The role auditory feedback in stutter-like disfluencies in the speech of simultaneous interpreters under stress

Sherrard, Carol Ann

THE ROLE OF AUDITORY FEEDBACK IN STUTTER-LIKE DISFLUENCIES IN THE SPEECH OF SIMULTANEOUS INTERPRETERS UNDER STRESS

Carol Ann Sherrard

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ABSTRACT

Starting from the finding that simultaneous interpreters have an increased number of stutter-like disfluencies in their speech when working through noise, the thesis sets out to explore the relationship between the stutters of normal speakers under stress and pathological stuttering.

Since the conditions under which pathological stuttering can be suppressed, and in particular the absence of auditory feedback, appear to involve distraction from auditory feedback, it is hypothesised that attention to auditory feedback is important in pathological stuttering. The thesis is designed to determine whether this is also true of the stutters of normal speakers under stress, particularly interpreters.

The role of stress is discussed in terms of its effects on attention deployment. It is proposed that the known attention-narrowing effect of stress or high arousal may be operating to direct attention intermittently to auditory feedback in all types of stuttering, including delayed auditory feedback stuttering.

Experiment 1 investigates the effect of reducing, amplifying, and delaying auditory feedback, and of speech tasks requiring different patterns of attention deployment, on the occurrence of stutters. The known effects of delayed auditory feedback are reproduced, but no effects of amplifying or reducing feedback are found. Interpreting elicits more stutters than shadowing, and a significant relationship is found between stutters and failures to attend to simultaneous task input.

Experiment 2 is designed to elicit stutters in normal speakers by inducing anxiety and fluctuations of attention, using electric shocks and a divided-attention speech task. Anxiety does not increase stutters, but there is some evidence that it increases attention to auditory feedback. The divided-attention task succeeds in increasing stutters, and a control condition of masked auditory feedback reduces stutters.

It is concluded that attention to auditory feedback plays a role in the stutters of normal speakers, but only when attention is divided or fluctuating, and that these findings are consistent with the view that pathological and normal stutters are related.

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Chapter One

Stutters in the speech of simultaneous interpreters

Starting-point of research

The ideas and research embodied in this thesis arose out of some incidental findings of an experiment in which the author was involved in the capacity of research assistant.

The aim of this experiment had been to investigate the differential effects of noise interference on simultaneous interpreting and shadowing. Rabbitt (1966, 1968) had found that if non-masking noise were administered during the presentation of verbal material, perception and later recognition of the material were not adversely affected, but later recall was significantly poorer than in subjects to whom the noise had not been administered. It was therefore hypothesised that moderate levels of noise would affect interpreting more adversely than shadowing, since simultaneous interpreting, which consists of giving a running oral translation of a speech in progress, appears to involve more storage and transformation of input than shadowing, which consists merely of repeating speech as it is heard.

Briefly*, the experiment consisted of requiring twelve professional simultaneous interpreters to shadow or translate into English a series of pre-recorded French passages, which were presented without noise, or at a signal-to-noise ratio of +5db (decibels) or -2db. The principal findings were that noise adversely affected both shadowing and interpreting in terms of omissions and errors, but the only differential effect of noise on the two tasks was in the greater number of errors made by interpreters with increasing noise levels. Omissions, errors, and ear-voice spans were greater overall in interpreters, reflecting the greater cognitive complexity of this task. The total number of corrections by interpreters increased with noise, although the ratio of corrections to errors decreased. Shadowers made only a negligible number of corrections.

* Full details are given in Gerver (1971)

It was concluded that, in accordance with Rabbitt's findings, translators' ability to translate and monitor their output was impaired by the concurrent difficulty of perceiving the passages through noise - that the additional attention required for perception correspondingly reduced attention available for other components of the task. In terms of the limited-capacity channel view of human performance (Broadbent, 1958), the effect of noise was to limit channel capacity. Shadowers' negligible corrections throughout were thought to reflect the lower level of processing assumed to be characteristic of this task.

Leaving aside now these results, it was also observed during the analysis of the experiment that there appeared to be an unusually high number of stutters in the speech of some of these interpreters, especially in the noise conditions.

Comparison between disfluencies in the speech of simultaneous interpreters and disfluencies in a standard population.

It was therefore decided to score interpreters' protocols according to Kasl and Mahl's (1965) speech disturbance categories. These categories were evolved for the purpose of accurately describing and quantifying disturbed or "flustered" speech as an index of anxiety in therapeutic interviews (Mahl, 1956). Except for one of the categories (AH) they have been shown to be directly related to transient anxiety levels. Brenner et al. (1965) have confirmed a correlation of what are known as the non-Ah categories with anxiety and have also shown a correlation with the information content of words.

The categories are:- AH (a sound more usually transcribed "er" in British English); stutter; repetition; sentence change and incompletion; omission of a word or part of a word; tongue-slip; intruding incoherent sound. A standard table of the average contribution of each of these categories to disturbed speech has been compiled by Kasl and Mahl, using data from "patients in initial and therapy interviews, interviewers, undergraduates, and faculty members". This table is given below in adapted form, and included in it here are examples of each category from the interpreters' protocols, together with the percentage of each category as it is represented in these interpreters' speech, for comparison.

Speech Disturbance Category.	Example	Percentage of all Disturbances (Kasl & Mahl data)	Percentage of all Disturbances (Interpreters)
AH	The international organisation of...ah brain research.	40.5	68.2
Stutter	Th- this meeting starts off a new era.	7.8	6.0
Sentence Change and incompletion	And supposing... and provided that one receives the right education.	26.5	8.8
Repetition	The time seems to have have come.	19.2	2.1
Omission	The light of hu... human science.	4.5	5.7
Tongue-slip	Specialists in the social scientists. (Specialists in the social sciences.)	0.7	8.3
Intruding incoherent sound	A scientifically established potential...dy...and has not yet been fully realised.	1.2	0.9

Table 1.1 Percentage composition of Kasl & Mahl's (1965) speech disturbance categories: Comparison of a standard population with data from simultaneous interpreters.

It will be seen that there are not a few discrepancies between the two sets of percentages*. In particular, the AH category is much bigger in the interpreters' data, and this is in line with Kasl and Mahl's findings that this category tends to increase in size when the speaker is engaged in what they call a "telephone-like conversation", or when the interlocutor is out of sight. In the case of the interpreters, there was of course no interlocutor, or at most their "audience" was imaginary. For this reason, it was decided to exclude the AH category from the comparison. A further justification for doing this was that the AH category differs from all the Non-Ah categories in that it is not increased by anxiety. Since the main feature of interest was stutter, the percentage contribution of this category to the whole Non-Ah category was determined for both interpreters and Kasl and Mahl's standard population. The comparison is shown below in Table 1.2 (Both noise conditions were combined for this comparison).

	INTERPRETERS		STANDARD POPULATION
	Signal	Signal+Noise	
STUTTER	14.2%	23.0%	13.0%

Table 1.2 Mean percentage contribution of stutter to Non-Ah speech disturbances.

* This may be partly due to the fact that Kasl and Mahl's definitions of the categories are not sufficiently unambiguous to make it clear whether certain errors are meant to be counted independently or not. The non-independence of categories of errors will be familiar and exasperating experience to anyone who has attempted to score speech material in this way, although published work seems to maintain a conspiracy of silence about the problem. Thus Kasl and Mahl say that word omission is "associated with" sentence change and repetition in an example such as "then their anni...wedding anniversary comes round", but they do not say whether this is to be counted a repetition, as well as an omission and a sentence change. In the interpreters' protocols, such an example is counted as omission and sentence change. Similarly, Kasl and Mahl give no direction on what to do with phrases which are adapted or refined without being exactly changed - "he's a human individual, a being" - this is counted as a repeat for the interpreters.

A Wilcoxon's matched-pairs signed-ranks test was carried out on the difference between these stutter percentages for the signal and signal+noise conditions. Subjects' percentages were significantly higher in the signal+noise conditions ($N=12$, $T=12$, $p<.05$). That this increase is not related to a general change in speech disturbances is shown by the fact that subjects' Non-Ah ratios (Non-Ah disturbances per 1,000 words) do not change significantly between the signal and signal+noise conditions. (Wilcoxon's test; $N=12$, $T=27.5$, $p>.10$).

These comparisons suggested that stutter tends to increase with noise interference, and provided some confirmation of the original impression that stutter became a more salient feature in the signal+noise conditions. Such a finding was considered sufficiently interesting to justify a study of the conditions under which stutters occur in normal speakers, and if possible to relate these conditions to what is known of pathological stuttering. In particular, it seemed possible that the specific variables obtaining in this experiment on interpreters - noise stress and the complex nature of the verbal task - might be relevant to the mechanisms underlying both kinds of stuttering.

Nevertheless, some justification is required for any attempt to relate pathological and non-pathological stuttering. There is a good deal of disagreement as to what exactly constitutes pathological stuttering, firstly in terms of the features considered relevant in describing and measuring it. Is it simply sound and syllable repetitions, or should we also include broken words, long silent "blocks", and facial distortions? A table of measures used in research by different investigators is given in Appendix A, and will give some idea of the range of features involved in stuttering. Secondly, and partly because the many different features of disfluency occur to differing extents in different stutterers, there are grounds for believing that "stuttering"may merely be a blanket term covering a whole range of disorders with unrelated aetiologies (Beech and Fransella, 1968).

Nevertheless,many of the features of disfluency which occur in stuttering are also found in normal speech, though not of course to the same degree. This is a fact about stuttering which distinguishes it in an important way from other disorders known to be disease entities, and which of itself suggests the approach to be adopted in this thesis - that of attempting to elicit or suppress stutters in normal speakers by manipulating variables known to, or hypothesised to, affect pathological stuttering.

The stutters in normal and pathological speech

The following quotation from Goldiamond (1965) reveals his ready assumption that the difference between stuttered and normal speech is one of quantity rather than quality of disfluencies:-

> "Stuttering may be defined by a high rate of certain forms of speech .... repetitions, breaks, pauses, arythmias, and other blockages may occur in normally fluent speech, but at a rate so low as not to define a communicative problem."

There is also a certain amount of rigorous observation and experimentation to support this view. Bloodstein (1970) carried out a careful and extensive survey and found that certain features which are generally accepted as being characteristic of stuttered speech occur also in the speech of children considered to be normal speakers. These features are sound and syllable repetition, sound prolongation, articulatory tension, word repetition, the consistency and adaptation effects*, and the tendency

*"Consistency" is a term used to refer to the tendency in stutterers' successive oral readings of the same material for disfluences to occur at the same points in the material each time it is read. "Adaptation" refers to the tendency for total disfluencies to decrease with successive readings of the same material.

for stutters to occur on polysyllabic and rare words. Furthermore, only a negligible number of the normally-speaking children exhibited no instances of disfluency from any of these categories, each type of disfluency occurring "in readily discernible amounts in both groups" (i.e. in stutterers and non-stutterers).

There are other studies which have found more exact parallels between the disfluencies in stuttered and in normal speech, in the case of adults as well as children. Silverman (1970a,b,c) for example has found that the detailed pattern of adaptation in normal speakers' oral reading is the same as that of stutterers' oral reading. Neelley and Timmons (1967) have shown the same similarity. A study by Lanyon (1969) indicates that a previously demonstrated positive correlation between non-fluency and the information-value of the words stuttered on during oral reading by stutterers (Quarrington, 1965) holds also for the oral reading of normal speakers, although he failed to find the same correlation for spontaneous speech in normals. MacKay (1970) has found the same pattern, and has also found it in speech under delayed auditory feedback.* Finally, Silverman (1971) has shown that pacing the oral reading of normal speakers with a metronome reduces the incidence of disfluencies in the same proportion as stutterers' disfluencies can be reduced by the same means.

It seemed reasonable then to accept at the outset the possibility that, not only are the behavioural ingredients of stuttered speech already present in normal speech, but that the same mechanisms may underlie both.

In Chapter Two we now proceed to a discussion of pathological stuttering.

*See Chapter Two for a description of delayed auditory feedback.

Chapter Two

Pathological stuttering and attention to auditory feedback.

Conditions under which stuttering is suppressed

Some of the most reliable and suggestive findings in the field of stuttering research concern the conditions under which pathological stuttering can be suppressed. Such conditions have included administering speech-masking white noise to the speaker through headphones (Maraist and Hutton, 1957; Burke, 1961; Murray, 1969) instructing him to speak in time to a metronome, whose beat may be auditory, visual or tactile (Brady, 1969; Fransella and Beech, 1965; Jones and Azrin, 1969) speaking in chorus with other speakers (Yates, 1963), speaking at the same time as another person, who may be reading different material, or even gibberish; shadowing another voice (Cherry and Sayers, 1956), speaking with delayed auditory feedback (Chase, Sutton, and Rapin, 1961; Yates, 1963), speaking through clenched teeth (Bloodstein, 1950), in a monotone, whispering (Yates, 1963), in a sing-song voice (Chase, 1958), speaking in a foreign language (Bloodstein, 1950); or in other ways changing the ordinary sound of his voice (Webster and Lubker, 1968).

While these treatments appear to be diverse and unrelated at first sight, there is one feature that stands out as being common to them all, and that is that they can be understood as distracting the speaker's attention from the usual sound of his voice. "Distraction" is given as the basis of these and similar suppression effects by many investigators (e.g. Barber, 1940), although none attempts to specify the mechanism involved.

The success of all these treatments, and in particular the dramatic success, with some subjects, of the technique of preventing the stutterer from hearing his own voice at all, by masking it with noise, indicate that at least one cause of stuttering is to be found in the stutterer's attention to his auditory feedback. Supporting evidence for this inference is found in the fact that stuttering is present to a negligible degree among the deaf and hard of hearing (Backus, 1938; Harms and Malone, 1939). Indeed, the implication of feedback processing in the case of stuttering is much stronger than in the case of some other disorders, such as Parkinson's disease and cerebellar tremor, where some defect of propioceptive feedback processing has only been speculated to be responsible by analogy with the oscillations observed in a servo system where feedback is delayed or absent (Dinnerstein, Frigyesi, and Lowenthal, 1962; Ruch, 1951). In the case of these disorders, it is much more difficult to manipulate feedback experimentally, and therefore much more difficult to discover the role that it is playing, than in the case of stuttering. Among the many studies of the effects of noise masking on stuttering, there are two important studies (Sutton and Chase, 1961; Webster and Dorman, 1970) one a replication of the other, which indicate that masking per se cannot explain the suppression of stuttering during the presentation of white noise. These studies found that noise presented during the pauses only of a stutterer's oral reading is equally effective in enhancing fluency. The importance of this finding lies in the fact that most of the previous studies of noise as a suppression agent have assumed that its effectiveness lay in its complete, or almost complete, masking of the voice. Theories of stuttering based on this assumption were thus falsified. In particular, the formerly dominant class of theories and hypotheses which postulated some malfunction of the hearing or auditory monitoring process, such as a delay in the reception of auditory feedback (Cherry and Sayers, 1956), or a fault in the integration of feedback between the two ears (Tomatis, 1956), or an over-dependence on auditory as opposed to tactile and kinaesthetic feedback cues while speaking (Gruber, 1965) and many other theories postulating global defects of the auditory monitoring system, (Maraist and Hutton, 1957), were falsified by this finding.

