PRODUCTION AND PERCEPTION OF PHONEMIC
VOWEL DURATION IN FRENCH

by

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ABSTRACT

The present study consists of two experiments which examine the use of vowel duration in French in such word pairs as "maître:mettre" and "pâte:patte".

The first experiment examines the use of vowel duration from the point of view of production. Subjects recorded sentences containing the words under study both in (unemphatically) stressed and unstressed position. Significant differences in vowel duration were found between the "long" and the "short" members of the pairs. No significant differences in vowel duration were found between the /ɔː:/-/a/ "long":"short" vowel ratios and the /ɛː:/-/ɛ/ vowel ratios. Vowel ratios were slightly smaller when words appeared in unstressed position than in stressed position but these differences were not found to be significant. Speakers from the Midi were observed to make the length distinction less frequently than speakers from other areas.

The second experiment examines the use of vowel duration by the same group of native speakers in distinguishing perceptually between members of such pairs as those mentioned above. Using a small computer, vowels of the "long" and "short" members of a pair were shortened and lengthened respectively in steps of approximately 16 msec. Subjects were asked to assign a lexical value to the stimuli so obtained. Subjects' responses were found to be influenced by shifts in vowel duration. Lengthening the "short" vowel had a greater effect in reversing listener judgement of the word than did
shortening the "long" vowel. When members of a pair were accompanied by a marked difference in vowel quality, shortening the "long" vowel had relatively little effect on the listeners' judgement of the word.

It thus appears that for the group of speaker/listeners selected, length does play a role in distinguishing, both productively and perceptually, between such pairs as "maître:mettre" and "pâte:patte".
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"The French don't care what they do actually, so long as they pronounce it properly."

(My Fair Lady, Act I, scene i)
Chapter 1

INTRODUCTION

Describing the phonological features of a language is a difficult and involved task. Language is constantly undergoing change; features that were at one time considered distinctive are often replaced by other distinctive features, or they simply disappear. In some cases, phonological changes occur at the segmental level. For example, ancient Greek contrasted aspirated and unaspirated voiceless stop consonants. In modern Greek, the aspirated stops have been replaced by fricatives and the feature of aspiration is no longer distinctive.

Such changes can also occur at the suprasegmental level. For example, differences in duration are considered in certain languages to be phonemic. In the French language, a difference in vowel duration between members of such pairs as "maître:mettre" and "pâte:patte" was at one time considered to be phonemic and in the "standard" pronunciation of French, the difference in duration is still observed. In the sound systems of many native speakers of French, however, the length contrast has tended to disappear and for these speakers, members of such pairs are homonymous.

The present study examines phonemic vowel duration, both from the point of view of production and that of perception, in such pairs as "maître:mettre" and "pâte:patte" in order to gain further insight into the status of the length contrast in contemporary French.
Chapter 2

LITERATURE REVIEW

2.1 Introduction

This chapter surveys the literature concerning vowel duration from two points of view. Section 2.2 deals with vowel duration from the aspect of production and section 2.3 discusses vowel duration from the aspect of perception.

2.2 Vowel Duration: Production

One of the most obvious factors influencing speech segment duration is rate of speech. There are, however, several other factors which influence segment duration. In the case of vowels, certain features of the phonetic environment play an important role in lengthening or shortening the vowel. Several investigators have found evidence to support the hypothesis that vowels preceding voiced consonants are generally longer than those preceding voiceless ones. Studies include those of House and Fairbanks (1953), Belasco (1958), Peterson and Lehiste (1960) for American English; Zimmerman and Sapon (1958) for Spanish; Delattre (1966) for French. In one of his early articles, Delattre suggests that "...la durée de la voyelle est inverse de la force d'articulation consonantique subséquente." (Delattre, 1966, p. 132). His findings have been substantiated by the studies of House and Fairbanks (1953) and Belasco (1958).
Stress has also been shown to have an influence on vowel duration. Fry (1955) found that the vowel of a stressed syllable is longer than the same vowel in unstressed position in such pairs as "object (noun):object (verb)". Lehiste (1970) and Nooteboom (1972), studying Estonian and Dutch respectively, demonstrated that position in utterance as well as the number of syllables in the utterance have a marked effect on vowel duration. Nooteboom found that with an increasing number of syllables in an utterance the vowel tends to be shortened. Other factors which have been found to influence vowel duration are the overall phrase length and the semantic importance of the word in which the vowel occurs.

Certain languages, however, make use of vowel lengthening at the phonological level. A difference in segment duration in these languages is the primary cue for distinguishing particular phonemes. For some languages, e.g. Japanese (cf. Fujisaki et al., 1973), Norwegian, Finnish, Czech (cf. Nooteboom, 1972), the vocal tract configuration is identical for two vowel phonemes which are distinguished solely by a difference in duration. In other languages, e.g. Swedish, Dutch, German, English (cf. Nooteboom, 1972), a difference in vowel duration is often accompanied by a difference in vowel quality. A phonological distinction in vowel length is said to be learned while a difference in vowel length which is influenced by the phonetic environment is said to be conditioned (Delattre, 1966). House (1961), for example, contends that in English the /iː/:/ɪ/ length difference is learned, while the /ɛ/ː/ɛ/ length difference is conditioned. The phoneme /iː/ is longer than /ɪ/ not because it is less open but because of the survival of a former distinctive feature of length
that was present in Middle English (/i:/). This length difference has changed to a less central/more central distinction with the difference in length remaining but slightly less marked.

Several studies concerning distinctive length have been carried out in languages that use length in a meaningful way. Phonemic vowel length has been examined by Hadding-Koch and Abramson (1964) and by Fant (1971) for Swedish. For German, Meyer (1904), Vietor (1923), and Weitkrus (1932) measured vowel durations of long and short vowels in stressed position and arrived at long:short ratios of 4:2 to 5:2 (references cited in Delattre and Hohenberg, 1968). Delattre and Hohenberg (1968) examined phonemic lengthening in German when the vowel occurred in unstressed position and concluded that the "tense" (long) vowel is always longer than its "lax" (short) counterpart even when the vowel is in unstressed position. Nooteboom (1972) studied Dutch vowels in nonsense syllables and examined the role of duration in distinguishing between vowel pairs that were also accompanied by a difference in quality. It was found that "...on the whole subjects seem to adhere to surprisingly fixed temporal patterns." (Nooteboom, 1972, p. 75). The role of phonemic vowel duration in Czech has been investigated by Chlumský (1928) and Janota and Jančak (1970).

