodies drove cars
14. After John read some baby stories
15. Noticing that they were throwing apples
16. When he was playing on the porch
17. Knowing how long more rapid progress was needed
18. Although he mentioned the problems to the president
19. Because the children had shouted in the house
20. Although the recruiting officers were persuasive men
21. When he told me to go quietly home
22. Although I asked where old George was
23. Although Hannibal sent troops almost a week ago
24. When I saw the wild Indians dance

The author wishes to thank K. Acevski for running the subjects and analyzing the data; Drs. E. Carterette, D. Lindsley and B. Collins and Miss N. Kelso for generously lending various pieces of equipment; Robert Bowman for running pilot subjects; Hans Schulz for translating the abstract into German; and Dr. F. N. Jones for providing funds from the UCLA Department of Psychology. The work was also supported financially by UCLA Grant 2428.

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Buchbesprechungen

Peterson, W. Wesley: Prüfbare und korrigierbare Codes. (Aus dem Engl. übers. von KURT WALLNER.) München u. Wien: R. Oldenbourg 1967. 380 S., 60 Abb. u. 16 Tab. DM 79.—.

Das Buch ist die Übersetzung eines der amerikanischen Standardwerke der Codierungstheorie, das eine Reihe während der letzten Jahre bekannt gewordene Codes zur Fehlererkennung oder Fehlerkorrektur systematisch beschreibt. — Der erste Teil erläutert die linearen Codes, deren bekannteste Anwendung der Hamming-Code ist. Als mathematische Grundlage werden dazu die Begriffe der modernen Algebra — vor allem Gruppen, Ringe, Körper, Vektorräume und Matrizen — eingeführt, während weitere Kapitel die Fehlerkorrekturmöglichkeiten sowie ihre Schranken diskutieren. Entsprechend baut die Darstellung der zyklischen Codes, zu denen die bekannten Bose-Chaudhuri-Codes zählen, auf Galois-Feldern und Polynom-Ringen auf. Hier bildet die Korrektur von Fehlerbündeln das Hauptinteresse für Anwendungen, doch werden auch andere Codierverfahren erläutert. — Neben den Aufgaben, die den einzelnen Kapiteln zur Vertiefung der mathematischen Ableitungen beigefügt sind, wird in Anmerkungen die relevante Literatur referiert und in Zusammenhang mit den verwendeten Begriffen gebracht. Das schon im amerikanischen Original umfangreiche Literaturverzeichnis ist für die Übersetzung noch wesentlich erweitert worden, so daß auch neuere Veröffentlichungen berücksichtigt sind.

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Verantwortlich für den Textteil: Prof. Dr. W. REICHARDT, 7400 Tübingen, Max-Planck-Institut für biologische Kybernetik, Spemannstr. 38 — Verantwortlich für den Anzeigenteil: Edgar Seidler, 1 Berlin 33, Heidelberger Platz 3. — Springer-Verlag, Berlin · Heidelberg · New York.
Druck der Universitätsdruckerei H. Stürtz AG, Würzburg. — Printed in Germany