Feedback in skilled motor tasks

We have seen above that the role of auditory feedback will need to be taken into account in any theory of stuttering behaviour. Regarding speech as a skilled motor task, we can derive some ideas about the possible role of auditory feedback in speech from an examination of the role of feedback in skills in general.

Skills are generally held to develop as a function of the decreasing, rather than increasing, use of feedback cues. Attention to feedback is a characteristic only of the initial learning phase of any skill. Thus, Annett and Kay (1956) write that "the skilled man is responding to fewer cues than the unskilled", and Miller, Galanter and Pribram (1960) state that:

> "when an action unit has become highly skilled it can be executed directly without being first expressed in a .... verbal form, and even without focal awareness".

This gradual relinquishing of attention to feedback cues is sometimes described as the development of automatic responding:

> "Automatism... refers to the running-off of sequences of behaviour without the need for conscious control... such automatism is involved in articulatory and grammatical behaviour." (Herriot, 1970)

Another aspect of skill is that referred to by Herriot above as the "running-off of sequences of behaviour". It is generally held of skilled performance that it involves larger behavioural units than unskilled performance. These are not merely "larger units", but are concatenations of many small units which have collapsed into a smaller number of large ones. In terms of feedback, this means that instead of a cue for each unit being required, as in the learning stage, in the skilled stage of performance a single cue can subsume, possibly in hierarchical fashion, (Bryan and Harter, 1899; Miller, Galanter and Pribram, 1960; Fuchs, 1962), many other cues which are implied by its presence. The way in which such a development would take place in a linguistic skill is described by Kimble and Perlmuter (1970):

> "With practice, the telegrapher moves from letter habits, to word habits, and even to phrase and sentence habits... the linguists have made essentially the same point in calling our attention to the fact that we do not talk in phonemes, but in words."

Finally, Lounsbury (1954) extends to speech movements Lashley's* (1951) point about the problem of serial order in behaviour:

> "The final triggering of the motor acts which produce the sounds of speech appears to be accomplished on the... lower level of motor skill organisation. The sequenced triggering of the individual motor acts in speech is accomplished at a rate which Lashley showed to be, like the individual motor acts in piano playing, too great for each such act to be under specific cortical control via feedback mechanisms."

<u>The disruptive effect of attention to feedback on skilled motor performance</u>

Attention to feedback seems, then, to be unnecessary to skilled performance, and may even be impossible during rapid sequences of skilled movements. It has been pointed out earlier that at least one source of the stutterer's difficulties appears to lie in his attention to his auditory feedback. Is attention to feedback disruptive to the performance of a skill? The evidence that it is, is mainly of a familiar and anecdotal order, although it has long been recognised by psychologists that an important difference between conditioned involuntary and conditioned

* Although Lashley's point was made with speech in mind, he was not concerned with speech at the motor level (MacNeilage 1970)

voluntary responses lies in that the former are more easily conditioned if conscious awareness of making the response is avoided. Thus, in a discussion of the automatization of voluntary responses, Kimble and Perlmuter (1970) state that:

> "responses acquired... 'at the expense of much labour' gradually lose their laborious quality. They become automatic, occur apart from any direct attention on the performer's part and are commonly called 'involuntary'. A closely related observation is that the act of paying attention to such performances.... tends to destroy the automaticity."

Posner and Keele (1968), in a paper concerned with the attention demands of movements, say similarly:

> "It has been proposed that automated movements not only do not require attention, but are harmed if attention is given to them. This view has been suggested.... anecdotally by athletes and musicians, who often indicate that one should not attend to a movement while executing it".

Kimble (1971) has discussed the inhibition of classically conditioned reflexes by attention to the response, and considers that conditioned reflexes are a sub-class of automatic behaviour, which includes heavily overlearned motor behaviour. If Kimble is correct, it follows that the automatic aspects of speech, at least, would be inhibited by having attention paid to them.

A theory of stuttering

The role of feedback in skilled performance, together with the apparently 'distracting' nature of the techniques which suppress stuttering, suggest that the stutterer attends inappropriately to his auditory feedback. Inappropriately, that is, for the smooth performance of a skilled task

Unlike the normal speaker, who, we may assume, performs the motor skill of phonation as he would perform any skilled motor task - without attending to feedback, the stutterer may never have fully acquired in his phonation the automaticity, the unconscious selection of feedback cues which permits the fluency of skilled behaviour. In his case, the articulation of certain speech sounds is performed with full conscious control, as a voluntary rather than an automatic act. In the terms of Kimble and Perlmuter, he is speaking in phonemes, not words.

What empirical evidence is there that stutterers attend to auditory feedback in the way that we have suggested? There is a certain amount of evidence, although it is mainly indirect and implies a general attentional disorder rather than the specific feature of attention to auditory feedback.

Andrews and Harris (1964) report that there are well-substantiated accounts of the onset of stuttering in adults following neurological disease which has resulted in dysphasia. In this case, the stuttering would occur at a time when these patients would be attempting to learn to speak again, and their speech behaviour would be conscious, and voluntary rather than involuntary. Similarly Morley (1957) relates the onset of stuttering to illness, injury, shock, or other factors "leading to speech consciousness and speech correction". Schlager and Gottsleben (1957) found that the incidence of stuttering was 17% among 516 mentally retarded children, and the incidence was particularly large among children with known brain damage or mongolism. (The usually quoted figure for the incidence of stuttering in the general population is 1%). This is relevant in view of McGhie's (1969) review of attentional deficits among brain damaged patients. He says that this syndrome includes marked fluctuations in attention - " a failure in the normal inhibitory processes resulting in abnormal distractibility", reporting a suggestion of Goldstein (1934) that one of the most characteristic features of the brain-damage syndrome is a "forced responsiveness to stimuli".

> "The apparent inattentiveness of such patients was a consequence of their involuntary attentiveness to inessential elements of the situation - external noises, the texture of the interviewer's clothing, the speaker's gestures, or any other stimuli which would normally be ignored". (McGhie, 1969).

Again reported by McGhie, Werner and Strauss (1941) did a series of experiments showing that brain-damaged children are less able to inhibit responses to background stimuli in tests of the figure-ground type; and Deutsch and Zawel (1966) have reported that this susceptibility to background stimuli is particularly pronounced in the auditory modality.

Martyn, Sheehan, and Slutz (1969) on the other hand, followed up a common belief that stuttering is more prevalent among the mentally retarded, and found no evidence to support this in a survey of 346 patients. However, the fact that they concentrated on retardation as such, rather than brain damage, and started out with the assumption that an intelligence factor might be involved, may explain the discrepancy of their results with those of Schlager and Gottsleben (1957), who mention a specifically brain-damaged group both as part of a larger group which had a high incidence of stuttering, and as a separate group showing an even higher incidence.

Finally, Kingdon-Ward (1941), gives a list of "states in which control by the higher cortical centres is in abeyance", and during which stuttering does not occur. This includes narcosis, hypnosis, anaesthesia, delirium, and intoxication. She also mentions that stuttering does not occur during screaming and shouting, or during the utterance of common expletives expressing strong emotion. The general point here seems to be that unmonitored speech is not stuttered.

Voluntary and automatic control of speech

The "attention-to-feedback" theory is given further support by findings in the pathology of speech itself which illustrate the point of Kimble and Perlmuter and of Posner and Keele concerning the disruptive effect of attention to feedback in skilled performance. It has been observed (Whitaker, 1970) that ictal speech automatisms cannot be performed by patients with brain damage of certain kinds if they attempt consciously to perform them. Ictal speech automatisms are formulaic, overlearned words and phrases, such as common greetings, exclamations, oaths, curses and obscenities. Whitaker considers them to be controlled by fully pre-encoded motor programmes, and to be ballistic responses which are not regulated by the monitoring of feedback, since they are exhibited by brain-damaged patients who are otherwise unable to speak at all. Whitaker describes a patient with severe alexia and agraphia who produced written automatisms of this kind - "he could write his name, address, and hometown birthplace, all without paying attention to the pencil, his hand, or the writing task". However, it was not only the case that feedback was unnecessary to performance, but that attention to feedback actually inhibited performance:- "as soon as he concentrated on the task he failed to be able to perform".

Whitaker points out that ictal speech automatisms are overlearned, and suggests that "the sub-cortical modality-specific parts of the (language) production system can tap a store of integral motor commands". Such over-learnedness is characteristic of language at the phonetic level, at least insofar as it is evidenced by the involuntary and unconscious nature of mechanisms such as allophonic variation and sandhi.* Over-learnedness is also indicated by a finding of Goldman-Eisler (1954) that the highest rates of articulation are attained during the utterance of common phrases and cliches.

It seems reasonable to hypothesise from these observations that phonetic behaviour in particular may consist of unmonitored, ballistic responses whose execution would be impaired by conscious control. This hypothesis, or at least the second half of it, is given added support by two indications concerning simultaneous interpreters' monitoring of their own voices. Firstly, Goldman-Eisler (1968) suggests that the interpreter uses a strategy of compressing as much as possible of his own speech into the pauses of the incoming message, in order "to listen without interference from his own output". The second indication is that interpreters

*"Allophonic variation" refers to changes in the pronunciation of a particular phoneme as determined by different phonetic environments. Thus /K/ in "key" is pronounced with following aspiration - 'kh', while /K/ in "ski" is not. This difference, unnoticed by the naïve English speaker, is sufficient to support a phonemic distinction in Hindi (Gleason, 1961). Similarly, /S/ following a voiced consonant, as in "dogs", is pronounced 'Z'; while following an unvoiced consonant, as in "cats", /S/ is pronounced 'S'.

"Sandhi" refers to changes brought about at the end of certain words according to the type of sound which begins the following word. Thus "never" pronounced 'neva' in isolation or before a word beginning with a consonant - 'neva go' - acquires a terminal 'r' when followed by a word beginning with a vowel - "never again".

Such automatic variations may look as though they are determined by questions of ease of pronunciation, or even of anatomy; but the fact that sequences of sounds which seem unnatural or impossible to speakers of one language may be commonplace in another shows that these features are quite conventional. Thus a transition vowel-to-vowel, as in French "la haie", pronounced 'la e', would be intolerable to an English speaker, and would be avoided in, for example "her age" by one of two expedients. One would be to add 'r' to the end of "her" (in isolation, or before a consonant, "her" has no 'r') - thus 'her age'. The other expedient would be to add a glottal stop at the beginning of "age".

frequently attempt to increase to the maximum the volume of the message they are interpreting, thus drowning out their own voice. Welford (1968) suggests, however, that interpreters do not listen to their own voices, because, according to his limited-capacity model of human information-processing, it is not possible to fully process two inputs at the same time. (As evidence in favour of his proposition that interpreters do not listen to their own voices, Welford points out that their speech is often drawling and lacks intonation, in precisely the way that one sounds when absently saying one thing while thinking of another). Broadbent (1952) has similarly concluded that "we cannot attend perfectly to the speech of others and to our own" from an experiment in which subjects failed both to reply to, and to hear adequately, rapidly-succeeding call-sign messages which overlapped with their replies. Poulton (1955) reached the same conclusion from an experiment involving alternate shadowing and the repeating of messages after they had been presented, in which subjects who shadowed often spoke gibberish without being aware that they were doing so. (In fact, a more likely explanation of the gibberish obtained in this experiment, which only occurred when subjects were first learning to shadow, is that subjects initially adopted a strategy of shadowing word for word, rather than the more successful strategy of shadowing in larger units (Chistovich et al., 1960), and consequently sometimes perhaps mis-identified a word on the basis of its first syllable, then abandoned the word on realising the error.)

It is interesting to note that this conclusion that it is not possible to listen to oneself and to another input requiring transformation at the same time implies that one's own voice is a "full input", requiring as much information-processing capacity as any input originating outside the organism. In contrast, it is proposed here that, in the experiments which led to this conclusion, it may not have been the voice _per se_ which required extra capacity, but rather the semantic and syntactic operations preceding the speech which expressed their finished product. It is also proposed that speech, at least on the phonetic level, is not monitored as a full input, and that in conditions where this does sometimes occur it is detrimental to fluent speech.

It is important here to distinguish between "attentional" or "conscious" monitoring, and "unconscious" monitoring of the voice, for want of better terms. While it is clear that, for most of the time, we do not consciously monitor feedback from our voices, the effect of removing auditory feedback from a speaker (usually done by administering voice-masking noise through headphones) is quite marked. The intensity of the voice is increased, the frequency composition changes, and intonation is usually lost or becomes very stereotyped - these effects are referred to collectively as the "Lombard Effect". Some continuous monitoring of the voice must then be taking place under normal conditions, but it seems unlikely that this kind of monitoring, which is related to such necessary information-processing "activities" as maintaining posture by means of kinaesthetic and tactile information, or perhaps the saccadic eye-movements in reading, requires the same order of attention as cognitive tasks. Information relevant to a cognitive or perceptual-motor task might be designated "full input", but information concerning the state and performance of the body should not be designated in the same way in order to avoid confusion, and perhaps also to avoid a fundamental mistake.

Feedback and distraction from feedback in theories of stuttering

The idea of attention to feedback, or at least of undue consciousness of one's own speech, is not a new one in theories of stuttering. Kingdon-Ward (1941) for example devotes a chapter to this question in a book on stuttering and its treatment. Johnson's (1959) influential diagnosogenic theory also implicates inappropriate attention to feedback, although this is feedback in its most general sense of "knowledge of results", at least in the first instance. In this theory, auditory feedback is not specified, and stress is laid on the kind of feedback received from approving or, more often, disapproving parents. (Thus perfectionist parents are said to mis-diagnose normal disfluencies in their child's speech for stuttering, and to criticise the child, thus making him anxious and over-conscious of his speech, and consequently even less likely to speak fluently.) Other writers make similar assumptions without explicitly regarding them as being related to attention to auditory feedback in any literal sense:-

> "By becoming aware of their speech and unsure of their ability to manage it adequately, they become stutterers. Like the centipede when told to watch how it walked, they too have difficulty once cautioned to watch how they talk". (Andrews and Harris, 1964).