French is not generally known as a language that makes extensive use of vowel length in a distinctive manner. However, if one looks diachronically at the development of the French sound system, it appears that certain vowel contrasts have arisen that are distinguished by a difference in duration. These contrasts have arisen from the loss of a consonant or consonants in the original
Latin forms, or through analogy to these forms.

 e.g. Latin: magister → maïestre (11th C.) → maître
      Latin: pasta → paste (12th C.) → pâte

The disappearance of the consonant(s) toward the end of the fourteenth century resulted in compensatory lengthening of the preceding vowel. The contrasts which arose were /a:/ /a/ and /ɛ:/ /ɛ/. The posteriorization of the /a:/ phoneme was subsequent to its lengthening and, according to Delattre, "Il semble...que, même aujourd'hui, ce soit la durée qui conditionne le timbre et non l'inverse." (Delattre, 1966, p. 107). The difference in quality was mentioned for the first time in 1753 by Boindin in his *Remarques sur les sons de la langue*. Michaelis and Passy (1897), in their *Dictionnaire Phonétique de la Langue Française*, indicate by means of phonetic transcriptions that length is a distinguishing characteristic in such pairs as "maïtre:mettre" and "pâte:patte" (in the latter case they indicate a qualitative difference as well). Rousselot (1927) questions the role of length in distinguishing such pairs as "maïtre:mettre" and "pâte:patte". According to him, the difference is a qualitative one (open:close). Nonetheless, he does admit that "l'a de pâte est plus long que l'a de patte." (Rousselot, 1927, p. 90). Grammont (1933) also explains the difference between /a:/ /a/ to be one of quality (posterior:anterior). He states further that in certain cases the open /ɛ/ may be long. Fouche (1958) claims that "...le système quantitatif du français est...essentiellement phonétique." (Fouche, 1958, p. 89) and does not regard length as being significant in French. Discussing phonemic vowel length in
French, Malmberg (1954) says:

Le nombre de cas où la quantité seule distingue deux mots (bette:bête; renne:reine) est restreint et le Français n'est pas habitué à attribuer beaucoup d'importance aux variations de quantité vocalique (Malmberg, 1954, p. 92).

Recent manuals of French pronunciation (Valdman et al., 1964; Péon, 1966) indicate that the length difference is still a factor in distinguishing certain words. Delattre (1951) points out the length distinction and states that the additional length of the long vowel in "maître" or "pâte" is relatively unstable.

Ce supplément de durée est instable parce qu'il est indépendant de l'influence psycho-physiologique de la consonne qui suit... C'est le seul cas où le signe de durée doive s'employer en français (Delattre, 1951, p. 16).

Experimental data to support the presence or absence of a distinctive feature of length in such pairs as "maître:mettre" and "pâte:patte" are scanty. In an early study (Delattre, 1938), Delattre recorded a native speaker of French reading sentences containing the minimal contrasts mentioned and found that in such minimal pairs as "maître:mètre" a measurable difference in duration was made. Comparing the ratio of the vowel lengths of "maître:mètre" to those of "serre:sec", where the vowel duration is phonetically conditioned, he found the first ratio to be much smaller. Delattre points out that whereas the phonetically conditioned length
difference in the pair "serre:sec" is due to the influence of the following consonant, the phonemic distinction in length in "maître:mètre" is consciously made (since the phonetic environments are identical). Delattre argues that the /ɛ/ of "maître" must be a phoneme distinct from the /ɛ/ of "serre" which, despite a great difference in length, belongs to the same phoneme as the /ɛ/ in "sec". As Delattre points out in a later article (Delattre, 1964), the use of this length distinction varies according to the area of France from which the speaker comes and "...it (the length distinction) is observed only in careful diction and by a minority of speakers." (Delattre, 1964, p. 99).

Martinet carried out a survey in 1941 (Martinet, 1945) concerning the status of the /ɑː:/ /a/ and /ɛː:/ /ɛ/ distinctions in the speech of Parisian subjects. The method of investigation took the form of a questionnaire in which subjects were asked whether they made a difference between pairs such as "pâte:patte". The study revealed that for the most part, Parisians distinguish between "un 'a' et 'e' bref" and "un 'a' et 'e' long". Martinet remarks, however, that:

En syllabe fermée, ils opposent, pour la plupart un 'e' bref à un 'e' long mais il est évident que cette opposition a de la peine à se maintenir. Les sujets nés entre 1900 et 1910 confondent, dans la proportion de près de deux tiers, les mots 'faite' et 'fête'. La distinction entre les deux 'a' est universelle en syllabe tonique ouverte et très générale dans les autres positions. Ici encore, beaucoup de sujets ne perçoivent pas de différence quantitative entre 'patte' et 'pâte' (Martinet, 1949, p. 36).
A follow-up of Martinet's study was done in 1956-57 by Reichstein (1960). Subjects were asked whether they made a difference between pairs similar to those used by Martinet. Subjects were also asked to read sentences containing the study words and the investigator indicated whether a difference in length was heard or not. The subjects used were Parisian school girls ranging in age from 13-15 years. Results showed that the /a:/ distinction that was well established in 1941 among adult Parisians was much less marked in the 1956-57 study. Comparing Reichstein's results to those of Martinet, we find that in 1941, the "pâte:patte" distinction was made in 100% of the cases while in the 1956-57 study, between 46-49% of the subjects made a difference. Similar results were quoted for the /ɛɛ:/ vowel contrast.

Deyhime (1967) carried out a further study concerning the status of the length distinction in French. The method of investigation again took the form of a questionnaire and sentence reading. Approximately 500 subjects were used and the subjects were from all parts of France (unlike the two previous studies). Deyhime found a difference between the vowel systems of subjects from the Midi and those from other parts of France. In the Midi the length oppositions under study were not apparent. He found that among non-meridional speakers (i.e. not from the Midi region), the /a:/ distinction was present but the /ɛɛ:/ distinction appeared with less regularity (used by only 44% of the non-meridional speakers).

A recent study by Léon (1972) dealing with the pronunciation of accented /ɛ/ among a group of young Parisians was under-
taken in part to examine the status of the /ɛː-/ɪ/ length distinction in the speech of young French students. A group of thirty-one boys, all born in or near Paris was selected. The subjects were all fourteen years old at the time of the study. Subjects were recorded reading a list of sentences containing the study words. Léon says that an effort was made to place the words in identical contexts; i.e. when involving members of the same minimal pair. The test pairs used were:

"bêle:belle"
"bête:bette"
"l'être:lettre"

Results support those found by Reichstein and Deyhime. Léon found that the opposition is just as unstable in the "langue populaire" as in the "langue cultivée".

The. surveys of Martinet, Reichstein and Deyhime relied on the speaker's ability to analyze his own speech and the investigator's skill in transcribing as accurately as possible what he heard. No instrumental analysis of the data was done. In the study by Léon, the investigator states that an attempt was made to minimize the difference between the sentence frames in which members of the same pair appeared. However, from the examples given in his study, it is evident that the sentences are not identical: "C'est l'être le plus idiot." and "C'est la lettre la plus idiote."; "Le mouton bêle." and "Betty est belle.". Based on the results of the studies mentioned earlier concerning the influence of phonetic
environment, stress, number of syllables in the utterance, etc., it would seem that differing phonetic contexts could be a factor in the neutralization of the length difference.

It appears then, that an investigation to determine the status of the length contrast in French is needed in which vowel durations are measured instrumentally rather than subjectively and where external factors influencing vowel duration are controlled.

2.3 Vowel Duration: Perception

Relatively few studies have been done concerning perception of duration of speech or non-speech stimuli. A study by Creelman (1962) examined the ability of human observers to discriminate differences in duration between short auditory signals. The listeners were presented with a 1000 Hz tone in a white noise background. The duration and intensity of the tone were varied and the listeners were asked to compare it to a tone of fixed length and intensity. The results of Creelman's study indicate that the perception of time is an independent process, not dependent on such factors as intensity.

Duration discrimination depends on sufficient intensity to mark the time unambiguously; it depends on detectibility but not on loudness (Creelman, 1962, p. 592).

Creelman proposed a model for the perception of duration based on the results of his study. In his model, human observers use
...a separate and independent mechanism
to measure short durations. This mechanism functions by 'counting' input pulses
during the duration to be judged (ibid.).

The counting mechanism would be analagous to an accumulator which could store neural pulses.

Abel (1972a) examined listeners' ability to discriminate between a pair of filled intervals of different durations and in a later study (Abel, 1972b) looked at listeners' ability to judge differences in duration of silent gaps between tone bursts. Abel also found discrimination of duration to be independent of the intensity of the stimulus. Her results support Creelman's neural counter model for the perception of duration.

The study of perception of non-speech stimuli appears to be related to temporal discrimination in speech perception, where cues to meaning in some languages depend on relative duration.

Perception of duration of speech stimuli has been studied indirectly by Denes (1955), who examined the effect of vowel duration on perception of voicing of the following consonant, and by Fry (1955), who investigated the effect of vowel duration on the perception of stress in English. In the first study, vowel lengthening resulted in a greater number of judgements of a following voiced consonant. In the second study, vowel lengthening played a major role in judgements of stress.

Discussing the perception of vowel duration, Lehiste (1972) suggests that the phonetic image of the vowel falls along a continuum and the listener "locates" the stimulus on the continu-
um by reference to certain articulatory target points stored in memory. She states further that a listener is not only able to compare the duration of two stimuli but also can match the stimuli with some kind of internal "durational image". This notion is based on Lehiste's work in 1970 on Estonian in which she found that listeners agreed consistently in assigning linguistic labels to stimuli differing only in the duration of a vowel or consonant. In languages using distinctive quantity, abrupt changes in manner of articulation serve as reference points with regard to timing judgements. This idea supports the notion of parallel processing in speech perception.

Whatever the process by which the duration of one segment is compared with that of another (or with a stored 'durational image') it can very well take place at the same time as the cues for the point of articulation are extracted from the same acoustic signal (Lehiste, 1972, p. 7).

Nooteboom (1972) also postulates an internal representation of vowel and syllable duration which is part of an internal representation language users have of how the words of their own language should sound. In his study, subjects were asked to adjust the vowel duration of a nonsense word according to some internally generated criterion, such that the word sounded as natural as possible. His results suggest that duration discrimination may be considerably better than the duration of one cycle of the vocal folds, or approximately 8 msec.
In an adjustment experiment in which three phonetically non-naive subjects were asked to keep an internally generated criterion for the duration of a stressed syllable nucleus...as constant as possible in successive settings, it was found that this could be done with a high degree of accuracy. The internal representation of a syllable nucleus duration may be more accurate than the spectrographic measurement of its acoustic correlate (Nootenboom, 1973, p. 42).

In a study by Hügins (1972), sentences containing words with altered speech segment durations were presented to listeners who were asked to indicate whether the vowel or consonant in question was "normal", "short", or "long". Results indicate that a difference in vowel length of 20 msec. could have perceptual relevance. Rossi (1972), using isolated vowels, attempted to specify the value of threshold for relative duration for the vowel /a/. Spectrum, fundamental frequency and intensity were held constant. Subjects were required to compare a fixed stimulus duration to variable stimulus durations. Results indicate that the jnd (just noticeable difference) or DL (difference limen) for duration increases significantly as the fixed duration increases. Between 60 and 140 msec., Rossi found the DL to be close to 30 msec. Between 130 and 290 msec., the DL was found to be a constant percentage (22.5%) of the fixed duration.

Delattre and Hohenberg (1968) studied the perception of vowel duration in German, specifically the duration of unstressed vowels. Synthetic speech was used and vowel durations were varied without varying vowel quality. The results of the investigation
show that there is a sharp boundary between judgements of "tense" and "lax" vowels. When a difference in vowel quality accompanied the length difference, it was found that duration was the more important cue in distinguishing the members of the pair.

In a similar study on the perception of vowel duration in Swedish by Hadding-Koch and Abramson (1964), three vowel pairs (long:short) were selected for study. The vowels of the first pair were very similar in quality and were distinguished largely by a difference in duration. The second pair was characterized by a marked difference in quality as well as the difference in duration. The third pair was chosen to exemplify a moderate qualitative difference along with the duration difference. Recorded speech was used and the long vowel of the minimal pair was shortened in degrees by means of tape cutting and splicing until it equalled the length of its short counterpart. The results show that in the case where a difference in duration was the only distinguishing feature, shortening the long vowel of the pair showed a constant decrease in "long" judgements. When the original long vowel reached the same duration as its short counterpart, subjects were unanimous in assigning the "short" member of the minimal pair to the stimulus. In the second case where a difference in vowel duration was accompanied by a striking difference in vowel spectrum, shortening the long vowel did decrease the number of "long" judgements but only by approximately 25%. In the third case where a difference in vowel length was accompanied by a slight difference in vowel spectrum, results were very similar to those of the first vowel pair. The conclusion arrived at was that in the first and third cases, the
vowels are distinguished by a feature of length, while in the second case the two phonemes are distinguished by a qualitative difference.

The perception of length as the primary cue distinguishing the pairs /ɑː:/ /a/ and /ɛː:/ /ɛ/ has yet to be investigated in French. It would be interesting to examine whether length is an important perceptual feature for French listeners in distinguishing such pairs as "maître:mettre" and "pâte:patte" or whether as Malmberg says:

...le Français n'est pas habitué à attribuer beaucoup d'importance aux variations de quantité vocalique (Malmberg, 1954, p. 92).
Chapter 3

AIMS OF THE INVESTIGATION

From the literature discussed in the previous chapter, it is apparent that most of the studies dealing with vowel length in French have taken the form of surveys. Little instrumental data have been gathered since Delattre's initial investigation in 1938.

The present study consists of two experiments which examine the use of phonemic vowel length by a small group of native speakers of French in such minimal pairs as "maître:mettre" and "pâte:patte".

3.1 Experiment I

Experiment I examines vowel duration from the point of view of production to determine if the native speakers selected make a measurable and/or significant distinction in length between members of such pairs as "maître:mettre" and "pâte:patte" when these words appear in the same frame sentence. It examines vowel duration when the study words appear in both stressed and unstressed positions (in this study stress refers to unemphatic stress in French which falls on the last syllable of a rhythmic group).

---

1 A rhythmic group is usually composed of a noun phrase or a verb phrase, more rarely of a whole sentence.
3.2 Experiment II

The second experiment examines the perception of differences in vowel duration and its use in distinguishing between members of a minimal pair. The specific questions raised are:

a) If the vowel in "maître" (or "pâte") is shortened, does the listener perceive the word as "mettre" (or "patte")? If so, by how much must the vowel be shortened in order to cause this reversal in the listener's perception of the word?

b) If the vowel in "mettre" (or "patte") is lengthened, does the listener perceive the word as "maître" (or "pâte")? If so, by how much must the vowel be lengthened in order to cause this reversal in the listeners's perception of the word?