The corollary of an attentional theory, an explicit "distraction hypothesis", has however been set up, and subjected to considerable experimental investigation. Beech (1967) sets up the distraction hypothesis to account for the effect of speaking in time with a rhythmic metronome, or any other rhythmic stimulus, in suppressing stuttering. The hypothesis:

> "assumes that at least part of the stutterer's difficulty comes from paying too much attention to the sound of his own voice, just as we may stumble if we pay too much attention to our leg movements as we are descending a flight of stairs".(Beech, 1967)

Beech and Fransella (1965) carried out an experiment on the distraction effect, and concluded that distraction alone cannot, however, explain the success of metronome-pacing in suppressing stuttering. They reasoned that, if distraction were the basis of this phenomenon, then an arrhythmic metronome should have the same effect as a rhythmic one. They compared stutterer's speech under these two conditions, and in accordance with their hypothesis they found that there were significantly fewer speech errors in the rhythmic metronome condition than in the arrhythmic condition. Although there were fewer errors in the arrhythmic condition than in a no metronome condition, this difference was not statistically significant.

It is important in interpreting the results of this experiment to notice that, in the rhythmic metronome condition, subjects were instructed to "read in synchrony with the metronome, producing each word or syllable in time with the beats, whichever he found easier", while in the arrhythmic metronome condition, the subject was merely told to "read at his usual rate". The two conditions are not comparable, since in the latter condition the subject could simply ignore the metronome beat, and in fact was probably obliged to ignore it if he were conscientious enough to try and make sure that he was reading at his "usual rate". The subjects in the rhythmic metronome condition, in contrast, had no choice but to listen to the metronome. Thus we cannot be sure or even reasonably confident that the subjects in the arrhythmic metronome condition attended to the metronome, and this experiment leaves the "distraction hypothesis" intact.

Brady (1969) has also compared stutterers' speech when paced with a rhythmic metronome with their speech when paced with an arrhythmic metronome. He instructed subjects to speak in time with the metronome in both conditions, thus making them truly comparable. He found a small difference between the effects of the two conditions, rhythmicity producing superior fluency, but

> "this difference was small compared with the marked increase in fluency obtained with both metronomes as compared with the subjects' speech unaided by either device."

In another experiment reported in the same paper, Brady replicated an experiment first carried out by Fransella (1967), and obtained similar results. In one condition of this experiment, subjects paced their speech with a rhythmic metronome, while reading out a list of words. In the other condition, subjects read out the same list of words while simultaneously performing a subsidiary "distracting" task of writing out a series of numbers which were presented to them, aurally, at random intervals. Performance with the metronome was superior to performance in the "distraction" condition, and Brady concluded that "rhythmicity", rather than distraction, is the basis of the metronome effect. Again, however, the essentially different natures of the two tasks used in this experiment precludes their comparability. Distraction by pacing, especially by rhythmic pacing, is quite different from the kind of distraction which occurs when attention is diverted temporarily to comparatively infrequent, randomly-occuring events, such as the aurally presented numbers were in the "distraction" condition of this experiment. The pacing of a continuous task requires constant attention to the pacing stimulus, while an intermittently performed task does not demand continuous attention. Thus the "distraction" condition in this experiment was in fact less distracting than the metronome condition.

Alongside these failures of irregular stimuli to distract attention and suppress stuttering, it is of interest to consider why the presentation of noises during the pauses in stuttered speech has the opposite effect (Sutton and Chase, 1961; Webster and Dorman, 1970). Superficially these stimuli appear to be very similar in nature, particularly in their lack of "rhythmicity", which Fransella and Beech in the study just mentioned conclude must be the secret of the metronome in suppressing stuttering. However, a possibly important difference between these two kinds of stimuli may be that the pause-triggered noise is of course predictable to the stutterer, since his own behaviour provides the cue for the stimulus to occur, while the irregular metronome is not predictable. This makes the pause-triggered noise similar in one respect to all of the continuous stimuli which have been found to suppress stuttering. These similarities suggest that is continuous or predictable distraction rather than rhythmicity per se which is the effective component in techniques which suppress stuttering.

There are other theories of stuttering which relate to the role of feedback in particular. Mysak's (1960, 1966) explanatory system is less of a theory than a specialist language and an analogy, borrowed from servo theory, for describing stuttering symptomatology. He takes several prevailing theories of stuttering, and by translating them into the language of servo theory shows how they can all be reduced to postulating a fault in the processing of feedback.

He compares the child's speech feedback system to two servo-systems operating simultaneously. One is the child's system for processing his own auditory feedback, and the other system embodies the social context of the child's speech, i.e. the supposed attitudes of others (approval or disapproval) towards his speech, and also his own attitude (confidence or anxiety), as shaped by those of others. Using these two systems, Johnson's diagnosogenic theory (Johnson, 1959) can be translated into a postulation of a fault in the social context system initially; the stutterer, because of early experiences of his parents' critical attitude towards his speech, even though the disfluencies he exhibited may have been quite normal at that particular stage of language development, comes to have a low threshold for error signals from his interlocutors (signals such as frowns, amused smiles, verbally expressed incomprehension or requests for repetition). Indeed he may even become a little paranoid, and perceive error signals when none were present.

In servo systems, false error signals result in oscillation or prolongation of output units until the"governor" or "executor" (decision components) intervenes. Once the stutterer has begun to act on these spurious error signals, and to repeat syllables, words or phrases, the social feedback fault (perception of spurious error signals) has been incorporated into his auditory feedback system, and becomes a henceforth habitual pattern of behaviour.

Given that such a person is quite likely to experience anxiety in situations where he has to speak, he is then even more likely to perceive spurious error signals, because of his anxiety. Now a false error signal can only be suppressed in a servo system by the direct intervention of the governor, or executor, whereas in normal fluent speech the matching between target and attained speech configurations is done by a comparator unit alone, by-passing the governor, or, in ordinary language, without awareness. Thus, in stuttered speech, automaticity is impossible because of the frequent reception of spurious error signals and the resulting frequent calls on attention.

Mysak's system is important in pointing out the likely consequences of attending to auditory feedback, and the servo analogy also enables it to explain why attention to auditory feedback should result in the specific effect of repeating and prolonging linguistic units. It also captures the circularity whereby attention to feedback perpetuates itself; the frequent interventions of the executor disrupt automaticity, which in turn disrupts fluent speech and induces anxiety, thus further increasing the probability of perceiving a spurious error signal. As it stands, however, Mysak's system cannot also explain the stutters which are observed when a person hears his own voice delayed by a short interval, that is, when he is subjected to delayed auditory feedback (DAF). Nor can the system as it stands account for the occasional stutters observed in the speech of normal speakers when they are anxious. In Chapter Three we now proceed to a consideration of attention factors in speech behaviour under DAF, as part of an attempt to relate all such "stuttering" phenomena within a single theoretical system.

Chapter Three

Delayed auditory feedback and stuttering.

Theories of stuttering based on the DAF effect

The speech disturbances brought about in some subjects when they hear their voice artificially delayed by a small interval (optimally 0.17 - 0.18 seconds; Yates, 1963a) have often been likened to suttering. The effect is typically one of repeating and prolonging linguistic units - phones, words, and phrases. It may be of interest to note here that speech is not the only activity which can be severely disrupted by delayed feedback. Similar effects have been shown in key-tapping (Chase et al 1959) and hand-clapping (Kalmus, Denes & Fry 1955), with delayed auditory feedback; while artificially delayed visual feedback disrupts handwriting in a similar fashion (Van Bergeijk and David, 1959).

Lee (1951) who first discovered the delayed auditory feedback (DAF) effect, as it is now known, termed it "artificial stutter", and was optimistic that a theory of stuttering would eventually be based on it. Many other writers also assume that the DAF effect and stuttering are intimately related (Doehring and Harbold, 1957; Chase, 1958; Zangwill, 1960).

Similarities between DAF speech and stuttered speech,other than their merely "sounding alike" have been shown. MacKay (1970) has indicated that both the DAF effect and stuttering are less likely to occur with increasing age, and that the stutters in both types of speech are more likely to occur on rare words. Webster and Dorman (1971) have shown that adaptation, the tendency of stutterers' disfluencies to decrease with successive oral readings of the same material, occurs also during the DAF speech of normals.

Some writers who have explicitly attempted to integrate pathological stuttering and DAF stuttering into a single theoretical framework have suggested that pathological stuttering is caused by the same factor that they have assumed DAF stuttering is caused by - namely a delay in the perception of auditory feedback (Cherry and Sayers, 1956; Tomatis, 1956; Stromsta, 1956). Such theories assume that the repetitions and prolongations of speech sounds produced by DAF reflect an attempt by the speaker to restore the normal temporal relationship between output and feedback. (Yates, 1965).

The difficulty in extending this idea to account for pathological stuttering is that the "normal" temporal relationship between output and feedback must be unknown to the stutterer, if his perception really is faulty. Put another way, if his perception of auditory feedback is faulty in the way suggested, then DAF must be normal for the stutterer, and if this were really so he would not be continually attempting to adjust his output according to some other norm, which must <u>ipso facto</u> be unknown to him. Furthermore, there is evidence that subjects learn to adapt to DAF and overcome the repetition and prolonging of speech sounds (although no amount of practice so far used has been successful in overcoming the other DAF effect of slowing the rate of speech)(Yates, 1963b) and presumably the stutterer should be able to adapt likewise. Nevertheless there remains the possibility that the stutterer's perception of his auditory feedback may be delayed only intermittently, and it has indeed been shown that adaptation to DAF is resisted if the DAF is applied intermittently (Hanley et al., 1958).

Other writers have gone further and attempted to provide an explanation of either DAF stuttering alone (Crossman, 1964), or of both DAF stuttering and pathological stuttering, (Fairbanks, 1954; Wolf and Wolf, 1959) by appealing to the servo-system analogy. In a servo-system, the "decision mechanism" (otherwise termed "governor" or "executor") must be cleared by receipt of a feedback signal from each unit of operation before the next unit can be triggered. If feedback signals are late, fail to arrive, or are subject to a sudden change in frequency, units may be repeated and executed with greater intensity and amplitude until feedback signals are received (Chase et.al., 1960; Welford, 1968).

However, this servo-system analogy fails to account for the fact that the almost complete elimination of speech feedback (either auditory, kinaesthetic, or both combined), which would be the analogue of the failure of signals feedback to arrive, does not produce stuttering, although sound prolongation, one feature of stuttering, does occur. (Hanley & Steer, 1949). Significant increments in amplitude are obtained with blockage both of kinaesthetic and of auditory feedback, together with articulation errors, (Ringel and Steer, 1963) but apparently nothing approaching stuttering has been obtained. It is, nevertheless, possible that blockage of proprioceptive feedback, which has not yet been satisfactorily accomplished (Hardcastle, 1970), may have this result.

Is the DAF effect related to pathological stuttering?

Some writers have maintained, on the other hand, that pathological stuttering and DAF stuttering are unrelated. Neelley (1961) for example, compared the speech of stutterers and of normal speakers under DAF. In his study, the speech of both groups showed little adaptation or consistency*, and so differed greatly from the speech of stutterers under normal conditions. In addition, judges were able to distinguish stutterers reading with normal auditory feedback from either group reading with DAF. Neelley concluded that there are substantial differences between pathological stuttering and DAF stuttering, and that the two sets of phenomena must be mediated by different mechanisms.

However, in view of the fact that the speech of the confirmed stutterer is overlaid with all kinds of concomitant features which are extraneous to the stutter itself, such as characteristic breathing, (Zangwill, 1960), intonation, and hesitation patterns, interjections,

* See footnote page 6 for meanings of "adaptation" and "consistency"

tics and grimaces (Andrews and Harris, 1964; Yates, 1963a) one could hardly expect pathological stuttering and DAF stuttering to be identical in all respects, or indeed in any respects other than the essential features of stuttering. The usual distinction between "primary" and "secondary" stuttering (e.g. Brain, 1965) is relevant here. Primary stuttering is found in the speech of the young child, and consists only of repetitions and prolongations. Secondary stuttering, found in older children and, more rarely, in adults, contains the repetitions and prolongations, together with circumlocution to avoid words or sounds which are habitually stuttered on, and some or all of the extraneous learned features mentioned above. The accompanying tics and grimaces are, incidentally, usually interpreted as distraction devices which enable the stutterer to momentarily forget his stutter, break out of his block, and continue speaking. Of course, as soon as the novelty value of these devices is exhausted, they cease to distract, and the stutterer is stuck with them as learned responses which have in the past been rewarded with fluent speech. (Andrews and Harris, 1964).

Neelly's criticisms thus do no great damage to the view that DAF stuttering and pathological stuttering are mediated by the same mechanism. But what can be offered in favour of this view?

Involuntary attention to DAF

There is some evidence that the disruption of normal speech brought about by DAF may be a function of involuntary attention to the delayed feedback, in the same way as it has been hypothesised in Chapter Two that pathological stuttering may be a function of inappropriate attention to auditory feedback.

Carey (1969) split subjects into two control groups and one experimental group. The control groups listened to recorded stories, and shadowed the same stories, respectively. The experimental group shadowed the same material with DAF. All were given recognition and retention tests, and the DAF group performed significantly worse than the two control groups on retention tests, but performed equally well on the recognition tests. There was apparently no difference in performance between the two control groups. The effect of DAF must therefore have been to distract attention away from the stories, to some extent, but not to mask them, since the good recognition scores show that overall perception of the stories was not impaired. King (1963, 1965) has also found impaired recall after presentation of DAF in an oral reading task.

Yates (1965) divided subjects into groups of high and low susceptibility to DAF and compared their performance on four dichotic shadowing tasks - shadowing a single message presented binaurally; and shadowing a message presented to one ear with either white noise, an irrelevant message, or delayed feedback of the shadowing presented to the other ear. Subjects whose susceptibility to DAF was high gave significantly poorer performances both in the DAF condition <u>and</u> in the irrelevant message condition, indicating poorer selective attention in this group as compared to the low susceptibility group.

Erlich (1966) used the Rod-and-Frame Test (in which correct judgements of a true vertical line require the inhibition of responses to a distracting tilted frame), a colour-word response-interference test (The Stroop Test, Stroop 1935), and DAF to compare styles of attention deployment in a large group of subjects. He found that subjects who were most susceptible to DAF were also poor performers on the colour-word interference task, but that the same subjects' performance on the Rod-and-Frame Test was good. From this he concluded that these subjects used attentional strategies in which salient or figural cues are responded to almost exclusively, while background properties of configurations are ignored. Such an interpretation clearly assumes that the stimulus properties of DAF are salient.

Further evidence in favour of relating DAF stuttering to enforced attention to AF is provided by the finding, arrived at by several investigators, that a difficult speech task is less disrupted by DAF than an easy one. Most investigators have attempted to explain this effect by suggesting that a difficult task requires closer attention than an easy task, and is thus more resistant to extraneous stimuli. Another possible explanation of this effect is that, in an easy task, there will be more processing capacity available which could be used to scan auditory feedback, and thus the probability of stuttering would be increased. Gerver, (1970) has found that repetitions of words, one feature of stuttered speech, occur more frequently during shadowing than during simultaneous interpreting by the same subjects, and he suggests that this may be attributable to spare channel capacity.