In addition, both experiments examine the relation between the speaker/listener's concept of his production and perception of the length difference and his actual performance.
4.1 Experimental Apparatus and Procedures

4.11 Corpus

Seventeen minimal pairs of words were selected for the study. Selection of the pairs was based on the phonetic transcription given in the *Micro Robert: dictionnaire du français primordial*. Ten of the pairs exhibited the /aː:/ /a/ contrast and seven the /ɛː:/ /ɛ/ contrast. The words chosen were monosyllabic in all but one case ("hâlê:allê") and were closed syllable words for all but three pairs ("las:lâ", "mât:ma", "bas:bat"). Two lists of sentences were constructed. List 1 consisted of ordinary French sentences. The study words appeared in sentence final position except in the case of an open syllable word pair. Both members of a minimal pair of words appeared in the same frame sentence but the sentences varied between pairs. As it was not possible to find suitable sentence frames for the pairs "mât:ma", "bas:bat", "bèlê:belle", they were omitted from the first list. List 2 consisted of a single frame sentence. The frame sentence was chosen based on the results of a pilot study (the subject, a native speaker of French from St. Pierre and Miquelon, was recorded reading both lists). The frame sentence selected was "Il a prononcé le mot '___' plus fort."

Each list began and ended with two buffer sentences.
4.12 Subjects

Twelve native speakers of French, six men and six women were subjects for the experiment. They were all born and raised in France and represented the following regions:

Subject 1: Grenoble
Subject 2: Albi
Subject 3 & 9: Quimper
Subject 4 & 11: Paris
Subject 5: Marseille
Subject 6 & 7: Toulouse
Subject 8: Jura
Subject 10: Bordeaux
Subject 12: Limoges

All subjects except Subjects 11 and 12 taught French or linguistics. Subjects had no prior knowledge of what was being examined in the experiment.

4.13 Instrumentation and Arrangement

The subject stood four to six inches from an Altec 681A LO microphone which was placed on a boom in an IAC 1204 sound-proof room. A Scully tape recorder Model 280-2, situated outside the booth, was placed such that the examiner (who was in the sound-proof room) could observe the VU meter through the double glass window. The tape movement was controlled by the examiner by means of a Scully remote control box.
4.14 Experimental Design

The subject was given written instructions in French explaining that the recording involved two lists of sentences and that the sentences should be read at a normal speaking rate and with the same normal intonation, i.e. with falling intonation at the end of each sentence. The subject was asked to read through the lists of sentences to familiarize himself with them. Practice reading of the first few sentences was allowed to determine if further instructions were needed. List 1 and List 2 were then recorded. List 2 was recorded a second time and the subject was asked not to stress the word in quotations or to make a pause between it and the following phrase "plus fort". Again, the subject was permitted to practise reading the sentences in this manner before being recorded.

After recording the lists, the subject was asked what he thought was being studied and whether or not he thought he made the length distinction in question. The subject was also asked if he felt he had read the sentences in a natural manner.

4.2 Analysis of the Data

4.21 Instrumentation

Mingograms were made of List 1 and the second recording of List 2 for each speaker. Using a Siemens Oscillomink graphic recorder, five signals were displayed on the mingograms:
1. Microphone signal (channel 1)
2. Duplex oscillogram (channel 2)
3. Fundamental frequency (channel 3)
4. Log of average speech power (channel 4)
5. Average speech power (channel 5)

The tape recorder used in making the mingograms was a Revox Model A77. The duplex oscillogram and fundamental frequency tracings were produced via a Frøkjer-Jensen transpitchmeter. Speech power was recorded by means of a speech power detector similar to the one developed by Peterson and McKinney (1961).

Some spectrograms were made on a Kay Sonagraph Model 7029A to aid in segmentation of the utterances.

4.22 Criteria for Determining Vowel Boundaries

1. Vowel Onset
   a). When preceded by a stop consonant, the beginning of the vowel was easily determined by examining the microphone and duplex oscillogram tracings. Vowel beginning was measured immediately after the ebburst following stop closure.
   b). When preceded by a fricative, the beginning of the vowel was measured at the point where the duplex oscillogram tracing associated with the fricative returned to the zero line (see Fig. 1).
   c). When preceded by a nasal, the beginning of the vowel was measured at the offset of the characteristic microphone and duplex oscillogram tracings associated with nasals (see Fig. 2).
Fig. 1 Mingogram of the word "faite".
Fig. 2 Mingogram of the word "mettre".
d). When preceded by /l/, the beginning of the vowel was determined by examining the speech power tracing in conjunction with the microphone and duplex oscillogram tracings (see Fig. 3).

e). When preceded by a period of silence, vowel beginning was easily determined at the point of voice onset measured on the fundamental frequency tracing.

2. Vowel Offset

a). When followed by a stop consonant (in this study all postvocalic stop consonants in question are voiceless), the end of the vowel was easily determined at the point of voice offset measured on the fundamental frequency tracing or by examination of the microphone and duplex oscillogram tracings.

b). When followed by a fricative, vowel offset was measured at the point where the duplex oscillogram tracing returned to the zero line before proceeding negatively for the fricative (see Fig. 4).

c). When followed by /l/, the end of the vowel was determined by a dip in the speech power and duplex oscillogram tracings. In a few difficult cases, spectrograms were made.

d). When followed by a nasal, vowel offset was measured at the onset of the microphone and duplex oscillogram tracings associated with nasals. In a few difficult cases, spectrograms were made.

e). When followed by a period of silence, the end of the vowel was measured at the point of voice offset measured on the
Fig. 3 Mingogram of the word "là".
Fig. 4 Mingogram of the word "tache".
fundamental frequency tracing.

4.23 **Determination of Average Measurement Error**

Five utterances were selected at random from the two lists. Each of these utterances was segmented and vowel durations were measured for the second time. This was done for all twelve subjects. The second duration measurement was compared to the first and, using the formula

\[
\sigma = \left[ \frac{1}{n} \sum_{i=1}^{n} (X_i - Y_i)^2 \right]^{\frac{1}{2}}
\]

where

- \(X_i\) is the value of the first measurement for the \(i^{th}\) word,
- \(Y_i\) is the value of the second measurement for the \(i^{th}\) word, and
- \(n\) is the number of words measured (in this case \(n=60\))

the average error was calculated and found to be 3.71 msec.
4.3 Results

4.31 Averages of "Long" and "Short" Vowel Durations

Average vowel durations were calculated for the following four categories:

1. "long" /a:/ (List 1)
   "short" /a/ (List 1)

2. "long" /a:/ (List 2)
   "short" /a/ (List 2)

3. "long" /e:/ (List 1)
   "short" /e/ (List 1)

4. "long" /e:/ (List 2)
   "short" /e/ (List 2)

for each speaker.

A treatments-by-subjects analysis of variance was run to determine if the difference between the "long" and "short" vowels in each of the above categories was significant. Levels of significance are indicated below.

Category 1  p < .001
Category 2  p < .001
For this group of speakers it appears that there is a significant length difference made between the members of such pairs as "maître: mettre" and "pâte:patte" when the words appear in either stressed or unstressed position.