Elliott (1956) found that the less the degree of contextual constraint in a passage (and therefore the more difficult the reading task), the less was the impairment when reading with DAF. The task of reading out the list of cardinal numbers is disrupted significantly more by DAF than the task of reading out a prose passage with a high information content. Fillenbaum (1963) used two rather different reading tasks with DAF to test this finding. His control and experimental groups both performed an "easy" task (reading out a list of colour names, printed in black on a white ground), and a "difficult" task which consisted of saying out loud the colours of the print of a list of colour words which were colour-printed in such a way that no colour-word was printed in the colour which it named. Subjects were asked to name only the colours of the print, and to disregard the meanings of the words (the Stroop Test, Stroop 1935) Interference in the form of another person's voice was administered to the control group through headphones as they performed each task. The experimental group performed both tasks with DAF. Both groups also performed both tasks without interference of any kind, to provide base samples of each subject's speech. There was no difference between speech performances or between tasks. The DAF group performed significantly worse than the controls on the easy task, and there was no difference between the DAF group and the controls on the difficult task, thus supporting Elliott's finding.

Another experiment with an apparently similar result, i.e. a difficult task (speaking in a foreign language) showing more disruption than an easy task (speaking in a native language), is reported by Rouse and Tucker (1966). Their experiment was suggested by an accidental finding. During a preliminary test of some DAF equipment, a foreign student failed to recognise the delayed voice as his own, and showed no speech disturbance whatsoever. To try and replicate this effect, Rouse and Tucker administered DAF to two experimental groups and one control group. The control group were American students reading English prose. The experimental groups were foreign students reading English prose, and American students reading French prose. These two groups of "foreign speakers" were alike in showing significantly less disruption than the "native speakers". Interviews conducted after the experiment indicated that foreign-speakers had consciously directed their attention to phonation, as opposed to comprehension of the passages, while the native speakers had done the reverse.

Thus the group which showed least disruption had not attended to the delayed feedback. This result supports Rouse and Tucker's hypothesis that the delayed voice must be scanned (or at least treated as one's own voice) before it can be disruptive. In this context it is interesting to consider a remark of Goldiamond (1965)

"The mechanism for 'tuning out' one's own verbal behaviour, or the dissociation of speech, seems worthy of further exploration. We have observed that compulsive talkers, that is, people who continually speak without seeming to listen to themselves, are unaffected by delayed feedback".

MacKay (1970) has replicated Rouse and Tucker's experiment, with the addition of an extra control group of foreigners reading in their own language. His results were in the opposite direction. Foreign-speakers in his experiment stuttered more than native speakers. This difference may, however, be due to the fact that quite different measures of speech disruption were used in the two studies. Rouse and Tucker counted as "errors" words omitted, substituted words, mispronounced words, repetitions of words, and prolonged words (characterised by internal syllable repetition). MacKay, on the other hand, counted only "the repetition of one or more speech sounds in sequence". Furthermore, a finding of MacKay's which is anomalous in view of his other results, and which he considers "curious", can be explained if Rouse and Tucker's results are accepted. This finding was that a "distraction ratio" (the rate of speech in an Irrelevant Voice Condition over rate in a normal condition) was consistently higher for native than for foreign speakers. If native speakers are more distracted by DAF than foreign speakers, it seems very likely that they would also be distracted by an irrelevant voice also.

Finally, the corollary of this hypothesis that DAF stuttering is a function of attention to the delayed auditory feedback is provided in a study by Chase et al. (1967). They found that "a DAF effect is not observed in the case of spontaneous swearing, whereas a marked DAF effect is demonstrated by the same subject in the case of propositional speech". Similarly, the DAF effect is not observed in epileptic patients vocalising during seizures, and in these subjects the effect "will only become demonstrable in association with the return of consciousness". This finding that DAF does not disrupt ictal speech automatisms, i.e. unmonitored speech, ties up with Whitaker's (1970) observation, discussed earlier (page 15) that brain-damaged patients of certain kinds cannot perform such automatisms if they attempt to do so consciously and with Kingdon-Ward's observation that pathological stutterers speak fluently when semi-conscious (page 14).

This chapter so far has presented a considerable body of evidence in favour of attributing the DAF effect, in part at least, to involuntary attention to the delayed feedback. If there is an attentional factor involved, this would clarify the nature of an apparently paradoxical finding, reported by several investigators, that DAF suppresses pathological stuttering. Soderberg (1969) reviews all the work done on DAF and stuttering up to 1969, and points out that studies which have shown no differences in the effect of DAF on the speech of stutterers and on the speech of normals have used small groups of subjects. A Study by Lotzmann (1961) on the other hand, according to Soderberg "one of the most extensive in DAF and stuttering research... because of the number of delay times and subjects used" investigated the effects of six different delay intervals on the speech of sixty-two stutterers, and found that the use of DAF either completely eliminated, or greatly reduced, stuttering. Similar results are reported by Nessel (1958) and Soderberg (1959, 1968). Webster, Schumacher and Lubker (1970), in an intensive study comparing the effects of different intervals of DAF the speech of six stutterers, found that all intervals used significantly and rapidly improved fluency for all subjects, the shorter intervals being most effective. In this study the factor of slowed speech rate was ruled out as a possible cause of the enhanced fluency.

Also consonant with the "involuntary attention" theory of DAF is a finding of Soderberg's (1959) that less severe stutterers performed significantly worse under DAF, while "Like Nessel('s finding)... the fluency and rate of some of the severest stutterers were practically normalised by DAF". The more severe stutterers would be more aided by having their attention distracted from their own immediate auditory feedback than would the less severe stutterers, whose attention to their own voice would be less frequent than that of the severe stutterers, and who would perhaps react more like normal speakers in substituting the DAF for their own immediate feedback, rather than treating the DAF merely as a distracting stimulus, as we would suggest the severe stutterers did.

<u>The disruptive effect of DAF on automatic aspects of speech</u>

Attention to feedback during a skilled activity seems likely to result in impaired performance, as was indicated in Chapter Two. If the auditory feedback effect is caused by involuntary attention to the delayed feedback, we would expect certain specific components of skilled performance in speech to be impaired, namely those which are usually automatic. It was also mentioned in Chapter Two that the conventional aspects of phonetic sequencing in speech, such as allophonic variation and sandhi, occur quite automatically and outside of consciousness. A study of DAF speech by Fairbanks and Guttman (1958) suggests that, under DAF, these conventional aspects of speech are in fact disrupted. They set out to "make an orderly, primarily phonetic description" of DAF speech, but encountered a "speech display that.... is often so chaotic that conventional measurements do not describe it". Errors were "so extremely varied and unusual that attempts to sort them phonetically were unproductive and it is considered that this unconventionality.... is itself a distinctive attribute." These "improbable phonetic elements", as the authors also describe them, are to be distinguished from ordinary tongue-slips, which, according to Boomer and Laver (1968) "obey phonologically orthodox sequence rules; that is, segmental slips do not result in sequences not permitted by normal phonology". The same point has been made by Wells (1951) " a slip of the tongue is always a phonetically possible noise.... it is extremely important to realise that phonetic possibility varies from language to language", and by Fromkin (1968) - "the substituted utterance obeys the morpheme structure and phonological rules of the language".

Experiment 1: A test of the attentional theory

The corollary of the theory that stuttering under DAF is a function of attention to the delayed feedback, and that stuttering in general is a function of attention to auditory feedback, must hold that stuttering would be less likely to occur when auditory feedback is less audible to the speaker. That this is the case in the extreme condition of complete masking of the voice is well-established, as has been pointed out in Chapter Two. The attentional hypothesis would also hold that stuttering would be less likely to occur when attention is fully occupied by a difficult task, and conversely that stuttering would be more likely to occur when performance of an easy task ensures that spare processing capacity is available, and could be used to scan auditory feedback. Evidence relating to the effect of task difficulty on stuttering has been presented in this chapter. The experiment to be described below set out to test the attentional hypothesis and its converse.

Two verbal tasks were used; shadowing and translating. It was assumed that shadowing would be an easier task than translating, and would therefore increase the probability of stuttering. In addition to level of task difficulty, levels of auditory feedback were also varied; subjects were submitted to a reduced feedback condition, a full feedback condition, and a delayed feedback condition. It was predicted that stutters would increase across these three conditions, as feedback became more intrusive in the verbal task.

SUBJECTS

The six subjects were student interpreters nearing the end of an intensive six-month training course in simultaneous interpreting. Four were female, and two male, their ages ranging from twenty-two to thirty. All had English as their mother tongue.

MATERIALS

Four French passages of approximately 500 words in length were recorded on tape by a native male French speaker at a rate of 120 words per minute. The tape speed used was $7\frac{1}{2}$ inches per second.

The passages were selected from issues of the Unesco Courier, and were abridgements of addresses by Unesco delegates on the subjects of literacy and education, human rights, and the contribution of brain research to the promotion of peace. They were fairly representative in levels of content and complexity of the kind of material which simultaneous interpreters are called upon to translate at non-technical international conferences.

APPARATUS

The stimulus tapes were played from a Uher Report Stereo tape recorder and simultaneously recorded on the top track of subjects' response tapes to facilitate later analysis. Subjects thus heard the stimulus tapes from a Revox Stereo G36 tape recorder, via a Uher sound mixing unit, a Shure Stereo Solophone amplifier, and Koss pro-4A headphones. Their oral responses were recorded by a boom microphone attached to their headsets onto the Revox. This tape recorder had separate record and playback heads, and so it was possible to obtain delayed auditory feedback from it by operating the record and playback heads simultaneously. The delay interval was a function of tape speed ($3\frac{3}{4}$ inches per second) and distance between the record and playback heads ($1\frac{1}{4}$ inches), and eventuated in a delay of 0.33 seconds. Full auditory feedback was obtained by using a device on the tape recorder enabling the speaker to listen through the headphones to the tape as it records; this output came direct from the record head. The ordinary headphone condition, whereby the speaker hears his own voice somewhat attenuated from outside the headphones, was designated as a reduced feedback condition. All inputs to the headphones were binaurally presented.

PROCEDURE

According to a 3x3 Graeco-Latin square design used four times (Table 3.1) subjects were divided into two groups of three subjects each. One male subject was assigned to each group. Groups differed only in respect of order of task, i.e. whether they first shadowed and then translated, or whether they first translated and then shadowed. Each subject thus experienced both tasks and all conditions. Subjects shadowed three passages with each feedback condition, and also translated three different passages with the same conditions in the same order.

Before starting the experiment proper, each subject was asked to shadow an extra passage, both as a warm-up task which it was hoped would overcome practice effects, which had been quite marked in previous experiments comparing shadowing and translating (Gerver 1971), and also in order to permit the subject to choose a preferred volume level for the input message, which was then kept fixed throughout for that subject. After completing the warm-up task, subjects were told that they would be shadowing three passages, and then translating three passages after a short rest (or _vice-versa_, according to groups). They were also told that, during one passage while translating, and during one passage while shadowing, they would hear their own voice played back through the headphones with a slight delay, and that if they found this disturbing they could slow down if they so wished. However, they were asked not to stop

Group 1 (Order 1)

Subject	Translating			Shadowing		
1	Fp3	Dp1	Rp2	Fp6	Dp4	Rp5
2	Rp1	Fp2	Dp3	Rp4	Fp5	Dp6
3	Dp2	Rp3	Fp1	Dp5	Rp6	Fp4

Group 2 (Order 2)

Subject	Shadowing			Translating		
1	Fp3	Dp1	Rp2	Fp6	Dp4	Rp5
2	Rp1	Fp2	Dp3	Rp4	Fp5	Dp6
3	Dp2	Rp3	Fp1	Dp5	Rp6	Fp4

Table 3.1 Experiment 1: Design

R = Reduced feedback

F = Full feedback

D = Delayed feedback

P = Passage

speaking altogether if they could avoid doing so.

TREATMENT OF RESULTS

Subjects' response tapes were transcribed and scored for stutters. A stutter was defined as a sound repeat (t-take), a sound prolongation (mmake), or one or more repeated syllables within a word (commi-committee). This was a narrower definition of a stutter than is used by many investigators, though not so narrow as that of Kasl and Mahl (1965), or of MacKay (1970), who count only sound repeats. Jones and Azrin, for instance, count sound repeats, sound prolongations, part word repeats, word interruptions, and word repeats; while Toomey and Sidman (1970) count as a stutter "any audible departure from or addition to the text".*

The stutters scored for each passage within each subject were divided by the total number of syllables uttered in that passage by the subject. Since the proportions obtained in this way were so small, they were multiplied by 1,000 for ease of reading and of calculation, and they thus represent the n umber of stutters per 1,000 syllables. The syllable was chosen as the basic unit in preference to the word, since, unlike the word, it is relatively invariant in length and therefore gives a more stable basis for comparison. Since the variances of the scores in the delayed feedback condition were vastly greater than the variances in the other conditions, a square root transformation was applied to the scores to stabilise the variance across conditions before doing an analysis of variance. This transformation resulted in an overall variance which was not significantly heterogeneous, according to Cochran's test for homogeneity of variance:- $C\ (2,12) = .35$. A square root transformation is also considered especially appropriate for data expressed as proportions (Alder and Roessler, 1968).

* For interest, a table of measures used by different investigators is given in Appendix A.

RESULTS

The analysis of variance showed the effects displayed in Table 3.2:-

Source	Sums of squares	Degrees of freedom	Mean square	F ratio	p
Task	7.40	1	7.40	8.41	<.01
Feedback	57.98	2	28.99	32.94	<.01
Task x Feedback	4.99	2	2.49	2.84	
Order x Task	1.19	1	1.19	1.35	
Order x Feedback	20.99	2	10.49	11.92	<.01
Order x Task x Feedback	3.05	2	1.53	1.74	
Pooled error	17.60	20	0.88		
Order	15.79	1	15.79	14.48	<.05
Error	3.52	4	0.88		

Table 3.2 Analysis of variance of stutters per 1,000 syllables.

Scheffe tests carried out after the analysis of variance revealed that the significant effect of feedback related to the greater effect of delayed feedback only. The comparison between reduced and delayed feedback was significant beyond the 1% level ($F = 50.14$, $F'1\% = 8.84$) and the comparison between full and delayed feedback was also significant beyond the 1% level ($F = 48.67$). The comparison between reduced and full feedback was not significant. The prediction that the full feedback condition would elicit more stutters than the reduced feedback condition was thus not borne out. Indeed, in the translating task there are slightly fewer stutters in this condition, as Table 3.3 shows, although this is not a significant reduction.

	SHADOWING			TRANSLATING		
	RF	FF	DF	RF	FF	DF
Group 1	4.1	6.5	27.3	7.5	6.5	71.3
Group 2	4.2	3.8	8.3	6.7	6.0	15.2
$\bar{x}$	4.2	5.2	18.1	7.1	6.3	43.3

Table 3.3 Mean stutters per 1,000 syllables. RF = reduced feedback, FF = full feedback, DF = delayed feedback. Group 1 translated first, Group 2 shadowed first.

Inspection of the analysis of variance table (3.2) and of Table 3.4 shows that translating elicited significantly more stutters than shadowing, a result which is in the opposite direction from the prediction that the easier task (shadowing) would elicit more stutters. However, hindsight suggests that the choice of shadowing and translating as easy and difficult tasks respectively was not a wise one, since

	SHADOWING	TRANSLATING	$\overline{X}$
Group 1	12.7	28.4	20.5
Group 2	5.6	9.3	7.4
$\overline{X}$	9.1	18.9	

Table 3.4 Mean stutters per 1,000 syllables. Group 1 translated first, group 2 shadowed first.

cognitive difficulty is here confounded with response difficulty. While translating was more difficult from the cognitive point of view, since more transformations are required between input and output, it was easier than shadowing from the response point of view, since subjects were here speaking their native language. Conversely, while shadowing was cognitively the easier task, it was more difficult in terms of responses, since subjects were having to speak in a foreign language.

The order x feedback interaction was also further investigated using Scheffe tests, and it was found that, as Tables 3.3 and 3.5 indicate, Group 2, who shadowed first, produced significantly fewer stutters than Group 1 had done when they in turn came to translate with DAF. This difference is significant beyond the 5% level ($F = 33.32$, $F'5\% = 31.30$). Thus adjustment to delayed auditory feedback in this experiment took the direction foreign-language task to native-language task, and there was no adaptation in the opposite direction, since Group 1 were not facilitated in their shadowing by having first translated.*

* In this respect, the warm-up task did not overcome order effects, although it was partly successful in that there was no order effect on semantic errors (see page 45). An experiment by Gerver (1970) showed clear order effects on semantic erros, both from shadowing to translating, and vice versa.

	RF	FF	DF	$\overline{X}$
Group 1	5.8	6.5	49.3	20.5
Group 2	5.4	4.9	11.7	7.4
$\overline{X}$	5.6	5.7	30.5	

Table 3.5 Mean stutters per 1,000 syllables. RF = reduced feedback, FF = full feedback, DF = delayed feedback. Group 1 translated first, Group 2 shadowed first.

In order to examine further the hypothesis that, when a stutter occurs, auditory feedback is being attended to, an analysis was carried out in order to determine whether the stimulus tape input was missed, or mis-perceived, at those points where stutters occurred. This was done by listening to both tracks of subjects' tapes simultaneously. The top track of these tapes carried the French stimulus passages, and the bottom track carried subjects' responses. All instances of errors or omissions in processing the French input which was simultaneous with a stutter were counted, and these scores compared with the same measures at words immediately before a stutter, and words immediately following a stutter. (It may seem restrictive to consider only the immediate environment of a stutter, but this had to be done because a good number of stutters were separated by less than three words in the delayed feedback condition.) The scores thus obtained from both tasks and all conditions were combined for the purpose of this analysis. The results are shown in Table 3.6.

	Subject	-1	Stutter	+1
Group 1	1	18	21	16
	2	17	27	20
	3	32	35	31
Group 2	1	2	5	2
	2	10	14	11
	3	5	7	2
	Totals	84	109	82

Table3.6 Total instances of missed or mis-perceived input simultaneous with stutters, with words immediately preceding stutters (-1), and with words immediately following stutters (+1).

The obvious group difference in table 3.6 is due to the fact that group 2 produced fewer stutters overall than group 1. The difference between stutter and words immediately preceding and following it is significant beyond the 2% level, according to Friedman's test (2df, $\chi^2 = 9.04$). However, it is not clear from this analysis alone whether a failure to attend to input means that the probability of attention to auditory feedback is increased, or whether it simply means that the stutter, caused by some independent factor, results in the failure to attend to input, or a failure to retain the input in store. A further analysis was therefore carried out, comparing the incidence of input silences*at the same points as in the above analysis. It was argued that, if the hypothesis that a stutter is caused by attention to auditory feedback is correct, then at points where there is no input to attend to (i.e. where there are silences in the input), there should be increased probability of a stutter. The results of this analysis are given in Table 3.7 on page 43.

These results are in the predicted direction, that is, there are more input silences concurrent with stutters and with words immediately before stutters than there are with words immediately following stutters. (One would indeed expect a high number of input silences at -1, as well as at

*i.e. silent pauses in the input passages stutter, since a silence need not immediately have the effect of directing attention elsewhere. However, the difference between (-1 + stutter) and +1, when submitted to Friedman's test was found to be not significant. Since subject 3 of group 1 and subject 3 of group 2 have scores tending in the opposite direction from those of the other subjects, a Chi square analysis was carried out in order to determine whether these two subjects differed significantly from the rest. The result, again, was not significant.

	Subject	-1	Stutter	+1
	1	9	13	11
Group 1	2	12	16	7
	3	4	6	10
	1	11	10	6
Group 2	2	18	10	7
	3	6	6	8
	Totals	60	61	49

Table 3.7 Total instances of input silences simultaneous with stutters, with words immediately preceding stutters (-1), and with words immediately following stutters (+1).

DISCUSSION

Some limited support was obtained for the hypothesis that when a subject stutters he may be attending to auditory feedback, in as much as it has been shown that stutters and failure to attend adequately to simultaneous input are related. But the finding that input silences are not significantly related to stutters makes it impossible to eliminate two alternative explanations. One is that the stutter itself causes the failure to attend to input at that moment; the other is that both stutter and failure to attend to input share a common antecedent cause.

The experiment confirms Rouse and Tucker's (1966) finding that a native-language task is more disrupted by disfluencies under DAF than is a foreign-language task. It must also be concluded that the added factor of cognitive difficulty in this experiment either increased stutters, or was outweighed by response difficulty. If the first interpretation is accepted, then these results are at variance with Fillenbaum's (1963) and Elliott's (1956) findings than an easy task elicits more stutters than a difficult task. Bearing in mind all the evidence in favour of this view which has previously been discussed, it seems more reasonable to accept the second explanation - that response difficulty was more important than cognitive difficulty in reducing the number of stutters in the shadowing condition. A finding of Gerver's (1971) may throw some light on these relative difficulties. He relayed the same set of French passages to three groups of native English-speaking subjects, who either listened to the passages, simultaneously interpreted them into English, or shadowed them. Comprehension tests given after the tasks showed that listeners had understood (or retained) most, next came interpreters, and finally shadowers. Gerver interpreted these results in terms of the amount of information-processing capacity used in each task. Higher-level transformation of the input by listeners and interpreters ensured comprehension and recall, but the apparently lower level of transformation required in shadowing meant that less capacity was used for the task. However, it is of interest to ask why these shadowers chose not to transform the material at a higher level, since in a similar though native-language task Carey (1971) found no difference in comprehension and recall between listeners and shadowers. It may be that, in Gerver's experiment, the response difficulty of shadowing in a non-native language precluded further transformation of the material. A fact compatible with this view is that professional interpreters very rarely interpret into a non-native language, and dislike doing so.

Rouse and Tucker state that their foreign-speaking subjects claimed to have resisted the effects of DAF by concentrating on articulating the foreign sounds. While, in doing this, they were behaving as we have suggested (page 13) the stutterer does in speaking "voluntarily" instead of automatically, they were at the same time deliberately excluding the feedback from each utterance from their attention. Their behaviour thus differed in an important respect from that of the stutterer, who, we have supposed, is primed to receive feedback from each utterance.

The failure of the full feedback condition to elicit more stutters than the reduced feedback condition may mean that increased feedback has no effect on stuttering behaviour at all, and that the implication of auditory feedback in stuttering is a mistaken one. It may mean, on the other hand, that the difference between the levels of feedback was not sufficiently great to have any effect. If the full feedback was in fact interfering with attention to the verbal task, we would expect to find more semantic errors in this condition. A supplementary analysis of semantic errors was therefore carried out to determine whether or not this was the case. "Errors" were defined as omissions, substitutions, and additions of words in relation to the French texts*. Total errors were converted to proportions by dividing them by the number of words in the French text, and these proportions were transformed to arc-sin scores for the analysis of variance. The mean proportions of errors in each feedback condition are given in Table 3.8.

	Reduced	Full	Delayed
SEMANTIC ERRORS	0.17	0.23	0.56

Table 3.8 Mean proportions of semantic errors in reduced, full, and delayed feedback conditions.

* See Appendix B for error-counting criteria

The analysis of variance indicated a significant effect of feedback ($p < .01$, $F = 9.42$, 1, 20 df), which Scheffe tests revealed as referring exclusively to the delayed feedback condition. The comparison between reduced and delayed conditions was significant beyond the 5% level ($F = 16.91$, $F'5\% = 8.56$), and the comparison between full and delayed conditions was also significant beyond the 5% level ($F = 10.60$). The comparison between the reduced and delayed condition was not significant.

There was thus no effect of full feedback on semantic errors, from which it can be concluded that full feedback did not distract attention from the verbal tasks of either translating or shadowing. It therefore seems reasonable to suppose that the failure of full feedback to elicit stutters lay in its failure to impinge on the subjects' attention. This again may be due to the difficult aspects of both translating and shadowing. Subjects' attention was so locked onto transforming input in translating, and articulating responses in shadowing, that the full feedback failed to distract them. The delayed feedback was, however, sufficiently demanding of attention to distract them, as the high proportion of semantic errors made in this condition demonstrates.

This finding that full feedback has no adverse effects on performance is in itself worthy of interest for two reasons. The first is that Treisman (1964) found that if an English message and its French translation are both presented binaurally to a subject with knowledge of both languages, there is a great deal of interference between the messages when the subject attempts to shadow one of them. Frequently the messages cannot be separated at all. This situation, at least in terms of inputs to the subjects, is very similar to that of the subjects who shadowed with full feedback in this experiment. Yet these subjects were able to separate the two inputs with no difficulty at all. Admittedly one of the inputs for these subjects was their own voice, which might be expected to have a special status in an information-processing sense, but their resistance to distraction is still at variance with a second point which has been made by Moray (1969). He has claimed that one's own voice is a distractor in verbal tasks, on the grounds that subjects often speak sotto voce in these tasks. Similar indications have been given by Goldman-Eisler (1968), Broadbent (1952), and Poulton (1955), as was mentioned earlier (pages 16-17).

Moray writes:-

> "This phenomenon of talking quietly or whispering or responding sotto voce recurs throughout the literature on selective listening. It is not obvious why talking less loudly should reduce the load on the central processor... it might be thought that the selection and organisation of output rather than the actual wiggling of the tongue and activation of the laryngeal muscles would be the major source of the load. It may be that it is not the output of the response that is causing the trouble, however, but its monitoring by the speaker .... The result of this is to add one extra task to the load on selective sharing of attention which confronts the subject."

Contrary to Moray's analysis, we are able to claim on the basis of this experiment that, even where there is a heavy demand on the central processor, and in addition when one's own voice is amplified, feedback from one's own voice need not be a distractor.

We have earlier used this very sotto voce phenomenon in interpreters to support the view that they prefer to work in conditions where their own voice is not audible to them. (See pages 16-17). However, it was also proposed there that under normal circumstances, one does not consciously monitor one's own voice. Evidence will be presented in the next chapter for the proposal that it is only in certain conditions - namely where high arousal or anxiety and divided attention are components of the situation - that one's own voice demands attention as a "full input", and becomes disruptive.

Chapter Four

Arousal, anxiety, and divided attention as determinants of stuttering

The effects of stress on speech

Chapter Three presented and discussed a body of evidence concerning enforced attention to DAF as a possible factor in DAF stuttering; Chapter Two discussed attention to auditory feedback as a factor in pathological stuttering. Nevertheless it is clear from self-observation that merely attending to one's auditory feedback is not a sufficient condition to produce stuttering. Some other factor or factors must also be involved.

The experiment on simultaneous interpreters described in Chapter One included stress, or at least arousal, and noise as dependent and independent variables respectively. It is well established that task complexity and exposure to noise independently heighten arousal (Berlyne et al., 1965). It is also accepted generally that noise effects are in fact the effects of increased arousal (Hockey, 1970). So that arousal may have been a factor contributing to the higher proportion of stutters observed in the signal + noise condition of that experiment.

It is a common observation that anxiety, or any kind of stress, can have a disruptive effect on speech. Thus Mahl (1956) states that:

> "Speech disturbances and short hesitancies may..... be conceived as predominantly indirect linguistic consequences of anxiety.... speech is..... an excellent instance of..... complex behaviour susceptible to the disruptive effect of concurrent anxiety."

Appley and Trumbull (1967) give "stutter" as an index of psychological stress in normals, along with such indices as tremors, loss of sphincter control, and performance shifts such as perseverative behaviours, increased reaction time, erratic responses, and so on. Kanfer (1958) provides experimental evidence for this effect of anxiety, or at least a noxious stimulus, on normal speech. He exposed an experimental group of subjects to a tone followed by electric shock during spontaneous speech, and later observed the effect on their speech of exposure to the tone alone, when it had become the conditioned stimulus. He found that both speech rate and heart rate increased, and he also found a significantly greater tendency for the experimental group to repeat words - one of the common measures of stuttering behaviour. That this effect was due to fear or anxiety in relation to the noxious stimulus, rather than a response to the tone alone, is shown by the fact that a control group, who received no shocks, but simply heard the tone, showed no such effects. Savage (1959), in a similar experiment using oral reading as the speech task, found that experimental subjects exposed to tone-shock pairings were more disfluent than a control group immediately before, during, and after later presentation of the tone alone.

DAF is frequently referred to as a stressor. Yates (1963b) points out that DAF has successfully been used in experiments purely as a form of stress, and he states that "the experience is uniformly acknowledged to be a stressful one" (1965). Funkenstein et al., (1957) used the "distracting properties" of DAF as a stressor, and Zangwill (1960) reports that "in some cases, definite signs of anxiety and distress, e.g. palmar sweating, are in evidence". Doehring and Harbold (1957) present indications that subjects whose speech is not disrupted by DAF undergo increased heart rate, while subjects whose speech is disrupted do not show this increase, suggesting that DAF may act either directly on the speech mechanism, or be deflected as a generalised stress affecting psychophysiological responses. While it is possible that the stress of DAF may be the result, rather than the cause, of the speech disturbances which it produces (although the Doehring and Harbold evidence suggests the reverse), there is no reason to rule out a reciprocal relationship between the stress and the disfluencies.

Thus in all the conditions so far considered in which normal speakers have exhibited stuttering behaviour, stress or anxiety or arousal have been present. Anxiety is also frequently, if not invariably, associated with pathological stuttering:-

> "(it is) an anxiety-motivated response that becomes 'conditioned' to the cues or stimuli associated with its occurrence." (Johnson, 1955).