4.32 Average "Long":"Short" Vowel Ratios

In an early study (Delattre, 1938), Delattre found that when the length distinction was made, the "long":"short" vowel ratios were close to 1.60.

In the present study, average "long":"short" ratios were calculated for each speaker and are presented in Table 1. In all cases they were found to be less than Delattre's ratio of 1.60.

4.33 Comparison of /a:/:/a/ with /ɛː:/:/ɛ/

In the three survey studies mentioned earlier (Martinet, 1945; Reichstein, 1960; Deyhime, 1967), it was found that the /a:/:/a/ distinction was more frequently maintained than the /ɛː:/:/ɛ/ distinction. A t-test was run for each subject to determine if there was a significant difference between the mean ratios of /a:/:/a/ and /ɛː:/:/ɛ/. None of the speakers showed a significant difference between the two vowel pairs.
TABLE 1

Average "Long":"Short" Vowel Ratios for Each Subject.

<table>
<thead>
<tr>
<th>Subject</th>
<th>List 1</th>
<th>List 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>1.23</td>
<td>1.22</td>
</tr>
<tr>
<td>S2</td>
<td>1.723</td>
<td>1.15</td>
</tr>
<tr>
<td>S3</td>
<td>1.36</td>
<td>1.30</td>
</tr>
<tr>
<td>S4</td>
<td>1.45</td>
<td>1.03</td>
</tr>
<tr>
<td>S5</td>
<td>1.18</td>
<td>1.09</td>
</tr>
<tr>
<td>S6</td>
<td>1.08</td>
<td>1.01</td>
</tr>
<tr>
<td>S7</td>
<td>1.03</td>
<td>1.03</td>
</tr>
<tr>
<td>S8</td>
<td>1.38</td>
<td>1.29</td>
</tr>
<tr>
<td>S9</td>
<td>1.16</td>
<td>1.11</td>
</tr>
<tr>
<td>S10</td>
<td>1.27</td>
<td>1.12</td>
</tr>
<tr>
<td>S11</td>
<td>1.07</td>
<td>1.12</td>
</tr>
<tr>
<td>S12</td>
<td>1.17</td>
<td>1.11</td>
</tr>
</tbody>
</table>
4.34 **Stressed vs. Unstressed Position**

Ideally the two lists would have shown the study words in (unemphatically) stressed (List 1) and unstressed (List 2) positions. However, due to the frame sentence chosen for List 2 ("Il a prononcé le mot '___' plus fort."), certain subjects had a tendency to emphasize the word in quotations despite having been asked not to.

Examination of the data reveals that for 10 of the 14 word pairs common to both lists, a greater percentage of speakers made a difference when the pair appeared in List 1 than when it appeared in List 2 (see Table 2). When a length difference was made in List 2, the "long":"short" ratios were generally reduced (only one subject, S11, had a greater average ratio for List 2 than for List 1. This subject felt she made no distinction in her speech between the word pairs under consideration). t-test results indicate, however, that there is no significant difference between the mean ratios for the two lists.

4.35 **Speaker Differences**

Comparing the mean "long" to the mean "short" vowel durations, it was found that for eight speakers, the "long" average duration was longer than the "short" average duration in each of the four categories mentioned in section 4.31. Three of the four speakers who did not have greater average "long" than average "short" values in all four categories were from the Midi region of France. This observation tends to support Deyhime's finding (Deyhime, 1967) that the speakers from the Midi region of France make the length distinc-
TABLE II

Presence or Absence of Length Distinction Between "Long" and "Short" Members of Each Pair for Individual Subjects.

<table>
<thead>
<tr>
<th></th>
<th>S₁</th>
<th>S₂</th>
<th>S₃</th>
<th>S₄</th>
<th>S₅</th>
<th>S₆</th>
<th>S₇</th>
<th>S₈</th>
<th>S₉</th>
<th>S₁₀</th>
<th>S₁₁</th>
<th>S₁₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>âne:Anne</td>
<td>++</td>
<td>--</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>--</td>
<td>++</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>las:là</td>
<td>++</td>
<td>--</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>--</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>--</td>
<td>++</td>
</tr>
<tr>
<td>pâte:patte</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>--</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Bâle:balle</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>-</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>mâle:mate</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>=</td>
<td>+</td>
<td>--</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>--</td>
<td>--</td>
<td>+</td>
</tr>
<tr>
<td>tâche:tache</td>
<td>++</td>
<td>-</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>--</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>--</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>hâlé:allé</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>--</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>--</td>
<td>+</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>mâle:malle</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>--</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>reine:renne</td>
<td>++</td>
<td>--</td>
<td>++</td>
<td>+</td>
<td>--</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>--</td>
<td>--</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>fête:faite</td>
<td>++</td>
<td>-</td>
<td>++</td>
<td>+</td>
<td>--</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>--</td>
<td>--</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>aile:elle'</td>
<td>+</td>
<td>++</td>
<td>-</td>
<td>++</td>
<td>--</td>
<td>++</td>
<td>++</td>
<td>-</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>l'être:lettre</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>±</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>maître:mettre</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>--</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>bête:bette</td>
<td>++</td>
<td>++</td>
<td>-</td>
<td>++</td>
<td>+</td>
<td>--</td>
<td>++</td>
<td>++</td>
<td>-</td>
<td>++</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>bègle:belle</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>++</td>
<td>--</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>bas:bat</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>++</td>
<td>--</td>
<td>++</td>
<td>--</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>mâle:ma</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>++</td>
<td>--</td>
<td>++</td>
<td>--</td>
<td>--</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

First entry corresponds to List 1
Second entry corresponds to List 2

+ = "long":"short" vowel ratios > 1
- = "long":"short" vowel ratios < 1

<table>
<thead>
<tr>
<th>S₁</th>
<th>Grenoble</th>
</tr>
</thead>
<tbody>
<tr>
<td>S₂</td>
<td>Albi</td>
</tr>
<tr>
<td>S₃</td>
<td>Quimper</td>
</tr>
<tr>
<td>S₄</td>
<td>Paris</td>
</tr>
<tr>
<td>S₅</td>
<td>Marseille</td>
</tr>
<tr>
<td>S₆</td>
<td>Toulouse</td>
</tr>
<tr>
<td>S₇</td>
<td>Toulouse</td>
</tr>
<tr>
<td>S₈</td>
<td>Jura</td>
</tr>
<tr>
<td>S₉</td>
<td>Quimper</td>
</tr>
<tr>
<td>S₁₀</td>
<td>Bordeaux</td>
</tr>
<tr>
<td>S₁₁</td>
<td>Paris</td>
</tr>
<tr>
<td>S₁₂</td>
<td>Limoges</td>
</tr>
</tbody>
</table>
tion less frequently than speakers from other areas of France. No significant difference between meridional and non-meridional subjects could be found by means of t-tests for the following four categories:

1. mean ratios (List 1)
2. mean ratios (List 2)
3. mean no. of ratios > 1 (List 1)
4. mean no. of ratios > 1 (List 2)

4.36 Speaker's Intuition vs. Speaker's Performance

A t-test was run to determine if there was a significant difference between subjects who thought they made the length difference and those who thought they did not (subjects who were unsure, or who felt they might make a difference in some cases were excluded from the test). The same categories as mentioned in section 4.35 were examined and the levels of significance for each category are shown below.