> "... stammering begins as a stress reaction, it continues as a phobic reaction." (Bluemel, 1960).

> "The severity of stuttering at any moment seems to be a function of the anxiety related to particular words, and the anxiety related to the speech situation in which the subject finds himself." (Andrews and Harris, 1964).

Edgren, Leanderson and Levi (1970), comparing controls (former hearseness patients) and stutterers in a public speaking situation, recorded from the stutterers some of the highest levels of urinary adrenaline ever obtained in the Stockholm Laboratory for Clinical Stress Research. The fact that the former hoarseness patients might also have good reason to fear a public speaking situation makes the stress levels recorded from the stutterers even more impressive.

Conversely, Bloodstein (1950) points out that stuttering is significantly reduced in social situations in which the stutterer is under less stress than usual. For instance, when speaking to himself, or to a child; when there is a sympathetic audience; when the need to impress favourably is reduced.

Is anxiety part of the cause of stuttering, or is it merely the result? Edgren et al. in the study mentioned above found that the tranquilliser Diazepam reduced stutterers' self-rated "tendency to stutter". Since the drug acted to reduce anxiety rather than to reduce stuttering (and there is independent evidence for the reduction in anxiety in the decrease which occurred in adrenaline secretion), these results suggest that it is anxiety which causes stuttering, and not vice versa. Nevertheless, it seems very likely that stuttering and anxiety would come to be connected by a vicious circle - anxiety causes stuttering, which in turn increases anxiety. Such an interpretation would help to explain why stuttering very frequently remits with maturity. Maturity might be expected to remove one of the factors perpetuating the vicious circle, namely the anxiety accompanying social contact.

Stuttering has thus been associated with noise, or high arousal resulting from exposure to noise, and with anxiety, in normal speakers. In stutterers it has been associated with anxiety.

General effects of arousal, noise, and anxiety on behaviour.

Perhaps the most interesting possible effect on behaviour of high arousal we could mention here is the role of arousal in Parkinsonism. Dinnerstein, Frigyesi and Lowenthal (1962) write that:

> "The behavioural disabilities in Parkinsonism have analogies in the speech disabilities found in stuttering. The tremor in Parkinsonism is superficially similar to the syllable repetition of stuttering speech. Slowness and delay in movement in Parkinsonism is somewhat analogous to the slowness and tense pauses of speech in stuttering. While the normal mechanisms involved in stuttering are uncertain, stuttering can be induced experimentally by delayed auditory feedback."

They add that this analogy was the starting-point of their interest in the possibility of a delay in proprioceptive feedback in Parkinsonism (again, the servo analogy). More pertinent to the present thesis, however, is the fact that Parkinsonism has been associated with abnormally high arousal (although this is seen by Dinnerstein et al. merely as a concomitant effect of a disorder of the reticular formation, which is involved both in the regulation of sensory conduction, and in arousal effects):-

> "The role of the reticular system in arousal is well established. Drugs and electrical stimulation that produce alerting may also produce tremor and rigidity. Conversely, those drugs that block arousal, and some lesions of the system, are often effective against extrapyramidal disorders. Moreover, extrapyramidal symptoms disappear in sleep and reappear on awakening... The postulated central synaptic transmitter, acetylcholine, produces alerting and worsens Parkinsonism. Anticholinergics can prevent arousal and are used in the treatment of Parkinsonism."

There are further similarities between Parkinsonism and stuttering, in that Parkinsonism patients also exhibit "behavioural paradoxes" - patients who can no longer walk are able to march or dance to music; and patients too slow and rigid to feed themselves can often catch a ball. Dinnerstein et al. suggest that "the oddly intact behaviours..... have a common characteristic. An external stimulus provided an alternative to proprioception". These behavioural paradoxes, and their suggested explanation, are strongly reminiscent of the conditions under which pathological stuttering is suppressed, and of the "distraction hypothesis". Nevertheless, the similarities are not quite complete, since Parkinsonian tremor can also decrease during voluntary movement, and is subject to voluntary inhibition, which makes it different in an important respect from stuttering, which tends to increase during propositional (voluntary) speech, and cannot be suppressed at will. However, it may be that only the most severèly affected Parkinsonism patients are subject to the bahavioural paradoxes (Dinnerstein et al. do not make this clear), in which case perhaps the close similarities between these two disorders could be taken more seriously - since it has been pointed out elsewhere in this thesis (page 32) that the severest stutterers are most assisted by DAF as a suppressor of stuttering.

What are the general effects of noise and anxiety on behaviour? Broadbent (1957) has stated that, once the initial effects of a noise have worn off (i.e. startle), sensory and motor functions are definitely known to be unaffected. In a later paper, however, (Broadbent, 1963) he mentions the fact that individuals with relatively high muscle tension show less effect of loss of sleep, in order to support the view that sleep loss is de-arousing. This argument can be extended to point out that, if muscle tension is a measure of arousal, and if noise increases arousal, as it is generally believed to do (Hockey 1970), then noise stress should increase muscle tension. Anxiety, on the other hand, is known to have specific effects on motor functions. Among these are an increase in the amount and variability of motor activity (Duffy, 1962), in tremor and body sway (Lewinsohn, 1956), and in muscle tension (Sainsbury and Gibson, 1964; Levitt, 1968) Williams and Stevens (1969) report a study of anxiety effects on motor aspects of speech itself. They obtained recordings of speech from pilots in situations of imminent crash, and these recordings when submitted to spectrographic analysis showed increases and large fluctuations of fundamental frequency. They attribute these to "a loss of precise control of musculature and an irregular respiratory pattern..... and possibly.... tremor".

In the main, however, research has concentrated on the effects of noise and anxiety on central processes, which will be discussed below.

While the effects on motor functions are by no means to be ignored in the etiology of stuttering, particularly if we consider the extreme accuracy of movement required in the articulation of speech, and that muscle tension may have an obvious role in the articulatory tension observed in some pathological stutterers, we propose to leave aside these effects other than to point out that explanations of stuttering above the neuronal level are not incompatible with these possible motor effects.

Turning now to the effects of noise and anxiety on central processes, a great deal of research has been devoted to the effects of noise in particular on behaviour. Put briefly, the overall findings are that, during long and complex tasks with moderate noise intensities, neither response organisation nor total output of work are adversely affected, but careful analysis of errors has shown momentary lapses of perceptual efficiency to occur (Broadbent and Little, 1960). Broadbent (1957) likens these to "internal blinks", since their effect is to completely shut off task information:-

> ".... the evidence is not quite conclusive as to the nature of the 'internal blink'; it might be due to a complete, though temporary, block in the analysis of all sensory information, or it might be due to analysis of information from some sense not used to the task. In ordinary terms, a mental blank or a shift of attention are the alternatives. There are reasons for believing the latter."

Similarly, Hockey (1968) has stated that in serial reaction tasks performed in noise, performance shows an increase in errors, but no difference in output:-

> "This latter evidence is strong support for concluding that noise affects perceptual processes rather than producing interruptions in response, which would suggest a reduction of output".

However, the fact that output is not reduced could be attributed to another effect of noise, which acts via its established effect on arousal, and which has been pointed out by Mackworth (1970):

> "As a result of increased arousal, either directly produced by the stimulus or for other reasons, the organism may have more attention available to distribute as he chooses."

Thus increased arousal may create extra information-processing capacity, which, if not fully under the subject's control, might explain the lapses of attention from the task in hand.

Finally, Helper (1957) gives physiological evidence that loud noise activates mechanisms of response to stress when the subject is performing a difficult task (in Helper's experiment, a complex continuous memory task).

<u>The narrowing of attention</u>

Noise, arousal, and anxiety have all been shown to have another, unitary, effect on behaviour - what is referred to as "narrowing" of attention, or "reduction of the range of cue utilisation" (Easterbrook, 1959; Zaffy and Bruning, 1966). Hockey (1968) states that the noise effect:

> "is in the same general class as similar demonstrations of increased narrowing with high anxiety levels, high incentive, threat of shock, and many other treatments which are generally regarded as increasing the level of stress in the performance situation".

and Callaway and Stone (1960) mention that arousal is correlated with narrowed "focus of attention".

The narrowing of attention in a task is shown when certain cues or signals are ignored, thus adversely affecting performance, and when other possible causes of failure to perceive the signals, such as simultaneous effects of other factors on vision or hearing, have been satisfactorily ruled out. Thus divers on the sea bed, where they are presumably under greatest stress, show increased latency to light signals on the periphery of their field of vision than when at the surface (Weltman, Egstrom, and Christianson, 1966).

Similarly, the effective range of peripheral vision is reduced in the laboratory by the addition of a centrally-located counting task with visual signals, or a counting task with auditory signals (Webster and Haslerud, 1964).

Callaway and Band (1958) have pointed out that stresses causing narrowing of attention may appear to affect the focus of attention in different ways, since this will improve performance on tasks which only require a single focus of attention, while performance will be impaired in tasks where it is necessary to sample from several sources of information. It is often the case that experiments in this field are so designed as to distinguish between spatially central and peripheral signals, with the effect, usually, that attention is narrowed to the former. Such studies give the impression that this effect on attention acts rather like an optimal strategy adopted to resist the stressful element in the situation, and that while many task stimuli are missed, the important ones somehow get selected and dealt with. This is perhaps an artefact of the kinds of tasks used, and of the particular interests of the investigators, since Hockey indicates that signals can be selected on the basis of merely high probability, for instance (Hockey, personal communication). Broadbent also mentions the possibility of selection of inappropriate foci of attention:-

"A high level of excitement may cause filtering to be more extreme and evidence to be considered almost entirely from one source....

Paradoxically, this may cause a man to appear more distractible at a task, since selection of an inappropriate source of information will completely exclude information from the task itself." (Broadbent, 1970).

And Wachtel (1968) found that attention to peripheral stimuli decreased, but attention to central stimuli was not increased, under threat of electric shock. It is tempting to suggest here that there may be some relationship between these changes in the deployment of attention, caused by any one of several agents of stress or arousal, and the lapses of attention observed in tasks performed in noise. In any event, what we do wish to suggest here is that the stutters observed in interpreters working through noise interference, in normal anxious speakers, in DAF speech, and pathological stutterers, may all represent just such lapses of attention from the verbal task in hand (i.e. linguistic decoding and encoding), and narrowed attention to an inappropriate source - namely auditory feedback. This is not to claim that all lapses of attention, even in verbal tasks, need be to this one source. The data from Experiment 1 show that not all instances of a failure to correctly transform input, or of input silence, correlate with a stutter, since there are many more semantic errors than stutters; and neither do all stutters correlate with a failure to transform simultaneous input correctly or with an input silence (although 82% of them do). The suggested lapses of attention in noise and other other stresses merely create the preconditions for stuttering, as it is viewd in this thesis, to occur.

Divided attention, arousal, and false positive responses

We may also consider here the factor of divided attention. Simultaneous interpreting involves division of attention between understanding current input, translating immediately preceding input, and monitoring output for errors*. Shaffer has shown, by measuring stimulus recognition times and response latencies in typing, and calculating

*Although Welford (1968) states on grounds of informal observation that interpreters do not monitor their output, Gerver (1970) has shown that they do correct themselves, and must, therefore, monitor output.

overlap, that such "transcription skills" can comprise literally simultaneous input and output operations. But even if this were not the case, material held in store would need to be rehearsed, if considered to be in a short-term memory store before a fixed capacity channel (Broadbent, 1958); or would take up space in a fixed capacity central processor (Moray, 1967). Whichever of the available models of attention is espoused, "attention" is divided in simultaneous interpreting. Evidence has also been presented that DAF enforces division of attention between auditory feedback and the verbal task, and we have in addition given evidence that pathological stuttering involves a component of attention to auditory feedback, which must entail an overall division of attention between linguistic encoding and auditory feedback during speech.

Walker, Shectman, and De Socio (1964) found apparently involuntary switches of attention during a divided-attention task. They required subjects to perform a visual tracking task, while at the same shadowing a list of digits presented over headphones. This shadowing task was designated as a "distracting stressor". Errors were observed in both tasks, and the authors concluded that "the greater part of the experimental scatter of the results comes from an unconscious and variable decision on the part of the operator to concentrate on one task rather than on the other."

Division of attention has consistently been shown, in vigilance tasks, to result in an increased likelihood of false positive responses based on either perception of a signal which was not in fact present, or the misinterpretation of a signal which was present. Mysak's (1960) use of the servo-system analogy to explain stuttering (discussed on page 22) entails regarding a stutter as a false positive response - the perception and consequent "correction" of an "error" which was not in fact present, giving rise to apparent repetition(s) of the same unit. Furthermore, narrowwing of attention is particularly likely to occur in situations where attention is divided (Hockey, 1968), since, as Lindsley (1960) points out, "the highest level of arousal may be associated with divided attention", and according to Kahneman (1970) "autonomic and skeletal manifestations of heightened tension abound" when a subject is resisting distraction. Arousal <u>per se</u>, or perhaps through the mediation of narrowed attention, has also been shown to increase the probability of false positive responses. Davis and Tune (1970) list several vigilance studies which have found that introverts, who are generally considered to be chronically overaroused, make significantly more false positive responses than extraverts.

There are thus two independent reasons for believing that narrowing of attention may occur in simultaneous interpreting and in DAF speech - the involvement of divided attention, and the involvement of high arousal; and where both are present in a task, divided attention will further increase arousal, which may further intensify narrowing. There are also two independent reasons for believing that false positive responses will be likely in situations where people stutter - that they are anxious, (highly aroused), and that their attention may be divided. Again, division of attention will act to further increase arousal and narrowing of attention.

<u>De-automatising effect of anxiety on skilled performance</u>

Apart from its general effect on attention, anxiety may have certain effects on skilled behaviour which could be seen as providing a direct mechanical explanation of stuttering. Welford (1968) believes that part of the learning of a skill consists of the:

> "building up of sequences of actions which tend to become 'higher units' of performance. The classical studies are those of Bryan and Harter ..... who found that as Morse code operators become more skilled they tend to pass from dealing with single letters as units to syllables,

words, and even phrases".

And in his chapter on the effects of loading and fatigue, Welford states that:

> "The building up of such units depends... upon the ability to carry out the individual actions accurately enough for one to follow another without the flow having to be interrupted in order to make corrections. Any change due to fatigue or any other factors that impairs accuracy will tend to break up these routines and make it necessary to deal once more with the task piecemeal."

Breakdown of a skilled task under stress will, then, mean a recourse to a strategy in which the smallest units of the task will be dealt with individually. In speech, the smallest (motor) units are phones (individual speech sounds). Next come syllables, words, phrases, and sentences. There is therefore ground for supposing that the breakdown of speech under stress may mean the separate production of phones, syllables and perhaps words. If we consider the frequent revision and editing of higher-level units such as phrase and sentence which takes place in normal, fluent, speech, the view that such editing would be transposed to a lower level under stress seems plausible. Quite clear predictions can be made concerning the effect which this lower-level processing would have on speech. Co-articulation phenomena are thought to reflect the hierarchical nature of speech production, since they reveal the interference of a later, or intended speech feature on current speech. Thus, for example, a vowel can be coloured by a succeeding consonant (Ohman, 1966). In a situation where the hierarchical generation of speech has broken down to the extent that phones are being produced individually, one would expect coarticulation phenomena to disappear. Some evidence for this has in fact been provided for the case of stuttering under DAF, although it was not the intention of the authors of the paper concerned to demonstrate this, nor do they evince the same kind of interest in the finding. Rawnsley and Harris (1954) using a sound spectrograph to compare the acoustic structure of utterances made under DAF and under normal conditions in the same subjects found that, if a fraction of a word is repeated, the first utterance of the fraction is like the structure of that fraction when spoken in isolation, whereas the repetition shows a change towards the structure of the fraction when incorporated in the word of which it is a part. If this notion of separate processing of lower-order units under stress is accepted, together with the increased probability of false positive responses with divided attention, then it would follow that a false positive response would be at the level of the smaller units - hence the repetition of phones and syllables, and less frequently words and phrases.

Experiment 2: Eliciting stutters by anxiety and divided attention

This chapter has in effect hypothesised that arousal, anxiety, and divided attention should increase the probability of stuttering on both stutterers and normal speakers. An experiment was devised to test this hypothesis for normal speakers* by requiring subjects to perform a divided-attention speech task while in a state of experimentally-induced anxiety. Control conditions involving masked speech, a simple task, and non-anxious subjects were incorporated in the experimental design (Table 4.1) in order to permit any stutters produced to be attributed to auditory feedback, divided attention, and anxiety respectively. Different combinations of tasks and conditions allowed any effects of the three independent variables to be separated.

* Actual stutterers were not included in this experiment because of (i) the greater difficulty of increasing their base-line of stutters, when the variables in question are supposed already present in their speech; and (ii) the statistical difficulties involved in using them in the same experiment as normal speakers, when their initial base-line of stutters is higher.

SUBJECTS

Twelve subjects were obtained by advertising in the University, and they were paid five shillings for taking part in the experiment, described to them as an investigation of the effects of anxiety on speech.

Eight subjects were male, and four female, their ages ranging from nineteen to thirty. They were assigned randomly to groups.

MATERIALS

Four prose passages were selected from a book on modern history (Pelling 1969), having regard to interesting content and the ability of the passages to stand independently as texts, so that there was no abrupt tailing-off of passages. It was hoped that passages selected in this way would retain subjects' interest throughout the experiment. (Although a few of the subjects spontaneously remarked after the experiment that they had found the content dull). The length of the passages ranged from 532 to 569 words. For presentation to the subjects, each passage was typed on two foolscap sheets.

APPARATUS

Anxiety group subjects were shocked on the back of the left hand, to which two half-inch square electrodes had been attached using electrode jelly and Elastoplast. Shocks were generated from a 6-volt accumulator via an inductance coil. Voltage on the coil could be varied from 1.3 to 6.5 volts.

In the masked voice condition, noise was produced from a Linear Diatonic generator which had a special "speech" setting for masking use, selecting noise of equal energy per cycle up to 1,000 hz, thereafter falling off at 12db per octave. This noise was relayed to subjects through

Koss Pro-4A headphones, together with a pure sine wave tone produced from a Feedback function generator. Noise and tone were mixed for combined binaural presentation to subjects by a Uher Stereo Mix unit, and fed through a Shure Stereo Solophone amplifier to their headphones.

A stylus maze was used in the divided-attention condition. The anxiety group received shocks when certain points in this maze were contacted, triggering micro-switches which activated the shock apparatus. These micro-switches were placed randomly through the maze as far as was possible - there were only a limited number of paths in which the switches would fit without obstructing other paths.

Subjects' responses were recorded via a Uher hand free-standing microphone onto a Tandberg 1221X tape recorder.

PROCEDURE

Anxiety group

Subjects of the anxiety group had their electrodes attached from the start of the experiment, when an individual shock level was set for each subject. This was done by giving successively greater shocks until the subject stated that he or she could not tolerate a higher level of shock. Subjects were not informed that they would in fact only receive shocks during the maze condition, and it was hoped that in this way their anxiety level would be kept high throughout the experiment.

Non-anxiety groups

This group performed exactly as the anxiety group, except that they had no electrodes attached and, of course, received no shocks.

Both groups

Four tasks were performed by each subject:-

1) A "base" task, in which a passage was simply read out, and which provided a sample of subjects' ordinary oral reading speech.

2) A divided-attention task, in which subjects read out a passage while at the same time following the stylus maze with their right hand. They were instructed to follow the maze in the reverse direction if they reached the end of it before finishing the passage. In order to prevent learning of the maze, it was hidden from subjects' view by a wooden box placed over it, with an open front through which the subjects' right arm passed.

3) A masked "base" task, exactly as task 1) described above, except that subjects' auditory feedback was masked by noise and a pure tone. E adjusted the intensity of the noise and the intensity and pitch of the tone until S was certain that he could not hear his own voice. S was instructed to count, and to pronounce the sound "s" during this adjustment period ("s" is the most difficult speech sound to mask completely).

4) A masked divided-attention task, which was the same as task 2) above, with the addition of masking.

Half of each group performed the masked tasks first, and this order was reversed for the other half. The base and maze tasks were performed alternately throughout for each subject.

Since two maze tasks with the same maze were required of each subject, a further precaution to prevent learning of the maze, with possible learning of the ½ position of the micro-switches by the anxiety group, was to change the direction of the maze for the second task by turning it through 90 degrees. Passages were presented in random order within subjects.

CONTROL GROUP

S's 1-3	Base F	Maze F	Base $\overline{F}$	Maze $\overline{F}$
S's 4-6	Maze $\overline{F}$	Base $\overline{F}$	Maze F	Base F

ANXIETY GROUP

S's 7-9	Base F	Maze F	Base $\overline{F}$	Maze $\overline{F}$
S's 8-12	Maze $\overline{F}$	Base $\overline{F}$	Maze F	Base F

Table 4.1 Design of Experiment 2. F = Feedback, $\overline{F}$ = no feedback.

TREATMENT OF RESULTS

Since part of the purpose of this experiment was to test the hypothesised view of a stutter as a false positive response, a stutter was defined accordingly as a part-word repeat, word repeat, within-word hesitation, or phrase repeat*, rather than confining the definition of a stutter to the phonetic level as some investigators do (e.g. Kasl and Mahl, 1965, MacKay, 1970). Any sequence of two or more words was considered a phrase. All measures were independent.

Subjects' tapes were transcribed and scored according to these measures, and the number of stutters scored was divided by the number of syllables uttered. This proportion was multiplied by 1,000 to give the number of stutters per 1,000 syllables.

For the analysis of variance, subjects' scores were submitted to a square root transformation, because there were a number of zeros, and because the scores were expressed as proportions (Alder and Roessler, 1968).

Unfortunately, part of one subject's tape was accidentally erased, but it was possible to reconstruct the data for this subject according to a procedure recommended by Winer (1962).

* In the anxiety condition, it was observed that sometimes the effect of a shock was to curtail the utterance of a word or phrase, which would then be re-started when the subject began speaking again. It seemed clear that these were instances of linguistic units which could not easily be continued after an interruption, either for reasons of breath-group or prosody, or of syllabification. Thus, if "can" is interrupted after "ca...", it is impossible to complete the word naturally. Similarly, if the phrase "in 1884 the University Settlement Movement was started" is interrupted after "1884", it is easier to re-start the whole phrase than to attempt to continue it from the point of the interruption. Such examples of word and phrase repeats were therefore omitted from the analysis, even though it is possible that some genuine stutters were excluded in this way.

RESULTS

The analysis of variance showed significant effects of feedback ($F = 14.15$, df 1, 23; $p < .01$) and of task (i.e. base or maze) ($F = 16.61$, df 1, 23; $p < .001$). There was no significant effect of anxiety ($F = 0.46$, df 1, 8), and there were no significant interactions (see Appendix C for full analysis of variance table). Table 4.2 shows that the effect of masking was to reduce the proportion of stutters, and that the significant effect of task referred to the greater proportion of stutters elicited by the divided attention (maze) task.

	ANXIETY		CONTROL		
	Base	Maze	Base	Maze	$\bar{X}$
F	3.2	5.0	2.2	6.3	4.2
$\bar{F}$	2.0	4.2	0.5	2.4	2.2
$\bar{X}$	2.6	4.6	1.3	4.3	

Table 4.2 Mean stutters per 1,000 syllables. F = feedback, $\bar{F}$ = no feedback.

Scheffe tests carried out after the analysis of variance, however, failed to show any significant effects of divided attention or of masking within the anxiety condition ($F = 1.29$, $F'5\% = 10.26$; 3, 23 df; and $F = 2.40$, $F'5\% = 10.26$; 3, 23 df, respectively). Nevertheless, Table 4.2 shows that the trends are in the expected direction, except in the case of the maze task in the anxiety condition, which elicited a lower mean proportion of stutters than the maze task in the control condition. These points taken together suggest that anxiety tended to attenuate the effects both of divided attention and of masking, and therefore may be to a certain extent independent of either variable, as opposed to being, for instance, intensified in its effect by divided attention or inhibited by masking, as would have been expected.

The Scheffe tests showed in addition that there was no significant difference between the maze and base tasks within the masked condition ($F = 5.99$, $F'5\% = 10.26$; 3,23 df), suggesting that masking tends to override the effect of divided attention. This would be expected, since masking eliminates the virtual *sine qua non* of stuttering - auditory feedback - but even so, the apparent attenuating effect of anxiety described above indicates that the effect of masking is not always absolute, as indeed is shown by the fact that it rarely *totally* suppresses stuttering, even though it can dramatically reduce it (Murray, 1969).

While these tendencies revealed by the Scheffe tests are interesting, they can of course only be true to the extent that their corresponding interaction terms in the analysis of variance failed to reach significance.

DISCUSSION

The predictions that masking would decrease stutters, and that divided attention would increase stutters, were thus fully borne out in this experiment.

The demonstrated effect of masking is important in extending the known effect of masking on pathological stuttering to the area of non-pathological stuttering, and is further evidence in favour of relating the two. The success of masking in significantly reducing stutters in the non-anxiety conditions indicates that the availability of feedback per se is a sufficient condition for a certain number of stutters to occur, and that factors such as divided attention act only to increase the probability of a feature which may occur independently. Auditory feedback seems then to be the factor which is most nearly a necessary and sufficient condition for stutters to occur (although, as was pointed out above, it is not strictly necessary), but against this must be set the fact that amplifying auditory feedback (as was done in Experiment 1) does not have any significant effect on the number of stutters occurring.

Whether the effect of divided attention was due to involuntary switches of attention to auditory feedback (assisted by the arousing and attention-narrowing effect of division of attention), whether it was due merely to an increased probability of false positive responses, or to all three factors combined, cannot be determined from these results. Nevertheless, it has been shown in this experiment that stutters are significantly related to a particular pattern of attention deployment, a finding which confirms the hypothesised relationship between stuttering and attention deployment.

In the light of this confirmed relationship, the failure of any significant effect of anxiety to appear runs counter to the expected effect of anxiety on attention deployment. This result indicates the rejection of arousal per se as an explanation of the effect of divided attention in increasing stutters, since it seems very unlikely that electric shocks would be less arousing than divided attention. Furthermore, a supplementary analysis has provided clear evidence that there was an effect of electric shocks, presumably an arousing one, making the 'arousal interpretation' of the divided attention effect even more unlikely.

This analysis followed on the confirmation that stuttering is related to attention-deployment, and was a further examination of this hypothesis, and also of the false-positive response view of a stutter, which was to some extent supported by the significant effect of divided attention in increasing stutters. The analysis was based on the argument that, if stutters occur in situations where auditory feedback is being attended to, then when more stutters occur, subjects should also detect (and correct) more of their phonetic errors. In addition, if a stutter is a false positive response, it should show an appropriate distribution when compared with hits and misses.

Subjects' phonetic errors (distortions, omissions, and additions of speech sounds, and misplaced word stresses) were therefore counted and categorised as either hits (corrected errors) or misses (uncorrected errors). These scores were divided by syllables uttered, multiplied by 1,000, and submitted to a square root transformation. An analysis of variance on these scores showed significant effects of feedback ($F = 8.51$, df 1,55; $p < .01$) and of anxiety ($F = 20.58$, df 1,55; $p < .001$). There was no significant effect of task (see Appendix C for analysis of variance table).*

Table 4.3 shows that the effect of masking was to decrease the proportion of hits relative to misses, and that the effect of anxiety was to increase the proportion of hits.

If the hit rate can be taken as an index of attention to auditory feedback, these results are in full accord with the hypothesis that anxiety increases attention to auditory feedback.

* Because of the post hoc nature of the analysis, and the fact that 'input signals', i.e. phonetic errors, could not be controlled, it was not possible to do an orthodox signal-detection analysis of these scores.

	ANXIETY	CONTROL	$\overline{X}$
F	0.9	0.3	0.6
$\overline{F}$	0.6	0.2	0.4
$\overline{X}$	0.7	0.3	

Table 4.3 Mean proportion of hits to misses per 1,000 syllables. F = feedback, $\overline{F}$ = no feedback.

It will be noticed that the stutter rate and the hit rate do not co-vary perfectly, since with divided attention stutters increase significantly, while the hit rate decreases slightly; and with anxiety the hit rate increases significantly, while the stutter rate increases only slightly. In the case of masking, nevertheless, both stutter rate and hit rate are significantly reduced. Table 4.4 sets out these relative changes in hit rate and stutter rate.

	HIT RATE	STUTTER RATE
Divided attention	decreases	increases significantly
Anxiety	increases significantly	increases
Masking	decreases significantly	decreases significantly

Table 4.4 Relative changes in hit rate and stutter rate.

Hit rate and stutter rate, although both have been argued for as indices of attention to auditory feedback, do not always co-vary. However, if we follow through the ex hypothesi view of a stutter as a false positive response, and compare the relative changes shown for divided attention* in Table 4.4 with the changes observed in hit rate and false positive rate in previous signal-detection experiments on divided attention (discussed in Mackworth, 1970) it is seen that the changes are in accord with these previous findings. Thus Broadbent and Gregory (1963) found that false positives increased, while hits decreased in a divided-attention task; and Wiener et al. (1964) observed many more false positives in a time-sharing condition as compared with a control condition.

This experiment has, then, provided some support for the view of a stutter as a false positive response. But this interpretation can only be accepted at the cost of concluding either that the anxiety levels induced were not sufficient to significantly increase stutters, or that anxiety has no effect on stutters, since the false-positive hypothesis would predict that stutters increase with anxiety. The latter alternative conclusion is a possible one, despite the strong traditional association of stuttering with anxiety, for it is quite possible that, while stuttering could result from an attentional peculiarity (or any other cause) only those stutterers made anxious by their handicap would come to the notice of therapists and research workers.