<table>
<thead>
<tr>
<th>Category</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category 1</td>
<td>p &lt; .01</td>
</tr>
<tr>
<td>Category 2</td>
<td>NS</td>
</tr>
<tr>
<td>Category 3</td>
<td>p &lt;&lt;.05</td>
</tr>
<tr>
<td>Category 4</td>
<td>NS</td>
</tr>
</tbody>
</table>

\(^1\)Not significant
Chapter 5

EXPERIMENT II

5.1 Experimental Apparatus and Procedures

5.1.1 Preparation of the Test Tape

Selection of the Recording. List 2 recorded by one of the subjects for the first experiment was selected for use in the second part of this study. Selection of the recording was based on the voice quality of the speaker, relative neutrality of accent, i.e. relative closeness to the so-called "standard" French pronunciation, and the presence of a length difference between members of a minimal word pair.

Selection of Word Pairs. Nine minimal pairs of words were selected, five exhibiting the /œː/:/a:/ contrast and four the /ɛː/:/ɛ/ contrast. The pairs were selected on the basis of the results of Experiment I. Criterion for selection was a minimum of eight of the twelve speakers with "long":"short" vowel ratios greater than 1.00 for the minimal pair in question. The pairs selected were:

"Bâle:balle"
"pâte:patte"
"mâle:malle"
"las:lâ"
"tâche:tache"
Vowel Editing. The selected words were spliced from the carrier phrase "Il a prononcé le mot '____' plus fort." from a dubbing of the original tape. To ensure that the isolated words had not been clipped or distorted as a result of splicing and dubbing, mingograms were made of the words from the spliced tape and compared with mingograms of the entire sentence taken from the original tape.

An intensity scale was established to convert centimeters (measured on the speech power tracing on the mingogram) to decibels. Differences in vowel intensity between members of the same minimal pair were measured on the mingogram and converted to decibels using the prepared scale. Discrepancies in intensity were adjusted with an attenuator. Mingograms were made of the intensity-adjusted words and differences in intensity were found to be 1 dB or less between the members of a minimal pair of words.

Using a PDP-12 computer and the program WAVES developed by Lloyd Rice, the isolated stimulus words were digitized and stored on computer tape. The set of programs WAVES digitizes the speech signal and permits the speech waveform, which can be displayed on the computer's oscilloscope screen, to be altered by means of adding or removing segments of the speech wave. The computer is able to sample the speech signal at a rate of up to 12,000 samples per se-
cond. This maximum sampling rate, however, is effective only for signal durations of less than approximately 1.5 seconds. For signals longer than this, the computer would be unable to transfer samples fast enough, due to the slow rate of transfer to the tape, and would begin to skip samples once the core buffer had been filled. The skipping of samples would result in a noticeable distortion of the signal. Therefore, the audio tape containing the nine word pairs was played at half speed. This signal was sent through a Rockland Programmable Dual Hi/Lo filter Model 1520 with the high frequency cutoff set at 3,000 Hz. The program's sampling rate was set at 6,000 samples per second, which would be equivalent to 12,000 samples per second if the tape were played back at normal speed.

Once the speech wave had been stored on computer tape in this manner, it was then possible to view it on the oscilloscope screen. The display of the speech wave could be moved back and forth across the computer's screen by means of a knob which was manipulated by the operator. The program allowed the operator to lengthen or shorten the vowel waveform by repeating or removing the number of cycles desired. The edited word was then stored on a separate computer tape. Vowel waveforms were lengthened or shortened at a point in the waveform, steady in terms of amplitude and shape, and the point of editing was always marked at a zero-crossing between two cycles of the fundamental (if the vowel was not spliced at the zero-crossing, noticeable distortion resulted).

It was calculated that each period in the vowel waveform corresponded to an average of 8 msec. for the speaker chosen. The
vowel waveform of each word was altered in five steps of two cycles (i.e. 16 msec.) for a total range of 64 msec. between the longest and shortest version of the edited word. Ninety stimulus words were prepared in this manner (five different versions of both members of the nine minimal pairs of words). Using the program WAVES, the digitized signal was converted to an analogue signal, fed back through the high-pass filter set at 6,000 Hz and recorded on audio tape using a Revox Model A77 tape recorder. The stimulus words were recorded in random order with the condition that stimuli from the same word or the same word pair were not in sequence. Six buffer words selected from the ninety test stimuli were recorded, three at the beginning and three at the end of the tape. The inter-stimulus interval was fixed at five seconds (the program WAVES allows the operator to set the desired number of seconds that are to precede and follow each output segment).

5.12 Subjects

Twelve native speakers of French served as subjects for the second experiment. In all but one case they were the same subjects used in the first experiment.

5.13 Test Procedure and Equipment

The test tape was played back on a Revox Model A77 tape recorder through Sharpe HA10 headphones at a level corresponding to 50-60 dB SPL measured through TDH-39 Maico Headphones with a Brüel and Kjaer 2203 precision sound level meter, a Brüel and Kjaer 4152 artificial ear and a 6cm³ coupler. The subject was seated in a
quiet room and was asked to underline on the answer sheet provided the word he heard. For each stimulus presentation the response sheet offered a choice of the "long" and "short" version of the word.

5.2 Results

In order to analyze the results of the perception test a tabulation of the listeners' responses was made in the following manner: The random list of test responses was reordered so that the five versions of each word were grouped together. Within each group of five, the words were ordered according to vowel duration, i.e. from longest to shortest. Each listener's response to a stimulus was classified as either "long" or "short" and entered opposite the corresponding word in the reordered list. All subjects' responses for that word were then examined and converted to a percentage (out of twelve) based on the number of listeners who heard that word as the original unedited version. The percentages were then plotted as a function of vowel duration measured in milliseconds (see Fig. 6 to Fig. 14).

In some cases the end points of the curve for the "long" version and the curve for the "short" version of a pair are not aligned. This is due to the fact that the differences between the vowel durations of the original "long" and "short" vowels were, in these cases, more than the 64 msec. range, e.g. the vowel durations of "pâte" and "maître" exceeded those of "patte" and "mettre" by 100 msec.
The shape of the curves in Fig. 6 to Fig. 14 indicate that the listeners' judgements were indeed affected by the altered vowel length of the original word. If the listener were basing his judgement solely on the feature of vowel length, however, one would expect the two curves to be the inverse of each other as in the figure below.

Fig. 5 Listeners' judgements based on vowel duration only.