On the other hand, since hits were significantly increased in the anxiety condition, and it seems uncontroversial to regard

* It has proved impossible to find any reports of signal-detection experiments on anxiety (or, of course, on masking) which give the actual scores or relative changes in hits and false positives.

the hit rate as a measure of attention to auditory feedback (particularly as it is reduced significantly in the masked condition) there is some support for the hypothesis that anxiety increases attention to auditory feedback. In this case, of the two alternative conclusions possible with regard to the effect of electric shocks on stuttering in this experiment, it is possible to accept the conclusion that the anxiety levels induced were not sufficiently high to increase stutters as a conclusion which is in accord both with the hypothesis that anxiety increases attention to auditory feedback, and with the other results in relation to anxiety.

Chapter Five

Conclusion

Summary of findings

For the purposes of this final discussion, the main findings of the research decribed in the thesis are listed below.

1 Simultaneous interpreters tend to stutter more when they are working through noise interference.

2 More stutters are observed during simultaneous interpreting than during shadowing of the same material.

3 Stutters are significantly associated with simultaneous errors of perception during interpreting.

4 The masking of auditory feedback significantly reduces stutters in non-pathological speakers.

5 Amplifying auditory feedback does not increase stutters.

6 Divided attention significantly increases stutters, but not the rate of detection of phonetic errors.

7 A moderate level of anxiety does not increase stutters, but it does significantly improve the rate of detection of phonetic errors.

The thesis set out to explore the possible relationship between the stutters of normal speakers under stress, DAF stuttering, and pathological stuttering. A theory was put forward which proposed that all these instances of stuttering represent momentary breakdowns of skilled, automatic speech as a result of intermittent attention to auditory feedback. In discussion of the nature of skilled behaviour, and of various kinds of stresses, indications were given of the ways in which such shifts of attention could occur, and of their likely effects on speech.

Two of the findings listed above clearly associate stutters with shifts of attention. These are the findings that stutters are significantly related to simultaneous failures of perception during interpreting, and that stutters are significantly increased during a divided-attention task. Furthermore, if the task of simultaneous interpreting is accepted as being a divided-attention task in literally the same way as, for instance, the maze task used in Experiment 2, then the finding that there are significantly more stutters elicited by the task of interpreting than by that of foreign-language shadowing is additional evidence of an association between stutters and shifts of attention. While the finding concerning failures of perception during interpreting is equivocal if taken alone (since the failures could be the result rather than the cause of the stutters) the other two findings suggest an interpretation of the first as supporting the theory that stutters are the result of momentary shifts of attention to auditory feedback.

The findings concerning phonetic error detection, a measure of attention to auditory feedback, also throw interesting light on shifts of attention. The hit rate does not perfectly co-vary with the stutter rate, but it does change in relation to the stutter-rate in expected ways if the stutter-rate is regarded as a false-positive rate. In particular, the fact that the hit rate decreases with divided attention, while the stutter rate increases, is in accord with the hypothesised rapid involuntary fluctuations of attention in this situation (analogous to the 'internal blinks' postulated by Broadbent in 1957 to account for momentary lapses of attention from tasks performed in noise) since the hit rate would increase rather with relatively sustained intervals of attending to auditory feedback, than with rapid random episodes of attending. Similarly, the fact that the hit rate increases significantly with anxiety, while the stutter rate is unaffected, reflects the more even effect of anxiety on the deployment of attention.

The finding that masking of auditory feedback significantly reduces stutters in normals is further evidence of the important role of auditory feedback, and reinforces the view that pathological and non-pathological stuttering are related. However, the failure, in Experiment 1, of amplified auditory feedback to increase stutters showed that the role of auditory feedback must be more complex than was at first thought.

It was as a result of this failure to find any effect of amplified auditory feedback that other possible factors contributing to the causation of stuttering had to be investigated. The possible factors were determined by considering further what was common to the situations of normal speakers under stress (including interpreters working through noise interference), the subjects affected by DAF, and the pathological stutterer. The common factors appeared to be high arousal (noise stress, anxiety) and, on more hypothetical grounds, divided attention.

Experiment 2 manipulated these two variables, but surprisingly (in view of the traditionally strong association of anxiety with stuttering in both pathological stutterers and normals) anxiety had no significant effect on stutters, even though it had an effect in improving the monitoring of phonetic errors, and therefore in increasing attention to auditory feedback. Perhaps surprisingly also, because of the less direct prior evidence of its possible involvement, divided attention had a very clear effect in increasing stutters.

It was concluded from this experiment that the anxiety levels induced had not been high enough to increase the rate of stutters.

This conclusion appears to throw some doubt on the hypothesised role of arousal via noise stress in the case of the stutters observed in simultaneous interpreters working through noise, since it seems likely that electric shocks would be more arousing than noise. The noise would, however, interfere more severely with the processes of the task of interpreting than electric shocks generally do with a task. Consider Rabbitt's (1968) remark concerning the rehearsal of verbal material heard through noise:-

> "Such a process would evidently require a highly complex and carefully-timed shifting of attention between material currently being presented and material held in storage. It would be consistent with this model that any increase in the complexity of one of these interlocking and competing processes would reduce the efficiency with which the others can be carried on ... Levels of noise which do not prevent listeners from hearing what is said to them may nevertheless prevent them from efficiently using the information which they receive."

Simultaneous interpreters subjected to noise stress might, therefore, suffer not only the effects of noise per se, but also the anxiety-provoking effect of lagging further and further behind the message they are attempting to interpret, since, in addition to the possibility of these effects postulated by Rabbitt, Gerver (1970, 1971) has shown the direct effect of increased ear-voice spans in interpreters working through noise. Keeping up with the input message must be a priority for the interpreter, for if he does not succeed in this he will eventually, and quite quickly, lose track of the message altogether. Furthermore, it is possible that interpreters' rhythms of attention deployment are sufficiently disrupted by the noise to result in the increased stutters which are observed, and there are thus two independent variables possibly contributing to these increased stutters - noise per se, and anxiety or arousal resulting from disruption of the task.

As far as simultaneous interpreters are concerned, then, the evidence which has been collected together in this thesis upholds the hypothesised role of auditory feedback and stress in stuttering. But the only direct evidence for variables affecting stutters which has been provided by this thesis has concerned divided attention, and auditory feedback. The role of stress must therefore remain hypothetical.

Implications for further research

The thesis has not produced any clear indications as to the role of stress and/or arousal in stuttering, and this is a question which further research might investigate. The problems of inducing anxiety experimentally and, more important, of knowing whether or not anxiety is present in subjects, are familiar ones (Martens and Landers, 1970). It may be possible to avoid them, and at the same time investigate further the similarities between stuttering and Parkinsonism by using drugs which are known to act on the reticular activating system to increase arousal.

Welford's (1968) suggestion that skilled behaviour will revert to piecemeal, single-unit responding under stress was mentioned earlier (page 60), and this is a question which could easily be examined in the context of speech by seeing whether syllables, words, or phrases predominate as repeated units in stuttering. Correction would need to be made statistically in order to allow for the differing ordinary probabilities of these units.

Amplified auditory feedback was found not to have any effect in Experiment 1, but a more adequate test of this, in the light of subsequent findings in the thesis, might be to combine it with a divided-attention task, and compare the result with the divided-attention task as a control.

Yates' (1965) and Erlich's (1966) experiments suggesting peculiarities of attention deployment in subjects susceptible to DAF (discussed on page 28) might be replicated in order to see whether the same is found of pathological stutterers, as the hypotheses put forward in this thesis would predict.

The relative role of response difficulty in shadowing a foreign language and in translating from a foreign language, respectively, a factor which made it difficult to assess the effects of 'task difficulty' in Experiment 1, could easily be elucidated by comparing native- and foreign-languages shadowing in the same subjects. Appropriate measures of response difficulty would be the number of phonetic errors, the rate of speech, and retention of the content of the material shadowed. Such an investigation might also throw some light on the general question of the attention demands of movements.

Finally, while the thesis has gone some way towards examining the view of a stutter as a false positive response to 'error' signals from auditory feedback, this idea might be further investigated in relation both to normal speakers and pathological stutterers. A major difficulty of performing signal-detection analysis of the kind proposed on speech errors is that the experimenter can have little control over the rate of signals. This entails measures such as, for instance, using subjects emitting a similar basic rate of speech errors, or finding statistical procedures which could overcome the problem of differing initial error base-lines.

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APPENDIX A

Measures of "stuttering" used by different investigators	Kasl & Mahl (1965)	Yeni-Komshian et al. (1969)	MacKay (1970)	Wingate (1964)	Jones & Azrin (1969)	Lanyon & Duprez (1970)	Webster & Dorman (1971)	Cherry & Sayers (1956)	Rouse & Tucker (1966)	Burke (1969)	Williams, Silverman & Kools (1968)	Bloodstein (1970)	Maraist & Hutton (1957)
sound repeat	*		*	*				*					*
sound prolongation				*	*	*	*			*		*	*
syllable repeat				*					*				*
part-word repeat					*	*	*			*	*	*	*
word repeat					*	*		*	*	*	*	*	
word omission							*		*				*
word abandoned							*			*			
within-word silence					*								*
silent hesitation								*					*
voiced hesitation												*	
interjection						*				*	*	*	
tongue-slip													*
mispronounced word									*				*
substituted word									*				*
non-textual addition													*
phrase repeat						*		*		*	*		
phrase revision											*		
disrhythmia											*		
articulatory tension											*	*	*
breathing disturbance								*				*	
motor disturbance								*				*	
rate of utterance		*					*		*				*

Appendix B

Error-counting Criteria

1. Semantic errors in translating (Experiment 1)

(i) An uncompleted word is counted as one omission.

(ii) Omissions of French rhetorical devices which do not affect the sense of a passage are not counted as errors.

(iii) Where substantial portions of the original French passage are omitted, the omissions are quantified with reference to the total number of French words not translated. (Any element which can stand as a free form in French is counted as a word, thus "ne... pas" = 2 words; "l'homme" = 2 words.)

(iv) An error of tense, number, or gender is counted as one substitution, even though it may affect several words.

(v) Wrong word-order affecting the sense, or a question translated as a sentence (or vice-versa) is counted as one substitution.

(vi) Errors which are later corrected are not counted, except in the analysis of input simultaneous with stutters and words immediately preceding and following stutters (page 41).

2. Phonetic errors (Hits and Misses, Experiment 2)

Counted as a phonetic error were the following:-

(i) Omission of one or more phones of a word.

(ii) Spoonerism (quantified with reference to the number of words affected).

(iii) Substituted phone.

(iv) Superfluous phone (other than a stutter).

(v) In translating, the repetition or transliteration of the original French (e.g. "searchers" instead of "researchers" or "research workers" for the French "chercheurs" - this kind of error is here construed as a tongue-slip)

(vi) In shadowing, the intrusion of an English word.

Each phonetic error identified according to the above criteria was denoted a "Miss", unless corrected, in which case it was denoted a "Hit".

APPENDIX C

1. Analysis of variance table of semantic errors, Experiment 1

(O=Order, T=Task, F=Feedback)

Source	Sums of Squares	Degrees of Freedom	Mean Square	F Ratio	P
O	0.29	1	0.29	1.16	
Error	1.01	4	0.25		
T	0.90	1	0.90	6.26	<.05
F	2.71	2	1.36	9.42	<.01
TxF	0.02	2	0.01	0.08	
TxO	0.59	1	0.59	4.08	
FxO	0.16	2	0.08	0.55	
TxFxO	0.02	2	0.01	0.06	
Pooled Error	2.89	20	0.14		

2. Analysis of variance table of stutters, Experiment 2

Source	Sums of Squares	Degrees of Freedom	Mean Square	F Ratio	P
A	4.20	1	4.20	0.46	
O	9.91	1	9.91	1.08	
AxO	11.29	1	11.29	1.25	
Error	72.27	8	9.03		
T	38.49	1	38.49	16.61	<.001
F	32.79	1	32.79	14.15	<.01
TxF	1.00	1	1.00	0.43	
TxO	0.08	1	0.08	0.03	
TxFxO	5.61	1	5.61	2.42	
TxFxA	0.82	1	0.82	0.35	
TxFxAxO	0.93	1	0.93	0.40	
FxO	0.76	1	0.76	0.34	
FxA	5.70	1	5.70	2.46	
AxT	8.05	1	8.05	3.47	
AxTxO	5.75	1	5.75	2.48	
AxFxO	3.13	1	3.13	1.35	
Pooled Error	53.28	23	2.32		

A = Anxiety, O = Order, T = Task, F = Feedback.

3. Analysis of variance table of hits and misses, Experiment 2

A = Anxiety, O = Order, T = Task, HM = Hits & Misses, F = Feedback.

Source	Sums of Squares	Degrees of Freedom	Mean Square	F Ratio	p
A	0.01	1	0.01	0.001	
O	0.22	1	0.22	0.05	
A x O	11.01	1	11.01	2.46	
Error	35.74	8	4.47		
T	0.18	1	0.18	0.08	
T x O	7.03	1	7.03	3.11	
HM	0.05	1	0.05	0.02	
HM x T	0.00	1	0.00	0.00	
HM x O	2.75	1	2.75	1.22	
HM x T x O	0.49	1	0.49	0.22	
F	5.73	1	5.73	2.53	
F x T	2.44	1	2.44	1.08	
F x O	0.15	1	0.15	0.07	
F x T x O	0.00	1	0.00	0.00	
F x HM	19.23	1	19.23	8.51	<.01
F x HM x T	0.52	1	0.52	0.23	
F x HM x O	5.89	1	5.89	2.61	
F x T x HM x O	1.89	1	1.89	0.84	
A x T	0.91	1	0.91	0.40	
A x HM	46.51	1	46.51	20.58	<.001
A x T x O	7.03	1	7.03	3.11	
A x HM x O	7.02	1	7.02	3.11	
A x T x HM	0.42	1	0.42	0.18	
A x T x HM x O	0.38	1	0.38	0.17	
A x F	0.99	1	0.99	0.44	

/cont.

3. Analysis of variance table of hits and misses, Experiment 2 (contd.)

Source	Sums of Squares	Degrees of Freedom	Mean Square	F Ratio	P
A x F x O	2.19	1	2.19	0.97	
A x T x F	1.49	1	1.49	0.66	
A x T x F x O	2.73	1	2.73	1.21	
A x HM x F	0.99	1	0.99	0.44	
A x HM x F x O	5.41	1	5.41	2.39	
A x T x HM x F	3.05	1	3.05	1.35	
A x T x HM x F x O	10.28	1	10.28	4.55	<.05
Pooled error	124.28	55	2.26		