Fig. 6 to Fig. 14 indicate that while length does appear to be affecting the listener's judgements, other factors are influencing his decisions as well.
Fig. 6 Listeners' judgements of original and edited versions of "Bâle" and "balle".
Fig. 7 Listeners' judgements of original and edited versions of "pâte" and "patte".
Fig. 8 Listeners' judgements of original and edited versions of "mâle" and "malle".

vowel duration in milliseconds

% judgements
Fig. 9 Listeners' judgements of original and edited versions of "las" and "là".
Fig. 10 Listeners' judgements of original and edited versions of "tâche" and "tache".
Fig. 11: Listeners' judgements of original and edited versions of "maître" and "mettre".
Fig. 12 Listeners' judgements of original and edited versions of "bête" and "bette".
Fig. 13 Listeners' judgements of original and edited versions of "bèle" and "belle".
Fig. 14 Listeners' judgements of original and edited versions of "l'Être" and "lettre".
5.21 **Vowel Lengthening vs. Vowel Shortening**

The results of the experiment indicate that the listener's judgement of a lengthened "short" vowel differs from his judgement of a shortened "long" vowel. For all the word pairs in the study (with the exception of "las:là" and "tâche:tache") a smaller shift in vowel duration was required to reverse the listener's judgement of the original "short" version of the word than to reverse his judgement of the original "long" version. This shift in duration is taken to be the difference in milliseconds between the vowel duration of the original word and the vowel duration corresponding to the 50% response point on the graph. The 50% response point is considered the category boundary between the "long" and "short" vowel. The average number of additional milliseconds needed to reverse the listener's judgement of the originally "short" version of the word (to the 50% response point) was 32 msec. The average number of subtracted milliseconds needed to reverse the listener's judgement of the originally "long" version of the word was 51 msec.

Comparing the effect of maximum lengthening and maximum shortening of the vowel on the listener's judgement, it was found that when the originally "short" vowel was maximally lengthened (i.e. by 64 msec.), only 19% of the listeners still heard it as "short". On the other hand when the originally "long" vowel was maximally shortened (i.e. by 64 msec.), 41% of the listeners still heard it as "long".
5.22. **Other Factors Influencing Listener Judgement**

Spectrograms were made of the original word pairs (i.e. before vowel editing) and the first three formant frequencies were measured.

Differences in formant frequency between the steady-state portion of the /ɛː:/ɛ/ word pairs were found to be non-significant. However, the vowels in "maître" and "l'être" were accompanied by a noticeable glide (the glide was remarked on by several of the listeners).

Differences in formant frequency between the /aː:/a/ word pairs were measured and it was found that, with the exception of "las:là", the second formant of the "short" version was consistently higher than the second formant of the "long" version. This observation is in keeping with the articulatory correlate of "anterior" (corresponding to a high second formant) vs. "posterior" (corresponding to a low second formant). The greatest difference between the second formants of the "long" and "short" versions was found for the pair "mâle:malle" (a difference of 150 Hz was measured). This larger vowel quality difference could account for the irregularity of the curve representing the listeners' judgement of the edited versions of "mâle" (see Fig. 8).

It appears, therefore, not too surprisingly, that when the vowel pair exhibits a difference in formant frequency, or when the "long" vowel is accompanied by a glide, shortening the originally "long" version has a smaller reversal effect on the listeners' judgement of the word than does lengthening the originally "short" version. Similar results were found by Hadding-Koch and Abramson
(1964) for Swedish. In their study, they found that when a vowel pair was differentiated only by a contrast in duration, shortening the "long" version had a great effect in reversing the listeners' judgement of the word. When the vowel pair was accompanied by a marked difference in vowel quality as well as a difference in duration, the effect of shortening the "long" version had a much smaller reversal effect on the listeners' judgement of the word (see Chapter 2, section 2.3 of the present study).

5.23 Listener's Intuition vs. Listener's Performance

All of the subjects felt that the task required, i.e. assigning a particular lexical item to the stimulus, was a difficult one and several subjects felt they were guessing part of the time. At the end of the test, subjects were asked what they felt they were basing their judgements on. Half of the speakers felt their judgements were based on vowel length and the other half said they thought their judgements were based on quality or on both quality and length. Examination of the test responses revealed no difference between the three groups.
6.1 Vowel Duration: Production

The first part of the study examined the use of vowel length by a small group of native speakers of French in the production of such pairs as "maître:mettre" and "pâte:patte". Several recent articles (Delattre, 1966; Deyhime, 1967, Léon, 1972) suggest that the length distinction is maintained infrequently in contemporary French. The results of the present study, however, indicated that, for the population selected, the "long" vowel was significantly longer than the "short" vowel when the words appeared in the same frame sentence in both (unemphatically) stressed and unstressed positions. The "long":"short" vowel ratios were not found to be so large as those measured by Delattre (Delattre, 1938).

No significant difference was found between the "long":"short" ratios for the /aː:/ /a/ contrast and those for the /ɛː:/ /ɛ/ contrast. This finding does not support Deyhime's suggestion (Deyhime, 1967) that the /aː:/ /a/ contrast in length is maintained with a greater degree of consistency than the /ɛː:/ /ɛ/ contrast.

Another tendency observed from the experimental results is that the speakers from the Midi region of France tended to make a difference in length less frequently than speakers from other areas. The difference between the vowel ratios for the two groups, however, was not found to be significant.
A difference was observed between the vowel ratios of List 1 and List 2. When the words appeared in (unemphatically) stressed position (List 1), the "long":"short" ratios were more frequently larger than unity than when they appeared in unstressed position (List 2). Also, the "long":"short" vowel ratios were generally larger when the words appeared in stressed position but these observed differences were not found to be statistically significant.

A comparison was made between the speakers who claimed they made a difference and those who claimed they did not. When the study words appeared in stressed position, a significant difference in "long":"short" vowel ratios was found between the two groups of speakers. No significant difference was found between the two groups when the words appeared in unstressed position.

The present study concerning the use of vowel length in French has several limitations. As the population examined was relatively small, it is not possible to draw any conclusions about the status of the length distinction among French speakers in general. The speakers selected were all highly educated and thus represented only one social group. In future studies it would be interesting to examine the use of vowel length, using a similar method of investigation, by a larger group of speakers including subjects from differing social and educational backgrounds.

A further limitation of the present study in determining the use of vowel length by the selected group of speakers was the relatively artificial atmosphere of the recording session. Although the subjects were asked to read the sentences in a natural
manner, many commented that they found it difficult to be completely natural and awareness of their pronunciation was heightened. This factor could have affected their production of the length contrast since Delattre observed that it is maintained only in "careful diction" (Delattre, 1964, p. 99). However, since the subjects were unaware of what was being examined it is unlikely that they were overly conscious of their production of the distinction in length between such pairs as "maître:mettre" and "pâte:patte". If more time had been available, it would have been interesting to record each subject on several occasions in order to examine the consistency of the length contrasts and the consistency of the "long":"short" vowel ratios.

In order to obtain more conclusive results concerning the status of the length distinction in French, future studies might benefit from using a controlled recording procedure and objective method of analysis, similar to that utilized in the present study, on a larger, more varied population of native speakers of French.

6.2 Vowel Duration: Perception

The second part of the study examined the listener's use of vowel length in distinguishing perceptually between such pairs as "maître:mettre" and "pâte:patte". The vowel durations of these words were varied in steps of two cycles of the fundamental frequency (or approximately 16 msec.) and listeners were asked to assign to the stimulus a lexical item (either the "long" or "short" version of the word).
Listeners' judgements were found to be affected by shifts in vowel durations. Lengthening the "short" vowel seemed to have a greater reversal effect on listener judgement than did shortening the "long" vowel. In the cases of "maître:mettre" and "pâte:patte", where the original "long" and "short" versions were separated by a difference of 100 msec., the addition of 64 msec. to the original "short" version was a greater alteration of the original duration from the point of view of percentage than the subtraction of 64 msec. from the original "long" version. For these word pairs this could explain the greater effect that lengthening the "short" version had on the listener's judgement of the word. In some cases, e.g. "mâle", vowel quality was a more important cue than length in making judgements of the edited versions of the originally "long" word. Vowel quality of the originally "short" vowel did not appear to be as important a cue as the length feature in assigning a lexical item to the stimulus. Because of the differing effect of lengthening the "short" version and shortening the "long" version, it was not possible to arrive at a critical unit of duration that, when added to the originally "short" version or subtracted from the originally "long" version, would reduce "short" and "long" responses respectively to the 50% response point. Using synthetic speech stimuli, many of the problems encountered in analyzing the results could be avoided. Formant frequencies for the "long" and "short" members of a pair could be averaged and held constant along with intensity and fundamental frequency while varying only vowel duration. In this way it would be possible to determine with greater accuracy the critical unit of
duration required to reverse listener judgement. In a recent study (Léon, 1972), Léon ran a listening test which consisted of the pairs "bête:bette", "bête:belle", and "l'être:lettre" recorded by ten native speakers. It was found that when the vowel duration of the "long" version exceeded that of the "short" version by approximately 30 msec., the words were consistently judged correctly by native listeners. This figure is close to the average of 32 msec. found in this study, which was needed to reverse the listeners' judgement of the originally "short" version to the 50% response level. By eliminating differences in formant frequency by means of synthetic speech, one could determine if the critical duration for reversing the judgement of the original "long" version to the 50% response point is around 30 msec.

In this study, the listening task did not require that the subject compare the duration of one stimulus to that of another. Rather, the listener had to base his judgement on some internally generated criterion. The results of the test tend to support Lehiste's notion of a "durational image" (Lehiste, 1970) to which the listener can compare the stimulus and arrive at a judgement about the length of the stimulus in relation to this internal "durational image".

6.3 Vowel Duration: Production and Perception

Comparing the results of the first experiment with those of the second experiment, the question arises as to the relation between the production and perception of the length difference. Is perception dependent on production or vice versa, or are the
two processes independent of each other?

The results of the second experiment do not indicate a difference between the responses of the speaker/listeners who claimed they made the length difference and those who claimed they did not. This observation would suggest that perception of the length distinction is not dependent upon its production. A consideration, however, that must not be overlooked in comparing the results of the two experiments, is that most of the subjects taught French to English speaking students. The pronunciation of "standard" French, therefore, was familiar to all the subjects, and in this standard French subjects were aware that a length distinction is made between such pairs as "maître:mettre" and "pâte:patte". This fact could have affected the results of the listening test, i.e. subjects may have learned to make and perceive the length distinction when teaching the standard French pronunciation to English speaking students even when the distinction does not occur in their own speech.

In examining the relation between production and perception of the vowel length feature in French, it would be more enlightening to run the listening test on subjects less aware of the standard pronunciation of French. One might find in such a study, that subjects who do not make the length distinction in their own speech do not perceive differences in vowel duration as consistently as those who are accustomed to making the length distinction.


BOINDIN. (1953). Remarques sur les sons de la langue.

CHLUMSKÝ, J. (1928). Česka kvantita, melodie a přízvuk (Prague).


Instructions for Experiment I:

1. La première liste contient trente-deux phrases françaises ordinaires. La deuxième liste contient trente-huit phrases toutes de la forme "Il a prononcé le mot '___' plus fort." où '___' sera toujours un mot français.

2. Lisez le numéro de chaque phrase, puis lisez chaque phrase à vitesse normale et avec la même intonation normale en faisant tomber la voix à la fin de chaque phrase.

3. Si vous faites une erreur quelconque en lisant ou que vous ayez une hésitation, répétez simplement la phrase en question.

4. Lisez les phrases une fois pour vous.
Liste 1

1. Il porte une cotte de maille.
2. Ils mangent de la glace.
3. Il l'a appelé bel âne.
4. Près de la ruche il y avait plusieurs rennes.
5. Il est là ce soir.
6. Il fait reposer sa patte.
7. Ils vont tirer à balles.
8. Je n'ai que la robe de fête.
9. Il s'est envolé sans elle.
10. Il faut qu'on le mâtre.
11. C'est sa première journée sans tache.
12. Il est las ce soir.
13. C'est un changement de lettre.
15. Il pourrait le faire mettre.
16. Il l'a appelée "Belle Anne".
17. Il est hâlé.
18. Il pourrait le faire maître.
19. Regardez ces bêtes.
20. C'est sa première journée sans tache.
22. Il est allé.
23. Ils vont tirer à Bâle.
24. Il s'est envolé sans ailes.
25. C'est un changement de l'être.

26. Elle adore ces mâles.

27. Il faut qu'on le mate.

28. Je n'ai que la robe de faîte.

29. Près de la ruche il y avait plusieurs reines.

30. Regardez ces bettes.

31. Il a acheté deux chaises.

32. Le petit chat est dans l'arbre.
List 2

1. Il a prononcé le mot "nette" plus fort.
2. Il a prononcé le mot "quatre" plus fort.
3. Il a prononcé le mot "là" plus fort.
4. Il a prononcé le mot "mettre" plus fort.
5. Il a prononcé le mot "l'être" plus fort.
6. Il a prononcé le mot "Anne" plus fort.
7. Il a prononcé le mot "renne" plus fort.
8. Il a prononcé le mot "tâche" plus fort.
9. Il a prononcé le mot "malle" plus fort.
10. Il a prononcé le mot "mate" plus fort.
11. Il a prononcé le mot "balle" plus fort.
12. Il a prononcé le mot "pâte" plus fort.
13. Il a prononcé le mot "maître" plus fort.
15. Il a prononcé le mot "mâte" plus fort.
16. Il a prononcé le mot "bat" plus fort.
17. Il a prononcé le mot "aile" plus fort.
18. Il a prononcé le mot "las" plus fort.
19. Il a prononcé le mot "âne" plus fort.
20. Il a prononcé le mot "elle" plus fort.
21. Il a prononcé le mot "ma" plus fort.
22. Il a prononcé le mot "patte" plus fort.
23. Il a prononcé le mot "lettre" plus fort.
24. Il a prononcé le mot "belle" plus fort.
25. Il a prononcé le mot "tache" plus fort.
26. Il a prononcé le mot "bas" plus fort.
27. Il a prononcé le mot "bette" plus fort.
28. Il a prononcé le mot "hâlé" plus fort.
29. Il a prononcé le mot "bèle" plus fort.
30. Il a prononcé le mot "fête" plus fort.
31. Il a prononcé le mot "mâle" plus fort.
32. Il a prononcé le mot "mât" plus fort.
33. Il a prononcé le mot "reine" plus fort.
34. Il a prononcé le mot "Bâle" plus fort.
35. Il a prononcé le mot "bête" plus fort.
36. Il a prononcé le mot "faite" plus fort.
37. Il a prononcé le mot "tasse" plus fort.
38. Il a prononcé le mot "dette" plus fort.